

Article

Prospective and hybrid alternative of renewable energy, for a sustainable mining.

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Summary

The mining is an energy-intensive industry that requires a stable source of electricity. With the increase in demand for minerals and the decrease in grades, the demand for energy is expected to increase by 36% by 2035. This increased demand relies on the use of fossil fuels since the electricity produced and purchased in the mining companies is Based primarily on fossil fuels, the costs of solar and wind energy storage systems have fallen on an unprecedented scale, encouraging mining companies to test these technologies. Among the influencing factors of the use of renewable energy, is the benefit to the community in the stage of operation and closure or post-closure of a mining project, the next factor is the profile of electricity consumption or demand is important for the calculation of its storage or not, of the renewable energies to be used. As a third factor is the calculation for consumption in the processes. The penetration ranges will determine if its energy storage is possible, and if it is possible to use hybrid control (solar - wind), for this the use of digital tools such as the Holmer program is important, it is an important tool that technical and economical. The government must have a perspective that helps on regulatory issues necessary to promote renewable energy projects with different incentives and interests according to the mining context.

Key Words: Renewable energy, mining industry, technologies, penetration rate, political analysis.

1. Introduction

(Paolo Natali and Kevin Haley, 2017) In the mining industry the use of energy is intensive and requires a reliable and constant access in its operations. The mining industry represents between 1.25% to 11% of global energy demand. On average, the energy sector depends on fossil fuels for 62%, that is, oil, gas and coal, 35% is made up of electricity. (Benjamin McLellan et al., 2018) Indicates that ferrous and non-ferrous minerals tend in a higher proportion of fossil fuel consumption to electricity. (about 87-88%) this compared to non-ferrous metals (about 60%).

In 2014, only 0.001% energy consumption in the mining and quarrying sector was solar, wind or other type or renewable energy installed on the site. (Benjamin McLellan et al, 2018)

(Juan Carmona, 2012) mentions that alternative energies are essential to be able to survive today and undoubtedly in the not too distant future, as we have seen the resources for fossil energies are They are depleting faster than was anticipated and than the population.

(Biomass Users Network, 2002) considers renewable energy technologies on a small scale to be a positive economic and environmental alternative in the generation of energy in remote rural communities, either by increasing the installed capacities in the electricity issue or by means of systems interconnected or isolated to a network.

(REN 21, 2016) considers links between governments, non-governmental organizations, academic and research institutions, international organizations and industries to mutually support each other, exchange knowledge and lead to actions towards the use of renewable energies.

(Nandwani, S, 2005) due to economic, environmental and political factors, it is necessary to find other sources of energy that are cheap, abundant, clean and that preserve the ecological balance. Energy from the sun, wind and the earth (geothermal) are the alternatives, but energy from the sun has an additional advantage compared to two other sources.

(Castrillón, Y, 2019) Wind energy is, among all renewable energies, the form of electrical energy production with the best present and, together with that obtained from biomass, the most promising future. The reduction of the costs of this technology, increasing by the fact that, due to the environmental awareness of citizens.

(Moratilla Soria, B., 2006) There are more and more wind farms present in the Spanish geography, mainly due to spectacular technological development and adequate support measures. It is detailed that in the last 15 years there has been an increase in the sector of use of wind energy, generation from this source has been multiplying exponentially and constitutes a reality currently on the rise

(Pinilla, A, 2008) mentions that, in recent studies , which the author of this contributes, speculates on the potential of wind energy in Colombia for the generation of commercial electricity, it is also mentioned about other uses and local developments in wind energy, especially in the water pumping sector.

(International Energy Agency, 2018) Regarding the generation of Electricity through hydroelectric plants and the combination of renewable energies, it can be observed that it is below 10% since 1971. As we can see this scenario in which oil consumption For the generation of electricity, it makes the option for wind or solar energy a technological option on the subject of electricity.

(Energy and Mines, 2018) Solar and wind generation projects have the great potential to supply the energy mining industries, indicating that the average energy expenses in the mining industries are at 15% of the total costs up to 40% when the issue of processing said minerals is included.

(Ernst & Young, 2017) Therefore, the cost savings due to energy issues is significant, since its consumption will probably increase in the future. Currently there are several solar and wind energy projects that are underway, such as Ernst and Young anticipate, by 2022, the investment of the mining sector in renewable energy will be more than double that of the current investment.

Despite the increasing use of renewable sources in the mining sector, the rate of use of wind or solar energy remains minimal, after the review of an extensive literature the review of a regulatory framework is detailed and specific studies in Australia Canada Chile and South Africa. These countries, which are rich in mineral resources and integrate renewable energy in their mining sites, have developed very advanced regulatory frameworks to support renewable energy systems.

The main focus of this literature is on solar and wind energy sources that supply very large-scale mining operations. It highlights factors to choose from in choosing energy supply and the renewable energy penetration rate that can be achieved with current technologies and policy analysis regarding this.

2. Materials and methods

This section describes renewable energy in mining and energy sources, its influencing factors, and then goes on to the study of the penetration ranges of renewable energies as well as their distribution, in the different mining processes, it will be detailed digital tools such as TRNSYS, INSEL and HOMER for their calculations of adequate requirements and the vision of the state and the private sector regarding the promotion of these renewable energy projects.

2.1. Renewable energy in mining

Interest in these renewable energies has increased in recent years, which have launched several projects, as well as new projects have been included (Rocky Mountain Institute, 2018) Where an updated list of renewable energy projects is maintained that are advertised and also launched on mining company properties.

Figure 1 highlights the recent trend in installed capacity, 59% are wind projects, 37% are photovoltaic solar energy and 4% are solar thermal energy.

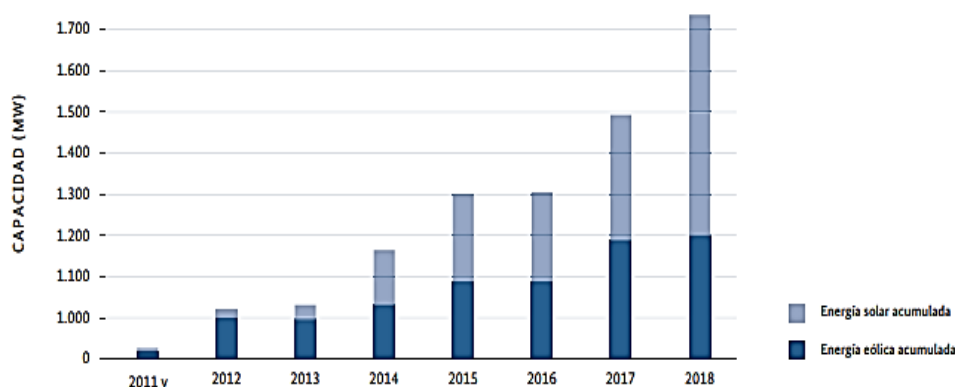


Figure 1. Cumulative renewable energy capacity

2.2. Influencing factors in renewable energies

Among the factors that we consider for the execution of renewable energy projects, it can be observed that the location, the design of the mine and the options of energy sources for an industrial sector. They influence the different stages of the project, such as exploration, operation and subsequent closure. These, in turn, benefit the mine in different aspects, the energy network itself and the communities in the closure of the mine.

Understanding the various costs and reliability of the various life-saving options within renewable energy projects, it could be said that energy from a stable hydroelectric-based electrical grid is less expensive than a capable solar or wind project. to compete with the prices offered by the network.

The report (World Bank Group, 2015) The power of the mine estimates at \$ 5cts / kwh. There could be opportunities to use energy sources in processes such as firefighting and lighting, where their supply is purely for the consumption of oil where, apart from price, supply and price volatility are taken into account.

Table 1 Factors that determine the energy supply agreement

Etapas de un proyecto minero	Mejoras de las energías renovables en minería	Condiciones en la red energética	Aspecto legal	Beneficiario
Exploración	Por la Ubicación	Sin conexión en la red Conexión a la red	Impuestos y subsidios	Mina
Operación	Por el diseño de Mina	inestable	Servicios Nacionales	Red
	Por opciones energéticas	Conexión a la red estable	Oportunidades sostenibles en la red	Comunidad
Cierre y posterior al cierre				

A 2016 study takes several considerations into account by comparing various energy solutions in mines. (The Collahuasi, 2018) Four simulations were carried out to evaluate financial impacts resulting from the 150 megawatt solar project at the Collahuasi mine in Chile. Energy savings per ton can be observed for various mining processes including concentration plant, desalination, utilities, electrical wiring, and leaching. It can be seen that the value of the shares of the company has increased this due to the considerable savings.

(Roman Votteler, 2016) In South Africa it evaluates combined systems of solar energy with diesel and wind energy with diesel in which it concludes that the diesel-based power plant outperformed hybrid solutions in terms of installation costs, space requirements and implementation deadlines. Regarding the evaluation, it is observed that hybrid wind solar energy solutions have a better performance in terms of fuel consumption, reducing carbon dioxide emissions, promoting a better institutional image and improving relations with the community. It is estimated that in the 20-year period could save 44 million euros by introducing solar energy 55 million euros by introducing wind energy. It is mentioned that the wind energy required 3 more months in terms of the solar energy infrastructure also presents a lower potential to create additional jobs.

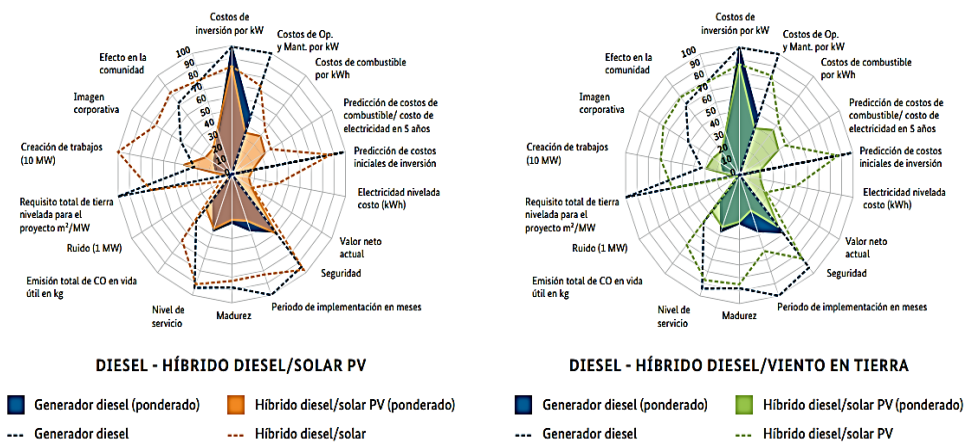


Figure 2. Comparison of diesel and hybrid solutions

(Roman Votteler, 2016) Mines should also consider whether there is a load shedding or scheduled shutdown to reduce overall demand and avoid potential blackouts.

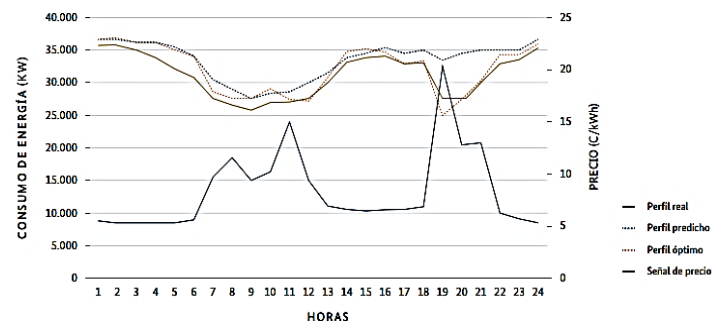


Figure 3. Electricity demand profile of an underground gold mine

(Rothen Rodrigo, 2015) In the large mining sector in Chile, the distribution by mining processes is detailed, the average consumption required in electric energy, it can be mentioned that 7% is the consumption referring to the Mining activities, 67% is referred to the consumption per concentrator plant, the issue of agglomeration, leaching, solvent extraction and electrolysis (LXSXEW) has a consumption of 7%, the smelter is in an average 13%, 3% in the refinery and 4% in other services that the mining activity includes. This delimits us which sectors can be more optimal in any industry to work with wind or solar renewable energies.

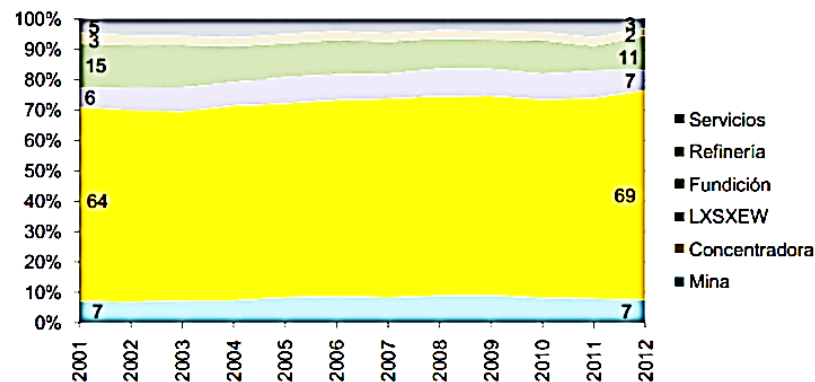


Figure 4. Electric energy consumption by mining process and its percentage distribution

2.3. Renewable energy penetration range

To choose whether the company chooses a renewable energy, it would have to know the percentage of electricity demand in the project. This is to know what factors in the mine you need such as the type of penetration of renewable energy so as not to interrupt the business model of the mine. It should be noted that while mining operations connected to a network can opt for renewable energies with a high penetration rate. But in mining operations where there is no connection to the grid, it is not viable since it cannot depend exclusively on solar and wind energy without storage.

(Isla Power, 2017) A penetration below 20% there is no need for storage and control systems, renewable energy must be used during maximum load, this penetration rate leads the generators to function as base load, but not at full load capacity, which will reduce costs in oil consumption

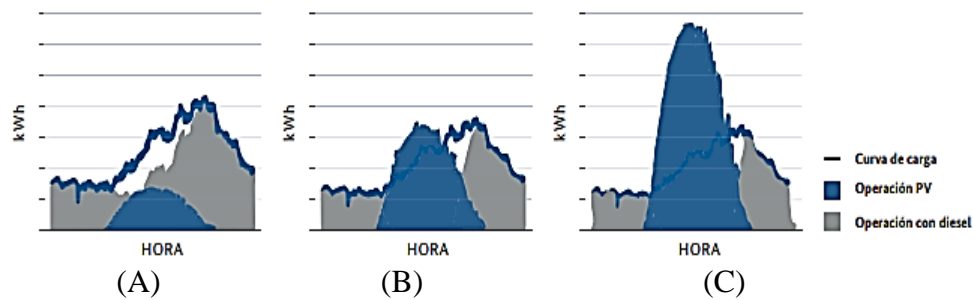


Figure 5. PV solar energy ranges

(A) **Low penetration range** - contribution to the system of 5 -20%, supported by generators, without control hybrid, no energy storage, higher fuel use

(B) **Medium penetration range** - 20 -50% contribution to the system, little use of generator sets, with hybrid control, optional energy storage, minimum fuel savings

(C) **Range of High penetration**- contribution to the system greater than 50%, probable energy storage, advanced hybrid control.

(Arena, 2017) In places where you work with generation profiles from wind and solar sources, you can achieve higher penetration rates of renewable energies. When merged with storage, penetration rates can increase even further. How can you see at the Zaldívar mine, 100% renewable energy is achieved, thanks to the combination of solar energy and wind energy. Which completely eliminates storage needs.

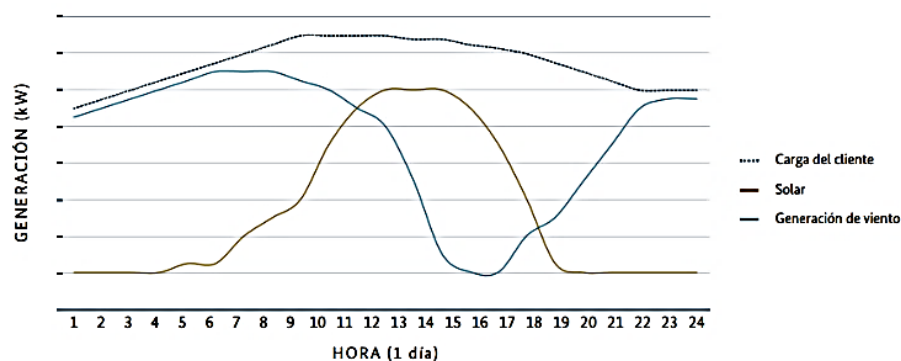


Figure 6. Wind, solar energy production profile versus load profile

2.4. Renewable energy distributionrenewable energy

When a project is not supplied solely to the mine, rent should be considered as one of the other options. At a time when electricity generation is higher than the demand of the mining project, among other related considerations is the scenario in which the mining company in the closure process provides said network connection to the surrounding communities through a mini net.

TO. Sale of energy to the grid, in which the excess energy generated by a renewable energy plant is sold to Ba electric company

B. Energy reinstallation in mining concession, is based on the renewable energy project regardless of whether the mining company is able to feed the network.

C. Electrification of nearby communities. The renewable energy project supplies energy to mining companies or communities close to them

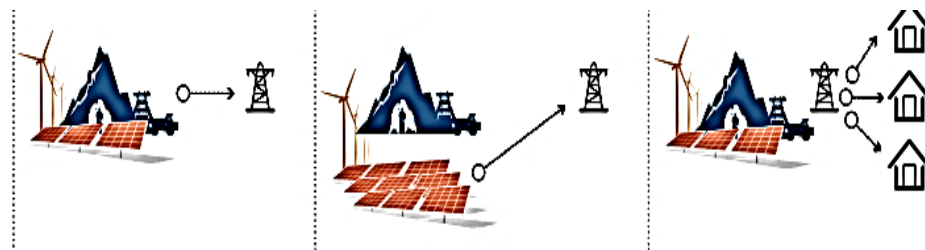


Figure 7. Renewable energy sales agreements

(Abo Wind, 2018) A clear example after the closure of a mine, where there is an opportunity to use reclaimed land for installation of renewable energy projects. In Germany, for example, several wind projects are being developed in former lignite mines. The Rocky Mountain Institute (RMI) made an analysis of the mines that the BHP company has and detailed that there is great potential for the application of renewable energy in the mine.

(Arena Wire, 2017) The Australian Coober Pedy project was based on a 3.9 megawatt diesel plant owned by EDL. In 2014, ARENA and EDL signed the investment in a wind, solar and battery power project that would be integrated into the existing power system for 20 years with the district council of Coober Pedy. This project began operating in March 2017, the objective was to displace 70% of diesel oil consumption. By September 2017, the city received 100% renewable energy for 35 hours uninterrupted, which marked an important milestone that it is possible to operate with 100% renewable inheritance.

3. Results

The digital tools will be in charge of integrating renewable energies into the electrical system of the mining unit, which will carry out a technical and economic analysis (in which it will detail the generation, transmission and consumption system in the different processes), this must include an analysis from the grid in isolation or connected in the power system of a mining unit.

TRNSYS, Transient System Simulation Program, includes a simulation package, with a dynamic graphical interface, said power simulations are given by energy sources, which makes it very versatile for its calculations in isolation.

INSEL It is a program that plans and monitors energy systems, the most outstanding thing is its analysis by blocks that are connected to a specific

solution, that is, they can include meteorological data, electrical components of renewable energies.

Regarding economic evaluation programs, the HOMER program evaluates power systems in an isolated manner, has sensitive calculation algorithms in technical-economic feasibility, its use is in conventional technologies and renewable energies.

We can also talk about the tools applied to mining processes of (M. Peirano, 2011) of the University of Chile that details a contribution of analysis of the effects of the transmission system in the mining industry, that is to say, it demarcates that these energy schemes cover large distances and also extensions of land. Which in this regard makes the generation of renewable energies very viable, since at present almost most of the electrical networks for industries are by wiring from the power generating plant to the point of operation.

An example of this analysis using digital tools is the one carried out at the Pampa Elvira thermo-solar plant located in the Antofagasta Province of the Antofagasta region in which we see the detail of the NPV of 21.15 million dollars, the IRR is 17.5% with a power of 34.37 Megawatts, and savings in fuel consumption of 8,840.3 m3.

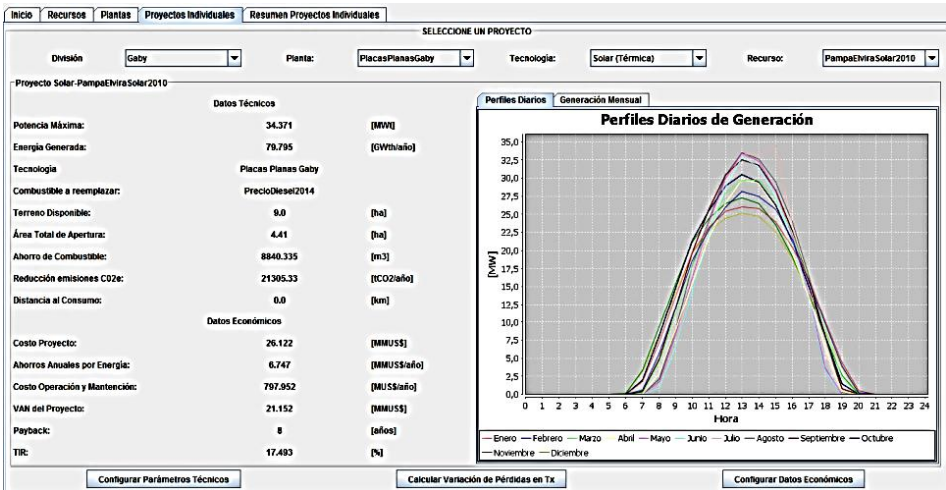


Figure 8 | Technical-economic analysis and generation profiles - Pampa Elvira Solar 2010 Project

3.1. The state and the private sector in renewable energies

From a technical perspective, the government must make the necessary regulatory changes to promote renewable energy projects that are relatively simple in infrastructure. There is great experience in developed states that have implemented bidding rounds for regulatory changes to support such renewable energy projects. For example: (. Meier, P et to the, 2015) commitment was conditional on financial support international technology, this increased initiatives in the energy department to include renewable energy options in its Integrated Resource Plan for 2010 to 2030

If we talk of renewable energy and mining, it should be mentioned that there are many ways of incentive and different interests to support these initiatives. But it should also be mentioned that there are mining organizations where, due to their conservative nature, there is no commitment to connect by said renewable energies as a whole. From my consideration, I believe that the

administration within the mining sector tends to be from a previous generation to a generation that cares about climate change and the insertion of new technologies.

4. Conclusions

Among the influencing factors of renewable energies, it is observed that the stages of a mining project determine aspects such as the benefit to the network and the community in the stage of operation and closure or post closure of the mine, the conditions in the energy network. They will also depend on the stage of a mining project, being the connection to the grid stable in the closure and post closure stages. The next determining factor is the optimal hybrid systems to use either solar diesel or wind diesel respectively. It should be noted that a profile of electricity consumption or demand is important for the calculation of its storage or not, of the renewable energies to be used. Another factor that influences renewable energy is its calculation by consumption in the processes that exist in the mining industry.

(Monroy, I, 2002) Indicates that electricity generation in the world is basically depending on fossil fuels. The analysis in Peru, in terms of energy resources referring to the use of coal and oil. Regarding the penetration ranges, you will determine if its energy storage is possible, and if it is possible to use hybrid control in its schemes for solar and wind energy. For this, the use of digital tools for renewable energies is important, the Holmer program, it is an important tool for the technical and economic viability in the use of this type of renewable energies such as wind and solar. It should be noted. According to (Castrillón, Y, 2019) He considers that one of the clean energy sources with the most current perspective within electricity production is renewable wind energy.

Regarding the supply of energy in the mining center, it covers three fields, a well-closed cycle in energy prospecting is the electrification of neighboring communities, which with automated control systems in its technical-economic analysis improve its proper use in the surrounding population.

In the matter of government, a perspective must be had that helps in regulatory matters necessary to promote renewable energy projects, this must be worked with different incentives and interests. As for the mining companies, they must integrate standards with renewable energies, and that reduce the consumption of oil, which mostly emit greenhouse gases.

5. Recommendations

According to the above, policies of wind and solar power plants should be implemented, since the mining industries since the energy in their processes is based on hydraulic energy and the consumption of fossil fuels. As part of this, it is the use of diesel-solar, diesel-wind hybrids that must be incorporated into the processes with digital controls for their use.

Review mining processes to optimize the use of renewable energy, adopt a long-term holistic approach when designing energy solutions, Develop premium products with low greenhouse gas emissions, to maximize efficiency and avoid environmental responsibility problems.

Opting for wind and solar systems has great benefits in distribution that in a post-closure and closure stage of the mining unit. These energy resources can be reused not only in the population that surrounds it, but also the network itself.

that it can influence with its energy contribution. This is technically and economically feasible in all mining projects.

6. Author contributions

This present explains the benefits in mining processes and communities, of a renewable energy network, in any mining project that opts for these systems. The application of hybrid solar-wind systems are important in the application of networks with significant energy demand. For this, it is important to use digital tools that determine the penetration ranges and the consumption of the mining processes. To all this, the promotion of these projects with adequate regulations is highlighted.

7. Conflict of interest

The authors declare that this article was carried out in the absence of commercial or financial relationships that could be interpreted as a possible conflict of interest.

8. Expressions of gratitude

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