Sunly Baseload App - Documentation

1. Overview

Renewable energy is often developed without keeping end-consumers' needs in mind. Consumers need electricity every hour of every day, not only when the sun shines or wind blows.

This leads to an unoptimized generation stack and price cannibalization for producers.

To solve this we've created a **simulator** that helps us figure out two things:

1. How much of the energy consumers use can come from green sources like solar, wind and batteries.
2. How much would that green energy cost if it were used to supply power all day long (called *baseload*).

The goal is to find **"the best"** asset stack, that helps to create the cheapest baseload price for end consumers.

2. Inputs

Wind Capacity, MW – Installed wind generation capacity.

Wind PaP Price, EUR/MWh – Contract price for wind energy (Pay-as-Produced).

PV Capacity, MW – Installed solar (PV) generation capacity.

PV PaP Price, EUR/MWh – Contract price for solar energy (Pay-as-Produced).

Target Baseload, MW – What is the baseload you want to meet?

Missing Energy Price, EUR/MWh – At what price do you buy energy back from the market when you don't meet baseload.

Xh Battery Capacity, MW – Charge/discharge power capacity of the battery with X-hour duration.

BESS Xh annual payment, EUR – Annual fixed cost for the corresponding battery system.

3. Outputs

Simulation id – Identifier for simulation run.

Year – Simulation year this result corresponds to.

BL 1 - Fixed Missing, EUR/MWh – Effective cost of delivered baseload, including storage and missing energy valued at VWAP (Volume Weighted Average Price).

BL 2 - VWAP Missing, EUR/MWh – Same as BL 1 but missing energy priced at a fixed penalty value instead of VWAP (Volume Weighted Average Price).

Break-even 1 - Fixed Missing, EUR/MWh – Required price to break even based on production, storage cost, wind and solar sellback (excess energy VWAP), and missing energy cost (fixed price).

Break-even 2 - VWAP Missing, EUR/MWh – Same as Break-even 1, but uses VWAP for missing energy pricing.

Break-even 3 - Excess En. Price Fixed 0, EUR/MWh – Required price to break even based on production, storage cost, wind and solar sellback (excess energy fixed price atm. 0), and missing energy cost (fixed price).

Annual avg spot, EUR/MWh – Average day-ahead market price over the simulation year.

Res share in BL, % – Share of baseload met by renewable energy (wind + solar + storage) as a percentage.

Nr of green BL hours, h – Number of hours when baseload demand was fully met.

Nr of hours, h – Total number of hours in the simulated year.

Wind cap price, EUR/MWh – VWAP (volume-weighted average price) of wind energy sent to the grid.

PV cap price, EUR/MWh – VWAP of solar (PV) energy sent to the grid.

Missing energy VWAP, EUR/MWh – Average spot price at which baseload shortfalls (missing energy) occurred.

Excess energy VWAP, EUR/MWh – Average spot price for energy overproduced and exported to the grid.

Baseload, MWh – Total annual energy demand as determined by the baseload level (in MWh).

Overproduction share, % – Share of produced energy (wind + solar) that was either curtailed or not used due to storage/grid limits.

Missing energy, MWh – Total MWh of energy that was needed to meet baseload but could not be delivered.

Cycle loss, MWh – Cumulative round-trip losses due to inefficiencies in charging/discharging storage systems. The round-trip efficiency for all BESS is 86%.

Wind prod, MWh – Total annual energy produced by wind farms. Solar prod, MWh – Total annual energy produced by solar panels.

Wind in BL, MWh – Wind energy that was directly or indirectly (via storage) used to meet baseload.

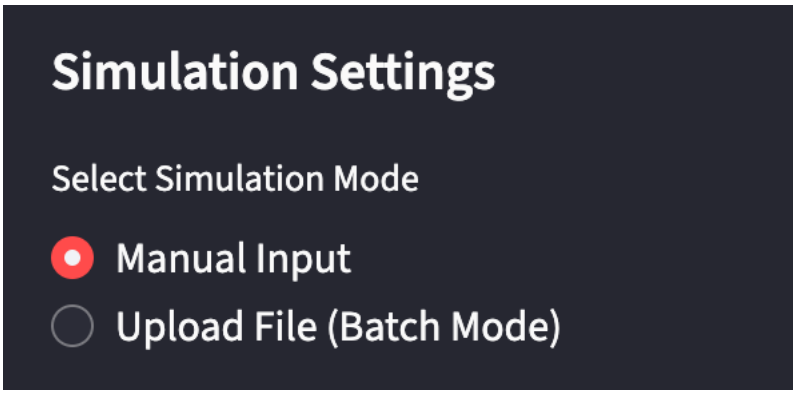
Solar in BL, MWh – Same as above, but for solar energy.

Excess wind, MWh – Wind energy that was exported to the grid beyond baseload needs.

Excess solar, MWh – Solar energy exported to the grid beyond baseload needs. BESS Xh avg cycles – Average daily full equivalent discharge cycles for the X-hour battery system.

4. How to use

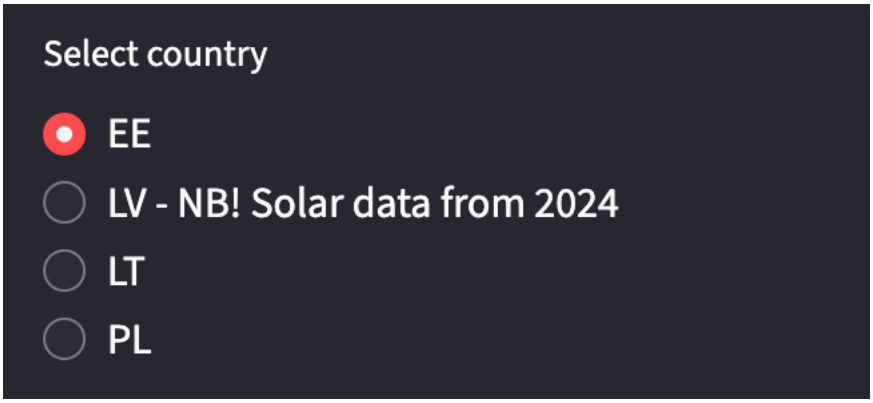
Start with choosing between these 2 Simulation Modes (they are explained below)



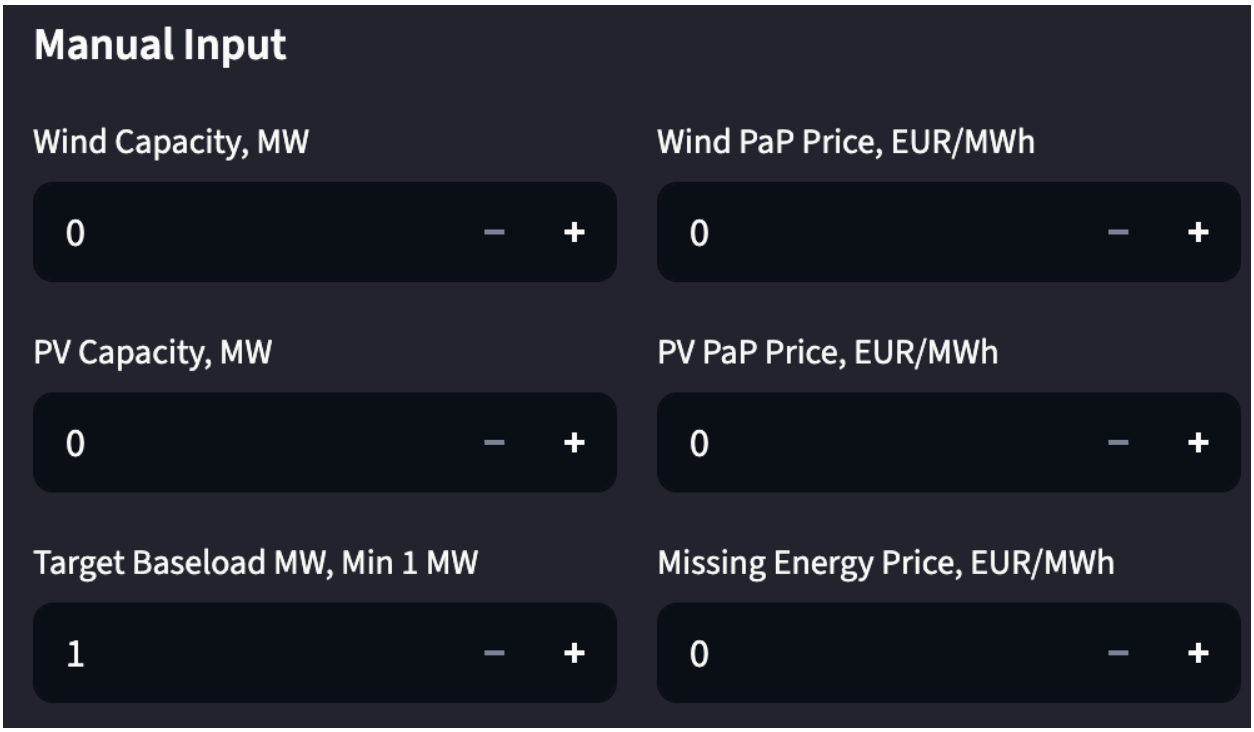
A. Manual Mode

Run one simulation at a time. Best for exploring and visualizing results interactively. The application shows outputs in a structured format with charts and graphs, making it easier to understand the results.

Step 1: Select your desired countries power curve.

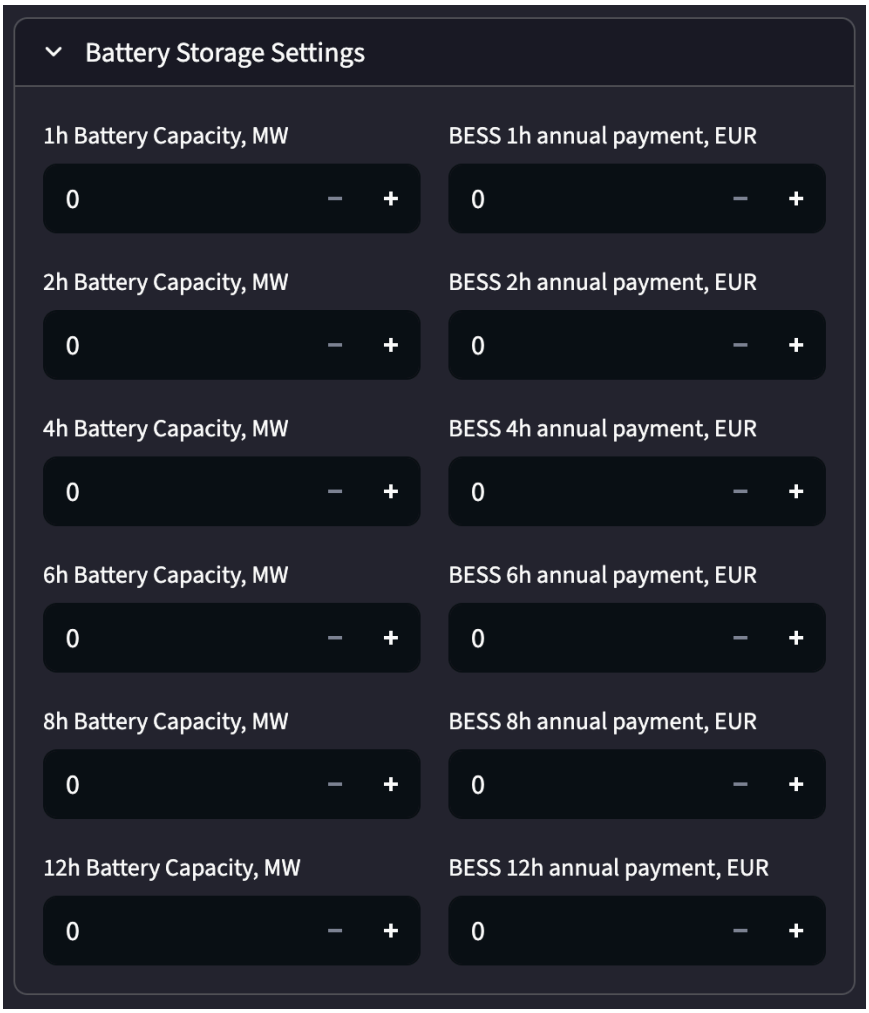


Step 2: Add your desired inputs for wind and solar, baseload and missing energy price.



Step 3: If desired, add BESS to the simulator. The BESS hours range from 1h to 12h.

For example – A 2h BESS with 50 MW capacity can store and release up to 100 MWh total. Input is required for both capacity and cost to include each storage type. All BESS systems use 86% round-trip efficiency.

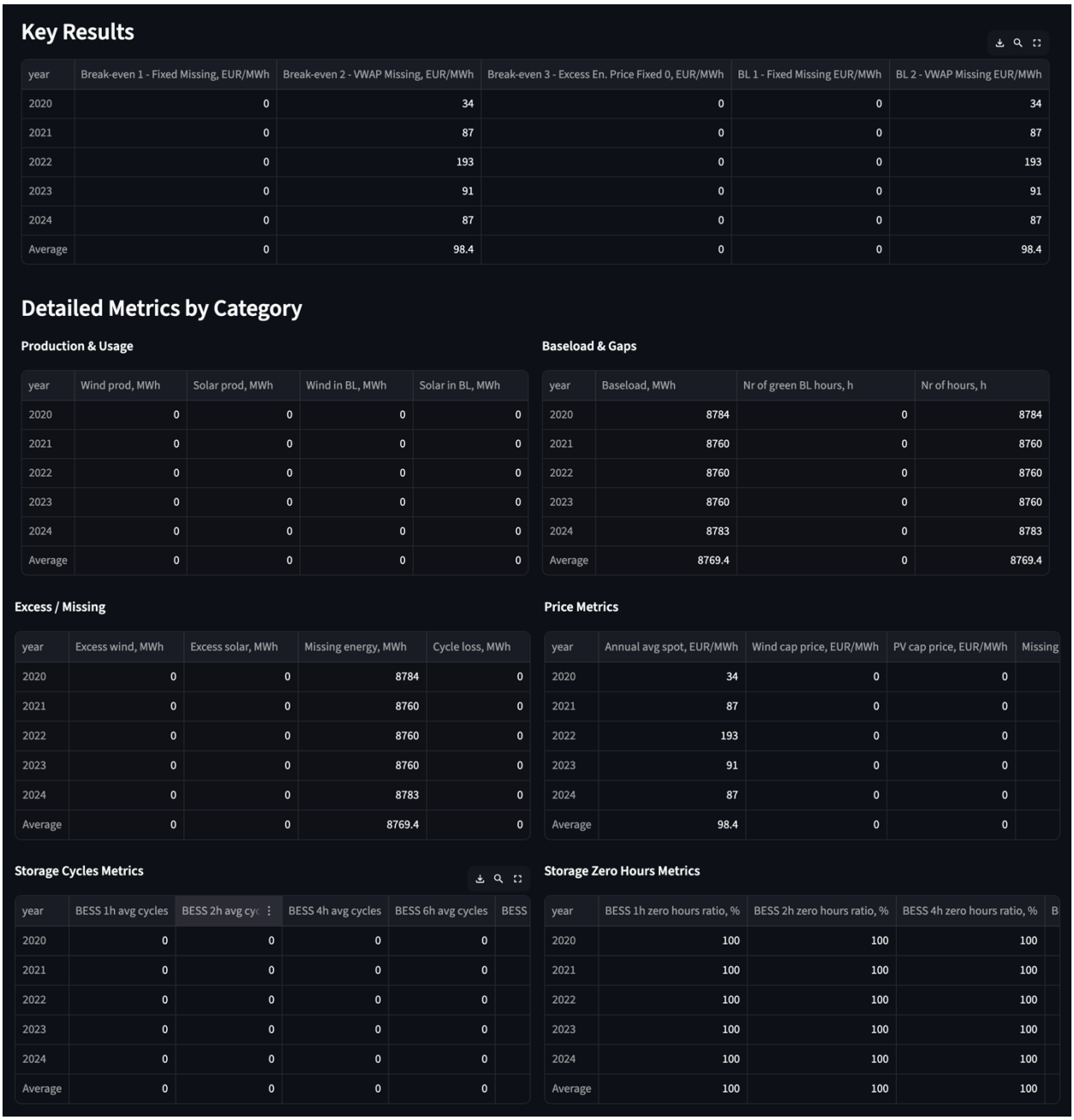


Step 4: To run the simulation, click on “Run Simulation” under the BESS inputs.

Step 5: Analyse your results – The output and input explinations can be found at the beginning of this documentation. Furthermore the explinations can be found in the simulator on the sidebar under the buttons “Input field explinations” and “Output field explinations”.

(These results were made with all the inputs being 0, except for baseload that was 1)

All outputs are made with power curves from 2020-2024 with the calculated average of those years.



Key Results

year	Break-even 1 - Fixed Missing, EUR/MWh	Break-even 2 - VWAP Missing, EUR/MWh	Break-even 3 - Excess En. Price Fixed 0, EUR/MWh	BL 1 - Fixed Missing EUR/MWh	BL 2 - VWAP Missing EUR/MWh
2020	0	34	0	0	34
2021	0	87	0	0	87
2022	0	193	0	0	193
2023	0	91	0	0	91
2024	0	87	0	0	87
Average	0	98.4	0	0	98.4

Detailed Metrics by Category

Production & Usage

year	Wind prod, MWh	Solar prod, MWh	Wind in BL, MWh	Solar in BL, MWh
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
Average	0	0	0	0

Baseload & Gaps

year	Baseload, MWh	Nr of green BL hours, h	Nr of hours, h
2020	8784	0	8784
2021	8760	0	8760
2022	8760	0	8760
2023	8760	0	8760
2024	8783	0	8783
Average	8769.4	0	8769.4

Excess / Missing

year	Excess wind, MWh	Excess solar, MWh	Missing energy, MWh	Cycle loss, MWh
2020	0	0	8784	0
2021	0	0	8760	0
2022	0	0	8760	0
2023	0	0	8760	0
2024	0	0	8783	0
Average	0	0	8769.4	0

Price Metrics

year	Annual avg spot, EUR/MWh	Wind cap price, EUR/MWh	PV cap price, EUR/MWh	Missing
2020	34	0	0	
2021	87	0	0	
2022	193	0	0	
2023	91	0	0	
2024	87	0	0	
Average	98.4	0	0	

Storage Cycles Metrics

year	BESS 1h avg cycles	BESS 2h avg cyc	BESS 4h avg cycles	BESS 6h avg cycles	BESS
2020	0	0	0	0	
2021	0	0	0	0	
2022	0	0	0	0	
2023	0	0	0	0	
2024	0	0	0	0	
Average	0	0	0	0	

Storage Zero Hours Metrics

year	BESS 1h zero hours ratio, %	BESS 2h zero hours ratio, %	BESS 4h zero hours ratio, %	B
2020	100	100	100	
2021	100	100	100	
2022	100	100	100	
2023	100	100	100	
2024	100	100	100	
Average	100	100	100	

You can also download the outputs as a full dataset by clicking the “All results” button and from there clicking on “Download results as CSV” where the browser will download the data frame to your computer.

All Results

	Simulation id	year	BL 1 - Fixed Missing EUR/MWh	BL 2 - VWAP Missing EUR/MWh	Break-even 1 - Fixed Missing, EUR/MWh	Break-even 2 - VWAP Missing, EUR/MWh	Break-even 3 - Excess
0	1	2020	0	34	0	34	
1	1	2021	0	87	0	87	
2	1	2022	0	193	0	193	
3	1	2023	0	91	0	91	
4	1	2024	0	87	0	87	

Download Results as CSV

Step 5: Charts

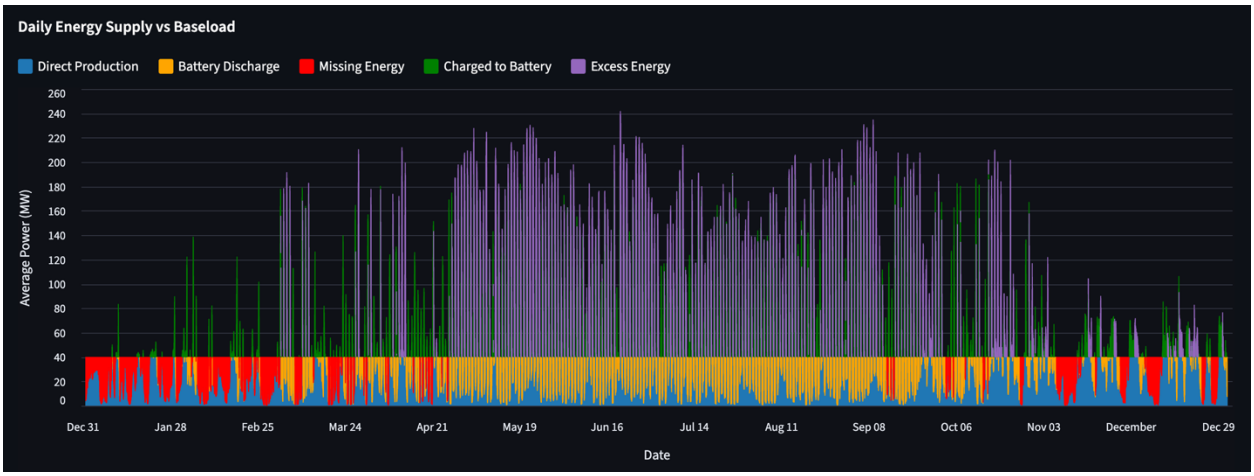
With each years power curves there are 3 generated charts.

Daily Energy Supply vs Baseload

This chart shows how **production** and **battery storage** work together to meet the baseload, and when excess energy occurs.

- **Blue** – Production directly meeting the baseload
- **Red** – Missing energy needed to meet the baseload (shortfall)
- **Green** – Surplus energy stored in the battery (charging)
- **Orange** – Battery discharging to cover production shortfall
- **Purple** – Excess energy sold to the market (when the battery is already full)

From this chart, you can see exactly when the system meets demand, when storage is used, and when excess energy is generated.

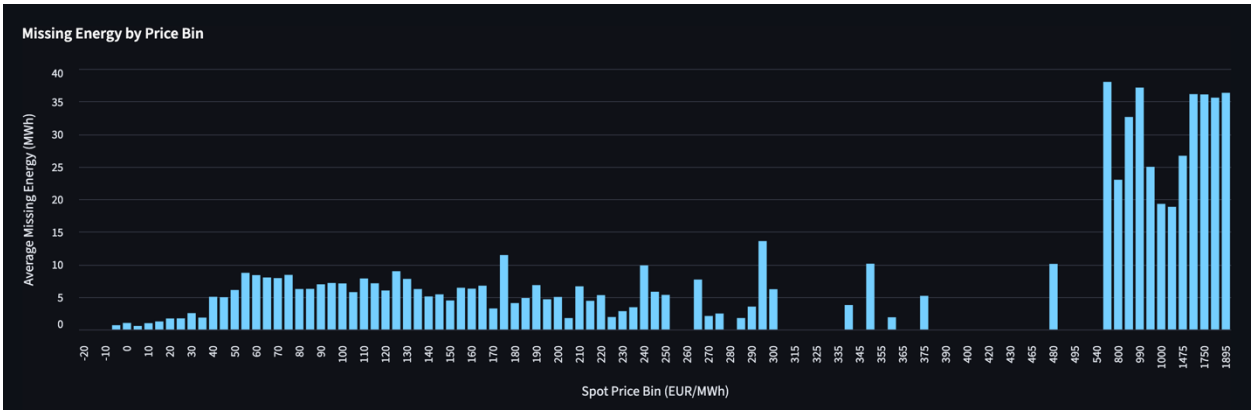


(This is chart is made with the inputs – 44 MW Wind Capacity, 244 MW Solar Capacity, 150 MW 4h BESS AND 40 MW Baseload)

Missing Energy by Price Bin

This chart shows **how much energy we bought from the market** and **at what price**. From this chart, you can quickly see which price ranges account for the largest share of market purchases.

- **X-axis:** Spot price bins in **10 EUR/MWh** intervals (e.g., 0–10, 10–20, 20–30, etc.).
- **Y-axis:** Amount of energy purchased in each price range.

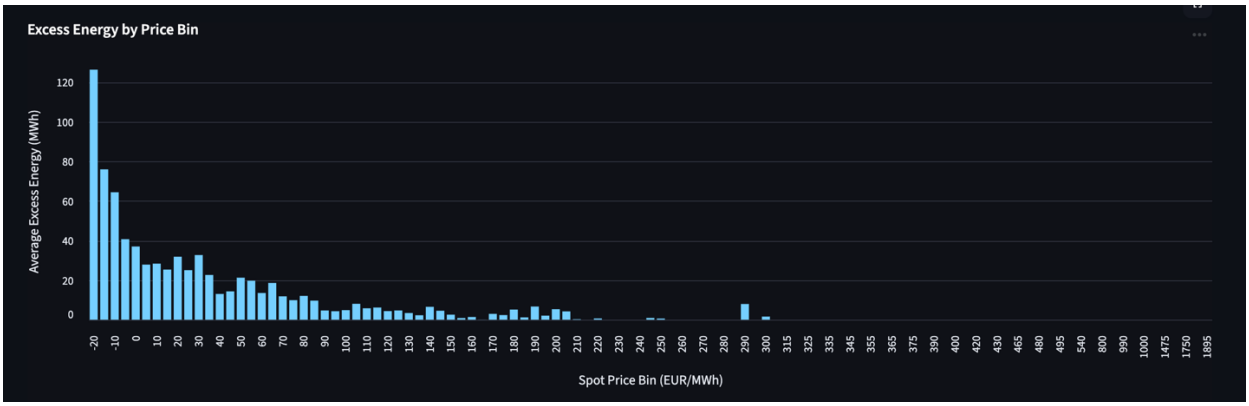


(This is chart is made with the inputs – 44 MW Wind Capacity, 244 MW Solar Capacity, 150 MW 4h BESS AND 40 MW Baseload)

Excess Energy by Price Bin

This chart shows **how much energy we sold to the with excess energy market** and **at what price**. From this chart, you can quickly see which price ranges account for the largest share of market sales.

- **X-axis:** Spot price bins in 10 EUR/MWh intervals (e.g., 0–10, 10–20, 20–30, etc.).
- **Y-axis:** Amount of energy sold in each price range.

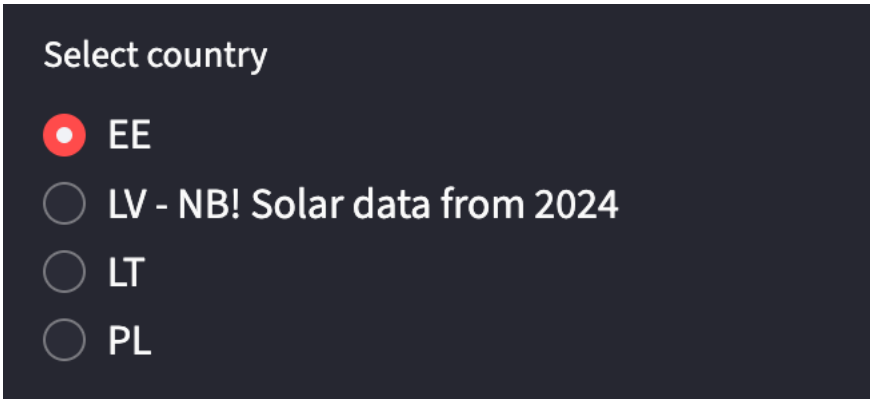


(This is chart is made with the inputs – 44 MW Wind Capacity, 244 MW Solar Capacity, 150 MW 4h BESS AND 40 MW Baseload)

B. Batch Mode (Upload File)

Run multiple simulations at once. You can download and prepare an Excel file with many scenarios, upload it, and the simulator will process all scenarios simultaneously. This is more efficient for testing many cases quickly, but without the same interactive visualizations as Manual Mode.

Step 1: Select your desired countries power curve.

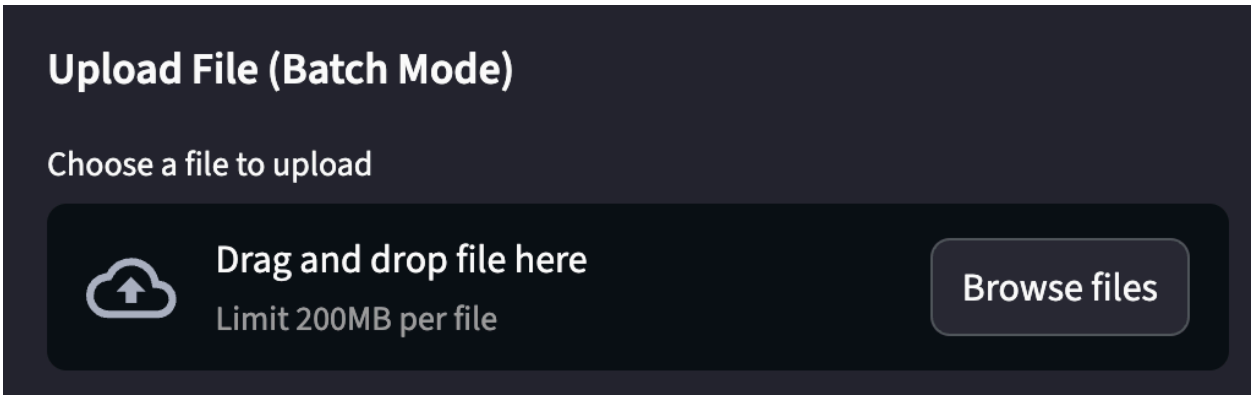


Step 2: Download the input template by clicking the button „Download Simulation Input Template“

Step 3: In the template, add all the inputs that are needed, bear in mind that each row in the input template represents a new simulation.

NB! Do not leave baseload blank as this will result in some calculations dividing by zero which will raise an error.

Step 4: Drag and drop or browse from files the Excel file and upload it into the simulator.



Step 5: To run the simulation, click on “Run Simulation” button under the upload file.

Step 6: The results come in a Data frame that can be downloaded. Each simulation has a Simulation id in the first column for distinction.