Self-consumption Hub-2

Manual

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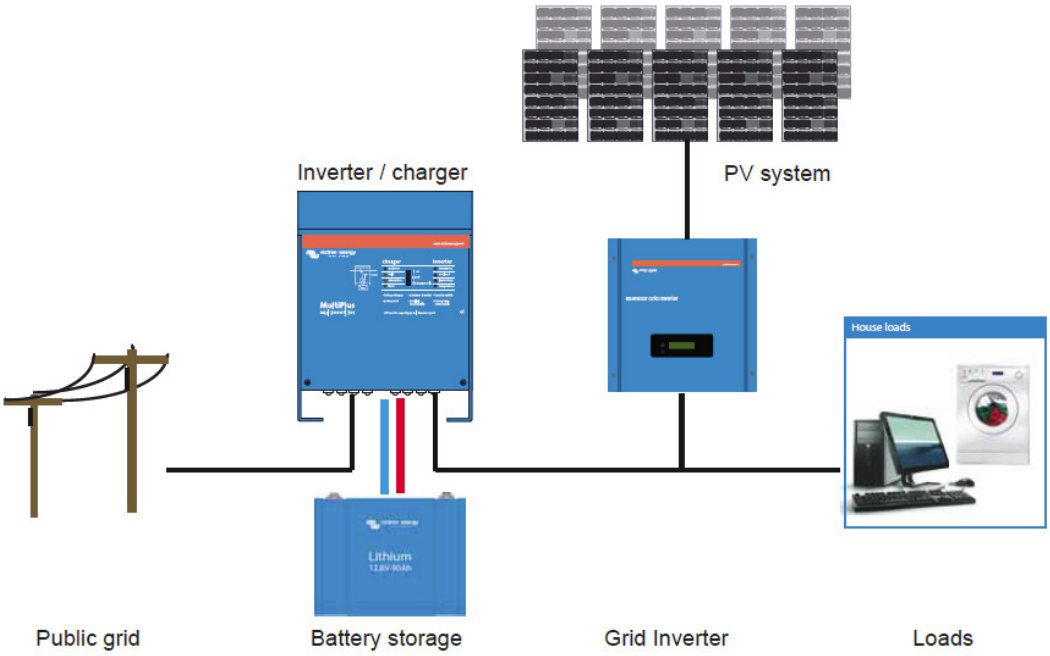

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2 Introduction to home energy storage

Electrical power generated by the sun and/or wind, and actual power consumption never match. The result is feedback of power into the grid when excess power is generated, and power needed from the grid when power generation is insufficient.

As more solar and wind power comes on line, it becomes increasingly difficult, and expensive, to ensure stability of the grid. Intermediate energy storage is therefore rapidly becoming an essential tool to keep power fluctuations on the grid within manageable limits. Moreover, as feed-in tariffs are decreasing, the business case for a home energy storage system that increases self-consumption becomes more solid every day.

Intermediate energy storage increases self-consumption of harvested solar and/or wind power. An additional benefit is that it can will as a backup power supply during a grid failure.

Such a system can be accomplished with different topologies, referred to as Self-consumption Hub 1, 2 and 3. This manual explains the working of Hub-2 and how to configure it. See our whitepaper on self-consumption for more information on the background, and the other topologies Hub 1 and 3.

3 Why a Victron Energy storage system?

With ten thousands of grid interactive and off-grid systems installed worldwide, we have the experience and the products to design the optimal system; from loads of a few hundred watts up to 90kW. We can provide the building blocks for a custom designed system. Most of the building blocks are available from stock.

4 System requirements

- A MultiPlus or more Multi's or Quattro's in parallel, with symmetrical inputs[1][2]
- A PV Inverter that, preferably, supports regulating output power through AC frequency shift.
- Battery:
  The core of the Hub consists of the battery, which is charged in case of excess solar/wind power and discharged when consumption exceeds production. Tubular plate OPzS and OPzV lead acid batteries have proven to perform very well in grid interactive as well as off grid systems. Lithium-iron-phosphate ($LiFePO_4$) batteries[3], although expensive, have the ideal specifications for grid interactive as well as off grid systems. See the white paper on Self-consumption for more detailed pros and cons of different battery types.
- This assistant works only in installations where there are no other chargers or loads connected to the battery.

[1] The Self-consumption Hub-2 assistant does not yet support three-phase systems. A software update that does support this is expected in May 2013.
[2] A parallel system with asymmetrical inputs is a system where the paralleled Multi's are connected to different AC sources.
[3] It is currently not possible to combine the Self-consumption Hub-2 assistant with BMS assistants. A software update in the assistants that does support this is expected at the end of 2013-Q2.

5 Note on anti-islanding related safety regulations

The anti-islanding protection settings in a PV inverter differ from country to country. In some countries, due to these settings, a PV inverter will not connect to (or frequently disconnect from) a MultiPlus or Quattro inverter/charger when the system is not connected to the grid. This is not a concern in the self-consumption Hub-2 algorithm, since the inverter/charger will disconnect from the grid only during the night, when the PV inverter is in standby.

It is also possible to install an ENS (anti islanding device) in between the inverter/charger and the grid. It is then allowed to change the PV inverter settings so that it will operate seamlessly with an inverter/charger even when the grid is not connected.

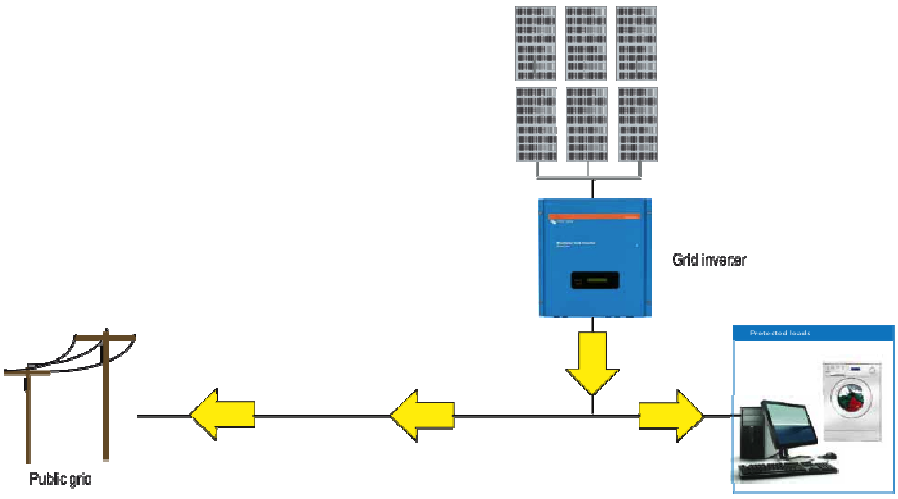
6 VE Storage Hub 2

6.1 Conventional grid-tied PV system

DC electrical power generated by the solar panels is converted to AC by a PV inverter. The generated energy is distributed to the loads, and any surpluses will be fed back into the grid.

Main disadvantages:

- A conventional grid-tied PV system is becoming less attractive financially due to increasing retail electricity prices and simultaneously decreasing feed in tariffs. Selling excess PV energy for let's say 15 Eurocents per kWh at noon and buying it back in the evening for 25 Eurocents seems like a bad deal. Better to store the excess for later use.
- The PV inverter will shut down in case of a utility power outage. No power will be available, even when the sun is shining.



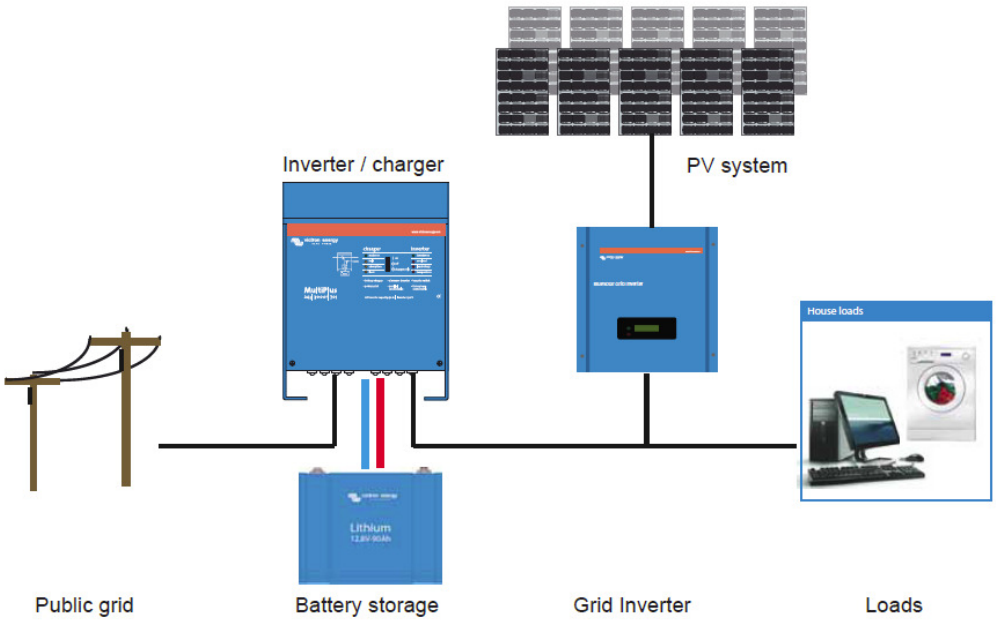
6.2 VE Storage Hub-2

Hub-2 is the most practical solution to add battery storage to an existing grid connected PV system. The AC input of the MultiPlus or Quattro inverter/charger is connected to the grid and the output to the loads and the PV inverter.

In case of insufficient PV power, the inverter/charger will supply additional power from either the battery or the grid.

In case of excess PV power, the inverter/charger will use the excess power to recharge the battery, and/or to feed power back into the grid.

In case of a utility power outage, the inverter/charger will disconnect from the grid and the system will continue to operate in island mode.



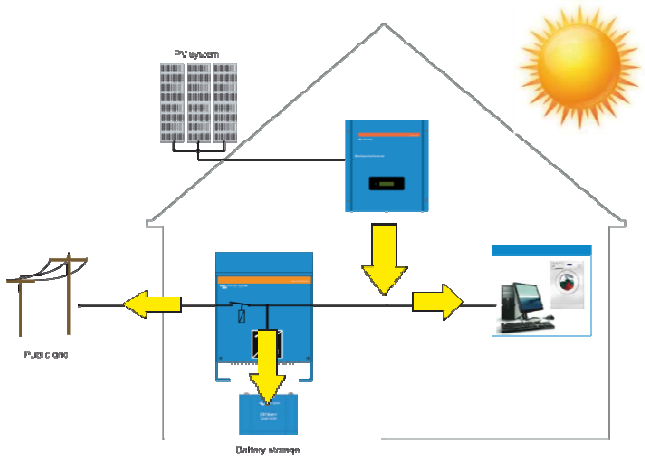
6.3 Description of the VE Storage Hub-2

The Victron MultiPlus (or Quattro) is more than just an inverter/charger. It will manage the energy flow in a PV system with battery back-up. This is accomplished by intelligent software which can be set up to do exactly what is needed in a specific environment.

The following situations are possible in a self-consumption system with grid tied PV:

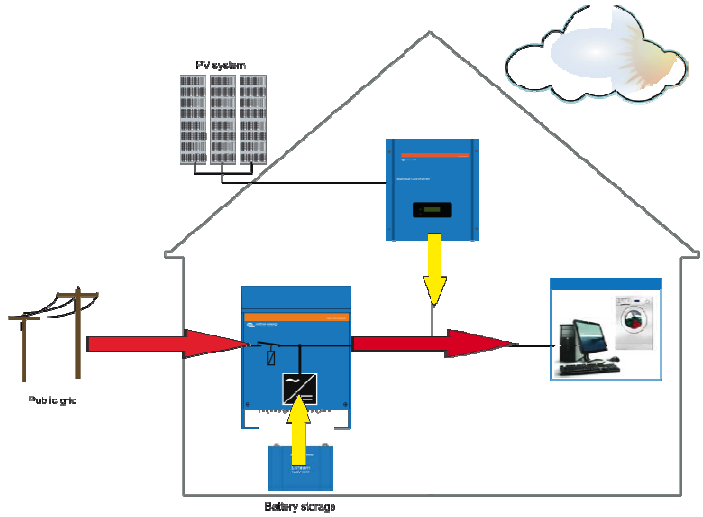
Situation 1: *enough solar power to supply the loads.*
Situation 2: *not enough solar power to supply the loads.*
Situation 3: *no solar power available.*

6.3.1 Situation 1 – Enough solar power



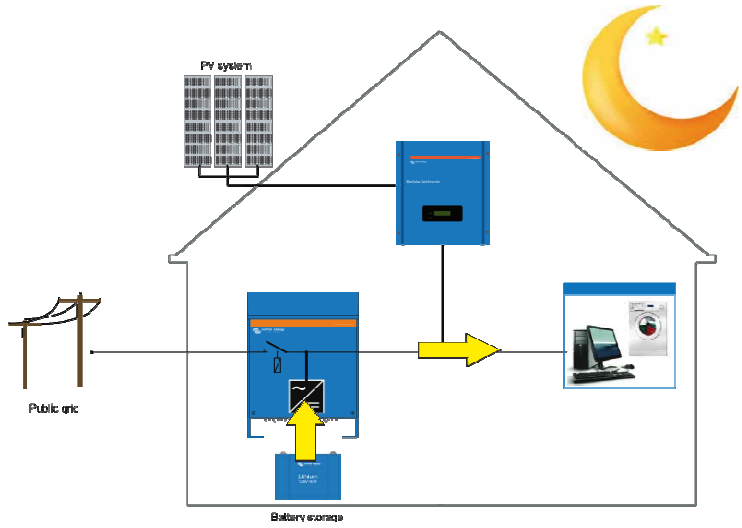
In this situation the grid is present and connected to the loads. The inverter/charger will see that the PV system is producing more energy than needed by the loads, resulting in a surplus of solar power. The surplus is used to charge the battery. All energy that is not absorbed by the battery, because it is fully charged or already being charged with the maximum charge current, is fed back into the grid.

6.3.2 Situation 2 – Not enough solar power to supply the loads



Limited shortages of power will be drawn from the grid, and larger shortages will be drawn from the battery.

6.3.3 Situation 3 – Night time, no solar power available



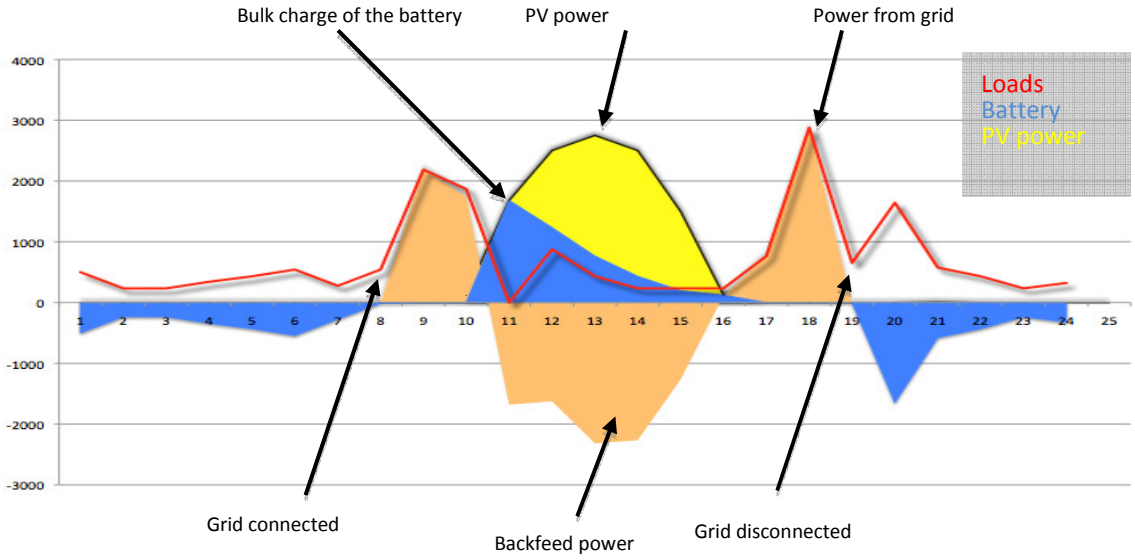
After a couple of days of monitoring PV power, the inverter/charger will synchronize its internal clock to the day/night rhythm. The inverter/charger will, without interrupting the AC supply, disconnect from the grid during the night and all energy for the AC loads will be drawn from the battery.

The grid will remain disconnected until one of the following two major events occurs:

1) Charge current starts to flow into the battery.
   This means that a new day has dawned, and that sufficient sunlight is available to provide power to the loads, with some surplus to charge the battery. The inverter/charger will then reconnect to the grid.

2) The battery has been discharged to a preset state of charge or a preset voltage, whichever comes first. The inverter/charger will then reconnect to the grid and switch to standby: it will not charge the batteries from the grid, nor power the loads from the battery. The loads are powered from the grid. It will start charging the battery with surplus PV power as soon as it is available and remain in charger only mode until a preset battery voltage has been reached. Note that the battery voltage drop can also be caused by heavy AC loads being switched on.

6.4 Energy balance over a 24h period



This graph shows the typical profile over a 24h period. At night all loads (red line) normally are modest and are being supplied by the battery (blue) until the low state of charge is reached. When this happens the Multi will connect itself to the grid (orange) which will then feed the total load instead but will not charge the battery with energy from the grid. At the moment that the sun starts shining the PV system activates itself (yellow) later that day and the inverter/charger prioritizes the PV energy to charge the battery. This continues until the battery is fully charged and ready for another “off grid” period whilst the surplus of power is being exported to the grid.

When night falls, and the PV inverter stops, the Multi switches over to night mode under control of an internal clock. This internal clock prevents erroneous switching when solar power ceases due to, for instance, a large cloud blocking the sunlight. The grid is disconnected and the loads are powered from the battery.

Note that the time-scale in the graph is typical for solar panels facing azimuth south. The algorithm will automatically adopt when panels are on a different azimuth.

6.5 Frequently asked questions

6.5.1 What happens when the battery is fully charged?

All surplus PV power will be fed back into the grid. In case of a power outage, the inverter/charger will increase its output frequency to limit the output from the PV inverter.

6.5.2 What happens when PV power exceeds battery charging capacity of the inverter/charger?

Surplus power will be fed back into the grid. If the grid is not available the inverter will increase its output frequency and hereby limit the output from the PV inverter to the power drawn by the loads and the charger.

6.5.3 What happens when stored energy is insufficient to ride through the night?

Once the battery is discharged to a preset state of charge or a preset voltage, whichever comes first, the inverter/charger will connect to the grid and maintain battery voltage at its nominal value, see also paragraph 8.4.3, Assistant page 4 – Sustain battery voltage. The load will be supplied by the grid, and the battery will remain discharged. The inverter/charger will start charging the battery as soon as there is excess solar power. Note that recharging the battery may take several days in case of limited PV power due to bad weather.

6.5.4 Are special settings needed for the PV inverter?

No. The PV inverter can be configured according to local regulations. It is important that, during a grid failure, the inverter/charger can reduce the delivered solar power to prevent overcharging the batteries. The inverter/charger can normally control the output power of a grid inverter by increasing the AC output frequency. If the PV inverter does not reduce its output power in response to increasing frequency, frequency will be increased until PV inverter disconnects.

If the grid is expected to be frequently unavailable, special settings, and a ENS, might be advisable to prevent frequent shut down of the PV inverter.

7 Installation

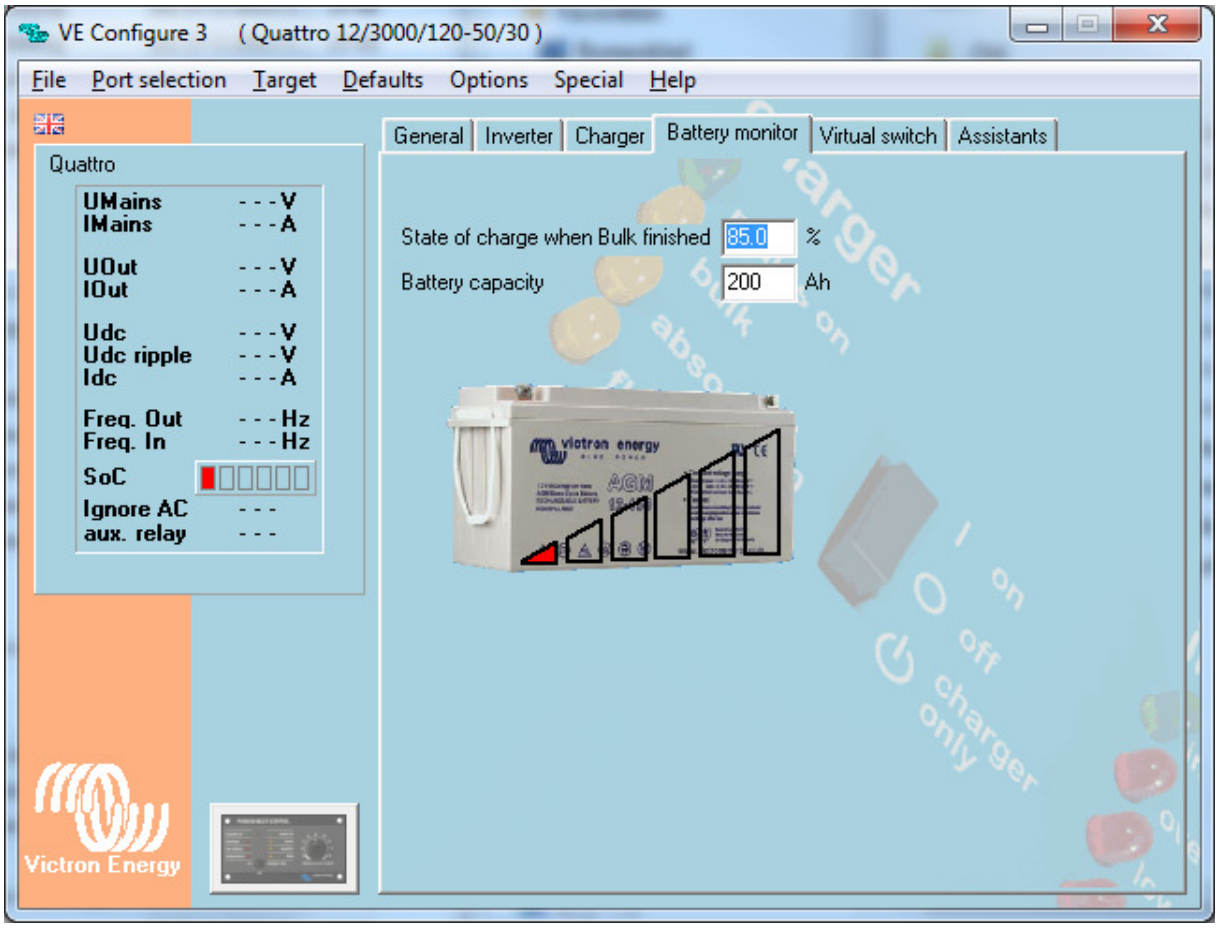
Refer to the manual of separate products (Multi, PV inverter) for all installation details.

8 Software configuration

8.1 Update the Multi/Quattro to the latest xxxx200 firmware.

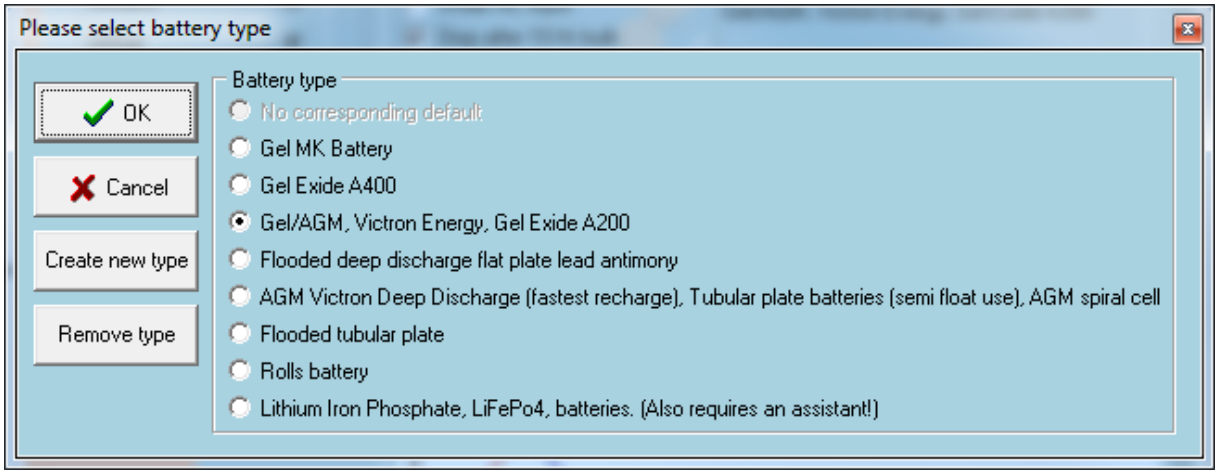
Follow the instructions in the 'VEConfigure3 requirements' document, available on our software page:
http://www.victronenergy.com/support-and-downloads/software/

8.2 Configure battery capacity in VEConfigure3



8.3 Select battery type

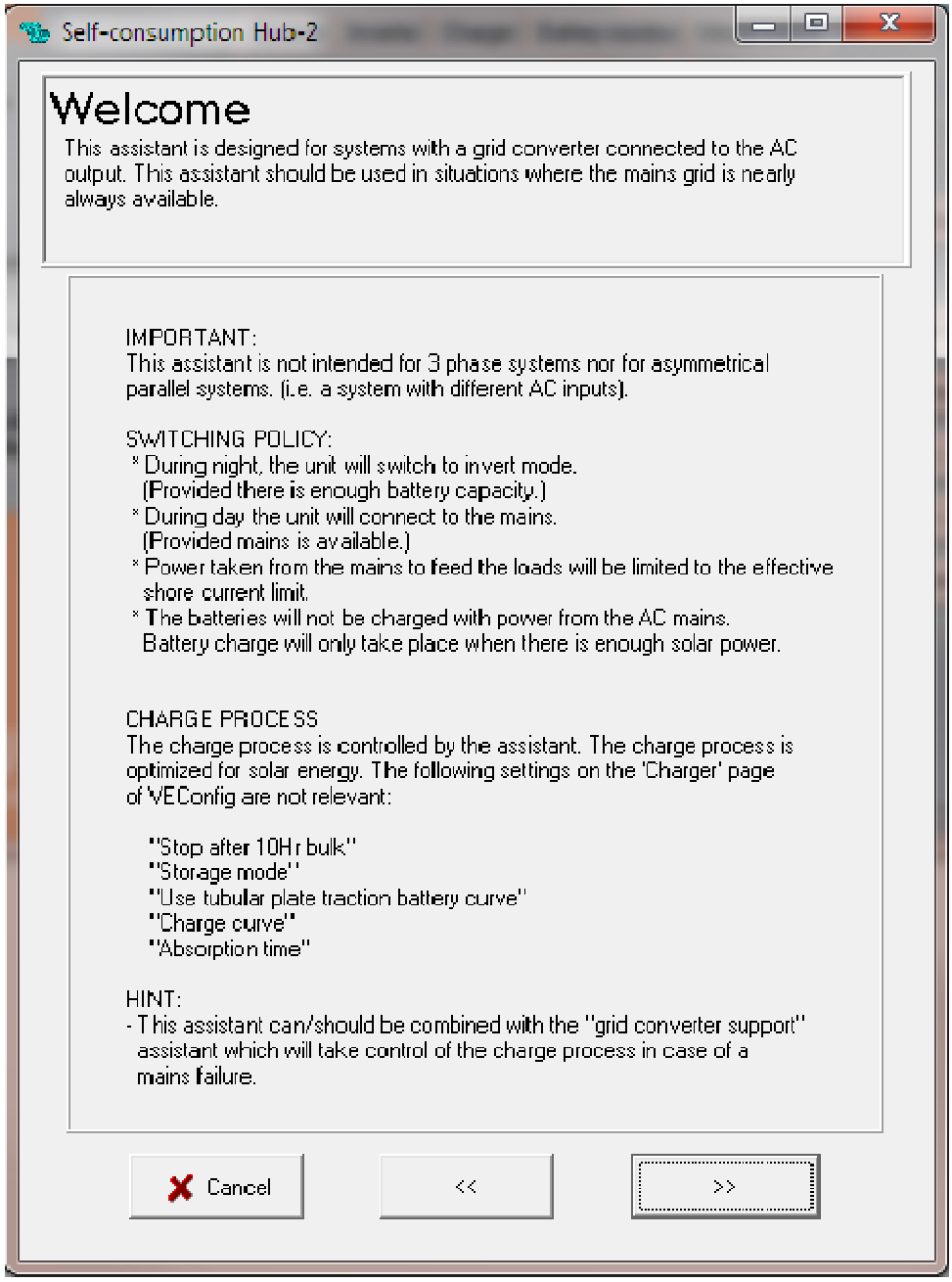
Go to the Charger-tab, and select the battery type:



8.4 Add and configure the Self-consumption Hub-2 assistant

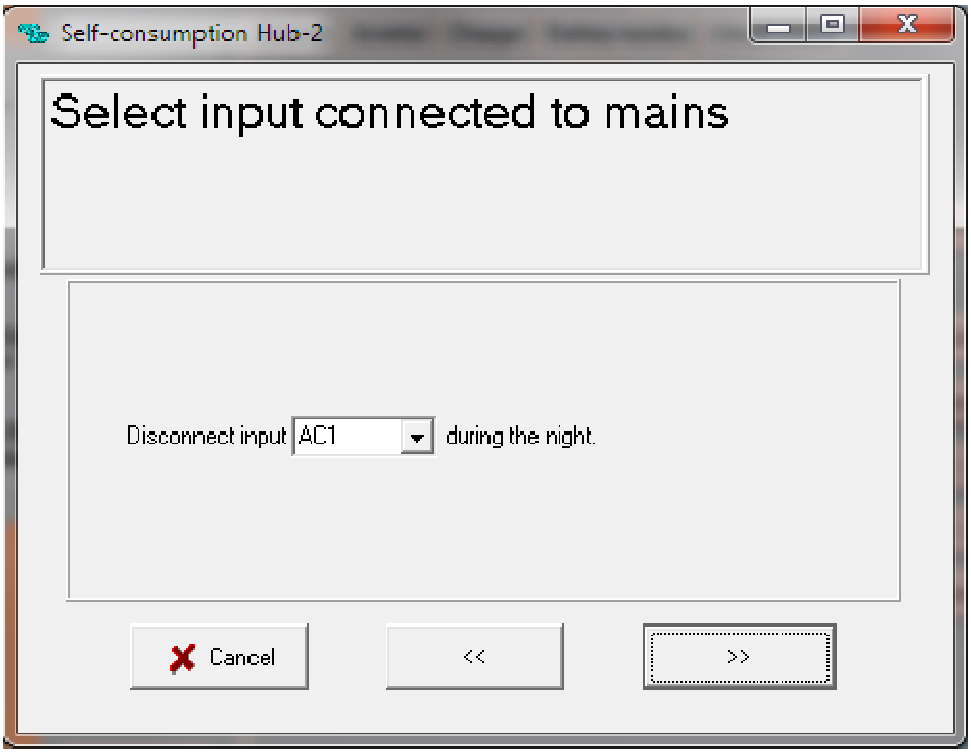
Add the Self-consumption Hub-2 assistant and press start to go through the configuration:

8.4.1 Assistant page 1 – Introduction

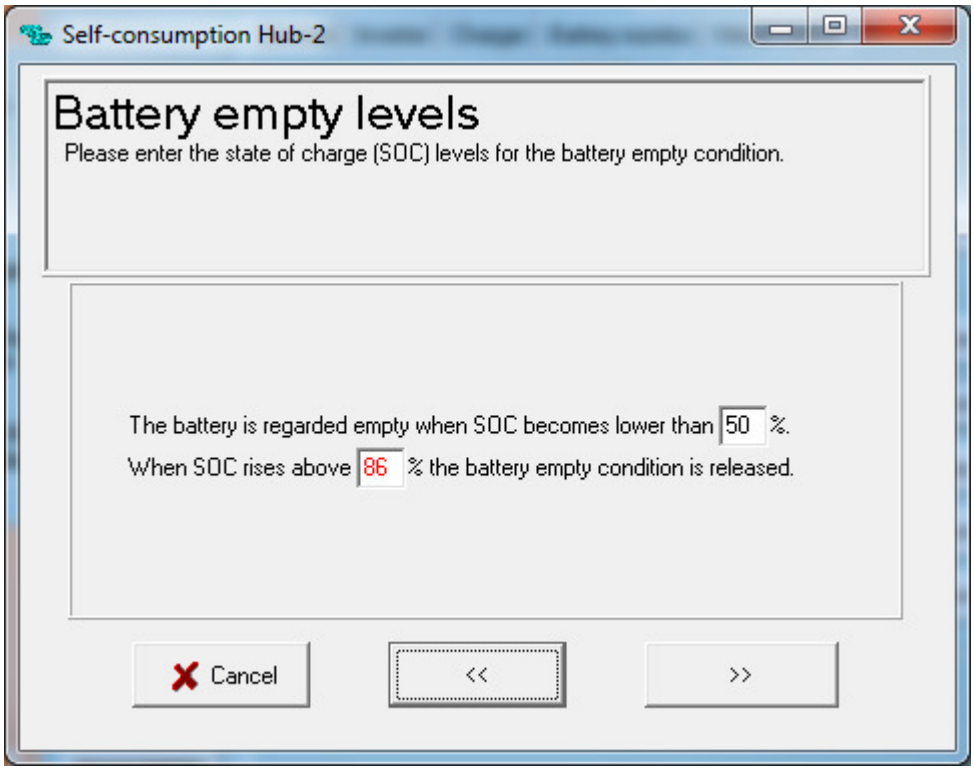


8.4.2 Assistant page 2 – Select the input connected to mains

Select the input that is connected to mains. This input will be disconnected during the night.



8.4.3 Assistant page 3 – Battery empty levels



Battery Type	Empty SOC	Release level
GEL / AGM	50%	86%
OpzS	30%	86%
LiFEPO4	20%	86%

Besides the low SOC level, the DC voltage will also be evaluated. The Multi will switch to grid when the DC voltage drops below the 'DC input low alarm level', default at 10.9VDC for a 12 volt battery. This alarm level can be configured in VEConfigure3, it is available on the inverter tab. The battery empty condition will be released when the state of charge rises above the release-level.

The release level is set directly above the setpoint to which the SOC will be set when the charger switches from bulk to absorption. See paragraph 8.2.

8.4.4 Assistant page 4 – Sustain battery voltage

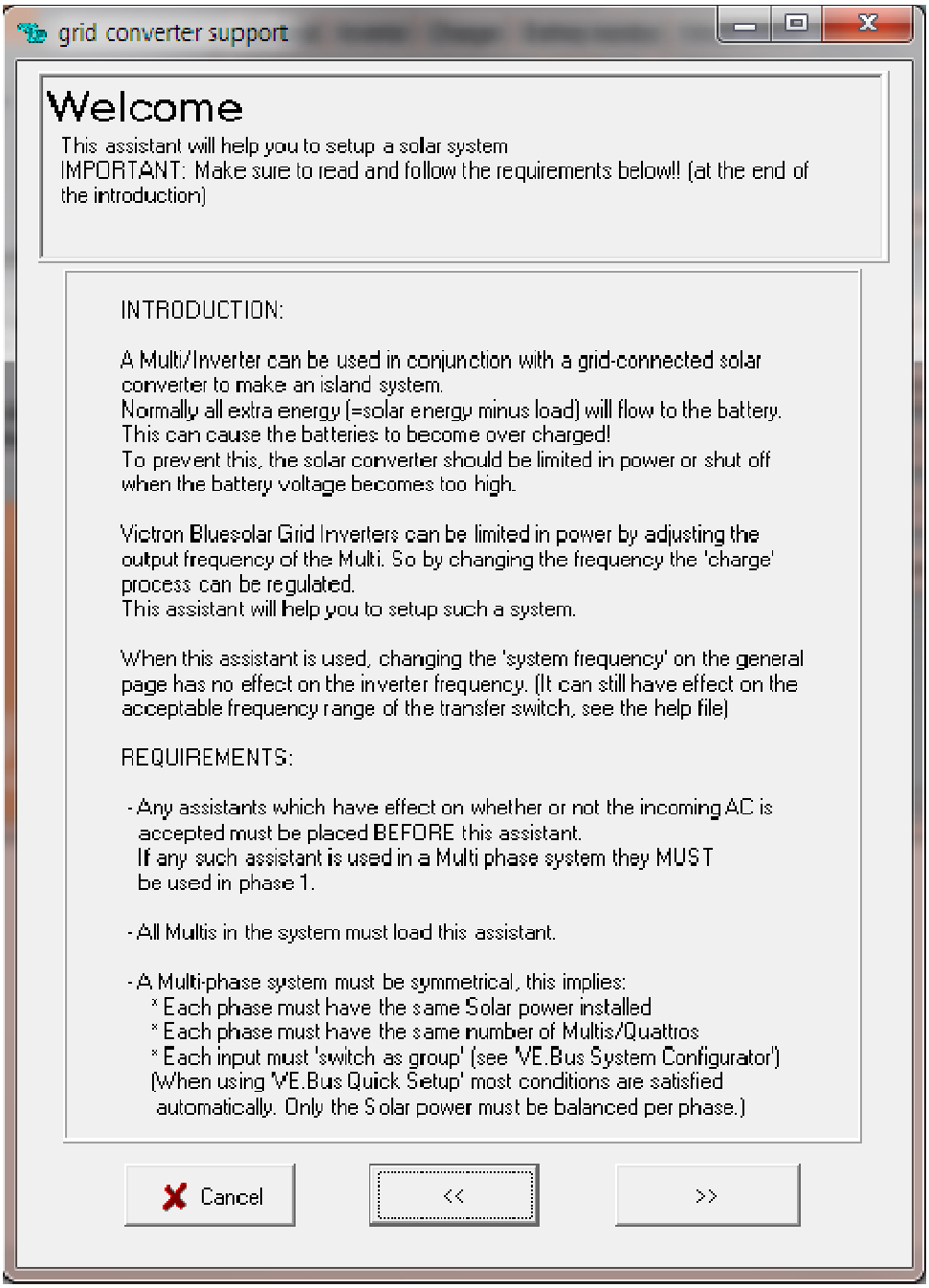
This setting can be left at the following values for all Victron Energy battery types. For other brands, consult your supplier.

Nominal system voltage	Sustain battery voltage
12V	12,5V
24V	25,0V
48V	50,0V

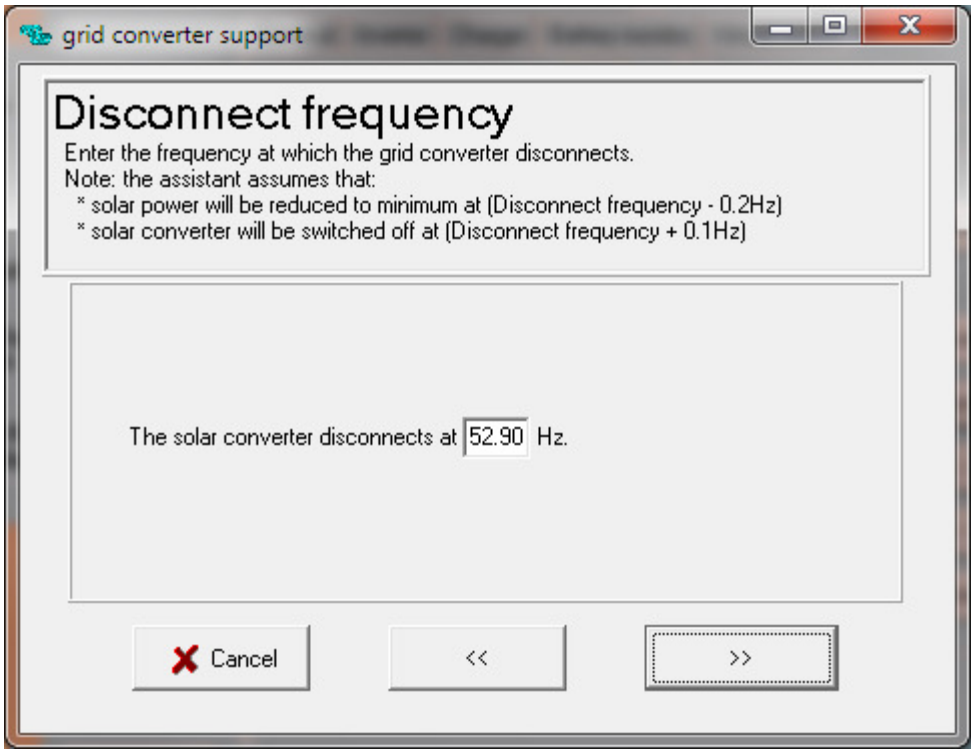
8.5 Add the “Grid converter support” assistant

In case there is a grid failure, the system will run in island mode. All excess solar energy will automatically be used to charge the batteries. To properly charge them, and prevent over-charging, the Grid converter support assistant is necessary. It will regulate the solar power by shifting the output frequency of the inverter.

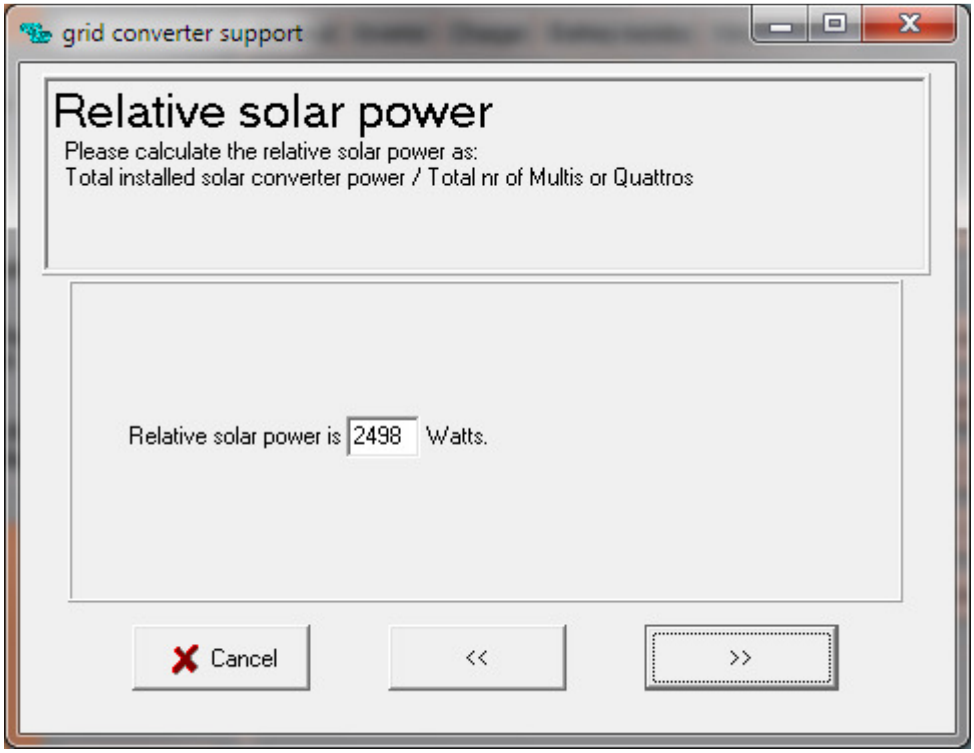
8.5.1 Assistant page 1 – Introduction



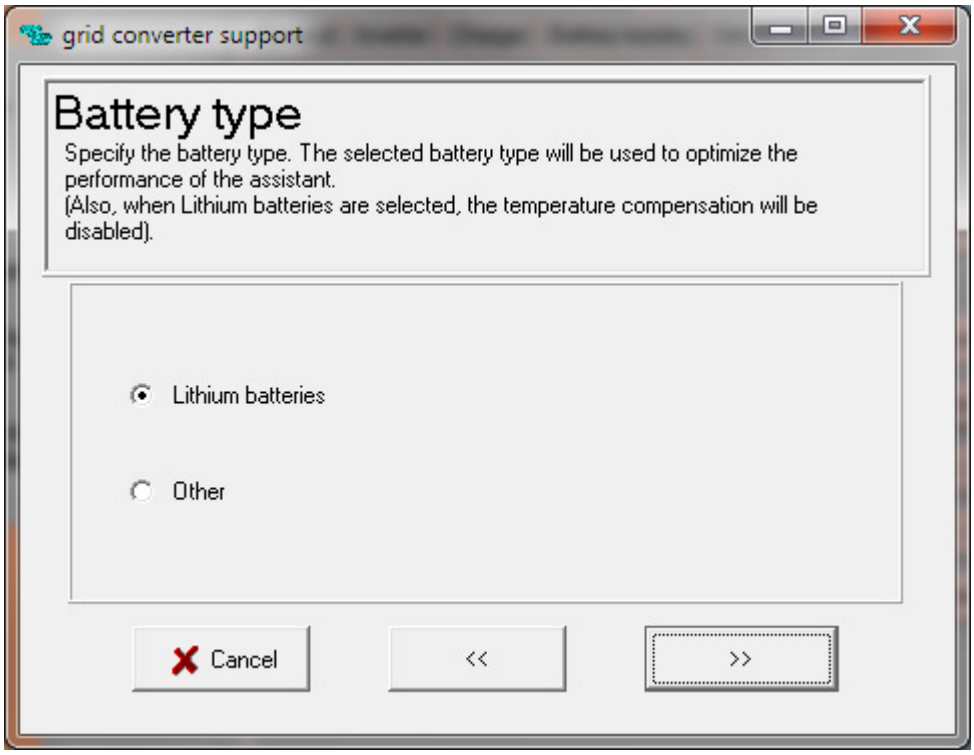
8.5.2 Assistant page 2 – Disconnect frequency



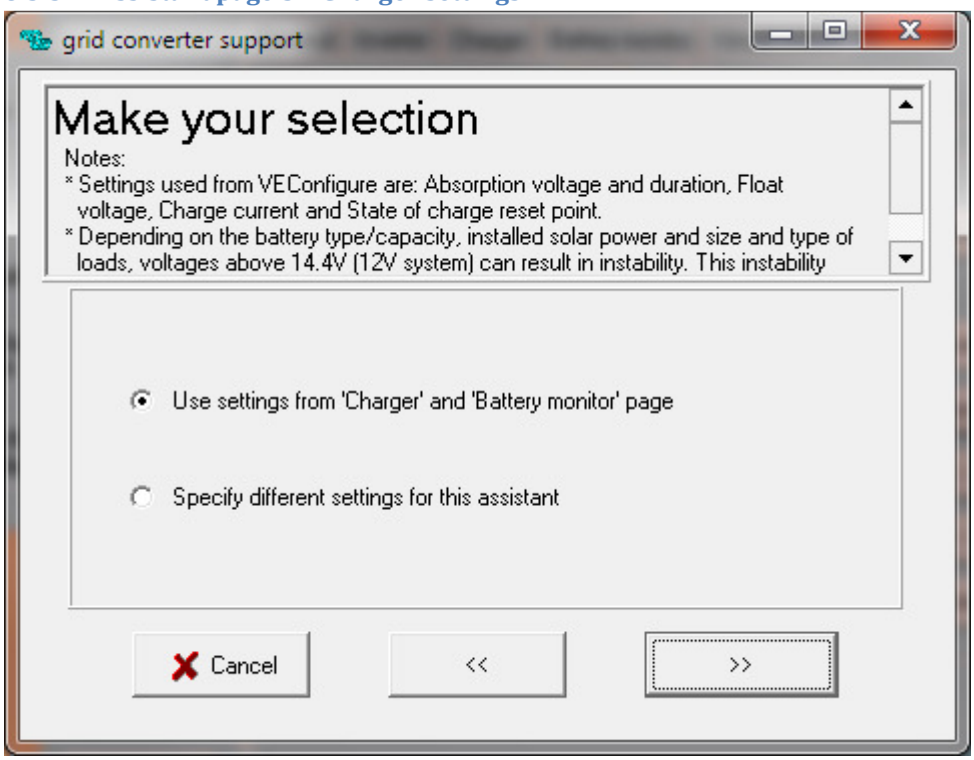
8.5.3 Assistant page 3 – Relative solar power



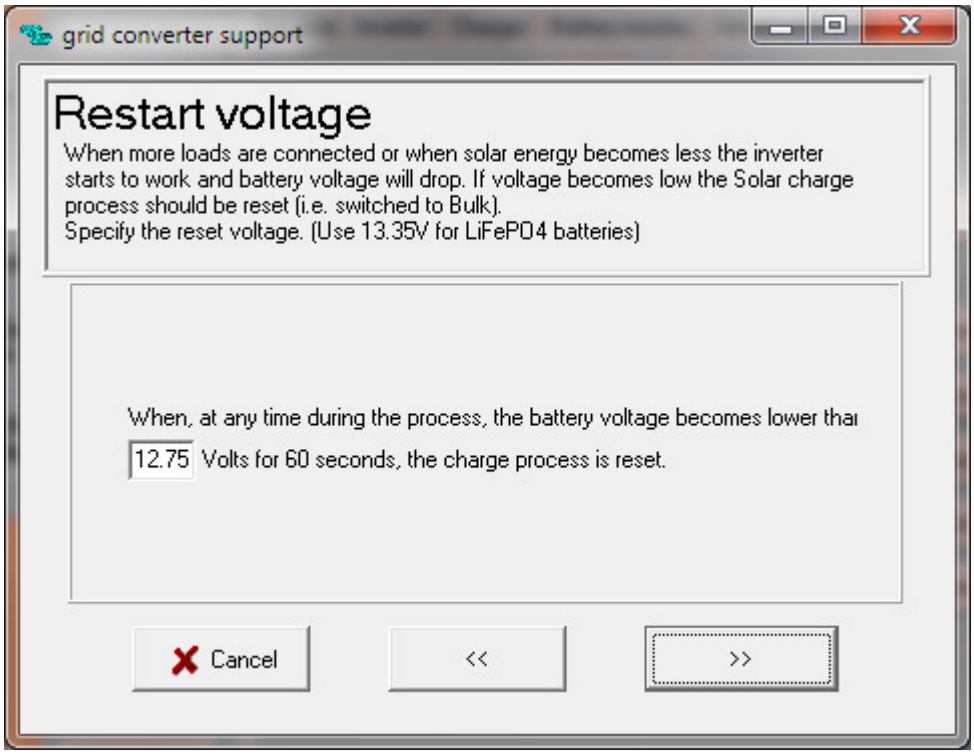
8.5.4 Assistant page 4 – Battery type



8.5.5 Assistant page 5 – Charger settings

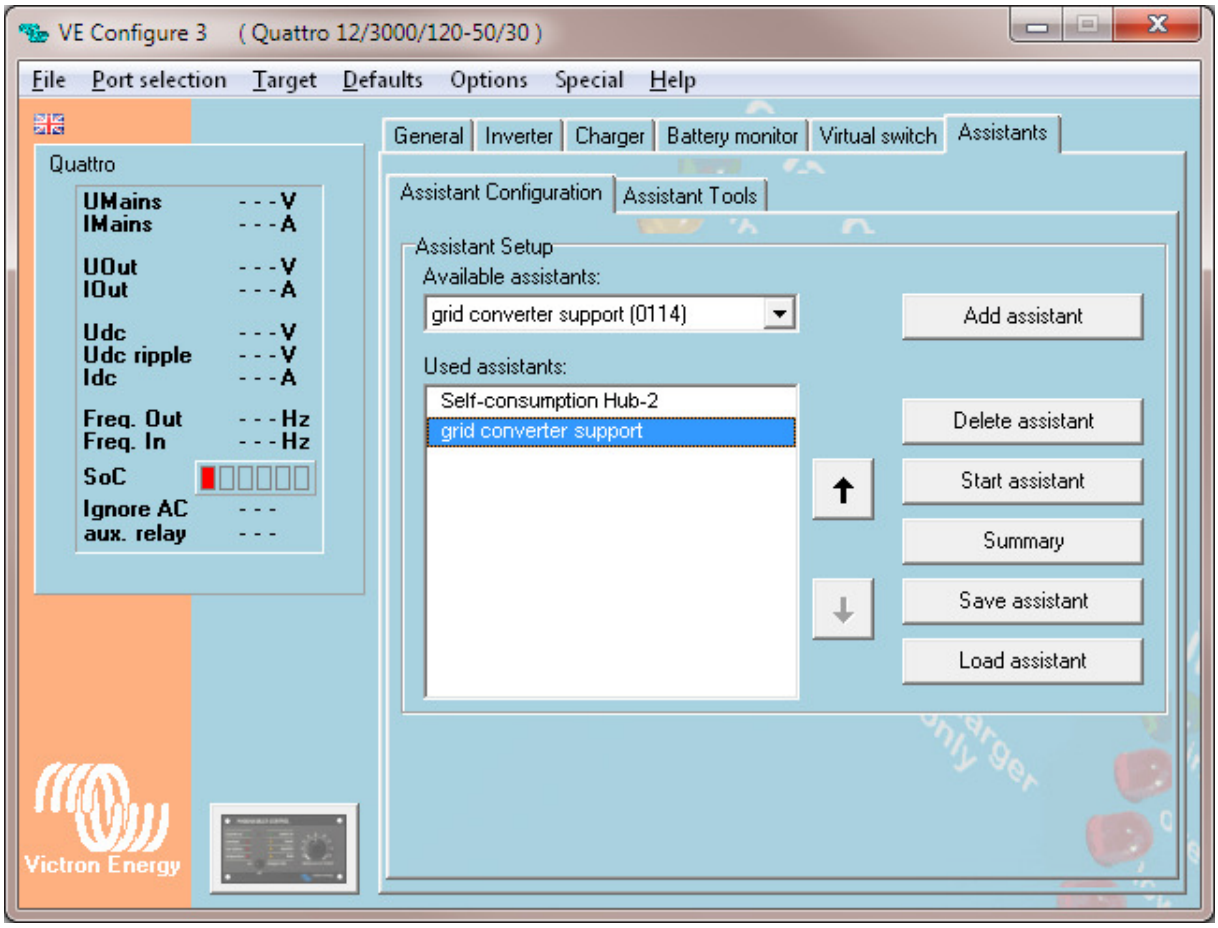


8.5.6 Assistant page 6 – Restart voltage



8.6 Check the order of the assistants

Both assistants need to be in the proper order from top to bottom to function, make sure they are listed like below example. Use the up and down button the change the order.



Note: it is, today, not possible to combine Lithium assistants together with the Self-consumption Hub-2 assistant. This manual will be updated as soon as it is possible to work with Lithium batteries.

8.7 Configure the PV inverter as requested by the local regulations

Consult the manual of the PV inverter, and configure it according to the local regulations. See also chapter 5 and paragraph 6.5.4.

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