THEnergy-Voltalia Report:

Optimizing costs of renewable energy for the mining industry

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THENERGY
SUSTAINABLE CONSULTING

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About Voltalia (www.voltalia.com)

• Voltalia is an international player in the renewable energy sector. The Company produces and sells electricity generated from wind, solar, hydro, biomass and storage facilities, with a total capacity of 911 MW either in operation or construction as of today.

• Voltalia is also a service provider, assisting its investor clients active in renewables at each project stages, from conception to operation and maintenance.

• With 550 employees in 18 countries over 4 continents, Voltalia is able to act worldwide on behalf of its clients.

• Voltalia has been listed on the Euronext regulated market in Paris since July 2014 (FR0011995588 – VLTSA) and is a component stock of the Enternext Tech 40 index and the CAC Mid&Small index. The Group is also included in the Gaïa-Index, an index for socially responsible midcaps.

About THEnergy (www.th-energy.net)

THEnergy is a boutique consultancy founded in 2013 focusing on microgrids/mini-grids and offgrid renewable energy. For industrial companies, THEnergy develops energy concepts and shows how to become more sustainable – combining experience from conventional and renewable energy with industry knowledge in consulting. THEnergy also advises investors and energy companies regarding renewable energy opportunities in rapidly changing markets. The initial focus was on commercial and industrial offgrid renewable energy projects, for example in mining (th-energy.net/mining), hospitality, telecommunications or on islands (th-energy.net/islands). Driven by investor needs, rural electrification and energy access have become additional consulting focusses. THEnergy has led several large-scale due diligence processes in rural electrification.

Content

1 Introduction

Mines are operating in a very cost competitive environment. After labor, energy is typically the second most important operating cost factor. It is no surprise that more and more mining companies around the world are adopting renewable energy to power their mines.

In general, adding renewables addresses three issues that are of interest to mine operations:

- Cost savings
- Reliability of power supply
- Sustainability

Cost savings are now often possible because the costs for renewables have decreased considerably over the past years. This is valid for both wind and solar power.

Solar and wind are cheap but are also intermittent sources of energy. Combined with traditional generators and managed by intelligent systems, they significantly decrease the price of energy of on-site power generation systems while improving its overall reliability. Sophisticated engineering comes with systems that integrate onsite renewables and traditional diesel, heavy fuel oil (HFO) and gas gensets. Optionally, they can also add energy storage and power from the grid. In fact, these hybrid microgrids are more reliable than the current grids in many mining countries.

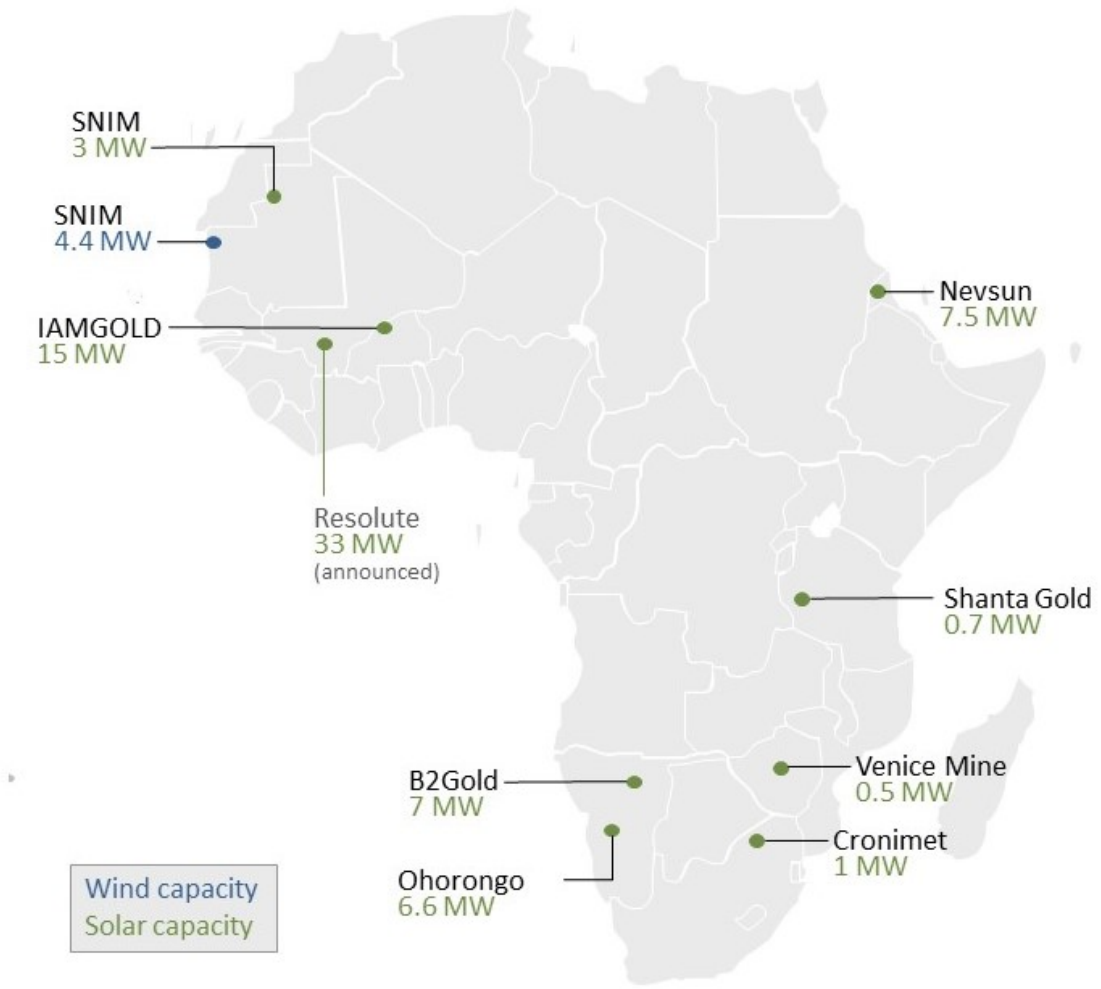
Many mining companies are under pressure regarding sustainability. That pressure comes from various stakeholders, including clients or shareholders. For instance, in the automotive industry, impacted by the strong growth of electric vehicles, BMW has set a goal for its supply chain to reduce its resource consumption per vehicle by 45% before the end of 2020.[1] This will only be achievable with more sustainable mining operations.

2 Onsite renewables facilities to power remote mines

In Africa, most of the solar and wind power plants powering mines have been added to existing remote power plants that are not connected to the grid. The value proposition of solar and wind consists of reducing diesel, HFO and gas consumption.

The following map gives an overview of onsite renewable energy projects in African mines that have already been commissioned or that were recently announced.

[1] BMW (2018), “Sustainable Value report 2017”.



Realized and announced on-site renewable energy projects for mines in Africa including cement

In the past, renewable energy was only economically applicable to a rather limited number of mines. Significant cost saving potential existed only for remote mining locations with particularly high energy costs due to the transport of the fuel. This has changed fundamentally since the costs for solar and wind power collapsed a couple of years ago. As a result, solar and wind are currently the cheapest source of energy almost anywhere in the world, allowing for energy cost reductions at numerous mines.

The key objective of renewables is to realize as much cost-saving potential as possible without running the risk of quality losses. In most remote locations, cost savings of 30% and more are achievable.

To many, wind and, above all, solar power plants have turned into commodities. The report shows how Voltalia, an experienced integrated renewable energy company, has managed to provide substantial additional cost reductions across the value chain, including in operations and maintenance (O&M).

3 Key success factors of cost-optimization for renewable energy plants at remote mines

The report addresses many cost reductions that can be achieved in solar-diesel or wind-diesel microgrids, likewise in systems that traditionally were running on heavy fuel oil (HFO) or gas.[2] The objective of these cost-reductions is to reduce the levelized cost of electricity (LCOE), which translate into a low-cost power supply for mining companies, in the form of power purchase agreements (PPAs). It is obvious that only those cost reductions that have a positive total impact on the LCOE make sense.

3.1 Experience in solar-diesel hybrid projects/microgrids

For many renewable energy companies, mining is one of the most attractive segments of hybrid and microgrids markets. This is because mining provides the potential for realizing large-scale solar or wind power plants and because mining companies are considered as particularly reliable off-takers.

Voltalia added a 4 MW solar power plant to diesel gensets in Oiapoque in Brazil (source: Voltalia)

Very few companies have had previous experience in microgrids or hybrid installations. For many, the hybrid plants they now propose to mining companies would be a first microgrid reference.

Hybrid projects and microgrids are a mature technology, however, they require experience. This experience starts with designing microgrids and optimizing the design regarding investment and O&M costs. Experiences with diesel generators, heavy fuel oil, and gas engines are extremely important. Many mistakes can be made by combining different energy sources and most of these mistakes will mainly result in high costs or even in operational issues.

Microgrids are about optimizing the whole power generation system. Experienced renewable energy companies know that not every kWh of solar or wind electricity generated leads to equivalent diesel, HFO or gas savings.

[2] In this report, sometimes the terms solar-diesel or wind-diesel hybrid are meant to cover also applications in which solar or wind are combined with HFO or gas as a flexible energy source.

An important component of a hybrid system is the microgrid control system which ensures that the different energy sources—including the output from fluctuating solar or wind power plants—are synchronized to the various loads of a mine. Sophisticated solutions also incorporate load management, especially if there is flexibility due to uncritical loads.

3.2 Synergies with large grid-connected solar and wind projects

The largest renewable energy system to date that has been built on-site at a mine is a 15 MW solar plant. Much bigger solar and wind power plants have been realized for grid-connected applications. In addition to the collapse of key component costs, the world's leading renewable energy companies have realized additional cost savings potential by optimizing the design and construction processes in large-scale projects.

Voltalia wind park in Serra do Mel, Rio Grande do Norte, Brazil

There are many advantages in microgrids that come from large-scale solar or wind energy projects. If the overall hybrid system is designed, a thorough understanding of the solar or wind subsystems is mandatory. Experience with a different kind of material and on various soil types will translate directly into cost-savings in hybrid applications. Quality control processes for main components such as solar modules are key success factors. They improve the quality of power plants, reduce costs and increase the output throughout its lifetime.

Hybrid projects with a typical size in the range of up to 15 MW only generate limited purchasing power. Larger players who also realize grid-connected projects often purchase components for more than 100 MW per year, which results in economies of scale and superior purchase conditions. From 2016-2018, Voltalia won 318,8 MW of new projects and commissioned in the same period 149,2 MW of renewable energy projects.

Economies of scale apply throughout the value chain, starting at designing a hybrid power plant via purchasing power. Furthermore, economies of scale also affect operation and maintenance.

3.3 Experience in remote projects

Traditional power generation costs are particularly high at remote off-grid mines. This is especially the case if there are no pipelines to the mine and if diesel, HFO or LNG is used for power generation. Typically, large trucks transport the fuel to the mines. Transport costs add to the market price of the fuel as well as to the health & safety, the security and the carbon impact. In general, the more remote the mine, the more attractive it is for renewable energy applications. Integrating solar or wind power means that more expensive fuel can be displaced.

The other side of the coin is that it is also more challenging to build solar or wind power plants on remote sites. The first aspect again is about logistics and transporting the material for the renewable energy plant to these distant mines. Even though solar power plants are made of many smaller components, this can be a challenge in underdeveloped rural areas.

During construction: Voltalia's Oiapoque project in North Brazil at the French Guiana border – 600 km from the next city, Macapá (source: Voltalia)

Many mounting systems require cement and heavy equipment. It is a big advantage to be experienced in systems that have been conceived for remote locations and that might be applied without the use of heavy equipment.

The second aspect is about quality. In remote locations, it is often recommended to ensure that key components are of higher quality than materials used in accessible places.

Finally, optimized spare part management is key at remote locations. Even high-quality components will not completely avoid failures and transporting spare parts to remote locations might take time and can potentially lead to down-times. Experienced renewable energy players have developed sophisticated spare part management systems that allow to resolve the most common and critical problems immediately. Similarly, they have identified critical skills and train local employees.

In the case of wind power, typically smaller wind turbines are used in remote locations, which has advantages in both logistics and spare part management.

3.4 Learning from managing different types of complex renewable energy projects

Furthermore, experience from projects that are not directly related to wind or solar power plants can help renewable energy players to cut costs in hybrid projects. Hydro projects are such an example.

They are typically more complex than solar or wind projects and require more permits and longer planning and realization processes. The lifetime of a hydropower plant goes far beyond the lifetime of a solar or wind power plant. Their average life span is somewhere from 50 to 100 years.

A Voltalia hydropower plant in French Guiana (source: Voltalia)

Moreover, banks play an even more important role in financing these long-term assets, when compared to wind or solar financing. In general, experience with a variety of project types is a benefit. In addition to hydro, solar-diesel hybrid, large-scale wind and solar systems, Voltalia can also rely on experience with the following project types:

- storage only
- solar + storage
- diesel + PV + hydro
- biomass

Each project type means additional learning. Advanced project management capabilities are the key to success in such a variety of projects. The more complex a project, the more sophisticated the project management. Experience in managing other complex projects will translate into cost optimization. This is also the case for smaller microgrids with renewables that are built at remote mines. Voltalia has a track-record in managing off-grid projects of various sizes, from utility size in Oiapoque to small size for telecom towers in Myanmar.

3.5 Track-record of projects in Africa

At the moment, many IPPs are entering the African markets for the first time. Many are only experienced in managing renewable energy projects in developed countries, for instance in Europe or in the USA. Doing business in Africa is associated with diverse challenges and risks.

A solar project of Voltalia in Tanzania (source: Voltalia)

Problem-solving abilities and ingenuity have also proved to be key success factors for managing projects in Africa. Building the right project teams that combine local knowledge with experience in large-scale renewable energy projects contributes to successful project execution.

A strong network on the African continent has proven to be a decisive factor. This includes project finance, as many companies struggle to finance projects in Africa. For Voltalia, the experience in raising more than €600M in project financing on a global basis was extremely helpful for financing hybrid projects. In this context, having strong relationships with DFIs and banking institutions, dedicated in-house project financing teams, and flexibility in providing and finding innovative financing solutions as well as complying with the environmental and social expectations of DFIs have significantly helped Voltalia. Especially for the African markets, innovative and creative financing solutions are becoming increasingly relevant as a key driver in the reduction of overall costs.

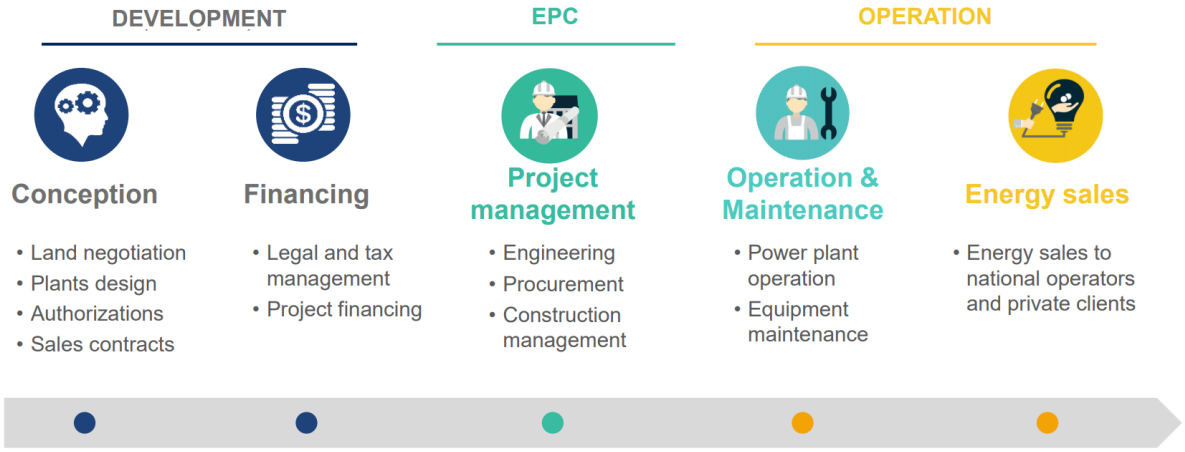
There are a variety of languages spoken and used for business in Africa. As a multi-lingual company who is operating in a multitude of countries, Voltalia is well-placed to operate and conduct business in a number of languages.

In Africa, socio-economic development (SED) approaches are of interest when renewable energy plants are built at remote mines. Voltalia has several projects running with local communities in various emerging countries, such as Brazil in Latin America or Kenya in Africa, and is capable of covering SED approaches in-house, which is a competitive advantage over others who do not have the same in-house expertise in these matters.

3.6 Optimal vertical integration and a lean organization

In order to optimize PPA tariffs, it is important to find the best mix of insourcing and outsourcing. Insourcing of core competencies allows for building up the various learning effects described above. For a large renewable energy group, engineering and procurement can be core competencies that are

worth keeping in-house in order to take advantage of the full cost-saving potential. Advanced in-house engineering capabilities ensure that complex systems such as hybrid power plants can be designed in the optimal and most cost-effective way.



Voltalia is an integrated renewable energy player (source: Voltalia)

The procurement function also offers various options for cost savings by sourcing commodities in a competitive way. Many components in solar and wind parks are commodities. Economies of scale and purchasing power create cost reduction potential. Regarding the purchase function, an excellent network to various suppliers is an important ingredient. Continuous interactions with key suppliers allow for identifying potential delivery shortages which might lead to unexpected delays and, as a consequence, increased costs.

Special control routines ensure the quality of the incoming material. This is particularly important for projects in new renewable energy markets. Typically, suppliers produce material of different quality standards and tend to supply smaller players and new, inexperienced markets with inferior components. This issue has been observed in Africa for many years. In general, a thorough understanding of key suppliers and their needs will lead to partnerships that are fruitful for both parties.

3.7 Operation and maintenance

Considerable cost-cutting potential has also been identified for operation and maintenance. Some saving potentials are purely related to the renewable energy plant, and direct learnings from large grid-connected plants can be applied. For example, the soil at most of the mine locations is particularly challenging. Finding out the perfect cleaning patterns for each plant will contribute to O&M cost improvements. Process optimization during the construction phase and experienced supervisors can systematically reduce the costs of solar and wind power plant operations.

More cost-cutting potential comes with the interplay of unsteady renewables and flexible gensets or engines. Integration of weather forecasting or storage will contribute to parameterizing the plant in a way that gensets or engines are run at loads that guarantee higher efficiency and lower maintenance. For example, not stopping diesel gensets in case of very short sunny periods will reduce the wear on the diesel gensets considerably, while diesel consumption is only slightly increased.

Reducing O&M costs also begins with designing the hybrid power plant in a way that the lifetime costs and benefits are taken into consideration. Another important aspect is a network of strong local partners and local presences in regions where hybrid power plants are operated.

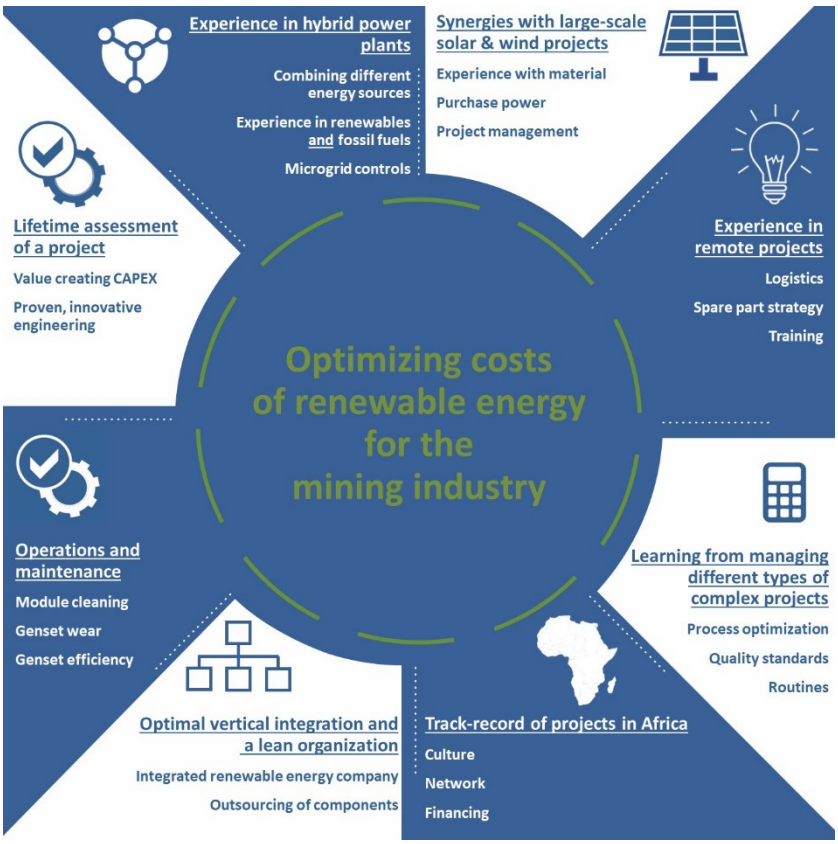
3.8 Lifetime assessment of a project

A lifetime analysis of the system considers all the different cost types and allows for designing the system that optimizes the microgrid according to the challenges of a particular mine. Cost optimization does not necessarily mean minimizing investment costs. Often, additional investments are paid off by lower O&M costs during the lifetime of the PPA. The use of higher quality components might increase investment costs, but it might help avoid unplanned outages in the future and is often overcompensated by the benefits of a steady power generation with additional revenues.

In the end, only experienced renewable energy players can make the right decision about which investments are likely to create additional value in the future. Proven, innovative engineering that optimizes cost over the lifetime of a project can makes the difference in offering the most attractive PPAs to mining companies.

4 Summary and outlook

The report shows that there is considerable cost reduction potential that comes from a variety of different factors. The following graph gives an overview of the main factors that contribute to optimizing costs for hybrid power plants and that enable IPPs to offer the best price PPAs to mining companies.



Select results of the report regarding cost optimization

During the last 14 years, Voltalia has gained experience in renewable energy projects including solar-diesel hybrid microgrids, projects in remote locations and in developing countries. This experience in combination with the increase of purchase power translates into significant overall cost-reductions in

the range of 20-30% in comparison to companies that newly enter the hybrid markets for remote mines.

This cost competitiveness is necessary to offer attractive PPAs to mining companies. As doubts about the feasibility of hybrid power plants at remote mines have vanished and several projects show that the renewables can be integrated without any danger of production losses, the focus now shifts from just demonstrating technical integration capabilities to managing the entire hybrid power plant in an optimal way. This also goes hand in hand with the fact that generally no subsidies can be expected for hybrid power plants in the African markets. Renewables must be cost-efficient to conquer the African mining markets. The report highlights the key success factors for renewable energy companies. It also provides miners with valuable insights regarding the business model of renewable energy players. The report serves as a guideline or check-list for choosing a reliable and renewable energy partner.

The addressed cost optimizations have led to even lower LCOEs for adding renewables to diesel gensets, HFO and gas engines. Mining companies will directly benefit from these improvements by either paying less for adding renewable energy assets or by signing PPAs with lower prices. This will directly affect the growth of hybrid microgrids for mines in the African markets. Short and mid-term expectations are that the total numbers of renewable energy projects for remote mines will grow very quickly. With these lower price levels, renewables will be a solution for the mass market – not only for a few select mines with particularly high energy generation costs.

Finally, it is very likely that more and more grid-connected mines will benefit from solar and wind energy through corporate PPAs. Here the renewable energy assets do not have to be in direct proximity of the mine. Miners will benefit from low electricity prices and long-term price visibility thanks to renewables and will also be eligible for the carbon reduction potential.

Legal Disclaimer

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