



White Paper

The Renewable Shift in Industrial Power in West Africa

Unlocking the Full Value of Hybrid Renewable Systems
to Cut Cost and Reliably Achieve Net-Zero Energy Supply

Case Study **West Africa**

November 2025



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Introduction

Industries with high energy demand, such as mines, data centres, industrial areas, but also remote or island grids face rising energy costs, supply challenges, and increasing pressure to decarbonize. The transition to renewable energy is no longer just an environmental imperative; it is a strategic opportunity to achieve significant cost savings, improve energy resilience, and meet ambitious net-zero targets.

This white paper explores the cost-saving potential and operational benefits of hybrid renewable energy systems, combining solar, wind, and battery storage to deliver stable and reliable power for both off-grid and grid-connected industrial operations. Through a detailed case study considering a fictive mine in West Africa, the paper assesses how renewable hybrids can supplement grid power supply and - in case of off-grid - conventional power generation based on diesel or heavy fuel oil (HFO), to reduce cost of electricity and dependency on volatile fossil fuel supply chains.

The analysis highlights how optimized technology mixes can achieve up to 80% reductions in cost of electricity while maintaining grid stability and reliability. Furthermore, it identifies pathways for industrial operators to progressively transition toward 100% renewable, carbon-neutral power supply, aligning economic and environmental performance.

Ultimately, the paper demonstrates that with a tailored system design and careful operational integration, hybrid renewable systems offer a clear business case delivering both immediate cost savings and a future-proof energy supply for energy-intensive industries.

Hybrid Plant Concept

Energy-intensive industrial operations in remote locations, whether off-grid or grid-connected, require secure and cost-effective power supply. Traditionally, these sites have relied on heavy fuel oil (HFO) or diesel generators in island microgrids, or on (often) expensive and carbon-intensive grid imports. Increasingly, solar, wind, and battery energy storage are being integrated into existing power systems as hybrid solutions, either to reduce fuel consumption in off-grid applications (fuel saver concept) or to lower grid dependency in grid-connected mines and industrial plants (behind the meter).

Hybrid systems integrate different renewable and conventional power generation and storage technologies to deliver reliable, stable, and cost-competitive electricity. Solar and wind provide clean, low-cost power, while batteries enable output smoothing, frequency regulation, and load shifting. In off-grid microgrids, batteries serve as spinning reserve replacement or even act grid forming, allowing fewer or even zero generators to run and reducing fuel consumption. In grid-connected systems, they can reduce peak demand & grid capacity, improve power quality, and provide backup during grid outages.

A sophisticated energy management system, combined with real-time renewable power generation forecasting, is an essential part of renewable hybrid systems optimising its utilization and integration with existing power generation and ensuring a dependable power generation system, despite the fluctuations of the renewable resources.

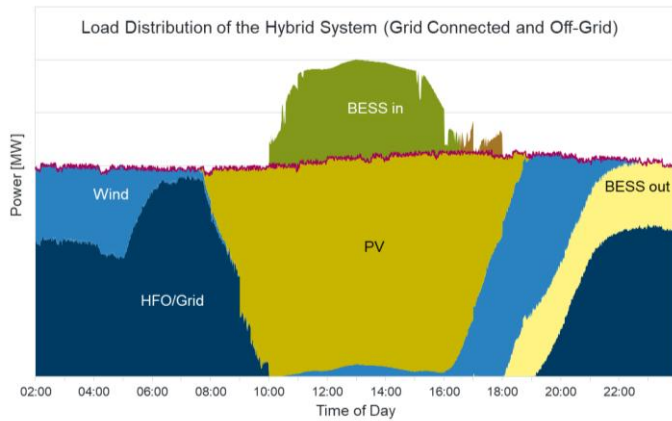


Figure 1 Energy distribution curve of a typical day for a hybrid system with PV power, wind power and BESS both off grid and grid connected mines.

Operating on 100% Renewable

Operating a power system with 100% renewable power generation during extended time periods is already a commercially viable case which has been successfully demonstrated in practice. B2Gold's Fekola Mine in Mali is operating entirely on solar power during sunny days while all HFO generators are switched off, resulting in a notably quiet engine hall. The 61 MW_p solar and 30MW/27MWh battery hybrid plant project was engineered from concept to implementation by Dornier Suntrace as EPCM Contractor to B2Gold in two stages and commenced operation in early 2021 (Phase 1) and 2025 (Phase 2) respectively. The project achieves a total renewable share of 32% annually.

Using a cutting-edge approach to evaluate thousands of configurations, balancing solar, wind, and battery sizes to identify the most economic and technically viable setup.

Case Study Basis

This case study assesses the electricity cost reduction potential when hybridizing a hypothetical mine in Western Africa with renewable energy and storage. The mine is assumed to have 40 MW of average load demand, which is provided either by 8 HFO genset in an off-grid scenario or by the grid, in a grid connected scenario.

In the off-grid case, the gensets form the backbone of supply. Adding solar and wind reduces the need for continuous genset operation, while batteries provide system stability by smoothing renewable output, covering short-term fluctuations, and enabling temporary operation with fewer gensets. In the grid-connected case, solar and wind integration reduce dependency on costly or carbon-intensive grid imports, while the battery supports peak shaving and serves as immediate back-up power source in case of grid interruptions. Different sizes of solar, wind, and battery energy storage were modelled, considering the region-specific cost for PV, Wind, Battery and balance of plant which is derived from Dornier's constantly updated cost data base and industry knowledge in the region.

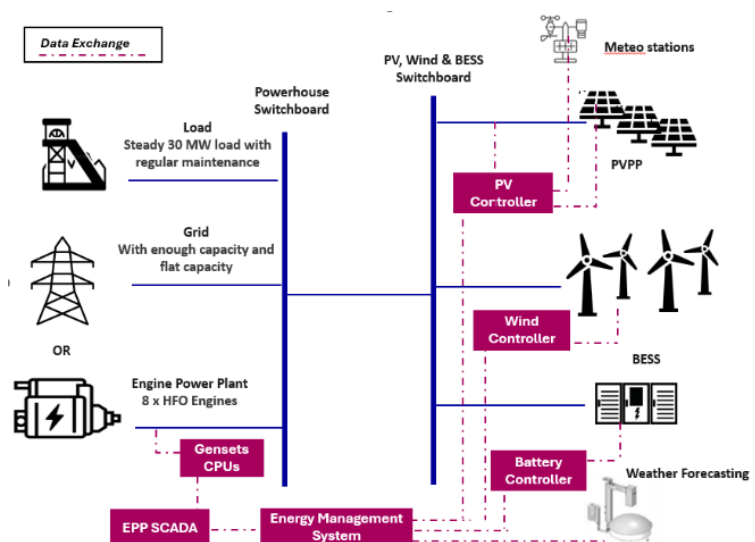


Figure 2: Basic schematic of an off-grid and grid-connected hybrid system with solar, wind and batteries.

The project's assumed lifespan is 15 years, and implementation follows an EPC model, using fuel prices and grid tariffs that align with industry benchmarks. The region offers high solar irradiation with GHI of 2100 kWh/m²/year, while wind potential is moderate, with average speeds of 7.2 m/s at a hub height of 120m assumed for this case study.

The system design was optimized using Dornier-Suntrace's AHEAD tool, a proprietary, state-of-the-art software platform that applies a particle swarm optimization algorithm. This cutting-edge approach evaluates thousands of configurations, dynamically balancing solar, wind, and battery sizing to identify the most economic and technically viable setup. The tool delivers an optimized system configuration that maximizes renewable share while ensuring strong economic viability through robust IRR and NPV outcomes.



Operating mines at 100% Renewable power during extended time periods has been demonstrated.

Results

Figure 3 identifies the optimal range for renewable energy integration for each analysed scenario highlighted in pink, by evaluating key financial metrics such as the net present value (NPV) of savings, internal rate of return (IRR), and payback period. A specific case within this range, marked by a black dotted line, is detailed further in Table 1. Additionally, the chart includes a sensitivity analysis, where dotted green and purple lines illustrate the impact of a $\pm 10\%$ change in fuel or grid costs on the project's NPV and IRR, respectively.

For PV + BESS configurations, the optimum operating range lies between 30–50%

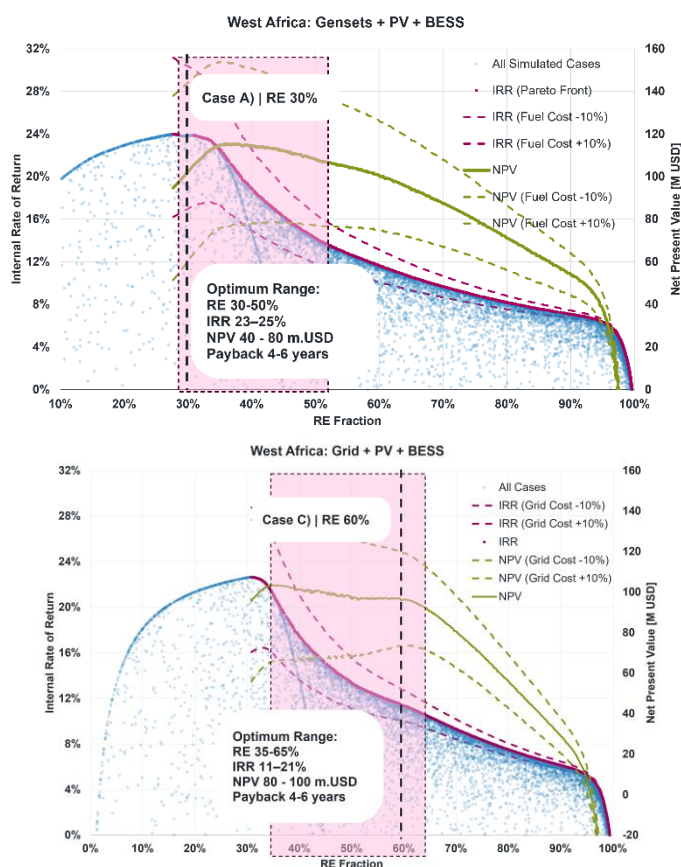


Figure 2 Illustration of the results from the hybrid simulations for off grid and grid connected hybrid systems

Table 1: Summary of the results from the hybrid simulations for off grid and grid connected hybrid systems

System Configuration	RE Fraction (%)	PV capacity (MW _p)	Wind Capacity (MW)	Battery Capacity (MW/MWh)	CAPEX (m. USD)	Reduction in Electricity Price (cents/kWh)
Case A) Gensets + PV + BESS	30	80	0	25/75	118	4
Case B) Gensets + PV + Wind + BESS	70	70	70	30/120	222	8.5
Case C) Grid + PV + BESS	60	160	0	70/420	326	10
Case D) Grid + PV + Wind + BESS	80	50	60	20/40	170	12

RE fraction, achieving peak IRRs of 23–25% and NPV values of \$40–80 million. This range is primarily driven by the high utilization of solar generation to offset costly fuel or grid power, with the BESS optimally sized for intra-day energy shifting and operational reliability. While the IRR tends to plateau beyond this point, the NPV remains consistently robust, confirming that even with higher renewable shares, the total project value and long-term cost savings remain significant. The amortization period of approximately 6–8 years further enhances the investment appeal, ensuring a relatively short payback horizon within the project's lifetime. Secondly, the PV + Wind + BESS architecture achieves its optimum performance at a 70–90% renewable fraction, yielding IRRs of 22–25% and a notably higher NPV of \$120–160 million. This superior outcome is attributed to the complementary generation profiles of solar and wind, which flatten the net load curve and increase BESS utilization. Moreover, sensitivity analysis reinforces the system's financial resilience even with $\pm 10\%$ variations in fuel or grid prices, both NPV and IRR remain positive and stable.

Conclusions

The data and case studies presented in this white paper deliver a clear message: the transition to hybrid renewable energy is a viable and strategic decision for industrial operations today. For mines and other energy-intensive industries, hybrid systems are no longer a niche alternative but the cornerstone of a resilient, profitable, and sustainable operation effectively hedging future electricity cost. The analysis demonstrates that whether starting with a PV + BESS system for a fast deployment, high-return impact or deploying a comprehensive PV + Wind + BESS portfolio for deep decarbonization, the financial case is compelling.

The optimization confirms that two clear, high-performance pathways exist. The PV + BESS configuration offers a capital-efficient entry point, achieving optimal returns at 20–50% renewable penetration with IRRs of up to 28% and amortization in within 4–5 years. This provides immediate relief from volatile fuel and grid costs. For operations targeting energy independence and maximum long-term value, the PV + Wind + BESS system is of most interest. It reliably can achieve 70–90% renewable fractions, maintain strong IRRs, and unlock the highest NPV and CO₂ emission reductions. The technology is proven, the financial models are robust, and the time for action is now.



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About Dornier Suntrace

Suntrace was established 2009 in Hamburg, Germany's largest renewable energy cluster of firms. Today, Suntrace provides essential elements to develop renewable energy projects for clients all over the world. The range of services reaches from renewable energy resource assessments over owner's engineering to project implementation. In addition to the full engineering, Suntrace also provides financial advisory and project development management. Having a portfolio of over 7.5GW of installed solar in 135 projects over more than 46 countries, Suntrace with its strong team has established itself in renewable energy market. From concept to full realization, Suntrace has expertise in solar, wind and storage hybrid system with conventional power systems. Suntrace is part of Dornier Group with approx. 100 Mio EUR turnover and more than 2.000 staff.

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