DEMANDS ON THE CONTROL SYSTEM OF AN INVERTER IN A PV STORAGE SYSTEM

MULTI FLOW TECHNOLOGY

1. Introduction

The trend in recent years of rising electricity prices and the falling costs of photovoltaic (PV) systems mean that the cost of generating electricity from PV is now significantly lower than the purchase price of electricity. With feed-in tariffs falling steadily at the same time, it is becoming an increasingly attractive proposition for system owners to use the energy they generate themselves rather than to feed it into the grid. To maximise what is referred to as self-consumption, electrical storage systems are frequently being used alongside energy management systems. These PV storage systems demand of the inverters much more complex control systems and current flows than has previously been the case. This is exacerbated by the fact that the use of storage systems is resulting in a greater focus not only on maximising self-consumption but also the use of additional functions, such as:

- Optimised response to load- and/or time-dependent electricity tariffs
- Improvements in grid quality (e.g. voltage retention)
- Emergency power in the event of a power failure

This article illustrates what effects these functions have on the technical demands placed on the inverter and how the Fronius Symo Hybrid series satisfies these demands.

2. Energy flows in the storage system

A fully configured PV storage system can be characterised by the five load flows shown below (Fig. 1).

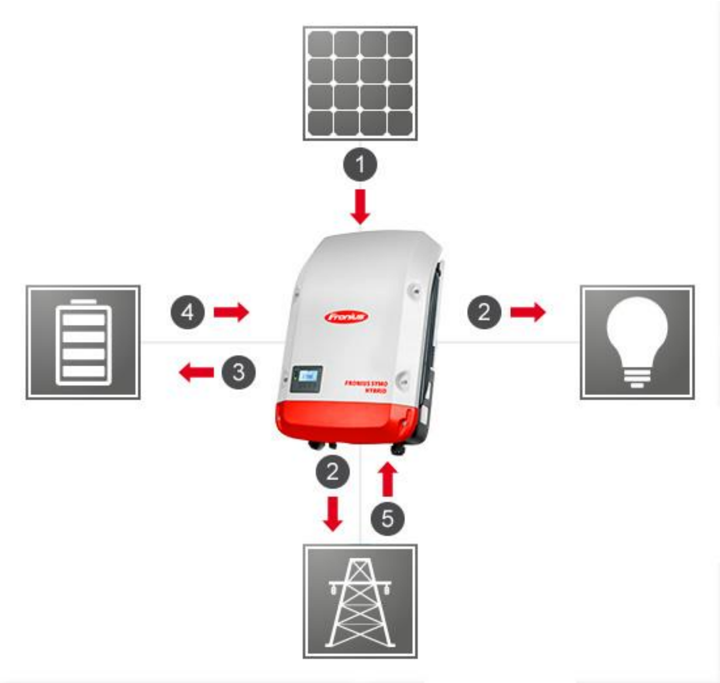


Fig.1: Energy flows in a storage system

1. PV generator → inverter: PV current
2. Inverter → consumer or into the grid: feed-in current
3. Inverter → battery: charging current to the battery
4. Battery → inverter: discharge current from the battery
5. AC grid → inverter: charging current to the battery from the AC grid

The first two energy flows are typical of a PV system with no storage facilities. However, storage systems must also be able to handle energy flows nos. 3 and 4 so they can charge and discharge the battery. Energy flow no. 5 – charging the battery from the AC grid – is not an absolute requirement as a basic function of a storage system, which is why this operating mode is not supported by every type of storage inverter. Be that as it may, this operating mode supports numerous additional applications, some of which are already important today and will become increasingly so in the future, as the following examples show.

2.1. AC charging function

Even though the AC charging function has no immediate relevance when it comes to optimising self-consumption, a closer examination reveals a wealth of applications that would not be possible were it not available. Charging via AC can take place using either energy sources on the private (domestic) grid or the public grid (grid supply). Examples of AC charging applications can be seen from the perspective of the three following stakeholder groups.

2.1.1. From the viewpoint of the system operator

/ Coupling with other energy sources (AC coupling)

There is a steadily growing range of small combined heat and power stations (micro CHPs) and even low-output wind farms on the market. These systems make electrical energy available even when PV yields are low (winter) and the PV storage system is running well below capacity. The AC charging function enables surplus electricity from these complementary (local) sources to be stored temporarily in the PV storage system and then drawn off at a later date.

Furthermore, AC coupling allows a storage system to be easily retrofitted into an existing PV system.

/ Conservation charging

If no, or very little, PV energy is available over longer periods (faulty PV modules, snow-covered PV generator, etc.), the AC charging function prevents deep discharge of the storage system and the ensuing premature degradation of the battery.

/ Minimum charge for emergency power situations

The configuration of many PV storage systems enables emergency power to be supplied to the property in the event of a power failure. Irrespective of the insolation conditions, AC charging ensures that there is always a certain minimum charge in the storage system. It is also worth noting that there will still be sufficient time to fully charge the system whenever notice of a grid shutdown is received.

2.1.2. From the viewpoint of electricity market players

/ Time-dependent electricity tariffs

The emergence of intelligent electricity meters (Smart Meters) has persuaded progressive electricity providers to offer their customers time-dependent electricity tariffs. This allows the storage system to be stocked up with electricity from the grid during low-price periods so that it can be used to heat the home during the periods when the price is higher. This facility is particularly useful at times when insolation levels are low.

/ Use of storage system flexibility for balance group optimisation

The role of the electricity markets (kWh markets), and hence their respective players, is to balance supply (generation) and demand (consumption) as equally as possible before the electricity is needed. As PV and wind in particular are susceptible to natural fluctuations, good forecasting tools together with a range of flexible options are essential if these energy sources are to be successfully integrated into the market. Decentralised battery banks (combined to create a “virtual power station”) are one such option.

2.1.3. From the viewpoint of grid operators

/ Improving grid quality

The increasing number of PV systems in grids is resulting in more and more pressure on them to contribute towards the provision of grid services. The use of storage systems means that PV systems are increasingly able to play a major role in voltage and frequency retention. An AC charging function that supplies energy to the storage system as needed in line with specific (e.g. local voltage-dependent) control mechanisms can enhance the usefulness to the grid of a PV system with a battery.

/ Participation in the electricity balancing market

Transmission network operators compensate for the imbalance in the electricity markets (generation and consumption not on a par at the point of delivery) by drawing on control power. Control power is purchased according to market factors (electricity balancing markets). In much the same way as the electricity market players employ flexibility (see above), the decentralised battery bank (combined to create a “virtual power station”) also offers a flexible option regarding the purchase of control power.

Fronius
SHIFTING THE LIMITS

3. Multi Flow Technology

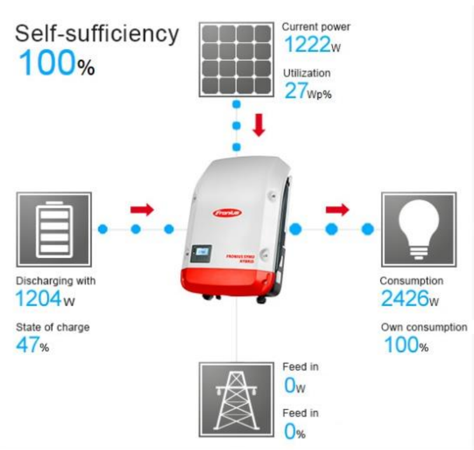
The energy flows described in the previous section are necessary to ensure the optimum operation of PV storage systems. Not only is the inverter required to manage these operating modes, the question whether these currents can flow in parallel (simultaneously) is also pertinent. The Multi Flow Technology used in the Fronius Symo Hybrid series represents a comprehensive approach to energy flow control in which the inverter becomes an intelligent control centre for all current flows. The following examples illustrate the advantages of Multi Flow Technology and highlight the differences compared with a storage system that does not benefit from the technology.

<table>
<tr>
<td>

/ Simultaneous supply to the home from PV and battery
To cover energy requirements in the home, the output from the PV system is used with any shortfall being simultaneously drawn from the battery.

If Multi Flow Technology were not available, i.e. if these energy flows could not be utilised in parallel, PV current would not be able to cover all the requirements of the household, even though some energy might still be present in the battery. Alternatively, the PV system would have to be turned off, resulting in the loss of energy.

</td>
<td>

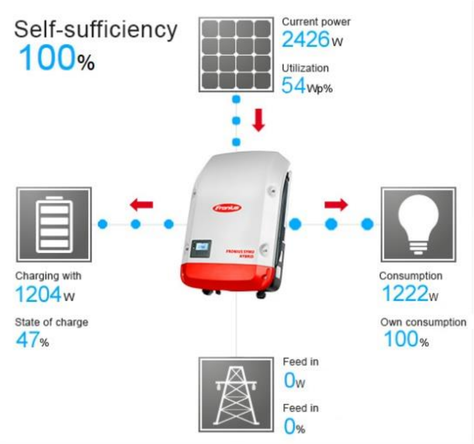


</td>
</tr>
<tr>
<td>

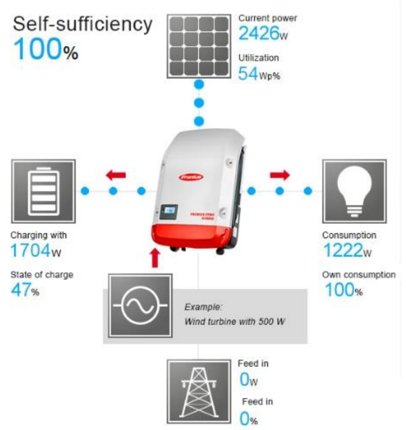
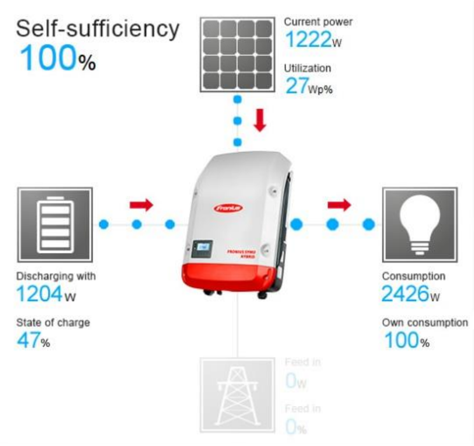
/ Charging the battery and supplying the home with PV
In cases where the output of the PV system exceeds the consumption of the household, the surplus energy will be stored in the battery. This surplus energy is not fed into the grid until the battery is fully charged.

Without Multi Flow Technology, the inverter would have to reduce power, resulting in the loss of the surplus energy.

</td>
<td>



</td>
</tr>
</table>

/ Simultaneous supply of the home and charging of batteries by PV and other energy producers To cover the energy requirements of the household, the output of the PV system and that of the other energy producers (e.g. a small wind generator or CHP) is used, with the surplus energy being stored in the battery at the same time. This enables a high degree of autonomy to be achieved, even in the winter months. Systems without Multi Flow Technology are not able to use the battery to temporarily store the energy provided by the other energy producers.	
/ Covering consumption in emergency power situations using PV and a battery In emergency power situations, the consumption in the home can be covered simultaneously by the PV system and the battery. Moreover, emergency power operation can continue even when the battery is discharged, assuming the output of the PV system is greater than the consumption in the home. In the case of systems without Multi Flow Technology, the energy from the PV system often cannot be used for emergency power operation and is consequently lost.	

4. Summary

The demands placed on an inverter in a storage system have become much greater than those of a conventional PV system with no storage facility. The inverter in a modern storage system should be able to intelligently control every conceivable energy flow and hence maximise self-consumption levels. To ensure that no energy is lost and the highest levels of energy efficiency are obtained, all energy flows must be able to be delivered simultaneously. It is difficult to imagine doing without the AC charging function for certain applications, and this function will become even more important in the future.

The Fronius Energy Package and Multi Flow Technology satisfy the stringent demands placed on the control system of a modern storage system. Multi Flow Technology ensures that the storage system can be used in a wide variety of applications, both now and in the future.