

OFF-GRID HYBRID POWER in the Sonoran Desert, Mexico

CASE STUDY



SYNERGi is the only patented hybrid solution that adapts to variables by dynamically synchronizing and optimizing site elements to reduce OPEX

Abstract

The Sinuoso site is located in North-West Mexico, on the edge of the Sonora desert and is a fully off-grid site with both 2G (with air-conditioning) and 3G cellular loads in self-contained cabinets. The site has approximately 7kW of solar already installed and was supposed to be running in a hybrid manner, cycling the batteries. The existing control system never worked and the generator was running 24/7. As a result, the client requested a replacement system that could be proven to operate in a hybrid charge/discharge manner, with the necessary logging to verify its performance.

Site parameters and requirements were as follows:

- Average load 3.5 to 4kW
- Re-use the 43 solar panels with approximately 7kW of solar power output
- Re-use the existing generator (25kVA Standby/20kVA Prime, 3-phase)



- Shelter is free-air cooled only, with average daily temperatures in the shelter of 35°C and often over 40°C.
- Bulk of the hybrid system output required to be AC, with minimal 48V DC load
- Utilize the 1500Ahr/48VDC battery provided

Existing Site Problems and Enatel's Solution

Enatel's SYNERGi provided the perfect solution with a configuration of five 2kW Enatel solar converters, nine 2kW rectifiers (phase balanced) and six 1.2kW inverters to be deployed for efficiencies and cost-saving.

By dynamically detecting conditions, the SYNERGi hybrid power system cycles the batteries, saving diesel and maintenance expenses by operating the existing generator in its optimum efficiency power range for longer periods. Enatel's 'solar optimization' feature also ensures that the genset does not run if solar power is available. SYNERGi incorporates its own self-learning algorithm to track sunrise through the seasons, thus giving well-defined stop conditions to the generator to ensure it does not run unnecessarily during the 'solar day'. Operating autonomously, it does not require connection to external date or time references and does not require links to weather forecasting web pages. These efficiencies significantly extend the life of the generator as well as giving the obvious benefits of fuel and service cost reduction.

The system being replaced was a mix of rectifiers, solar converters, and inverters all from different manufacturers. A PLC was acting as the controller. As mentioned, it never operated properly, if at all in a hybrid state.

The SYNERGi solution is a single modular design, sourced solely from Enatel and takes up about a quarter of the space, presenting a harmonized, single-controller solution where all the power modules work in a unified and coordinated manner.

The 1500Ahr AGM lead-acid battery was supplied by the customer. It was a low-cost reconditioned battery and provided with the acknowledgement that it was not actually appropriate for this application and would likely last much less than 12 months.



Long term a more 'fit-for-purpose' battery is to be provided and would likely be a 'high-cycle' sealed lead-acid battery. LiFePO4 lithium batteries are also being considered for the trial.

The solar panels already installed on site were 43 WebelSOLAR 180W solar panels:

Each panel has the following ratings:

- Maximum Power Output: 180W
- Open Circuit Voltage: 44.5V
- Voltage at maximum power: 32.3V
- Tolerance : ±5%

The panels are estimated to have been installed for four to five years. They were all re-deployed to power a total of 5x 2kW Enatel SM2048HE, 97% efficient solar converters (each converter has its own 99.5% efficient MPPT). This involved arranging either 8 or 9 panels in series as follows:

Generators

Eight Panel String

16 panels
 Two solar converters
 $V_{total} = 258.4V$ (maximum power)
 $I_{max} = 4.9A$
 Power = 1.4kW (at the panels)

Nine Panel String

27 panels
 Three solar converters
 $V_{total} = 290.7V$ (maximum power)
 $I_{max} = 4.9A$
 Power = 1.6kW (at the panels)

The complete SYNERGi solution included five 2kW Enatel solar converters, nine 2kW rectifiers (phase-balanced) and six 1.2kW inverters.

The existing generator was retained: a replacement would cost US\$25,000.

A comparison of the actual operation over one month before and after the SYNERGi

	Before	After	Saving
Run hours per month	720	76.5	89.4%
Average diesel use per month	2038 litres	275 litres*	86.5%
Average diesel cost per month	US\$1530	US\$206.25	86.5%
CO ₂ emissions	5,400 kg	729 kg	86.5%
Genset service period	Monthly	6 monthly	
Cost of servicing per month	US\$1933	\$1933 over 6 months = \$322	83.3%
Predicted generator life	3.5 years (30,000 hrs)	>20 years	
Amortised genset cost per month	US\$595	\$104	85%
Total cost per month	US\$4058	\$632.25	\$3426
Average battery DoD	Unknown	40%	
Predicted battery life	Unknown	2 years	

Annual CO₂ savings: 56,052 kg

The logs show average power of the generators during hybrid operation to be 11kW. This operates the generator at approximately 55% of standby (61% of prime) power.

This comparison is based on the cost of diesel: \$13.68 MXN (US\$0.75) and cost of servicing: \$35,373 MXN (US\$1933) per month.



Solar Distribution Panel
 Solar input isolators
 Solar input surge suppressors
 AC output distribution

Main SYNERGi Distribution panel
 AC input (with surge suppression)
 Battery Breaker
 DC output breakers (feeds to inverters)

24kW Power Block:
 Up to 12x 2kW rectifier modules
 Output: 500A/-48V maximum
 Provided with 9x 2kW rectifiers

10kW Solar Power Block:
 5x 2kW output modules
 Output: 208A/-48V maximum
 For this site: 150A/-48V maximum

6x 1.5kVA (1.2kW) Inverters
 7.2kW/9.0kVA

SYNERGi Controller
 Full genset start/stop control including patented genset anti-stall and dynamic diesel genset optimization (D²GO).

Generator Run Time

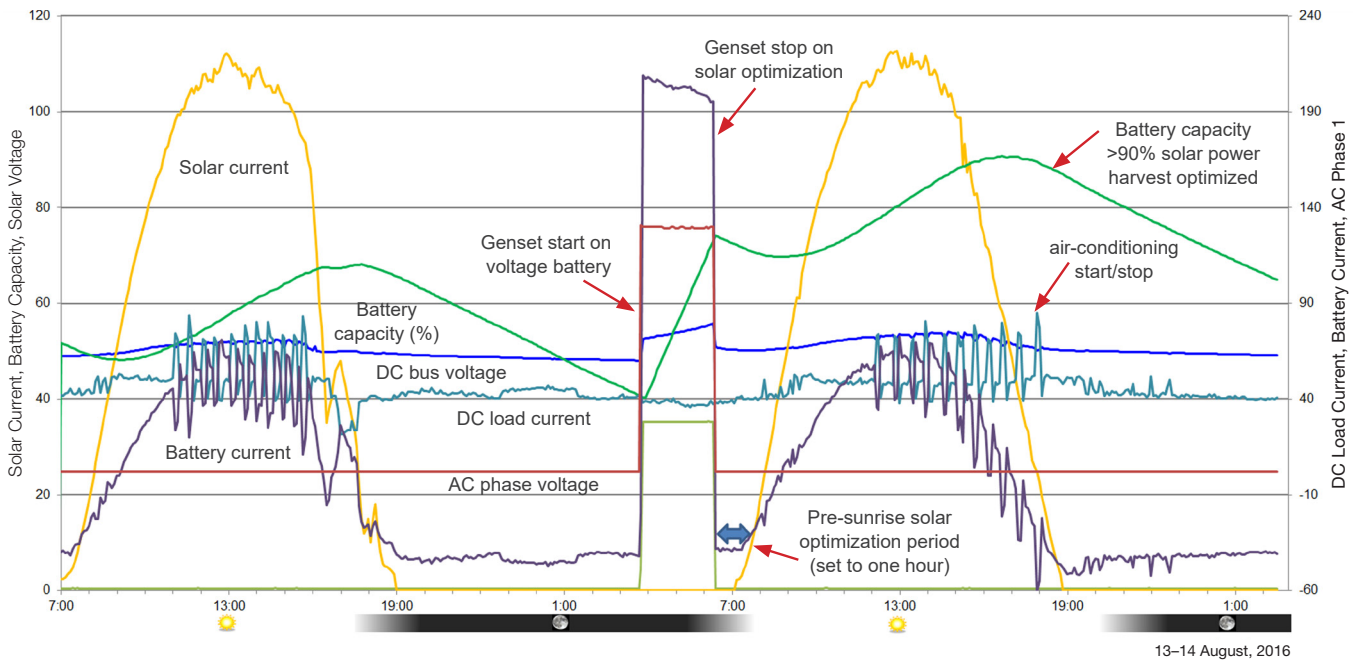
2:11:00
 4:59:00
 4:59:00
 4:59:00
 4:59:00
 3:52:00
 7:59:00*
 2:36:00
 4:02:00
 1:15:00
 4:59:00
 4:07:00
 4:59:00

Generator Stop Time

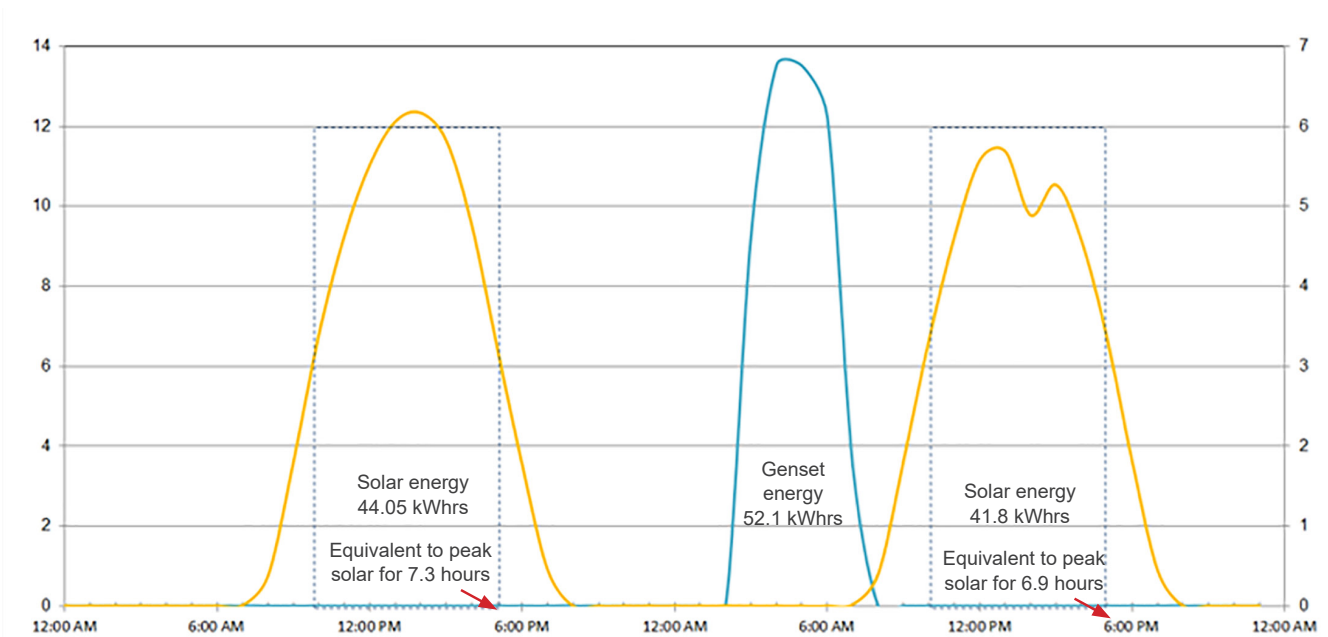
01/08/2016 07:00:24 am
 03/08/2016 02:20:56 am
 05/08/2016 3:56:36 am
 07/08/2016 03:06:32 am
 09/08/2016 06:18:56 am
 11/08/2016 06:50:52 am
 12/08/2016 05:27:22 am
 14/08/2016 06:20:22 am
 16/08/2016 06:20:12 am
 18/08/2016 06:21:04 am
 19/08/2016 01:50:06 am
 21/08/2016 06:20:30am
 23/08/2016 06:02:04 am

*This is an eight-hour monthly 'extended charge' that is programmed into the SYNERGi controller that guarantees the battery is fully charged at least once a month. The duration and interval of the extended charge are programmable parameters.

Sinuoso (Mexico) Hybrid Performance Solar and Generator Energy Over Two Days



Over the month of August, the proportion of solar energy use to generator energy use was 1.4 times that of the generator, indicating that all the solar energy available was being used by the site load. SYNERGi's solar optimization feature successfully prevents the unnecessary running of the generator during the solar day. On this site, the savings of >US\$3400 per month payback for the SYNERGi system would be under one year.



From site log data over the month of August, the peak output power was seen to be at 1pm each day and regularly reached >6.0kW. The graph illustrates the solar harvest being maximized with equivalent full power output on average for over seven hours per day, while the generator was only required to run once over the two days.

Single Site Benefits*



90% Saving

7,722 hours less run time



83% Saving

US \$19,332 service cost saved



87% Saving

21,156 L less diesel used



87% Saving

56,052 kg less CO₂ emissions

*Estimated Annual Savings