Energy Storage Systems

All-In-One Solution

Battery Storage
Introducing the **Energy Storage System**

The functionality of the Hub-Assistants is almost completely replaced by the new ESS Assistant!

Energy storage: Use a battery to store excess solar power (day), to later use it when there is not enough solar power available to power the loads (evening and night). [Grid is stable and 99.99% available](Link to ESS Manual)
Multis and Quattro's can be used as a Grid-parallel Storage System,

An **Energy Meter** is installed at the distribution box of the house or office.

The CCGX will control the storage system: whenever there is excess solar power available, it is used to charge the batteries.

And shortages of solar power are supplemented with power from the battery.
Grid parallel vs in series

Parallel

Serial
Energy Storage Assistant.

What is needed:

- Multiplus or Quattro charger/inverter
- Color Control GX or Venus GX
- Batteries
- Energy meter (not always needed)
- MPPT and/or PV inverter
Energy Storage Assistant.

Features: Grid parallel energy storage system that optimizes self consumption.

- Wide range of available inverter/chargers. From 500VA – 15kVA (max. 180kVA)
- Both wired and wireless connection to the Energy meter central distribution box is possible.
- No-break UPS output. (optional)
- Phase compensation. (optional)
- Built-in ENS- anti-islanding / loss of mains detection. (limited numbers see VEconfigure)
Standard AC-coupled PV
Add the Energy Storage & Meter
Add critical loads
AC-Coupled PV on output
DC-Coupled PV
All combination are possible
Pure Energy Storage - no PV

Keep Battery Charged

Always available
Multi + MPPT without BMV: no correct state of charge?

The solution: Update CCGX or Venus to latest release v2.xx

In ESS system the MPPT is connected to the CCGX.
VE.Bus SOC now also increases when MPPT is charging
BMV no longer needed!
When battery is full, excess solar power can be feed in to grid
Battery full and still too much solar from MPPT?
In an ESS installation, the PV Inverters are connected in parallel to the inverter/charger. Because of this, the size of the PV array and the PV inverter is not limited by the maximum nominal power of the inverter/charger.

In an ESS installation, it is possible to connect AC-Coupled PV power on the output of the inverter/charger. In that case, make sure PV inverter size doesn’t exceed the Multi/Quattro capacity.

The **Factor 1.0 rule** applies !!
All (or a combination) is also possible

Factor 1.0 rule for PV inverter
Communication CCGX – Power meter

Wired Max. 5m  Wireless Max. 100m
ESS without grid meter

- It can also work without grid meter.
- All loads and ac-coupled PV must be installed on AC-out
- Factor 1:0 rule applies for PV Inverters.

**Important: Factor 1.0 rule**
For example: 8000VA Multi = max 8000Wp of installed PV Solar Modules
ESS without grid meter

<table>
<thead>
<tr>
<th>Setting</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>Optimized (with BatteryLife)</td>
</tr>
<tr>
<td>Control without grid meter</td>
<td>OFF</td>
</tr>
<tr>
<td>Inverter AC output in use</td>
<td>ON</td>
</tr>
<tr>
<td>Feed-in excess solarcharger power</td>
<td>ON</td>
</tr>
<tr>
<td>Phase compensation</td>
<td>ON</td>
</tr>
<tr>
<td>Minimum Discharge SoC (unless grid fails)</td>
<td>75%</td>
</tr>
</tbody>
</table>
Important considerations

• The 1:0 rule do not install more kWp solar than the kVA rating of the Multi or Quattro
• Check if the PV inverter is capable of reducing power or turning on or off based on frequency shift
• This ESS Assistant prevents overcharging battery by turning the PV inverter off

![ESS (Energy Storage System) Frequencies]

- The solar converter will start reducing its output power at 50.20 Hz.
- Output power will be reduced to minimum when the frequency is 52.70 Hz.
- The converter will disconnect when the frequency is higher than 53.00 Hz.
Also in parallel or in 3 Phase
3 Phase system
Perfect Energy Storage System

- Easy configuration in the CCGX
- Operate with and without grid-meter
- Compatible with many battery brands
- DC-Coupled and/or AC-Coupled PV
- Enable/disable feed-in
- Zero feed-in for Fronius PV Inverters
- Configurable Sustain levels (LITHIUM)
ESS Details

• What about the HUB systems?
• No Feed In
• Fronius PV inverters and Victron
• Battery size, DOD and Inverter size
• Dynamic Cut-Off
• Sustain Mode
• Battery Life configuration
• Phase compensation
• Grid Setpoint
• AC current sensor
• Battery compatibility (other brands)
What about the Hubs?

Hub-1: deprecated except for policy 3: Invert priority
Hub-2: deprecated except for policy 2: Invert priority
Hub-4: deprecated entirely

What does deprecated mean? It means **no support**.

In case of problems, first update to ESS and then contact us again in case of trouble.
No feed-in systems

1. Use MPPT, do not use a PV Inverter

2. Still want to use a PV Inverter? Then at least take a Fronius. (and use Zero Feed-in)

Remember: to prevent feed-in for a PV Inverter, you need to sabotage it. Leads to flickering, overloads, and more problems.
ESS Menu – No Feed In

Mode: Optimized (with BatteryLife)

Control without grid meter: OFF

Feed-in excess solarcharger power: ON

Phase compensation: ON

Minimum Discharge SoC (unless grid fails): 10%

BatteryLife state: Self consumption

Limit charge power: OFF

Limit discharge power: OFF

Zero feed-in (Fronius PV inverters only): OFF

Zero feed-in active: No
CCGX & Fronius PV Inverters

By connecting a Fronius PV Inverter and Color Control GX (CCGX) together you can:

1. See Fronius information on the CCGX screen.
2. Monitor the Fronius on the VRM Portal.
3. Fronius kWh reading will be used for the solar yield and also the consumption tab on VRM.
ESS – Zero feed-in with a Fronius PV Inverter

• The ESS system can control the Fronius Power Reduction feature, resulting in a **beautiful zero feed-in system**.
• Except of course for systems that have other brands of PV Inverters. (BUT : coming soon)
PV inverters – Fronius PV inverters

Link to: Fronius in ESS
Battery size

Small batteries will be more cost effective:
all available storage capacity is used every day, but will be charged and discharged with high currents:
especially with lead batteries this will reduce battery life time
Deep cycle use!
Battery size

Large batteries, combined with a relatively large PV installation: can store excess power during good days, which can then be used during several consecutive days of bad weather and provide longer autonomy during a power outage, requires using the UPS output

Lower deep cycle use! Longer lifetime
Controlling depth of discharge (DOD)

When there is less PV power available than needed by the loads, energy stored in the battery will be used to power the loads. This continues until the battery is considered empty.

There are three parameters that check if the battery is empty:

1. Minimum Discharge SOC configured in the CCGX. (unless grid fails)
2. Battery Voltage. See Dynamic Cut-off section, further down below.
3. * Low cell signal from a BMS:
   * Victron VE.Bus BMS or BMV
   * 3rd party Canbus enabled BMS
What is depth of discharge (DOD)?
Inverter/charger size

Because it is installed parallel to the grid and the loads, the inverter size can be reduced to (much) smaller than the max expected nominal and peak load.

For a household with one family, the MultiPlus xx/3000 can already manage nearly all appliances, when not more than one of them is running at the same time.

This means a MultiPlus xx/3000 can already reduce the power consumption during late spring, summer days and early autumn with sufficient storage to (nearly) zero.
Dynamic cut-off

The problem: slowly discharging until 9.5 V kills a battery.
But setting Low voltage disconnect at 11.5 V is no solution either.

The solution= dynamic cut-off
Dynamic cut-off

Dynamic cut-off is useful for batteries with a high internal resistance like OpZs.

All three DC input low parameters (-shut-down, -restart and -pre-alarm) on the Inverter tab (Veconfig) are not effective. They are overridden by the Dynamic cut-off levels, together with the restart level.

The Dynamic cut-off mechanism is in effect: when mains is available and during a mains failure (system is in Inverter mode).
'Discharge' vs. 'DC input low shut-down voltage' curves for the battery types.

The curve can be adjusted in the assistant.
Dynamic Cut-off

This feature makes the DC-input low shut-down level a function of the battery current drawn from the battery. When a high current is being drawn from the battery, a lower shut-down voltage threshold is being used, for example 10 V.

And similarly, when the battery is only being discharged slowly, a high DC cut-off voltage is used, for example 11.5 V.

This way, voltage drop caused by the internal resistance in the battery is compensated. Making battery voltage a much more reliable parameter to stop discharging when a battery is empty.
Dynamic cut-off is automatically chosen by the program, based on the type of battery.

Advice:
Leave it on default!
For Lithium: yes, it can be changed!!
# Open Battery voltage vs. Soc

<table>
<thead>
<tr>
<th>S.O.C % Charged</th>
<th>No load voltage reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>12.9</td>
</tr>
<tr>
<td>90%</td>
<td>12.8</td>
</tr>
<tr>
<td>80%</td>
<td>12.6</td>
</tr>
<tr>
<td>70%</td>
<td>12.5</td>
</tr>
<tr>
<td>60%</td>
<td>12.3</td>
</tr>
<tr>
<td>50%</td>
<td>12.1</td>
</tr>
<tr>
<td>40%</td>
<td>11.9</td>
</tr>
<tr>
<td>30%</td>
<td>11.8</td>
</tr>
<tr>
<td>20%</td>
<td>11.7</td>
</tr>
<tr>
<td>10%</td>
<td>11.6</td>
</tr>
<tr>
<td>0%</td>
<td>10.5</td>
</tr>
</tbody>
</table>

Open voltage measured +/- 2 hour after charging to float!!

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Victron Company Profile
Sustain Mode is to prevent battery damage caused by leaving batteries in a deeply discharged state.

During Sustain Mode, the batteries will slowly be charged from the grid; maximum charge current is 5 Ampère.

The default Sustain level is 12.5V for lithium batteries and for non-lithium batteries, 11.5 V for the first 24 hours, and after that it is raised to 12.5 V.

Excess solar power will also be used to charge the batteries.

Sustain stops as soon as there has been sufficient excess solar power available to raise the battery voltage 0.1 V above the sustain level.
What about the Sustain mode?

Sustain is activated only after the battery has been flagged as empty.

What happens during a mains outage?

- Minimum Discharge SOC configured in the CCGX is ignored.
- Dynamic cut-off is still active.
- Low cell signal from the VE.Bus BMS is still active.
- Low cell signals from 3rd party canbus enabled BMS-es are ignored. System relies on the protection inside such a Lithium battery to trip.
Sustain mode in VEconfigure

ESS (Energy Storage System)

Sustain voltage
When batteries are left in a deep discharged state during a prolonged period, there is a severe chance they will be damaged.

To prevent this, the sustain mechanism will kick in and keep the batteries at a minimum voltage by charging them with a small current whenever necessary.

For more info, refer to the controlling depth of discharge chapter of the Energy Storage manual.

Sustain voltage during the first 24 hours of sustain 23.00V.
Sustain voltage after 24 hours 25.00V.
Sustain Mode:

- **100% SOC**
- **85% SOC start absorption**
- **Battery empty level - High SOC setting**
- **Battery empty level - Low SOC setting**
- **Reset Sustain empty level 12,5 - 25 - 50 Volt**
- **Low Sustain empty level 12 - 24 - 48 volt**
- **Inverter DC low shut down 9,3 - 18,6 - 37,2 volt**
- **Dynamic cut off - will change his value, based on the current draw from the battery.**
- **This voltage must be higher than the reset empty sustain level.**

**Risk of battery damage**

**Battery damage**

**All three DC input low parameters (-shut-down, -restart and -pre-alarm) on the Inverter tab are not effective. They are overridden by the Dynamic cut-off levels, together with the restart level.**
As the expected amount of solar energy decreases by less sunshine, the system will increase the SOC value automatically, so the less expected Solar will be capable to re-charge the battery at the end of the day to around 100% SOC again.

As the expected amount of solar energy increases by more sunshine, the system will decrease the SOC value automatically, so the more expected Solar will be capable to re-charge the battery at the end of the day to around 100% SOC again.

Why should you deep discharge your battery every day and continue with low SOC of the battery all the time through a bad weather period, with the result of damage to the battery?
Battery Life

“There is no point in discharging a battery today / tonight, when you already know that it will not be recharged tomorrow.”

- Longer battery life for lead & passive balanced Lithium
- Be prepared for a mains outage
- Mandatory for Victron 12.8V lithium batteries, because they have passive balancing !!

- For lithium batteries counts: no Battery Life -> no warranty!
Battery Life

How does it work?

Daily DoD lower limit is adjusted every day:

- On good days the limit will be decreased (more use of battery)
- On bad days the limit will be increased (less use of battery)

As a result, you’ll see this low SOC limit being increased during the winter, and then it will be relaxed (=lowered) again in the summer.

The battery life feature prevents low battery state of charge over a long period. Battery Life ensures that, on average, the battery will be recharged to 100% SOC, about every day.
Battery life

To do this we introduce a dynamic lower limit on the state of charge. Discharging is allowed only if the state of charge exceeds the limit.

The limit is adjusted every day.

- On days with little or no surplus PV power the limit will be raised.
- And on 'good' days the limit is lowered again.

The limit indicates how much surplus PV power we expect during the day; a low limit means we expect a lot of PV power available to charge the battery. Ensuring that the system will not discharge more energy at night than it is expected to charge the next day.
Battery life in CCGX/VenusGX
Battery life in CCGX/VenusGX

- Optimized (with battery life)
- Optimized (without battery life)
- Keep batteries charged
- External control
Battery Life in CCGX/VenusGX

Today’s value of dynamic lower DoD limit

Configurable minimum
(Set to 5% for Lithium 50% for Lead)

Self consumption:
normal operation (discharge allowed)

Discharge disabled:
current SoC below actual SoC limit

Force charge:
slow charge started when SoC below actual limit for more than 24 hours. Lasts until SoC limit reached
Phase compensation

Phase compensation is used to have a storage ESS system connected to only one phase, and compensate on that phase for the other two phases, thereby effectively regulating the total power of all three phases combined.
### Phase compensation

<table>
<thead>
<tr>
<th>Load</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100 W</td>
<td>400 W</td>
<td>200 W</td>
<td>700 W</td>
</tr>
</tbody>
</table>

**On - One phase L1**

<table>
<thead>
<tr>
<th>Inverter/charger</th>
<th>-700 W</th>
<th>0 W</th>
<th>0 W</th>
<th>-700 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution box</td>
<td>-600 W</td>
<td>400 W</td>
<td>200 W</td>
<td>0 W</td>
</tr>
</tbody>
</table>
Grid Setpoint

The power taken from the grid when in self-consumption mode. Setting this value slightly above 0W will prevent the system to feed back power to the grid when there is a bit of over-shoot in the regulation. The default is value 50W, but should be set to a higher value on large systems.

Play with the settings. Can be positive or negative level
Grid Setpoint in ESS – NO feed in !!

Old !!!
An ESS system will always try to keep the AC input current on 0 Ampere

Average use is zero watts

New !!!
An ESS system will always try to keep the AC input current on 0 Ampere

Average use is 30 watts, but zero feed in.
Configure the Grid Set point in CCGX
The AC Current sensor is a simple external current sensor used to measure AC Current, Power (VA) and calculate energy of a PV inverter connected to the AC input or output of a Multi or Quattro.

These values can then be displayed and sent to the VRM-website by the Color Control.

The two measurement wires can be connected to the AUX and/or temperature sense input of a Multi or Quattro.
AC current sensor configuration in CCGX

1. Power up the system.
2. After a few seconds, the display will come to life. If not, check the wiring of the system.
3. Within 60 seconds after power up, the CCGX will detect the meter. The meter will show up in the device list on the display. When selected, the CCGX will show a page with current measurements.
4. Select 'Settings' from the device list and select 'Wired AC Sensors'. This will show the list of known
AC current sensor (PV inverter not Fronius)

Also the 3 phase Energy Meter ET340 can be used to measure the PV inverter output.

These values can be displayed and sent to VRM website by the Color Control.

See: Energy Meter manual
Battery Compatibility
We also connect to other battery technologies that require a deeper integration and communication between the power electronics and the battery management hardware.

https://www.victronenergy.com/live/battery_compatibility:start

- BMZ ESS 3.0 and ESS 7.0
- LG Chem Resu 6.4
- Redflow ZBM and ZCell
- Aquion AHI
- Freedomwon Lithium
- AXIstorage 7s/9s
- Pylontech US2000/Phantom
- BYD B-Box lithium
- Pylontech US2000B and Phantom-S
- Simpliphy Power
- BlueNova ES
BYD B-box

- Huge Chinese lithium and Electric Car manufacturer
- CanBUS-BMS compatible from Venus v2.xx
- But, also works with Allow-to-charge and Allow-to-discharge contacts
- Nice for Off-grid!
- 19” racks and wall mount

Link to BYD Bbox
State of Charge sources in system

1. Dedicated battery monitor (BMV7xx)
2. Multi or Quattro (VE.Bus SOC)
3. Battery system (Lynx Ion BMS, LG Resu, BYD B-Box, etc)
Selecting the source

<table>
<thead>
<tr>
<th>System setup</th>
<th>14:51</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System name</strong></td>
<td>ESS</td>
</tr>
<tr>
<td>AC input 1</td>
<td>Grid</td>
</tr>
<tr>
<td>AC input 2</td>
<td>Not available</td>
</tr>
<tr>
<td>Battery monitor</td>
<td>Automatic</td>
</tr>
<tr>
<td>Auto selected: MultiPlus 12/500/20-16 on VE.Bus</td>
<td></td>
</tr>
<tr>
<td>Synchronize VE.Bus SOC with battery</td>
<td>Off</td>
</tr>
</tbody>
</table>
The Multi knows the SOC

Useful with Assistants:
- ESS Assistant (stop discharging at xx % SOC)
- Generator start/stop

Not for Hub-2!!
When enabled, the CCGX will continuously copy the State of Charge from the selected Battery monitor to the VE. Bus system (Multi / Quattro).

Now the Multi always knows the SOC from the BMV. Useful for assistants based on SOC.

Note: not possible in HUB2 disadvantage of the BMV synchronization of the SOC at 100%

• Texts inside the assistant (in VEConfigure)

Without technical training, no support!

EN: Victron Energy service and support channels are, unfortunately, not equipped to help untrained persons.

DE: Der Service und die Kundenbetreuung von Victron Energy sind leider nicht dazu ausgelegt, ungeschulte Personen zu unterstützen.

NL: De Victron Energy service- en ondersteuningskanalen zijn helaas niet toegetoerust om ongetraind personeel te helpen.