TP1 Project-I | Informatique-2
Solar World Map and PV Modelling
[2 Classes (3 hr + 3 hr)]

Santanu Saha | santanu.saha@unilim.fr

January 2024

- This project is alloted for 2 TP classes only, where each class is 3 hr. In total, 6 hrs.
- The TP1 project can be done in group with a maximum of 3 students.
- Refer to demo-program, lecture notes and TD exercises for the project.
- Solution Submission Deadline - 23:59 hr, 15th May, 2024
- Reference to different colour code for contour plots can be found here

Our day to day energy requirements for electronic devices (mobile, laptop, desktop etc.), transportation, cooking, etc. are mostly obtained through gasoline (petrol) and electricity generated at different power stations. Worldwide, the electricity is generated through use of carbon resources such as coal, petroleum, natural gas and nuclear energy. Most of these energy resources are non-renewable (finish soon in ~100 years) and cause pollution by releasing green and toxic gases - CO, CO_2, SO_x, NO_x. These gases are causing global warming and climate change (le réchauffement climatique et le changement climatique), a serious problem in coming future.

In order to deal with this global problem, EU and France has joined hands in developing new technologies as substitute for polluting carbon resources (natural gas, petroleum, coal). One such technology is solar technology (sunlight based) such as photovoltaics (cellule photovoltaïque). The photovoltaic device under presence of sunlight (lumière du soleil) produces electricity (électricité). These are mostly installed as solar panels (panneau solaire) which are set up on the roof top of the house (toit de la maison).

The performance of the photovoltaic devices depends on the (a) weather conditions and (b) amount of sunlight a place receives in a day. In the TP1 project, we will first analyse the global weather (temperature) and solar irradiance (solar power received per unit area) and use this data to calculate the amount of solar energy that can be generated at each and every point on the world map.

A dataset on the global weather pattern (i) Annual Average Temperature (^{0}C) and (ii) Annual Solar Irradiance (solar power received per unit area in kWh/m_2) has been curated based on world metrological data (1975-2010). The data is in "World-Temp-Irr.csv" file.

(A) READING CSV FILE ON GLOBAL WEATHER PATTERN

Read the given csv file with pandas and matplotlib library to list out the columns, head, tail, maximum and minimum values in each column. Follow Demo Program. **[10 (4+1+2+3) marks]**

(i) What are the columns and minimum, maximum values of each column ?

(ii) Use the information obtained to make scatter plot following the demo program.

(iii) Make two separate plots for (a) Temperature and (b) Solar Irradiance. Give appropriate title to the figures.

(B) READING-WRITING CSV FILE FOR PROCESSING WITH PYTHON

A formula has been provided which uses the metrological information of a geolocation and solar device performance to estimate power efficiency and output power of a solar technology. Here we consider (a) Silicon photovoltaics and (b) Perovskite photovoltaics

$$T_{PCE} = \frac{1}{\eta_{ST}} \left[\frac{\eta_{NST} - \eta_{ST}}{T_{NST} - T_{ST}} \right] \times 100$$

$$\eta_{NST} = \frac{(T_{NST} - T_{ST}) \times T_{PCE} \times \eta_{ST}}{100.0} + \eta_{ST}$$

$$P_{out} = P_{in} \times \frac{\eta_{NST}}{100.0}$$

Here, ST $\rightarrow$ standard condition, NST $\rightarrow$ non-standard condition. η is efficiency in percentage and P_{out} is output power from photovoltaic device, P_{in} is annual solar irradiance. T_{PCE} is the rate of photoconversion efficiency with change in temperature (rel. % / ^{0}C).

Photovoltaic Technology	T_{PCE} (rel.%/^{0}C)	η_{ST} (%)	T_{ST} (^{0}C)
Silicon	-0.15	20.4	25
Perovskite	-0.11	17.9	25

Table 1: Temperature coefficients and photovoltaic efficiencies under standard conditions of different solar technologies

(i) Implement a python program which read in the csv file in (1) “World-Temp-Irr.csv” and uses above formula to estimate the η_{NST} and P_{out}. The program should take in information on different PV technologies as attributes (T_{ST},η_{ST},T_{PCE}) **[10 (4+2+4) marks]**

(ii) Print out these quantities to csv file, each for both Si and Perovskite.

(iii) Further create two files : (i) World Map and (ii) Europe only. Follow the demo program on reading/writing csv files. In total there will be four output csv files : World-Si, World-Perovskite, Europe-Si and Europe-Perovskite. (Europe Map : 35N to 72N, 25E to 65W).

(C) ANALYSIS OF THE OUTPUT CSV FILES - WORLD

[10 (4+2+4) marks]

(i) Read the generated csv files of the world map. Print the columns, head and tail of the file. Print out the maximum and minimum values of each column.

(ii)Print out the latitude and longitude for minimum and maximum efficiency with corresponding power output in each case (Si and Perovskite).

(iii) Make a coloured scatter plot of the efficiency and power output for both Si and perovskite (4 figures).

(D) ANALYSIS OF THE OUTPUT CSV FILES - EUROPE

[6 (2+2+2) marks]

(i) Read the generated csv files of the Europe. Print the columns and head of the file.

(ii) Print out the latitude and longitude for minimum and maximum efficiency with corresponding power output in each case (Si and Perovskite).

(iii) What geolocation does these set of latitude and longitude refer to ? List them out.