OnSSET/Global Electrification Platform

Hands-on 6: How to run an electrification analysis using OnSSET[1]

Installation:

1. First, go here and click **Code** > **Download zip** to download the OnSSET code.
2. This exercise has a prerequisite that you have Anaconda/Python and the OnSSET package installed. To install these, follow the instructions in Hands-On 5.

If you have any questions, you can post them on the OnSSET Forum.

Learning outcomes

By the end of this exercise, you will be able to:

1) Calibrate and run a scenario for Benin using OnSSET

2) Perform different key processes in the OnSSET tool

3) Create maps in QGIS to visualize the results.

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[1] This exercise is an exercise developed by Korkovelos, A., Sahlberg, A., Khavari, B., 2019. Exercise 6: How to run an electrification analysis using GEP scenario generator [WWW Document]. OnSSET Teaching Kit. URL https://onsset.github.io//teaching_kit/courses/module_2/Excercise%206/ (accessed 2.18.21).

OnSSET

The objective of this session is to learn how to use the OnSSET tool to run an electrification scenario. This covers the basic operations of the Jupyter Notebooks, how to enter input data, and where to find them.

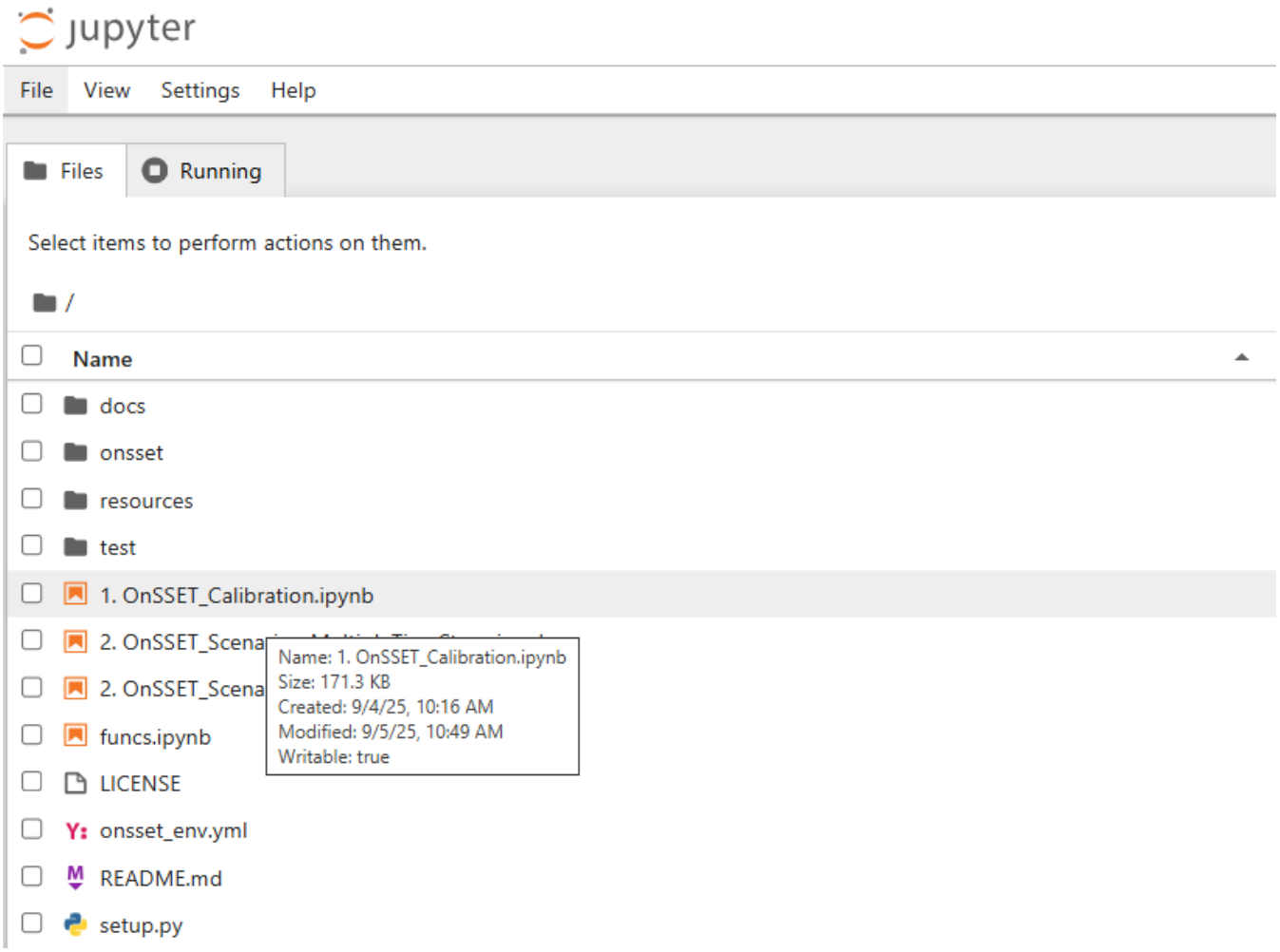
Save and un-zip the folder you downloaded in the start of the exercise, which will be named **onsset-ol**. This contains all of the code required to run the electrification analysis. Also, create a folder named **Results** where you want to save the results of your analysis. Apart from this, you will need the csv-file containing the extracted GIS data from Hands-On 5, as well as a few files available in the *Benin_datasets folder*. Go to the **onsset-ol** folder and open **Jupyter Notebook**.

To launch the Jupyter Notebook, open Anaconda Prompt and run the following three commands:

- **cd PATH** (replace PATH with the location on your computer where you have downloaded and extracted the *onsset-ol* folder)
- **conda activate onsset_env**
- **jupyter notebook**

Part 1: Calibrate the input file

Click on the **1.OnSSET_Calibration.ipynb** file, which is the interface for running the electrification tool.



This opens the Jupyter Notebook that is used to calibrate the csv-file created in the previous exercise.

Run all the cells from top to bottom.

Step 1. GIS Data Selection

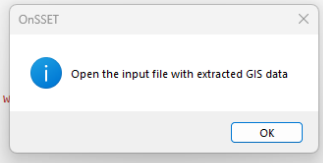
In this step, select the **GEP-OnSSET_InputFile.csv** created in the previous exercise.

1. GIS data selection

First, run the cell below to browse to the directory your input CSV file is located at and select the input file.

```
[*]: import tkinter as tk
from tkinter import filedialog, messagebox
root = tk.Tk()
root.withdraw()
root.attributes("-topmost", True)
messagebox.showinfo('OnSSET', 'Open the input file w
input_file = filedialog.askopenfilename()

onsseter = SettlementProcessor(input_file)
onsseter.conditioning()
```



Step 2. Start year

In this step, leave the start year unchanged (2024).

Step 3. Enter baseline country specific data

In this step, update the demographic and current electrification status parameters as follows:

pop_start_year = 14462724

urban_ratio_start_year = 0.51

grid_elec_ratio_start_year = 0.57

grid_urban_elec_ratio = 0.70

grid_rural_elec_ratio = 0.44

3. Enter baseline country specific data

Enter the demographic and grid electrification status parameters

Demographics and Social components - Current

```
[9]: pop_start_year = 14462724       ### Write the population in the base year (e.g. 2024)

urban_ratio_start_year = 0.51 ### Write the urban population population ratio in the base year (e.g. 2024)

grid_elec_ratio_start_year = 0.57   ### Write the grid electrification rate in the base year (e.g. 2024)
grid_urban_elec_ratio = 0.70      ### Write urban grid electrification rate in the base year (e.g. 2024)
grid_rural_elec_ratio = 0.44         ### Write rural grid electrification rate in the base year (e.g. 2024)
```

Step 4. Calibration of start year values and general information

Run the first cell in Step 4. This calibrates the population and provides some additional basic information based on the GIS data. If successfully run, a preview should appear with a preview of the GIS input data. If this table does not appear, or does not appear correctly, this may be caused either by an error in the csv-file or the code.

	Country	Pop	NightLights	TravelHours	GHI	WindVel	Hydropower	HydropowerDist
5164	Benin	16.62	0.17	0.483333	1774.0	4.271014	1052.360	12.777800
66346	Benin	12.50	0.00	1.933333	2002.0	3.531412	180.775	24.386513
27859	Benin	8.10	0.00	0.561181	1723.0	4.141857	4223.690	34.062804
53322	Benin	8.68	0.00	2.133333	2028.0	4.067400	801.460	17.188996
75917	Benin	7.60	0.00	2.666667	1893.0	3.516520	282.508	17.584223
28397	Benin	6.86	0.00	1.573979	2079.0	3.951072	224.466	51.032794
81866	Benin	20.77	0.00	2.033333	2063.0	3.452668	224.466	24.617685

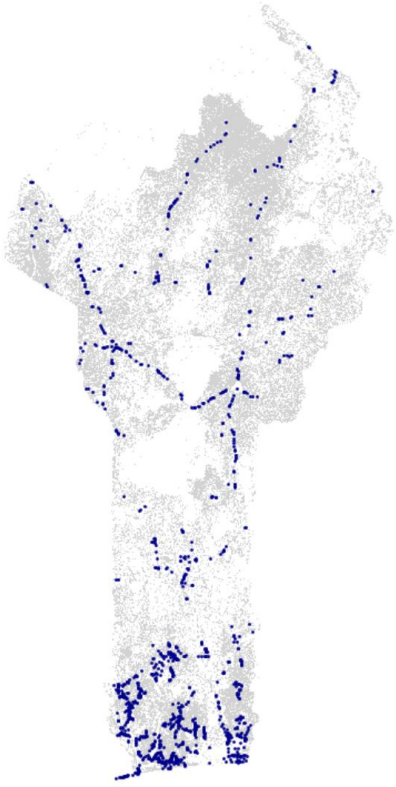
Based on the input data in the previous steps, in the next cell the code now creates some additional layers that are useful for the electrification analysis. This can be an iterative process which requires calibration from the user. One of the most important steps in the electrification analysis is the identification of the currently electrified settlements. Based on their location, the model then decides how easy it is to extend the grid to neighboring cells, or rather choose an off-grid technology.

The model calibrates which settlements are likely to be electrified in the start year, to match the national statistical values defined above. A settlement is considered to be electrified if it meets all of the following conditions:

- Has more night-time lights than the defined threshold (this is set to 0 by default).
- Is closer to the existing grid network than the distance limit.
- Has more population than the threshold.

In the next cells, you may leave the input thresholds as they are and run all the cells to calibrate the population to match the official statistics and identify which settlements are likely electrified already. You should see a map of electrified settlements in blue at the end of this section.

Note: In case you get an error at any point, commonly this is because you have not clicked Run on all cells after updating the input values, or the input values are not in the correct format (e.g. using a comma instead of a dot for decimals)



Step 5. Exporting calibrated file

In this step, you will select where to save the calibrated file in the pop-up window that appears in the very last cell. After this, you are ready to run a scenario.

Part 2: Run a scenario

In this part, open the Jupyter Notebook called **2. OnSSET_Scenarios.ipynb**.
This is the notebook used to run scenarios and calculate the least-cost technology in every step.

Start by running the first cells to import all the necessary codes and Python packages.

Step 1. GIS data selection

In this section, open the necessary files.

- First, select the file created in the last step, called **OnSSET_InputFile_Calibrated.csv**
- Next, select the file called **bj-2-pv.csv** located in the *Benin_datasets* folder
- Next, select the file called **bj-2-wind.csv** located in the *Benin_datasets* folder
- Finally, select the file called **Existing.shp** located in the *Benin_datasets* > *MV* folder

1. GIS data selection

First, run the cell below to browse to the directory your input CSV file is located at and select the input file.

[2]:
```
messagebox.showinfo('OnSSET', 'Open the input file with calibrated GIS data')
input_file = filedialog.askopenfilename()

onsseter = SettlementProcessor(input_file)
onsseter.conditioning()
```

[3]:
```
messagebox.showinfo('OnSSET', 'Open the file with hourly PV data')
pv_path = filedialog.askopenfilename()
messagebox.showinfo('OnSSET', 'Open the file with hourly Wind data')
wind_path = filedialog.askopenfilename()
```

[4]:
```
messagebox.showinfo('OnSSET', 'Open the existing MV lines')
existing_mv = filedialog.askopenfilename()
x_mv_exist, y_mv_exist = onsseter.start_extension_points(existing_mv)
x_coordinates = x_mv_exist
y_coordinates = y_mv_exist
```

[5]:
```
col_name = max(
    [c for c in onsseter.df.columns if c.startswith("FinalElecCode")],
    key=lambda x: int(re.search(r"\d{4}$", x).group())
)
existing_loc_x = np.array(onsseter.df.loc[onsseter.df[col_name] == 1, SET_X_DEG].tolist())
existing_loc_y = np.array(onsseter.df.loc[onsseter.df[col_name] == 1, SET_Y_DEG].tolist())
```

[6]:
```
x_coordinates = np.append(x_mv_exist, existing_loc_x)
y_coordinates = np.append(y_mv_exist, existing_loc_y)
```

Step 2. Modelling period and electrification rate

In this section, you define the end year of the analysis and the target national electrification rate by that year. Leave the values unchanged, which will run a scenario aiming at 100% electricity access by 2030.

Step 3. Enter country specific data

In this step, you can define country-specific demographic and techno-economic parameters.

In sub-section **a. Demographic and Social components**, update the following demographic parameters:

- end_year_pop = 15507000
- urban_ratio_end_year = 0.51
- num_people_per_hh_urban = 3.1
- num_people_per_hh_rural = 3.6

a. Demographics and Social components

```
[8]: end_year_pop = 15507000          ### Write the expected population in the END year (e.g. 2030)

     urban_ratio_end_year = 0.51      ### Write the urban population population ratio in the END year (e.g. 2030)

     num_people_per_hh_urban = 3.1      ### Write the number of people per household in urban areas
     num_people_per_hh_rural = 3.6    ### Write the number of people per household in rural areas
```

In sub-section b, c and d, proceed with the default values.

Step 4. Start a scenario run, which calculate and compare technology costs for every settlement in the country

This step runs the algorithm to calculate the least-cost electrification technology in every settlement of the country. Note that this will take some time (from minutes to several hours depending on your country, computer, etc.).

Step 5. Results, Summaries and Visualization

This step displays the results of the scenario, including a summary table, some charts and a map of where each technology is selected.

Based on the optimal split identify per technology:

- New connections by 2030
- Additional capacity needed
- Investments requirements

	Population	Nouvelles connexions	Capacity (MW)	Investissements (millions USD)
Grid	11433608	6972808	632	2349.69
SA_Diesel	0	0	0	0.00
SA_PV	3216738	3216738	86	579.02
MG_Diesel	0	0	0	0.00
MG_PV	780321	780321	128	379.04
MG_Wind	0	0	0	0.00
MG_Hydro	69043	69043	1	13.18
Total	15499713	11038913	849	3320.94

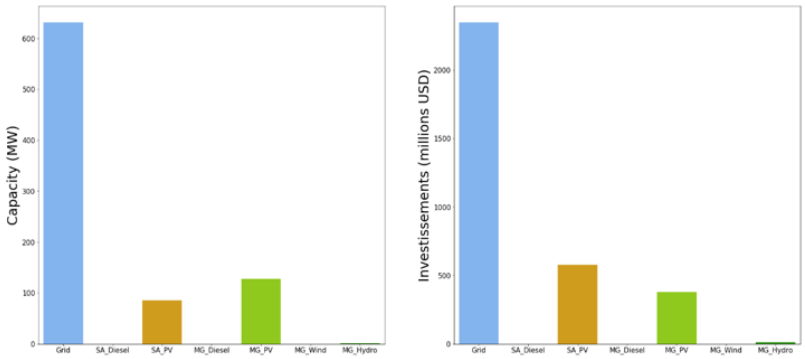


Figure 11

(Picture source: OnSSET teaching material: https://doi.org/10.5281/zenodo.457403 licensed under CC-BY 4.0)

Step 6. Export results

In the first cell, name your scenario. In the next cell, run it and click *OK* in the box that appears, and browse to the folder where you want to save your results. Run the final two cells to save the csv-files with information for each settlement and summaries for the whole country. The csv-file named "**Results**" can be used to generate maps in QGIS.

You can check what all of the columns in the Results file represent in this document, or the OnSSET documentation.

Visualization of electrification results in GIS

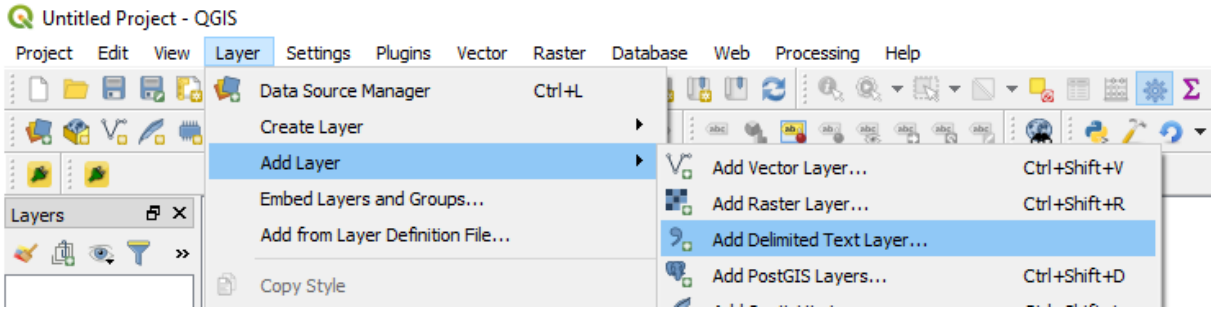
The following section provides a guide to the basic steps one must take in order to visualize the results of the electrification in a QGIS environment. Please follow the step-by-step process and in case you have further questions you can use the OnSSET forum.

Part 1

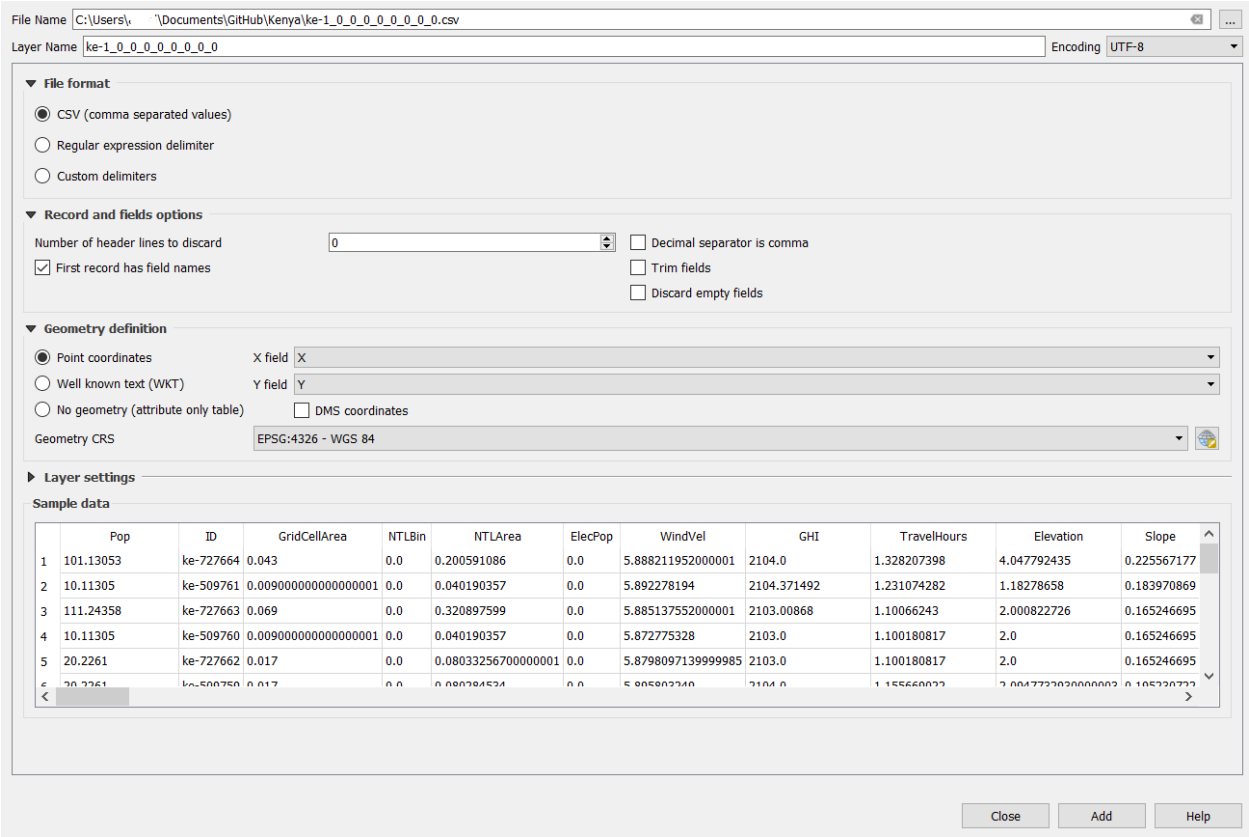
Step 1. Importing the .csv file with the results

After running your OnSSET analysis you will have a csv-file with the results. If you simply import this csv-file into any GIS software you will get a point layer. When visualizing your results, we would, however, like to visualize the clusters that you have used for the population layer. The instructions below will explain how to visualize your csv-file with your population clusters.

1. Start with importing your csv by going to **Layer → Add Layer → Add Delimited Text Layer**.

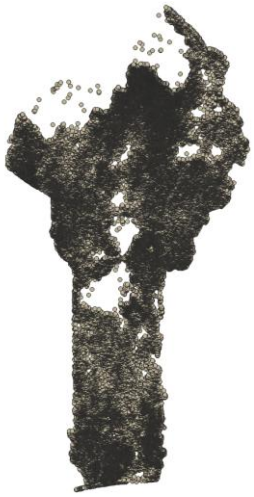


2. The following window will open up:



3. Under *File format* make sure that *CSV (Comma separated values)* is checked. A preview of the file is seen in the bottom of the window. Click *Ok*. Next, the coordinate system of the layer must be defined. In the *Geometry CRS* box, select **WGS84**. Also, in the **X field** and **Y field** select **X_Deg** and **Y_Deg**. Finally, click *Add* to load the layer. When the file is loaded (which might take some time) you should be able to see the file in the Layers Panel at the bottom left of your screen.

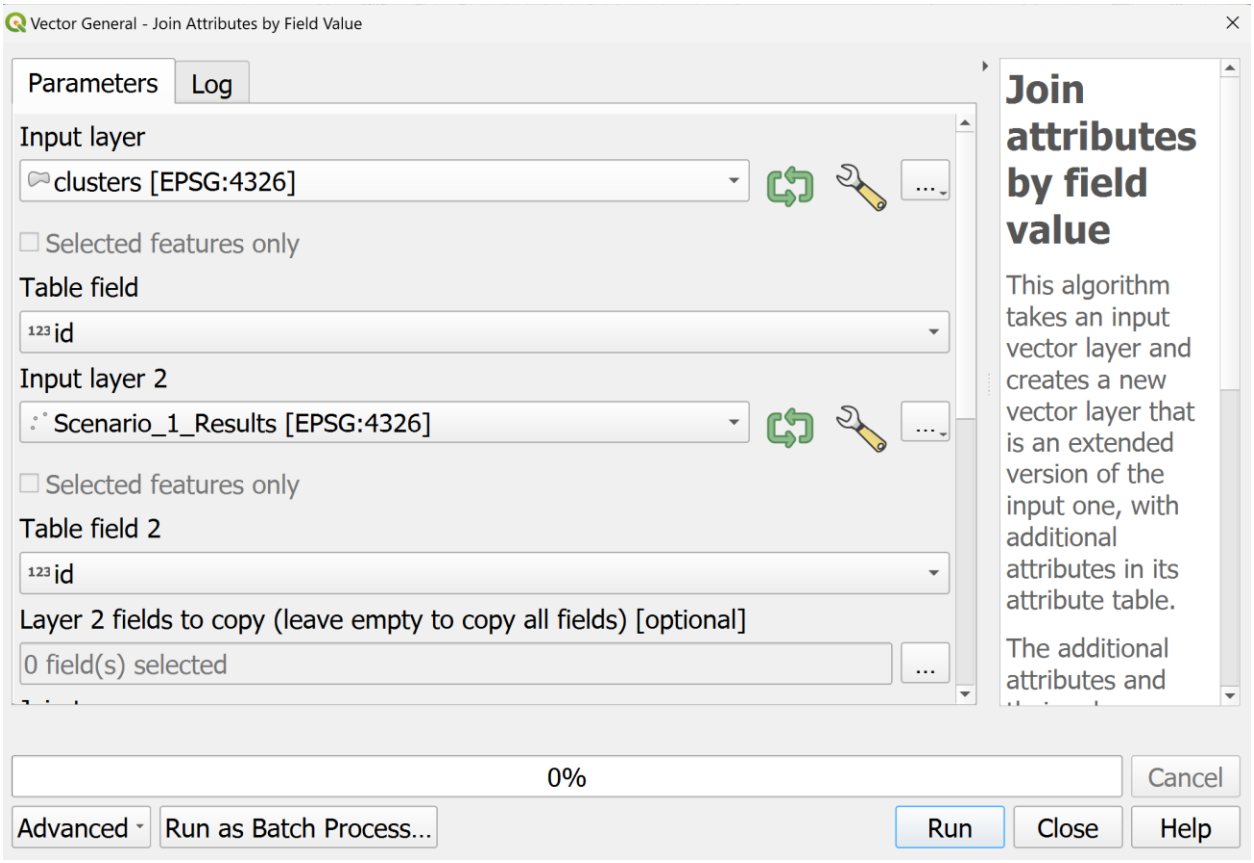
4. After clicking on **Add** you will see that you have added a point layer to your map canvas.



5. Now add the clusters that you used as your population layer during the extraction process by going to **Layer Add Layer Add Vector Layer** or simply drag it onto your map canvas.

6. Now we will merge the layers. In the Processing Toolbox, search for the tool called **Join Attributes by Field Value**.

7. The following window opens up:



The idea behind this is to take the attribute table of one layer and add it to the attribute table of another layer using a field in each layer as an identifier.

In the **Input layer**, select the *clusters* for the country, and in the **Table field** select *id*.

In the **Input layer 2**, select the *data from your csv file (e.g. Scenario_1_Results)*, and in the **Table field 2** select *id*.

This means that all the rows with the same ID in your population clusters and your input file will be matched to one another.

When finished click on **Run**. This will create a new layer with the shape of the clusters and the information from the csv-file.

Step 2. Displaying useful information in QGIS

The map of the new joined layer does not convey much information at first. Change this by right-clicking on the joined layer in the *Layer Panel* and choose *Properties*. Select the ***Symbology*** tab and at the top change from *Single symbol* to ***Categorized***.

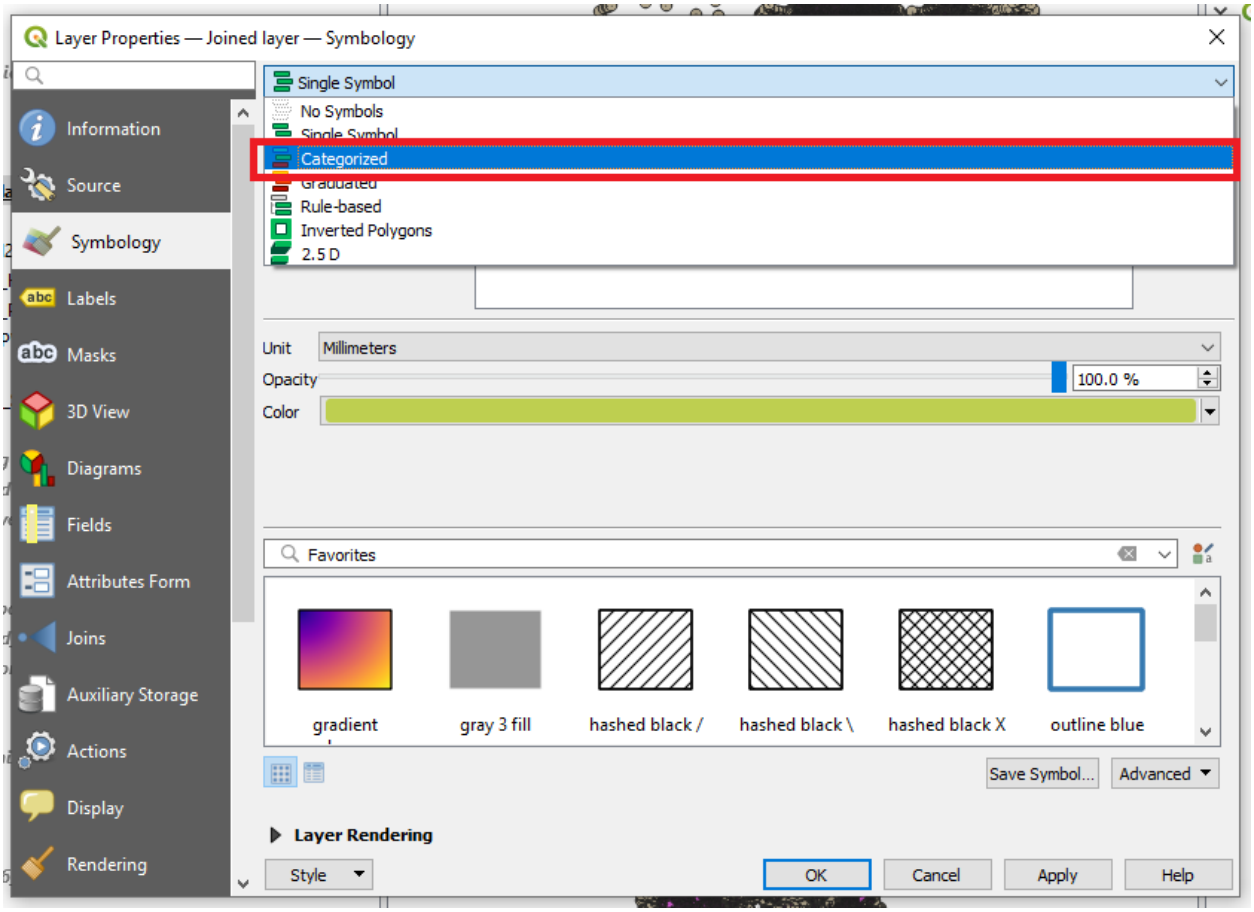


Figure 18

Next, choose the ***Value*** option, and from the drop-down list scroll down and choose **Technology20XX** (replace XX with the specific year) to display the technology option that is estimated to provide electricity in the given year. Next, click on *Classify* to show all technology options that are utilized in the results.

For a description of the different columns in the results file, see the *Output Column Description* file in the Hands-On 5 folder. This is useful when you wish to visualize other information from your results.

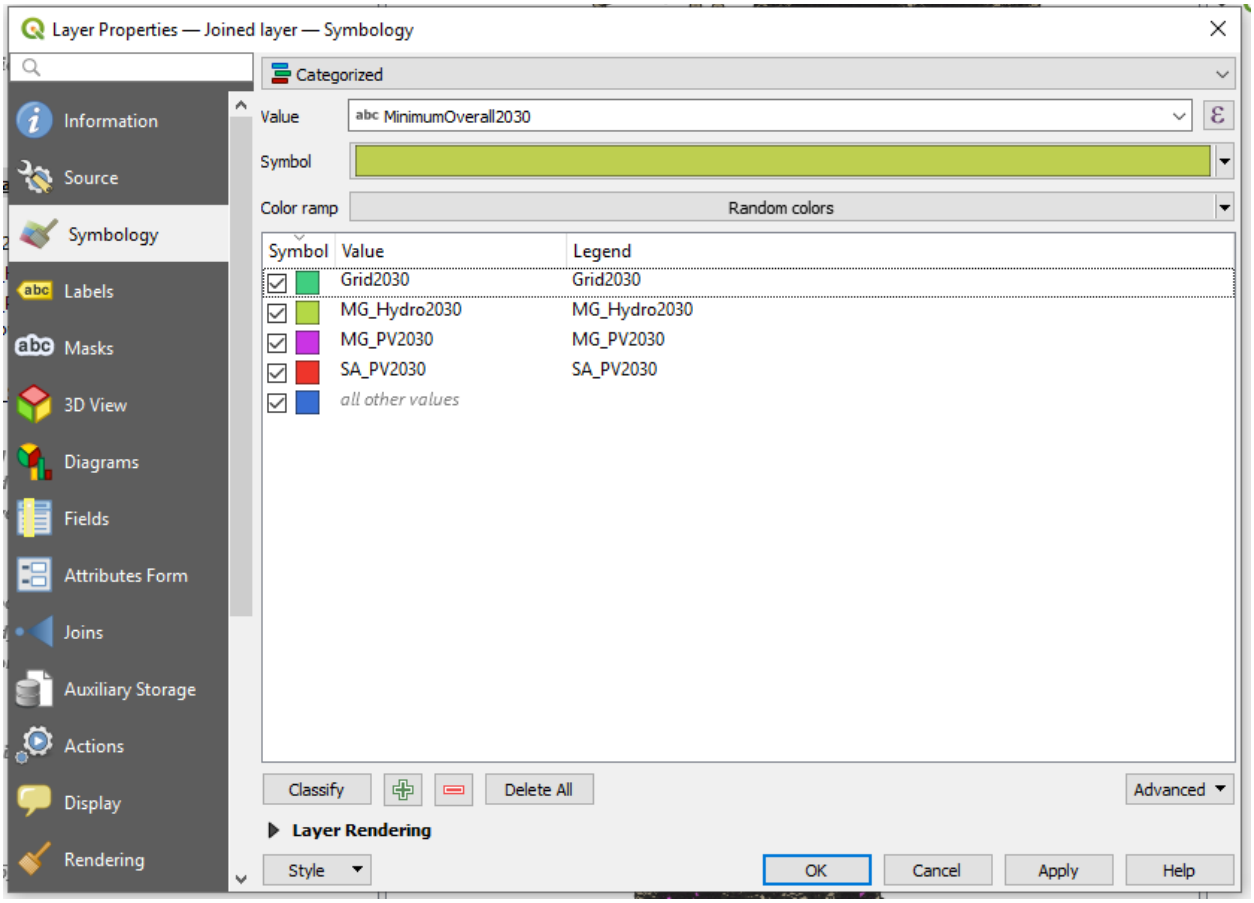


Figure 19

After choosing what to display, one must also make sure that the information can be understood clearly. The first step is to change the appearance of the symbols. For each technology, click anywhere on the colored bar next to the ***Symbol*** field and then on ***Simple fill,*** then choose the same color for **Fill color** and **Stroke color**.

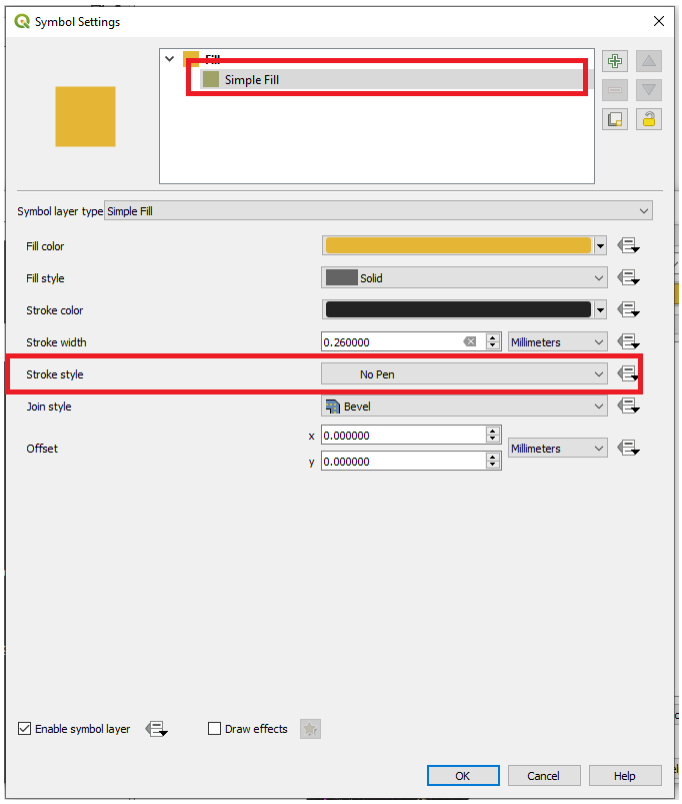


Figure 20

It is suggested to use the following color coding to match the colors on the Global Electrification Platform:

GEP Code (FinalElecCode)	Least Cost Technology	Suggested Color Cod (Hex)
1	Existing grid	#4e53de
2	Grid Extension	#a6aaff
3	SHS	#ffc700
5	PV Hybrid Mini-Grid	#e628a0
6	Wind Hybrid Mini-Grid	#1b8f4d
7	Hydro Mini Grid	#28e66d
99	Unelectrified	#808080

Finally click ***Apply***. It will take some time for the map to draw in QGIS.

Part 2

The next step is to add some informative text and figures to the map. In QGIS this can be done in the **Print Layout** view. Open it by selecting *Project* > *New Print Layout*

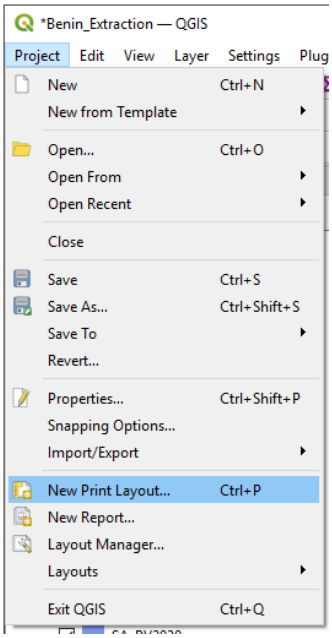


Figure 21

This will prompt you to choose a name for your map. Choose a name and click *OK* or leave it blank to use a random name.

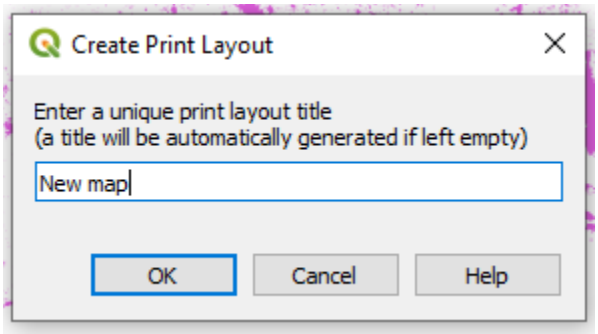


Figure 22

At this stage the map canvas opens.

1. First set the properties of your map. This you can do through the **Layout** menu at the top of the screen and go to **Page setup**. Set *Page size* to **A4** and choose

Orientation as **Portrait** (these settings may already be in place, then leave it as is).

2. On your left-hand side you have a number of different tools that you can use for opening maps and preparing your map.

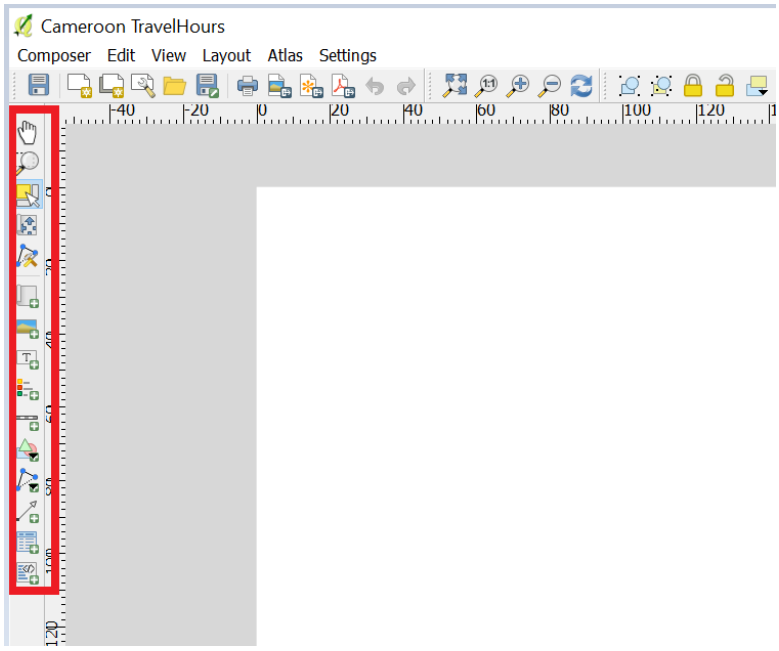


Figure 23

3. Click on **Add new map** on the left-hand side of the window to start creating a map.

Figure 24

4. Next, put the cursor in one corner of the paper and click and drag to define the area the map should extend to. The display of the normal QGIS window will appear in this area.

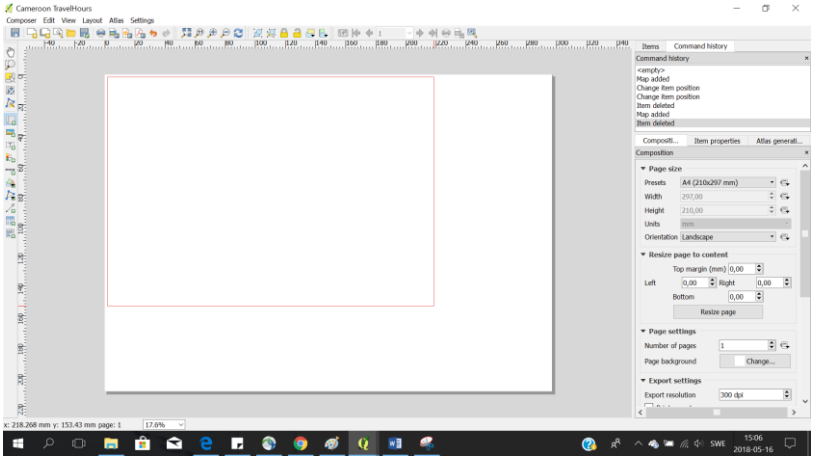


Figure 25

5. In the QGIS map composer every item (e.g., Legend, Title, Scale bar) may be edited by clicking on the item and then choosing the *Item Properties* tab on the right. This includes the size, scale, position, extent, and other attributes.
6. Add Title, Legend, and Scale bar from the menu to the left. Adjust their position and style to create an informative map.
7. Finally, export the map as a picture by going to clicking the  icon (top menu on the screen), and save it in the *Results* folder.

Once the map of technology split is satisfactory and saved in the *Results* folder, close the *Composer* window. Open the *Properties* window of the layer and go to the *Style* tab once more. On the top, change from *Categorized* to *Graduated*. Now, choose the MinimumOverallLCOE2030 column on the top to display the LCOE achieved in each cell. Press *Classify, Apply* and *OK* to draw the LCOE map.

Open the *Composer* window and insert a Title, Legend and Scale bar and save the new map once satisfied with the layout.

Congratulations for completing the hands-on exercises! If you have questions or want to contribute to the OnSSET community please go to onsset.org to find out more!