Off-Grid Systems Modelling with MicroGridsPy

Hands-on 6

GitHub repository for source code:

[SESAM-Polimi/MicroGridsPy-SESAM: MicroGridsPy - SESAM-PoliMi (github.com)](https://github.com/SESAM-Polimi/MicroGridsPy-SESAM)

MicroGridsPy is an open-source project, currently under active development, check out the detailed online documentation for usage guidance and updates:

https://microgridspy-documentation.readthedocs.io/en/latest/

Learning outcomes

By the end of this exercise, you will learn how to:

1) Explore the MicroGridsPy User Interface functionalities

2) Understand how to initialize and input generator parameters

3) Understand how generator parameters affect results

Important requirement

Ensure that MicroGridsPy is correctly installed and functioning within the dedicated conda environment. It will be also required a stable internet connection. Additionally, it is suggested (though not strictly required) to have Gurobi installed for improved performance of the model optimization. Refer to the installation procedure and guidance provided in Hands-on 1 for detailed instructions.

Introduction

Launch the Application: Recap

Let's briefly recap how to launch the user interface after having correctly creating the MicroGridsPy environment using conda and downloading the MicroGridsPy folder.

- Launch Spyder Using Anaconda. To launch Spyder, an integrated development environment (IDE) for Python, users can proceed this in two ways:
    1. Using Anaconda Prompt: Open the Anaconda Prompt, activate the mgpy environment (if not already activated), type the command *spyder* and press enter to open Spyder.
    2. Using Anaconda Navigator: Launch Anaconda Navigator, activate the mgpy environment from the "Environments" tab. Then, in Anaconda Navigator's "Home" tab, find "Spyder" in the list of available applications and click "Launch" to open Spyder.
- Launch the Interface within Spyder: Once Spyder is open, follow these steps to launch the MicroGridsPy interface:
    1. Check if the default layout is suitable; if not, set it from the "View" button.
    2. Locate the MicroGridsPy working folder using the Spyder interface's "File" menu.
    3. Open the project folder by double-clicking on it.
    4. Navigate to the "Code/User Interface" folder within the project folder.
    5. Look for the app_main.py file and double-click on it to open it.
    6. Run app_main.py by pressing F5 or using the "Run" button in Spyder's toolbar.

Upon completing these steps, the MicroGridsPy interface will launch within Spyder resulting in this situation:

Hands-on objective

In this hands-on session, we will delve into the Renewables parameters page of MicroGridsPy interface to master its usage. Our goal is to understand how to manipulate and analyze renewables parameters within the software effectively.

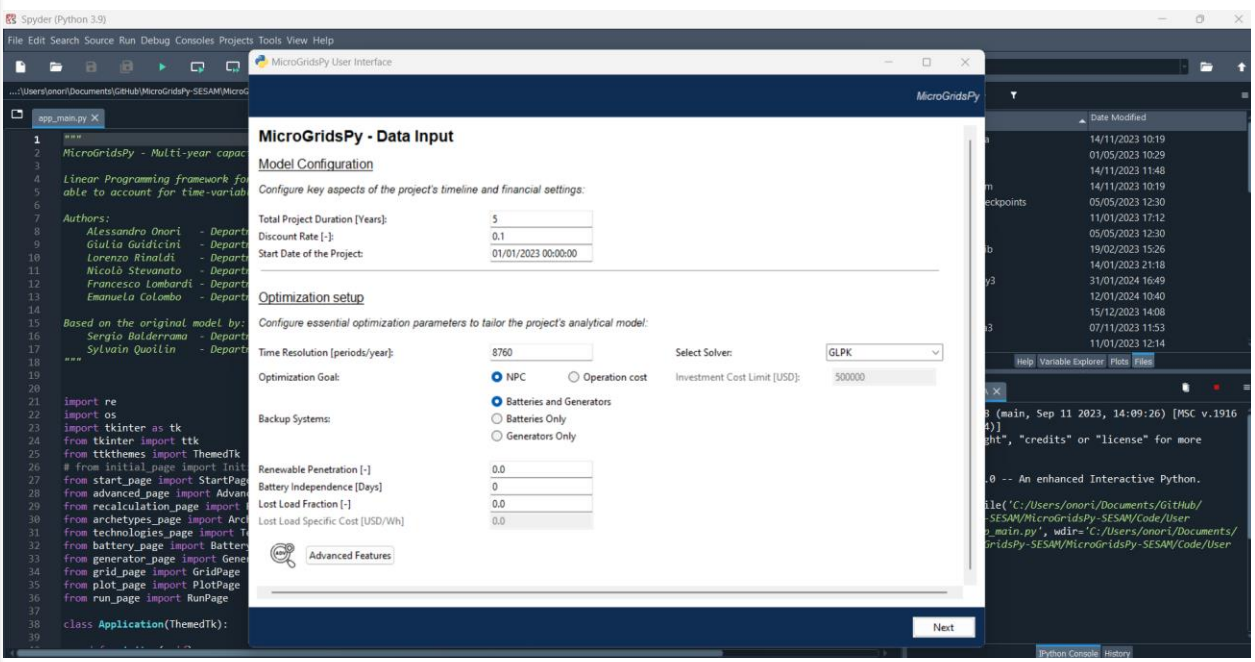
Default configuration

To recap, the default configuration we'll work with includes a 20-year model horizon, hourly operation, a 10% discount rate, and a focus on minimizing net present costs. The model is allowed to consider both batteries as storage system and generators as backup system and there are no additional constraints implemented. The exemplative case study focuses on Sub-Saharan village in Zambia with an annual growth rate of 5%, leveraging NASA Power Project data for resource assessment (specifically solar and wind). Technology characterization includes photovoltaic modules, wind turbines, battery banks, and diesel generator with exemplative but not realistic parameters.

Note

If you have Gurobi installed with an activated license, you can choose to leave Gurobi as the default solver for your MicroGridsPy simulations. This solver is known for its capabilities and speed, which can significantly expedite the optimization process.

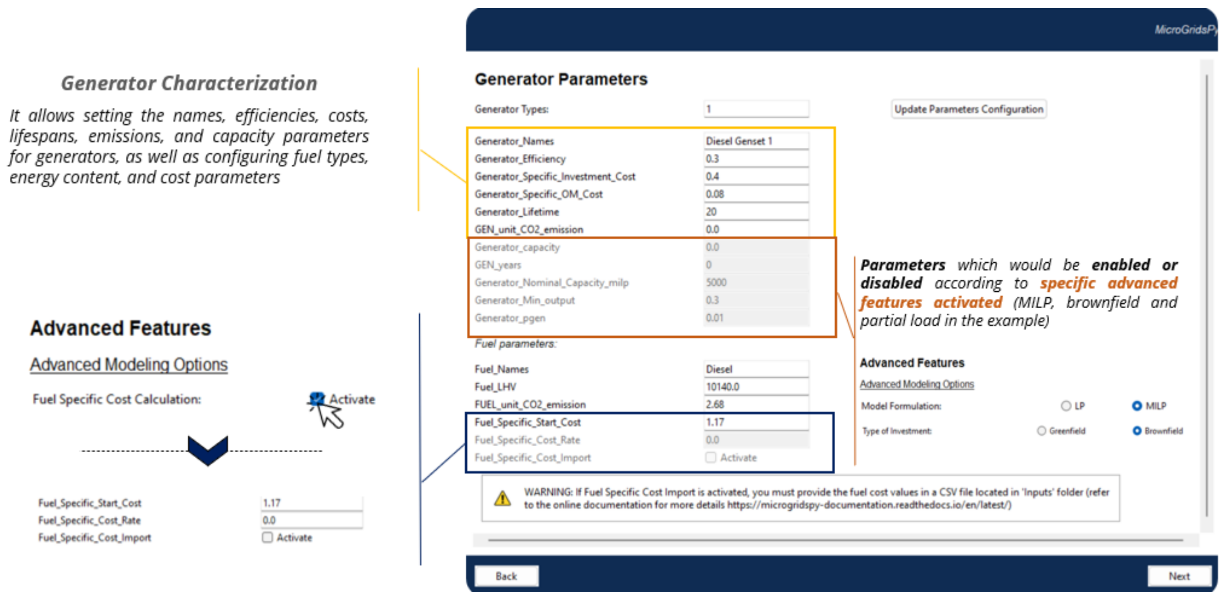
However, if you don't have a Gurobi license, you can opt to use the open-source free-to-use solver option, "GLPK," but making a specific adjustment. Please select "GLPK" from the solver dropdown menu and set the time horizon to 5 years. While this configuration may result in slight variations in the results (though not significantly), it substantially reduces the computational effort and the time required for solving. You can expect the solving time to be approximately 45-60 minutes (depending on your system computational performace), striking a favorable balance between result accuracy and computational efficiency.



Generator Parameters

The Generator Characterization feature in MicroGridsPy allows for detailed configuration of various parameters pertinent to generators. In the interface, users can input and adjust parameters for generator types such as diesel gensets, including their names, efficiencies, investment and operational costs, lifespan, emissions, and capacity details. For instance, users can configure a diesel generator with a name like "Diesel Genset 1," set its efficiency, and define specific investment costs. Operational costs, lifespan, CO2 emissions, and other characteristics can also be tailored to reflect the real-world application of the generator.

The layout provides an intuitive and scrollable providing tooltips and data validation.



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

Exercise

In the evolving landscape of global energy, conventional power generation sectors are also undergoing significant changes, particularly in the face of environmental policies and fuel cost volatility. For instance, diesel generator costs have been subject to fluctuations due to oil price instability. Meanwhile, biogas generators have become more competitive due to advances in biogas production technologies and a push towards reducing greenhouse gas emissions. These changes have a ripple effect on the deployment and operation costs of mini-grid systems.

In this exercise, we will examine the dynamics of a mini-grid system using MicroGridsPy's robust simulation capabilities, contrasting two types of generators: diesel and biogas. The mini-grid in this scenario will operate without battery storage, focusing solely on the generators' performance and cost-effectiveness. Diesel generators, while reliable and quick to deploy, have higher operational costs due to fuel prices and are significant contributors to CO2 emissions. Biogas generators, on the other hand, can offer lower operational costs if a steady supply of biogas is available and tend to have a lower carbon footprint. However, the utilization of biogas technology often necessitates the inclusion of a biomass digester, which introduces additional logistical considerations and costs. In rural areas, while the availability of raw materials for biogas production—such as agricultural waste or animal manure—can be abundant, the collection, management, and efficient digestion of biomass can pose challenges.

You will configure the following parameters for each generator type:

Parameter	**Diesel**	**Biogas**
Efficiency	30%	35%
Specific Investment costs	0.4 $/kW	1.5 $/kW
Specific O&M Cost	8%	4.5%
Lifetime	20 years	20 years
Fuel LHV	10140 Wh/lt	6110 Wh/lt
Fuel unit CO2 emissions	2.68 kgCO2/lt	0 kgCO2/lt
Fuel specific cost	1.17 $/lt	0 $/lt

In the simulation, input these parameters for the respective generator types, ensuring other variables remain at their default settings to isolate the impact of generator selection on the minigrid's economics and sustainability. Feel free to choose the color plot you prefer for biogas generator technology.

Please note that the values provided for the diesel and biogas generators in this exercise are not meant to represent realistic current market or operational conditions. Participants are encouraged to critically evaluate these values, identifying any criticalities that may arise from these assumptions.

After running the model with each generator configuration, document the key results and analyze the comparative performance in terms of cost, efficiency, and emissions. Take notes also of the values for the overall emissions of the system which are listed in details within the Results_Summary.xlsx file.

Please refer to the previous hands-on guides for detailed steps on running the model and interpreting the results. This exercise aims to enhance your understanding of how different generator technologies can be evaluated within a mini-grid system to meet specific energy needs sustainably and cost-effectively.

Well done on completing the hands-on 6!