Maximizing Hybrid Microgrid Solar Power Usage and Reducing Fuel Costs

By New Sun Road

Introduction

Microgrids offer independent, local power - cleaner energy closer to the point-of-use, reducing transmission costs and creating resilience. Microgrids are defined as power systems with controls that integrate one or more sources and storage to provide electricity to users or loads. Hybrid microgrids combine a traditional diesel or propane generator with renewable energy creating a bridge to cleaner energy with optimized capital costs for 24/7 electricity and reduced operating costs.

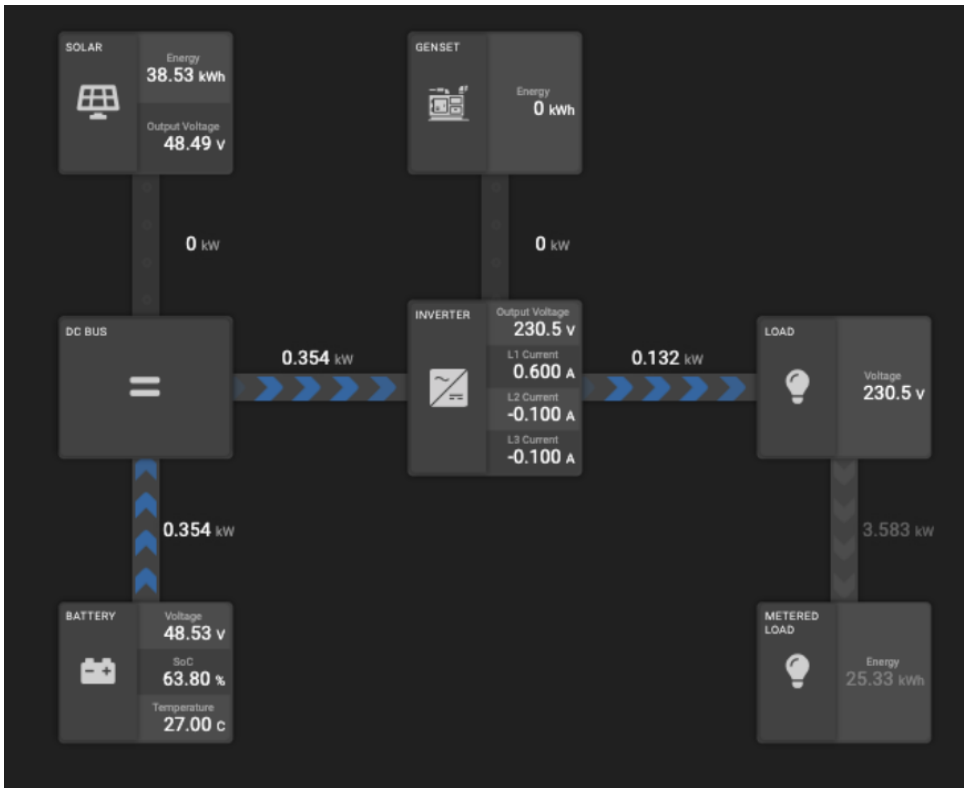
Hybrid microgrids with New Sun Road's Stellar remote control platform optimizes performance, to lower generator fuel costs and maximize renewable energy usage. Stellar Microgrid OS™ uses AI (artificial intelligence) algorithms incorporating data from on-site IoT (internet of things) devices, weather forecasts with satellite measurements to forecast solar energy generation and energy usage to trigger optimally timed generator operations. The AI pipeline automatically learns and recalibrates system parameters that allow it to improve battery state-of-charge (SoC) estimates, minimize periods of solar over supply, tune forecast models, and simulate different control scenarios. New Sun Road conducted a study on three hybrid microgrids in Tanzania, finding that Stellar's automated optimization increases solar power usage by 10-20% and resulted in diesel fuel savings of up to 10% or more annually.

Background and Microgrid Set up

Microgrid in Tanzania

New Sun Road conducted a performance comparison on three PowerGen microgrids operating in rural Tanzania over 3 to 4 months in Londoni/Chipinga, Leshata and Kalenge. Each microgrid consisted of solar panels, battery storage, a diesel generator, an inverter and a set of loads (electricity users) operated as an isolated grid.

Stellar sample monitoring screen for energy access microgrids with solar production (PV inverter), battery storage (Battery), generator operation (genset) and use (Metered Load)



Stellar achieves operational savings by managing which power sources are used to charge the battery and meet the load, ensuring that excess solar power (curtailment) and fuel usage are kept to a minimum.Typically, microgrid controllers use fixed set points called a “deadband” to start and stop generators based on the battery SoC e.g. start at 50% SoC and stop at 70% SoC. A battery charged by the generator at night and then by solar early in the day can reach 100% SoC by mid-day and result in curtailed (“spilled”) solar energy in the afternoon. If the battery is charged according to predicted available solar for that day, then generator operation can be optimized to cover just the shortfall and maximize solar energy usage while reducing fuel costs.

Stellar Microgrid OS is a remote control and monitoring platform that offers not only AI automated operation but also provides alerts, notifications, service tracking, load shedding, reports and aggregated fleet data for a fleet of microgrids.

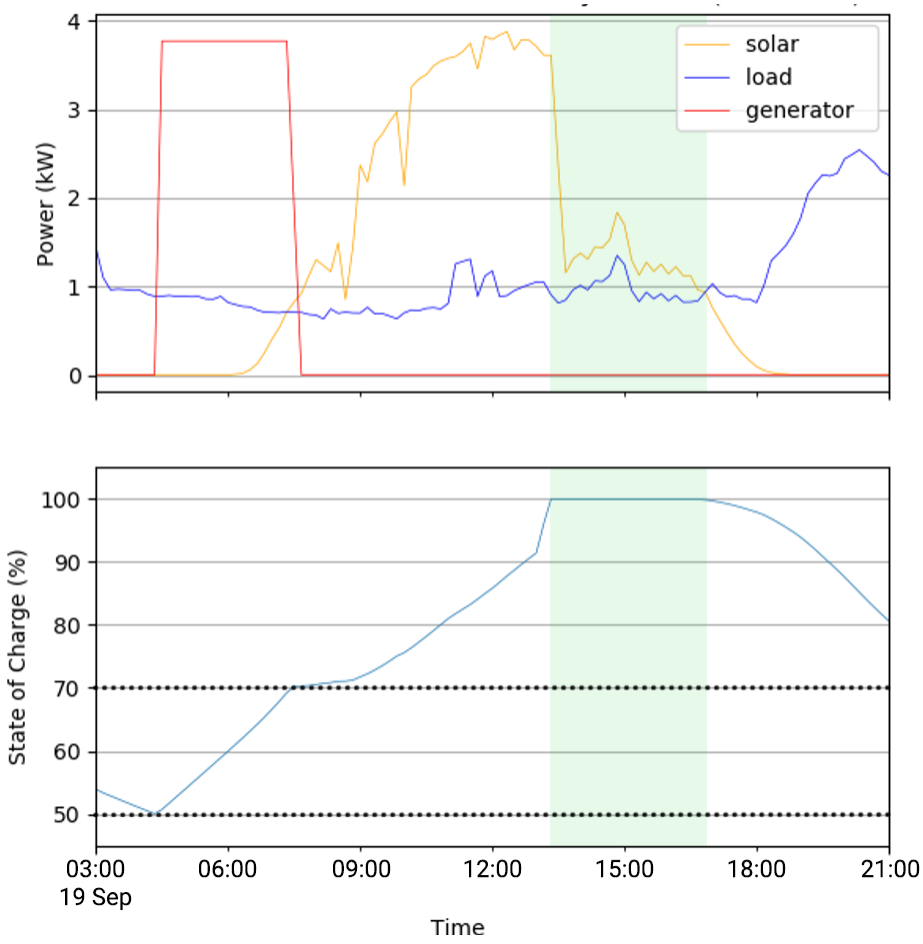
Simulating Baseline Operations Methodology

To establish the comparison, New Sun Road used a simulation of business-as-usual (BAU) based on the recommended battery deadbands set by PowerGen who is the microgrid owner-operator. A deadband has a fixed upper and lower value where in between the system functions at its baseline operation. For Leshata the upper value was 70% state of charge and for Kalenge and Londoni it was 80%. The lower deadband was 50% for Leshata and Londoni and 53% for Kalenge.

In order to have an accurate comparison, the BAU simulation excluded periodic generator tests programmed into Victron Color Control. The simulation and optimization do not account for the generator going offline due to mechanical failure or lack of fuel, so these events were excluded from the comparison. The following figures compare a sample day of the BAU simulation (deadband controlled) to the optimized performance using New Sun Road's predictive control.

It is important to note that these conditions are seasonal where power and load change with cooler temperatures and solar availability. With Tanzania being close to the equator, seasonal changes are less than in a temperate or polar location.

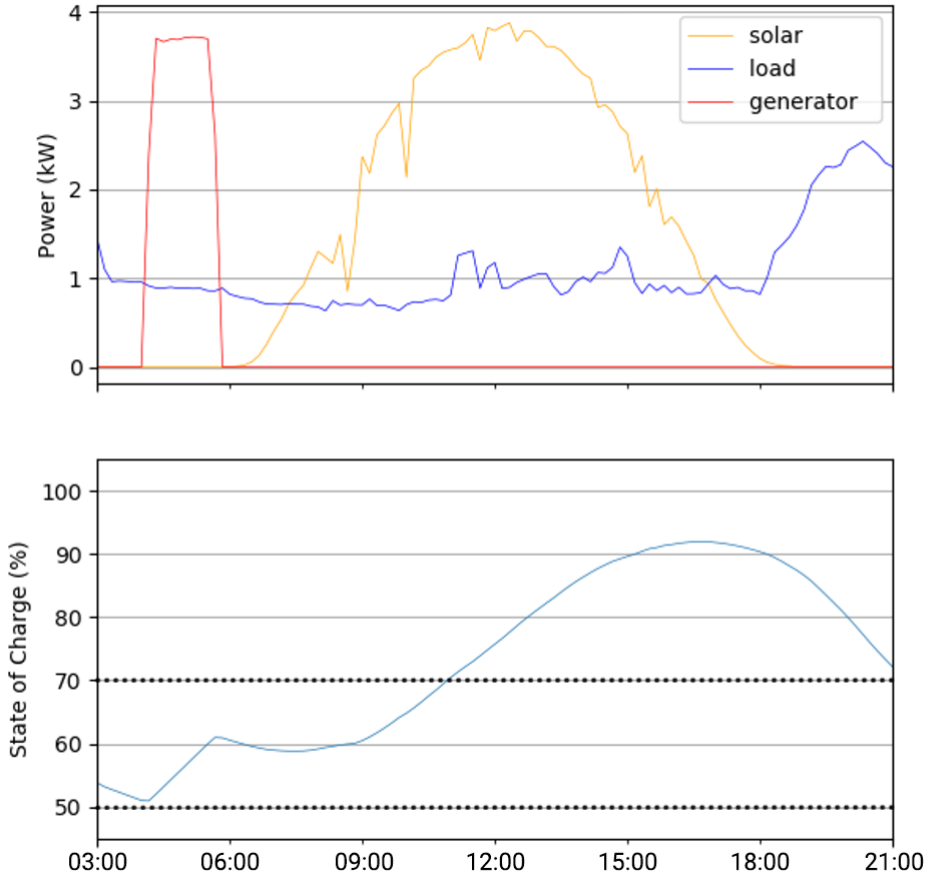
Deadband Controlled Solar Diesel Hybrid Microgrid (BAU Simulation)



In the business-as-usual (BAU) scenario, the load or usage throughout the day (purple) is fairly consistent but starts to increase around 7 pm as darkness sets in. Solar power (yellow) is used during the day and charges the battery but at 2 pm the excess solar power is curtailed (green shading) as the battery reaches full charge and there is more solar power being generated than is needed to meet the load.

Second graph shows the battery discharging to provide power in the very early morning to meet loads. From about 4 am until 7:30 am, the generator is running and charging the battery. At 7:30 am, solar begins to power the microgrid loads and the generator stops charging the battery. By 9 am there is enough solar power being generated to meet loads and start charging the battery until it is fully charged at 2 pm. After 2 pm, solar is only powering the loads and any excess solar power is lost or curtailed. As the sun sets at 7:30 pm, the battery powers the microgrid.

New Sun Road Controlled Solar Diesel Hybrid Microgrid (actual)



With New Sun Road, Stellar Microgrid OS optimizes microgrid performance and shows the generator is run about 30% less (red). Because solar power is not curtailed (yellow), fuel usage is reduced. The battery charge is kept within a mid range of 50-90% to maintain its capacity. Every few days, depending on the manufacturer's recommended settings, Stellar allows the battery to fully charge to maximize battery health and extend performance.

Stellar Microgrid OS™ uses AI (artificial intelligence) algorithms incorporating data from on-site IoT (internet of things) devices, weather forecasts with satellite measurements to forecast solar energy generation and energy usage to trigger optimally timed generator operations. Stellar operates the generator at its most efficient output and manages the battery SoC to extend its lifetime.

Field Data Optimizing Hybrid Microgrid Performance

Data presented below from the three sites in Tanzania, Londoni, Kalenge and Leshata, show performance in actual systems. At times the generator was off-line which accounts for some gaps in the data which were excluded from the analysis.

Londoni serves over 200 customers and has a solar PV capacity of 60 kW. Stellar operations generated 24% in fuel savings yielding an estimated savings of over $2000 annually. Stellar

offers a report on estimated emissions (CO_2, NO_x, SO_x) based on generator fuel consumption. The CO_2 savings reported in the tables below is from using the maximum amount of solar power available based on Stellar's optimized operations.

LONDONI Month	Date range included	BAU time curtailed (%)	NSR control time curtailed (%)	BAU gen energy (kWh)	NSR control gen energy (kWh)	Gen energy savings (%)	Fuel savings (l)*	CO2 savings (kg)
August	*13-27*	*18*	*3*	*850*	*787*	*7*	*31.5*	*85*
Sept	**	**	**	**	**	**	**	**
Oct	*3-13*	*27*	*4*	*671*	*560*	*17*	*55.5*	*150*
Nov	*1-22*	*38*	*15*	*1063*	*613*	*42*	*225*	*608*
Total	***48 days***	***29***	***9***	***2584***	***1960***	***24***	***312***	***842***

Generator fuel efficiency assumed to be 20%. At about $1/liter (2243 kSh) annual savings = $2372

*** Generator offline*

In Kalenge, Tanzania, the microgrid system serves 178 off-takers and has a solar capacity of 20 kW. New Sun Road's Stellar remote monitoring and control platform optimized performance against the 53%-80% deadband default, reducing fuel consumption by 12%.

KALENGE Month	Date range included	BAU time curtailed (%)	NSR control time curtailed (%)	BAU gen energy (kWh)	NSR control gen energy (kWh)	Gen energy savings (%)	Fuel savings (l)*	CO2 savings (kg)
Aug	*13-30*	*17*	*7*	*320*	*287*	*10*	*16.5*	*45*
Sept	*1-30*	*23*	*12*	*295*	*269*	*9*	*13*	*35*
Oct	*1-31*	*22*	*9*	*609*	*531*	*13*	*39*	*105*
Nov	*1-30*	*23*	*9*	*599*	*522*	*13*	*38.5*	*104*
Total	***109 days***	***22***	***9***	***1823***	***1609***	***12***	***107***	***289***

****Generator fuel efficiency assumed to be 20%. At about $1/liter (2243 kSh) annual savings = $358***

In Leshata, Tanzania, Powergen's microgrid serves 145 and provides 7 kW of power. Over the period of the analysis, New Sun Road was able to reduce fuel usage by 7%.

LESHATA Month	Date range included	BAU time curtailed (%)	NSR control time curtailed (%)	BAU gen energy (kWh)	NSR control gen energy (kWh)	Gen energy savings (%)	Fuel savings (l)*	CO2 savings (kg)
June	*1-30*	*26*	*16*	*331*	*303*	*9*	*14*	*38*
July	*1-14*	*14*	*9*	*193*	*186*	*4*	*3.5*	*9*
August	*1-31*	*20*	*12*	*430*	*417*	*3*	*6.5*	*18*
Sept	*1-30*	*20*	*10*	*407*	*350*	*14*	*28.5*	*77*
Oct	*1-20*	*8*	*6*	*319*	*315*	*1*	*2*	*5*
Nov	*13-30*	*18*	*11*	*204*	*184*	*10*	*10*	*27*
Total	***143 days***	***19***	***11***	***1884***	***1755***	***7***	***64.5***	***174***

****Generator fuel efficiency assumed to be 20%. At about $1/liter (2243 kSh) annual savings = $164***

Summary and Conclusion

Data shows that Stellar operations were able to provide significant fuel savings at the three sample sites, Londoni-Chipinga (24%), Kalenge (12%) and Leshata (7%) relative to a business-as-usual control simulation. Most of the savings was achieved by running the generator for shorter, more targeted periods and about 40% more often than usual. In general, the larger the solar PV the more fuel savings. Optimizing the size of each microgrid component - solar, battery storage and generator - and considering the capability of the control system can reduce capital and operating costs.

New Sun Road's Stellar Microgrid OS pulls data from the Stellar Edge Controller, however in the cases where control parameters can be set remotely via an API interface, such as through the Victron inverter, Stellar can provide optimization without additional on-site hardware.

Site	**Londoni**	**Kalenge**	**Leshata**
Solar PV size	60 kW	20 kW	7kW
# of meters	203	178	145
AI optimization	Stellar Microgrid OS™	Stellar Microgrid OS™	Stellar Microgrid OS™
Inverter	Victron	Victron	Victron
# of data days	48	109	143
% increase of solar PV	20%	13%	8%
Generator savings	24%	12%	7%
Fuel savings (liters)	6.5/day	0.98 /day	2.21/day
CO_2 emissions reduced	17.5 kg/day	2.7 kg/day	1.2 kg/day

By forecasting different scenarios and managing which power sources are charging the battery for storage, renewable energy can be maximized, asset life extended and costs minimized, saving 10% or more on fuel in hybrid microgrids. New Sun Road's Stellar Microgrid OS automatically optimizes the performance of hybrid microgrid systems to reduce carbon footprint and saving hundreds to thousands of dollars annually per system in reduced fuel use and delivery overhead.