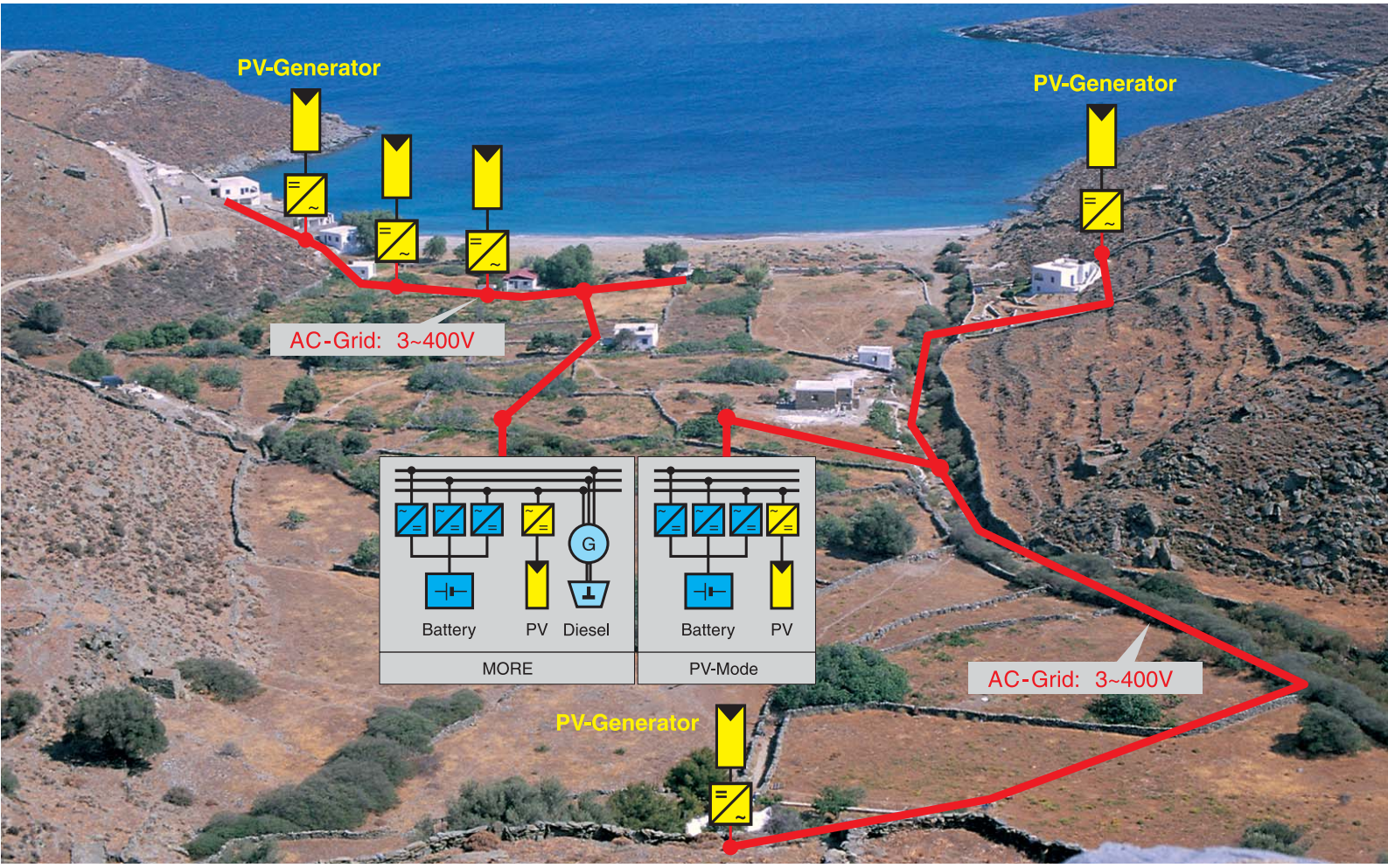
Kythnos Island

20 Years' Experience of System Technology for Renewable Energies



New Generation of Modular Hybrid Power Supply Based on AC-Coupling

The Power Supply on Kythno

The Greek island of Kythnos is one of the less known islands of the Cyclades. It can be reached from Athens in three hours by ship. Approx. 2000 inhabitants lead a calm life in five villages. Only at the peak of the season and on important holidays comes the island to life when mainly Greek tourists invade it. This can also be seen in the consumption of electrical energy on the island that varies from 300 kW in winter time to peaks of 2000 kW during high season.

The history of the energy supply on Kythnos Island is really unique and shows several superlatives in this area. One of the first larger hybrid systems for decentralised power supply was commissioned at the beginning of the eighties on the Greek island of Kythnos to supply several villages. The first wind park in Europe and a PV power plant with a nominal power of 100 kW each were integrated into the low capacity supply system which before was only based on diesel generators. One of the objectives with this plant was to investigate control strategies for the integration of large portions of wind and PV energy into weak electricity supply grids. Due to increasing energy requirements and progress in technical development the system was continuously extended and examined. In 2000 another large project was finalised. A 500 kW wind energy converter and a large battery storage were integrated. For the first time it is now possible during off-peak times to supply electrical energy to the island without any diesel generators in case there is enough wind. The new control system installed by SMA defines the optimal system configuration fully automatically depending on energy consumption and the available renewable energy. Apart from power peaks at the height of the season the contribution of renewable energy is counted on to be over 50%. In spite of the extremely high contribution of renewable energy the grid quality could once again be drastically improved with the new system.

The experience gained on Kythnos was the basis for the development of the AC coupled system technology as it is realised in the new modular hybrid systems with Sunny Island. Once again Kythnos was chosen for the installation and test of the first systems in this new technology.

500 kW wind turbine

The 500 kW wind turbine (Vestas V39/500) was installed in 1998 and is able to supply the whole island during periods of low consumer load and high wind speed. In this situation all diesel generators can be switched off and the island grid is controlled by the battery converter.

New modular hybrid power supply with Sunny Island

The first modular power supply systems with the battery inverter Sunny Island were installed on Kythnos in 2001 in the frame of the European projects PV-Mode and MORE:

- A single-phase PV-battery system at a farm house.
- A three-phase PV-battery system feeding a micro grid at a remote bay.
- A three-phase PV-battery-diesel system feeding a micro grid at a remote bay.

These systems are based on the same technology (AC-coupling) in a low power range as is used for the whole island power supply of Kythnos in a Megawatt range.

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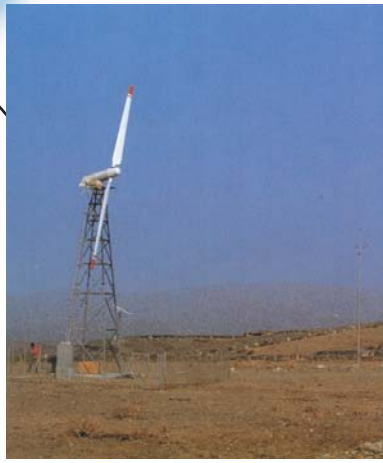



PV MODE

Agios Georgios
Agios Sostis
KASTRO ORTAS
KAKOVOLO
PETRA
297
KOLONA
Loutra
Λουτρά
Agia Irini
PYRGOS
Agios Nikolaos
Kythnos
Κύθνος
WIND PARK
Profitis Ilias +336
Panagia Vrisiani
Prodromos
Agios Stefanos
Agios Giannis
VRIOKASTRO
PETROXOUNI
Merichas
Μερίχας
Dryopis
Δρυοπίς
Prodromos
Lefkes
Λεύκες
Agioi Theodori
Agios Konstantinos
Panagia Kanala
Παναγιά Κανάλα
Agios Manas
Agios Dimitrios

Battery inverter system

The battery array has an energy content of approx. 400 kWh. Within a short time the system is able to supply a power of 500 kW for 10 min. to the island grid. The operation mode without diesel generator can be started if the average power from wind and solar energy is higher than the consumer load. The island grid is balanced by the battery converter in this condition.

Diesel power station

The power station consists of 5 Diesel Gensets (MWM, 12 Cyl. turbo diesel) with 400 kW nominal power each. The control system starts and stops the diesel generators fully automatically depending on the load situation. In parallel operation with the diesel generators, the battery inverter is used to stabilize the grid and as a spinning reserve for the diesel generators.

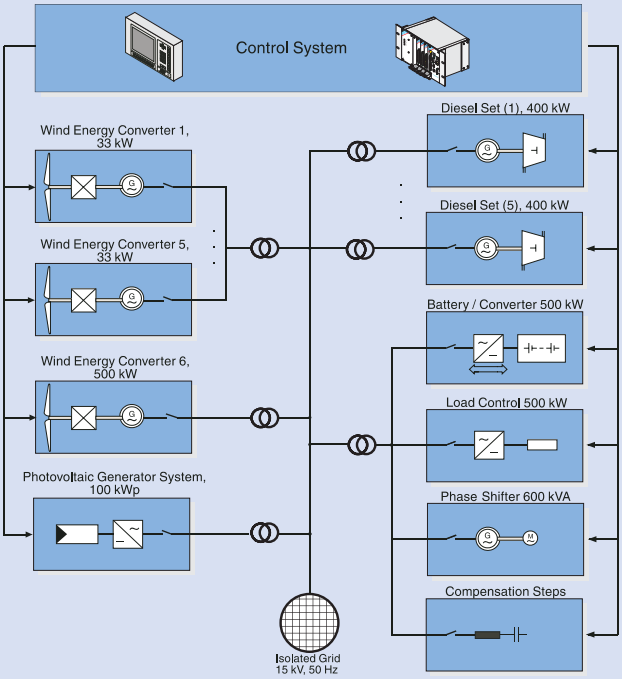
Wind park

The first wind park in Europe consisting of 5 wind turbines was installed on Kythnos in 1982, a cooperation between PPC, MAN, SMA and University Kassel. One major question in this project was how to establish a stable grid and which control strategy to use. So the pitch control of the wind energy converters was used to set the amount of power supplied and to regulate power flow in the grid. The wind park was also integrated in the new fully automatic control system in 1998.

PV power plant

The PV power plant with a nominal power of 100 kWp is feeding into the island grid via a grid connected inverter which was delivered by SMA in 1992. The PV modules were installed in the first projects on the island in 1983.

Control system of the island power supply



The fully automatic control system which was manufactured and installed by SMA in 1998 takes over the control for the complete power supply of the island. A special challenge in this project was the integration of a wind energy converter with a capacity of 500 kW into an island grid where often during the winter consumer power is only 300 kW. This could be realised with a combination of a battery converter, a rotating phase shifter and a fast load control that takes over load peaks from the wind turbine during gusty wind.

The history of hybrid systems on Kythnos

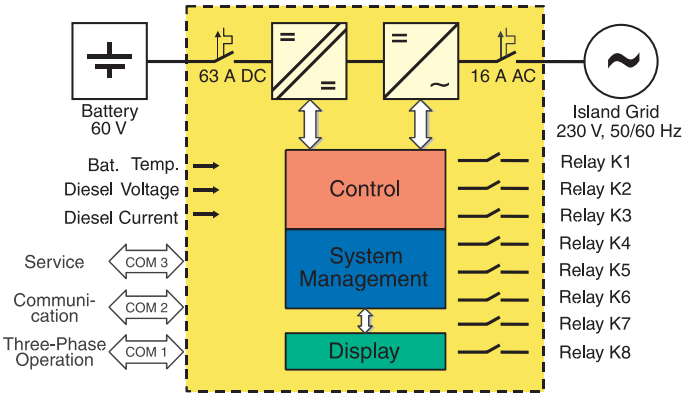
1982	Installation of the first wind park in Europe (5 x 20 kW)
1983	Installation of a 100 kW PV system with battery storage
1989	Exchange of the wind turbines (5 x 33 kW)
1992	Installation of a new grid-connected inverter for the PV system
1998	Installation of the 500 kW wind turbine
2000	Operation of the new fully automatic autonomous power supply system with a 500 kW battery storage
2001	Installation of three new small stand-alone modular hybrid systems and AC coupled PV systems

The Future of Village Power Supply in Remote Areas

Photovoltaic power supply systems in off-grid operation should be robust, inexpensive and reliable. Most importantly they need to have a modular structure so they can be extended later.

The advanced bi-directional battery inverter Sunny Island is the central component and the grid master of a modular power supply system and enables small scale island utilities for remote areas. This technology and the Sunny Island have been developed in cooperation with the ISET e.V. and the University of Kassel.
The connection on the AC side is the main feature which allows a simple extension of output power.

Sunny Island battery inverter

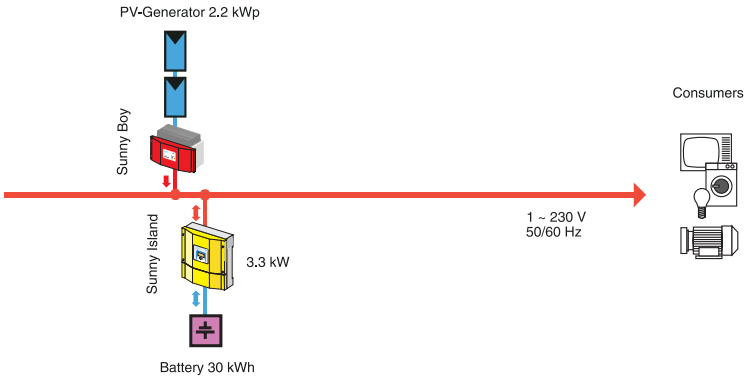


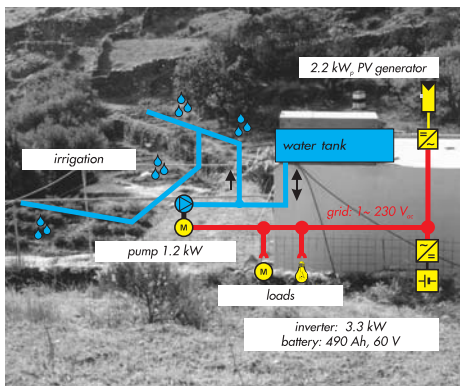
Sunny Island block circuit diagram

- Simple design of island grids due to connection of all components on the AC side
- Reliable and safe power supply with utility quality in remote areas
- Easy integration of photovoltaic plants, wind energy, small hydro plants and diesel generators
- Power supply for single houses or even small villages
- Expandable design (1-phase or 3-phase combinations, parallel operation from 2 kW up to 30 kW)
- Load management
- Optimal battery life

Sunny Island on Kythnos Island

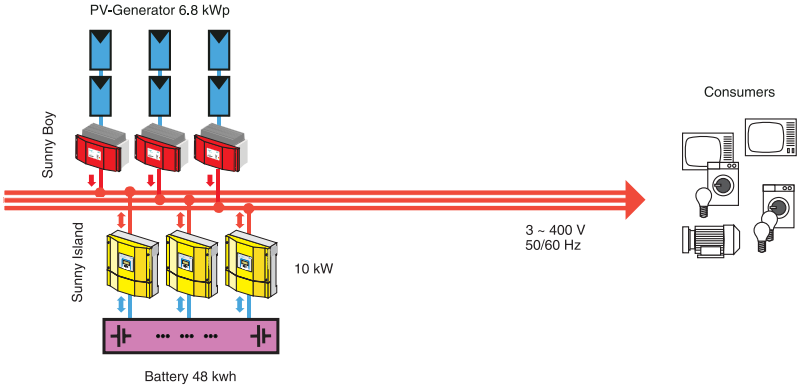
In 2001 three basic AC system types were put into operation on the island of Kythnos. For the first two system types the consistent parallel AC-coupling of all components leads to inverter-based PV stand-alone systems with Sunny Island as the grid master, the third system shows the integration of a diesel generator. The parallel coupling makes it possible to establish island utilities with up to 30 kW nominal power.

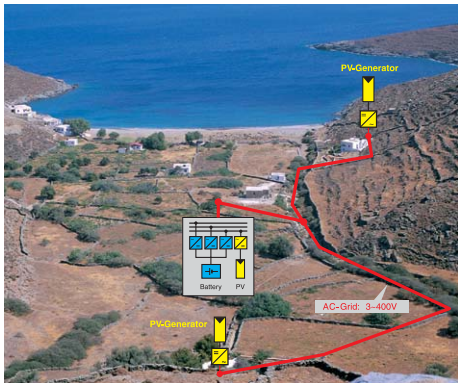




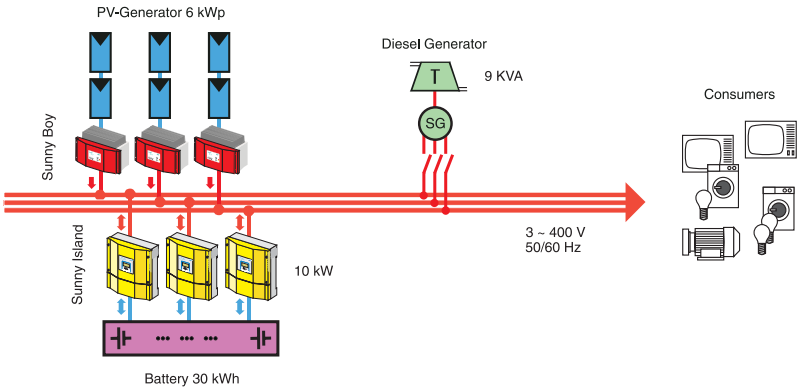
Single-phase PV-battery system at a farm house. The solar energy can now be simply fed to the island grid with Sunny Boy string inverters (project PV Mode).

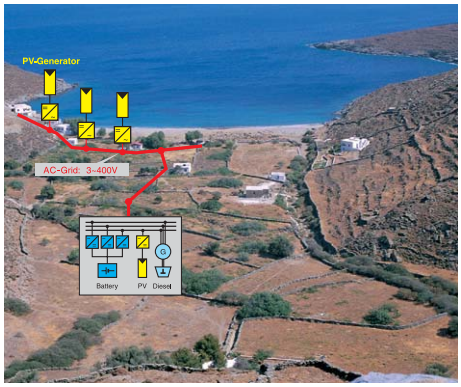
Sunny Island – the system solution for modular island grids



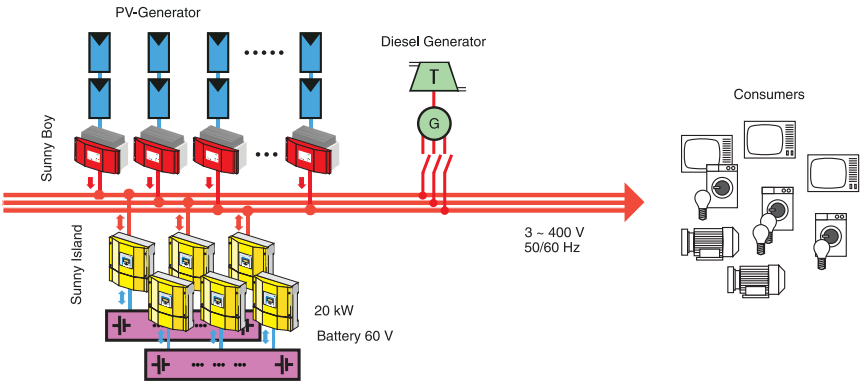


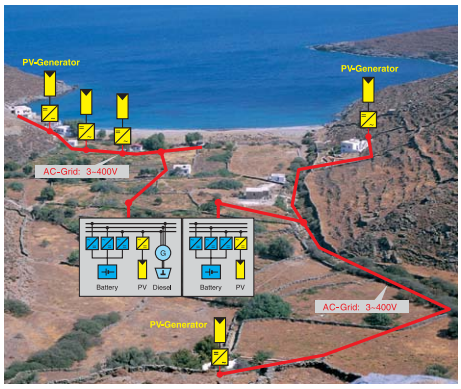
Three-phase PV-battery system feeding a micro grid at a remote bay (project PV Mode).





Three-phase PV-battery-diesel system feeding a micro grid at a remote bay (project MORE). This system operates in two modes: Sunny Island as the grid forming unit or the diesel genset as the grid forming unit.





Parallel coupling of two three-phase micro grids for the supply of the whole village as a future option.

Acknowledgement:
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Partners:

ISET · AEH · CRES · ARMINES · UNIKASSEL VERSITÄT · WIP · Municipality of Kythnos · SMA

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