

**Off-Grid Systems Modelling  
with MicroGridsPy**

# **Handbook MicroGridsPy Interface Walkthrough**



**WORLD BANK GROUP**



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**Climate Parliament**



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**KTH  
VETENSKAP  
OCH KONST**



**UNIVERSITY OF  
CAMBRIDGE**

**Version 1.0**

# Installing MicroGridsPy using Conda

The installation of MicroGridsPy is streamlined through a package manager after setting up a suitable Python distribution. Users can establish a dedicated environment containing all required dependencies to run the software. Once configured, the main application can be initiated through an integrated development platform, providing access to the MicroGridsPy user interface.

## 1 | Install the Conda Package Manager

Install MicroGridsPy easily using the **free conda package manager** from the Anaconda distribution for **Python 3**, which streamlines setup for data science applications.

## 2 | Create a new Environment

To create a modelling environment that already contains everything needed to run MicroGridsPy, it's required to download the **environment YML file** from the . After placing the **mgpy\_win.yml** file in "**C:/Users/youruser**", you can create and activate the new mgpy environment by running the following command in the Anaconda Prompt terminal:

```
conda env create -f mgpy_win.yml
```



anaconda / packages / conda 23.11.0

### MicroGridsPy Environment

This branch contains environment files for setting up MicroGridsPy across different versions and platforms. Use these files to configure your environment on Windows or macOS using [Conda](#).

#### Quick Start

- Install [Anaconda](#) or [Miniconda](#) if you haven't already.
- Download the environment YAML file for your desired version and place it in "C:/Users/youruser"
- Create and activate the mgpy environment by running the following command in the Anaconda Prompt terminal:

```
conda env create -f mgpy_win.yml
conda activate mgpy
```



# Installing MicroGridsPy using Conda

The installation of MicroGridsPy is streamlined through a package manager after setting up a suitable Python distribution. Users can establish a dedicated environment containing all required dependencies to run the software. Once configured, the main application can be initiated through an integrated development platform, providing access to the MicroGridsPy user interface.

## 3 | Activate the Environment

User can activate the new mgpy environment by running the following command in the Anaconda Prompt terminal:

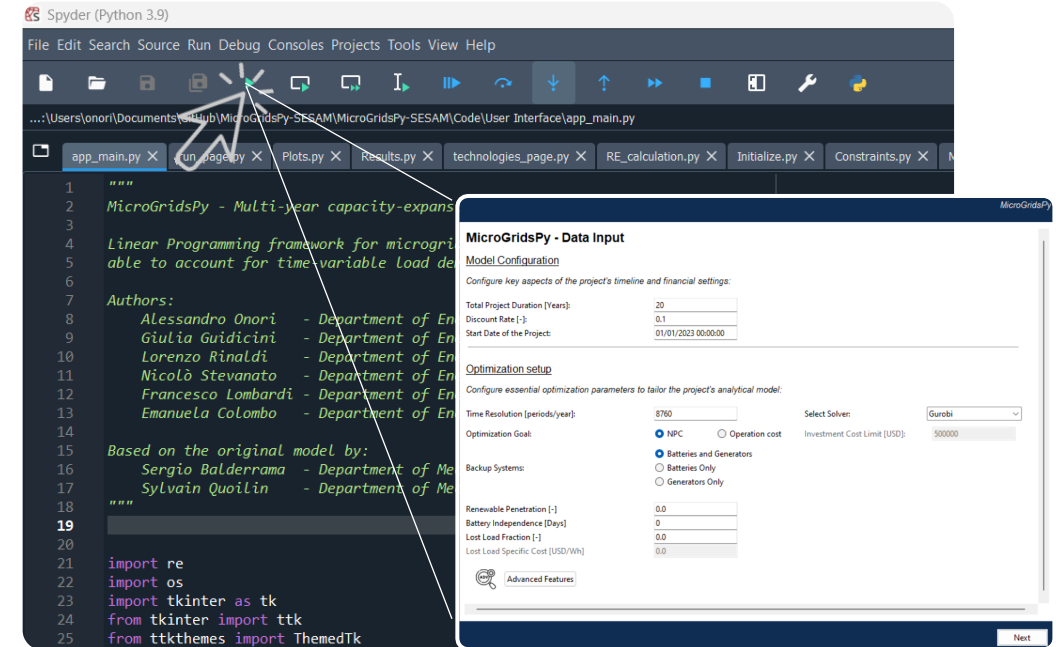
```
conda activate mgpy
```

## 4 | Open Spyder and RUN app\_main.py

After activating the mgpy environment, open the Spyder IDE by running:

```
spyder
```

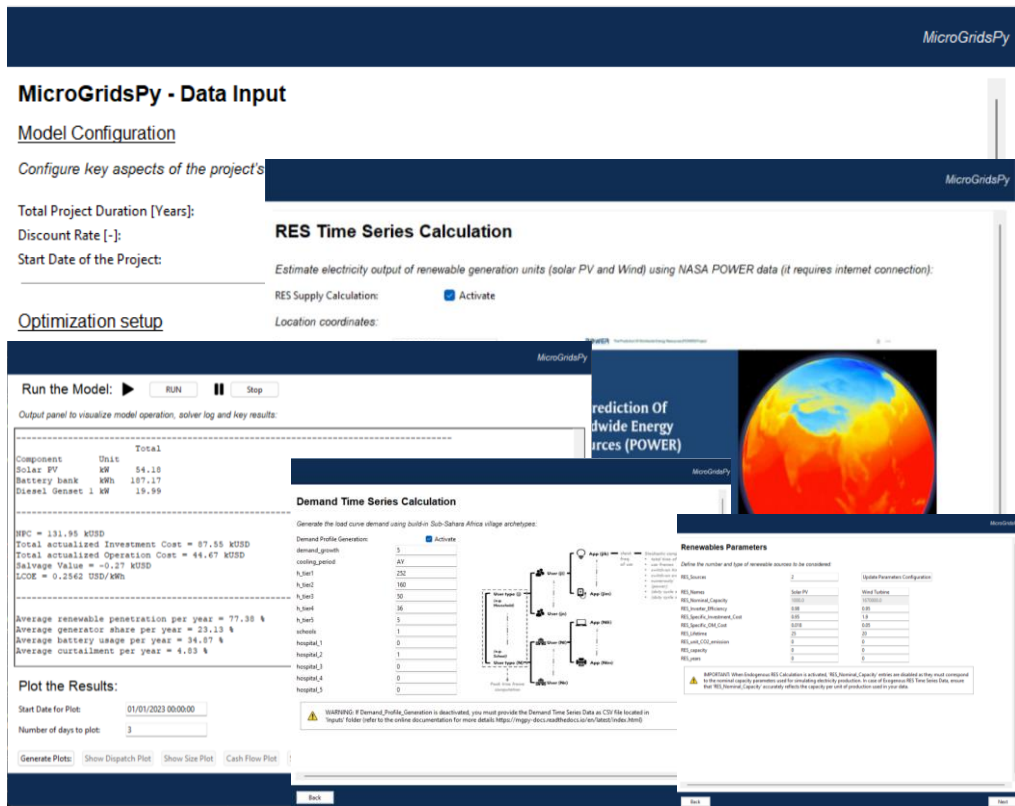
Run the **app\_main.py** file located into the **Code/User Interface** folder to open the **interface** and interact with it.



**Spyder** is a free and open source scientific environment written in Python, for Python, and designed by and for scientists, engineers and data analysts. It features a unique combination of the advanced editing, analysis, debugging, and profiling functionality of a comprehensive development tool

# Graphical User Interface

The graphical user interface (GUI) application provides a **user-friendly way** to **define and input data** for MicroGridsPy. It is organized into different pages, each tailored to a specific aspect of the model.



## Comprehensive Data Input and Validation

Features robust data input for basic parameters, RES time series, and technology configurations, with input validation and tooltips on each page for accurate and clear data entry.

## Dynamic Parameters Management and Visualization

The interface dynamically updates and manages parameter entries in response to user selections. This automatic enablement and disablement of options streamline the data input process, enhancing user interaction and decision-making through effective visualization.

## Efficient Run Functionality and Results Visualization

It includes functionalities for progress tracking and visual display of results, making the modelling process seamless and efficient.

Run this python script within your working IDE to open the application



Code/User Interface/**app\_main.py**



# Model Configuration

## Total Project Duration [years] Discount Rate [%] (0-1)

They mainly affect the actualization of the costs and, therefore, the technology selection and sizing of the mini-grid.

## Time Resolution

It affects result accuracy. Users can adjust it, but must ensure that any external time series data correspondingly match this resolution

## Optimization Goal

- **Net Present Cost:** focuses on optimizing both investment and operation costs
- **Operation Cost:** targets minimizing only operational expenses with an option to limit capital expenditure

☒ Operation cost

Investment Cost Limit [USD]:

MicroGridsPy

### MicroGridsPy - Data Input

#### Model Configuration

Configure key aspects of the project's timeline and financial settings:

Total Project Duration [Years]:	<input type="text" value="20"/>
Discount Rate [-]:	<input type="text" value="0.1"/>
Start Date of the Project:	<input type="text" value="01/01/2023 00:00:00"/>

#### Optimization setup


Configure essential optimization parameters to tailor the project's analytical model:

Time Resolution [periods/year]:	<input type="text" value="8760"/>	Select Solver:	<input type="text" value="Gurobi"/>
Optimization Goal:	<input checked="" type="radio"/> NPC <input type="radio"/> Operation cost	Investment Cost Limit [USD]:	<input type="text" value="500000"/>

Backup Systems:

☒ Batteries and Generators  
☐ Batteries Only  
☐ Generators Only

Renewable Penetration [-]	<input type="text" value="0.0"/>
Battery Independence [Days]	<input type="text" value="0"/>
Lost Load Fraction [-]	<input type="text" value="0.0"/>
Lost Load Specific Cost [USD/Wh]	<input type="text" value="0.0"/>

 [Advanced Features](#)

Next

# Model Configuration

MicroGridsPy

MicroGridsPy - Data Input

Model Configuration

Configure key aspects of the project's timeline and financial settings:

Total Project Duration [Years]:

20

Discount Rate [-]:

0.1

Start Date of the Project:

01/01/2023 00:00:00

Optimization setup

Configure essential optimization parameters to tailor the project's analytical model:

Time Resolution [periods/year]:

8760

Select Solver:

Gurobi

Optimization Goal:

☒ NPC

☐ Operation cost

Investment Cost Limit [USD]:

500000

Backup Systems:

☒ Batteries and Generators

☐ Batteries Only

☐ Generators Only

Renewable Penetration [-]

0.0

Battery Independence [Days]

0

Lost Load Fraction [-]

0.0

Lost Load Specific Cost [USD/Wh]

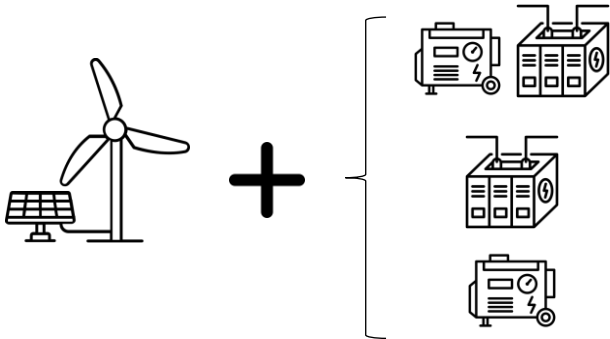
0.0

Advanced Features

Next

## Backup and Storage Systems

The user has the option to specify constraints on the types of technologies used for backup and storage within the model



## Optimization constraints

- **Renewable Penetration:** minimum percentage of total electricity from renewable sources
- **Battery Independence:** number of days the battery can power the grid without external support
- **Lost Load Fraction and Cost:** Threshold for unmet demand, with associated costs applicable only if there's a non-zero lost load

# Model Configuration

MicroGridsPy

## MicroGridsPy - Data Input

### Model Configuration


Configure key aspects of the project's timeline and financial settings:

Total Project Duration [Years]:	20
Discount Rate [-]:	0.1
Start Date of the Project:	01/01/2023 00:00:00

### Optimization setup

Configure essential optimization parameters to tailor the project's analytical model:

Time Resolution [periods/year]:	8760	Select Solver:	Gurobi
Optimization Goal:	<input checked="" type="radio"/> NPC <input type="radio"/> Operation cost	Investment Cost Limit [USD]:	500000
Backup Systems:	<input checked="" type="radio"/> Batteries and Generators <input type="radio"/> Batteries Only <input type="radio"/> Generators Only		
Renewable Penetration [-]	0.0		
Battery Independence [Days]	0		
Lost Load Fraction [-]	0.0		
Lost Load Specific Cost [USD/Wh]	0.0		

 Advanced Features

Next



GUROBI  
OPTIMIZATION

vs



*GLPK and Gurobi are currently compatible with MicroGridsPy and integrated options in the interface:*

- **GLPK:** An open-source, free-to-use option for small to medium optimization problems
- **Gurobi:** A faster, commercial solver suitable for large problems. Free for academic use; installation recommended from Gurobi's website. Requires license activation.



GLPK is suitable for a range of optimization problems but **operates slower** than commercial solvers like Gurobi on large or complex issues. Performance can vary, with **Gurobi often being significantly faster**, which is crucial for large-scale or urgent tasks



# Advanced Features

It enables **advanced features** such as **capacity expansion**, special financials setup, **grid connection options**, and advanced linear or **mixed-integer optimization**. It also **supports multi-objective** and **scenario-based optimization**.

Renewable Penetration [-] 0.0  
Battery Independence [Days] 0  
Lost Load Fraction [-] 0.0  
Lost Load Specific Cost [USD/Wh] 0.0



Advanced Features



## Advanced Features

### Advanced Modeling Options

Capacity Expansion:

☐ Activate

Step Duration [Years]:

20

Minimum Last Step Duration [Years]:

1

Model Formulation:

☒ LP

☐ MILP

Generator Partial Load:

☐ Activate

Type of Investment:

☒ Greenfield

☐ Brownfield

Grid Connection:

☐ On-grid

☒ Off-grid

Grid Availability:

☐ Activate

Grid Connection Type:

☒ Purchase Only

☐ Purchase/Sell

Fuel Specific Cost Calculation:

☐ Activate

WACC Calculation:

☐ Activate

cost\_of\_equity

0.12

cost\_of\_debt

0.11

tax

0.02

equity\_share

0.1

debt\_share

0.9

### Advanced Optimization Configuration

Multi-Objective Optimization:

☐ Activate

Multi-Scenario Optimization:

☐ Activate

Plot Max Cost:

☐ Yes

☒ No

Number of Scenarios:

1

Update

Pareto points:

2

Pareto solution:

1

Back

Next



# Endogenous RES Time Series Estimation

## Location Coordinates

Input latitude and longitude in DMS system (degrees, minutes and seconds)

## Solar PV parameters

Specifications for **solar panel module**, including **nominal power**, **tilt angle**, **azimuth**, and **efficiency-related coefficients** to calculate **solar generation potential** accurately

## Wind turbine parameters

Select the **turbine type and model**, see the associated **rated power** and input **drivetrain efficiency** to estimate **wind energy generation**



Models available:

- **Horizontal Axis:** Alstom.Eco.80 and NPS100c-21
- **Vertical Axis:** Hi-VAWT.DS1500 and Hi-VAWT.DS700



Code/Inputs/WT\_Power\_Curve.csv

MicroGridsPy

### RES Time Series Calculation

Estimate electricity output of renewable generation units (solar PV and Wind) using NASA POWER data (it requires internet connection):

RES Supply Calculation: ☒ Activate

Location coordinates:

lat	-11 33 56.4
lon	30 21 3.4

Solar PV panel parameters:

nom_power	1000
tilt	10
azim	180
ro_ground	0.2
k_T	-0.37
NMOT	45
T_NMOT	20
G_NMOT	800

Wind turbine parameters:

Turbine type:	Horizontal Axis
Turbine model:	Alstom.Eco.80
Rated Power [W]:	1670000
Drivetrain efficiency:	0.9

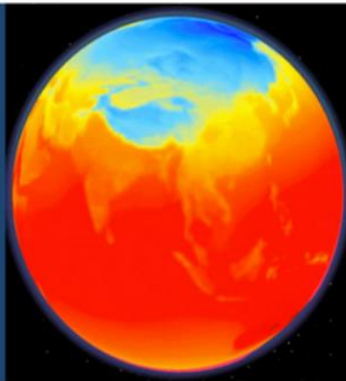
**! Internet Connection required**

WARNING: If RES Supply Calculation is deactivated, you must provide the RES Time Series Data as CSV file located in 'Inputs' folder (refer to the online documentation for more details <https://microgridspy-documentation.readthedocs.io/en/latest/>). In addition, please consider that the NASA POWER server may not work during the weekend.

The Prediction Of Worldwide Energy Resources (POWER) Project

Provides solar & meteorological data from NASA research for support of renewable energy, building energy efficiency, & agricultural needs.

The NASA POWER Team @ NASA Langley Research Center



Next

# Exogenous RES Time Series

## RES Time Series Calculation

Estimate electricity output of renewable generation units

RES Supply Calculation: ☐ Activate



Old Input Files

Demand

desktop

Direct Emissions

Fuel Specific Cost

Grid Availability

Parameters

RES\_Time\_Series

WT\_Power\_Curve



Numbered columns equal to the number of renewables

	1	2	...
1	Hourly electricity output in W for each renewable sources unit		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
....			

Hours in a year



	1	2
1	0	432812,5
2	0	461477,8
3	0	430550,8
4	0	318517,4
5	0	156753,5
6	0	346411,4
7	21,26435	612342,8
8	193,8794	589845,4
9	382,0014	455267,6
10	561,6518	302666,6
11	708,8004	186153
12	805,386	101622,2
13	840,2869	52911,46
14	810,5032	28713,44
15	718,4495	268
16	574,5458	55



Code/Inputs/RES\_Time\_Series.csv

# Endogenous Load Demand Estimation

## Demand drivers

Estimate the demand growth as a percentage change expected annually and select the cooling period to consider seasonal variations in energy usage:

- **NC** = No Cooling
- **AY** = All Year
- **OM** = Oct-Mar
- **AS** = Apr-Sept

## Households

Number of households across various wealth tiers, reflecting the socioeconomic diversity of the village. The wealthier classes own more energy intensive appliances and in larger number.

## Public Services

Number of educational and healthcare facilities in the village. It includes 5 tiers of health facilities, ranging from rural dispensaries (Tier 1) to sub-county hospitals (Tier 5). Similarly, it adopts an archetypical load for a rural primary school.



Code/Demand\_archetypes

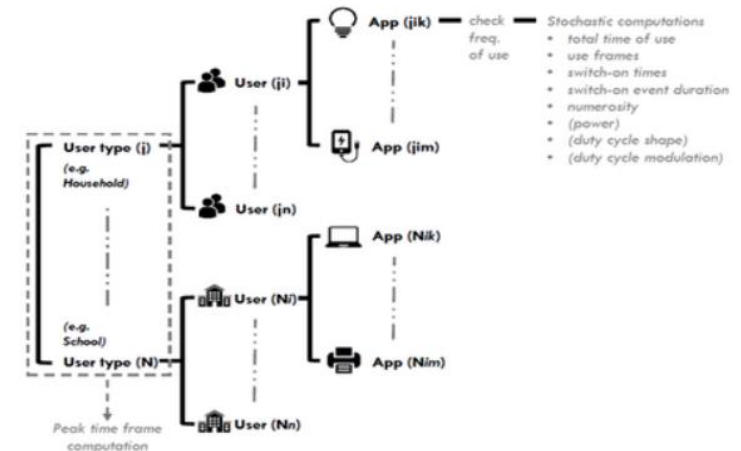
## Demand Time Series Calculation

Generate the load curve demand using build-in Sub-Sahara Africa village archetypes:

Demand Profile Generation:

demand_growth	5
cooling_period	AY
h_tier1	252
h_tier2	160
h_tier3	50
h_tier4	36
h_tier5	5
schools	1
hospital_1	0
hospital_2	1
hospital_3	0
hospital_4	0
hospital_5	0

Activate



WARNING: If Demand\_Profile\_Generation is deactivated, you must provide the Demand Time Series Data as CSV file located in 'Inputs' folder (refer to the online documentation for more details <https://microgridspy-documentation.readthedocs.io/en/latest/>)

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# Exogenous Load Demand

## Demand Time Series Calculation

Generate the load curve demand using build-in Sub-Sahara Africa

Demand Profile Generation: ☐ Activate

+

Old Input Files

Demand

desktop

Direct Emissions

Fuel Specific Cost

Grid Availability

Parameters

RES\_Time\_Series

WT\_Power\_Curve

 Code/Inputs/Demand.csv

Numbered columns equal to the number of years

	1	2	...
1	Hourly electricity demand in W for year of the time horizon		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
....			

Hours in a year

EXAMPLE

	1	2	3	4	5
0	3872,779	4066,418	4269,739	4483,226	4707,388
1	3967,331	4165,698	4373,983	4592,682	4822,316
2	4254,747	4467,484	4690,859	4925,401	5171,672
3	4257,689	4470,573	4694,102	4928,807	5175,247
4	4217,078	4427,932	4649,328	4881,795	5125,885
5	4241,818	4453,909	4676,604	4910,435	5155,956
6	5655,901	5938,697	6235,631	6547,413	6874,784
7	8785,677	9224,961	9686,209	10170,52	10679,05
8	8401,853	8821,946	9263,043	9726,195	10212,51
9	7895,185	8289,944	8704,441	9139,663	9596,647
10	9973,921	10472,62	10996,25	11546,06	12123,36
11	9666,069	10149,37	10656,84	11189,68	11749,17
12	9279,889	9743,884	10231,08	10742,63	11279,76
13	10536,52	11063,35	11616,52	12197,34	12807,21
14	20070,08	21073,58	22127,26	23233,62	24395,31
15	14148,2	14855,61	15598,39	16378,31	17197,22
16	11612,5	12193,12	12802,78	13442,92	14115,06
17	8648,98	9081,429	9535,5	10012,28	10
18	10247,71	10760,1	11298,1	11863,01	12

CSV



# Renewables Parameters

## Renewables Characterization

*It allows setting types, capacities, efficiencies, costs, lifespans, emissions, and expected operational output for renewable energy technologies*

**Parameters** that would be **enabled or disabled** according to **specific advanced features activated** (brownfield in the example)

## Advanced Features

Advanced Modeling Options

Type of Investment:

☐ Greenfield

☒ Brownfield

MicroGridsPy

### Renewables Parameters

Define the number and type of renewable sources to be considered:

RES\_Sources  Update Parameters Configuration

RES_Names	Solar PV	Wind Turbine
RES_Nominal_Capacity	1000.0	1670000.0
RES_Inverter_Efficiency	0.98	0.95
RES_Specific_Investment_Cost	0.95	1.9
RES_Specific_OM_Cost	0.018	0.05
RES_Lifetime	25	20
RES_unit_CO2_emission	0	0
RES_capacity	<input type="text" value="0"/>	<input type="text" value="0"/>
RES_years	<input type="text" value="0"/>	<input type="text" value="0"/>

**IMPORTANT:** When Endogenous RES Calculation is activated, 'RES\_Nominal\_Capacity' entries are disabled as they must correspond to the nominal capacity parameters used for simulating electricity production. In case of Exogenous RES Time Series Data, ensure that 'RES\_Nominal\_Capacity' accurately reflects the capacity per unit of production used in your data.

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# Renewables Parameters

Define the number and type of renewable sources to be considered:

RES_Sources	<input type="text" value="1"/>	<input type="button" value="Update Parameters Configuration"/>
RES_Names	Solar PV	Wind Turbine
RES_Nominal_Capacity	1000.0	1670000.0
RES_Inverter_Efficiency	0.98	0.95
RES_Specific_Investment_Cost	0.95	1.9
RES_Specific_OM_Cost	0.018	0.05
RES_Lifetime	25	20
RES_unit_CO2_emission	0	0
RES_capacity	0	0
RES_years	0	0



Define the number and type of renewable sources to be considered:

RES_Sources	<input type="text" value="1"/>	<input type="button" value="Update Parameters Configuration"/>
RES_Names	Solar PV	
RES_Nominal_Capacity	1000.0	
RES_Inverter_Efficiency	0.98	
RES_Specific_Investment_Cost	0.95	
RES_Specific_OM_Cost	0.018	
RES_Lifetime	25	
RES_unit_CO2_emission	0	
RES_capacity	0	
RES_years	0	

The interface includes an "**Update Parameters Configuration**" button for applying new settings to renewable energy sources. In particular:

1. Set the number of renewable sources in **RES\_Sources**
2. **Press the button** to update the entries for each parameter
3. Visualize the **new set of default values** for each parameter
4. **Edit** the values as preferred

# Battery bank Parameters

## Battery Bank Parameters

Initialize the parameters related to the battery bank system:

Battery_Specific_Investment_Cost	0.15
Battery_Specific_Electronic_Investment_Cost	0.05
Battery_Specific_OM_Cost	0.06
Battery_Discharge_Battery_Efficiency	0.98
Battery_Charge_Battery_Efficiency	0.98
Battery_Depth_of_Discharge	0.8
Maximum_Battery_Discharge_Time	5
Maximum_Battery_Charge_Time	5
Battery_Cycles	6000
Battery_Initial_SOC	1.0
BESS_unit_CO2_emission	0.0
Battery_Nominal_Capacity_milp	1000
Battery_capacity	0.0

### Battery bank Characterization

It allows setting investment costs, operational costs, charge and discharge efficiencies, battery lifecycle details, and CO2 emissions

**Parameters** which would be **enabled or disabled** according to **specific advanced features activated** (MILP and brownfield in the example)

### Advanced Features

Advanced Modeling Options

Model Formulation:

☐ LP

☒ MILP

Type of Investment:

☐ Greenfield

☒ Brownfield

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Next


# Generator Parameters

## Generator Characterization

It allows setting the names, efficiencies, costs, lifespans, emissions, and capacity parameters for generators, as well as configuring fuel types, energy content, and cost parameters

## Advanced Features

### Advanced Modeling Options

Fuel Specific Cost Calculation: 

Fuel\_Specific\_Start\_Cost

Fuel\_Specific\_Cost\_Rate

Fuel\_Specific\_Cost\_Import

1.17

0.0

☐ Activate

## Generator Parameters

Generator Types: 1

Update Parameters Configuration

Generator_Names	Diesel Genset 1
Generator_Efficiency	0.3
Generator_Specific_Investment_Cost	0.4
Generator_Specific_OM_Cost	0.08
Generator_Lifetime	20
GEN_unit_CO2_emission	0.0
Generator_capacity	0.0
GEN_years	0
Generator_Nominal_Capacity_milp	5000
Generator_Min_output	0.3
Generator_pgen	0.01

Fuel parameters:

Fuel_Names	Diesel
Fuel_LHV	10140.0
FUEL_unit_CO2_emission	2.68
Fuel_Specific_Start_Cost	1.17
Fuel_Specific_Cost_Rate	0.0
Fuel_Specific_Cost_Import	<input type="checkbox"/> Activate


Parameters which would be enabled or disabled according to specific advanced features activated (MILP, brownfield and partial load in the example)

## Advanced Features

### Advanced Modeling Options

Model Formulation: ☐ LP ☒ MILP

Type of Investment: ☐ Greenfield ☒ Brownfield

 WARNING: If Fuel Specific Cost Import is activated, you must provide the fuel cost values in a CSV file located in 'Inputs' folder (refer to the online documentation for more details <https://microgridspy-documentation.readthedocs.io/en/latest/>)



# Generator Parameters

Generator Types:

2

Update Parameters Configuration

Generator_Names	Diesel Genset 1
Generator_Efficiency	0.3
Generator_Specific_Investment_Cost	0.4
Generator_Specific_OM_Cost	0.08
Generator_Lifetime	20
GEN_unit_CO2_emission	0.0
Generator_capacity	0.0
GEN_years	0
Generator_Nominal_Capacity_milp	5000
Generator_Min_output	0.3
Generator_pgen	0.01

Generator Types:

2

Update Parameters Configuration

Generator_Names	Diesel Genset 1
Generator_Efficiency	0.3
Generator_Specific_Investment_Cost	0.4
Generator_Specific_OM_Cost	0.08
Generator_Lifetime	20
GEN_unit_CO2_emission	0.0
Generator_capacity	0.0
GEN_years	0
Generator_Nominal_Capacity_milp	5000
Generator_Min_output	0.3
Generator_pgen	0.01

Generator_Names	Diesel Genset 2
Generator_Efficiency	0.3
Generator_Specific_Investment_Cost	0.4
Generator_Specific_OM_Cost	0.08
Generator_Lifetime	20
GEN_unit_CO2_emission	0.0
Generator_capacity	0.0
GEN_years	0
Generator_Nominal_Capacity_milp	5000
Generator_Min_output	0.3
Generator_pgen	0.01

The interface includes an "**Update Parameters Configuration**" button for applying new settings to generator parameters. In particular:

1. Set the number of generators in **Generator Types**
2. **Press the button** to update the entries for each parameter
3. Visualize the **new set of default values** for each parameter
4. **Edit** the values as preferred

# Exogenous Fuel Specific Cost

## Advanced Features

### Advanced Modeling Options

Fuel Specific Cost Calculation:



+

Fuel\_Specific\_Start\_Cost

1.17

Fuel\_Specific\_Cost\_Rate

0.0

Fuel\_Specific\_Cost\_Import

☒ Activate

+

- Direct Emissions
- Fuel Specific Cost
- Grid Availability
- Parameters
- RES\_Time\_Series
- WT\_Power\_Curve

Numbered columns equal to the number of fuel types

1 2 ...

1	Yearly price of each type of fuel
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
....	

Years in the time horizon

EXAMPLE

Years	
1	1.5
2	1.6
3	1.7
4	1.8
5	1.9
6	2.5
7	2.1
8	2.2
9	2.3
10	2.4



Code/Inputs/Fuel Specific Cost.csv

# Plots layout

MicroGridsPy

## Plot Colors

Select the plot colors from the drop-down menu:

RES_Colors	<input type="text" value="Orange"/>	<input type="checkbox"/>	<input type="text" value="Teal"/>	<input type="checkbox"/>
Generator_Colors	<input type="text" value="Blue"/>	<input type="checkbox"/>		
Battery_Color	<input type="text" value="Turquoise"/>	<input type="checkbox"/>		
Lost_Load_Color	<input type="text" value="Red"/>	<input type="checkbox"/>		
Curtailment_Color	<input type="text" value="Yellow"/>	<input type="checkbox"/>		
Energy_To_Grid_Color	<input type="text" value="Green"/>	<input type="checkbox"/>		
Energy_From_Grid_Color	<input type="text" value="Purple"/>	<input type="checkbox"/>		

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Users can **select colors** from a **dropdown menu** to represent different components such as renewable energy sources (RES), generators, batteries, lost load, curtailment, and energy exchanged with the grid, enhancing the **clarity and distinction of various data sets** in graphical representations




## Plot Colors

Select the plot colors from the drop-down menu:

RES_Colors	<input type="text" value="Orange"/>	<input type="checkbox"/>	<input type="text" value="Teal"/>	<input type="checkbox"/>
Generator_Colors	<input type="text" value="Blue"/>	<input type="checkbox"/>		
Battery_Color	<input type="text" value="Turquoise"/>	<input type="checkbox"/>		
Lost_Load_Color	<input type="text" value="Red"/>	<input type="checkbox"/>		
Curtailment_Color	<input type="text" value="Yellow"/>	<input type="checkbox"/>		
Energy_To_Grid_Color	<input type="text" value="Green"/>	<input type="checkbox"/>		
Energy_From_Grid_Color	<input type="text" value="Purple"/>	<input type="checkbox"/>		

# Running the model

MicroGridsPy

Run the Model:   

Output panel to visualize model operation, solver log and key results:

3	7.26808587e+07	-3.01160701e+08	1.46e-11	1.87e-02	3.20e+02	6s
4	1.21716508e+07	-6.83947325e+07	4.18e-11	4.00e-03	6.77e+01	7s
5	4.60624692e+06	-2.06643859e+07	4.73e-11	1.19e-03	2.08e+01	8s
6	1.88890462e+06	-8.21351814e+06	6.91e-11	4.52e-04	8.26e+00	9s
7	6.59352041e+05	-2.13170363e+06	1.03e-10	1.21e-04	2.24e+00	10s
8	4.28764434e+05	-9.97308592e+05	1.11e-10	6.18e-05	1.14e+00	10s
9	3.09756868e+05	-1.83612110e+05	9.28e-11	1.70e-05	3.68e-01	11s
10	2.41376078e+05	5.08096725e+03	1.63e-10	6.37e-06	1.67e-01	12s
11	2.05363112e+05	3.41015142e+04	4.03e-10	4.98e-06	1.26e-01	13s
12	1.86211605e+05	5.57477328e+04	5.57e-10	3.95e-06	9.81e-02	14s
13	1.73203705e+05	7.11370186e+04	7.31e-10	3.23e-06	7.91e-02	15s
14	1.68797347e+05	7.99969999e+04	8.33e-10	2.81e-06	6.97e-02	16s
15	1.61331182e+05	1.00491854e+05	9.99e-10	1.78e-06	4.74e-02	17s
16	1.55440859e+05	1.12034229e+05	1.91e-09	1.16e-06	3.34e-02	18s
17	1.52375433e+05	1.12598232e+05	5.66e-09	1.12e-06	3.13e-02	19s
18	1.51813960e+05	1.13349275e+05	5.56e-09	1.07e-06	3.02e-02	20s
19	1.50669285e+05	1.14577059e+05	7.30e-09	1.00e-06	2.84e-02	21s
20	1.49535683e+05	1.18076170e+05	2.33e-08	8.04e-07	2.43e-02	23s
21	1.45921631e+05	1.20627929e+05	5.54e-07	6.81e-07	2.01e-02	24s
22	1.40000919e+05	1.23373742e+05	2.18e-07	5.36e-07	1.43e-02	25s
23	1.37650056e+05	1.25757414e+05	7.42e-07	4.04e-07	1.05e-02	27s

Plot the Results:

Start Date for Plot:

Number of days to plot:

Generate Plots:

Show Dispatch Plot

Show Size Plot

Cash Flow Plot

Show Pareto Curve



New Run

Upon initiating the model with the 'Run' button, users can **monitor the solver's log** and the **system's operational actions** in **real-time**. This output panel provides a **live feed** of the **model's processing data** displaying also potential errors messages.



# Obtaining key results

MicroGridsPy

Run the Model:   

Output panel to visualize model operation, solver log and key results:

Component	Unit	Total
Solar PV	kW	54.18
Battery bank	kWh	187.17
Diesel Genset 1	kW	19.99

NPC = 131.95 kUSD

Total actualized Investment Cost = 87.55 kUSD

Total actualized Operation Cost = 44.67 kUSD

Salvage Value = -0.27 kUSD

LCOE = 0.2562 USD/kWh

Average renewable penetration per year = 77.38 %

Average generator share per year = 23.13 %

Average battery usage per year = 34.87 %

Average curtailment per year = 4.83 %

Plot the Results:

Start Date for Plot:

Number of days to plot:

After execution, it displays **key sizing results** such as capacity installed of renewables, backup and storage selected technologies. It provides a **summary of the system's costs**, including the net present cost (NPC), investment costs, operational costs, and the levelized cost of electricity (LCOE). Additionally, it offers **annual statistics** like renewable penetration, generator share, battery usage, and curtailment.

# Displaying plots

## Plot the Results:

Start Date for Plot:

Number of days to plot:

Generate Plots:

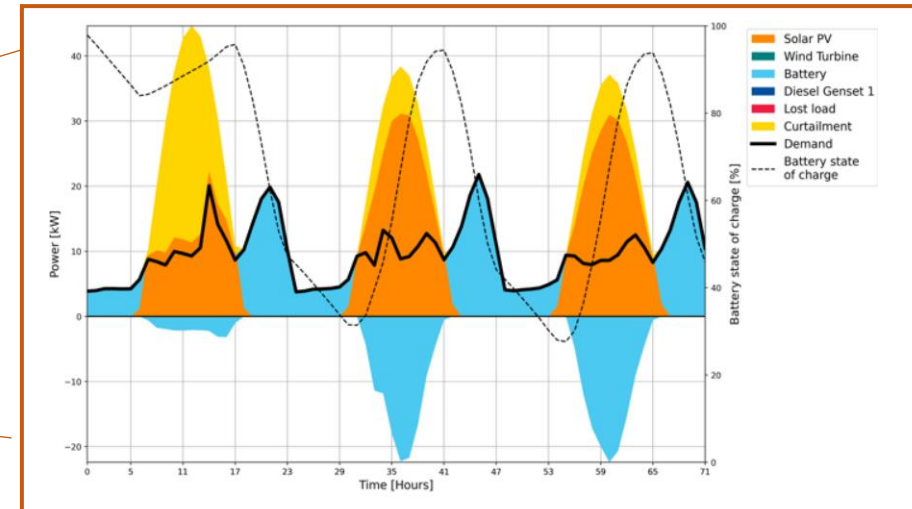
Users can create visual **plots of model outputs** by setting a date range and choosing from various plot types. The buttons **generate graphs for energy dispatch, system sizing and financial analysis**, providing a comprehensive view of the model's performance over the selected timeframe.

## Plot the Results:

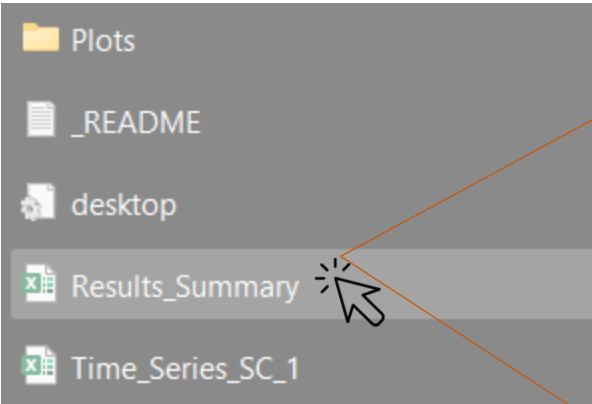
Start Date for Plot:

Number of days to plot:

Generate Plots:



# Results Folder



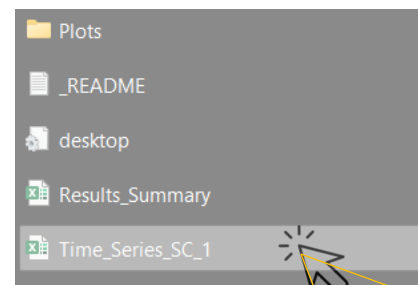
Code/Results/Results\_Summary.xlsx

The Results\_Summary spreadsheet details **grid capacities, project costs, and annual cash flows**. It also quantifies energy distribution across generators, renewables, batteries, and grid usage, with scenario comparisons.

				Total
Weighted Net present cost	System	-	kUSD	131,944
Net present cost	System	1	kUSD	131,944
Total Investment cost	System	-	kUSD	87,544
Total fixed O&M cost	System			
Total variable O&M cost	System			
Salvage value	System			
Levelized Cost of Energy	System			
Levelized Cost of Energy scenarios	System			
Investment cost	Solar PV			
	Generators share	Renewables penetration	Curtailment share	Battery usage
	%	%	%	%
	Year 1	0,58	99,55	20,83
	Year 2	1,11	99,1	17,14
	Year 3	1,99	98,32	13,7
	Year 4	3,5	96,94	10,7
	Year 5	5,78	94,81	8,37
	Year 6	8,72	92,02	6,73
	Year 7	11,88	88,97	5,42
	Year 8	14,99	85,89	4,24
	Year 9	18,04	82,8	3,17
	Year 10	21,08	79,69	2,26
	Year 11	24,2	76,5	1,59
	Year 12	27,31	73,32	1,07
	Year 13	30,37	70,17	0,69
	Year 14	33,38	67,09	0,41
	Year 15	36,33	64,08	0,21
	Year 16	39,21	61,15	0,1
	Year 17	42,02	58,32	0,03
	Year 18	44,75	55,58	0,01
	Year 19	47,41	52,94	0
	Year 20	49,98	50,4	0

Component	Solar PV	Wind Turbine	Battery bank	Diesel Genset 1	Lost load cost	Replacement cost	Fuel cost
Scenario	-	-	-	-	1	1	1
Unit	kUSD	kUSD	kUSD	kUSD	kUSD	kUSD	kUSD
Year 1	0,93	0	1,68	0,64	0	0,94	0,18
Year 2	0,93	0	1,68	0,64	0	0,99	0,37
Year 3	0,93	0	1,68	0,64	0	1,02	0,7
Year 4	0,93	0	1,68	0,64	0	1,05	1,29
Year 5	0,93	0	1,68	0,64	0	1,06	2,24
					0	1,05	3,55
					0	1,04	5,08
					0	1,02	6,73
					0	1	8,51
					0	0,97	10,44
					0	0,94	12,58
					0	0,91	14,91
					0	0,87	17,41
					0	0,83	20,09
					0	0,79	22,96
					0	0,75	26,02
					0	0,73	29,28
					0	0,72	32,74
					0	0,76	36,42
					0	0,83	40,32

# Results Folder



The Time\_Series spreadsheet contains **hourly data of the system's energy balance**, including **technology energy production, battery energy flows, demand, lost load, and curtailment**. Additionally, it tracks the **state of charge of the batteries** and the **fuel consumed** by the generators. Each year of the time horizon is reported on a different sheet.

Scenario 1											
Flow	Electric Demand	RES Production		Generator Production	Battery Discharge	Battery Charge	Lost Load	Curtailment	Battery SOC	Fuel Consumption	CO2 emission
Component		Solar PV	Wind Turbine	Diesel Genset 1						Diesel	Diesel
Unit	Wh	Wh	Wh	Wh	Wh	Wh	Wh	Wh	Wh	Lt	kg
2023-01-01 00:00:00	3872,8	0	0	0	3872,8	0	0	0	183173,3	0	0
2023-01-01 01:00:00	3967,3	0	0	0	3967,3	0	0	0	179125,1	0	0
2023-01-01 02:00:00	4254,7	0	0	0	4254,7	0	0	0	174783,5	0	0
2023-01-01 03:00:00	4257,7	0	0	0	4257,7	0	0	0	170438,9	0	0
2023-01-01 04:00:00	4217,1	0	0	0	4217,1	0	0	0	166135,8	0	0
2023-01-01 05:00:00	4241,8	0	0	0	4241,8	0	0	0	161807,4	0	0
2023-01-01 06:00:00	5655,9	1129,2	0	0	4526,8	0	0	0	157188,2	0	0
2023-01-01 07:00:00	8785,7	10295,2	0	0	0	596,3	0	913,2	157772,6	0	0
2023-01-01 08:00:00	8401,9	20284,6	0	0	0	1756,1	0	10126,8	159493,5	0	0
2023-01-01 09:00:00	7895,2	29824,3	0	0	0	1936,1	0	19993	161390,8	0	0
2023-01-01 10:00:00	9973,9	37638	0	0	0	2166,3	0	25497,8	163513,8	0	0
2023-01-01 11:00:00	9666,1	42766,8	0	0	0	2184,9	0	30915,8	165655	0	0
2023-01-01 12:00:00	9279,9	44620	0	0	0	2081,5	0	33258,7	167694,8	0	0
2023-01-01 13:00:00	10536,5	43038,5	0	0	0	2130,5	0	30371,5	169782,7	0	0
2023-01-01 14:00:00	20070,1	38150,4	0	0	0	2228,5	0	15851,8	171966,6	0	0
2023-01-01 15:00:00	14148,2	30508,9	0	0	0	3126	0	13234,8	175030	0	0
2023-01-01 16:00:00	11612,5	21068,6	0	0	0	3186,3	0	6269,8	178152,5	0	0
2023-01-01 17:00:00	8649	10911,9	0	0	0	1045,8	0	1217,1	179177,4	0	0
2023-01-01 18:00:00	10247,7	1321,6	0	0	8926,2	0	0	0	170069,1	0	0
2023-01-01 19:00:00	14243,3	0	0	0	14243,3	0	0	0	155535,2	0	0

 Code/Results/Time\_Series\_SC\_1.xlsx





*In collaboration with World Bank Group and  
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Lecture 1: OnSSET/Global Electrification  
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Programme, Energy Sector Management  
Assistance Program and World Bank Group



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