



## Hybrid solar, heavy fuel oil and diesel power micro grid network – Loulo gold mine in Mali.

### Motivation:

Incorporation of renewable energy into traditional fossil fuel power generation networks, called PV hybridization, is a key driver for the reduction of greenhouse gas emissions and reduction of the cost of energy. Most common is the introduction of photovoltaic (PV) plants together with battery energy storage (BESS) and integrating this into the existing thermal power generation grid network to deliver power of stable voltage and frequency. Battery energy storage technology has undergone rapid development and improvement in the past few years; however, the total cost of ownership over time as well as the possibility of future new materials of manufacturing, leaves many end-users reluctant to make major investments just yet. Thus, **PV hybridization without storage** appears to be the most relevant solution, but with many technological challenges that have been now risen thanks to the solution delivered jointly by SPIE Industrie & Tertiaire, SOLAÏS and the O.I.E. research laboratory of MINES Paris - PSL, with the support of ARMINES.

### Technical Solution:

The technical solution for PV generation without BESS requires the incorporation of detection and forecasting. **Forecasting** requires the input of PV production from the previous day along with meteorological data input into short-term forecasting models, from 5 minutes and up to one hour. Input into these models comprise local irradiance measurements from pyranometric sensors in multiple orientations, actual PV production and inverter set points as well as **detection** of satellite images in 15-minutes intervals for up-to-date information on cloud formation over a 50 km radius around the PV plant. The satellite data is acquired from the Heliosat-2 method applied by Meteosat Second Generation in a geostationary orbit and are provided by the SoDa web service operated by Transvalor. A predicted output from the PV plant is fed into the power management system to ready the thermal power plant for a start-up or reduction of generation units to support the deficiency or over-supply of electrical energy to the grid network.

This traditional means of local site and satellite detection methods does not allow one to fully preempt imminent overcast conditions which will negatively impact the PV power production. The current satellite data is limited to 3 km spatial and 15 km temporal resolutions. Therefore, the accuracy of the PV plant predicted output needs to be further improved. Using a network of hemispherical fisheye cameras strategically placed in the immediate surroundings of the PV plant real time imagery of the approaching cloud cover or formations which were undetected by the satellite imagery or irradiation sensors is captured. This is fed to sophisticated algorithms which predict the drop or increase in PV yield on a per second basis allowing the power management system to action a start or unloading command to the high-speed diesel generator. The resulting outcome is

the delivery of maximum renewable energy penetration into the micro grid network all the while maintaining an optimal spinning reserve.

**Implementation:**

The introduction of PV into the micro grid of Loulo gold mine was undertaken in August 2020 by Africa Power Services. 24 MWp single axis horizontal azimuth tracking units were installed to augment the 65 MW of heavy fuel oil and diesel generated power supply. The use of predictive PV power output technology has avoided the capital investment into BESS. As reported in the Q1 2022 Group Sustainability Report the resultant reduction of fossil fuel since commissioning of the power plant is 15.6 megalitres which equates to 42,050 tonnes of CO2 equivalent emissions.





### Barrick's testimony

Barrick is fully committed to reducing our impact on the environment. This project is an example of how we partner with suppliers and technology leaders to deliver a world class project in one of the most remote geographies Africa. Initially we started at a reduced scale to prove the concept and test the maturity of the technology. The commissioning coincided with the Covid-19 pandemic which placed a limitation on the ability of product specialists to travel to site to perform the work. This posed an interesting challenge where we needed to make use of our own in-house skills assisted and directed through the use of remote technology to commission the inverters at a reduced output. As soon as the technology partners could travel to site, the plant was ramped up to full production. The success of the initial 20 MWp plant translated into a justification for further increase of PV as well as incorporation of BESS. – *Rousseau Jooste, Chief engineer AME*

### About Barrick ([www.barrick.com](http://www.barrick.com))

Barrick Gold Corporation (TSX : ABX ; NYSE : GOLD) is a sector-leading gold and copper producer, operating mines and projects in 18 countries in North and South America, Africa, the Middle East and Papua New Guinea. The company's portfolio spans the world's most prolific gold and copper districts, and it is focused on high margin, long life assets.

### About Africa Power Services ([www.africapowerservices.com](http://www.africapowerservices.com))

Based in Bordeaux (France), Africa Power Services (APS) is a subsidiary of the family-owned holding company Delmas Investissement et Participations. With a history of more than 170 years on the African continent, the Delmas group has decided to spin off one of its key activities: services related to energy production. Today, APS is capitalising on this long experience to develop, design, install, operate, maintain, or lease energy production plants that are increasingly environmentally friendly. APS teams have demonstrated their skills and know-how through numerous EPCM (Engineering Procurement Construction Management) projects for thermal and hybrid power plants, commissioned on the African continent for mining clients, national electricity companies and oil

companies. Its teams also provide after-sales support for these facilities, including full operation and maintenance by its African subsidiaries.

**About SPIE ([www.spie.com](http://www.spie.com))**

The integration of a large PV plant on the mine's MV network required the implementation of a tool for managing the means of production but also tools for weather forecasting and monitoring clouds. These were developed by SOLAIS and integrated by SPIE into the overall architecture of the site through dedicated and priority communication links. The cooperation between SOLAIS and SPIE was essential to the success of this project. The specific skills of SOLAIS have resulted in unique and reliable systems. The operating tools developed are a great support for decision-making for the customer, who thus has the possibility of planning his interventions on the thermal power plant.

**About O.I.E. / MINES Paris - PSL / ARMINES ([www.oie.minesparis.psl.eu](http://www.oie.minesparis.psl.eu))**

The "Observation, Impacts, Energy" Center (O.I.E.) is a research team part of the Department Energy and Processes of MINES Paris - PSL, whose activities are at the crossroads of energy, environment, and Earth observation, including satellite, numerical meteorological model, and in-situ sensors. The center studies and models "renewable energy" resources and the environmental impacts related to their exploitation, using fundamental and applied scientific disciplines (data sciences, metrology, physics, environment) and information and communication technologies. More particularly, the center O.I.E. has active and long-track international record on solar radiation modelling, assessment and forecast involving Earth Observation systems and advanced data science techniques. The center is notably contributing to the PVPS (Photovoltaic power systems) program of the International Energy Agency, as a sub-task leader of Task 16 "Solar Resource for High Penetration and Large-Scale Applications".

**About Solais ([www.solais.fr](http://www.solais.fr))**

SOLAIS is an independent company based in France and specialized since 2008 in photovoltaic engineering and consulting, positioning itself in the professional market (investors, industrialists, energy providers and local authorities). SOLAIS advises and supports its clients on all issues: technical, economic, financial, insurance, legal, tax, etc. to ensure the design, development, financing, implementation, and operation of their photovoltaic installations. Since 2009, SOLAIS has been conducting or participating in numerous research projects in collaboration with the O.I.E. and PERSEE research laboratories of MINES Paris - PSL / ARMINES on solar resource characterization, solar resource and photovoltaic production forecasting, storage management and participation in the EPEX SPOT energy market.

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