System design and analysis for Solar and hybrid system
太阳能储能系统设计要点及性能分析

Speaker：陈健 Dr. Johnny Chen
SMA Solar Technology AG.

Agenda

1. SMA GROUP AND SMA SUNBELT IN A NUTSHELL
2. 100% DIESEL FREE OPERATION IN CARIBBEAN ISLANDS
3. SELECTED REFERENCES

SMA GROUP AND SMA SUNBELT IN A NUTSHELL

Highlights

SMA is a leading global specialist for PV system technology

- Founded in 1981
- >65 GW installed base
- Complete portfolio to serve all PV segments
- 20 subsidiaries with strong service capabilities and access to all channels
- Award-winning 20 GW production to achieve scale

Sunbelt is the off-grid, hybrid and storage specialist @ SMA

- 100% subsidiary of SMA Solar Technology AG
- Focus on off-grid, hybrid and battery based solar projects in the sunbelt region
- Business model covers component and solution sales as well as system integration
- Executed >100 MW of hybrid & storage projects

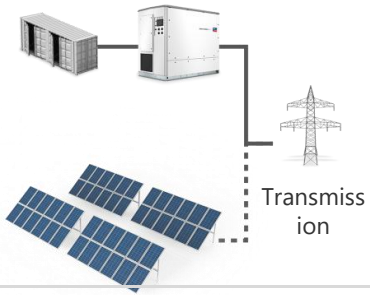
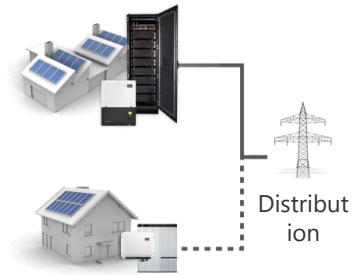
Key Figures SMA Group

Sales 2017:	891 Mio. Euro
EBITDA 2017:	97,3 Mio. Euro
Inverter output sold 2017:	8,5 GW
Employees:	> 3.000
O&M portfolio:	2,6 GW
Patents and utility models:	>1.000

Product Innovations

➢ SMA has know-how & products to benefit from strong growth in the field of battery storage.

SMA PROVIDES STORAGE SOLUTIONS FOR ALL BATTERY TYPES AND APPLICATIONS

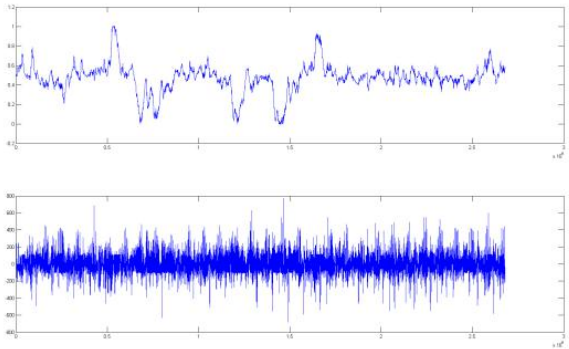
Segment	SMA Offering	Illustration	SMA Contribution
Utility Front-of-Meter  69% SMA's share in Utility segment 18%[1]	**Grid storage** Grid services Renewable integration Deferral Balancing	 Transmiss ion	System integration Energy management System design/ Engineering Grid simulation Efficient battery inverters O&M Services
Residential, Commercial & Industrial Behind-the-Meter 31%  SMA's share in R/C segment 7,9%[1]	**Behind-the-meter** Energy shifting Peak shaving ToU[2] Power Quality	 Distribut ion	System integration Energy management Calculation of energy savings Efficient battery inverters

➢ SMA has already supplied battery inverters and system technology for > 1GW

SMA PROVIDES SIZING OF THE COMPLETE BATTERY SYSTEM AND DETAILED ENGINEERING IN-HOUSE

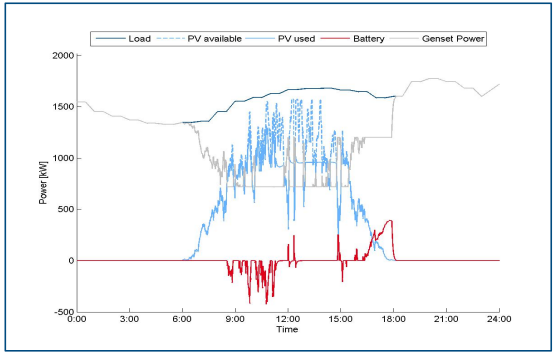
Sizing

- With proprietary software we simulate the output of the battery and can have a detailed load profile for battery degradation
- We design the battery specifically for the project and simulate the output and savings

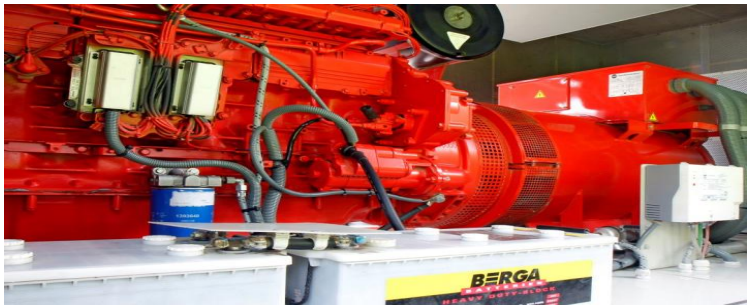


Engineering

- We can take standard containers, perform own adaptations or design complete DC system as well on a building
- We provide the complete detail engineering including electrical and mechanical



SMA HYBRID TEST CENTER ALLOWS FOR PROFESSIONAL TESTING OF ALL HYBRID CORE COMPONENTS



- Test facility for up to 6 MVA simulations
- Fully automized testing procedure with remote monitoring
- Integration of several gensets (80 – 800kVA)
- Long time test for battery integration

Prequalified battery technologies

SONY, Narada, TESVOLT, NGK, LG Chem, saft, GILDEMEISTER energy solutions, SAMSUNG SDI, SAMSUNG, FIAMM, EXIDE BATTERIES

Prequalified genset controller

DEIF power in control, ComAp, WOODWARD, DEEP SEA ELECTRONICS

› **Testing core components in our laboratories avoids draw bags during the installation and commissioning phase.**

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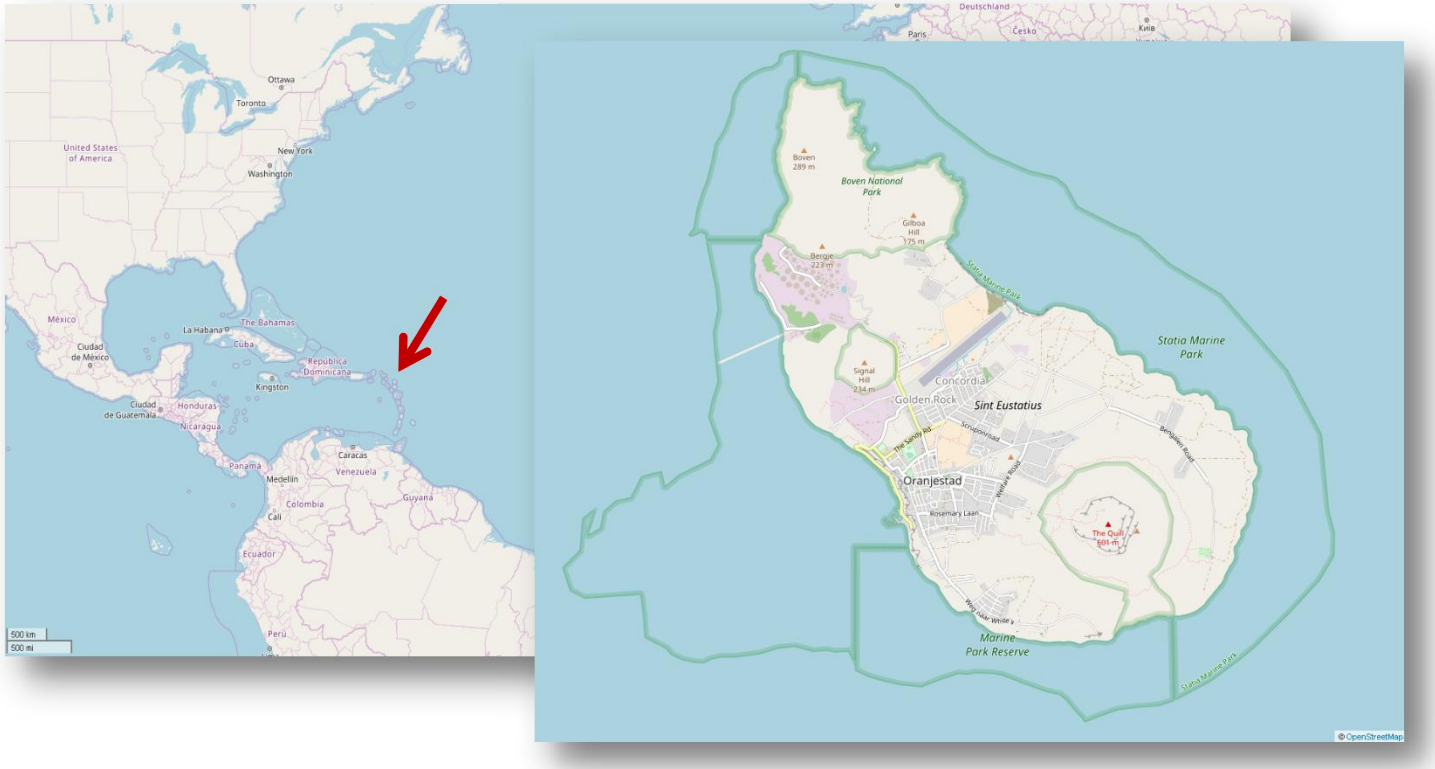
2 100% DIESEL FREE OPERATION IN CARIBBEAN ISLANDS

3 SELECTED REFERENCES

Caribbean Island of St. Esutatius, Netherlands Antilles



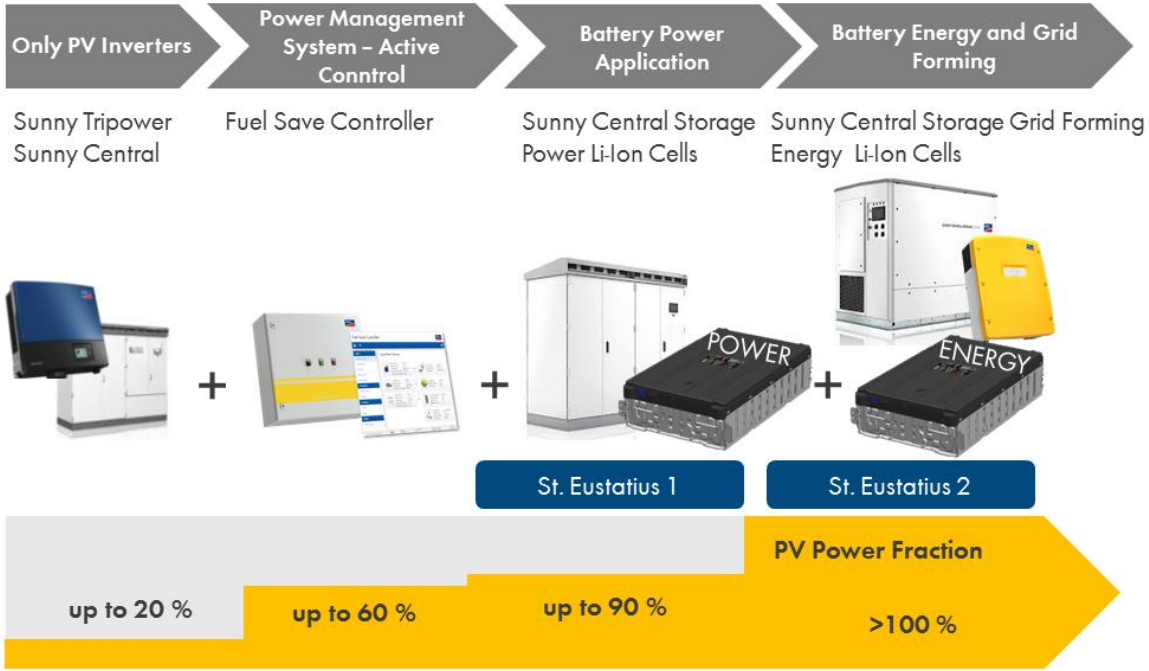
- Belongs to Netherlands Antilles, 21 km², approx. 4000 Inhabitants

STUCO Solar + Storage Main driving factors

- Up to 2015, STUCO 100% depending on fossil fuel (5.3 MVA diesel gensets capacity). More than its 78% income was going directly in fuel related operational costs.
- Dutch Government financed the installation to reduce exposure of STUCO to the high cost of fuel with significant operational losses.
- The installation offsets sufficient fuel to significantly eliminate operational losses.

STUCO Solar + Storage outcome

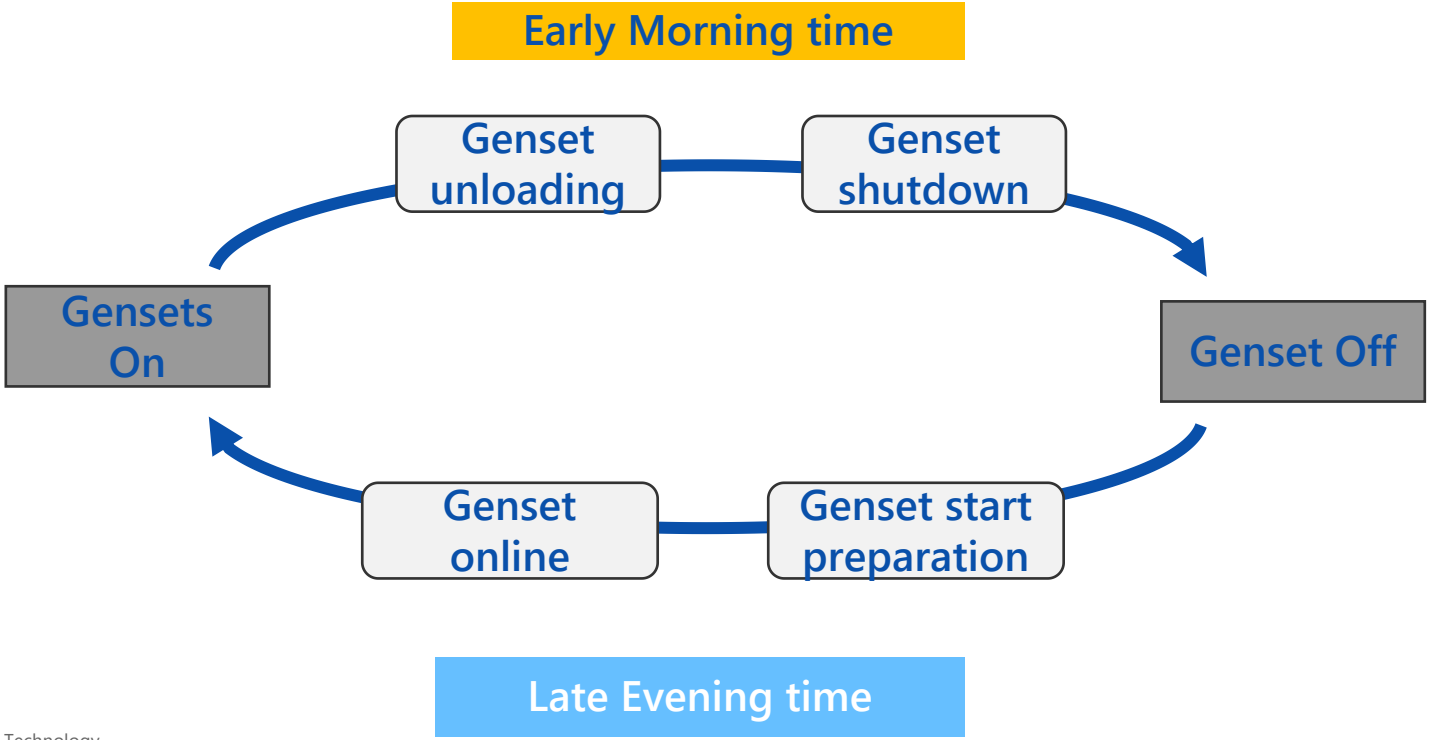
- In 2017 St. Eustatius' grid became the first island in the Caribbean to be entirely powered by a Solar PV and BESS



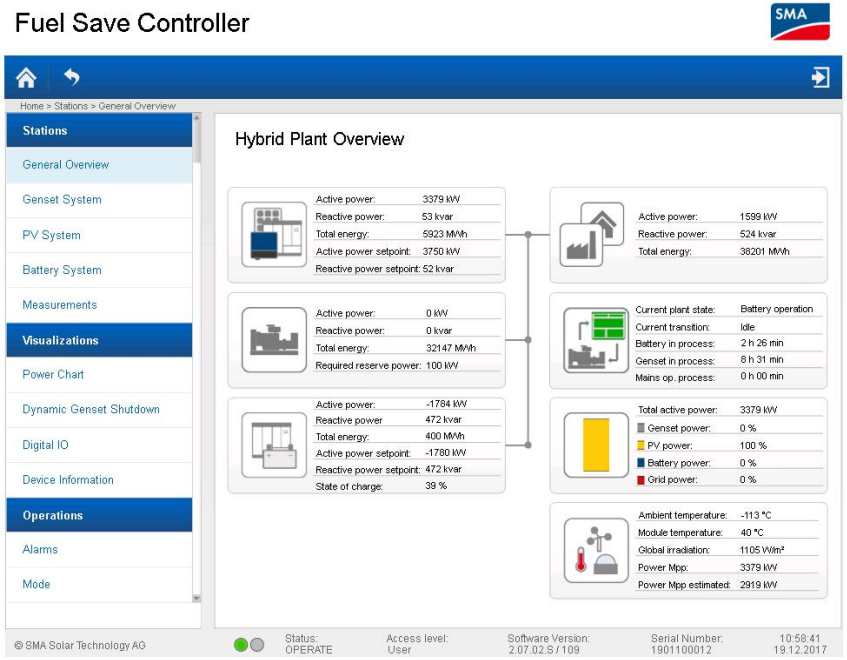
STUCO Solar + Storage features

- Commissioning: November 2017
- Requirements: Resiliency against hurricanes Cat 5., 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: 5 MVA
- 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 1 x MVPS 2000
- and 74 SMA Sunny Tripower 25000TL-30
- EMS: FSC 2.0 with Automatic Genset Shutdown

Operation Concept
Dynamic Genset Shutdown by Fuel Save Control

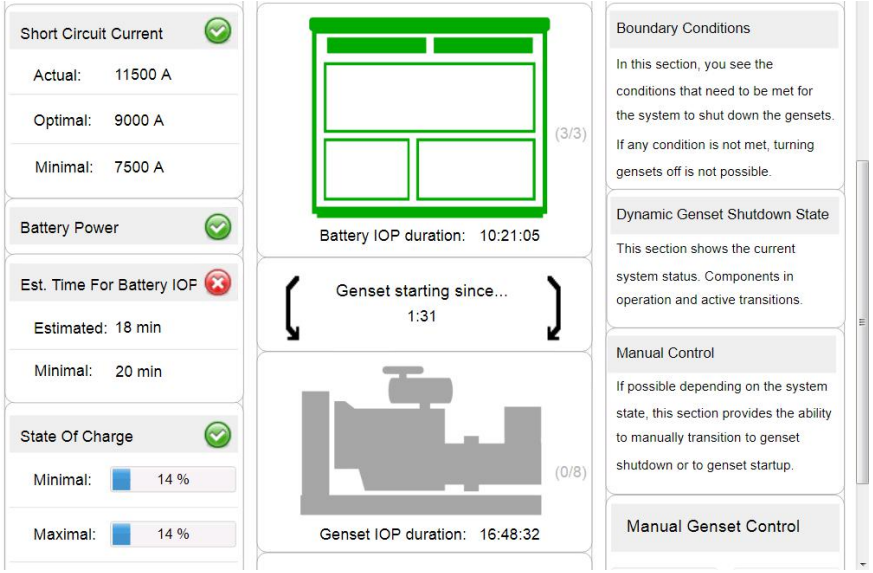


STUCO Solar + Storage Graphical user interface FSC



100% Solar Power and 3.38 MW PV

10 hours and 21 minutes in Diesel-Off Mode



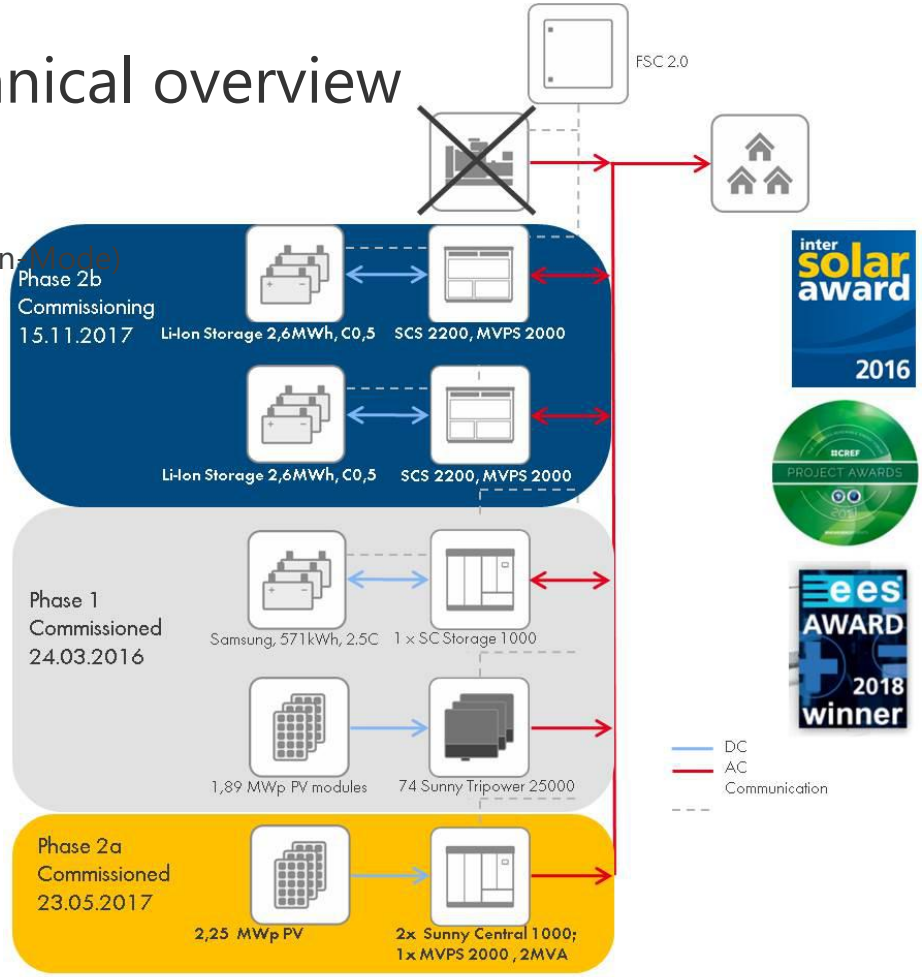
Solar and storage in statia technical overview

GRID FORMING BATTERY INVERTERS
Day operation without Diesel Generators (Diesel-Off-Mode)
Full redundancy for generator operation (large UPS in Diesel-On-Mode)

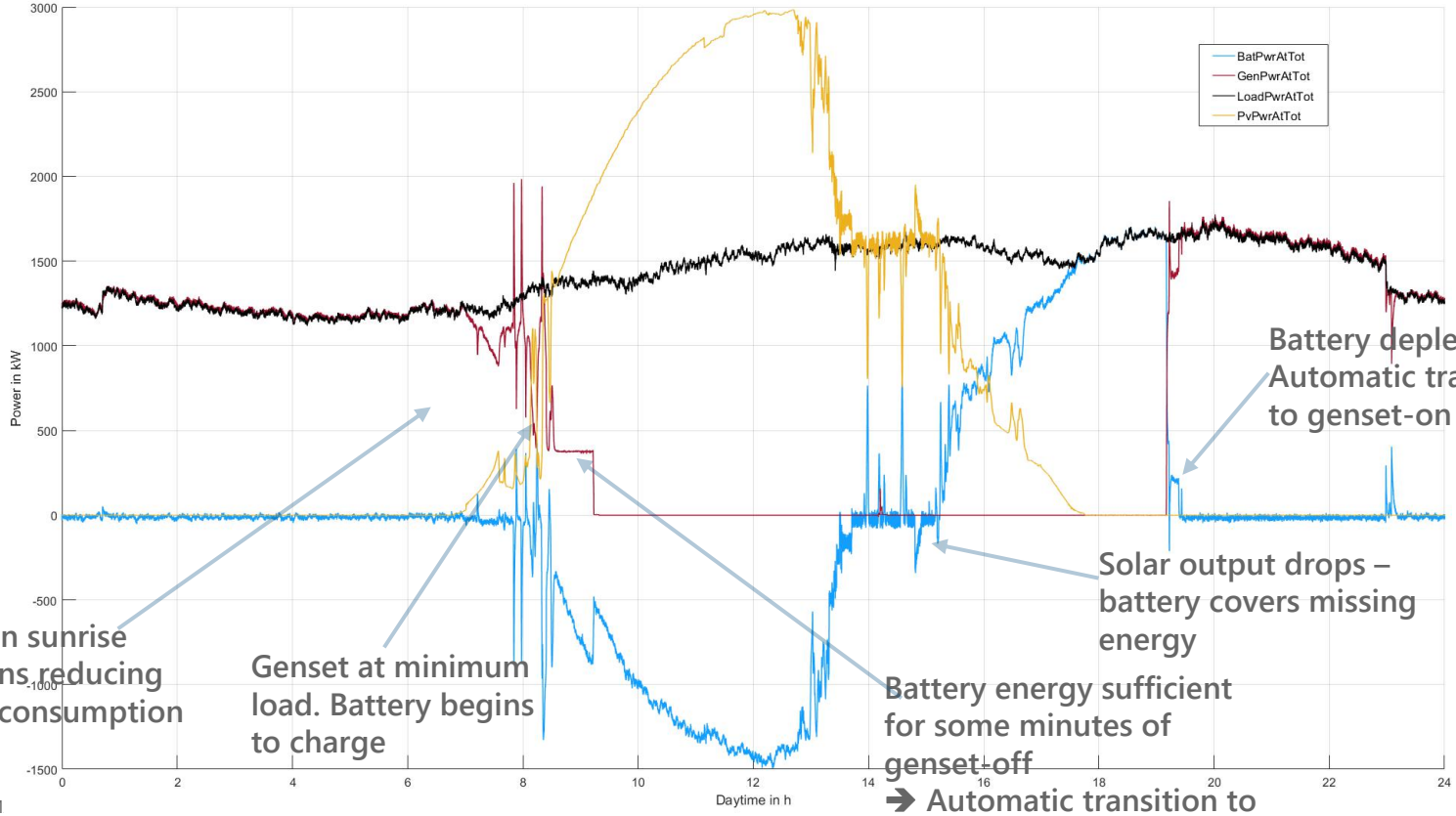
- **Voltage source**
- Frequency regulation
- Spinning Reserve Provision
- Synchronisation Diesel On-Mode Diesel Off-Mode

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^2/a
Used PV energy	6 494 547 kWh
Solar energy fraction	Min 45%



Typical day with beautiful Weather in Statia



PV on sunrise begins reducing fuel consumption

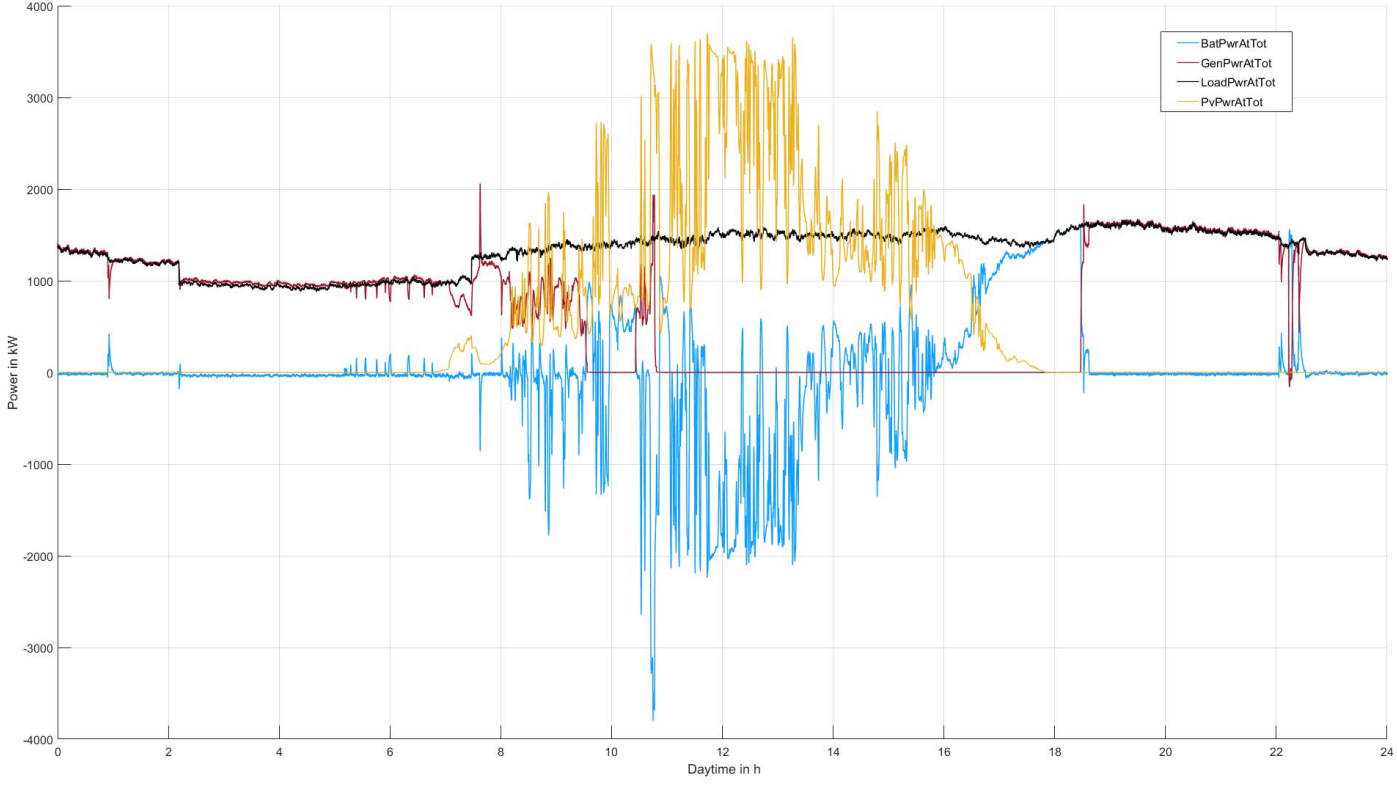
Genset at minimum load. Battery begins to charge

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

Solar output drops – battery covers missing energy

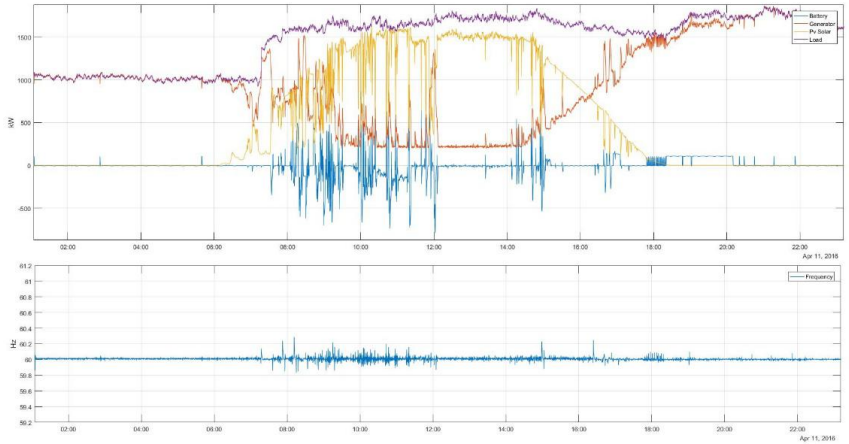
Battery depleted ➔ Automatic transition to genset-on

Typical cloudy day in Statia

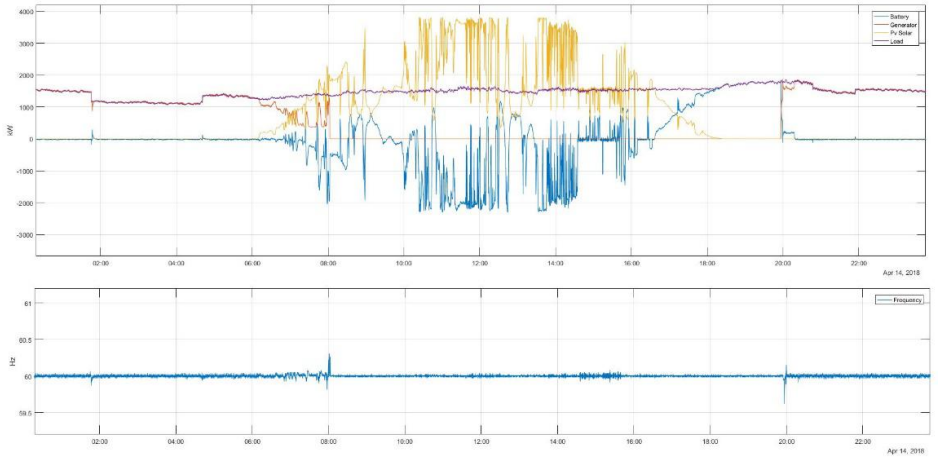


Frequency response on cloudy days

Phase 1:
Active power and frequency
on 11.04.2016



Phase 2:
Active power and frequency
on 14.04.2018

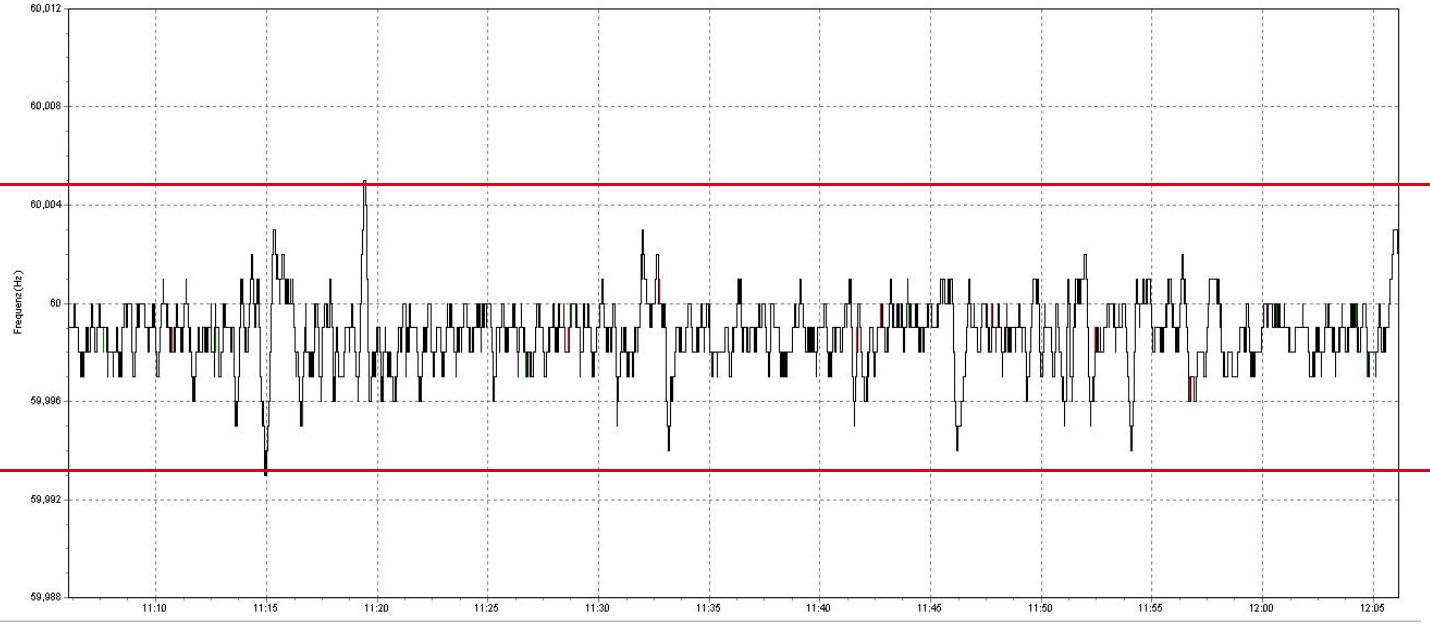


Normal Frequency Stability in Diesel Off Mode Operation

- Frequency bandwith of 0,013Hz

60,005 Hz

59,992 Hz



STUCO Solar + Storage– RESILIENCY summary

- Withstand Hurricane Cat 5 forces at 5°solar panel angle
- Energy lost from 15 to 5 degrees: 1.04% but land saved 33%, spacing between rows reduced from 3 meters to 1 meter
- Design to coexist with agriculture, minimum height 2m
- Agriculture enhanced by water catchment provision – about 2.6 Mio liters per year
- Maximization of Renewable Energy injection (min 45%)
- Maintenance costs for conventional generators drastically reduced
- Grid stability, frequency and voltage, enhanced during load steps
- Grid faults effectively cleared with grid forming inverter, 40A 3-phase at 12.5kV in 300msec
- 30min to shut down and protect system prior to approaching system and 1hour to re-activate system after passing hurricane

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Frequency response services – grid connected battery

Langenreichenbach, Germany

SMA's large scale on-grid project is a 16 MW / 10 MW prequalified PRL (Primärregelleistung – Frequency response) system. The system will be installed within a substation and connected at 33 kV to provide grid stability.

The project uses lead acid batteries and is the first of a series of project of the same type.

Project

- Location: Bennewitz, Germany
- Commissioning: June 2018

Plant information

- 10 MW PRL (Primärregelleistung) qualified battery system combined with Lead Acid batteries
- Serves for frequency regulation at the grid via demand power/storage supply and provision of reactive power

SMA System Technology

- 9 x SCS 1900 and 9 x MVPS 1900
- Plant Control and SCADA System
- Engineering, Technical Design, Consulting, Simulation and Sizing

SMA system solutions for grid-connected systems

Frequency response services – grid connected battery
Pelham, United Kingdom

The main application of the project is the capacity market and frequency response services but also features other applications like Triads management and reactive power provision.

This project is the largest battery project in the European Union in a single location till date.

The complete project timeline from contract signature till commissioning was reached within 5,5 months

Project

- Location: Pelham, UK
- Commissioning: November 2017

Plant information

- Installed battery power: 64 MVA
- Installed battery storage: 50 MWh of Li-Ion NMC batteries for frequency regulation
- Connected at 132 kV

SMA System Technology

- 26 SMA Sunny Central Storage 2475 with noise reduction packages
- 26 Medium Voltage Block 2475
- 7 Customized SMA E-houses
- SMA Power Plant Controller
- EMS

SMA system solutions for grid-connected systems

Storage Application for Grid Ancillary Services
24 MW grid connected battery, Korea

SMA's large scale on-grid storage system can provide the grid management services needed to secure grid operations even without conventional power plants. It can take on the frequency-dependent control of active power feed-in, stabilize the voltage with reactive power supply and help re-establish supply after grid failure. Transmission losses and complicated grid congestion management can therefore be avoided just as costly grid infrastructure investments can.

Project

- Location: KEPCO power grid, Korea. Several locations
- Commissioning: Q1 2016

Plant information

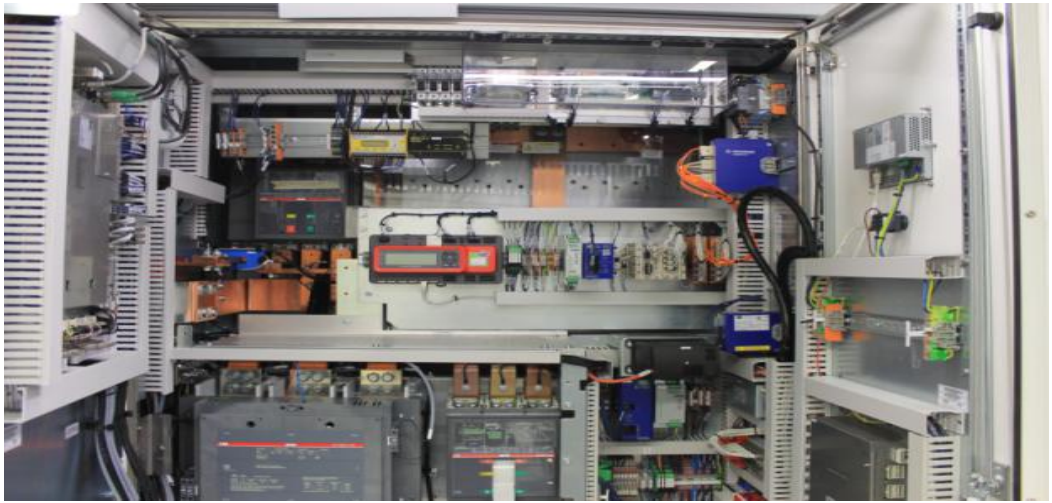
- 24 MW battery system combined with Li-Ion batteries from a Korean manufacturer
- Serves for frequency regulation at the grid via demand power/storage supply and provision of reactive power

SMA System Technology

- 24 SMA Sunny Central Storage SCS 1000
- DC and AC
- Engineering, Technical Design, Consulting, Simulation and Sizing
- Turnkey delivery

SMA system solutions for grid-connected systems

Storage Application in Grid Ancillary Services
M5BAT, Aachen, Germany



The world's first modular, large-scale battery storage system with a capacity of 6.25 MW is being built in Aachen, Germany.

The Modular Multi-Mega-watt Multi-Technology Medium Volt-age Battery Storage (M5BAT) project will focus on the following areas: integrating renewable energy sources, testing the decentralized supply of control power to stabilize grid operation, and facilitating electricity trading at competitive prices.

Project

- Location: Aachen, Germany
- Commissioning:Q3 2015
- Collaboration with: E.ON Energy Research Center at RWTH Aachen University E.ON, Exide and Beta Motion.

Plant information

- Installed battery power: 6.25MW in 5 different sub-plant 1.25MW each.
- Each sub-plant contains different battery technology (Li-Ion, Lead acid, and NaNiCl)

SMA System Technology

- 12 SMA Sunny Central Storage SCS630
- Implementation of different battery technology interface and operation sequence

SMA system solutions for grid-connected systems

Large scale island electrification with PV, diesel and storage St. Eustatius, NL Antilles

Today the solar plant covers 23% of the island's total energy requirement. The main challenge was the grid stability due to fast power fluctuations related to cloud movement. SMA Sunbelt integrated a Li-Ion storage facility to absorb such fluctuations, provide energy shifting and frequency stability functionalities also at night time.

The observed solar fraction reaches 88% at midday.

Project

- Location: Dutch Caribbean, Island of St. Eustatius
- Commissioning: 2016
- Specific requirements: Exposure to salty air and hurricanes, fast cloud movement

Plant information

- Installed PV power: 1,89 MWp
- Installed Storage: 1 MW, 570kWh
- Diesel Capacity: 4 MVA
- Annual energy yield: 3.200 MWh
- Annual diesel savings: > 850.000 liters

SMA Sunbelt Energy GmbH

- System design, simulation and engineering
- Procurement and delivery of entire control and storage system
- Commissioning and consulting during operation

SMA system solutions for hybrid applications

Island electrification by combining PV, batteries and diesel Saba, NL Antilles

The PV-diesel-battery plant is presently in its final stages on the island of Saba, located in the Caribbean. The power application battery plant is designed for the ramp rate control for the 1,142 MWp PV plant.

The battery system has been designed to allow for a second phase expected for 2018.

Project

- Location: Saba, Caribbean NL
- Commissioning: November 2017

Plant information

- Installed PV power: 1,142 MWp
- Installed battery power: 800 kW
- Installed battery storage: 393 kWh

SMA System Technology

- SMA Fuel Save Controller
- 1 SMA Sunny Central Storage 800
- 34 Sunny Tripower 25000TL-30

SMA system solutions for hybrid applications

Hybrid energy supply for an urban area
Cobija, Bolivia

The world's largest PV-diesel hybrid power plant system with battery storage was commissioned in December 2014, in the Bolivian province of Pando.

Thanks to the SMA Fuel Save Solution a reduction in fuel consumption of approx. 1.9 Mio liters per year can be reached.

Project

- Location: Cobija, Bolivia
- Commissioning: December 2014

Plant information

- Installed PV power: 5,2 MW
- Installed battery power: 2,2 MW
- Annual yield: 7,500 MWh
- Diesel generator rating: 15,2 MVA
- Annual diesel savings: Approx. 1,900,000 liters

SMA System Technology

- SMA Fuel Save Solution incorporates the SMA Fuel Save Controller
- 6 SMA Sunny Central SC800CP-XT
- 4 SMA Sunny Central Storage SCS630

SMA system solutions for hybrid applications

Grid ancillary services in western Australia

The grid in Western Australia is weak and due to the increased penetration of renewables requires further support. Thanks to SMA's technology, the 500kW/1250 kWh Battery Energy Storage System (BESS) provides ancillary services to the local utility and enhances grid stability

Project

- Location: Western Australia
- Commissioning: Q4 2015

Plant information

- Installed battery power: 500 kW
- Battery capacity (EOL): 1250 kWh
- Battery technology: Li-Ion

SMA System Technology

- SMA Fuel Save Solution incorporates the SMA Fuel Save Controller
- 1 SMA Sunny Central Storage SCS 500

SMA system solutions for hybrid applications

Thank You

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