

# LARGE SCALE PV DIESEL STORAGE HYBRID SYSTEM DIESEL OFF-MODE, GRID FORMING SCS, ST. EUSTATIUS



Today, solar energy covers 46% of St. Eustatius' total electricity need. Grid Forming SCS 2200 inverters allow to operate the island grid for 10.5 hours in Diesel Off-Mode operation with 100% Solar Power Fraction. In total a 5.9MWh Li-ion storage facility has been integrated for energy shifting and grid services. Thanks to the SMA Fuel Solution about 4,560 tons CO2 per year can be saved. The project has been designed, and implemented by the SMA Sunbelt Energy GmbH.

## Project "St. Eustatius Phase 1+2"

- Location: St. Eustatius, Caribbean
- Commissioning: November 2017
- Requirements: Grid Forming Inverter, overall power and energy management system

## Plant information

- Installed PV power: 4.15 MWp
- Installed Storage capacity: 5.9 MWh
- Diesel capacity: 4 MVA
- Annual energy yield: 6,400 MWh
- Annual diesel savings: > 1,700,000 liters
- Island Load: ~2MW

## System Technology

- Battery: 2 x SCS 2200 Grid Forming in 2 x MVPS 2200 and 1xSCS 1000 in MVPS 1000
- PV: 2xSC CP XT1000 in 1xMVPS 2000 and 74 SMA Sunny Tripower 25000TL-30
- Control: FSC 2.0 with Automatic Genset Shutdown

SMA system solutions for hybrid applications



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## Unique Selling Points

- Automatic Genset Control and transition to Diesel Off-Mode and Diesel On-Mode
- Integration of all components and existing genset infrastructure into control scheme
- Co-generation with Diesel in Diesel-On Mode
- Voltage and frequency source in hot-standby for uninterrupted power supply also at night (UPS function)
- 3 layer built-in redundancy concept
- Short circuit clearance in 120ms
- European grid quality ( $\pm 0.005\text{Hz}$  deviation)
- Services in operation period

## Partner

- End Customer: STUCO, Utility of St. Eustatius
- PV and Installation : Eco Energy, Curacao
- Finance: Dutch Ministry of Economic Affairs

## SMA Sunbelt Energy

- Electrical Design, Network Design, Operation case definition, overall project management, procurement and delivery
- Containerized Li-Ion Storage Facility
- Supply of battery storage cells from Samsung SDI

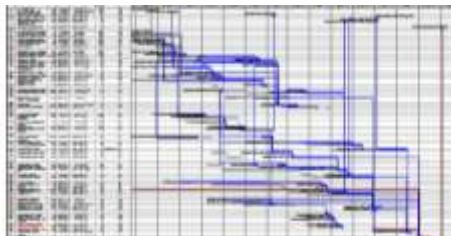
## SMA System Technology

- 2 Sunny Central Storage 2200 Grid Forming
- 1 FSC 2.0 with Automatic Genset Shutdown
- 2 Sunny Central 1000 in MVPS 2000
- 1 Sunny Central Storage 1000
- 74 SMA Sunny Tripower 25000TL-30

SMA System Solutions for hybrid applications



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	Current plant state:	Battery operation
	Current transition:	Idle
	Battery in process:	2 h 25 min
	Genset in process:	8 h 31 min
	Mains op. process:	0 h 00 min

## Key Personnel

- Project Engineer: Hamed Sadri (Sunbelt)
- Project Manager: Wiebke Krüger (Sunbelt)
- Commissioning: Paul Robert Stankat, Tobias Becker and Oliver Schoemann (SMA AG)

## Project phases

- Tender: July 2016
- Signature of contract: August 2016
- Construction PV: Jan- May 2017
- Delivery Storage: September 2017
- Commissioning: October 2017
- Acceptance: 15. November 2017

## Key strengths

- One system solution from one hand
- Overall System Engineering
- Turnkey delivery of integrated Li-Ion Storage Systems
- Inhouse Matlab based model for battery usage and heat generation; fuel saving forecasting

SMA system solutions for hybrid applications



# TECHNICAL OVERVIEW



## GRID FORMING BATTERY INVERTERS

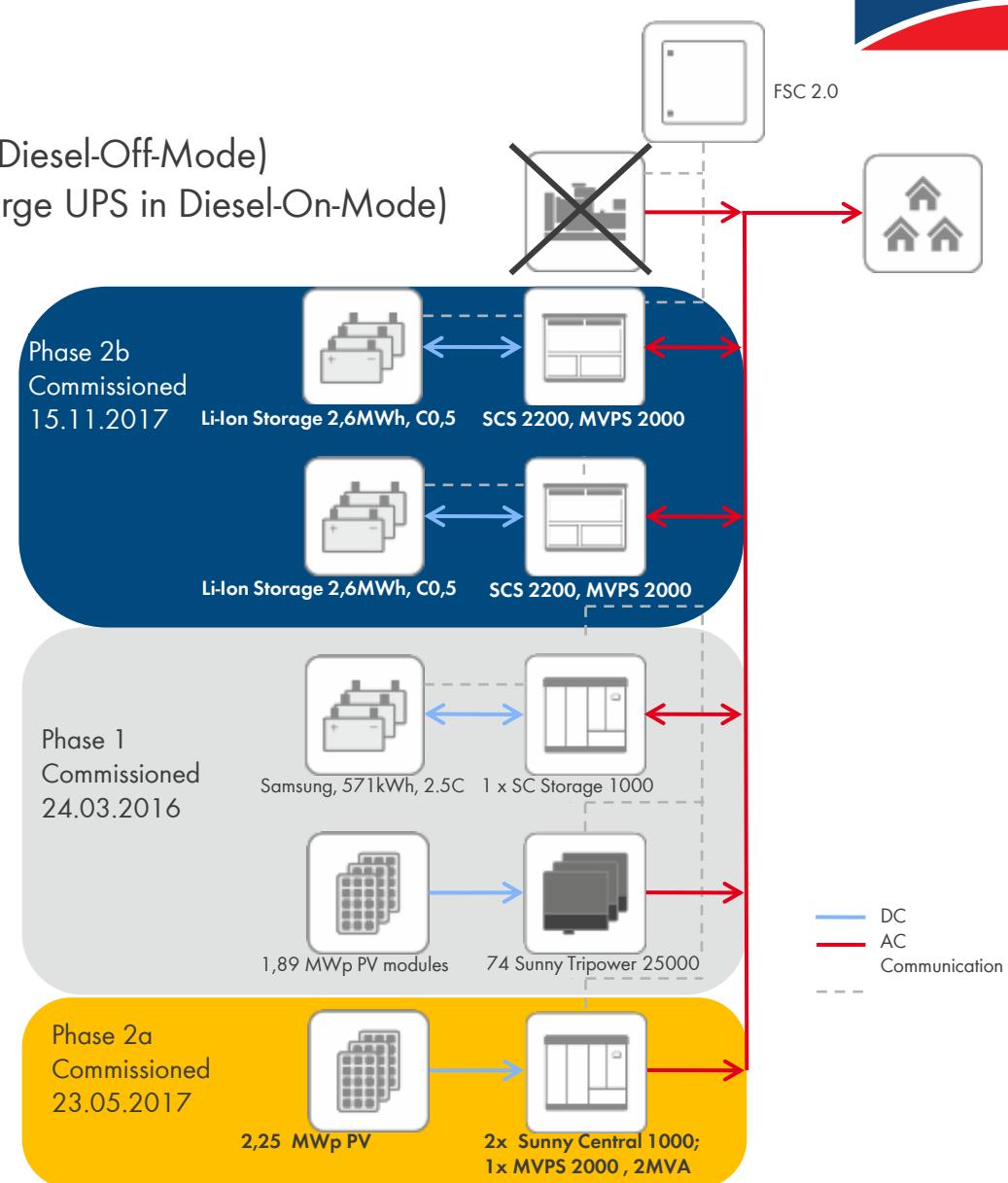
Day operation without Diesel Generators (Diesel-Off-Mode)

Full redundancy for generator operation (large UPS in Diesel-On-Mode)

- **Voltage source**
- Frequency regulation
- Spinning Reserve Provision
- Synchronisation Diesel On-Mode
- Diesel Off-Mode

### St. Eustatius II

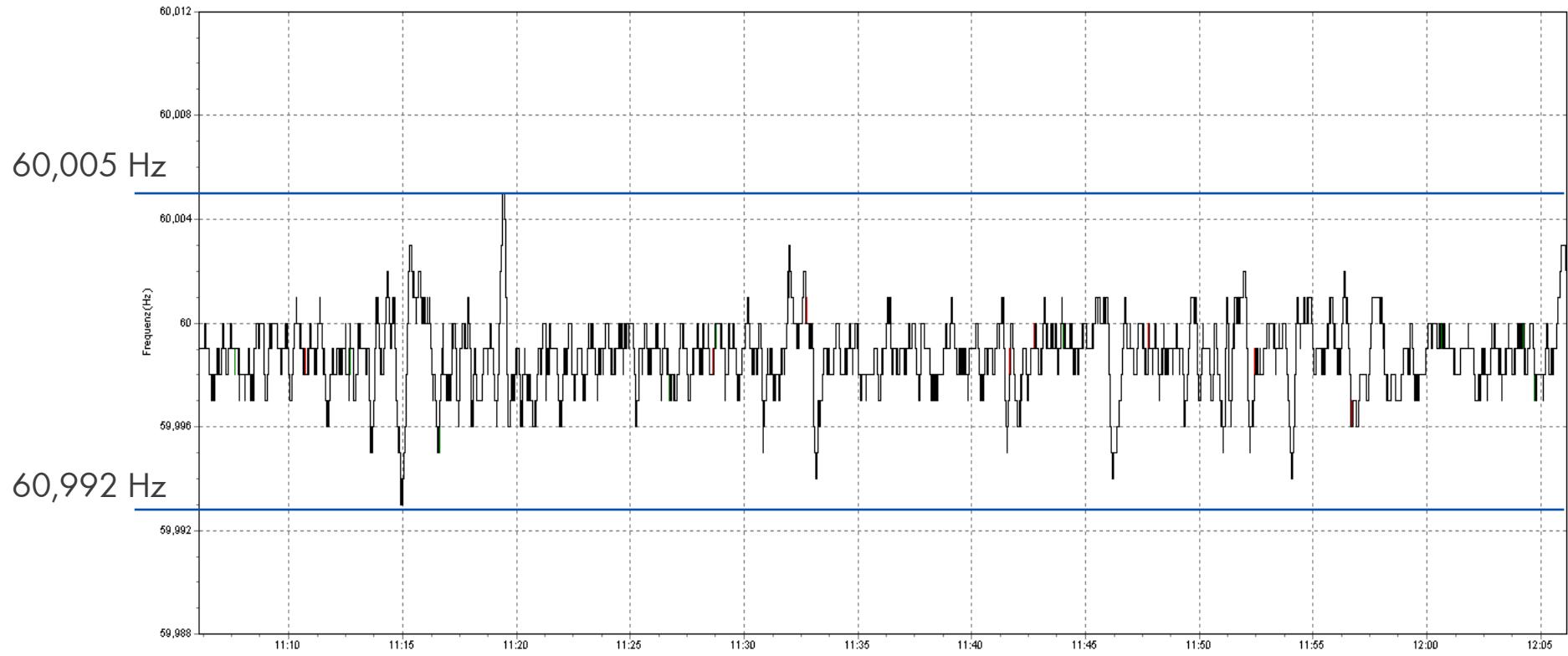
Estimated fuel savings	1 728 000 liters/a
Solar Energy Produced (net)	6,4 GWh /a
CO2 savings	4,561 to CO <sup>2</sup> /a
Used PV energy	6 494 547 kWh
Solar energy fraction	46%



# FREQUENCY STABILITY IN DIESEL OFF MODE



Frequency bandwith of 0,013Hz

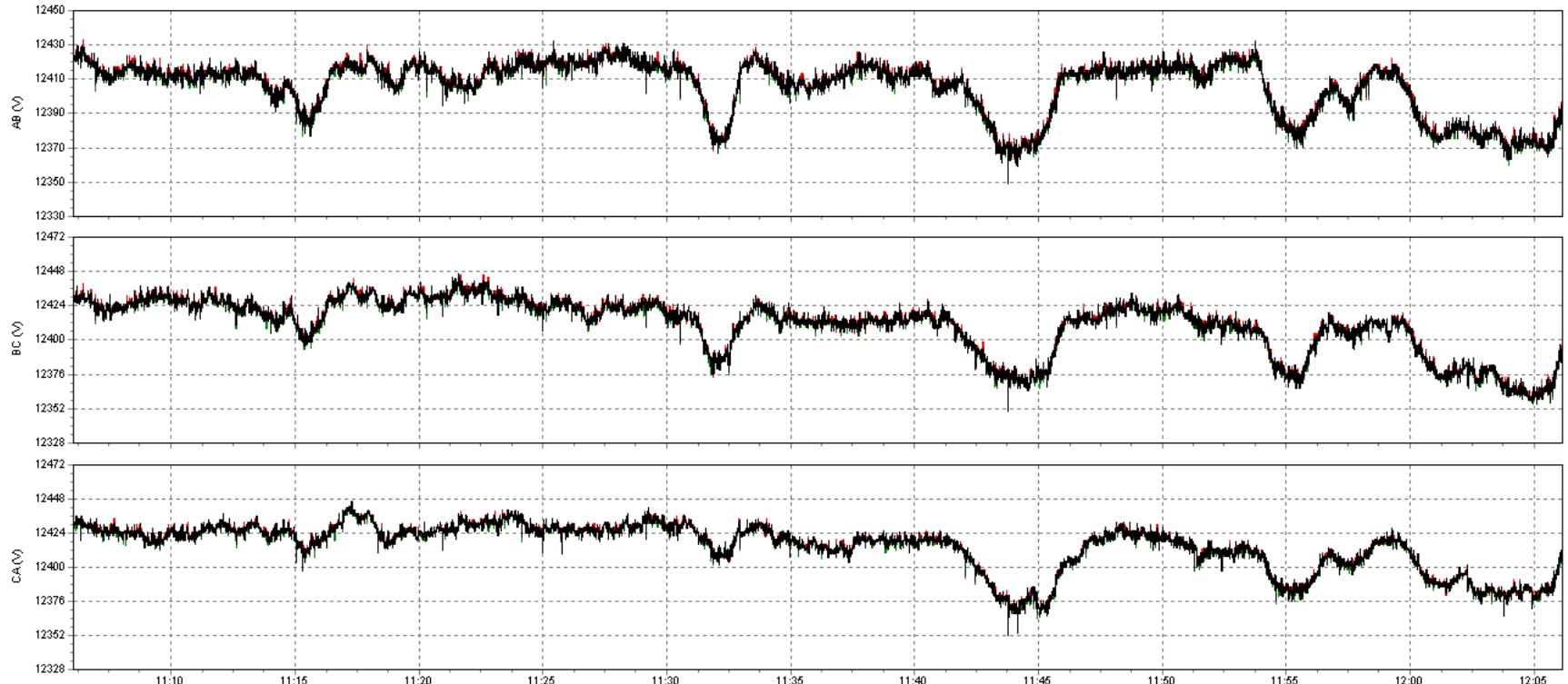


➤ Recording on 31.10.2017 from 11.00 am to 12.05pm during step load tests

# VOLTAGE STABILITY IN DIESEL OFF-MODE WITH 1MW STEP LOAD TESTS (50% LOAD SHEDDING)

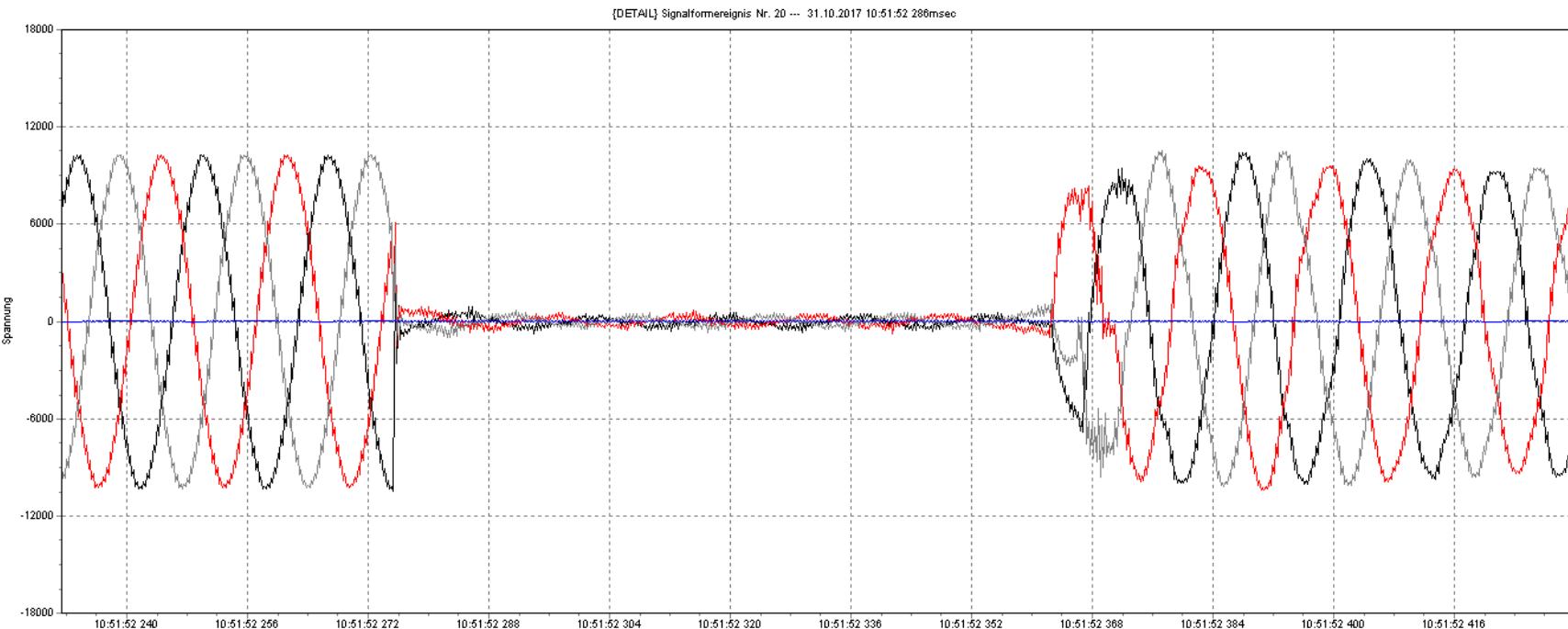


The voltage stays between 12,43kV and 12,37 kV → Voltage Fluctuation of 0,4%



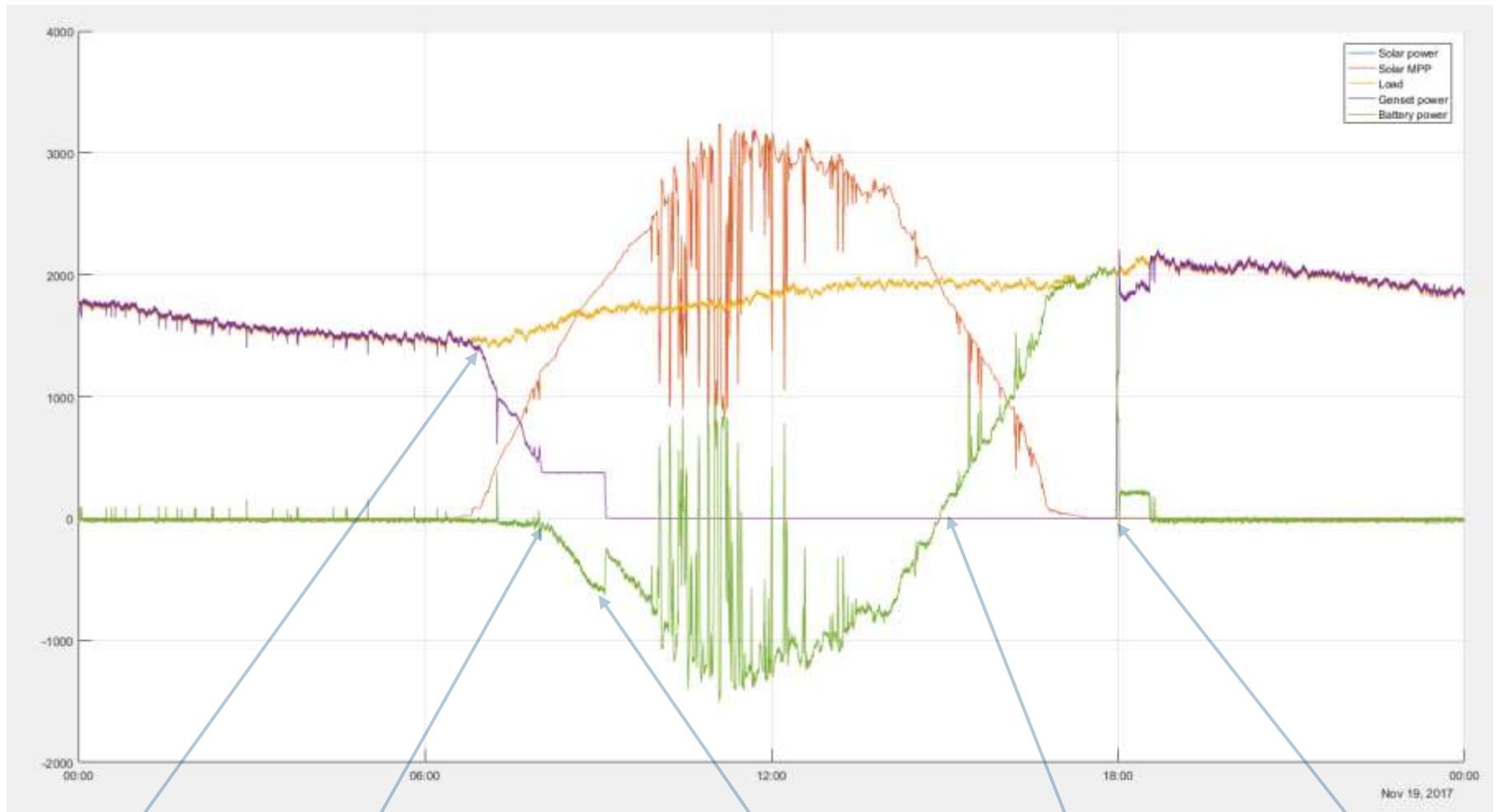
➤ Recording on 31.10.2017 from 11.00 am to 12.05pm during step load tests

# 3 PHASE SHORT CIRCUIT CLEARANCE IN 120MS



➤ Recording 31.10.2017

# FUEL SAVE CONTROLLER „DIESEL OFF MODE“ DAYTIME WITHOUT DIESEL



PV on sunrise begins  
reducing fuel  
consumption

Genset at minimum load.  
Battery begins to charge

Battery energy sufficient for some minutes  
of genset-off  
→ Automatic transition to genset-off

Solar output drops –  
battery covers missing  
energy

Battery depleted → Automatic  
transition to genset-on

# GRAPHICAL USER INTERFACE FSC



## Fuel Save Controller

Hybrid Plant Overview

Stations

- General Overview
- Genset System
- PV System
- Battery System
- Measurements
- Visualizations**
- Power Chart
- Dynamic Genset Shutdown
- Digital IO
- Device Information

Operations

- Alarms
- Mode

Status: OPERATE   Access level: User   Software version: 2.07.02-S1.199   Serial number: 1901180012   10.68.41   19.12.2013

Hybrid Plant Overview

Active power: 3379 kW  
Reactive power: 03 kvar  
Total energy: 9323 MWh  
Active power export: 3790 kW  
Reactive power export: 52 kvar

Active power: 1599 kW  
Reactive power: 524 kvar  
Total energy: 30201 MWh

Active power: 0 kW  
Reactive power: 0 kvar  
Total energy: 32147 MWh  
Required reserve power: 100 kW

Current plant state: Battery operation  
Current transition: Idle  
Battery in process: 2h 26 min  
Genset in process: 5h 31 min  
Main in process: 0h 00 min

Total active power: 3379 kW  
 Genset power: 0 %  
 PV power: 100 %  
 Battery power: 0 %  
 Grid power: 0 %

Ambient temperature: -11.3 °C  
Module temperature: 40 °C  
Global irradiation: 1105 W/m<sup>2</sup>  
Power Mpp: 3379 kW  
Power Mpp estimated: 2919 kW

Boundary Conditions

Short Circuit Current

- Actual: 16950 A
- Optimal: 9000 A
- Minimal: 7500 A

Battery Power

Estimated Time For Battery IOP

Estimated: 1 h 16 min  
Minimal: 30 min

State Of Charge

Minimal: 98 %  
Maximal: 99 %  
Difference: 0 %

Battery Isolated Operation

Battery IOP duration: 2:27:28

Stable Operation

Genset IOP duration: 13:27:09

Information

Boundary Conditions

In this section, you see the conditions that need to be met for the system to shut down the gensets. If any condition is not met, turning gensets off is not possible.

Dynamic Genset Shutdown State

This section shows the current system status. Components in operation and active transitions.

Manual Control

If possible depending on the system state, this section provides the ability to manually transition to genset shutdown or to genset startup.

Manual Genset Control

Start Request   Stop Request

# ST. EUSTATIUS IN THE MEDIA



YouTube Long version <https://youtu.be/xBM7Rdz5ajA>

YouTube Short version: <https://youtu.be/vP8ljKZnoO8>

PM <https://www.sma.de/en/newsroom/current-news/news-details/news/2876-system-solution-from-sma-provides-caribbean-island-with-100-solar-power-supply.html>

Blog <https://en.sma-sunny.com/en/st-eustatius-100-solar-power-in-the-caribbean/>