Home Sim

Software tool for simple simulation of photovoltaic system with battery for buildings

Short manual

SW version: 0.1 beta

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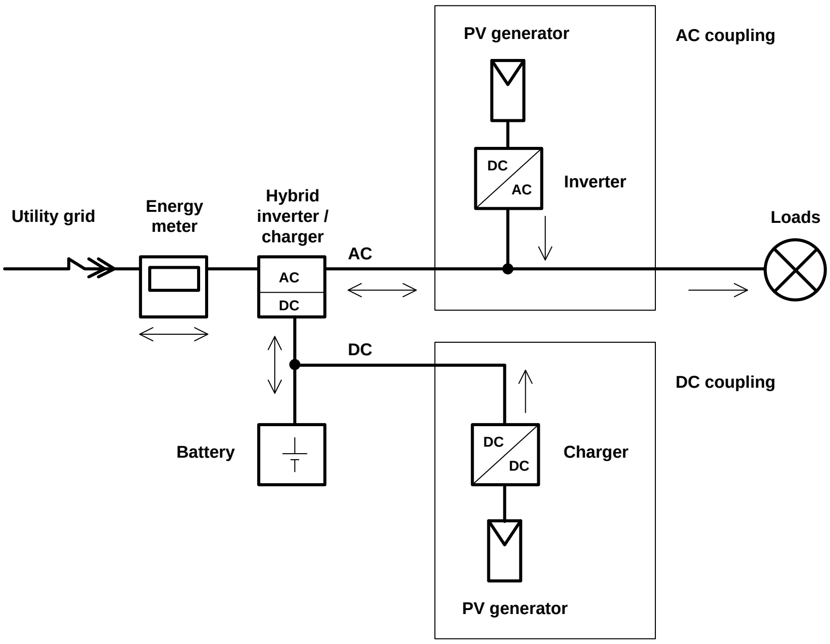
Purpose

The software tool is intended to be used for performing simple simulations of annual operation of PV systems with battery in buildings. The main objective is to set a balance of the PV gains, local energy consumption and possible energy storage system (battery, ESS).

Topology of integration of PV source

There are two basic concepts how to integrate the PV system when using the ESS to the building grid. First is based on AC coupling – the basic connection of connecting a PV source to the AC grid. This concept is recommended when the loads occur mostly on sunny hours. The other concept DC coupling connects the PV source to the battery system voltage and is recommended if loads during night are typical. Nevertheless both concepts are used and the decision depends on the system designer. In some solutions the PV generator is split and both concepts are used.



Program appearance and behavior

A simple model to perform annual simulation on hourly time resolution was implemented using Excel sheets. This program was chosen from several reasons: it is a common environment typically installed on PCs, the interface is simple, understandable and widely used. It enables effective work with data and its visualization at the same time. The simulation file is divided into 4 basic sheets for user interaction (other for advanced parameter setting and performing simulations are initially hidden)

Sheet *PVsystem* defines the PV system parameters (module electrical and thermal parameters), PV generator layout, cable losses and inverter/charger parameters. It performs elementary checks of the PV generator to inverter configuration. For output the monthly irradiation on module plane and energy yield is presented (table and graphs).

Sheet *HourlyMetoData* gives the input for irradiance and ambient temperature to be used in simulations. Solar irradiance on module plane has to be used as the transition from horizontal to module place is computationally extensive (using e.g. Perez model) and is not integrated in the first versions. PV cell operational temperature T_{cell} is being derived from ambient temperature T_{Air} and current irradiation G by:

$$T_{cell} = T_{Air} + \frac{NOCT-20}{800} G \qquad ,$$

using nominal operational temperature (*NOCT*) that can be found in PV module datasheet (typically 45 °C).

Sheet *Load* is used to define the electrical load inside the building. This can be easily done by selecting various predefined appliances and their count. The appliances have initial value of typical power while operation and standby power and its typical usage is defined based on hourly fraction of operational time during weekdays and weekends. All these values can be altered if needed. A graph presenting the daily energy profile with hourly resolution for weekdays and weekends separately together with energy statistics is shown as an output.

Sheet *HybridSystem* is used to define the parameters for hybrid inverter and for the battery. The inverter parameters define its efficiencies for both directions of energy conversion (AC/DC) and its power limitations. For battery the efficiencies have to be defined together with capacity and state of charge limits.

When all the parameters in the above described sheets are defined, the result in *HybridSystem* sheet can be found. An *Overview* table shows the monthly statistical data of the system (energy generation, grid consumption, battery cycling, system losses…). Several graphs depict the monthly as well as annual system performance in term of energy sources, f_u, f_s, losses…

Simulation process

The main simulation time-step is one hour, so the sheet where it processes uses 8760 rows to cover a year, each representing state at hour *N*. The simulation starts with half-charged battery. *SOC* and grid interaction for row *N* is being derived from excess energy at row *N* and *SOC* at row *N-1*. Firstly, the excess of energy is computed, if it is positive and the battery is not full, then the excess of energy will be stored in the battery. Otherwise, in the case that the battery gets fully charged, the rest is not locally utilized and it leads to grid injection or PV power limitation. If the excess power is negative, firstly the battery is used for the rest of energy needed to supply the loads. If the battery is empty (e.q. there is SOC limitation) the energy needed is covered from the grid. In the end the sum of energy taken from the grid, injected to the grid and used from PV is used to calculate the annual statistics.