# Model Assumptions and Formulation

## 1. Introduction

This document summarizes the assumptions underpinning the energy flow optimization model and describes its mathematical formulation. The goal of the model is to minimize total system cost—comprising grid import costs, lost-cost-of-storage (LCOS) charging costs, and revenues from exports—over a set of discrete time periods.

## 2. Key Assumptions

\*\*Time Resolution\*\*: The model operates on fixed, equal-length time intervals. All data (PV production, demand, prices) are known a priori for each time step.

\*\*Perfect Foresight\*\*: Forecasts for PV generation, load demand, electricity buying/selling prices, and LCOS values are assumed perfect and deterministic.

\*\*PV Availability\*\*: PV generation is non-dispatchable but can be split at each time step among self-consumption (load), storage charging, and grid export.

\*\*Battery Characteristics\*\*:

* - \*\*Energy Capacity (B\_CAP)\*\*: Total energy the battery can store is 160kWh.
* - \*\*Power Rate Limit (B\_RATE)\*\*: Maximum charging/discharging power per time interval is 100kW.
* - \*\*Round-Trip Efficiency (EFF)\*\*: Fraction of energy retained when charging is 92%
* - \*\*State of Charge (SoC)\*\*: Continuous variable bounded between 0 and B\_CAP.
* - \*\*No Degradation Dynamics\*\*: Battery capacity and efficiency remain constant over the horizon.

\*\*Grid Interaction\*\*:

* - The grid have a maximun capacity for buying: 700 kW
* - The grid have a maximun capacity for Selling: 700 kW
* - \*\*Prices\*\*: Buying price (p\_buy) and selling price (p\_sell) vary over time but are predetermined.

\*\*No Start-Up or Cycling Costs\*\*: Apart from the LCOS charge applied during discharge, no additional fixed costs (e.g., start-up, minimum up/down times) are modeled.

\*\*Network Losses\*\*: Electrical losses in wiring and transformers are neglected.

## 3. Mathematical Formulation

### 3.1 Sets and Indices

T: Ordered set of time periods (hours).

### 3.2 Parameters

1. PV\_t: PV generation available at time t.
2. D\_t: Electrical demand (load) at time t.
3. p^buy\_t, p^sell\_t: Grid buying and selling prices (€/kWh) at t.
4. lcos\_t: Levelized cost of storage charging (€/kWh) at t.
5. B\_CAP, B\_RATE, G\_CAP, EFF as defined above.

### 3.3 Decision Variables

1. pv2load\_t, pv2batt\_t, pv2grid\_t ∈ ℝ₊: Split of PV to load, battery, and grid.
2. grid2load\_t, grid2batt\_t ∈ ℝ₊: Grid import to load and to battery.
3. batt2load\_t, batt2grid\_t ∈ ℝ₊: Battery discharge to load and to grid.
4. soc\_t ∈ [0, B\_CAP]: Battery state of charge.

### 3.4 Constraints

1. PV Conservation: pv2load\_t + pv2batt\_t + pv2grid\_t = PV\_t, ∀ t.
2. Load Balance: pv2load\_t + grid2load\_t + batt2load\_t = D\_t, ∀ t.
3. Grid Power Limits: grid2load\_t + grid2batt\_t ≤ G\_CAP; pv2grid\_t + batt2grid\_t ≤ G\_CAP, ∀ t.
4. Battery Charge/Discharge Limits: pv2batt\_t + grid2batt\_t ≤ B\_RATE; batt2load\_t + batt2grid\_t ≤ B\_RATE, ∀ t.
5. State of Charge Dynamics: soc\_t = EFF\*(pv2batt\_t + grid2batt\_t) - (batt2load\_t + batt2grid\_t) for t = t0; soc\_t = soc\_{t-1} + EFF\*(pv2batt\_t + grid2batt\_t) - (batt2load\_t + batt2grid\_t) for t > t0.

### 3.5 Objective Function

Minimize total cost over all time steps: min Σ\_{t∈T} [ p^buy\_t\*(grid2load\_t + grid2batt\_t) - p^sell\_t\*(pv2grid\_t + batt2grid\_t) + lcos\_t\*(batt2load\_t + batt2grid\_t) ].

### 3.6 Solution Approach

The model is formulated as a linear program and solved using the open‑source CBC solver via Pyomo. After solving, flows are aggregated into DataFrames for analysis, and results (plots, Excel outputs) are generated automatically.