Building a PyPSA Model

Modelling the Integration of Hydropower into Modern Energy Systems for Africa

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Open Energy Transition
from the creators of PyPSA meets Earth

International Centre for Hydropower

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Introduction

In this document, we provide a step-by-step guide to building a PyPSA model in eight exercises. These notes must be used in conjunction with the Google Colab Notebooks provided, course notes, and class activities. Collectively, these resources provide the skills and context for developing PyPSA models.

The approach uses a mini-grid as a foundation to demonstrate basic functionality and introduce users to the components of PyPSA and data source management. In the final exercise, participants will be introduced to applying this modelling approach to a national grid.

The minigrid analysed is shown in the image below. It is based on the Upper Blinkwater Project.

- A description of the project can be found here.
- The data for the project can be found here.

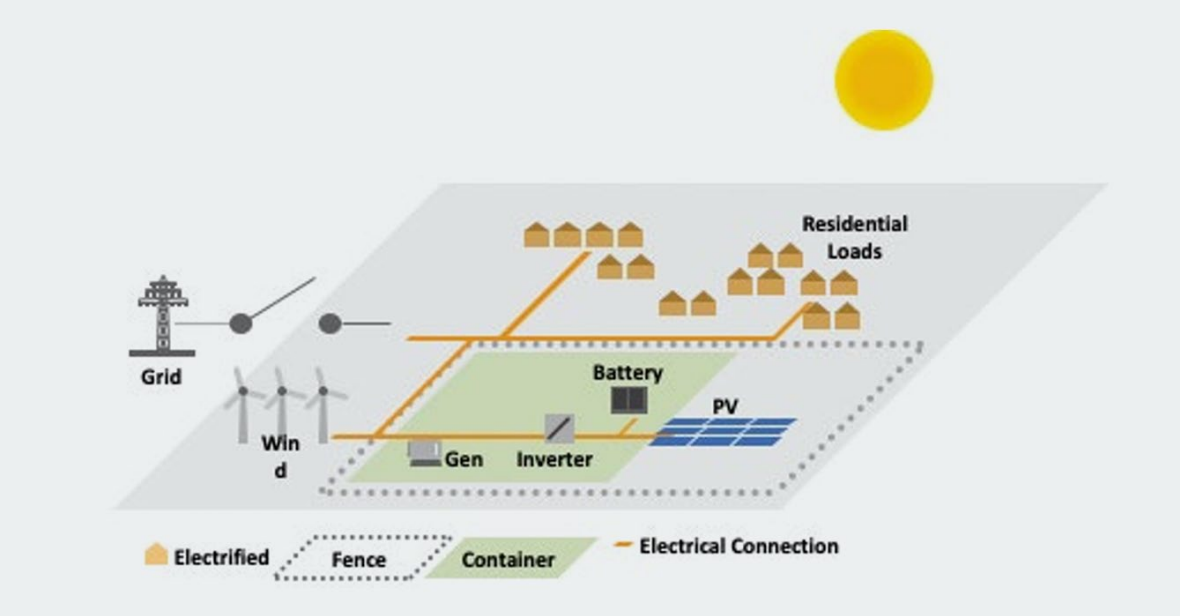

Figure 1: Example mini-grid[1]

This course's objective is to introduce users to the PyPSA toolbox, which provides many of the tools and code needed to simplify the model development process. Participants interested in furthering their skills should consider taking formal courses on using Python and courses on energy systems and geographic information systems.

[1] Ravanbach, B., Hanke, B. and Kühnel, M., 2020. The Upper Blinkwater Minigrid South Africa, Eastern Cape Project Summary & Lessons Learned. Link

Exercise 1: Building a three-node network

Expected time to complete: 60 minutes

Link to Google Colab Notebook

Link to Excel workbook

Objectives:

- Familiarise participants with the input spreadsheet and Google Colab environment.
- Build a three-node network and run the optimiser.
- Interpret the results.

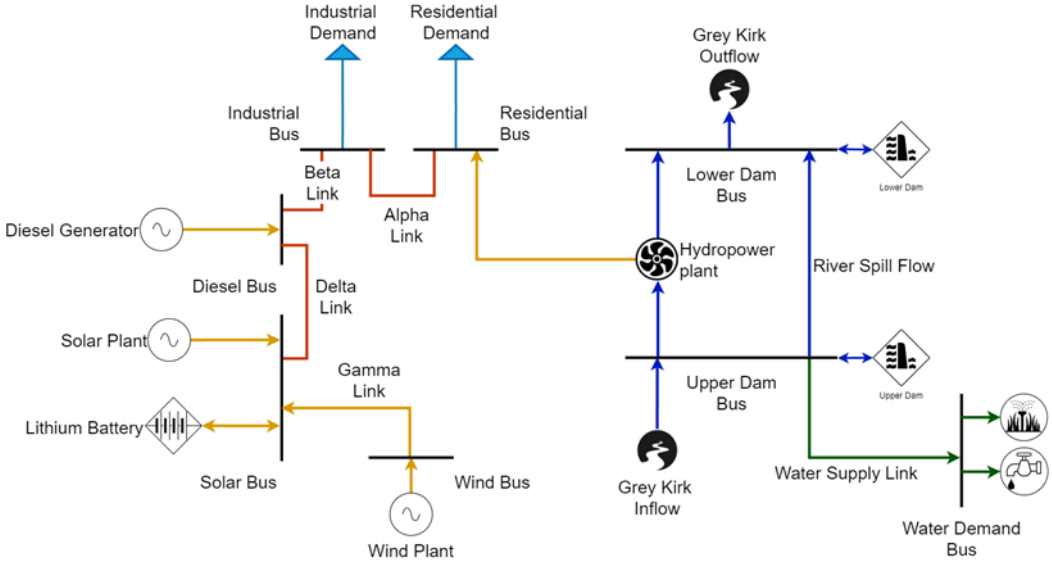

Figure 2 Network diagram for Exercise 1

Step 1: View the tabs in the worksheet.

- Note that some data contains component characteristics and time series data.
- Some data is hidden. Right-click on any tab and click “Unhide”, then select any sheet to view it. To hide the sheet, right-click on the tab and click “Hide”.
- The notebook also provides information on the input and outputs for all the components.
- Notice that the time-series data is prepopulated for 2024.

Step 2: Add three busses

name	Residential Bus	Industrial Bus	Diesel Bus
carrier	AC	AC	AC

Step 3: Link the busses

Link name	bus0	bus1
Link Alpha	Industrial Bus	Residential Bus
Link Beta	Diesel Bus	Industrial Bus

Step 4: Configure the links with the same values

Variable	Value	Units
p_nom	80	kW
efficiency	1	
capital_cost	0	currency/MW
marginal_cost	0	currency/MWh
p_nom_extendable	FALSE	
ramp_limit_up	1	timesteps
ramp_limit_down	1	timesteps
p_min_pu	0	
p_max_pu	1	
committable	TRUE	
min_up_time	0	timesteps
min_down_time	0	timesteps

Step 5: Add in loads

Load Name	bus	p_set	Units
Residential Load	Residential Bus	50	kW
Industrial Load	Industrial Bus	50	kW

Step 6: Add in the Diesel Generator and Slack Generators

Generator names	Diesel Generator CUE Diesel CUE Residential CUE Industrial		Units
carrier	AC	AC	
efficiency	1	1	
marginal_cost	10	1000	
p_nom	80	1	kW
p_nom_extendable	FALSE	TRUE	
p_nom_min	0	0	kW
ramp_limit_up	1	1	timesteps
ramp_limit_down	1	1	timesteps
p_min_pu	0	0	

We use CUE, or Cost of Unserved Energy, to represent slack generators. This can be used to identify areas with insufficient generation capacity to meet demand. Without these generators, the model will give an infeasible output that cannot be traced.

Step 7: Run the model and observe the results.

- Open the Google Colab notebook.
- Copy the file to the "ICH_Training" folder in your Google Drive.
- Import the model
- Inspect the network.
- Run the optimise cell
- View the outputs

Step 8: Observe the output charts

- **Tooltip Display:** When you hover over a point on the line chart, a tooltip appears, displaying information about the data point, such as the x and y values.
- **Zooming:** You can zoom into a specific area of the chart by clicking and dragging to create a box around the region you want to zoom into. Double-clicking the chart resets the zoom.
- **Panning:** After zooming in, you can pan around the chart by clicking and dragging the chart itself. This allows you to explore different parts of the zoomed-in data.
- **Legend Click:** Clicking on an item in the legend hides or shows the corresponding line in the chart. This helps in focusing on specific data series.
- **Legend Double Click:** Double-clicking an item in the legend isolates that line, hiding all other lines. Double-clicking again resets the view to show all lines.
- **Image Format Options:** Users can choose to download the chart as a PNG or JPEG image. This choice is often available through a small menu or by clicking the icon multiple times to cycle through available formats.

Download the completed model for Exercise 1