Planning Guidelines

SMA SMART HOME

The System Solution for Greater Independence

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1 Information on this Document

This document provides support when you are planning an energy management system with the system solution SMA Smart Home. The contents of the following sections build on each other.

Section heading	This section answers the following questions:
PV Energy for Internal Power Supply and Self-Consumption	What are the effects of internal power supply and self-consumption? What are the requirements for high energy self-sufficiency and self-consumption quotas? What product solutions for intelligent energy management are offered by SMA Solar Technology AG in the context of SMA Smart Home?
Internal Power Supply and Self-Consumption with SMA Smart Home	How does the basic solution for intelligent energy management work and how is it set up? How does the SMA Integrated Storage System work and how is it set up? How does the SMA Flexible Storage System work and how is it set up?
Functions for Energy Management Systems	How does the dynamic limitation of active power feed-in for prevention of derating losses work? How does forecast-based charging for prevention of derating losses work? How does the power control at the grid-connection point work? How does active power feed-in limitation to 0% or 0 W (Zero Export) work? What functions are available for intelligent load control? How does intermediate storage work in principle? How does power control at the grid-connection point work for the individual SMA product solutions?
Components for Energy Management Systems	Which SMA products belong to the SMA product solutions offered? What other products are required?
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2 PV Energy for Internal Power Supply and Self-Consumption

In light of the continuing trend towards lower feed-in tariffs, the focus of system design has increasingly shifted away from maximizing PV generation towards intelligent energy management. There are two key objectives here:

- as much self-consumption of the generated PV energy as possible

  and

- full coverage of the energy requirement with PV energy (= self-sufficiency) if possible.

Both of these are economically viable as soon as the PV generation costs fall below the costs of purchasing electricity.

What Are the Effects of Internal Power Supply and Self-Consumption?

An almost total self-consumption of the PV energy makes the operator more independent of the feed-in tariff which now barely covers costs, and it increases the effective value of each generated kWh. An almost complete internal power supply makes the operator more independent of rising electricity prices and reduces the average cost of each kWh used.

Internal power supply and self-consumption also relieve the burden on the utility grid since the energy produced on site is also consumed directly on site. For this reason, the importance of technical solutions for optimization of internal power supply and self-consumption is growing constantly.

Normally, self-consumption of PV energy takes place naturally. Whenever a load is switched on while the sun is shining, the PV energy generated at that time is consumed directly.

This means that the energy generated by the PV system naturally flows first to the active loads within the household grid – only the surplus flows into the utility grid. For this reason, a primary function of energy management is to intelligently coordinate the operation of loads with the availability of PV energy, with regard to both quantity and time.

What Are the Requirements for High Energy Self-Sufficiency and Self-Consumption Quotas?

The first important requirement for effectively increasing the internal power supply* and self-consumption** is the right balance between annual PV generation and annual energy demand:

- If the annual PV generation is considerably lower than the annual energy demand, a significant proportion of the PV energy can almost always be used on site. This also applies when the timing of the main energy demand and the main PV generation do not coincide exactly. The high self-consumption quota is then purchased with a low self-sufficiency quota.
- If, however, the annual PV generation is much higher than the annual energy demand, only a small proportion of the PV energy can be used on site. Much of the generated PV energy must be fed into the utility grid. This results in a low self-consumption quota. The self-sufficiency quota, on the other hand, is higher.

A changed ratio of PV generation to electrical consumption, therefore, always increases either the self-sufficiency quota or the self-consumption quota. For this reason, the right balance between energy generation and energy consumption is indispensable.

A second important requirement for a high self-sufficiency quota and a high self-consumption quota is an appropriate load profile: The distribution schedule of the PV power is defined in quite narrow limits by the alignment of the PV array and the weather. For this reason, the load profile determines almost solely how well PV generation and energy demand match each other during the course of the day. Besides using electrical storage systems, effective matching of the load profile is the only way to simultaneously optimize both the self-sufficiency quota and the self-consumption quota.

* The internal power supply is specified by the self-sufficiency quota.
** The self-consumption is specified by the self-consumption quota.

Increased Self-Consumption Through Intelligent Energy Management

If the ratio of PV generation and energy demand remains constant, internal power supply and self-consumption can only be optimized by intelligent energy management. For this purpose, SMA Solar Technology AG offers the following product solutions:

- Basic solution for intelligent energy management: Sunny Home Manager and radio-controlled sockets
- Simple storage solution for new PV systems: SMA Integrated Storage System
- Flexible storage solution for new and existing PV systems: SMA Flexible Storage System

Sunny Home Manager and Radio-Controlled Sockets – Basic Solution for Intelligent Energy Management

The first step in intelligent energy management is the recording and evaluation of the energy flows in the household. This energy monitoring looks at both the total energy consumption and that of individual home appliances using the measurement function of the radio-controlled sockets.

Based on the information compiled in this way, the Sunny Home Manager creates an overview with various views and diagrams in Sunny Portal. The user can then use this overview to understand the energy flows in his/her household and can decide in which areas it is worth deploying intelligent energy management. The Sunny Home Manager also provides recommendations on the times at which the user can switch on specific devices in order to significantly increase self-consumption.

The next step is active energy management in the form of automatic load control in the household. Via the on/off switch function of the radio-controlled sockets or via control commands through data connection, loads can be switched on by the Sunny Home Manager precisely when the PV system is generating sufficient energy or when the energy costs are particularly low.

Example for the optimization of energy utilization:

We assume a typical, single-family home with an annual PV generation of 5000 kWh, an annual energy demand of 5000 kWh, and a natural self-consumption of 30%. In this example, the Sunny Home Manager can improve the energy balance through intelligent load control as follows:

- Due to the high direct consumption by the controlled loads, the self-consumption quota increases from 30% to typically 45%.
- Accordingly, the purchased electricity amount decreases from 3500 kWh to 2750 kWh per year. This equals 55% of the entire annual energy demand. The electricity bill is decreased by 22%.

SMA Integrated Storage System – the Simple Storage Solution for New PV Systems

With an electrical storage system, you can intermediately store PV energy. This intermediate storage supplements the automatic load control and further increases internal power supply and self-consumption.
The SMA Integrated Storage System provides a simple storage solution that is designed for extremely efficient operation. The most important elements are a Sunny Boy Smart Energy and a Sunny Energy Meter. The Sunny Boy Smart Energy is a PV inverter with integrated lithium-ion storage (storage capacity: 2 kWh). The SMA Energy Meter can also be optionally replaced by the Sunny Home Manager 2.0. This enables intelligent energy management.

Example for the optimization of energy utilization:

We assume a typical, single-family home with an annual PV generation of 5000 kWh, an annual energy demand of 5000 kWh, and a natural self-consumption of 30%. In this example, the SMA Integrated Storage System uses the available battery capacity of 2 kWh to optimize the energy balance as follows:

- Due to the additional usable energy from the battery-storage system, the self-consumption quota increases from 30% to typically 55%.
- Accordingly, the purchased electricity amount decreases from 3500 kWh to 2400 kWh. The purchased electricity of 2400 kWh corresponds to 48% of the annual energy demand; this includes storage losses of 3%. The electricity bill is decreased by 32%.

SMA Flexible Storage System – the Flexible Storage Solution for New and Existing PV Systems

The SMA Flexible Storage System can be fitted with a customized battery-storage system. The inverter power and the system size can also be selected to suit the requirements of each household. The SMA Flexible Storage System can be based on two different battery inverters: the Sunny Island for low-voltage batteries or the Sunny Boy Storage for high-voltage batteries.

The most important elements of an SMA Flexible Storage System with Sunny Island are one or more SMA PV inverters, one or more Sunny Island inverters, a battery, an SMA Energy Meter or a Sunny Home Manager 2.0. The Sunny Island is a battery inverter for parallel grid and off-grid operation. Three Sunny Island inverters can be connected to form a three-phase cluster.

The most important elements of an SMA Flexible Storage System with Sunny Boy Storage are a Sunny Boy Storage, an SMA Energy Meter and a battery. The SMA Energy Meter can also be optionally replaced by the Sunny Home Manager 2.0. This enables intelligent energy management. The Sunny Boy Storage is a single-phase, AC coupled battery inverter for parallel grid operation.

Example for the optimization of energy utilization:

We assume a typical, single-family home with an annual PV generation of 5000 kWh, an annual energy demand of 5000 kWh, and a natural self-consumption of 30%. In this example, the SMA Flexible Storage System uses the available battery capacity of 5 kWh to optimize the energy balance as follows:

- Due to the significantly larger battery-storage system, the higher usable energy leads to an increase in the self-consumption quota from 30% to typically 65%.
- Accordingly, the purchased electricity amount decreases from 3500 kWh to 2150 kWh. The purchased electricity of 2150 kWh corresponds to 43% of the annual energy demand; this includes storage losses of 8%. The electricity bill is decreased by 38%.

3 Internal Power Supply and Self-Consumption with SMA Smart Home

3.1 Basic Solution for Intelligent Energy Management

Using the intelligent load control, the Sunny Home Manager uses its control options to shift the operation of flexible loads to times with high PV generation.

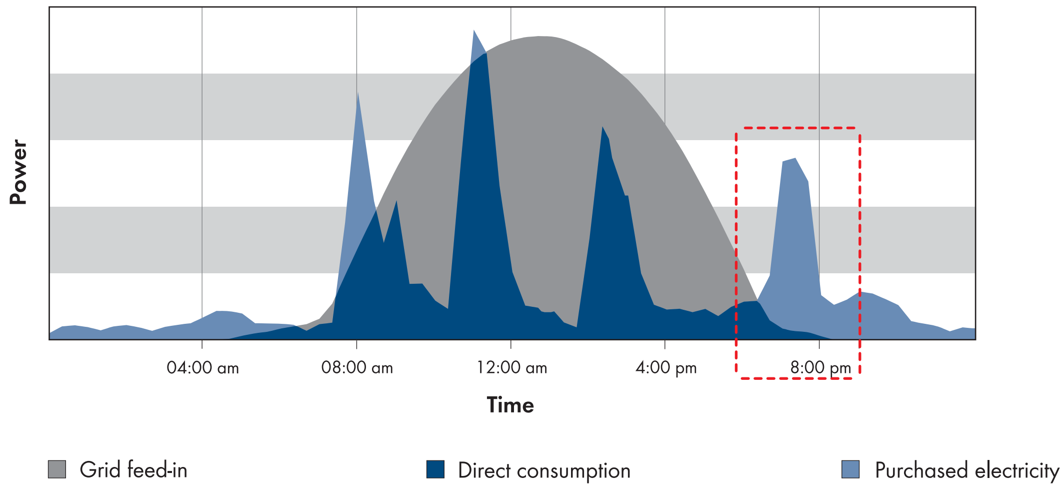


Figure 1: Daily profile of a PV system, consumption and self-consumption – without load control (example)

The red frame in this example shows a load peak in the evening. This load peak, for example, is caused by a washing machine that is switched on manually in the evening.

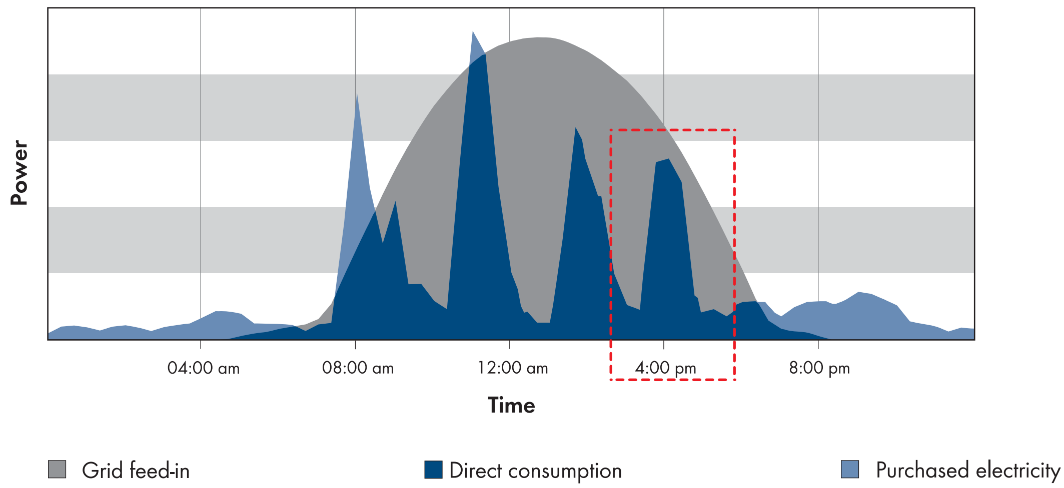


Figure 2: Daily profile of a PV system, consumption and self-consumption – with load control (example)

The red frame in this example shows the shifting of the load peak to the afternoon. Due to the automatic control by the energy management system, operation of the washing machine is shifted to a time period in which cheaper PV energy is available. As a result, the self-consumption of PV energy increases, the costs for purchased electricity decrease.

The Sunny Home Manager forms the core of the SMA basic solution for intelligent energy management (see Section 11.1 "Country-Dependent Availability of the SMA Products for Energy Management Systems", page 65).

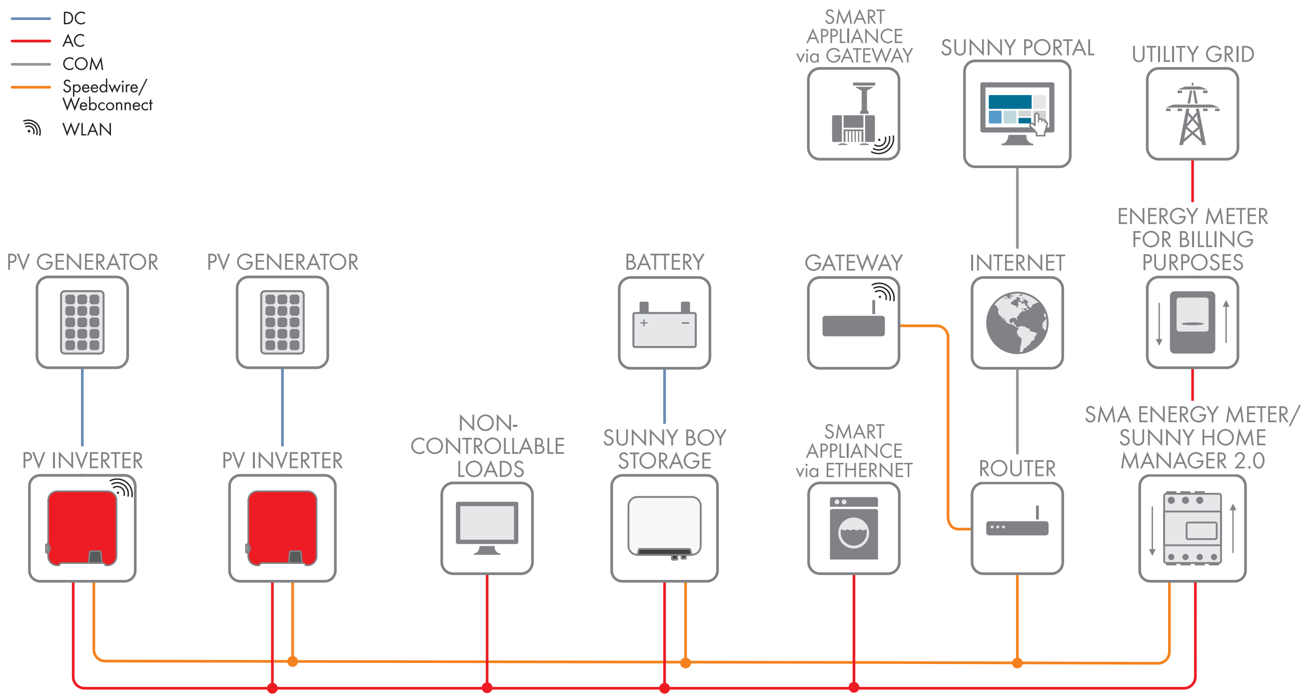


Figure 3: PV system with Sunny Home Manager (example)

The Sunny Home Manager offers the following energy management functions:

- Visualization of PV system data in Sunny Portal (see Section 4.1.2, page 18)
- Intelligent load control (see Section 4.1, page 18)
- Dynamic active power limitation (see Section 4.2.1, page 23)
- Zero Export: Limitation of Active Power Feed-In to 0% or 0 W (see Section 4.3.2, page 29)
- Access to grid management services via Modbus interface, e.g. for active power limitation by the grid operator

3.2 Simple Storage Solution for New PV Systems

The SMA Integrated Storage System is the simple storage solution for new PV systems.
With the SMA Integrated Storage System, automatic load control and intermediate storage can be combined.

For intelligent use of the intermediate storage, the SMA Integrated Storage System takes the data from PV generation and consumption forecasts into account.

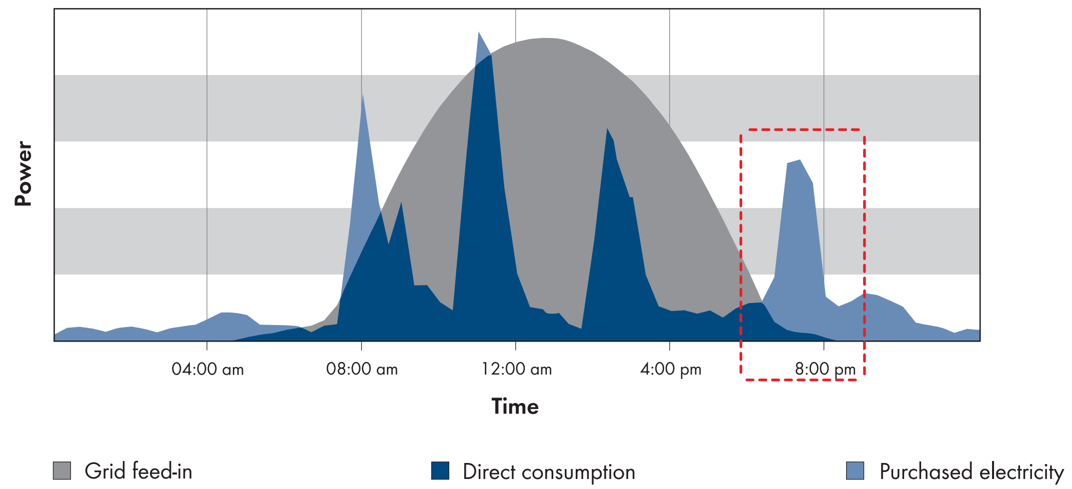


Figure 4: Daily profile of a PV system, consumption and self-consumption – without load control and intermediate storage (example)

The red frame in this example shows a load peak in the evening. This load peak, for example, is caused by a washing machine that is switched on manually in the evening.

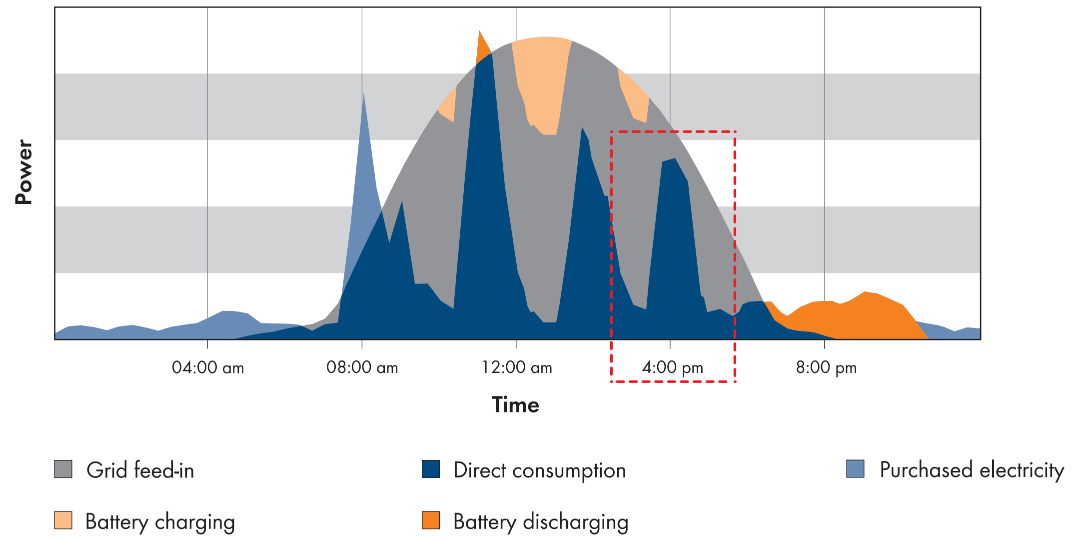


Figure 5: Daily profile of a PV system, consumption and self-consumption – with load control and intermediate storage (example for SMA Integrated Storage System)

In the morning at about 10:00 a.m. the battery is briefly charged with PV energy. This charged PV energy is used at around midday to cover a load peak. During the midday period when there is increased PV energy, the battery is charged again. In the evening, part of the load is supplied by battery discharging. In parallel, operation of a load is shifted to a time period with cheaper PV energy (see Section 3.1, page 9).

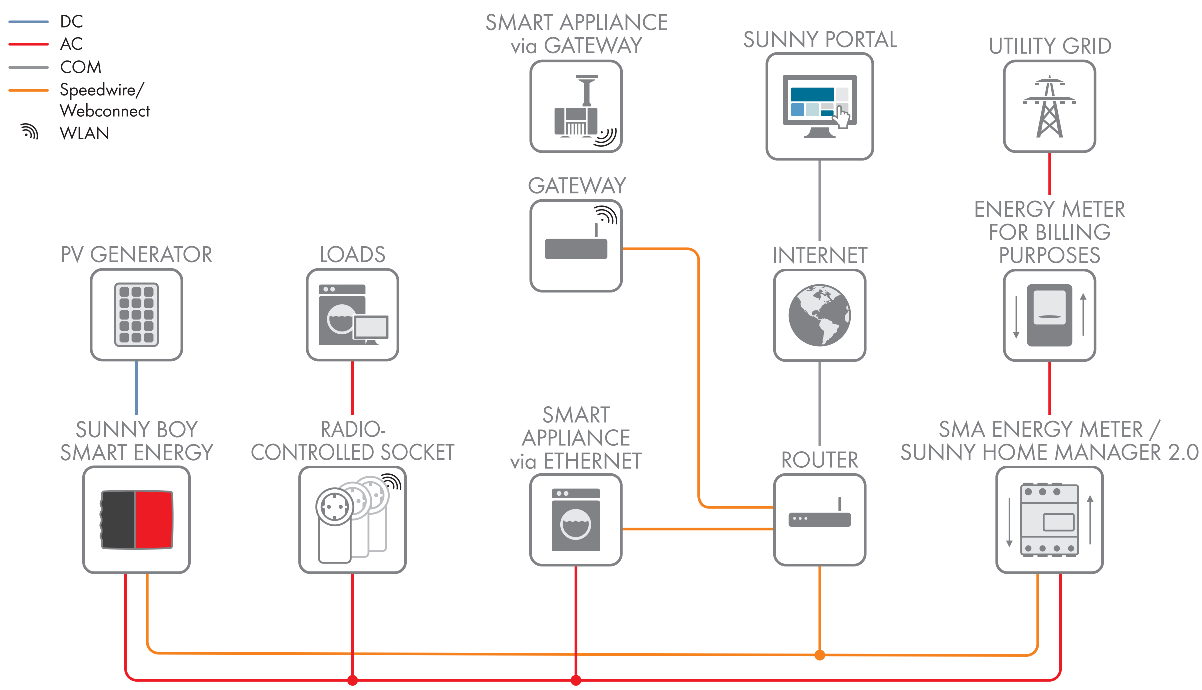


Figure 6: Overview of an SMA Integrated Storage System (example)

The most important elements of the SMA Integrated Storage System are the Sunny Boy 3600 / 5000 Smart Energy with integrated lithium-ion battery and the optional Sunny Home Manager. The integrated lithium-ion battery has a storage capacity of 2 kWh and enables optimally efficient operation in a typical, single-family household.

In addition to the functions in Section 4.1.2, battery charging and discharging is also illustrated on the **Energy balance** page in Sunny Portal. This shows when the PV energy stored intermediately in the battery is consumed in the household, during the evening for example. Purchase of electricity can be avoided and the energy costs are decreased.

The Sunny Boy Smart Energy and the SMA Integrated Storage System offers the following energy management functions:

Functions	**Sunny Boy Smart Energy**	**SMA Integrated Storage System**
Visualization of PV system data in Sunny Portal (see Section 4.1.2, page 18)	✓	✓
Intelligent load control (see Section 4.1, page 18)	–	✓
Dynamic active power limitation (see Section 4.2.1, page 23)	✓	✓
Forecast-based charging (see Section 4.2.2, page 24)	✓	✓
Zero Export: Limitation of Active Power Feed-In to 0% or 0 W (see Section 4.3.2, page 29)	✓	–
Automatic unbalanced load limitation (see Section 4.3.3, page 29)	✓	✓
Cumulative power control at the grid-connection point (see Section 4.3.4, page 32)	✓	✓
Access to grid management services via Modbus interface, e.g. for active power limitation by the grid operator	✓	✓

✓ Can be utilized – Can not be utilized

3.3 Flexible Storage Solution for New and Existing PV Systems

With the SMA Flexible Storage System, automatic load control and intermediate storage can be combined.

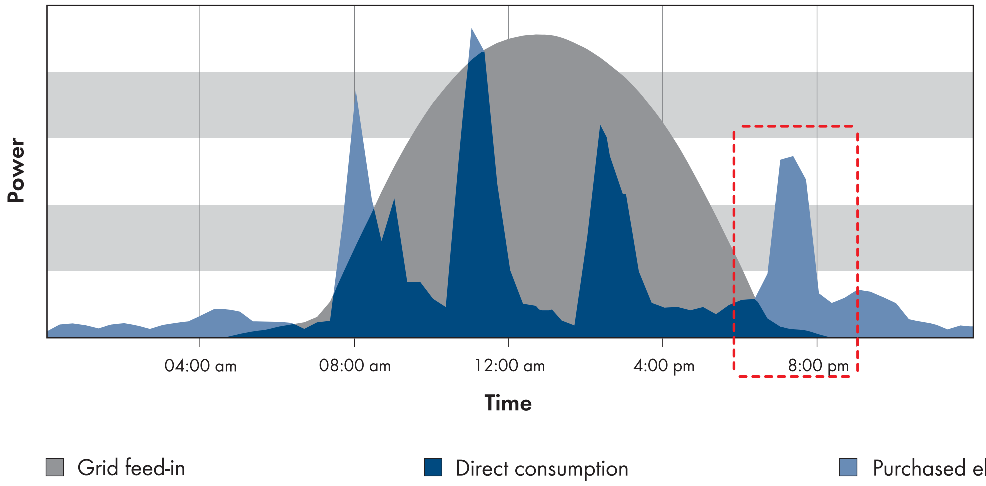


Figure 7: Daily profile of a PV system, consumption and self-consumption – without load control and intermediate storage (example)

The red frame in this example shows a load peak in the evening. This load peak, for example, is caused by a washing machine that is switched on manually in the evening.

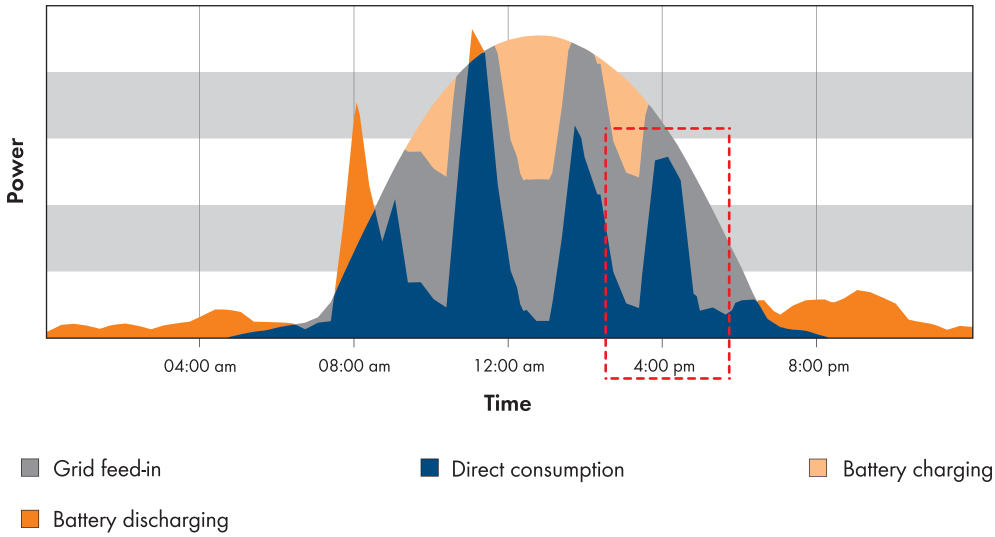


Figure 8: Daily profile of a PV system, consumption and self-consumption – with load control and intermediate storage (example for SMA Flexible Storage System)

Due to the greater battery capacity in the SMA Flexible Storage System, a greater portion of consumption can be covered by intermediate storage. In this example, the coverage is 100%. This means that there is no longer a requirement for purchased electricity.

In addition to the functions in Section 4.1.2, battery charging and discharging is also illustrated on the **Energy balance** page in Sunny Portal. This shows when the PV energy stored intermediately in the battery is consumed in the household, during the evening for example. Purchase of electricity can be avoided and the energy costs are decreased.

The SMA Flexible Storage System is a flexible storage solution to enhance new and existing PV systems in the context of intelligent energy management. The SMA Flexible Storage can be installed with the Sunny Island or the Sunny Boy Storage.

SMA Flexible Storage System with Sunny Island

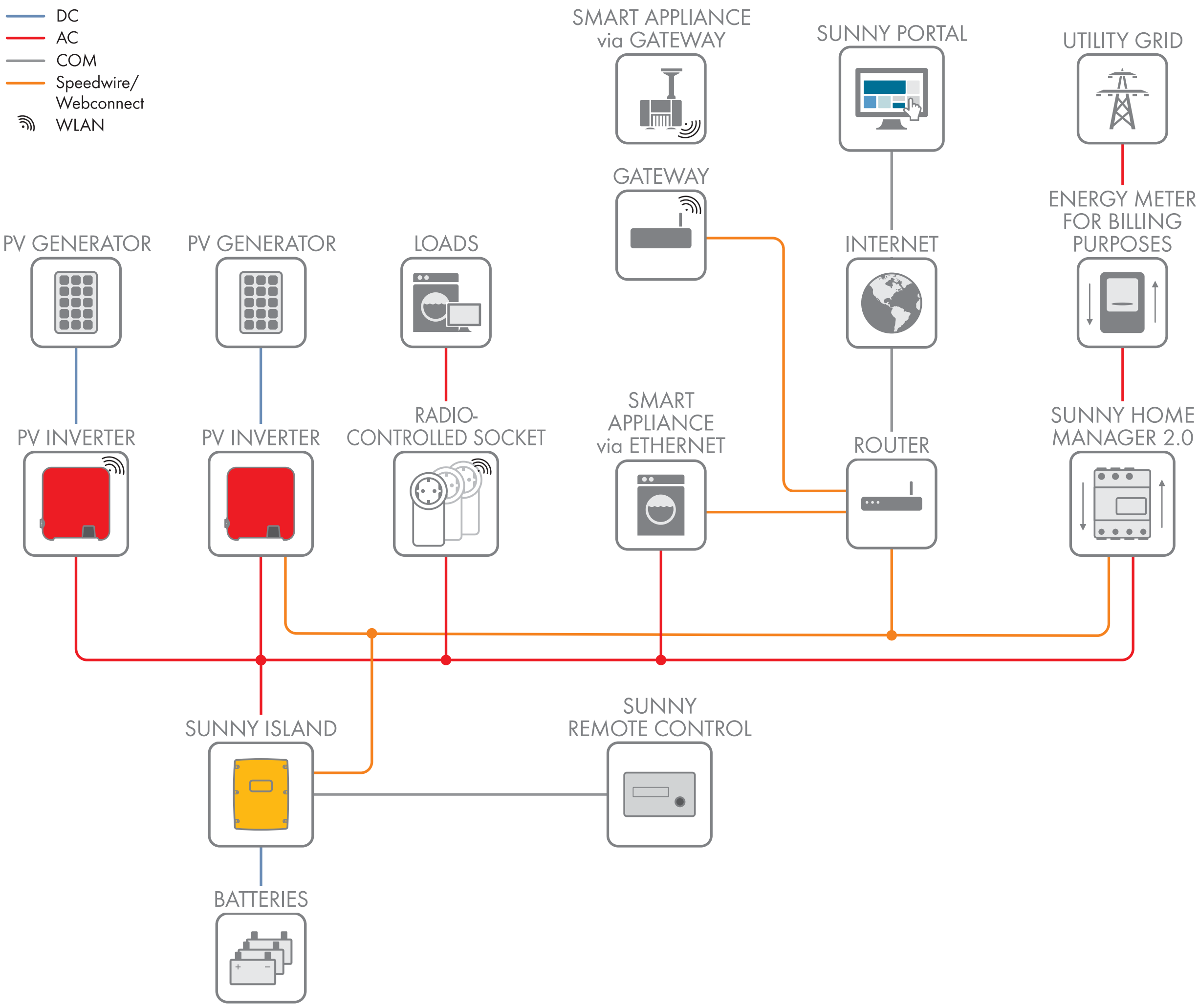


Figure 9: PV system with SMA Flexible Storage System with Sunny Island (example)

At the core of the SMA Flexible Storage System with Sunny Island are the Sunny Island 3.0M / 4.4M / 6.0H /8.0H and the Sunny Home Manager. The Sunny Island can use different battery types with different battery capacities and thus, with regard to system design, offers great flexibility. Also, in the SMA Flexible Storage System, different SMA PV inverters can be used.

When using the Sunny Island inverter, the SMA Flexible Storage System can be set up as single-phase and three-phase and can be extended with a battery-backup function. The SMA Flexible Storage System with battery-backup function supplies the loads with electricity in the event of a grid failure and also forms a battery-backup grid (see the Planning Guidelines "SMA Flexible Storage System with Battery Backup Function" at www.SMA-Solar.com).

The SMA Flexible Storage System with Sunny Island offers the following functions depending on the expansion stage:

Functions	**Sunny Island with Sunny Home Manager**	**Sunny Island with Sunny Home Manager and additional energy meter for PV production***
Visualization of system data in Sunny Portal (see Section 4.1.2, page 18)	✓	✓
Intelligent load control (see Section 4.1, page 18)	✓	✓
Dynamic active power limitation (see Section 4.2.1, page 23)	✓	–
Forecast-based charging (see Section 4.2.2, page 24)	✓	✓
Zero Export: Limitation of Active Power Feed-In to 0% or 0 W (see Section 4.3.2, page 29)	✓	–
Automatic unbalanced load limitation (see Section 4.3.3, page 29)	✓	✓
Cumulative power control at the grid-connection point (see Section 4.3.4, page 32)	✓	✓
Access to grid management services via Modbus interface, e.g. for active power limitation by the grid operator	✓	✓**

* SMA micro inverters or PV inverters from third-party suppliers can be integrated into the SMA Flexible Storage System with Sunny Boy Storage, Sunny Home Manager and additional energy meter as PV production meter (see Section 6.3.3 "PV Inverters in the SMA Flexible Storage System", page 43).

** When using PV inverters from third-party providers, it must be ensured that the grid operator can access the required grid management services via the interfaces or user interfaces of the third-party provider.

✓ Can be utilized – Can not be utilized

SMA Flexible Storage System with Sunny Boy Storage

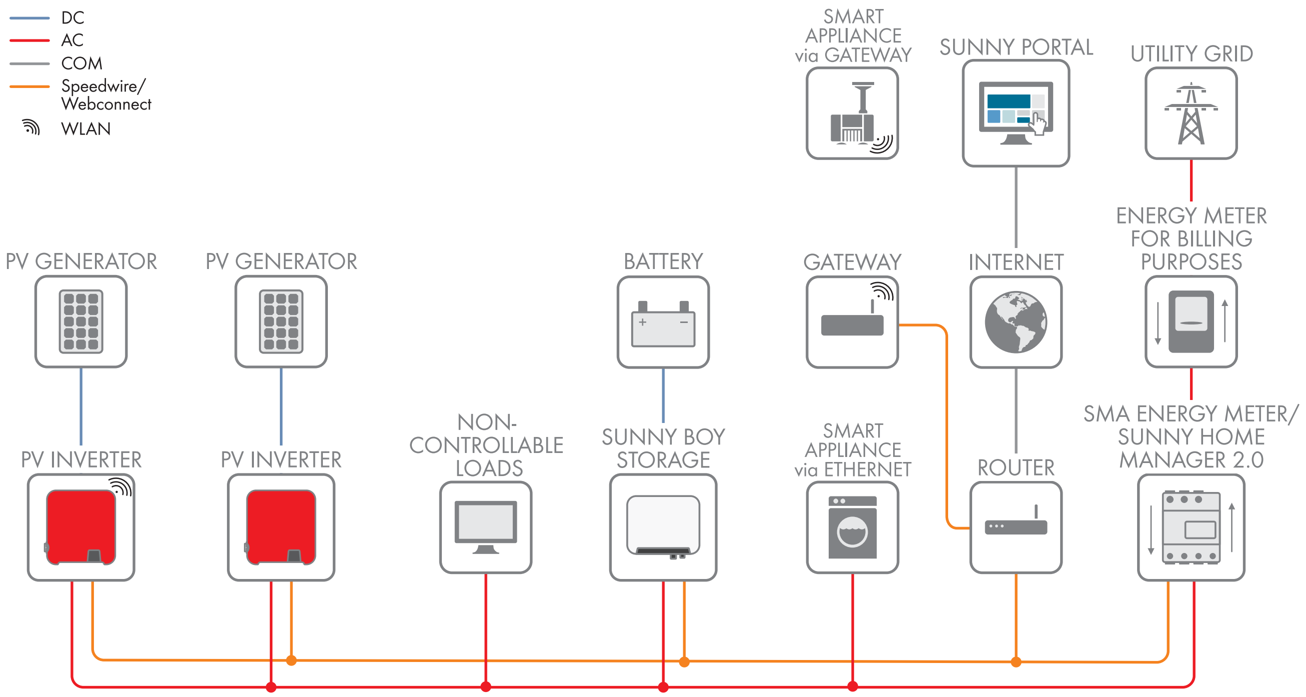


Figure 10: PV system with SMA Flexible Storage System with Sunny Boy Storage (example)

At the core of the SMA Flexible Storage System with Sunny Boy Storage is the Sunny Boy Storage 2.5.
The Sunny Boy Storage is a single-phase, AC coupled battery inverter for parallel grid operation. The Sunny Boy Storage converts the direct current supplied by a battery into grid-compliant alternating current. With a lithium-ion battery and the SMA Energy Meter, the Sunny Boy Storage becomes an SMA Flexible Storage System.

The SMA Energy Meter can also be optionally replaced by the Sunny Home Manager 2.0. This enables intelligent energy management.

The SMA Flexible Storage System with Sunny Boy Storage offers the following functions depending on the expansion stage:

Functions	Sunny Boy Storage	Sunny Boy Storage with Sunny Home Manager	Sunny Boy Storage with Sunny Home Manager and additional energy meter for PV production*
Visualization of system data in Sunny Portal (see Section 4.1.2, page 18)	✓	✓	✓
Intelligent load control (see Section 4.1, page 18)	–	✓	✓
Dynamic active power limitation (see Section 4.2.1, page 23)	✓	✓	–
Forecast-based charging (see Section 4.2.2, page 24)	–	✓	✓
Zero Export: Limitation of Active Power Feed-In to 0% or 0 W (see Section 4.3.2, page 29)	✓	✓	–
Automatic unbalanced load limitation (see Section 4.3.3, page 29)	✓	✓	✓
Cumulative power control at the grid-connection point (see Section 4.3.4, page 32)	✓	✓	✓
Access to grid management services via Modbus interface, e.g. for active power limitation by the grid operator	✓	✓	✓**

* SMA micro inverters or PV inverters from third-party suppliers can be integrated into the SMA Flexible Storage System with Sunny Boy Storage, Sunny Home Manager and additional energy meter as PV production meter (see Section 6.3.3 "PV Inverters in the SMA Flexible Storage System", page 43).

** When using PV inverters from third-party providers, it must be ensured that the grid operator can access the required grid management services via the interfaces or user interfaces of the third-party provider.

✓ Can be utilized – Can not be utilized

4 Functions for Energy Management Systems

4.1 Intelligent Load Control

4.1.1 Energie Monitoring - Measuring and Understanding Energy Flows

The household makes use of electrical energy in different ways. To enable effective energy management, therefore, it is necessary to understand in detail the energy flows in the household.

In an SMA Smart Home, energy consumption can be measured at various points:

- The integrated measuring device of the Sunny Home Manager 2.0 and SMA Energy Meter at the grid-connection point provides the electrical measured values for PV generation, for grid feed-in, and for purchased electricity as a cumulative value across the phases for the entire household.
- Using the available radio-controlled sockets, the Sunny Home Manager can individually measure and monitor the energy consumption of specific loads. The more loads that are monitored in this way, the more complete is the energy consumption data basis of the household.

The Sunny Home Manager collects all the information on the energy flows and makes it available for evaluation via Sunny Portal in various diagram displays.

The information can be used to answer the following questions, for example:

- What is the energy consumption of the household?
- How much energy is supplied by the PV system?
- How much energy is required by selected loads?
- How often and for how long are these loads in operation?

Answering these questions will enable you to analyze and understand the energy flows in the household, e.g:

- Which loads require the most energy?
- Which loads possibly require too much energy and should be replaced by more energy-efficient models?
- Which usage habits for loads should possibly be changed in order to use PV energy more effectively?
- What effect would switching to a different electricity tariff have on the energy costs?

Using this knowledge, energy management measures can be defined. These measures can lead to savings in energy costs and also help to protect the environment. For automatic load control, these findings provide guidelines on when it is most efficient to switch on certain loads.

4.1.2 Visualization of PV System Data in Sunny Portal

Sunny Portal offers various functions for visualizing and controlling the energy flows in the household:

- By way of the **Energy balance** page, an overview of the energy consumption in the household, energy generation by the PV system and the feeding in of excess PV energy into the utility grid is available at all times. The charging and discharging of any available battery is also visualized. Depending on the time period selected, values from the past can also be displayed.

  As a result of the forecasts determined for PV generation and consumption, information on manual load control is provided which can increase self-consumption.
- The page **Load balance and control** shows the energy consumption, energy mix and the time of operation for selected loads. You can select various time periods and views in the overview.
- By means of various settings, selected loads can be automatically operated at times when primarily PV energy is consumed or when energy is available at optimum cost. As a result of the PV generation forecast available and the consumption behavior experienced, an optimum increase in self-consumption can be achieved (see Section 4.1.4 "Mode of Operation of Load Control", page 20).
- System status information can be used to monitor the proper operation of the PV system.

4.1.3 Components of Load Control

In SMA Smart Home you can use various types of radio-controlled sockets.

They can be used to control home appliances and they enable optimization of energy consumption and the self-consumption quota through load shifting. The radio-controlled sockets also measure the power consumption of the connected loads and thus enable energy monitoring.

The following radio-controlled sockets can be integrated into an SMA Smart Home:

- Edimax SP-2101W WLAN radio-controlled socket (available via the online shop)

Edimax SP-2101W WLAN radio-controlled socket

As an adapter for a load, the Edimax SP-2101W WLAN radio-controlled socket can switch on the power supply or interrupt it. It also measures the power that the load requires for operation.

Radio-controlled sockets are registered via a special Edimax app at the local router. With this, they can be controlled by the Sunny Home Manager 2.0 via the WLAN connection.

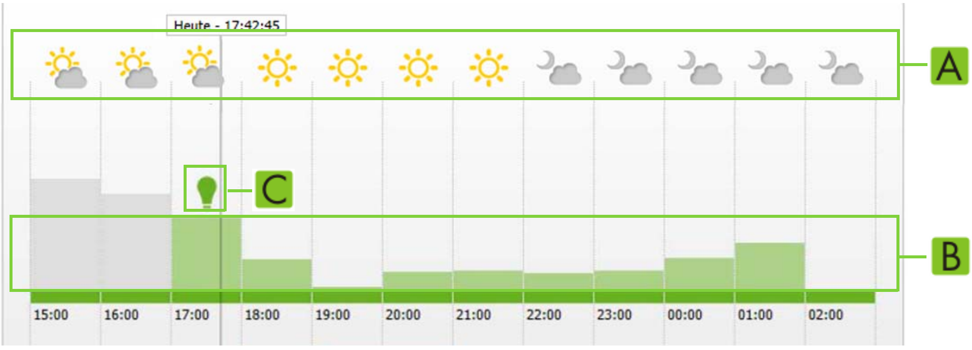
Information: Only the Edimax SP-2101W WLAN radio-controlled socket is compatible with the Sunny Home Manager 2.0. Other radio-controlled sockets from Edimax that can only switch are therefore unable to work with the Sunny Home Manager 2.0.

Bearing in mind the compatibility of the Edimax SP-2101W WLAN radio-controlled socket with the Sunny Home Manager 2.0, observe the following regarding the firmware version of the devices:

- Sunny Home Manager 2.0 firmware from version 2.0.6.R
- Edimax SP-2101W firmware up to version 2.03
- Edimax SP-2101W firmware from version V2 v1.00 (available May 2017 via the Edimax update process)

4.1.4 Mode of Operation of Load Control

Using various displays and settings in the system pages of Sunny Portal, you can display current information, e.g. status information, energy balances, and forecasts for PV generation and for specific electrical consumption in the household. From these, the Sunny Home Manager derives action recommendations and uses these recommendations to control the loads.

<table>
<tr><th>Function</th><th>Explanation</th></tr>
<tr><td>Creation of a PV yield forecast</td><td>
The Sunny Home Manager continuously logs the energy generated by the PV system. It also receives location-based weather forecasts via the Internet. Based on this information, the Sunny Home Manager creates a PV yield forecast for the PV system.
To query forecast information, you must fill in the following input fields on the System properties page in Sunny Portal:
Longitude
Latitude
Nominal PV system power
If one of the three entries is missing, either the weather symbols are not displayed, the power forecast is not present, or it is incorrect.


If the weather forecast is set correctly, the hourly weather symbols (A) are displayed on the page Current Status and Forecast.
The power forecast for each hour of the forecast time period is shown as a green bar (B). If the mouse pointer is moved over these bars, numerical values are displayed.
The green light bulbs (C) above the bars refer to time periods in which, according to the power forecast, there will be a high proportion of surplus PV energy which could be consumed effectively by manual switching on of a load. In this way, by manual switching of loads (e.g. vacuum cleaning if there is a lot of sunshine in the afternoon), it is possible to actively increase the self-consumption of PV energy.
</td></tr>
<tr><td>Creation of a load profile</td><td>
The Sunny Home Manager logs data on PV generation, grid feed-in and purchased electricity. Based on PV generation, grid feed-in and purchased electricity, the Sunny Home Manager determines how much energy is typically consumed at certain times and uses this to create a load profile for the household. This load profile can be different for each day of the week.
The Sunny Home Manager receives the measured data for PV generation, grid feed-in and purchased electricity via the installed energy meter (integrated measuring device or SMA Energy Meter) or from the inverters directly via the data connection.
</td></tr>
</table>

Function	Explanation
Configuration and system monitoring via Sunny Portal	Sunny Portal serves as the user interface of the Sunny Home Manager. The Sunny Home Manager establishes the Internet connection to Sunny Portal via a router and the user can make all the required settings for the Sunny Home Manager system via Sunny Portal. You can call up data on energy consumption and generation and also forecasts and information on energy use via diagrams and tables. In addition, basic PV system monitoring is also possible via Sunny Portal.
Automatic load control using radio-controlled sockets	Specific loads connected to radio-controlled sockets can be switched on and off by the Sunny Home Manager. The Sunny Home Manager uses the PV yield forecast and the load profile to determine favorable points in time for optimization of internal power supply and self-consumption. In accordance with the system operator's specifications and taking the determined time periods into account, the Sunny Home Manager controls switch-on and switch-off of the loads. Also, radio-controlled sockets provide the facility to individually monitor the energy consumption of loads.
Automatic control of loads with direct data connection	As an alternative to radio-controlled sockets, the Sunny Home Manager can also communicate directly with loads in the household via data connection and can exercise control in this way. For this, the loads must be fitted with an appropriate energy management data protocol. The load notifies the Sunny Home Manager of its energy requirement via direct data exchange. Then the Sunny Home Manager sends control commands to the load via the data connection and these ensure optimal use of the available energy.

4.1.5 Application Examples

The following application examples of load control in SMA Smart Home are available in the download area of the Sunny Home Manager at www.SMA-Solar.com:

- SMA SMART HOME - Load control via MUST time period (example: washing machine)
- SMA SMART HOME - Load control via CAN time period (example: pond pump)
- SMA SMART HOME - Control of loads with relay or contactor (example: heating element)
- SMA SMART HOME - Home Appliance Energy Management via EEBUS
- SMA SMART HOME - Battery Charging Management with Time-of-Use Energy Tariffs

4.1.6 Distinguishing Between Self-Consumption Systems and Feed-In Systems in SMA Smart Home

In the system properties in Sunny Portal, you can set the system type for the relevant system. There are two system types:

- Self-consumption system
- Feed-in system

Self-consumption system

The objective in a self-consumption system is to consume as much of the generated PV energy oneself as possible. This works best if the loads in the household are switched on whenever the sun is shining and the PV system is generating a lot of electricity.

The Sunny Home Manager uses its intelligent energy management to ensure that the controllable loads are switched on automatically when there is sufficient PV energy available.

Self-consumption systems are attractive whenever the feed-in tariff for PV energy is significantly below the purchase cost of grid current. Therefore, high self-consumption contributes to lowering the energy costs.

The energy meter must be installed in such a way that the household loads can consume the PV energy before the feed-in or grid-connection point. Then only the surplus PV energy is fed into the utility grid.

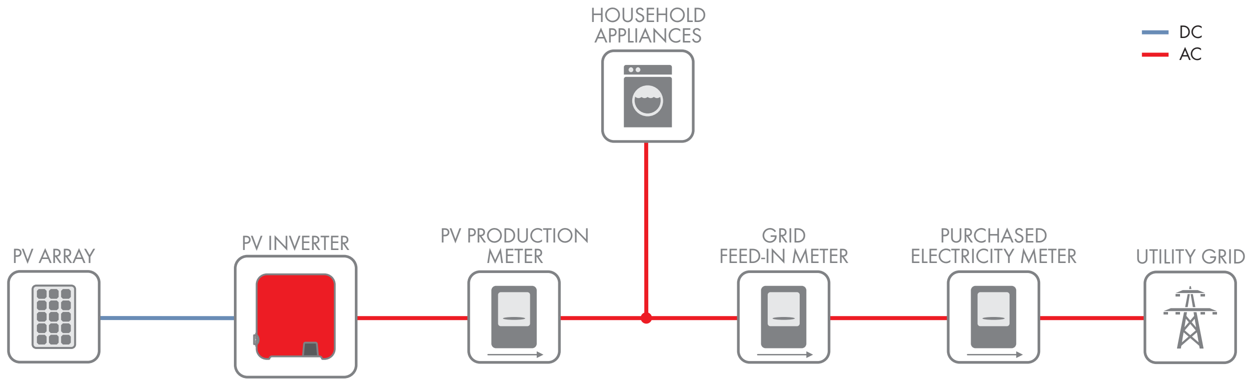


Figure 11: Energy meter installation in a self-consumption system (example)

Feed-in system

The objective of a feed-in system is to feed all the generated PV energy into the utility grid in order to receive the relevant feed-in tariff.

Feeding in of generated PV energy is attractive whenever the feed-in tariff is significantly above the purchase cost of grid current. In this case, the grid feed-in of PV energy is an attractive source of income for the PV system operator. Energy management for such systems is of limited value.

The energy meter must be installed in such a way that the household loads do not consume the PV energy directly:

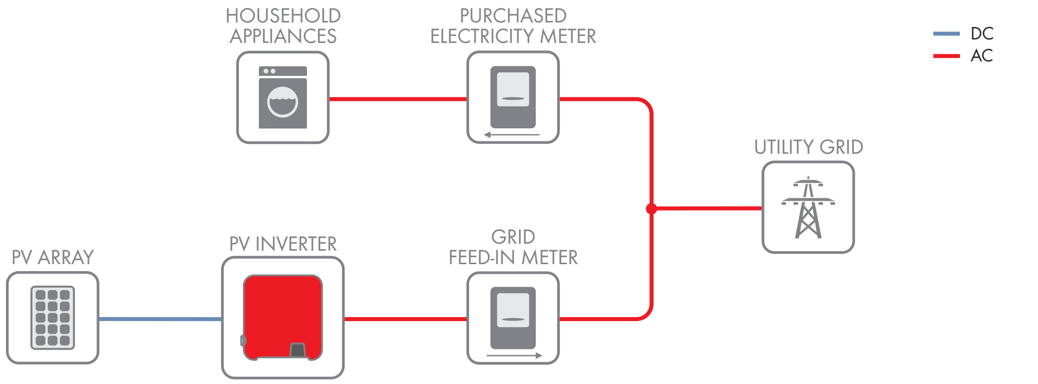


Figure 12: Energy meter installation in a feed-in system (example)

Restriction with feed-in systems with Sunny Home Manager

In feed-in systems with Sunny Home Manager, you cannot configure a CAN time period in Sunny Portal for load control.

4.2 Dynamic Limitation of Active Power Feed-In to Avoid Derating Losses

4.2.1 General Information regarding the Limitation of Active Power Feed-In

Country-specific regulatory requirements, for example the Renewable Energy Sources Act (EEG) in Germany, can call for permanent limitation of active power feed-in for your PV system, that is, a limitation of the active power fed into the utility grid to a fixed amount or a percentage share of the installed nominal PV system power. Ask your grid operator, if required, whether a permanent limitation of active power feed-in is necessary.

For the limitation of active power feed-in, the active power that is fed into the utility grid is monitored via an SMA Energy Meter. The amount of active power fed in depends on the current PV generation and on the consumption in the household. However, it can be affected by the charging of a battery. If the active power feed-in exceeds a prescribed threshold, the Sunny Home Manager will limit the PV generation of the inverters.

Use of the Sunny Home Manager to limit active power feed-in

In addition to the dynamic limitation of PV generation, the Sunny Home Manager can also use intelligent energy management to ensure that loads in the household are switched on at precisely those times when there is so much PV energy available that the feed-in limit would be reached. If switching on a load means that more power is consumed directly in the household, then the PV generation must not be reduced by as much or must not be reduced at all.

Example: Limitation of the active power feed-in to 70% of the installed nominal PV system power

Due to ideal solar irradiation, the system can currently produce 90% of the installed nominal system power of 10 kW, that is, 9 kW. The grid operator instructs the Sunny Home Manager to limit the system's active power feed-in to 70% (= 7 kW). When implementing the grid operator's specifications, the Sunny Home Manager includes the self-consumption in the household.

- At this time, 1 kW is being consumed by loads in the household. The Sunny Home Manager therefore limits the PV generation from the 9 kW currently possible to 8 kW. This way, 1 kW can be used for the loads in the household and the maximum permitted 7 kW is still fed into the utility grid.
- As part of intelligent energy management, the Sunny Home Manager now also switches on a load with 500 W. This means that only derating from the currently possible 9 kW to 8.5 kW is required. The 500 W load draws energy at virtually no cost as it would otherwise be lost due to derating.

The Sunny Home Manager can be used alone or as part of a storage solution for the limitation of active power feed-in.

If required, ask your grid operator whether a permanent limitation of the active power feed-in is necessary and whether you are allowed to use the Sunny Home Manager for this purpose (see the Manufacturer's Declaration "Feed-In Management In Accordance with the Renewable Energy Sources Act (EEG) 2012 with SMA Sunny Home Manager (SHM) from SMA" available at www.SMA-Solar.com).

From firmware version 1.13.xx.R, the Sunny Home Manager enables the limitation of active power feed-in to 0% or 0 W. This "Zero Export" mode can also be used for storage solutions (see Section 4.3.2, page 29).

4.2.2 Avoiding Derating Losses Through Forecast-Based Battery Charging in SMA Storage Solutions

On days with strong sunshine around noon, a large portion of the available PV power may have to be derated to limit the active power feed-in due to local requirements. The Sunny Home Manager energy management already ensures that, especially on such days, the controllable loads in the household are switched on exactly at those times in order to consume the energy that would otherwise be derated.

In addition, the energy from the noon peak can also be stored in the battery of the battery inverter. This is particularly effective since the stored energy can then be used when required at a later time.

Battery inverters draw power to charge the battery from a surplus of generated PV energy. This means that, before PV energy is fed into the utility grid, the system first attempts to use the energy to charge the battery. On days with strong sunshine, there may be a surplus of PV energy in the morning and the battery may even be fully charged before the noon peak. In this case, limitation of the PV feed-in is necessary at noon as the battery can no longer use the surplus PV energy.

This curtailment is avoided during forecast-based charging. Based on a PV power generation forecast and load planning, it is being forecast whether derating losses are expected at noon of the following day due to the limitation of PV feed-in. Already in the afternoon of the current day or in the morning of the next day, only the amount of energy is fed into the battery to absorb the forecast derating losses with the remaining battery capacity. This way, sufficient battery capacity will remain for the noon period so that the energy, which would otherwise be derated, can be charged to the battery.

SMA Flexible Storage System with Sunny Island and Sunny Boy Storage

In Sunny Portal, in the device properties of the Sunny Home Manager, you can active the optimized storage management for the Sunny Island or Sunny Boy Storage. This setting is deactivated by default.

When the forecast-based battery charging is activated, the Sunny Home Manager can ensure a forecast-based battery charge through activation of the battery inverter.

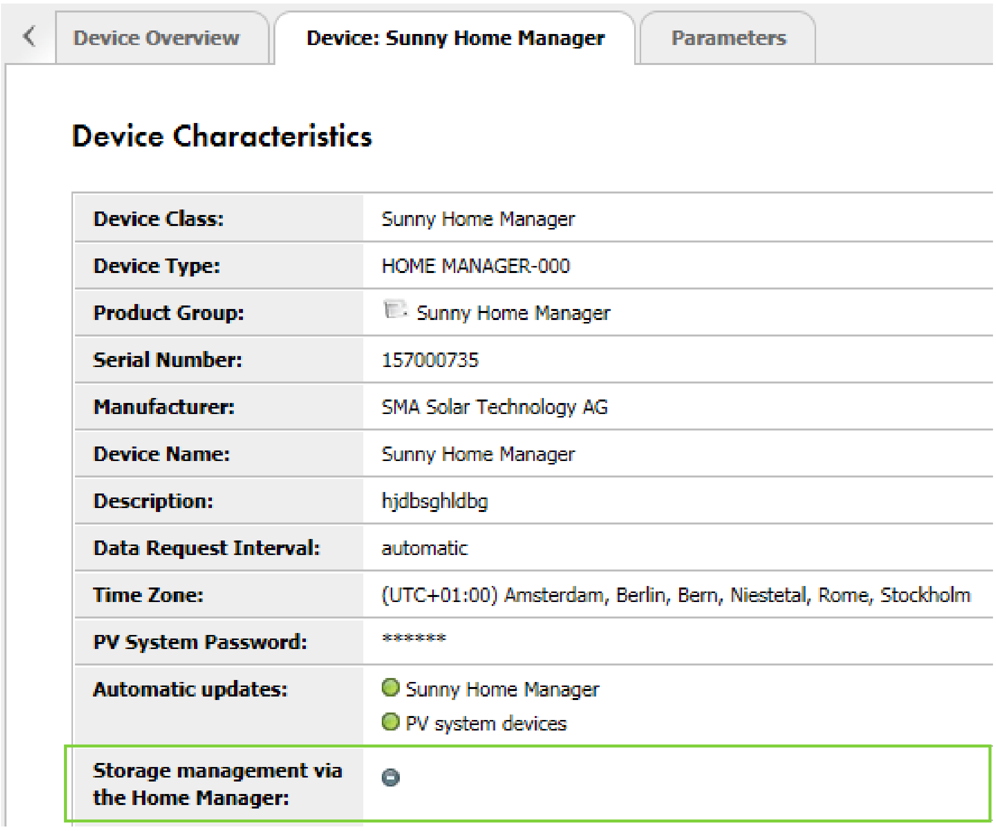


Figure 13: Device properties of the Sunny Home Manager (example)

The LED symbol has the following meaning:

- Green = active, optimized storage management via the Sunny Home Manager
- Gray = inactive, regular storage management via the Sunny Island

For the purpose of avoiding derating losses with forecast-based battery charging, you can find an estimation of energy use in Section 4.2.3.

SMA Integrated Storage System

Here, in accordance with the setting for active power feed-in limitation, optimization of the 2 kWh battery-storage system is always activated. Both with and without the Sunny Home Manager, an inverter-internal generated forecast regarding a probable derating during the noon peak brings about delayed charging of the battery during the morning. If the active power feed-in limitation is set to 100%, this optimization is practically deactivated.

Examples of power control with the SMA Integrated Storage System and the SMA Flexible Storage System

Below, the power control of the SMA Integrated Storage System and the SMA Flexible Storage System is illustrated by way of examples from Sunny Portal.

Example 1: Avoiding derating losses through forecast-dependent charging

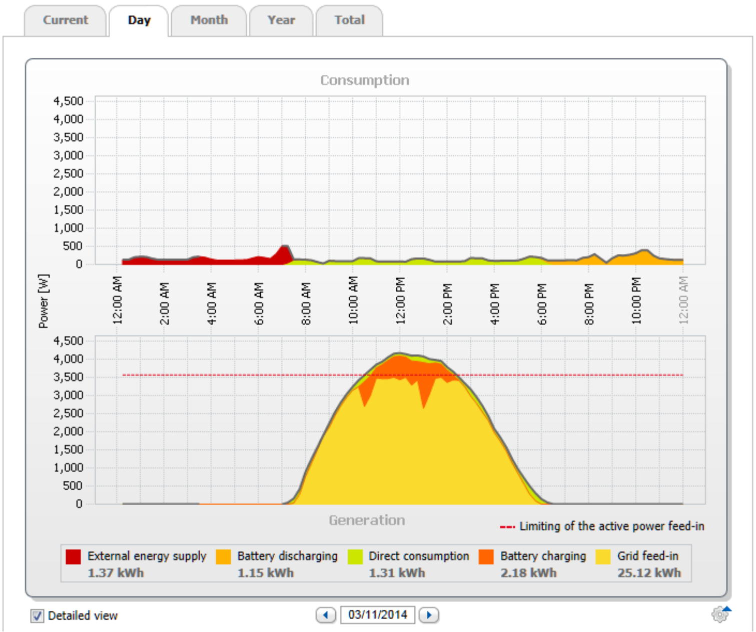


Figure 14: Consideration of PV generation and consumption in Sunny Portal (example 1)

The current daily forecast of the system predicts a limitation of active power feed-in around noon when the energy requirement of the loads is very low and PV production is high. For this reason, derating losses can be expected.

In accordance with this forecast, the SMA Integrated Storage System / SMA Flexible Storage System does not begin to charge the battery until late morning. The derating losses are almost completely avoided through battery charging.

Example 2: Avoiding derating losses through direct consumption and battery charging

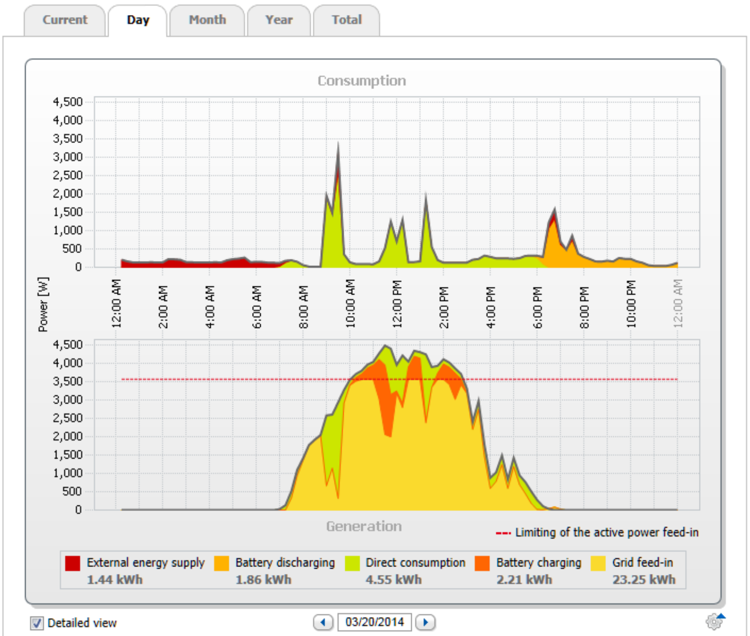


Figure 15: Consideration of PV generation and consumption in Sunny Portal (example 2)

As in example 1, the current daily forecast anticipates limitation of the active power feed-in around noon. In this case, however, the loads have a slightly higher energy demand. To avoid derating losses, therefore, the SMA Integrated Storage System / SMA Flexible Storage System schedules direct consumption and intermediate storage for the midday period.

In accordance with the forecast, the SMA Integrated Storage System / SMA Flexible Storage System begins to charge the battery in the late morning. The derating losses are avoided through direct consumption and battery charging.

Example 3: Avoiding derating losses through direct consumption

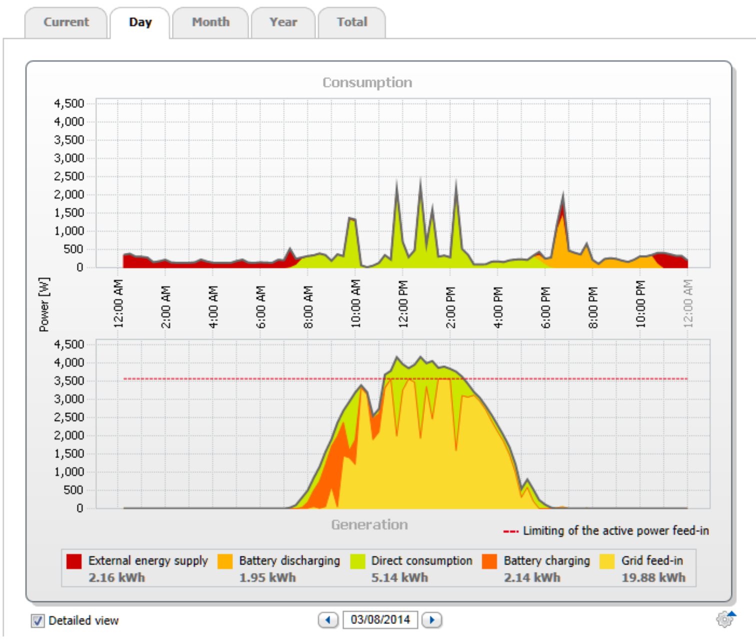


Figure 16: Consideration of PV generation and consumption in Sunny Portal (example 3)

As in examples 1 and 2, the current daily forecast anticipates limitation of the active power feed-in around noon. In this case, however, the loads have a much higher energy demand. The expected derating losses are therefore avoided completely through direct consumption.

The SMA Integrated Storage System / SMA Flexible Storage System, therefore, fully charges the battery during the morning and, in this example, avoids derating losses exclusively through direct consumption, for example, through intelligent load control.

Example 4: No forecast for derating losses

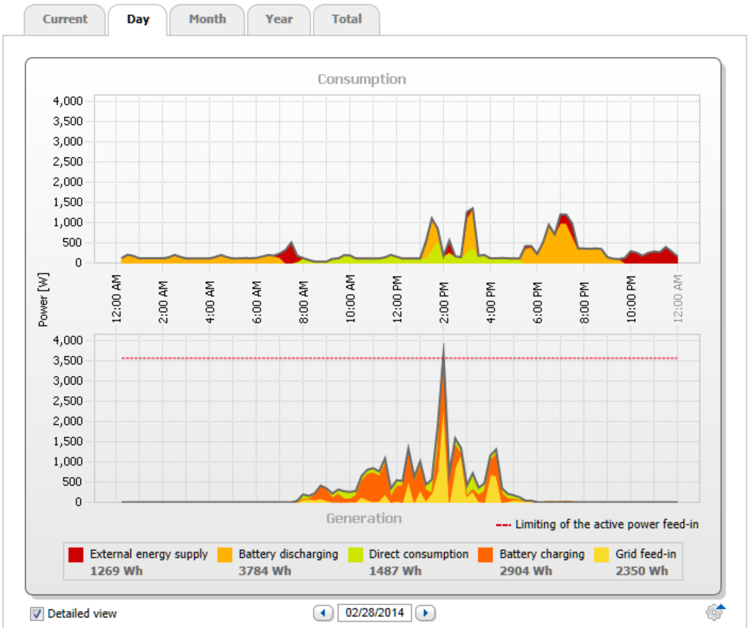


Figure 17: Consideration of PV generation and consumption in Sunny Portal (example 4)

If no limitation of active power feed-in is forecast for the current day, the SMA Integrated Storage System / SMA Flexible Storage System works in accordance with the general power control (see Section 4.3.1 "General Power Control", page 29).

4.2.3 Example of Avoiding Derating Losses with Forecast-Based Battery Charging

With the SMA Flexible Storage System, you can choose between an economically optimized mode of operation (activation of the forecast-based battery charging) and an optimized mode of operation with regard to the self-sufficiency (no activation of the forecast-based battery charging).

The working principle of the forecast-based battery charging is explained and illustrated graphically in Section 4.3.3. Below, we consider the advantages and disadvantages of forecast-based battery charging using an example. We assume a limitation of the feed-in power of 60% as required in the incentive program for electrical energy storage in PV systems (see Section 7.1, page 46).

Example:

Input data:

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Total battery capacity: 10000 Wh, of which the Sunny Island uses 50% for intermediate storage of the PV energy.

The usable battery capacity therefore amounts to 5000 Wh.

The following figure illustrates the percentage derating losses with and without forecast-based battery charging:

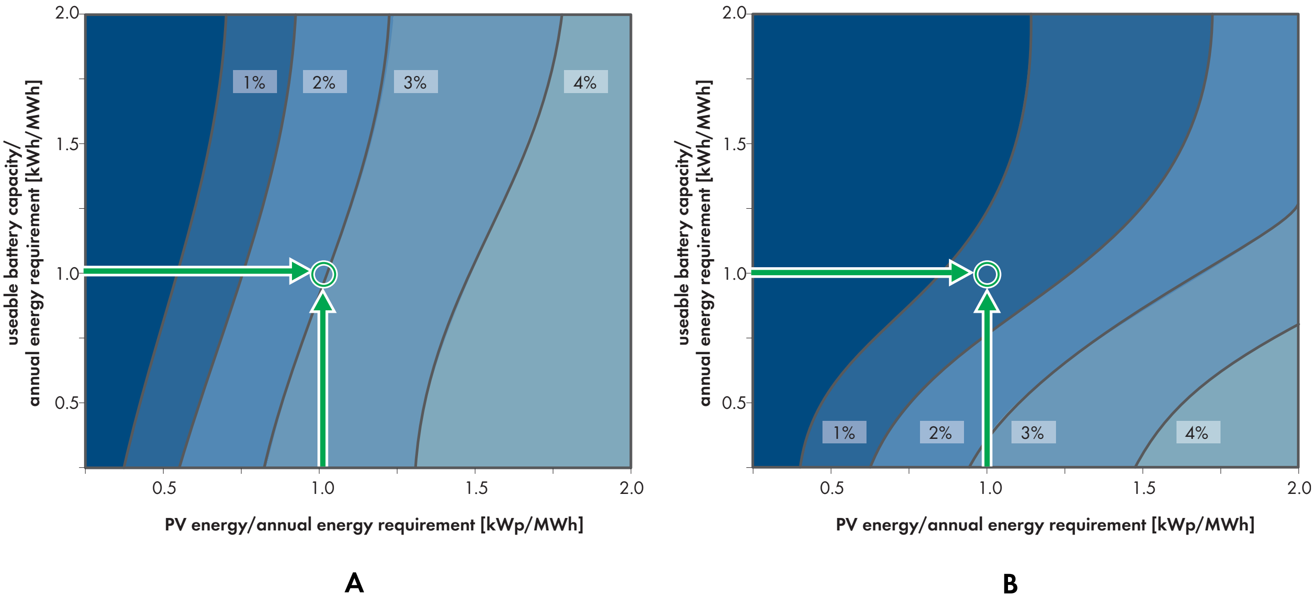


Figure 18: Annual percentage losses based on the PV generation with limitation of grid feed-in to 60% - without (A) and with (B) forecast-based battery charging

If we assume a PV generation of 4500 kWh per year for a PV system with a power of 5 kWp, we see the following results:

- With fixed active power feed-in limitation, 315 kWh of the generated PV energy is derated - this equals 7% of 4500 kWh (the value of 7% applies for all configurations)
- Without forecast-based battery charging, 135 kWh of the generated PV energy is derated - this equals 3% of 4500 kWh (see Figure 18 A)
- With forecast-based battery charging, only 67 kWh of the generated PV energy is derated - this equals 1.5% of 4500 kWh (see Figure 18 B)

Through forecast-based battery charging, we could thus intermediately store 68 kWh of PV energy (135 kWh – 67 kWh) in the battery and use it to supply the household instead of having it derated. By shifting the charging operation from morning to noon, the PV system could also feed in more during the morning.

Conclusion: If we compare the options with and without forecast-based battery charging, the forecast-based battery charging results in a positive financial effect in most cases. However, it is possible that the forecasts are not correct. As a result, the battery may be used less which can lead to lower self-sufficiency quotas.

4.3 Power Control at the Grid-Connection Point

4.3.1 General Power Control

In the interests of the highest possible internal power supply and the highest possible self-consumption, the power control at the grid-connection point has the following objectives:

- Before the PV system feeds into the utility grid, this electrical energy should be consumed directly or stored intermediately in a battery.
- Before the loads draw energy from the utility grid, this energy should be provided by the PV system or by discharging the battery.

The energy management system achieves these objectives taking the forecast for PV generation and electricity consumption for the current day into account.

4.3.2 Zero Export: Limitation of Active Power Feed-In to 0% or 0 W

Some grid operators permit connection of PV systems only on condition that no active power is fed into the utility grid. The PV energy is therefore consumed exclusively at the place where it is generated.

During the limitation of active power feed-in to 0% or 0 W, it must be ensured that the active power currently generated by the PV inverters is controlled in such a way that it equals the power currently being consumed in the household. If, in this situation, an active load in the household is switched off, the inevitable active power feed-in will be reduced to a value less of than 2% of nominal PV system power within a reaction time of 1.5 to 2.5 seconds. This means that PV systems can be created with 100% self-consumption.

- From firmware version 1.11.4.R, the Sunny Home Manager enables the limitation of active power feed-in to 0% or 0 W.

  From firmware version 1.13.X.R of the Sunny Home Manager, battery inverters are fully supported (exception: SMA Integrated Storage System is not supported).
- The Sunny Boy Storage 2.5 can limit the active power feed-in of PV inverters to 0 % or 0 W from firmware version 02.02.01.R.

For this, the following requirements must be met when installing the PV system:

- In the event of an interruption of the communication for system control, the connected PV inverters must be capable of limiting their active power feed-in to a predefined value (see PV inverter documentation).
- An SMA Energy Meter must be used to measure grid purchase and grid feed-in power levels at the grid-connection point.
- Configuration of the active power limitation settings to 0% must be done by a qualified person.
- All necessary installation measures must be carried out and checked in accordance with the documentation of the products used.

Use of energy meters during zero export:

- Only the SMA Energy Meter 10 and 20 are supported.

4.3.3 Avoiding Unbalanced Load

Requirements of the “VDE Forum Network Technology / Network Operations (FNN)”

When using an SMA Flexible Storage System in Germany, the requirements regarding symmetry and monitoring of feed-in power must be implemented in accordance with the Technical Information "Connecting and Operating Storage Units in Low Voltage Networks" published by the FNN. Requirements:

- In these systems, the battery inverter must be connected to the same line conductor supplied by a single-phase PV inverter. If there are only three-phase PV inverters connected, the battery inverter can be connected to any line conductor.

- The requirements of the technical information “Connection and Operation of Storage Units in Low-Voltage Networks” published by the FNN influence the discharge behavior of the battery inverter. When using systems with one battery inverter and single-phase PV inverter, the feed-in power of all inverters (minus the power of the load) must not exceed 4.6 kVA per phase. Therefore, the SMA Flexible Storage System reduces the maximum discharge power of the battery inverter as required.

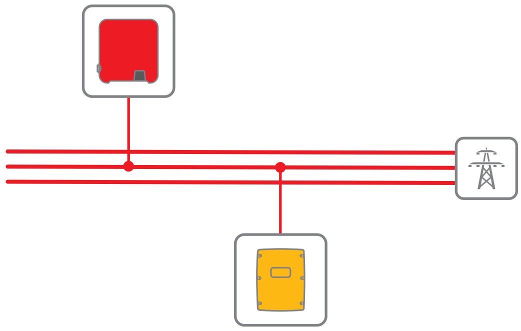
Examples regarding the implementation

In the following illustrations, the Sunny Island is shown as an example for battery inverters.

Example 1:

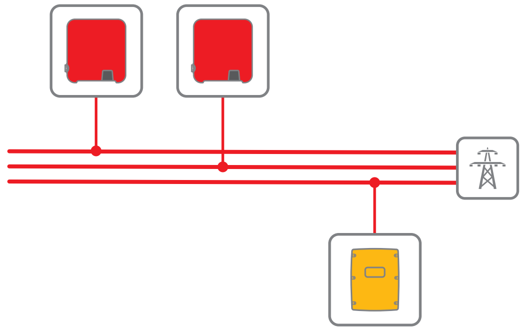
All PV inverters are single-phase and are feeding in asymmetrically (Sunny Boy). The PV inverters are connected to one line conductor.

In these systems, the battery inverter must be connected to the same line conductor in which the PV inverters feed into.



Example 2:

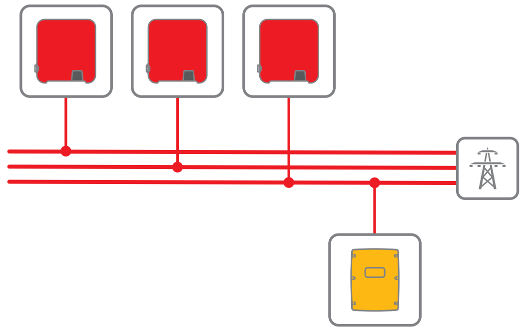
All PV inverters are single-phase and are feeding in asymmetrically (Sunny Boy). PV inverters are connected to two line conductors. The battery inverter must be connected to a line conductor via a single-phase PV inverter. TIP: Connect the battery inverter to the line conductor being supplied with the least PV energy. This will increase the control range for increased self-consumption.



Example 3

All PV inverters are single-phase and are feeding in asymmetrically (Sunny Boy). One PV inverter is connected to each line conductor.

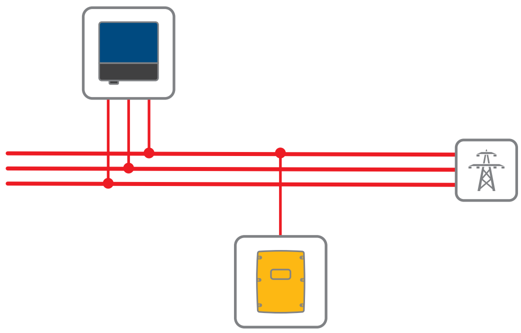
The battery inverter can be connected to any line conductor. TIP: Connect the battery inverter to the line conductor being supplied with the least PV energy. This will increase the control range for increased self-consumption.



Example 4:

All PV inverters are three-phase and are feeding in symmetrically (Sunny Tripower).

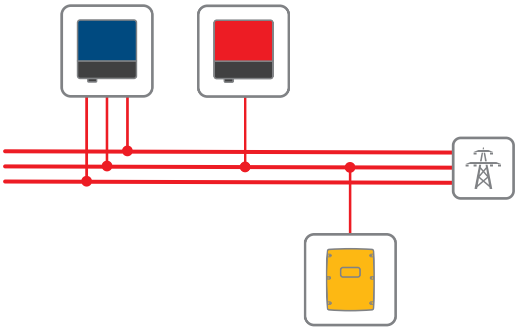
The battery inverter can be connected to any line conductor.



Example 5:

The PV system consists of three-phase PV inverters (Sunny Tripower) and single-phase PV inverters (Sunny Boy). The PV system is feeding in asymmetrically.

The battery inverter must be connected to a line conductor via a single-phase PV inverter.*



Using the SMA Energy Meter

For the single-phase SMA Flexible Storage System to be able to monitor the limitation of the feed-in power, the measuring device SMA Energy Meter must be used. Only the SMA Energy Meter provides the phase-specific measured values of the feed-in power that are required for the limitation to 4.6 kVA. If the limitation of the feed-in power is exceeded, the battery inverter reduces its feed-in power.

The SMA Energy Meter must also be used for three-phase PV inverters in the single-phase and in the three-phase SMA Flexible Storage System since the SMA Energy Meter supplies the measured values at the required level of breakdown.

* The battery inverter can only discharge the battery if less than 4.6 kVA are being fed in on the line conductor of the battery inverter at the point of interconnection.

4.3.4 Power Control in Accordance with the Summation Current Principle

If, with a three-phase grid connection, an SMA Integrated Storage System or a single-phase SMA Flexible Storage System is installed, power control in accordance with the summation current principle also applies.

Requirement: cumulative meter values

A requirement for power control in accordance with the summation current principle is the output of cumulative meter values in a three-phase system. A cumulative meter value is the total power aggregated over all three phases. A cumulative meter value, however, does not permit any conclusion to be drawn about the state of each individual phase.

The SMA Energy Meter can output cumulative measured values (see Section 6.5, page 44).

In the SMA Integrated Storage System, the Sunny Boy Smart Energy controls the intermediate storage over all three phases of the grid connection. In a single-phase SMA Flexible Storage System, the Sunny Boy Storage or Sunny Island exercises control over the intermediate storage.

For power control in accordance with the summation current principle, the storage system uses the cumulative values of the SMA Energy Meter or of the bidirectional meter for grid feed-in and purchased electricity.

$$P_{\text{total power}} = P_{\text{phase conductor 1}} + P_{\text{phase conductor 2}} + P_{\text{phase conductor 3}}$$

Implementation of the summation current principle is explained below with the example of the SMA Flexible Storage System and three different situations.

Situation 1:

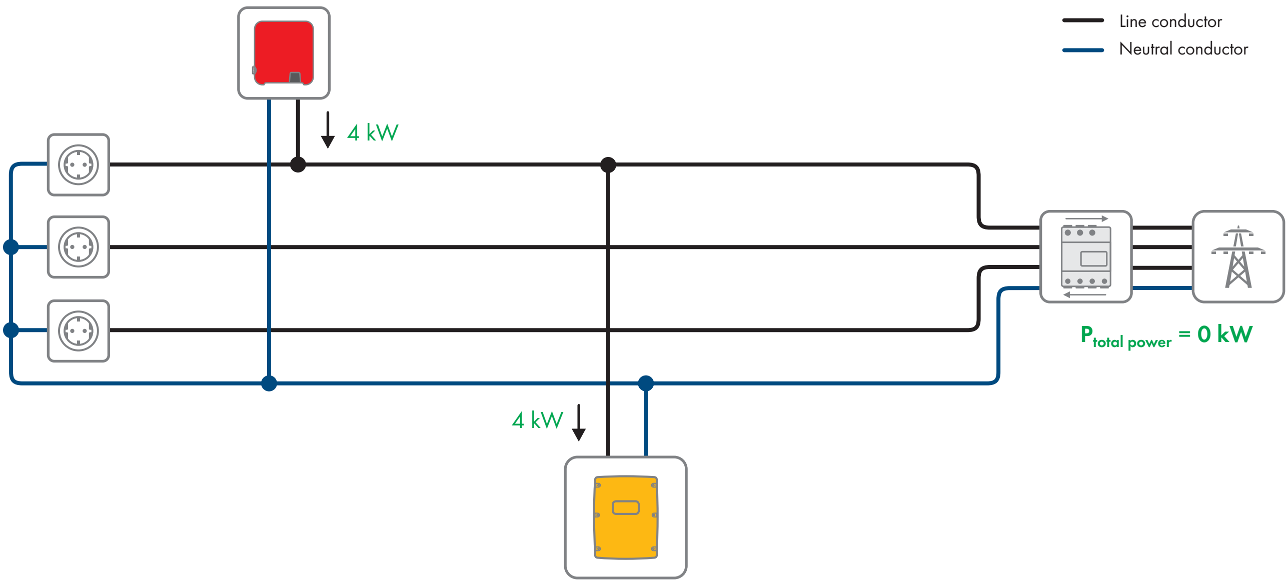


Figure 19: The battery inverter charges the battery.

It is early morning. At sunrise, the PV system begins to feed in and after a while reaches electric power of 4 kW. The loads are still switched off.

$$P_{\text{total power}} = 4\text{ kW} + 0\text{ kW} + 0\text{ kW} = 4\text{ kW}$$

First, the PV system feeds the total PV power into the utility grid via phase 1. The battery inverter recognizes the grid feed-in and uses the PV power of 4 kW to charge the battery.

$$P_{\text{total power}} = 0\text{ kW} + 0\text{ kW} + 0\text{ kW} = 0\text{ kW}$$

Energy is no longer fed into the grid.

Situation 2:

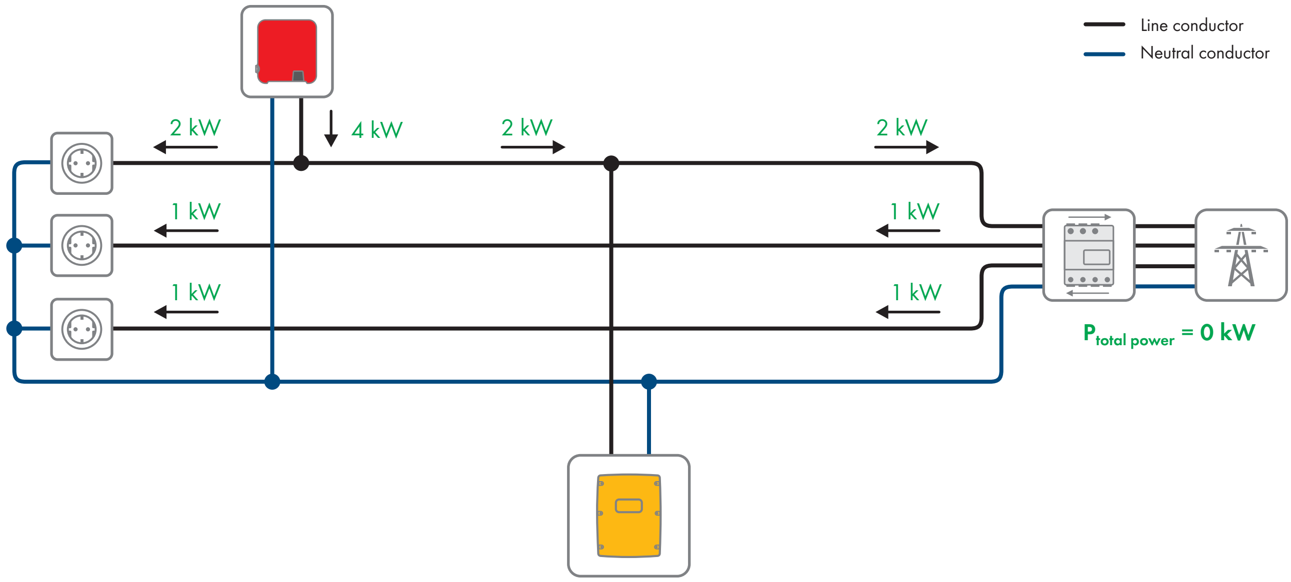


Figure 20: The loads are using the total PV power.

It is around noon. The battery is fully charged. The PV system provides 4 kW. The load on phase 1 uses the power generated by the PV system directly which, therefore, now only feeds 2 kW into the utility grid. The loads on phases 2 and 3 draw their power from the utility grid.

The total power at the bidirectional meter for grid feed-in and purchased electricity is shown as follows:

$$P_{total\ power} = 2\ kW - 1\ kW - 1\ kW = 0\ kW$$

From a cumulative perspective, there is no grid feed-in and no purchase of electricity taking place. The battery inverter does not intervene and leaves the state of charge of the battery unchanged.

Situation 3:

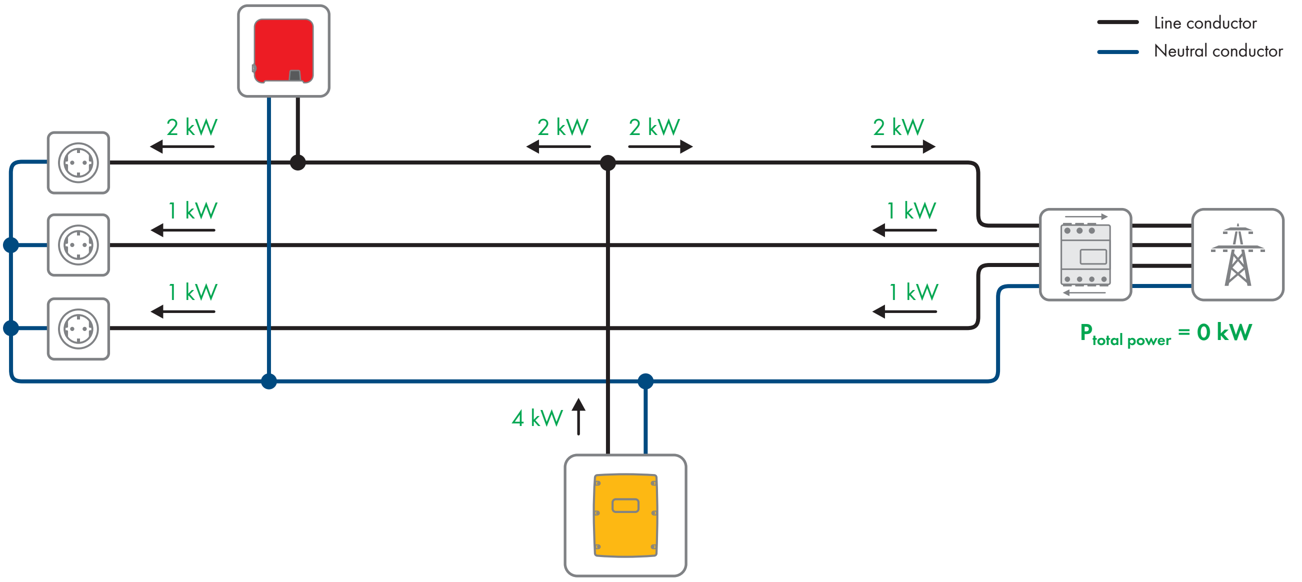


Figure 21: The battery inverter supplies the loads with energy from intermediate storage.

It is now evening. The PV system is not feeding in. The loads are switched on and are drawing 2 kW of electric power on phase 1, 1 kW on phase 2, and 1 kW on phase 3.

The total power at the bidirectional meter for grid feed-in and purchased electricity is shown as follows:

$$P_{total\ power} = -2\ kW - 1\ kW - 1\ kW = -4\ kW$$

The utility grid is now the sole energy source for the loads and supplies them with 4 kW. The battery inverter detects the purchased electricity and consequently uses the energy from intermediate storage to supply the loads.

The total power at the bidirectional meter is then as follows:

$$P_{total\ power} = 2\ kW - 1\ kW - 1\ kW = 0\ kW$$

The energy stored intermediately by the battery inverter in the battery is sufficient to supply the loads. No more electricity is purchased from the grid.

5 Loads in Energy Management Systems

5.1 Suitability of Loads for an Energy Management System

An important form of intelligent energy management is automatic load control. Without any compromises in convenience or security of supply, the operation of suitable loads is rescheduled to times with high PV generation. To be able to benefit from these advantages, it is important to know which loads are suitable for operation in an energy management system:

- Loads should be capable of consuming a significant portion of the locally generated PV energy. The higher the energy demand of load per day, the more worthwhile is the control of such a load.
- Loads should be in operation either daily or on fixed days during the week.
- Loads should be flexible with regard to time and should not be obliged to produce a specific result immediately after being switched on.

Examples of suitable loads

The following loads are particularly suitable for an energy management system - not least because they are flexible with regard to time:

- A **heat pump** for provision of warm water requires 3 kWh to 5 kWh of energy per day and runs daily.
- A **washing machine** requires 1 kWh to 1.25 kWh of energy depending on the program selected and it runs several times each week.
- A **dryer** requires 1.5 kWh to 2.5 kWh of energy depending on the program selected and it runs several times each week.
- A **dishwasher** requires 1.5 kWh of energy for each wash and typically runs daily.
- A **heating element** for a hot-water tank requires 2 kWh to 3 kWh of energy and is in operation daily.
- A **charging station for electric vehicles** requires 4 kWh to 22 kWh of energy and is in operation daily.

Examples of unsuitable loads

The following loads are unsuitable for an energy management system:

- A **desk lamp** with an energy requirement of e.g. 20 Wh can only consume a very small portion of the PV energy.
- **Toasters** and **kettles** are only switched on when they are required. Toast and hot water is required promptly.
- An electric **lawn mower** typically runs once or twice each month and must be pushed manually.
- An **electric cooker** is switched on when the user wishes to cook. The food is to be prepared promptly and not simply whenever sufficient PV energy is available for operation of the electric cooker.

5.2 Options for Load Control

The Sunny Home Manager is offered by many manufacturers of heating systems, charging stations for electric cars and household appliances as an energy manager for use with PV systems. A prerequisite is that there is a compatible controlling interface between the devices and systems in the household via which the Sunny Home Manager can send its control commands.

In principle, there are two types of control which are used in such cases:

- Control via radio-controlled sockets
- Control via direct data connection

Control via radio-controlled sockets

Switching three-phase loads using only one common actuator

Three-phase loads that are dependent on the simultaneous availability of all phases (e.g. three-phase motors), must not be controlled via three separate actuators (e.g. three radio-controlled sockets). In this case, you must use a single actuator with control of a three-phase contactor.

With this type of control, the devices can be started or stopped directly via connecting or interrupting the main power supply (e.g. a pond pump).

Alternatively, a relay or a three-phase contactor, which in turn can start a load, can also be controlled via the radio-controlled socket. This method can be used to switch on large loads (e.g. a large pump or a heater with three-phase power connection).

The SG-Ready switching contacts of heat pumps can also be controlled by radio-controlled sockets. These switching contacts then start the heat pump in a special operating mode in which surplus PV energy can be used to operate the heat pump.

Control via direct data connection

Some modern home appliances have an Ethernet or WLAN connection with which the data of the device can be called up via the local network. If there is an Internet connection via the network router, the manufacturers of household devices can use this data for maintenance purposes, for example. Visualization and control of the household devices via mobile devices (e.g. via app in the Smartphone) is possible.

A further application of this direct data connection is the control of the device via the Sunny Home Manager in the energy management system. For this, a compatible data protocol must be implemented in the respect device via which information for energy management can be exchanged. On such data protocol is the EEBUS/SPINE industry standard. The SMA-proprietary SEMP protocol serves as an additional data protocol (information at www.sma.de/partner/sma-developer.html). (See Section 6.2 for further information on supported devices)

The directly controllable loads send information on the load type, the planned energy requirement, and the preferred operating time period to the Sunny Home Manager. The Sunny Home Manager factors this information into its load control, and also, taking the optimization targets you have configured in the context of load control into account, sends appropriate start and stop signals to the loads.

5.3 Control of Heat Pumps

Below, the control of ON/OFF heat pumps and inverter heat pumps in the context of energy management is explained (for information on supported products, see Section 6.2).

ON/OFF heat pumps

An ON/OFF heat pump is a heat pump whose compressor runs with a constant speed during operation and draws a constant level of power.

In general, there are three options for controlling ON/OFF heat pumps:

- Control via radio-controlled sockets (230 V on/off)

  ON/OFF heat pumps of the Stiebel WWK electronic and Tecolor TTA series can be controlled by the Sunny Home Manager via radio-controlled sockets. Thereby, the radio-controlled socket must always control the electric circuit that supplies the compressor of the ON/OFF heat pump (for more details on the electrical connection see the manufacturer documentation of the heat pumps).

  The following ON/OFF heat pump can be controlled in this way:

Manufacturer	Models
Stiebel Eltron	• WWK 220 electronic • WWK 300 electronic / WWK 300 electronic SOL • WWK 221 electronic • WWK 301 electronic / WWK 301 electronic SOL
Tecalor	• TTA 220 electronic • TTA 300 electronic / TTA 300 electronic SOL • TTA 221 electronic • TTA 301 electronic / TTA 301 electronic SOL
AEG Haustechnik	• WPT 220 EL / WPT 300 EL / WPT 300 EL plus

- Direct control via the SG-Ready input of the heat pump (normal / energy-intensive)

  With this type of control, the heat pump is started even if the normal target temperature in the storage tank is reached. A higher target temperature is temporarily activated via the SG-Ready input. This results in the heat pump being forced to run in order to continue heating the water in the tank. The radio-controlled socket must be in "Switch-only mode". In addition, a constant power consumption must be entered in the load profile of the heat pump in Sunny Portal.
- Direct control via communication using data exchange protocol (SEMP)

  You can find a list of the loads that support this type of control in Section 6.2.

Inverter heat pumps

An inverter heat pump is a heat pump where the rotating speed of the compressor during operation is controlled in such a way that, in accordance with the available temperature profile, an optimum performance level is achieved (CoP). The heat pump control is capable of adjusting the energy consumption according to the situation. If the energy manager specifies a defined, available PV surplus power via the data connection, the heat pump control can refer to this specification and thus actively increase the PV self-consumption.

In general, there are three options for controlling inverter heat pumps:

- Direct control via the SG-Ready input of the heat pump (normal / energy-intensive)

  With this type of control, the heat pump selects the power consumption in accordance with its own optimization specifications. Thus, power-based control via the Sunny Home Manager is not possible.
- Direct control via communication using data exchange protocol (SEMP)

  With this type of control, the heat pump bases its power consumption on the specifications of the Sunny Home Manager and can therefore be optimally integrated into energy management.

  You can find a list of the loads that support this type of control in Section 6.2.

6 Components for Energy Management Systems

6.1 Product Overview

6.1.1 SMA and Radio-Controlled Sockets for Basic Solution

SMA and radio-controlled sockets	Sunny Home Manager
Sunny Home Manager 2.0 incl. integrated measuring device	✓
Compatible WLAN radio-controlled sockets (e.g. Edimax), available via electronics retailers	●
PV inverters*	✓

* To communicate with the Sunny Home Manager, PV inverters need a communication interface via SMA Speedwire fieldbus (see Section 6.3.1, page 41).

✓ Required – Not required ● Optional

For the individual products, there are country-specific restrictions on availability (see Section 11.1, page 65).

6.1.2 SMA and Radio-Controlled Sockets for Simple Storage Solution

SMA and radio-controlled sockets	Sunny Boy Smart Energy	SMA Integrated Storage System
Sunny Home Manager 2.0 incl. integrated measuring device	–	✓
Compatible WLAN radio-controlled sockets (e.g. Edimax SP-2101W), available via electronics retailers	–	●
PV inverters*	Sunny Boy Smart Energy	Sunny Boy Smart Energy

* To communicate with the Sunny Home Manager, PV inverters need a communication interface via SMA Speedwire fieldbus (see Section 6.3.1, page 41). The Sunny Boy Smart Energy already has two integrated Speedwire interfaces for communication, for example, with the Sunny Home Manager.

✓ Required – Not required ● Optional

For the individual products, there are country-specific restrictions on availability (see Section 11.1, page 65).

6.1.3 SMA and Radio-Controlled Sockets for Flexible Storage Solution

SMA Flexible Storage System with Sunny Island

SMA and radio-controlled sockets	Sunny Island with Sunny Home Manager	Sunny Island with Sunny Home Manager and additional energy meter for PV production
Sunny Home Manager 2.0 incl. integrated measuring device	✓	✓
Compatible WLAN radio-controlled sockets (e.g. Edimax SP-2101W), available via electronics retailers	●	●
PV inverters*	✓	✓**
SMA Energy Meter	–	1 time

SMA and radio-controlled sockets	Sunny Island with Sunny Home Manager	Sunny Island with Sunny Home Manager and additional energy meter for PV production
Sunny Island 3.0M / 4.4M / 6.0H / 8.0H	✓	✓
Sunny Remote Control	✓	✓
BatFuse B.01/B.03	✓	✓
SMA Speedwire data module Sunny Island	✓	✓

* To communicate with the Sunny Home Manager, PV inverters need a communication interface via SMA Speedwire fieldbus (see Section 6.3.1, page 41).

** SMA micro inverters or PV inverters from third-party suppliers can be integrated into the SMA Flexible Storage System with Sunny Island, Sunny Home Manager and additional energy meter as PV production meter. In doing so, the additional energy meter must be installed as PV production meter (see Section 6.3.3, page 43). It is recommended to use the SMA Energy Meter as PV production meter.

✓ Required – Not required ● Optional

For the individual products, there are country-specific restrictions on availability (see Section 11.1, page 65).

SMA Flexible Storage System with Sunny Boy Storage

SMA and radio-controlled sockets	Sunny Boy Storage	Sunny Boy Storage with Sunny Home Manage r	Sunny Boy Storage with Sunny Home Manager and additional energy meter for PV production
Sunny Home Manager 2.0 incl. integrated measuring device	–	✓	✓
Compatible WLAN radio-controlled sockets (e.g. Edimax SP-2101W), available via electronics retailers	–	●	●
PV inverters*	✓	✓	✓**
SMA Energy Meter	✓	–	1 time
Sunny Boy Storage 2.5	✓	✓	✓

* To communicate with the Sunny Home Manager, PV inverters need a communication interface via SMA Speedwire fieldbus (see Section 6.3.1, page 41).

** SMA micro inverters or PV inverters from third-party suppliers can be integrated into the SMA Flexible Storage System with Sunny Boy Storage, Sunny Home Manager and additional energy meter as PV production meter. In doing so, the additional energy meter must be installed as PV production meter (see Section 6.3.3, page 43). It is recommended to use the SMA Energy Meter as PV production meter.

✓ Required – Not required ● Optional

For the individual products, there are country-specific restrictions on availability (see Section 11.1, page 65).

6.2 Smart Appliances

Up to now, the following home appliances have been fitted with the energy management data protocol and have been tested with SMA Smart Home (date: June 2016, addition devices in preparation):

- Stiebel Eltron heat pumps in conjunction with the Stiebel Eltron ISGweb and the EMI software module:

System/heat pump	Models
Integral systems	• LWZ 303/403 (Integral/SOL) from manufacture date 08/2008 • LWZ 304/404 (SOL) • LWZ 304/404 Trend • LWZ 504
Air/water heat pumps	• WPL 10 I, IK, AC • WPL 13/20 A basic • WPL 13-23 E / cool • WPL 34/47/57 • WPL 15/25 A(C)(S)
Brine heat pumps	• WPF 10-16 M • WPF 20-66 / HT • WPF 04-16 / cool • WPC 04-13 / cool

- Tecalor heat pumps with ISG web and EMI software module

System/heat pump	Models
Integral systems	• THZ 303/403 (Integral/SOL) from manufacture date 08/2008 • THZ 304/404 (SOL) • THZ 304/404 Trend • THZ 504
Air/water heat pumps	• TTL 10 I, IK, AC • TTL 13/20 A basic • TTL 13-23 E / cool • TTL 34/47/57 • TTL 15/25 A(C)(S)
Brine heat pumps	• TTF 10-16 M • TTF 20-66 / HT • TTF 04-16 / cool • TTC 04-13 / cool

- Mennekes AMTRON® wall charging station (models Premium and Xtra) for electric vehicles

6.3 PV Inverters

6.3.1 PV Inverters with Sunny Home Manager

PV inverters can communicate in two different ways in SMA Smart Home with the Sunny Home Manager:

- Wired via Ethernet

  In this case, the PV inverter must be connected via a network cable to a network switch or the router in the local network.

- Wireless via WLAN

  Depending on the ambient conditions, wireless networks can have a limited range. In free-field conditions without any disruptive objects, a high radio range is possible. In buildings with solid concrete and steel walls, however, the range can be limited to a few meters. Range problems can be eliminated with standard WLAN repeaters.

The Sunny Home Manager supports the following PV inverters from SMA Solar Technology AG. The PV inverters must have the current firmware version in each case (see the inverter product page at www.SMA-Solar.com).

PV Inverters with integrated Speedwire interface

- Sunny Boy:
  - SB 3600SE-10 / SB 5000SE-10
  - SB1.5-1VL-40 / SB2.5-1VL-40
  - SB3.0-1AV-40 / SB3.6-1AV-40 / SB4.0-1AV-40 / SB5.0-1AV-40
  - SB 1300TL / SB 1600TL / SB 2100TL
  - SB 3000TL-21 / SB 3600TL-21 / SB 4000TL-21 / SB 5000TL-21 / SB 6000TL-21
- Sunny Tripower:
  - STP 5000TL-20 / STP 6000TL-20 / STP 7000TL-20 / STP 8000TL-20 / STP 9000TL-20 / STP 10000TL-20 / STP 12000TL-20
  - STP 15000TL-30 / STP 20000TL-30 / STP 25000TL-30

PV Inverters with integrated WLAN interface

- Sunny Boy:
  - SB1.5-1VL-40 / SB2.5-1VL-40
  - SB3.0-1AV-40 / SB3.6-1AV-40 / SB4.0-1AV-40 / SB5.0-1AV-40

PV Inverters with retrofittable Speedwire interface

Refer to the following documents at www.SMA-Solar.com for information on which PV inverters can be retrofitted with which Speedwire interface:

Title	Document type	Information
Speedwire/Webconnect data module	Installation manual	PV inverters which can be retrofitted with Speedwire/ Webconnect data module and which support the function "Limitation of active power feed-in"
Speedwire/Webconnect Piggy-Back	Installation manual	PV inverters which can be retrofitted with Speedwire/ Webconnect Piggy-Back and which support the function "Limitation of active power feed-in"

Information regarding all PV inverters

Support of the Tigo TS4-R module technology in connection with an SMA string inverter

In Sunny Portal in the system overview, a special tool for the visualization and analysis of the module technology performance is displayed.

No support for the Sunny Boy 240 and the Sunny Multigate

The Sunny Boy 240 and the Sunny Multigate are not intended for use in Sunny Home Manager systems.

Data on PV generation from the PV inverter

All the SMA PV inverters listed in this section can transmit their PV generation data directly to the Sunny Home Manager. For this reason, a separate PV production meter is not necessary.

If inverters from other manufacturers are to be integrated into the systems, an SMA Energy Meter must be installed centrally as a PV production meter. The PV production meter is then configured appropriately via the Sunny Home Manager settings in Sunny Portal. The generation data from SMA PV inverters is no longer used. For this reason, dynamic active power control in such mixed systems is no longer possible. The inverters must be limited to a fixed active power limit.

Maximum number of supported PV inverters

The Sunny Home Manager supports a maximum of 24 SMA inverters within one system. This is also the maximum number of devices.

With 24 SMA inverters within one system, radio-controlled sockets or directly controllable loads can no longer be supported.

6.3.2 PV Inverters in the SMA Integrated Storage System

Use of the Sunny Boy 3600 / 5000 Smart Energy with other PV inverters	Operating conditions	Permitted
1 Sunny Boy Smart Energy + additional PV inverters	• The PV inverter must be of the type Sunny Boy or Sunny Tripower. • The Sunny Home Manager must be installed.*	yes
1 Sunny Boy Smart Energy + additional Sunny Boy Smart Energy devices	–	no
1 Sunny Boy Smart Energy + PV inverters from another manufacturer	–	no

* The Sunny Home Manager is part of the SMA Integrated Storage System. If no Sunny Home Manager is installed, the SMA inverters must be equipped with SMA Webconnect.

The Sunny Boy 3600 / 5000 Smart Energy independently records the PV generation data and sends this data to the Sunny Home Manager. In the SMA Integrated Storage System, therefore, you must not install a PV production meter which sends data for PV generation to the Sunny Home Manager.

If there is a PV production meter in the SMA Integrated Storage System, the Sunny Home Manager can no longer distinguish whether the energy fed into the household grid originates from the PV system or from the battery. If a PV production meter in the SMA Integrated Storage System sends PV generation data to the Sunny Home Manager, PV system monitoring in Sunny Portal is not possible.

Integrated Communication Interfaces with Switch Function

The Sunny Boy 3600 / 5000 Smart Energy has two integrated Speedwire interfaces for connecting network cables. Similar to a network switch, the Sunny Boy Smart Energy can forward data packages in the Speedwire network.

6.3.3 PV Inverters in the SMA Flexible Storage System

Use of the Sunny Boy Storage or of Sunny Island with other PV inverters	Operating conditions	Permitted
Sunny Island with PV inverters	• The PV inverter must be compatible with the Sunny Home Manager. • The PV inverter must not be a Sunny Boy Smart Energy.	yes
1 Sunny Boy Storage + PV inverter	• The PV inverter must be of the type Sunny Boy or Sunny Tripower. • If the PV inverter is not equipped with SMA Webconnect, the Sunny Home Manager must be installed.	yes
1 Sunny Boy Storage + further Sunny Boy Storages	–	no
1 Sunny Boy Storage + PV inverters from another manufacturer 1 Sunny Boy Storage + SMA micro inverter	• An additional energy meter must be installed as a PV production meter. • The entire PV generation must be routed via the additional energy meter, otherwise no distinction can be made between PV generation and grid feed-in / purchased electricity. When the additional PV production meter is installed, this value is being taken as PV generation value instead of the values provided by the PV inverter. • The SMA Energy Meter must be used as a PV production meter.	yes

6.4 Radio-Controlled Sockets for Load Control

Different types of WLAN radio-controlled sockets are supported, depending on the firmware version of the Sunny Home Manager 2.0. The Edimax SP-2101W WLAN radio-controlled socket is supported with firmware version 2.00.00.R.

The respective compatible WLAN radio-controlled sockets are listed at www.sma.de on the Sunny Home Manager 2.0 product page in the "Accessories" area.

Information: The Sunny Home Manager 2.0 does not support the SMA Bluetooth radio-controlled socket.

The Sunny Home Manager Bluetooth HM-BT-10 does not support any WLAN radio-controlled sockets.

6.5 Energy Measuring Device SMA Energy Meter

The Sunny Home Manager 2.0 contains an integrated measuring device that corresponds to the measuring function of the SMA Energy Meter. If the Sunny Home Manager 2.0 is installed at the grid-connection point, no further measuring device is necessary for the basic function. Where necessary, an additional SMA Energy Meter can be installed for measuring the PV generation power (see Section 6.3, page 41).

The SMA Energy Meter determines electrical measured values at the connection point and makes them available via Speedwire. The SMA Energy Meter can record energy flows in both directions (counting direction: grid feed-in and purchased electricity or PV generation). It can be connected both three-phase and single-phase.

The SMA Energy Meter is **not** an active electrical energy meter as defined in the EU Directive 2004/22/EG (MID). It must not be used for billing purposes.

The SMA Energy Meter and the Sunny Home Manager 2.0 are licensed for a limiting current of 63 A per line conductor. From firmware version 1.02.04.R of the SMA Energy Meter, installations with more than 63 A per line conductor are possible if one external current transformer is used for each line conductor.

Additional material in the event of more than 63 A per line conductor from firmware version 1.02.04.R:

From firmware version 1.02.04.R of the SMA Energy Meter and for the Sunny Home Manager 2.0, installations with more than 63 A per line conductor are possible. With an SMA Energy Meter installation of more than 63 A per line conductor, one external current transformer is required for each line conductor. SMA Solar Technology AG recommends current transformers designed for a secondary current of 5 A. The current transformers should have at least accuracy class 1.

6.6 Communication

Router

A router / network switch connects the Sunny Home Manager via the Internet to Sunny Portal.

When using the Sunny Home Manager, SMA Solar Technology AG recommends a permanent Internet connection and the use of a router which supports the dynamic assignment of IP addresses (DHCP – Dynamic Host Configuration Protocol).

The measured value measured by the integrated measuring device is also made available to other devices in the local network via the Ethernet connection of the Sunny Home Manager 2.0 to the router.

SMA Energy Meter

An additional SMA Energy Meter must be located in the same local network as the Sunny Home Manager 2.0. The SMA Energy Meter must also be connected via a network cable either to the network switch or to the router with integrated network switch.

The network cables must meet the following cable requirements:

- Cable type: 100BaseTx
- Shielding: S-FTP or S-STP
- Plug type: RJ45 for Cat5, Cat5e, Cat6, Cat6a
- Number of insulated conductor pairs and insulated conductor cross-section: at least 2 x 2 x 0.22 mm²
- Maximum cable length between two nodes when using patch cables: 50 m
- Maximum cable length between two nodes when using installation cables: 100 m
- UV-resistant for outdoor use

i SMA Energy Meter in SMA Integrated Storage System

To ensure data transmission between the SMA Energy Meter and the Sunny Boy Smart Energy within the SMA Integrated Storage System, both devices must be connected **directly** with each other. For this, network cables must be used which meet the listed cable requirements.

6.7 Maximum Number of Devices in the Energy Management System

The following maximum number of devices applies for energy management systems:

- Maximum of 24 devices
- Of the 24 devices, a maximum of 12 devices may be controlled actively by the Sunny Home Manager. If the system contains additional radio-controlled sockets, these can be used in energy monitoring to measure and visualize device consumption.

The term device includes all components that exchange data with the Sunny Home Manager, i.e. SMA inverters, radio-controlled sockets, and smart loads. An SMA Energy Meter does not count as a device.

An energy management system fitted to the maximum can, for example, consist of the following components:

- 2 x SB 5000TL
- 1 x Sunny Island
- 1 x heat pump with direct data connection
- 20 x WLAN radio-controlled sockets

7 Intermediate Storage Systems

7.1 SMA Integrated Storage System

System design with Sunny Design or Sunny Design Web

If the PV system power is no more than 50 kWp, the requirements listed in this section are, with regard to the system design for an SMA Integrated Storage System with Sunny Design or Sunny Design Web, covered automatically.

Requirements on the PV Array

The product must only be operated with PV arrays of protection class II in accordance with IEC 61730, application class A. PV modules with a high capacitance to ground may only be used if their coupling capacity does not exceed 1.4 μF.

If you are using Sunny Boy 3600 / 5000 Smart Energy, the PV modules for each DC input of the PV inverter must fulfill the following requirements:

- All PV modules must be of the same type.
- The same number of series-connected PV modules must be connected to each string.
- All PV modules of any one string must be aligned identically.
- All PV modules of any one string must have the same tilt angle.
- The maximum input current per string must be observed and must not exceed the through-fault current of the DC connectors (see the PV inverter installation manual).
- The thresholds for the input voltage and the input current of the inverter must be observed (see the PV inverter installation manual).
- On the coldest day based on statistical records, the open-circuit voltage of the PV array must never exceed the maximum input voltage of the inverter.
- The positive connection cables of the PV modules must be fitted with the positive DC connectors (see the DC connector installation manual).
- The negative connection cables of the PV modules must be fitted with the negative DC connectors (see the DC connector installation manual).

Integration of Additional PV Inverters

In addition to the Sunny Boy 3600 / 5000 Smart Energy, you can integrate more PV inverters from SMA Solar Technology AG into the SMA Integrated Storage System. Requirement:

- The Sunny Boy 3600 / 5000 Smart Energy should always be connected at the PV array to the string whose PV modules receive the last sunlight of the day. This means that in the evening, full charging of the battery is supported.

7.2 SMA Flexible Storage System

7.2.1 Supported Batteries

Sunny Island

The Sunny Island supports lead-acid batteries of types FLA and VRLA as well as various lithium-ion batteries. It is important to observe the capacity:

- Lead-acid batteries with a capacity of 100 Ah to 10000 Ah can be connected.
- Lithium-ion batteries with a capacity of 50 Ah to 10000 Ah can be connected.

Lithium-ion batteries are especially suited for intermediate storage of PV energy due to their high cycle stability.
The lithium-ion batteries must be compatible with the Sunny Island:

- The battery must comply with the locally applicable standards and directives and be intrinsically safe.
- The battery must be approved for use with the Sunny Island.

  The list of lithium-ion batteries approved for the Sunny Island is updated regularly (see the Technical Information “List of Approved Lithium-Ion Batteries” at www.SMA-Solar.com).
- If no lithium-ion battery approved for the Sunny Island can be used, use a lead-acid battery.

Sunny Boy Storage

The Sunny Boy Storage must only be operated in connection with an intrinsically safe lithium-ion battery approved by SMA Solar Technology AG (see Technical Information "Overview of approved lithium-ion batteries" under www.SMA-Solar.com).

Lithium-ion battery for Sunny Island and Sunny Boy Storage

The battery management of lithium-ion batteries controls the operation of the battery. To enable battery management, the lithium-ion battery must be connected to the battery inverter via an RJ45 data cable.

In the case of compatible lithium-ion batteries, SMA Solar Technology AG has only tested the communication between the battery inverter and the battery management of the lithium-ion battery. For information on other technical properties of the batteries, please contact the respective manufacturer of the lithium-ion battery.

7.2.2 Circuitry Overview and Material List of the Single-Phase SMA Flexible Storage System with Sunny Island

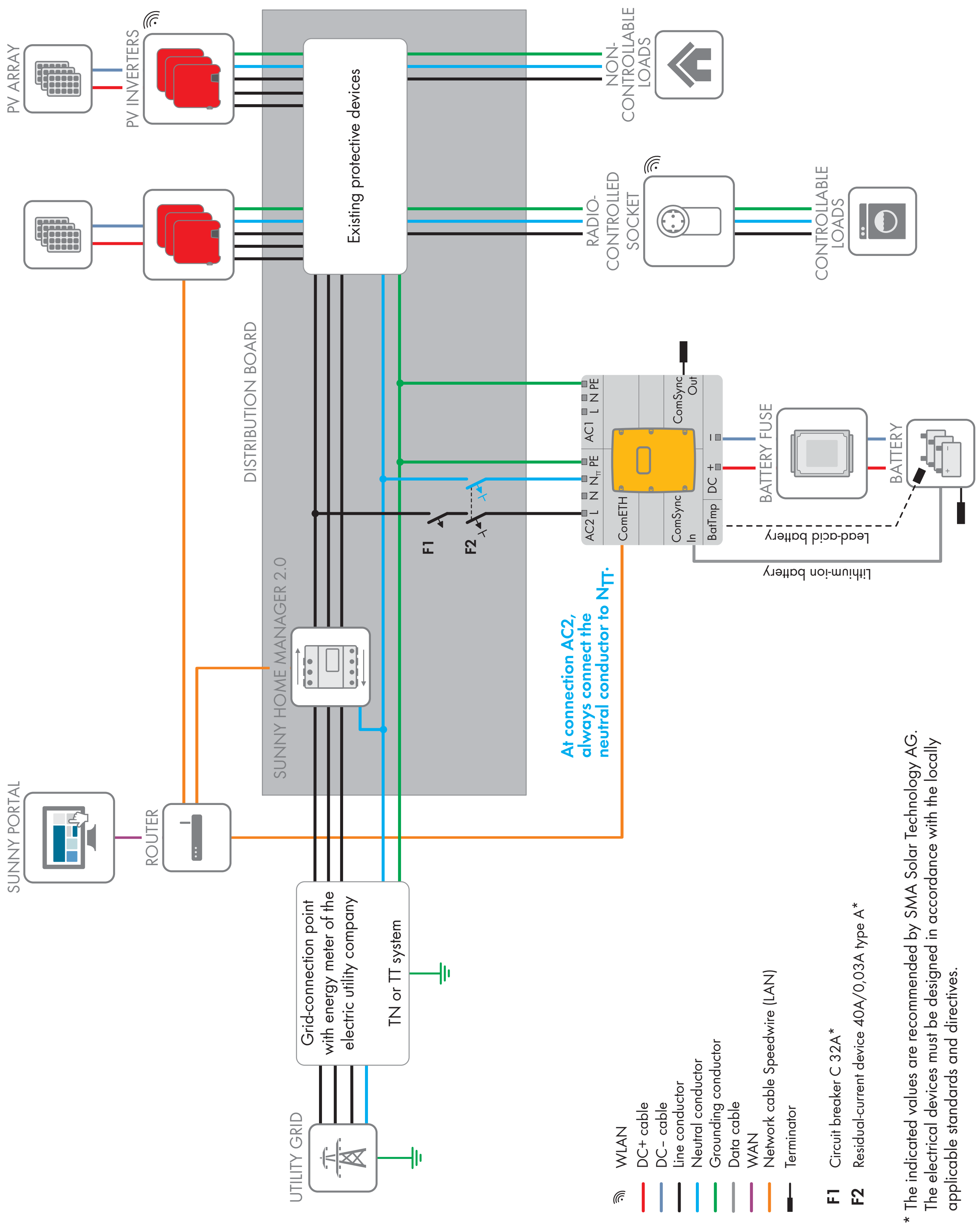


Figure 22: Circuitry of the single-phase SMA Flexible Storage System with Sunny Island for TN and TT systems (example)

Material for circuitry of the single-phase SMA Flexible Storage System with Sunny Island

Material	Number of units	Description
Circuit breaker for protection of the Sunny Island inverter	1	32 A, C rating, 1-pole
Residual-current device	1	40 A/0.03 A, 1-pole + N, type A

A **wiring diagram** will be supplied whenever a Sunny Island 3.0M / 4.4M / 6.0H / 8.0H is ordered.

7.2.3 Circuitry Overview of a Single-Phase SMA Flexible Storage System With Sunny Boy Storage and Optional Sunny Home Manager

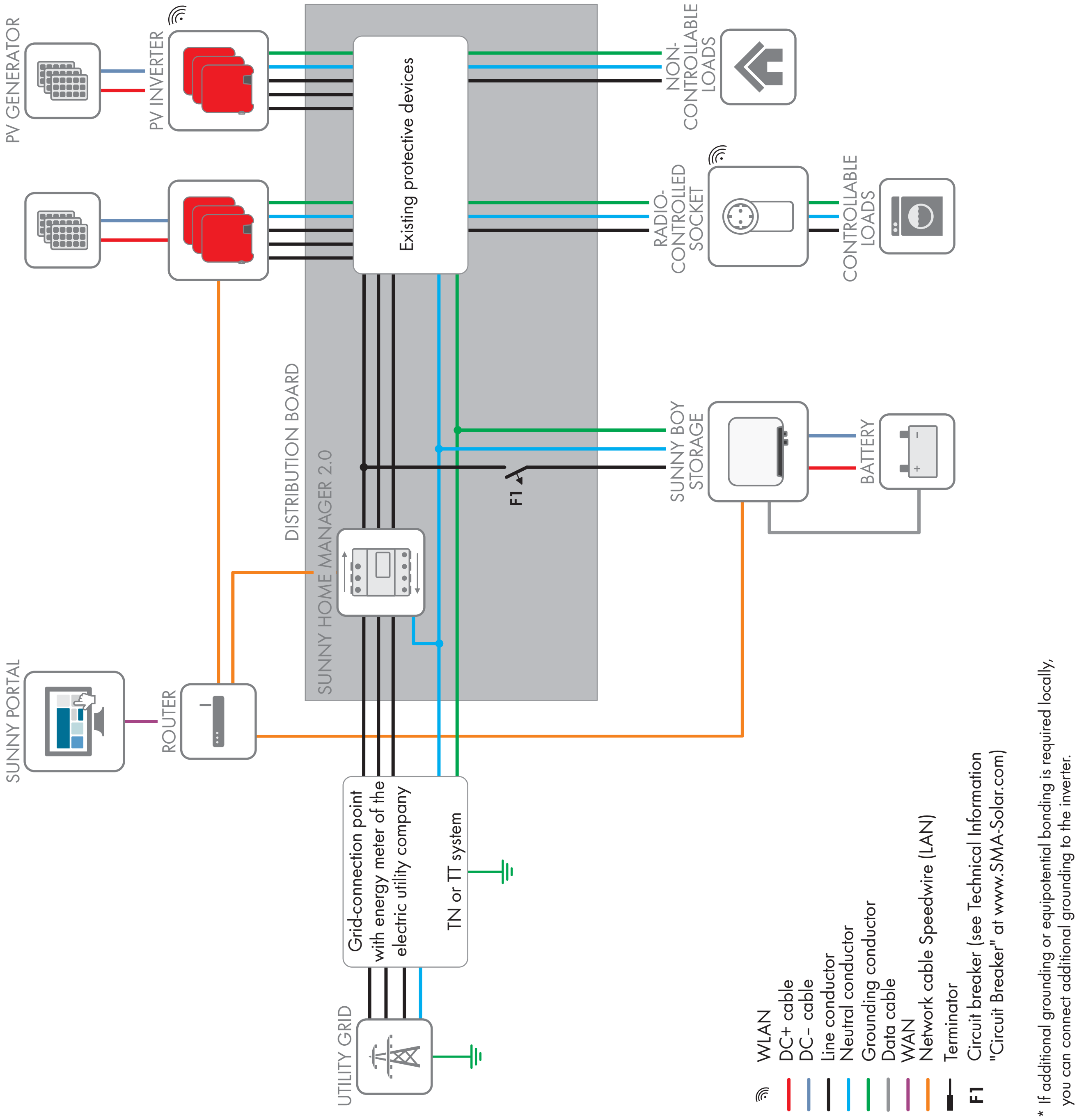


Figure 23: Circuitry of a single-phase Sma Flexible Storage System with Sunny Boy Storage and optional Sunny Home Manager (example)

7.2.4 Circuitry Overview and Material List of the Three-Phase SMA Flexible Storage System

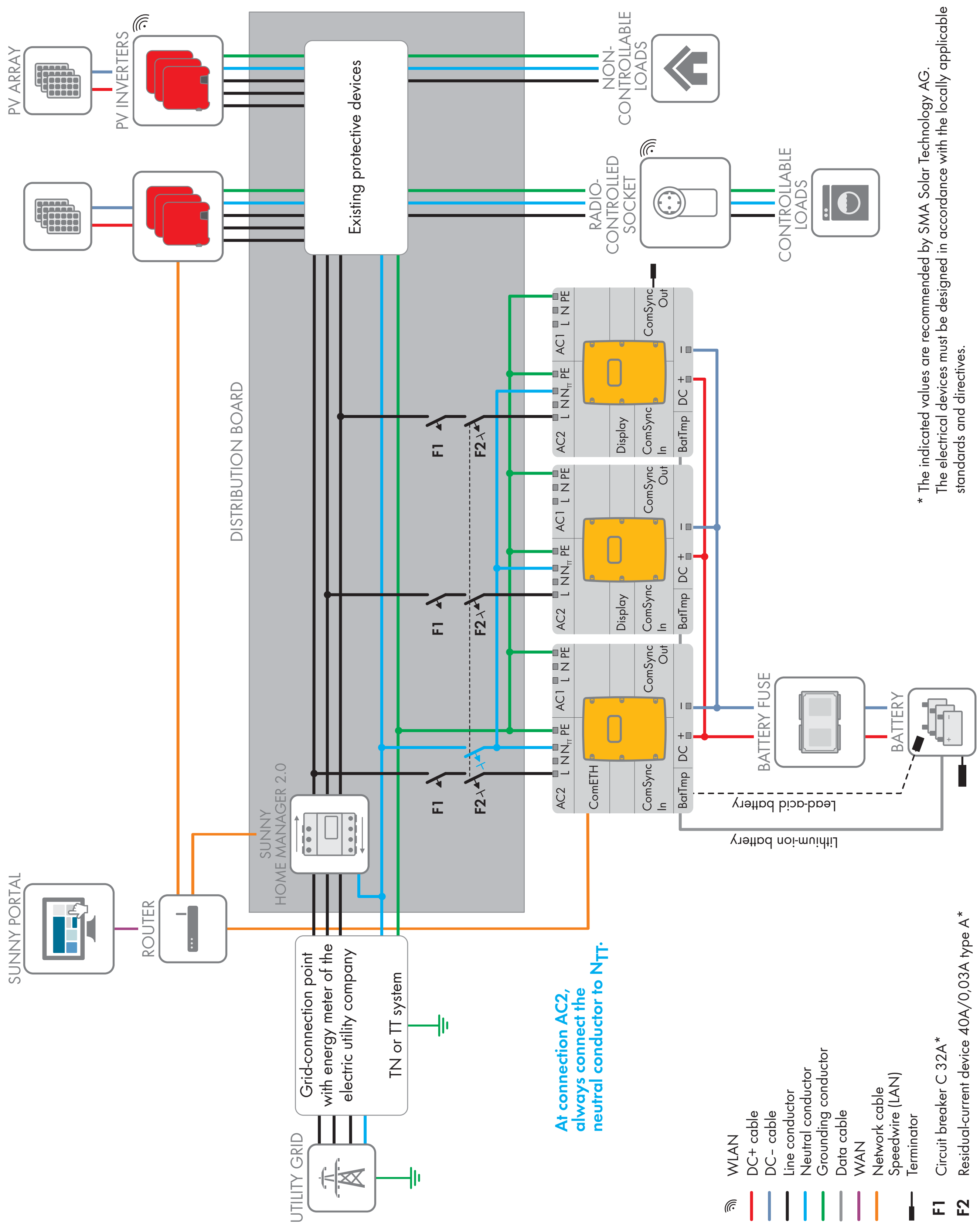


Figure 24: Circuitry of the three-phase SMA Flexible Storage System for TN and TT systems (example)

Material for Circuitry of the Three-Phase SMA Flexible Storage System

Material	Number of units	Description
Circuit breaker for protection of the Sunny Island inverter	3	32 A, C rating, 1-pole
Residual-current device	1	40 A/0.03 A, 3-pole + N, type A

A **wiring diagram** will be supplied whenever a Sunny Island 3.0M / 4.4M / 6.0H / 8.0H is ordered.

7.2.5 System Design of an SMA Flexible Storage System with Diagrams

The design serves as an orientation and a starting point for in-depth system planning. The considerations on system planning put forward in this section refer exclusively to intermediate storage of PV energy in the SMA Flexible Storage System.

In order to design the system using these diagrams, the following starting parameters must be known:

- Peak power of the PV system
- Usable battery capacity
- Annual energy demand of the loads

Diagrams for System Design

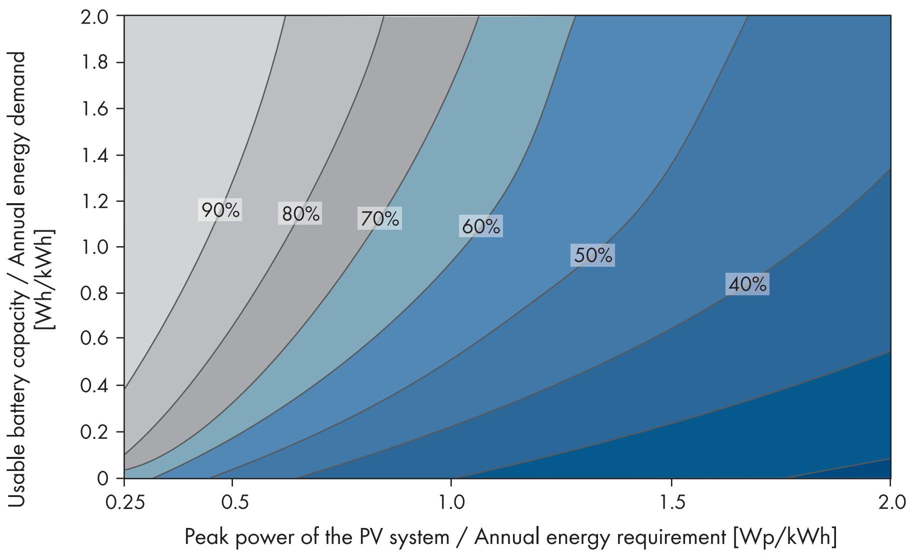


Figure 25: Estimation of the self-consumption quota

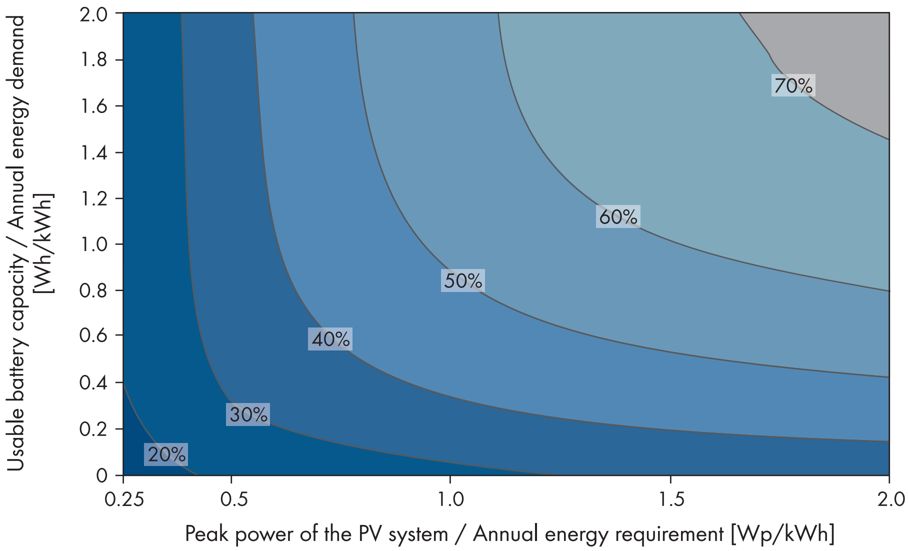


Figure 26: Estimation of the self-sufficiency quota

Step 1: Estimating the Self-Consumption Quota for Energy Management without Intermediate Storage

To design an SMA Flexible Storage System, you estimate in the first step the possible self-consumption quota for energy management without intermediate storage. The self-consumption quota for energy management without intermediate storage always takes into account the natural self-consumption attainable in one year which is dependent on the annual energy demand and on the peak power of the PV system. Increased self-consumption through automatic load control also influences the self-consumption quota for energy management without intermediate storage.

Example:

Input data:

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Usable battery capacity: 0 Wh, as in step 1 the self-consumption quota is estimated without intermediate storage.

$$\frac{\text{Peak power}}{\text{Annual energy demand}} = \frac{5{,}000\ \text{Wp}}{5{,}000\ \text{kWh}} = 1\ \text{Wp/kWh}$$

$$\frac{\text{Usable battery capacity}}{\text{Annual energy demand}} = \frac{0\ \text{Wh}}{5{,}000\ \text{kWh}} = 0\ \text{Wh/kWh}$$

Transfer the calculated values to the diagram to estimate the self-consumption quota.

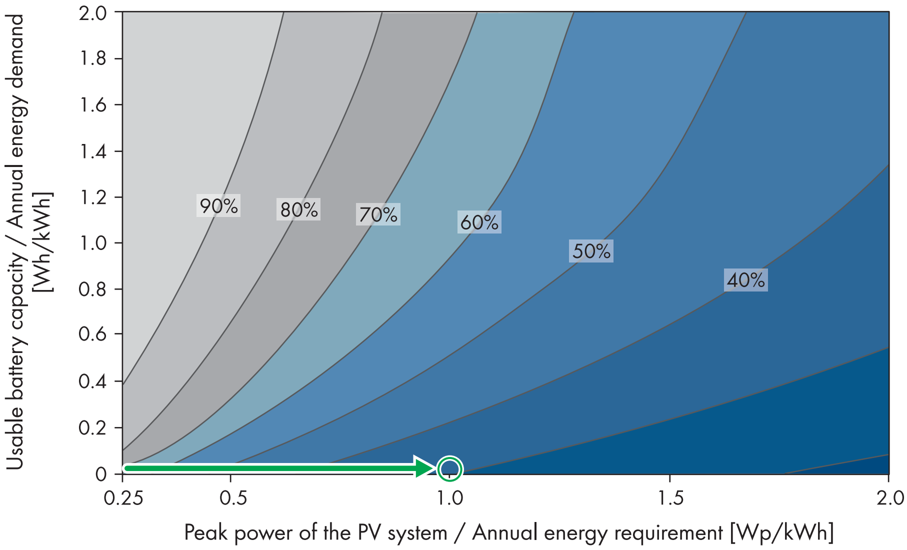


Figure 27: Estimation of the self-consumption quota without intermediate storage

The estimate reveals that, with energy management without intermediate storage, the on-site loads use 30% of the generated PV energy.

Step 2: Estimating the Self-Consumption Quota for Energy Management with Intermediate Storage

With the SMA Flexible Storage System, you can influence the self-consumption quota by changing the battery capacity. You must bear in mind that intermediate storage of the PV energy requires frequent charging and discharging of the battery. This frequent charging and discharging quickly raises the number of battery charging cycles. The maximum number of charging cycles of a battery is limited and depends on the used battery capacity. The number of possible charging cycles does, however, influence the service life of a battery.

To extend the service life of the battery, the Sunny Island uses only a portion of the total battery capacity for intermediate storage. This portion depends on the battery technology used and is referred to as usable battery capacity in the following. The usable battery capacity can be configured on the Sunny Island.

With lead-acid batteries, the usable battery capacity is approximately 50% of the total battery capacity, and for lithium-ion batteries it is approximately 80%. For detailed information on the usable battery capacity and the possible charging cycles, contact the battery manufacturer.

Example:

Input data:

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Total battery capacity: 10000 Wh, of which the Sunny Island uses 50% for intermediate storage of PV energy.*

The usable battery capacity therefore amounts to 5000 Wh.

$$\frac{\text{Peak power}}{\text{Annual energy demand}} = \frac{5{,}000\ \text{Wp}}{5{,}000\ \text{kWh}} = 1\ \text{Wp/kWh}$$

$$\frac{\text{Usable battery capacity}}{\text{Annual energy demand}} = \frac{5000\ \text{Wh}}{5000\ \text{kWh}} = 1\ \text{Wh/kWh}$$

Transfer the calculated values to the diagram to estimate the self-consumption quota.

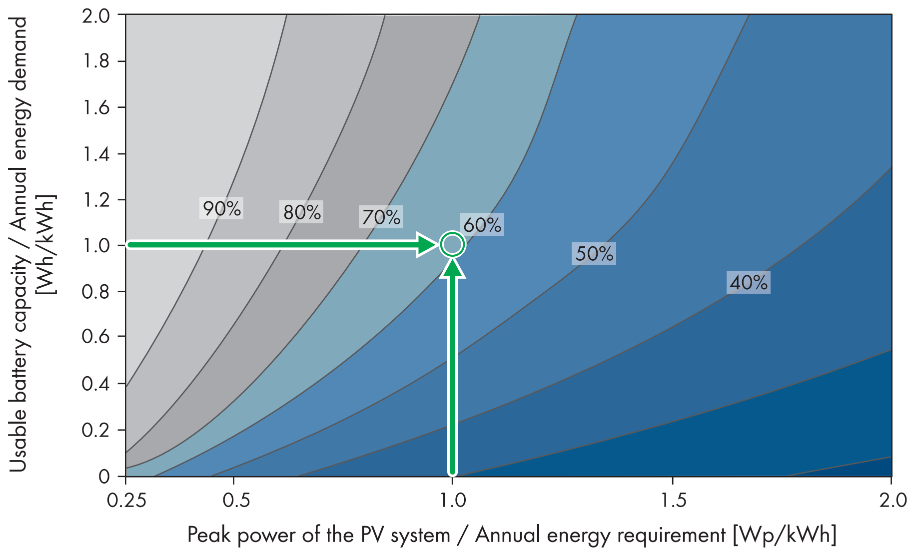


Figure 28: Estimation of the self-consumption quota with intermediate storage

The estimate reveals that the self-consumption quota, with energy management with intermediate storage, is approximately 60%.

* Due to the seasonal battery operation of the Sunny Island, the use of the battery for intermediate storage is limited in winter and extended in summer. Therefore, a usable range of 50% for intermediate storage can continue to serve as the basis for the estimate.

Step 3: Calculating Increased Self-Consumption through Intermediate Storage of the PV Energy

Example:

Input data:

- Self-consumption quota with energy management without intermediate storage: 30%
- Self-consumption quota with energy management with intermediate storage: 60%

$$\text{Self-consumption rate with buffering} - \text{Self-consumption rate without buffering} = 60\% - 30\% = 30 \text{ percentage points}$$

In this example, the self-consumption quota increased by 30 percentage points due to intermediate storage of energy.

Step 4: Estimating the Battery Service Life

Taking the guaranteed PV feed-in tariff for a 20-year period as a basis, the battery will need to be replaced at least once due to its calendar life expectancy. Therefore, for optimal efficient use of the battery, we recommend that you replace it after approximately ten years.

The first step in sizing the battery consists of establishing the number of annual nominal energy throughputs.
In one nominal energy throughput, the battery is fully discharged once and then charged again to 100%.
The number of nominal energy throughputs per year can be calculated as follows:

$$\text{Annual nominal energy throughput} = \frac{\text{Generated PV energy} \cdot \text{increased self-consumption}}{\text{Total battery capacity}}$$

You can calculate the battery life using the total number of nominal energy throughputs for 100% cycles specified by the battery manufacturer:

$$\text{Battery life} = \frac{\text{Total number of nominal energy throughputs}}{\text{Annual nominal energy throughput}}$$

Example:

Input data:

- Generated PV energy: 4500 kWh (assumed value for a PV system in central Germany with a peak power of 5000 Wp of the PV system)
- Increased self-consumption (step 3): 30 percentage points
- Total battery capacity: 10 kWh
- Total number of nominal energy throughputs for 100% cycles: 1200 (lead-acid battery, OPzV, from the datasheet of a battery manufacturer)

$$\text{Annual nominal energy throughput} = \frac{4500 \text{ kWh} \cdot 0.30}{10 \text{ kWh}} = 135$$

$$\text{Battery life} = \frac{1{,}200}{135/a} = 8.89 \text{ years} \sim 9 \text{ years}$$

Influence of battery capacity on battery life

To increase a battery life that is too short, you can select a larger battery capacity. Changing the battery capacity also results in a change in increased self-consumption.

- Repeat current system design from step 2.

Step 5: Estimating the Self-Sufficiency Quota for Energy Management without Intermediate Storage

Example:

Input data:

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Usable battery capacity: 0 Wh, as in step 5, the self-sufficiency quota for energy management without intermediate storage is estimated.

$$\frac{\text{Peak power}}{\text{Annual energy demand}} = \frac{5{,}000 \text{ Wp}}{5{,}000 \text{ kWh}} = 1 \text{ Wp/kWh}$$

$$\frac{\text{Usable battery capacity}}{\text{Annual energy demand}} = \frac{0 \text{ Wh}}{5{,}000 \text{ kWh}} = 0 \text{ Wh/kWh}$$

Transfer the calculated values to the diagram to estimate the self-sufficiency quota.

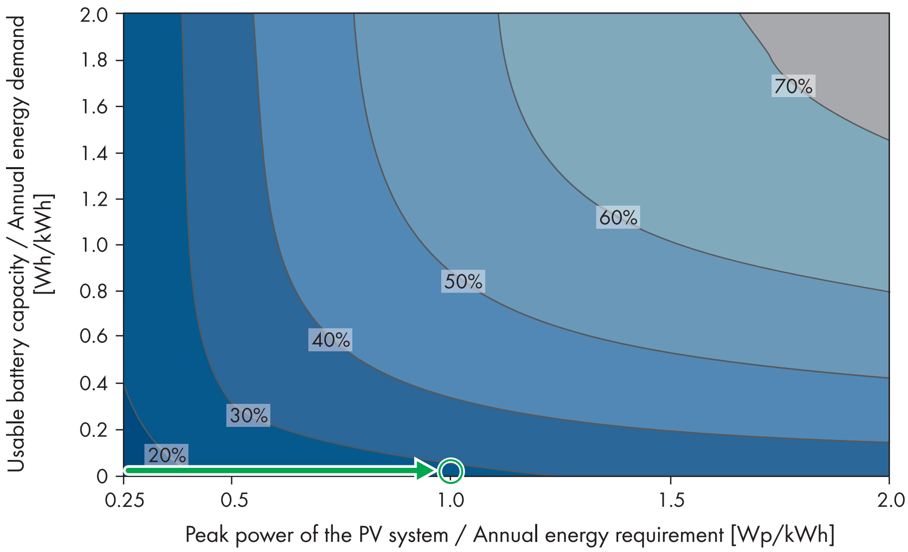


Figure 29: Estimation of the self-sufficiency quota without intermediate storage

The estimate reveals that with energy management without intermediate storage, a self-sufficiency quota of approximately 28% is achieved.

Step 6: Estimating the Self-Sufficiency Quota for Energy Management with Intermediate Storage

Example:

Input data:

- Peak power of the PV system: 5000 Wp
- Annual energy demand: 5000 kWh
- Total battery capacity: 10000 Wh, of which the Sunny Island uses 50% for intermediate storage of the PV energy.

The usable battery capacity therefore amounts to 5000 Wh.

$$\frac{\text{Peak power}}{\text{Annual energy demand}} = \frac{5{,}000\ \text{Wp}}{5{,}000\ \text{kWh}} = 1\ \text{Wp/kWh}$$

$$\frac{\text{Usable battery capacity}}{\text{Annual energy demand}} = \frac{5000\ \text{Wh}}{5000\ \text{kWh}} = 1\ \text{Wh/kWh}$$

Transfer the calculated values to the diagram to estimate the self-sufficiency quota.

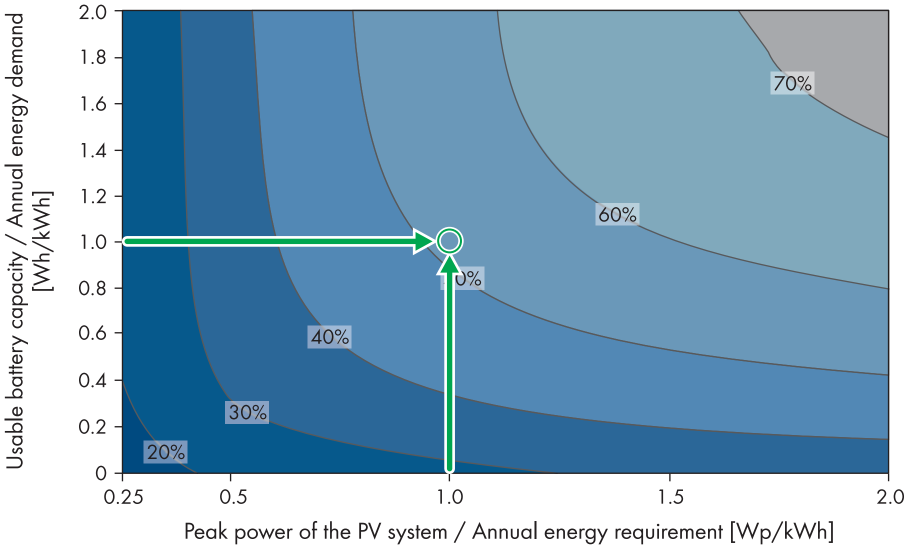


Figure 30: Estimation of the self-sufficiency quota with intermediate storage

The estimate reveals that the self-sufficiency quota, with energy management with intermediate storage, is approximately 52%.

8 System Design with Sunny Design

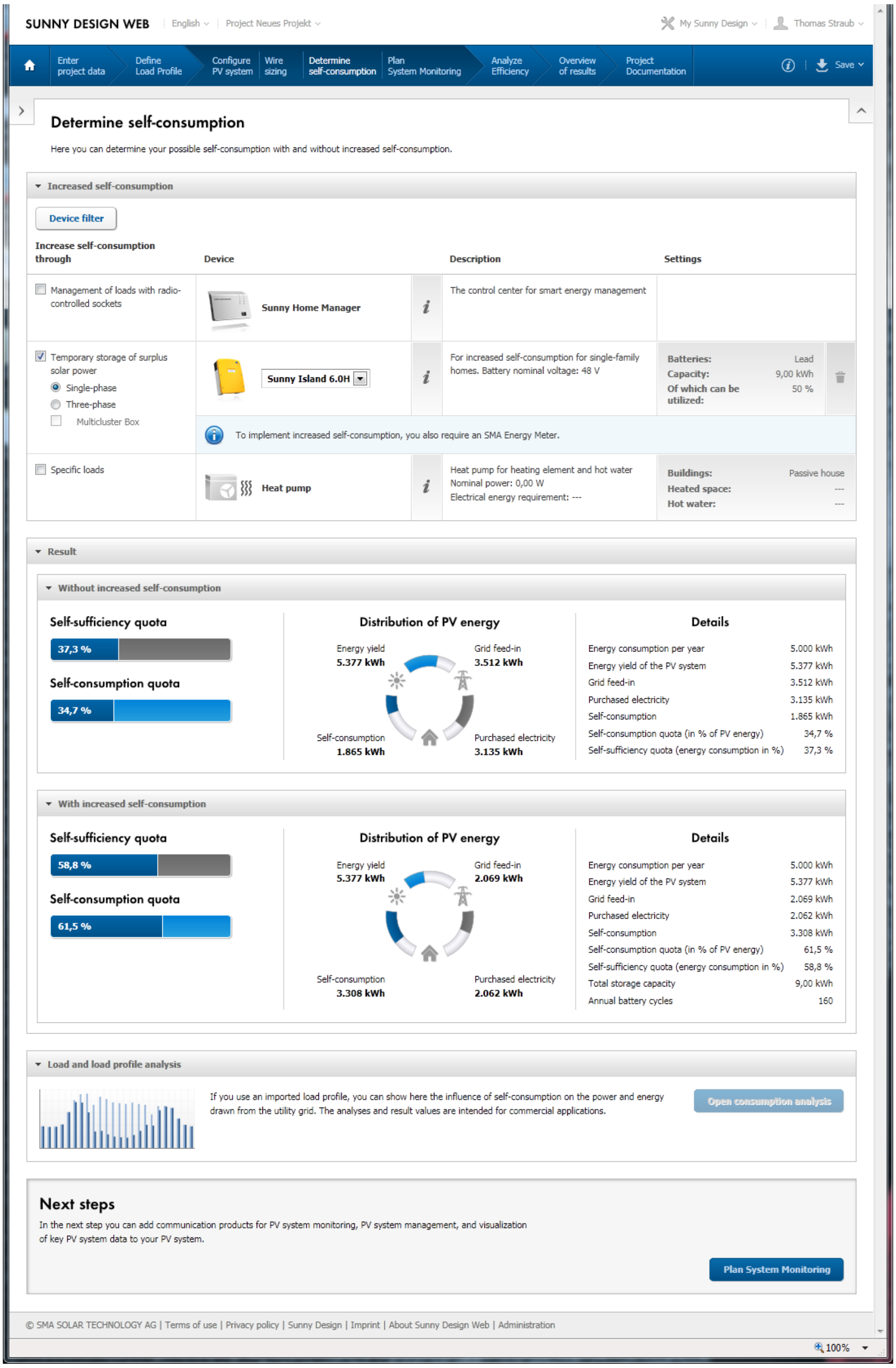


Figure 31: Example of system design with Sunny Design Web with determination of self-consumption

Sunny Design is a software for planning and designing PV systems and PV hybrid systems. Sunny Design offers possible suggestions about how your PV system, your SMA Integrated Storage System or your SMA Flexible Storage System should be designed. You also obtain an estimate of the self-consumption quota and the self-sufficiency quota that you can achieve with the proposed solutions for energy management.

Sunny Design is available as an online version "Sunny Design Web" and as a desktop version "Sunny Design 3". You can only use the online version of Sunny Design Web via the Internet (www.SunnyDesignWeb.com). You must install the desktop version of Sunny Design 3 on your computer and, after initial registration, you do not need an Internet connection (for documentation and download, see www.SMA-Solar.com).

9 Frequently Asked Questions

Is it possible to measure currents of more than 63 A per line conductor with the SMA Energy Meter and/or Sunny Home Manager 2.0?

If one additional external current transformer is installed for each line conductor, the SMA Energy Meter and/or Sunny Home Manager 2.0 can be operated with currents of more than 63 A per line conductor.
SMA Solar Technology AG recommends current transformers designed for a secondary current of 5 A. The current transformers should have at least accuracy class 1.

Can I only use the Sunny Boy Smart Energy within the SMA Integrated Storage System?

If no automatic load control is required, you can also equip a PV system solely with the Sunny Boy Smart Energy. With this option however, you implement only the intermediate storage of PV energy.

To use the Sunny Boy Smart Energy inverter without the Sunny Home Manager, you require an SMA Energy Meter and a router / network switch for the Internet connection to Sunny Portal.

Can I also use the Sunny Boy Smart Energy as an Off-Grid System or as a Battery-Backup System?

The Sunny Boy Smart Energy must not be used in off-grid systems or in battery-backup systems since it cannot provide its own utility grid. To set up an off-grid system or a battery-backup system, SMA Solar Technology AG offers the Sunny Island (for information on the Sunny Island in an off-grid system and in the SMA Flexible Storage System with a battery-backup function, see www.SMA-Solar.com).

Is the Sunny Boy Smart Energy compatible with other battery types?

No: The Sunny Boy Smart Energy must only be operated with the Battery Pack Smart Energy of type "BAT-2.0-A-SE-10".

Is the SMA Integrated Storage System also available with a larger battery capacity?

No: The Sunny Boy Smart Energy is fitted with one Battery Pack Smart Energy with a battery capacity of 2 kWh. The usable battery capacity of the SMA Integrated Storage System therefore amounts to 2 kWh.
Increasing the battery capacity through an additional Battery Pack Smart Energy is not possible.

Is a three-phase implementation of the SMA Integrated Storage System also possible?

No: Parallel operation of multiple Sunny Boy Smart Energy devices is not possible.

Can devices with BLUETOOTH interface also communicate with the Sunny Boy Smart Energy?

No: The Sunny Boy Smart Energy has only two Speedwire interfaces. These enable fast and secure communication but require a connection with network cables.

Can devices with BLUETOOTH interface also communicate with the Sunny Boy Storage?

No: The Sunny Boy Storage, however, is equipped with a Speedwire and WLAN interface.

Can existing PV systems be retrofitted with the Sunny Home Manager or the SMA Flexible Storage System?

Yes. New and existing PV systems can be retrofitted with the Sunny Home Manager or the SMA Flexible Storage System.

Do any limitations apply to the PV System when using the SMA Flexible Storage System?

No: The SMA Flexible Storage System is technically independent of the peak power of the PV system. Whether the intermediate storage of PV energy on site makes economic sense will need to be evaluated in each individual case.

- Use Sunny Design Web to design and evaluate an SMA Flexible Storage System (Sunny Design, see www.SMA-Solar.com).

  or

- Use the method described in this document to design and evaluate an SMA Flexible Storage System (see Section 7.2.5 "System Design of an SMA Flexible Storage System with Diagrams", page 52).

Can PV inverters from other manufacturers be installed together with a Sunny Island or a Sunny Boy Storage?

If you want to retrofit an existing PV system with the Sunny Island or a Sunny Boy Storage for intermediate storage of PV energy, but do not require active power limitation, you can use PV inverters from any manufacturer. Active power limitation may be stipulated by the grid operator or may bring financial rewards due to local legislation (e.g. the PV storage incentive program in Germany).

Which batteries can be used with the SMA Flexible Storage System?

The Sunny Island supports all lead-acid batteries of types FLA and VRLA as well as various lithium-ion batteries (see Section 7.2.1, page 47). The Sunny Boy Storage supports selected lithium-ion batteries (see Technical Information "Overview of approved lithium-ion batteries" under www.SMA-Solar.com).

Which battery capacities can be implemented with the SMA Flexible Storage System?

The battery capacity for an SMA Flexible Storage System with Sunny Island can be freely selected within a wide range.

- Lead-acid batteries with a capacity of 100 Ah to 10000 Ah can be connected.
- Lithium-ion batteries with a capacity of 50 Ah to 10000 Ah can be connected.

This corresponds to a maximum storage capacity of 480 kWh for a battery with 48 V and 10,000 Ah.

The battery capacity for an SMA Flexible Storage System with Sunny Boy Storage is prescribed by the lithium-ion battery used.

Is it possible, in addition to the PV system, to connect other AC sources to the SMA Flexible Storage System?

You can also connect other AC sources to a Sunny Island or Sunny Boy Storage, for example, a combined heat and power plant (CHP plant). Within the SMA Flexible Storage System, you should note the following:

i The Sunny Home Manager does not support wind power inverters or CHP plants

Up to now, the Sunny Home Manager only supports PV inverters. If your Sunny Island or Sunny Boy Storage combines various AC sources (e.g. a PV system and a small wind turbine system), the Sunny Home Manager can only detect the PV inverters and limit their power. In the Sunny Home Manager system, up to now, no wind power inverters or CHP plants are displayed in Sunny Portal. Since the data from wind power inverters or CHP plants cannot be taken into account by the Sunny Home Manager, the data calculated in Sunny Portal and the displayed diagrams may be inaccurate.

Can I connect a single-phase system for intermediate storage of energy to a three-phase PV inverter?

Yes: Single-phase systems for intermediate storage of energy can also be connected to three-phase PV inverters.

Note: With single-phase Sunny Island systems for intermediate storage with three-phase inverters, the optional battery-backup function only works to a limited extent since, in the event of a grid failure, the three-phase PV inverter cannot be used for battery recharge (see Planning Guidelines "SMA Flexible Storage System with battery-backup function").

How much maintenance work does the SMA Flexible Storage System involve?

The Sunny Island and the Sunny Boy Storage are largely maintenance-free (see operating manual of the Sunny Island or Sunny Boy Storage). Information on battery maintenance can be obtained from the battery manufacturer.

Will I receive information on the Sunny Boy Storage in Sunny Portal?

Yes: The Sunny Boy Storage is equipped with a Webconnect function as standard. The Webconnect function enables direct data transmission between the inverters and the Internet portal Sunny Portal without any additional communication device and for a maximum of four inverters per Sunny Portal system.

It is also possible to integrate the Sunny Boy Storage into Sunny Portal via Sunny Home Manager.

What is the rated power of the Sunny Island?

Product	Rated power of the Sunny Island inverter
Sunny Island 3.0M	2.3 kW
Sunny Island 4.4M	3.3 kW
Sunny Island 6.0H	4.6 kW*
Sunny Island 8.0H	6.0 kW*

* For the intermediate storage of PV energy in Germany, the output power of the Sunny Island inverter is limited to 4.6 kW per phase due to standard requirements.

Is it possible for two Sunny Islands or Sunny Boy Storage to feed in via a single phase?

No: Only one Sunny Island or Sunny Boy Storage per phase is allowed to feed in.

Can I use a Sunny Island or Sunny Boy Storage only within the SMA Flexible Storage System?

If no automatic load control and no limitation of the active power feed-in are required, you can equip a PV system solely with a Sunny Island or Sunny Boy Storage and do without the complete SMA Flexible Storage System installation. With this option, however, you implement only the intermediate storage of PV energy.

For a purely Sunny Island storage system, the following SMA products are required:

- Sunny Island 3.0M / 4.4M / 6.0H / 8.0H
- SMA Speedwire data module for Sunny Island
- SMA Energy Meter
- Sunny Remote Control
- BatFuse B.01/B.03

In a Sunny Island storage system, the SMA Energy Meter must be connected directly to the Sunny Island via a network cable.

The Sunny Island receives no data regarding PV generation. This means that the Sunny Island cannot display some of its parameters, e.g. the increased self-consumption values.

For a purely Sunny Boy Storage system, the following SMA products are required:

- Sunny Boy Storage
- SMA Energy Meter

Can the Sunny Boy Storage be operated with three phases?

No: The Sunny Boy Storage can only be operated with one phase.

Can the Sunny Boy Storage without a Sunny Home Manager limit active power feed-in of a PV system?

Yes: The Sunny Boy Storage without a Sunny Home Manager is able to limit active power feed-in of a PV system under the following conditions:

– A maximum of three inverters can be installed in the PV systems.
– All PV inverters in the PV system must be equipped with Webconnect function.

Can the Sunny Boy Storage be used as WLAN access for PV inverters?

No: As all network participants, PV inverters also need a direct WLAN access.

10 Glossary

Battery-backup function

The battery-backup function in the context of these planning guidelines is the capacity of an energy management system to also function as a battery-backup system.

Battery-backup system

A battery-backup system provides an electricity supply for loads in the event of grid failure. In this case, in the event of grid failure, the battery-backup system automatically switches from the utility grid to the alternative energy source, e.g. PV system and battery.

Battery charging

Battery charging is the power that is currently being charged to the battery.

Battery cycle

In a battery cycle, the battery is discharged once from 100% of the nominal capacity to a depth of discharge specified by the manufacturer and than recharged up to 100% of the nominal capacity.

Battery discharging

Battery discharging is the power that is currently being drawn from the battery. Battery discharging takes place when the energy demand of the loads exceeds the current power of the PV system.

Cycle stability

The cycle stability is a characteristic for the service life of a battery. The cycle stability indicates how many times a battery can be discharged and charged before the available battery capacity falls below a specific value (see the battery manufacturer's specifications).

Direct consumption

The direct consumption is the power that the loads draw directly from the PV system. Flexible loads are switched on at the time when their energy demand is completely covered by the PV system.

Energy management

Energy management is the total of all measures to optimize the consumption of the energy made available by a PV system. The objective of this optimization is either the highest possible self-sufficiency quota or the highest possible self-consumption quota.

Energy management system

An energy management system optimizes energy flows automatically and intelligently, increases self-consumption, or improves internal power supply.

Feed-in meter

The feed-in meter is an energy meter for recording grid feed-in.

FNN

The FNN is the network technology / network operation forum in the Association for Electrical, Electronic and Information Technologies.

Grid failure

A grid failure is an outage of the utility grid. If the utility grid deviates from the country-specific thresholds for voltage and frequency, the Sunny Island will react in the same way as if a utility grid failure has occurred.

Grid feed-in

The grid feed-in is the electric power that is currently being fed into the utility grid.

Intermediate storage

Intermediate storage in a battery is a means of energy management. It enables the consumption of PV energy independent of the time of generation, e.g. in the evening or during bad weather. This means that time-controlled electrical appliances can also be operated with PV energy.

Internal power supply

With internal power supply, the loads in your household cover their energy demand with PV energy generated on site. Internal power supply is made up of direct consumption and battery discharging.

Natural self-consumption

A typical four-person household in Germany, with a 5 kWp PV system, achieves a self-consumption quota of approximately 30% through natural self-consumption. However, this is only a rough approximate value due to the dependence of the self-consumption quota on the individual generation profile and the load profile. The orientation of the PV array, the weather, and temporary shading are decisive factors determining the individual generation profile, while individual consumption habits are decisive for the load profile.

Purchased electricity

The purchased electricity is the electric power that is currently being drawn from the utility grid.

Purchased electricity meter

The purchased electricity meter is an energy meter for recording purchased electricity.

PV generation

The PV generation is the electric power that is currently being provided by the PV system.

PV production meter

The PV production meter is an energy meter for recording PV generation.

Self-consumption

Self-consumption is a measure of the amount of PV energy used at the point of generation or in the immediate vicinity. Self-consumption is made up of direct consumption and battery charging.

Self-consumption quota

The self-consumption quota is the current ratio of self-consumption to PV generation.

Self-sufficiency quota

The self-sufficiency quota is the current ratio of internal power supply to the energy demand of all loads. The loads can cover their energy demand from the PV system, from the utility grid, and from any available batteries.

VDE

The VDE is the Association for Electrical, Electronic and Information Technologies, its sciences and the technologies and procedures based on them.

11 Appendix

11.1 Country-Dependent Availability of the SMA Products for Energy Management Systems

This section is an overview of the most important SMA products for energy management systems and their availability by country (as of March 2017, further availabilities on request).

Country	**Australia**	**Belgium**	**Denmark**	**Germany**	**France**	**Greece**	**Great Britain**	**Italy**	**Luxembourg**	**The Netherlands**	**Austria**	**Portugal**	**Switzerland**	**Spain**	**Czech Republic**
Sunny Home Manager 2.0 	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sunny Boy Smart Energy 	✓	✓	–	✓	–	–	✓	✓	–	✓	–	–	–	–	–
Sunny Boy Storage 	✓	✓	–	✓	–	–	✓	✓	–	–	✓	–	✓	–	–
Sunny Island 3.0M / 4.4M / 6.0H / 8.0H 	–	✓	✓	✓	–	–	✓	–	–	–	✓	–	✓	–	–
SMA Energy Meter 	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ SMA product is available – SMA product is **not** available

Additional information, e.g. on the availability of PV inverters, is available at www.SMA-Solar.com.

11.2 Information on Planning Mounting Locations

The products within the SMA Smart Home system solution have requirements with regard to their mounting locations:

- Sunny Home Manager
- Radio-controlled sockets
- SMA Energy Meter
- Sunny Boy 3600 / 5000 Smart Energy
- Sunny Island 3.0M / 4.4M / 6.0H / 8.0H with battery
- Sunny Boy Storage
- Sunny Remote Control
- BatFuse B.01/B.03

The following points should be considered as early as the planning stage:

☐ The minimum clearances to walls, objects, SMA products or other technical devices must be complied with.

☐ The ambient conditions at the planned deployment sites must meet the requirements the individual products place on the mounting locations.

☐ The maximum cable routes and radio ranges between the listed SMA products and to other devices must be feasible.

☐ The cable cross-sections and conductor materials of the planned cables must meet the requirements of the listed products.

☐ SMA Integrated Storage System: The Sunny Boy Smart Energy with the Battery Pack Smart Energy must only be operated at an ambient temperature of 0°C to 40°C and a relative humidity of 5% to 95%.

☐ SMA Flexible Storage System: The planned battery room must meet the requirements of the battery manufacturer.

Links to additional information can be found at www.SMA-Solar.com:

Energy management system	Document title	Document type
Sunny Home Manager 2.0*	Sunny Home Manager	Operating manual
SMA Integrated Storage System	Sunny Home Manager	Operating manual
	Sunny Boy 3600 / 5000 Smart Energy Battery Pack Smart Energy	Operating manual
	SMA Energy Meter	Installation manual
SMA Flexible Storage System with Sunny Island and Sunny Boy Storage*	Sunny Home Manager	Operating manual
	Sunny Island 3.0M / 4.4M / 6.0H / 8.0H	Installation manual
	Sunny Boy Storage 2.5	Operating manual
	Sunny Remote Control	Mounting instructions
	BatFuse B.01/B.03	Installation manual
	SMA Energy Meter	Installation manual

* For the requirements on the mounting location of the installed PV inverters, see the PV inverter installation manual

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www.SMA-Solar.com