Abstract
The Sunny Island has been developed in order to have new generation of battery inverters suitable for the use in hybrid systems and electricity supply of small villages. The concept of connecting the system on the AC side is completely new. Two years after market launch and more than 100 systems set up in 14 countries all over the globe, the advantages of this new generation of hybrid systems could be impressively demonstrated. Flexibility, reliability, a system control and monitoring feature which are completely new in this low power range make the hybrid system with Sunny Island a long-term and efficient investment. Today, this new concept and the various and simple upgrade possibilities provide options in the field of rural electrification that were not possible several years ago.

1. Introduction
The Sunny Island is the first and only completely modular inverter for island grids which allows the connection of different grid-feeding elements (PV plants, wind power plants, power generation units, combined heat and power units (CHP), miniature hydro power systems) on the AC side (AC coupling). Competitive products on the market allow the connection only on the DC side (DC coupling). The difference of the system structure is shown in figure 1.

The possibility to connect an unlimited number of Sunny Islands or even 3-phase Sunny Island systems voltage controlled on the AC side is also unique [1]. This feature allows any scaling of Sunny Island systems in terms of power. A simple expansion of the system is now possible if the load demand will grow up in future.
The advantages of the AC coupling and the connection in parallel of several Sunny Islands on the AC side are:

- structure 100% compatible with the utility,
- simple installation, as standard components utility products can be used,
- all grid-feeding components add up their power in parallel operation,
- any scaling is possible and applicable for larger systems (from 3 kW up to the megawatt range),
- can be extended on all levels without any problem,
- can be combined with off-grid and utility interactive energy generators,
- construction of distributed systems, and
- highest reliability due to redundant system configuration.

2. Operating results from more than 100 different plants
More than 100 plants are operated with the Sunny Island in 14 different countries distributed in 4 continents until now. Approx. 90% of the plants installed are island grids, the rest are utility backup plants. A diesel genset is used in approx. 75% of all cases. About the half of all the plants are 3-phase systems. 8% of the plants use wind power plants to generate electricity. One Sunny Island system coupled with a 10 kVA water turbine also operates successfully. The following table shows some
different systems in detail and demonstrates the Sunny Island’s wide range of applications.

<table>
<thead>
<tr>
<th>Application</th>
<th>Typ</th>
<th>regenerative Energy</th>
<th>Battery</th>
<th>Genset / Grid</th>
<th>Operation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Power supply for a farmhouse</td>
<td>1 ~</td>
<td>2,2 kWp PV</td>
<td>490 Ah</td>
<td></td>
<td>1/2001</td>
<td>Greece</td>
</tr>
<tr>
<td>2 4 water supply systems for several villages</td>
<td>1 ~</td>
<td>6,0 kWp PV</td>
<td>800 Ah</td>
<td>5/2002</td>
<td>Thailand</td>
<td></td>
</tr>
<tr>
<td>3 Power supply for a flat</td>
<td>1 ~</td>
<td></td>
<td>775 Ah</td>
<td>3,7 kVA</td>
<td>10/2001</td>
<td>Italy</td>
</tr>
<tr>
<td>4 Power supply for holiday houses</td>
<td>3 ~</td>
<td>6,6 kWp PV</td>
<td>800 Ah</td>
<td>9 kVA</td>
<td>5/2001</td>
<td>Greece</td>
</tr>
<tr>
<td>5 Power supply for holiday houses</td>
<td>3 ~</td>
<td>6,0 kWp PV</td>
<td>800 Ah</td>
<td></td>
<td>5/2001</td>
<td>Greece</td>
</tr>
<tr>
<td>6 2 village power supply systems in north India (Himalaya)</td>
<td>3 ~</td>
<td>7,5 kWp PV</td>
<td>500 Ah</td>
<td>100 kVA</td>
<td>8/2001</td>
<td>India</td>
</tr>
<tr>
<td>7 Emergency power supply for a hotel</td>
<td>3 ~</td>
<td></td>
<td>190 Ah</td>
<td>9,4 kVA Publ Grid</td>
<td>3/2002</td>
<td>Germany</td>
</tr>
<tr>
<td>8 Power supply for a car repair station</td>
<td>3 ~</td>
<td></td>
<td>800 Ah</td>
<td>30 kVA</td>
<td>1/2002</td>
<td>Germany</td>
</tr>
<tr>
<td>9 Power supply for a museum boot</td>
<td>3 ~</td>
<td>6,0 kWp PV</td>
<td>800 Ah</td>
<td>55 kVA</td>
<td>12/2002</td>
<td>Germany</td>
</tr>
<tr>
<td>10 Power supply for a hospital</td>
<td>3 ~</td>
<td>8,0 kWp PV</td>
<td>600 Ah</td>
<td>30 kVA</td>
<td>6/2002</td>
<td>India</td>
</tr>
<tr>
<td>11 Power supply for holiday houses</td>
<td>3 ~</td>
<td>3,6 kWp PV 5,0 kW Wind</td>
<td>2600 Ah</td>
<td>30 kVA</td>
<td>10/2002</td>
<td>South Africa</td>
</tr>
<tr>
<td>12 Power supply for a flat</td>
<td>3 ~</td>
<td>1,7 kWp PV</td>
<td>450 Ah</td>
<td>8 kVA*</td>
<td>10/2001</td>
<td>Germany</td>
</tr>
<tr>
<td>13 Test plant HYBRIX with 9 Sunny Islands parallel</td>
<td>3 ~</td>
<td>30 kWp PV 10 kW Wind</td>
<td>2<em>2200 Ah 1</em>800 Ah</td>
<td>20 kVA 8 kVA</td>
<td>12/2002</td>
<td>Spain</td>
</tr>
<tr>
<td>14 Alpine lodge with 20 kW peak load with only 3 Sunny Islands</td>
<td>3 ~</td>
<td>10 kW Water Turbine</td>
<td>1400 Ah</td>
<td></td>
<td>7/2003</td>
<td>Germany</td>
</tr>
</tbody>
</table>

Table 1:  A selection of different applications with Sunny Island

The problems that came up in the first year after the market launch during installation and commissioning have been reduced to a minimum by a better menu structure of the Sunny Island, an improved guidance in preliminary stages and very good documents for assistance in commissioning also in case of very complex systems. The close and good customer contact during market launch resulted in an improvement of the Sunny Island within the last years. Due to this upgrade, the Sunny Island should be unique in market in terms of flexibility and reliability. The very high customer satis-
faction reflects this success. Today after the successful market launch it’s planned to use the Sunny Island in a lot of rural electrification projects.

In particular, the Sunny Island is characterized by the wide range of management features like a very sophisticated battery management as well as an energy-, load- and generator management compared to other products. Due to these features, the Sunny Island becomes a system manager for island grids. The management features have an impact on the plant performance as well as the reliability of the systems that is as high as the efficiency and the reliability of the devices themselves. The experiences of the last 2 years show that the customers intensely use the different possibilities. Advantages of the management features are for example a reliable plant operation, even in the case of a failure of a component such as the diesel set, and a substantially increased battery lifetime. The following measurements of one of the plants on the Greece island Kythnos show the good charging control and the interaction of PV plant and diesel sets.

Figure 2: Real battery measurement data over two days from one Sunny Island system on the Greece island Kythnos
3. The Future of Village Electrification
Within the last years, the solar energy as an alternative to a grid design or pure diesel generators has established more and more for the electrification of remote rural areas. However, the problem was up to now that hardly any PV or hybrid system fulfilled the requirements in terms of flexibility, reliability and extendibility. Thus, many small systems were often installed instead of bundling the electricity supply and designing small grids. This is mainly the result of limited technical possibilities. The new system technology of AC coupling together with the Sunny Island set new standards, that proved its qualification in many plants throughout the world. The following figure impressively illustrates the design and possible extendibility of the future electricity supply of small villages.

![Figure 3](image)

**Figure 3** A growing AC coupled system for typical rural village electrification

4. Design of Hybrid Systems
The design of a hybrid system has a wide impact on the plant performance which is similar to the impact of the performance of the components themselves or of the system’s operational control. In many cases, a too largely scaled system is the reason for a very poor plant performance. Frequent plant failures, disconnections due to system errors and failures often result from under dimensioned systems or a poor plant
control and rarely directly from component failures. Thus, the basis for an economic and reliable hybrid system is the right plant design. Due to the multitude of different requirements and input data, it is difficult to make general statements in respect of the optimal plant design. Thus, a lot of experience is necessary for an optimal plant design.

SMA has the aim to well support the customer in terms of engineering questions in this area. For these purposes, SMA provides workshops and individual support programs where SMA’s experience becomes a benefit for the customer. Moreover, in June 2003 the Sunny Island® System Kits have been introduced. The customer can choose from 4 base packets and different upgrades. More than 16 different supply systems can be easily designed. A system kit always consists of the Sunny Island, a battery and all necessary installation components. One kit contains an additional diesel set and another kit has an additional CHP.

A simple computer-aided tool for the support in design questions will be developed in order to allow a simple plant design in the future that is optimized in terms of economic criteria.

5. Conclusion
The Sunny Island and the AC coupling have proved in many systems worldwide and have shown the advantages of this technology for different applications. Due to the introduction of Sunny Island System Kits, the support in system design, the optimally coordinated components and the integrated system management feature, reliable and efficient hybrid systems can easily be realized. For the first time, the requirements of rural electrification in terms of a future-proof power supply are met. This is impressively demonstrated by a project in China where more than 80 Sunny Islands are used for the electricity supply of 27 different small villages. Additional planned or discussed projects show that the Sunny Island will expand its outstanding position in this area within the next years.

References
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