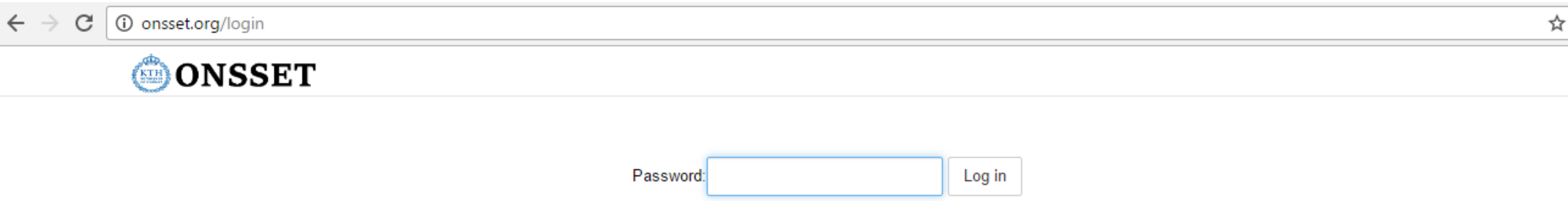
Hands on experience with the online ONSSET tool

ONSSET - The **O**pe**N** **S**ource **S**patial **E**lectrification **T**ool

Welcome to ONSSET.org



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This page contains the full code for the **O**pe**N** **S**ource **S**patial **E**lectrification **T**oolkit. The designed modules will guide you through the code, as well as the various parameters that can be set to explore any scenario of interest. The code is split up into blocks, and each one has a preceding block of text to explain its function.

ONSSET in 6 Steps

Step 1. Acquire the necessary GIS data for the area of interest[1]

Step 2. Use python techniques to extract useful information[2]

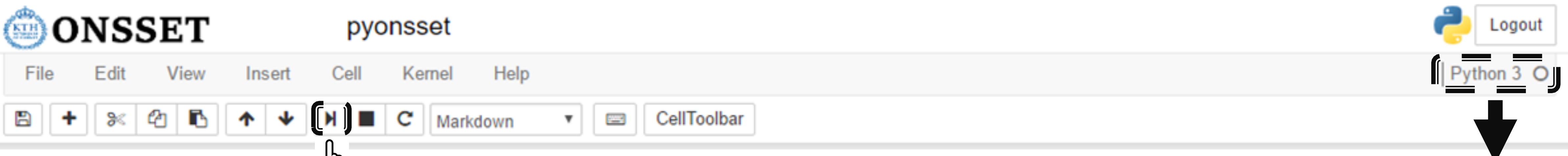
A GIS environment (ArcGIS, QGIS, GRASS) is required

Due to the complexity involved in GIS processing and time limitations of this session, a csv file with all the necessary GIS information has already been prepared by KTH dESA. The csv files are available in the shared folder.

1) The list of Datasets and potential sources are available .

2) A sample GIS to CSV extraction code is available .

Pyonsset is the python module behind the ONSSET tool

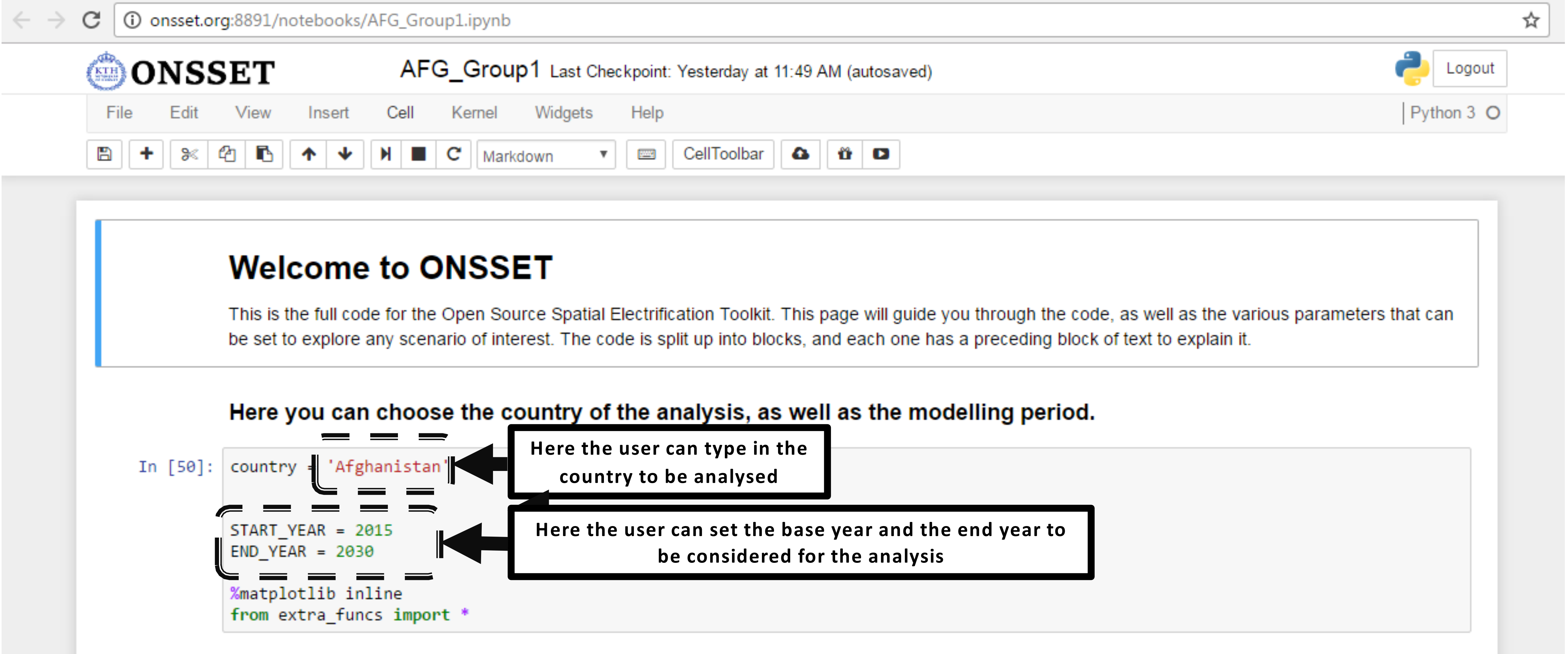


The runner button runs each block of code at a time

The mode circle defines the progress of a task. If full, the model is performing a task.

Run the model step by step and observe what function is active at any time..

Country selection



Step 3. Enter country-specific data

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Step 3a. Enter country specific data (Social)

These are values that vary per country. They should be changed accordingly to better reflect the selected country's current and expected development.

In [52]:

```
pop_2015 = 33120999
pop_2030 = 42394000

urban_ratio_2015 = 0.574
urban_ratio_2030 = 0.622

num_people_per_hh = 7
```

Here the user can insert population based characteristics about the country of selection. Include values both for the base and the end year of the analysis.

Potential sources

- UN DESA Population division, 2015
- The World Bank
- Reports on Country socio-economic statistics

Step 3b. Enter country specific data (Energy Access Target)

In [53]:

```
scenario = 4500 #  in kWh/household/year (examples are 22, 224, 695, 1800, 2195)

df = condition(df)
df = grid_penalties(df)
df = wind(df)
df = pop(df, pop_2015, urban_ratio_2015, pop_2030, urban_ratio_2030)
```

Here the user can insert the electricity access level to be achieved by every household within the defined timeframe.

Step 3. Enter country-specific data

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Step 3c. Enter country specific data (Preparation - Calibration) ¶

The cell below contains the procedures to prepare the geospatial data and make it ready to process a scenario. This includes setting grid penalties, calculating wind capacity factors and estimating current population and electricity access a values.

The most important part is to set the actual electricity access rate, and then to adjust the other parameters to let the software which settlements are electrified and which not.

In [54]:
```
elec_actual = 0.3
```

This is the country's electrification rate in the base year.

The user will have to insert manually four parameters:

1. **Night time light intensity value (Digital number)**
2. **Population level per settlement**
3. **Distance of the settlements from the electric grid**
4. **Distance of the settlements from the national road network**

and iterate accordingly so the model reaches the same electrification rate

This will need to be repeated until a satisfactory value is reached!

In [55]:
```
# Set the minimum night light intensity, below which it is assumed there is no electricity access.
min_night_lights = 3

# In addition to the above, one of the below conditions must be reached to consider a settlement eelctrified.
pop_cutoff = 2000
max_grid_dist = 10  # in km
max_road_dist = 10  # in km
```

Step 3. Enter country-specific data

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Step 3d. Enter country specific data (Technology specifications & costs)

The cell below contains all the information that is used to calculate the levelised costs for all the technologies, including grid. These should be updated to reflect the most accurate values.

The following values can be provided by KTH dESA, based on OSeMOSYS, the open source optimization model for long-run integrated assessment and energy planning.

In [56]:
```
grid_price = 0.077 # This is the grid cost electricity USD/kWh a
grid_capacity_investment_cost = 1898.98  # The cost in USD/kW to
grid_losses = 0.21  # The fraction of electricity lost in transm
base_to_peak = 0.5296 # The ratio from peak grid demand to base
```

Here the user can insert pricing/costing information related to the national grid of the selected country. Grid_price refers to the cost at which the national grid is expected to be producing electricity over the modelling period.

This is the diesel price USD/liter as expected in the years of the analysis

In [57]:
```
diesel_price = 0.65
```

This is the expected diesel price over the modelling period.

These are the capital costs in USD/kW for each different technology.

In [58]:
```
sa_diesel_capital_cost = 1500
sa_pv_capital_cost = 5000
mg_diesel_capital_cost = 1000
mg_pv_capital_cost = 4000
mg_wind_capital_cost = 3000
mg_hydro_capital_cost = 5000
```

Here the user can insert Capital costs for the off-grid technologies.

Step 4. Calculate the LCoE per technology for every settlement in the country

Here is an example of how the different technologies perform under certain assumptions:

- **Distance from the National Electricity grid**: 20 km
- **Global Horizontal Irradiation:** 1500 kWh/m2/year
- **Hydro Availability:** Positive
- **Wind capacity factor:** 40%
- **Diesel price:** 0.345 USD/liter

LCoE Tables

Example of LCoE variation per technology depending on number of people per settlement

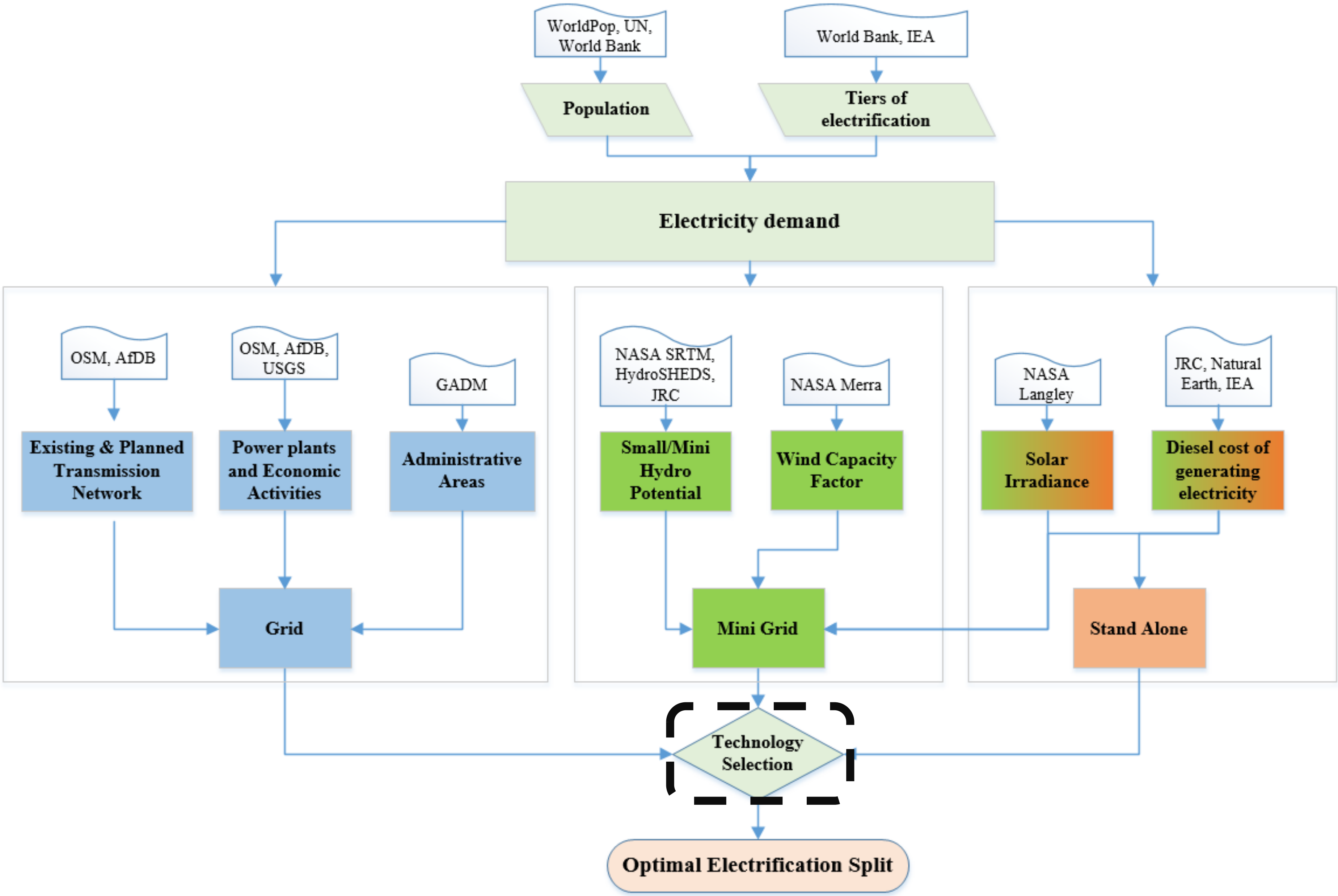
	grid	sa_diesel	sa_pv	mg_diesel	mg_pv	mg_wind	mg_hydro
10 people	22.343413	0.202476	0.543061	4.174740	4.144666	3.892932	3.855849
500 people	1.183240	0.202476	0.543061	0.739085	0.943454	0.691720	0.645202
1000 people	0.763193	0.202476	0.543061	0.573335	0.789014	0.537280	0.499585
2000 people	0.502091	0.202476	0.543061	0.456132	0.679809	0.428075	0.397133
5000 people	0.333594	0.202476	0.543061	0.352134	0.582908	0.331174	0.306582
10000 people	0.257903	0.202476	0.543061	0.299719	0.534070	0.282335	0.261071

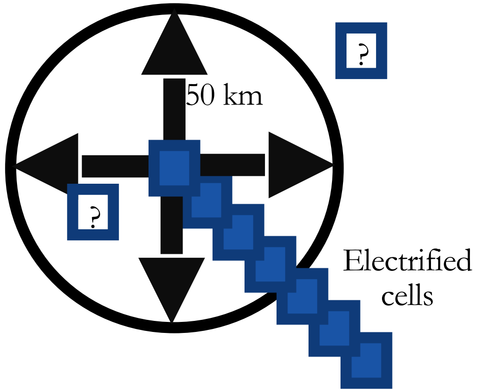
Grid LCoE reduces in areas with high population density and proximity to the national grid

Stand alone systems LCoEs change on later stage according to transportation costs

Mini-grid LCoEs depend usually on resource availability and fuel costs

Step 5. Grid extensions - The electrification algorithm





1. Is the total additional MV line less than **50 km**?

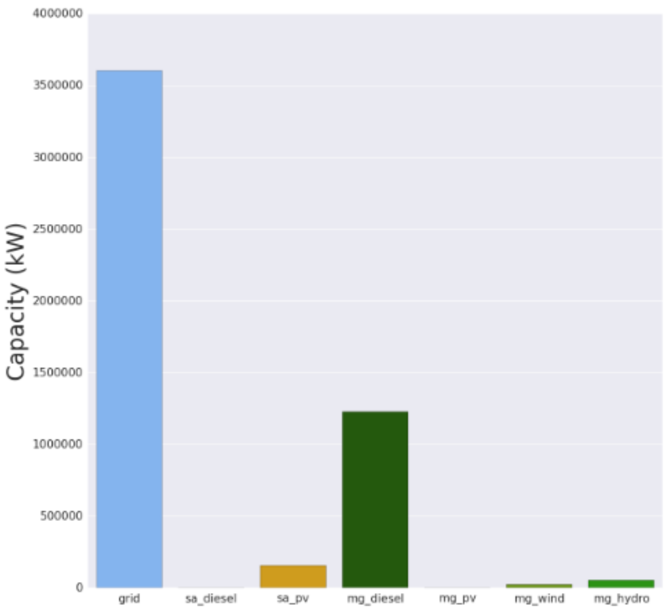
2. Is there **adequate amount of people** (thus demand) to justify an extension of the grid?

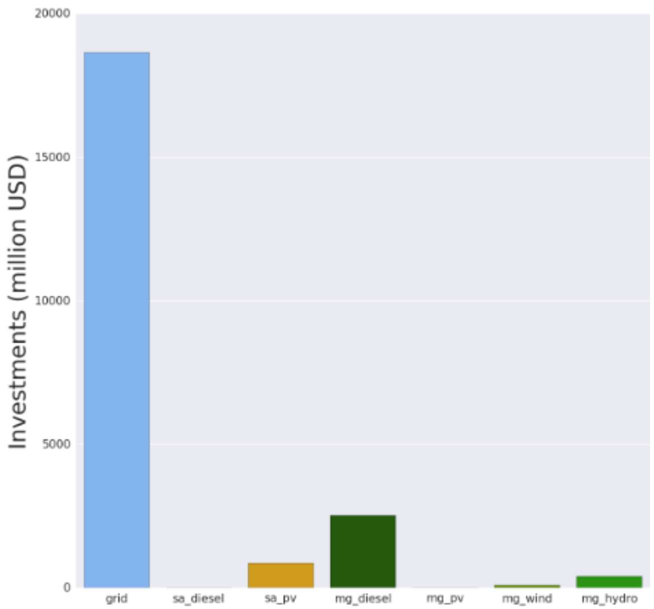
Step 6. Results, Summaries and Visualization

Based on the optimal split identify per technology:

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

	Population	New connections	Capacity (kW)	Investments (million USD)
grid	36062520	26023100	3605964	18648.91
sa_diesel	0	0	0	0.00
sa_pv	447335	447335	155630	855.97
mg_diesel	5861689	5861689	1229037	2531.54
mg_pv	2117	2117	708	4.10
mg_wind	63415	63415	22833	98.41
mg_hydro	369643	369643	54252	405.53
Total	42806722	32767302	5068427	22544.46



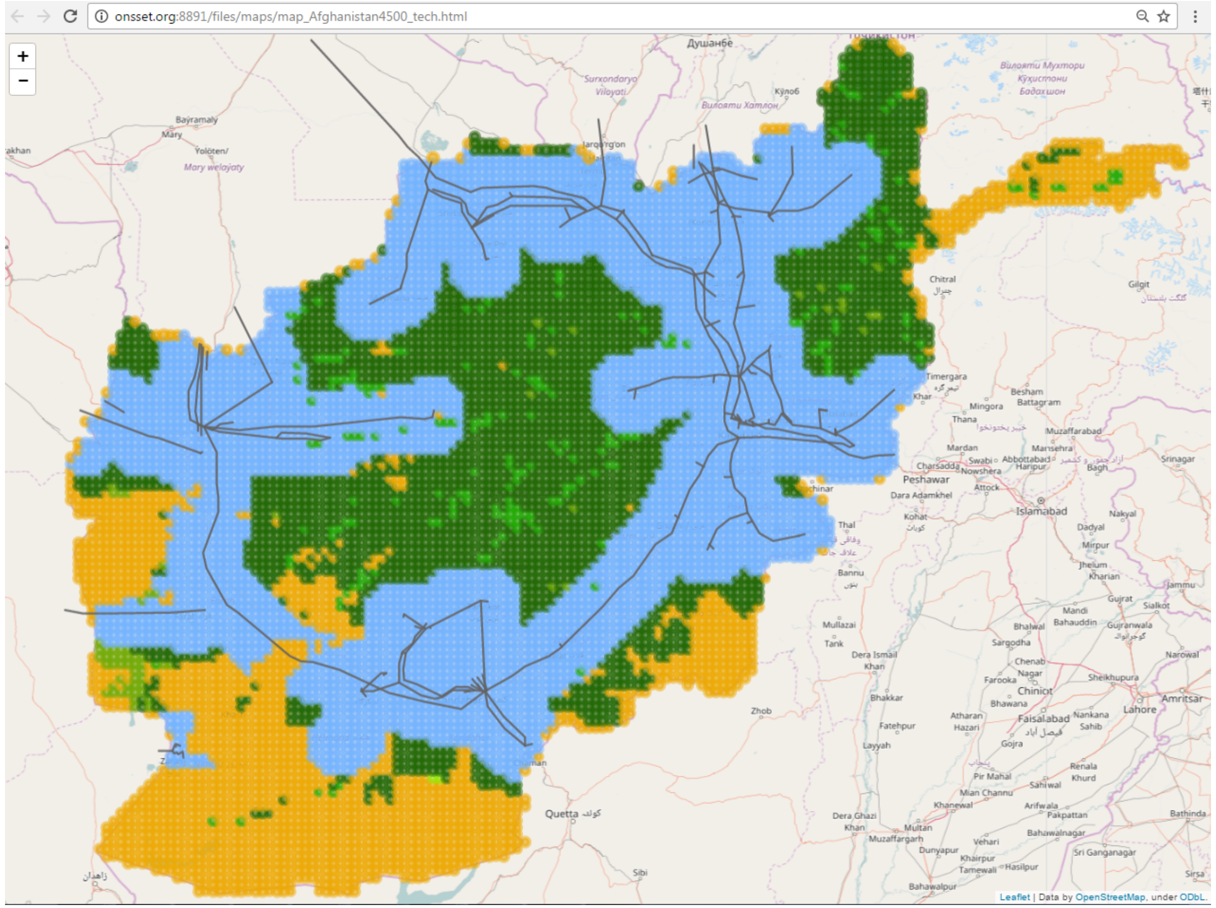


Step 6. Results, Summaries and Visualization

Map of technology split

Colour coding for technology split:

•Grid •SA Diesel •SA PV •MG Diesel •MG PV •Wind •Hydro



Map of electricity cost

Colour coding for LCOE, in USD/kWh

0.077 0.6