



Projet cofinancé par le Fonds européen de développement régional

## LIVING LAB developed within the StoRES project

### Computation details and hypothesis

#### I. Description of raw data

The following data are available at a 15-minutes resolution.

- Power production [W]: Production of the photovoltaic system
- Power storage charge [W]: Charge of the battery system (battery + inverter)
- Power storage discharge [W]: Discharge of the battery system (battery + inverter)
- Power grid import [W]: Electricity consumed from the grid to supply the load demand
- Power grid export [W]: Electricity exported to the grid (excess of production)
- Load consumption [W]: whole electricity consumption of the consumer
- Battery state of charge (SOC) [%]: The SOC is given according to the nominal capacity of the battery

The “Direct use” of PV production is also displayed. It is the minimum value between “Power production” and “Load consumption”. It corresponds to the electricity which is directly self-consumed from the PV plant (without using the storage system).

#### II. Data correction

The timeseries which are collected might include some “NaN” values due to a default in the monitoring process. When possible, the « NAN » values are corrected according to the following energy balance:

$$\text{LOAD} - \text{IMPORT} - \text{DISCHARGE} = \text{PRODUCTION} - \text{CHARGE} - \text{EXPORT}$$

This correction is possible if there is only one NAN value per timestep.

#### III. Self-consumption and self-sufficiency ratios

The self-consumption ratio (SCR) and the self-sufficiency ratio (SSR) are calculated for both with and with battery.

- $\text{SCR}_{\text{no\_battery}} = \text{PV direct use} / \text{production}$
- $\text{SSR}_{\text{no\_battery}} = \text{PV direct use} / \text{consumption}$
- $\text{SCR}_{\text{with\_battery}} = (\text{PV direct use} + \text{Charged\_energy}) / \text{production}$
- $\text{SSR}_{\text{with\_battery}} = (\text{PV direct use} + \text{Discharged\_energy}) / \text{consumption}$

With  $\text{PV direct use} = (\text{LOAD} - \text{IMPORT} - \text{DISCHARGE} = \text{PRODUCTION} - \text{CHARGE} - \text{EXPORT})$ , which represents the share of electricity produced by the PV plant and directly consumed by the load.

## IV. Battery performance figures

### IV.1. Storage system efficiency

The efficiency given for each month is the ratio between the “Battery\_Discharge\_Energy” and the “Battery\_Charge\_Energy”, **since the beginning of operation**.

$$(\text{Storage system efficiency})_{\text{month } n} = \frac{\sum_1^n \text{Energy monthly discharged}}{\sum_1^n \text{Energy monthly charged}}$$

For instance, if the system started to operate at the beginning of the year :

- The efficiency for January will be the ratio between the Discharge and Charge Energies during January.
- When computing the efficiency for February, the energies **during** January **and** February are considered
- March efficiency : January, February and March
- And so on...

### IV.2. Number of full Equivalent Cycles

The number of full equivalent cycles is the ratio between the overall discharged energy and the nominal storage capacity. Adapted from *Electrochemical Energy Storage for RE and Grid Balancing* p429 (the original formula is based on current in Ah).

## V. Average profiles

The following average profiles are calculated from the raw data :

- One complete year: the calculation is made on the last 12 months available in the database
- Seasonal profiles: all the available data are used and may include similar months over different years:
  - Winter (December, January, February), Summer (June, July, August), Interseason (the remaining months)
  - Working Days (WD), Non Working Days (NWD). Except for the weekends, the NWD are defined according to each country.

### V.1. Computation method

Computation of **Battery\_Discharge**, **Battery\_Charge**, **Grid\_import** and **Grid\_export** from average **load** and **production** profiles

The following algorithm is run:

If  $\text{Energy\_in\_battery}(t-1) - \text{Energy\_in\_battery}(t) > 0$

**Battery\_Discharge** =  $[\text{Energy\_in\_battery}(t-1) - \text{Energy\_in\_battery}(t)] * 60/\text{timestep}$

**Battery\_Charge** = 0

Else

**Battery\_Charge** =  $-\text{Energy\_in\_battery}(t-1) + \text{Energy\_in\_battery}(t) * 60/\text{timestep}$

**Battery\_Discharge** = 0

The initial value of **Energy\_in\_battery** (for the first timestep 00:00) is based on the SOC average value at 00:00. If not available (no data, too many missing data), the value is  $0.5 * Usable\_Capacity$ . Using either method makes almost no difference.

If **load** > **production**

**Self\_consumption** = **production**

**Surplus** = 0

Else

**Self\_consumption** = **load**

**Surplus** = **production** - **load**

**Energy\_deficit** = **load** - **Self\_consumption**

If **Energy\_deficit** > 0

**Energy\_in\_battery** (t) = **Energy\_in\_battery** (t-1) - **Energy\_deficit**

Else

**Energy\_in\_battery** (t) = **Energy\_in\_battery** (t-1) + **Energy\_deficit**

If **Energy\_in\_battery** (t) < 0

**Energy\_in\_battery** (t) = 0

If **Energy\_in\_battery** (t) > **Useful\_Capacity**

**Energy\_in\_battery** (t) = **Useful\_Capacity**

If **consumption\_from\_storage** - **Energy\_deficit** >= 0

**Grid\_import** = 0

Else

**Grid\_import** = (**Energy\_deficit** - **consumption\_from\_storage**) \* 60 / timestep

If **Energy\_in\_battery** (t-1) > **Energy\_deficit**

**consumption\_from\_storage** = **Energy\_deficit**

Else

**consumption\_from\_storage** = **Energy\_in\_battery** (t-1)

If **Energy\_in\_battery** (t-1) + **Energy\_surplus** > **Useful\_Capacity**

**Grid\_export** = (**Energy\_in\_battery** (t-1) + **Energy\_surplus** - **Useful\_Capacity**) \* 60 / timestep

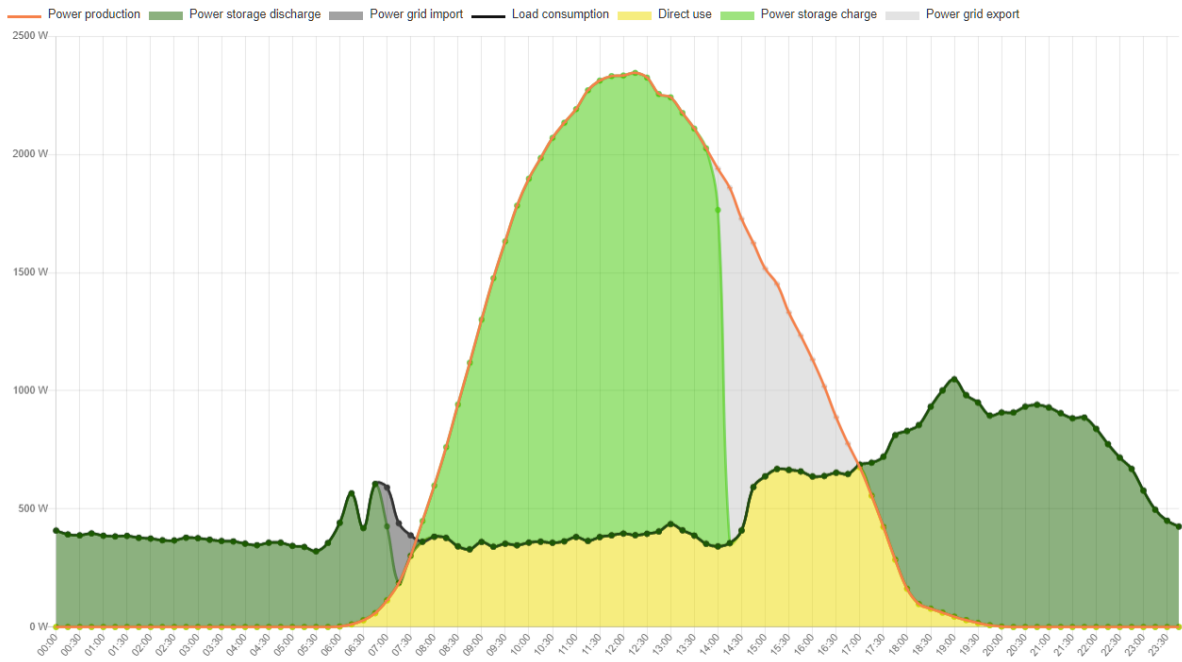
Else

**Grid\_export** = 0

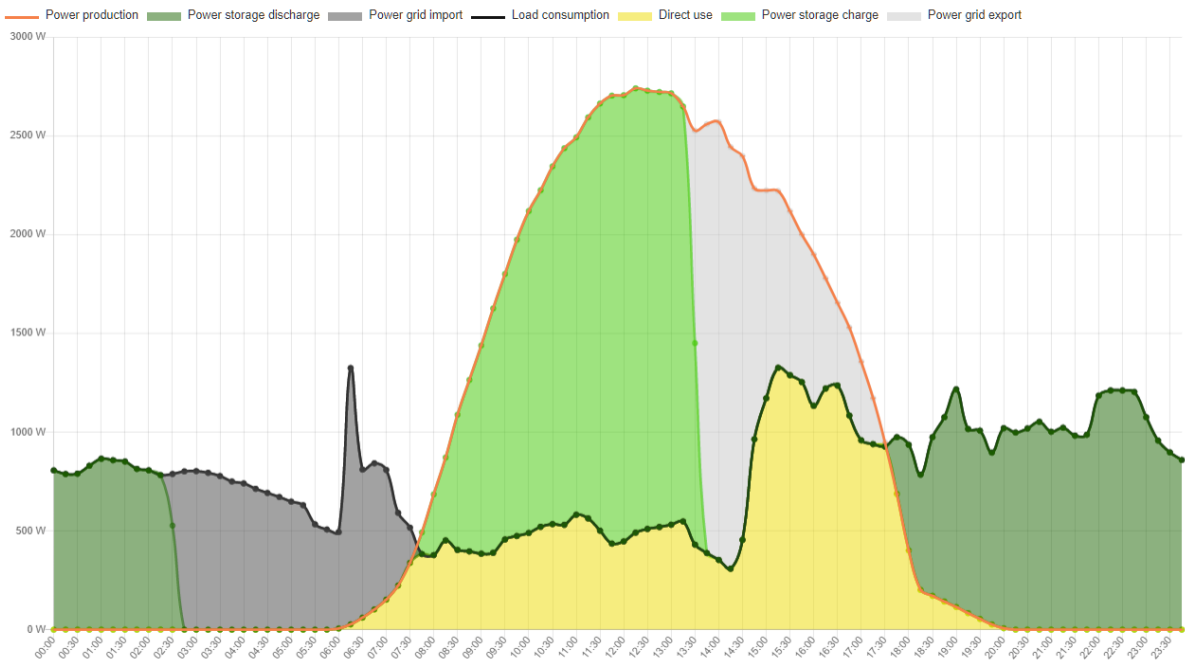
**Energy\_surplus** = **Surplus** \* timestep / 60

## V.2. Examples

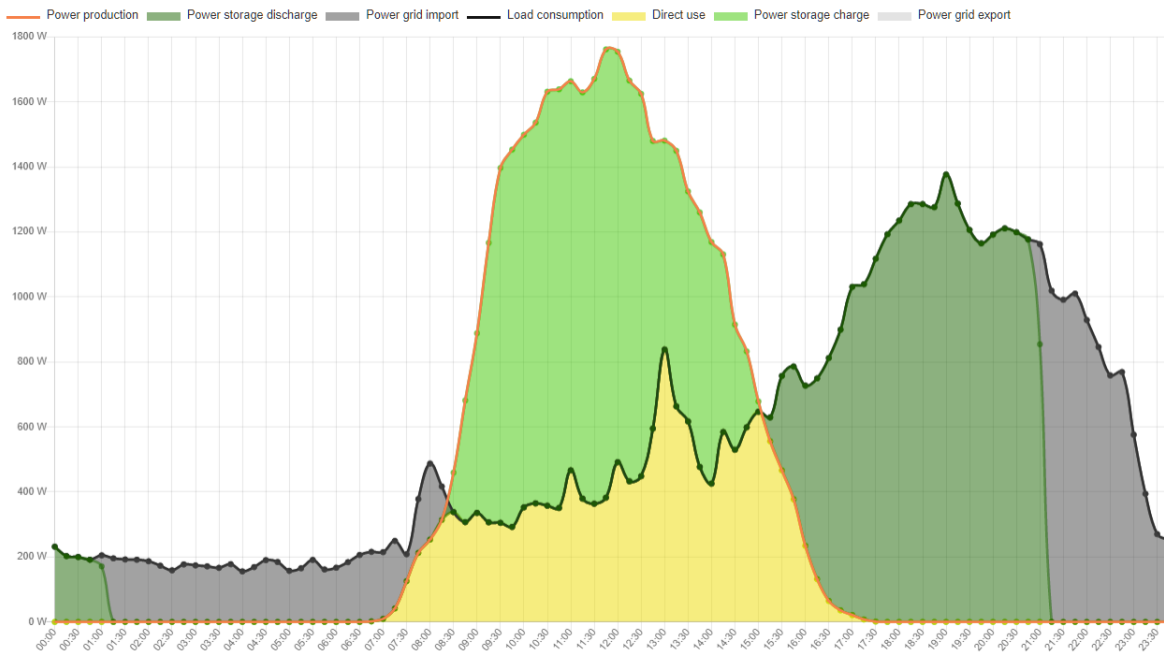
### V.2.1. Year



### V.2.2. Summer Working Days



### V.2.3. Winter non-working days



## VI. Parametric Study

The parametric study simulates the SCR, SCR and Prosumer ratio, by varying the PV capacity (in kWp) and the storage capacity (in kWh).

The ranges of variation are :

- 0 to 30 kWh for the storage
- 0 to PV\_max, where PV\_max is given by the roof surface multiplied by 17% (efficiency of solar modules)
  - If the roof surface is not known, PV\_max = 15 kWp, except for the site "Greece 5" where PV\_max = 30 kWp

The simulation is based on the algorithm used for the computation of average profiles, except that the calculation is performed for each available timestamp in the data, and not for average days.

The PV production profile for a given PV capacity is calculated homothetically.