

A tool for building integrated energy systems design

Sizing and operation of PV and battery systems in buildings with flexible loads

Introduction

This online tool aims to promote self-sufficiency in buildings with flexible loads, by properly sizing the photovoltaic and battery storage systems to be installed in a building, and providing an efficient schedule for the flexible loads. The tool has been developed in the framework of *"Cost-effective rehabilitation of public buildings into smart and resilient nano-grids using storage - BERLIN"* project. The objective of BERLIN is to implement cross-border pilot measures to support innovative and cost-effective energy rehabilitations in public buildings based on the nano-grid concept, the building block for smart micro-grids. The project focuses on increasing grid penetration, combined with energy storage and demand-side management, along with enhancement of energy efficiency in buildings. The goal is to increase the level of self-resilience in public buildings and to make them greener, smarter, and sustainable.

The tool calculates the proper size of a hybrid PV+storage system to achieve one of the following objectives:

- Maximum self-sufficiency
- Maximum net present value (NPV)
- Cost-effective solutions for enhanced self-sufficiency

The tool also incorporates an option for an exhaustive analysis, that delivers the results for all possible PV and battery system size combinations. The required inputs are: electrical consumption, building location, PV and battery size range for the analysis, electricity costs, and the policy applying to renewables in the region of the case study. A financial analysis is undertaken for a period of 5-25 years (based on user's choice), taking into consideration several technical and financial parameters. The tool can be used by both professionals and non-professionals users. An analytic description of the analysis methods of the tool is available in [1].

Feel free to use the tool for your analyses.

For further information contact: Prof. Georgios Christoforidis: gchristoforidis@uowm.gr

Please cite as:

[1] N. S. Kelepouris, A. I. Nousdilis, A. S. Bouhouras and G. C. Christoforidis, "Enhancing Self-Sufficiency in Buildings with Hybrid PV-Battery Systems and Demand Side Management: A sizing tool," IEEE Int. Conf. Environ. Electri. Eng. And IEEE Ind. Commer. Power Syst. Europe (EEEIC / I&CPS Europe), 2021, pp. 1-6, doi: 10.1109/EEEIC/ICPSEurope51590.2021.9584559.



Manual

This document is a short manual, providing the user with simple instructions. The procedure that should be followed to get the desired results is divided into 8 separate steps:

- Step 1: PV System Data
- Step 2: Storage System
- Step 3: Consumption Data
- Step 4: Electricity Charging Mechanism and Prices
- Step 5: Policy Data
- Step 6: Financial Data
- Step 7: Analysis Options
- Step 8: Getting the Results

These steps are further analyzed in the remaining document.



Step 1: PV System Data

- **i.** The "*PV production profile*" is essential for the tool calculations. The user should select one of the following two options:
 - a) If PV power measurements of a specific installation are available, the user can import these data in a *.xlsx* file and upload it by clicking *"Upload"*. The data should be entered using the template that can be downloaded from the corresponding button. Next, user should enter the PV capacity (in kWp) of the measured PV installation.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results					
Description 🗖												
Please import the technical parameters for the photovoltaic (PV) system. Note that there are two options for the PV power profile: either by providing measurements of a nearby PV or by indicating the location of the building that will host the PV system.												
PV Production	Profile*	Use My	Measurements	~								
Use my measu	rements *											
Select a file:	Περιήγηση Δε	εν επιλέχθηκε αρχείο.	Upload File									
Installed PV ca	pacity [kWp]	1										

The next image is an overview of the *.csv* template file. Power should be imported in kW, considering a 15-min time interval.

	В	С	D	E	F	G	н	1	J	К	L	М	N
1	Time	January	February	March	April	May	June	July	August	September	October	Novembe	December
2	00:00	0	0	0	0	0	0	0	0	0	0	0	0
3	00:15	0	0	0	0	0	0	0	0	0	0	0	0
4	00:30	0	0	0	0	0	0	0	0	0	0	0	0
5	00:45	0	0	0	0	0	0	0	0	0	0	0	0
6	01:00	0	0	0	0	0	0	0	0	0	0	0	0
7	01:15	0	0	0	0	0	0	0	0	0	0	0	0
8	01:30	0	0	0	0	0	0	0	0	0	0	0	0
9	01:45	0	0	0	0	0	0	0	0	0	0	0	0
10	02:00	0	0	0	0	0	0	0	0	0	0	0	0
11	02:15	0	0	0	0	0	0	0	0	0	0	0	0
12	02:30	0	0	0	0	0	0	0	0	0	0	0	0
13	02:45	0	0	0	0	0	0	0	0	0	0	0	0
14	03:00	0	0	0	0	0	0	0	0	0	0	0	0
15	03:15	0	0	0	0	0	0	0	0	0	0	0	0
16	03:30	0	0	0	0	0	0	0	0	0	0	0	0
17	03:45	0	0	0	0	0	0	0	0	0	0	0	0
18	04:00	0	0	0	0	0	0	0	0	0	0	0	0
19	04:15	0	0	0	0	0	0	0	0	0	0	0	0
20	04:30	0	0	0	0	0	0	0	0	0	0	0	0
21	04:45	0	0	0	0	0	0.009749	0	0	0	0	0	0
22	05:00	0	0	0	0	0.018789	0.022621	0.010327	0	0	0	0	0
23	05:15	0	0	0	0	0.032497	0.034546	0.022116	0	0	0	0	0
24	05:30	0	0	0	0	0.045242	0.045536	0.032984	0.015007	0	0	0	0
25	05:45	0	0	0	0.019205	0.066868	0.060371	0.045288	0.02599	0	0	0	0
	() ·	PV pro	oduction (k	W)	+					÷ •			



- BERLIN
- b) If no PV power measurements are available, the user can indicate the coordinates of the installation position or can place a pin on the provided map. Followingly, the PV panels orientation should be provided (slope and azimuth). The tool then communicates with the PVGIS platform¹ and obtains the necessary climatic data for the specific location in order to estimate the PV power output. The calculation procedure is described in detail in a relevant publication².

PV system Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
Description 🖃							
Please import the technical paramete providing measurements of a nearby	rs for the photovolta PV or by indicating th	ic (PV) system. The location of th	Note that th ne building th	ere are two optio at will host the I	ons for the PV p PV system.	ower profile: eith	er by
PV Production Profile*	PV Syst	em Position	~				
Location *							
Latitude		1	Longitude				
40.35752352236373			21.7731468	38373293			
Address							
Enter Address			Search				
Nouóc Φιέρ Μπεράτ Fier Berat Auλώνας Vigre 💶	Pogradec Kopurdá Korçe Karçe	ολώρινα οριά Εδ	Εδεσσα Εδεσσα Βέροια	σεσσαλ Θεσσαλ Καλαμ	ονίκη Ε	трорала 0	[]
Apyupókaatipo Gjirokaster Aytot Sapávra Sarande	Κόντσα Πάτιγκο Μανοδένδοι	29 Κοζάνι ε90 Γρεβενά	Ολυμπος	Κατερίνη Λεπτοκαρυά	23 Tisu	Ουραγουπολη Υμκήτη Σάρτη τοχώρι	+
Google	Метооро	Καλαυπάκα	[55] Συντομεύσει	ς πληκτρολογίου 8202	2 Δεδομένα χάρτη Goo	jle 20 χλμ 🛄 Ό	ροι Χρήσι
Single Slope (deg)*		•		22	0		
Azimuth (deg)*		•		0	0		

¹ https://ec.europa.eu/jrc/en/pvgis (Assessed January 2021)

². G. C. Christoforidis, I. P. Panapakidis, T. A. Papadopoulos, G. K. Papagiannis, I. Koumparou, M. Hadjipanayi and G. E. Georghiou, "A Model for the Assessment of Different Net-Metering Policies", Energies, 2016, 9(4), 262; doi:10.3390/en9040262.



ii. The next option of this step refers to the type of analysis. The user can select between an analysis that examines multiple PV sizes in a given range (Parametric analysis: Yes) and an analysis that considers a single PV size (Parametric analysis: No).

Parametric PV size analysis *	● Yes ○ No	
Single PV size (kWp)*	•	50 0
Range of PV size*	Min: 1-100 kWp	Max: 1-100 kWp

iii. In the last section of this tab, the "PV System derating factor" that corresponds to the degradation of the solar panels, and the efficiency of the hybrid inverter have to be introduced.

PV System derating factor* 0-10 %
Hybrid Inverter Efficiency* 70-100 %



Step 2: Storage System Data

The characteristics of the Battery Storage System (BSS) are defined in this tab. The user is able to perform an analysis for different BSS sizes.

Initially, the user defines the BSS maximum size that is desired for the analysis. The analysis range spans form 0 kWh up to user defined maximum size (*in kWh*).

The user should also define the *"usable battery capacity"* that is usually provided by the battery manufacturer or can be calculated if the maximum and minimum operational state of charge (SoC) are known. For example, for a SoC operational range of 10-90%, the usable capacity is calculated as 80%.

The *"maximum charging/discharging rate"* of the BESS, as a percentage (%) of the nominal battery capacity should also be provided. For example, if 50% is selected here, a 10 kWh BESS will have a maximum rate of 5 kW.

The "Battery dc-to-dc roundtrip efficiency" should be inserted. This efficiency includes the losses of battery charging and discharging processes, at the dc-side of the BSS, excluding the losses on the hybrid inverter.

Finally, the expected *"maximum lifecycles"* should be inserted, as declared by the manufacturer of the BSS. A number of 8000 cycles could be used as a typical value for Li-Ion batteries.

PV system	Storage system	Consu	mption	Charges	Policy	Financial	Analysis	Results				
Description □ Please import the technical parameters of the battery storage system (BSS).												
Maximum BSS	size for analysis*		kWh									
Usable battery	capacity*		%									
Maximum char battery capacit	rging rate (as a rate of ty)	*	%									
Maximum disc battery capacit	harging rate (as a rate o y)	f *	%									
Battery dc-dc r	oundtrip efficiency*		%									
Maximum lifec	ycles*		>=500									



Step 3: Consumption Data

The consumption of the installation should be inserted in this tab. It can be provided in the form of monthly energy, yearly energy, or in the form of typical daily power profiles as measured in the building under study. Also flexibility options of the load consumption are defined in this tab.

i. Consumption data

a) Monthly consumption energy data: Select the country of the installation under study and insert the energy consumption of each month over a year, in kWh.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
escription	Ξ							
Please impo form of typic consumptior	rt the electricity demand al daily power profiles as 1.	of the building under s measured in the bu	study. It can be ilding under stu	e provided in th dy. Please also	ne form of mon o define the flex	thly energy, yea ibility options o	arly energy, or of the load	in the
Consumption	period*	Monthl	y	~				
Typical Count	ry Consumption*	Greece v						
January	Consumption	0	February	Consumption	n C			
March	Consumption	0	April	Consumption	n C			
May	Consumption	0	June	Consumption	n C			
July	Consumption	0	August	Consumption	n C			
September	Consumption	0	October	Consumption	n C			

b) Yearly consumption energy: Select the country of the installation under study and insert the total energy consumption over a year, in kWh.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
Description	Ξ							
Please import form of typica consumption.	t the electricity demand al daily power profiles as	of the building under s measured in the bui	study. It can be Iding under stu	e provided in dy. Please al:	the form of mor so define the fle.	nthly energy, yea xibility options	arly energy, or of the load	in the
Consumption p	period*	Yearly		~				
Typical Countr	y Consumption*	Greece ~						



c) Customized Profiles: The user has the option to upload own consumption by means of an .xlsx file using the provided template. The template can be downloaded by clicking at the corresponding button.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results					
Description	Ξ											
Please import the electricity demand of the building under study. It can be provided in the form of monthly energy, yearly energy, or in the form of typical daily power profiles as measured in the building under study. Please also define the flexibility options of the load consumption.												
Consumption p	period*	Custom	ized Profiles	J								

The next image is an overview of the .csv template file. Power should be imported in kW, considering a 15-min time interval. Consumption should be inserted in the specified columns per month, taking into consideration a classification between working and non-working days.

	A	в	С	D	E	F	G	н	1	J	K	L	M	N	0	P	Q	R	S	т	U	V	
1			Janu	uary	Febr	ruary	Ma	arch	A	pril	M	ау	Ju	ne	Ju	ly	Au	gust	Septe	mber	Octo	aber	-
2	ime Instan	Time	W	NW	W	NW																	
3	1	00:00	0.821277	0.898479	0.798084	0.759603	0.687991	0.751013	0.533072	0.568152	0.428518	0.466787	0.40296	0.364253	0.45815	0.532315	0.576348	0.5414	0.580354	0.658113	0.859998	0.7446	
4	2	00:15	0.821277	0.898479	0.798084	0.759603	0.687991	0.751013	0.533072	0.568152	0.428518	0.466787	0.40296	0.364253	0.45815	0.532315	0.576348	0.5414	0.580354	0.658113	0.859998	0.7446	
5	3	00:30	0.821277	0.898479	0.798084	0.759603	0.687991	0.751013	0.533072	0.568152	0.428518	0.466787	0.40296	0.364253	0.45815	0.532315	0.576348	0.5414	0.580354	0.658113	0.859998	0.7446	
6	4	00:45	0.821277	0.898479	0.798084	0.759603	0.687991	0.751013	0.533072	0.568152	0.428518	0.466787	0.40296	0.364253	0.45815	0.532315	0.576348	0.5414	0.580354	0.658113	0.859998	0.7446	
7	5	01:00	0.635964	0.71306	0.649225	0.674496	0.573084	0.688369	0.45227	0.472126	0.325582	0.387531	0.407821	0.36568	0.495214	0.586997	0.690773	0.789178	0.492735	0.587279	0.587111	0.5567	
8	6	01:15	0.635964	0.71306	0.649225	0.674496	0.573084	0.688369	0.45227	0.472126	0.325582	0.387531	0.407821	0.36568	0.495214	0.586997	0.690773	0.789178	0.492735	0.587279	0.587111	0.5567	
9	7	01:30	0.635964	0.71306	0.649225	0.674496	0.573084	0.688369	0.45227	0.472126	0.325582	0.387531	0.407821	0.36568	0.495214	0.586997	0.690773	0.789178	0.492735	0.587279	0.587111	0.5567	
10	8	01:45	0.635964	0.71306	0.649225	0.674496	0.573084	0.688369	0.45227	0.472126	0.325582	0.387531	0.407821	0.36568	0.495214	0.586997	0.690773	0.789178	0.492735	0.587279	0.587111	0.5567	
11	9	02:00	0.551832	0.65138	0.575362	0.606672	0.552996	0.641945	0.456888	0.4387	0.281569	0.326869	0.460797	0.357541	0.528073	0.654645	0.785349	0.981204	0.475248	0.592331	0.578435	0.5394	
12	10	02:15	0.551832	0.65138	0.575362	0.606672	0.552996	0.641945	0.456888	0.4387	0.281569	0.326869	0.460797	0.357541	0.528073	0.654645	0.785349	0.981204	0.475248	0.592331	0.578435	0.5394	
13	11	02:30	0.551832	0.65138	0.575362	0.606672	0.552996	0.641945	0.456888	0.4387	0.281569	0.326869	0.460797	0.357541	0.528073	0.654645	0.785349	0.981204	0.475248	0.592331	0.578435	0.5394	_
14	12	02:45	0.551832	0.65138	0.575362	0.606672	0.552996	0.641945	0.456888	0.4387	0.281569	0.326869	0.460797	0.357541	0.528073	0.654645	0.785349	0.981204	0.475248	0.592331	0.578435	0.5394	
15	13	03:00	0.585565	0.681221	0.55978	0.696747	0.605921	0.651547	0.500738	0.398841	0.258976	0.316962	0.377633	0.352836	0.534805	0.597102	0.797729	1.047575	0.434375	0.497282	0.544991	0.4410	
16	14	03:15	0.585565	0.681221	0.55978	0.696747	0.605921	0.651547	0.500738	0.398841	0.258976	0.316962	0.377633	0.352836	0.534805	0.597102	0.797729	1.047575	0.434375	0.497282	0.544991	0.4410	
17	15	03:30	0.585565	0.681221	0.55978	0.696747	0.605921	0.651547	0.500738	0.398841	0.258976	0.316962	0.377633	0.352836	0.534805	0.597102	0.797729	1.047575	0.434375	0.497282	0.544991	0.4410	
18	16	03:45	0.585565	0.681221	0.55978	0.696747	0.605921	0.651547	0.500738	0.398841	0.258976	0.316962	0.377633	0.352836	0.534805	0.597102	0.797729	1.047575	0.434375	0.497282	0.544991	0.4410	
19	17	04:00	0.579521	0.648703	0.588838	0.611102	0.617685	0.630256	0.456759	0.409129	0.251805	0.315191	0.348786	0.310452	0.51773	0.55946	0.7666	0.937635	0.397001	0.455587	0.495963	0.3999	
20	18	04:15	0.579521	0.648703	0.588838	0.611102	0.617685	0.630256	0.456759	0.409129	0.251805	0.315191	0.348786	0.310452	0.51773	0.55946	0.7666	0.937635	0.397001	0.455587	0.495963	0.3999	
21	19	04:30	0.579521	0.648703	0.588838	0.611102	0.617685	0.630256	0.456759	0.409129	0.251805	0.315191	0.348786	0.310452	0.51773	0.55946	0.7666	0.937635	0.397001	0.455587	0.495963	0.3999	
22	20	04:45	0.579521	0.648703	0.588838	0.611102	0.617685	0.630256	0.456759	0.409129	0.251805	0.315191	0.348786	0.310452	0.51773	0.55946	0.7666	0.937635	0.397001	0.455587	0.495963	0.3999	
23	21	05:00	0.617595	0.655103	0.653448	0.580337	0.727778	0.627212	0.503509	0.488202	0.249603	0.292534	0.377734	0.296731	0.515301	0.499415	0.795861	0.800253	0.431296	0.436156	0.448679	0.4300	
24	22	05:15	0.617595	0.655103	0.653448	0.580337	0.727778	0.627212	0.503509	0.488202	0.249603	0.292534	0.377734	0.296731	0.515301	0.499415	0.795861	0.800253	0.431296	0.436156	0.448679	0.4300	
25	23	05:30	0.617595	0.655103	0.653448	0.580337	0.727778	0.627212	0.503509	0.488202	0.249603	0.292534	0.377734	0.296731	0.515301	0.499415	0.795861	0.800253	0.431296	0.436156	0.448679	0.4300	
26	24	05:45	0.617595	0.655103	0.653448	0.580337	0.727778	0.627212	0.503509	0.488202	0.249603	0.292534	0.377734	0.296731	0.515301	0.499415	0.795861	0.800253	0.431296	0.436156	0.448679	0.4300	
27	25	06:00	0.788979	0.703986	0.851835	0.714329	0.965835	0.680231	0.715487	0.582028	0.274116	0.31632	0.436128	0.379458	0.509418	0.427678	0.762018	0.758727	0.41611	0.489441	0.503648	0.4317	
28	26	06:15	0.788979	0.703986	0.851835	0.714329	0.965835	0.680231	0.715487	0.582028	0.274116	0.31632	0.436128	0.379458	0.509418	0.427678	0.762018	0.758727	0.41611	0.489441	0.503648	0.4317	
29	27	06:30	0.788979	0.703986	0.851835	0.714329	0.965835	0.680231	0.715487	0.582028	0.274116	0.31632	0.436128	0.379458	0.509418	0.427678	0.762018	0.758727	0.41611	0.489441	0.503648	0.4317	
30	28	06:45	0.788979	0.703986	0.851835	0.714329	0.965835	0.680231	0.715487	0.582028	0.274116	0.31632	0.436128	0.379458	0.509418	0.427678	0.762018	0.758727	0.41611	0.489441	0.503648	0.4317	
31	29	07:00	0.92676	0.680702	1.079229	0.801129	1.063107	0.780349	0.883215	0.784652	0.403473	0.44201	0.586223	0.498126	0.557027	0.467215	0.711174	0.678582	0.467657	0.474046	0.649745	0.5906	
32	30	07:15	0.92676	0.680702	1.079229	0.801129	1.063107	0.780349	0.883215	0.784652	0.403473	0.44201	0.586223	0.498126	0.557027	0.467215	0.711174	0.678582	0.467657	0.474046	0.649745	0.5906	
33	31	07:30	0.92676	0.680702	1.079229	0.801129	1.063107	0.780349	0.883215	0.784652	0.403473	0.44201	0.586223	0.498126	0.557027	0.467215	0.711174	0.678582	0.467657	0.474046	0.649745	0.5906	
34	32	07:45	0.92676	0.680702	1.079229	0.801129	1.063107	0.780349	0.883215	0.784652	0.403473	0.44201	0.586223	0.498126	0.557027	0.467215	0.711174	0.678582	0.467657	0.474046	0.649745	0.5906	
35	33	08:00	0.987681	1.07578	1.060633	0.950537	1.065449	0.918249	1.054723	0.750009	0.504951	0.579355	0.590515	0.491801	0.675057	0.390365	0.719043	0.421265	0.514112	0.631397	0.783808	0.8595	
36	34	08:15	0.987681	0.822207	1.060633	0.898053	1.065449	0.99504	1.054723	0.917045	0.504951	0.584186	0.590515	0.341602	0.675057	0.560305	0.719043	0.678025	0.514112	0.605131	0.783808	0.6692	-
			Buildin	ng Cons	umptio	n (kW)	(÷						: ◀								•	





ii. Load flexibility options

The user should enter the percentage of load demand energy of each time zone (00:00 - 08:00 and 16:00 - 24:00) that is flexible and can be shifted towards other time zones.

Demand Side Management* On										
Flexibility of building consumption*										
	00:00 - 08:00	16:00 - 24:00								
Winter	0	\$								
Spring	0									
Summer	0									
Autumn	٥	0								



Step 4: Electricity Charging Mechanism and Prices

In this tab, the user should insert the cost for absorbed electrical energy, selecting the appropriate charging mechanism of the electricity provider company. The user can choose between either a *"flat pricing"* scheme, i.e., constant electricity charges throughout the period of a day, or a *"zonal pricing"* scheme, where the prices vary per time zone.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
Description (Ξ							
Please insert zonal pricing	the cost of electrical en	ergy, selecting the ap	propriate charg	ing mechani	sm of your elect	tricity provider c	company: flat	pricing or
L		Elat		Zonal Pric	ina			
				Zonarric	ing			
Production cha	arges*	€/kWh						
Network charg	es*	€/kWh						
Taxes on elect	rical energy*	€/kWh						
VAT*		%						

In the dynamic pricing scheme, the user should specify if two or three charging zones exist, by checking accordingly the *"Zone C"* option. The starting hour of each zone should be declared in an ascending order, beginning from Zone A. The ending hour is automatically filled in. Electricity costs should be inserted accordingly.

PV system Storage syste	m Consumption	Charges Poli	cy Financial	Analysis	Results
Description 🖃					
Please insert the cost of electric zonal pricing	al energy, selecting the a	ppropriate charging med	hanism of your ele	ctricity provider o	company: flat pricing or
	○ Flat	Pricing 🖲 Zonal	Pricing		
	Zone A		🛛 Zone B		■ Zone C
Beginning Time	、	·			
Production charges	€/kWh	€/kWh		€/kWh	
Network charges	€/kWh	€/kWh		€/kWh	
Taxes on electrical energy	€/kWh	€/kWh		€/kWh	
VAT	%				





All values should be entered before VAT. Specifically,

- *"Production charges"* correspond to the charges per kWh for the generation of electrical energy. It includes supply costs as well.
- *"Network charges"* correspond to the cost per kWh that are charged to the prosumer for the use of distribution network and transmission system.
- *"Taxes on electrical energy"* include all other charges that may be applicable per kWh of absorbed energy.
- *"VAT"* is the VAT that applies to the total electricity cost (sum of the above).



Step 5: Policy Data

The user should provide the renewables incentive policy existing in its region, along with the costs and revenues related to PVs, BSSs, and DSM of a building.

- "Self-consumption" refers to a policy incentive scheme that rewards prosumers for increasing their self-consumed PV energy and compensates any extra PV energy that is injected to the utility grid. The compensation price per kWh injected into the grid is inserted in the last field of this tab.
- *"Pure self-consumption"* is similar to the previous scheme lacking the compensation for PV surplus energy.

Furthermore, the user can define any added cost or added income that may apply to the prosumers for operating a PV or/and a PV-storage-DSM system.

PV system	Storage system	Consu	Imption	Charges	Polic	y Financial	Analysis	Results	
Description (Ξ								
Please provide building. 'Self- compensates compensation	e the renewables incenti consumption' refers to a any extra PV energy tha for PV surplus energy.	ive policy o a policy ind t is injecte	existing in j centive sch ed to the ut	your region, ald neme that rewa illity grid. 'Pure	ong with ti ords prosu self-cons	he costs and reven mers for increasing umption' is similar	ues related to P g their self-cons to the previous	Vs, BSSs, and umed PV ener scheme lackin	DSM of a gy and g the
Select Policy*			Self-Co	nsumption	~				
Added cost for	owning a PV system*		€/year						
Added income PV+BESS+DSM	to incentivize I solution	*	€/year						
Compensation the grid	for PV energy injected	to \star	€/kWh						



Step 6: Financial Data

The user should define the cost of purchasing the equipment, the Operation and Maintenance (O&M) costs of the hybrid PV-storage system, the subsidy as a percentage of the overall system cost, the discount rate, the inflation rate, and the electricity inflation rate.

"Investment cost for PV and hybrid inverter" includes the cost of PV panels, the hybrid inverter, engineering, administrative, and balance of systems costs (per kWp installed), whereas *"Investment for BSS cost"* refers to the battery storage system cost (per kWh) and includes the cost of the battery bank and the battery controller.

PV system	Storage system	Consu	mption	Charges	Policy	Financial	Analysis	Results	
Description	3								
Please import	the PV and BSS investi	nent cost,	the discou	nt and the infla	ition rate, an	d other financial	parameters req	uired for the a	nalysis.
Investment cos	st for PV and hybrid invo	erter*	€/kWh		$\hat{}$				
Investment cos	st for BSS*		€/kWh		$\hat{\cdot}$				
BSS annual co	st decrease (% per year)*	[0-50]		\$				
Operation & Ma investment cos	aintenance costs (% of t st)	the *		•		10	≎ [0 − 2	0]	
Subsidy for inv investment cos	estment (% of the st)	*		•		50	≎ [0 − 1	00]	
Discount rate (%)*			•		0	≎ [-50 −	50]	
Inflation rate (%	%)*			•		0	≎ [-50 -	50]	
Electricity cost	s inflation rate (%)*			•		0	≎ [-50 –	50]	



Step 7: Analysis Options

Once all the technical and economical data have been inserted, the user has to select among the available analysis methods, based on the desired objective, and then define the analysis period (in years). The offered analysis methods are the following:

- *"Exhaustive Analysis"*: this analysis returns results for all possible PV and battery size combinations. It is not as fast as the rest methods; however, it may be useful for research and sensitivity analysis purposes.
- "Solution that maximizes NPV": this option activates a thorough investigation of PV and BSS size combinations and delivers the optimal one that achieves the highest NPV. The analysis method is based on a metaheuristic algorithm and quickly provides a sole solution.
- "Solution that maximizes self-sufficiency": this option activates a thorough investigation of PV and BSS size combinations and delivers the optimal one that achieves the highest NPV. The analysis method is based on a metaheuristic algorithm and quickly provides a sole solution.
- "Cost-effective solution for increased SSR": this option activates a thorough investigation of PV and BSS size combinations and delivers a set of solutions that achieve a highly self-sufficient building and a high NPV at the same time. The analysis method is based on a metaheuristic algorithm and quickly provides a set of solutions.

For the last three options, the tool also offers an operation schedule for the flexible loads. The schedule corresponds to the optimal solution for each objective (maximum NPV, maximum self-sufficiency, most cost-effective solution).

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
Description	among the available and	alysis methods of the	e tool, based on	the desired	objective, and d	efine the analys	sis period.	
Analysis metho PV+BESS+DSM	od for the sizing of 1 *	 Exhaustive Analysis Solution that maximizes NPV Solution that maximizes self-sufficiency Cost-effective solution for increased SSR 						
Analysis period	l (years)*	[5-25]						



Step 8: Getting the Results

The analysis starts as soon as the user clicks at the "Show Results" button.

PV system	Storage system	Consumption	Charges	Policy	Financial	Analysis	Results	
			Show Res	sults				
			Get Static	Data				

If any of the inserted data are invalid or missing, an error message shows up informing the user that it should check the corresponding input fields with a red error message underneath.

Some of your inputs are invalid. Please check the corresponding fields with an error	or message underneath them.
Get Static Data	-

When the analysis is finished, the results will be visualized on the same tab. Analysis has a duration of several seconds to several minutes depending on the selected analysis method in Step 7.

To export the input data and the results in form of a *.pdf* or editable *.xlsx* file, the user should click on the proper buttons that appear on the right-top of the page.