SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING
LRESE - Laboratory of Renewable Energy Sciences and Engineering

Solar Energy Conversion Devices and Plants: Exercise 1

In this exercise, you will evaluate the potential of solar energy and of a solar energy technology of your choice in Switzerland. This is a team work (groups of up to 4), that will be graded (22% of final mark). Submission deadline of a 3-page (two-columns per page) report is September 29, 2025, 14:15, by email to Prof. Haussener.

Solar Energy Potential in Switzerland

Utilize GIS (geographic information system) data to estimate the potential of solar energy in Switzerland. We suggest to use one of the free and open source software for GIS data analysis, namely the Quantum GIS standalone software (https://www.qgis.org/en/site/). Download the Meteo Swiss 2014 daily solar irradiation data (GHI and DNI) from moodle (note that this data is restricted to academic use). The Swiss country boundary data can also be downloaded from moodle.

Utilize this data and tool to estimate the potential of solar energy and solar technologies in Switzerland (as a function of season). Choose one of the introduced solar energy technologies (photovoltaics, concentrated solar, solar fuels, etc.) and describe the technology and what conversion efficiencies you expect and why. Use the solar data to estimate the potential of this technology for Switzerland. Provide a locally resolved figure(s) and discuss your results in light of the energy need of Switzerland (as a function of day or season). In an ideal scenario, is this energy sufficient to satisfy Switzerland's needs for electricity, fuel and heat? Consult the most recent Swiss Energy Statistics to justify your answer by quantitative statements. In a more realistic scenario, does it make sense to use every available location in Switzerland to convert solar energy, by how much do you expect the potential be reduced considering practical implications (local solar irradiation, accessibility of location, economic potential of location, etc.)?

Write a 3-page (two columns per page) report, which describes the solar energy potential for Switzerland, the basics of the solar technology you chose, the potential for this technology, and how much this technology can contribute to the corresponding energy need of Switzerland in an ideal and more realistic case. Consider that the irradiation is varying every day and, particularly, during the seasons.

Useful Hints:

The data for GHI and DNI are for the whole year of 2014, and performing the computation for each day will be very laborious. Luckily, QGIS has the possibility to use Python-based scripts to help in automatizing the task. Here are some tips that you can follow to perform the calculations:

- Get familiar with QGIS by following the examples in the training manual (*QGIS-testing-TrainingManual-en.pdf*, located on moodle). Pay special attention to module 2, module 3 (Attributes, and field calculator), module 7, and module 8 (Conversion raster to vector, and calculating the area for each polygon).

- Same for QGIS-python by following some of the examples in the manual (*QGIS-testing-PyQGISDeveloperCookbook-en.pdf*). Pay special attention to chapter 3 and chapter 11.

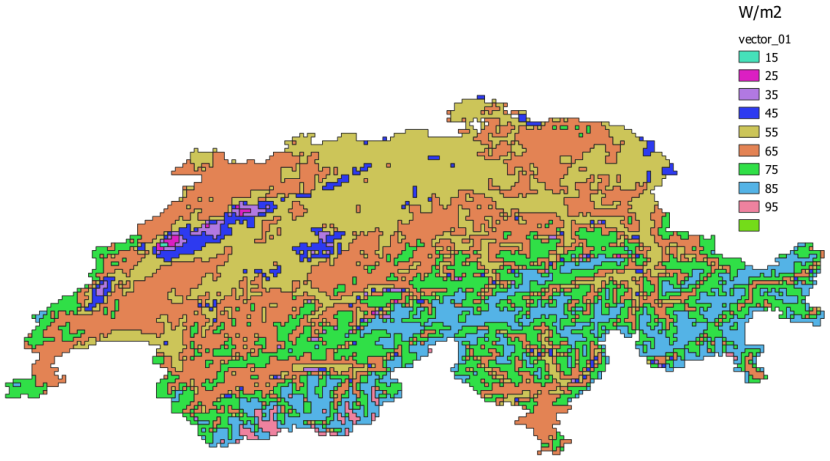

Figure 1: Vector layer after reclassification of the solar irradiation.

Once you are familiar with QGIS software, you can start by manually extracting the GHI for the first day of the year 2014 in Switzerland follow these steps:

1. Import the corresponding raster of the solar irradiation in Switzerland to QGIS.
2. Change the symbology of the figure to have a better idea of the solar distribution (note the unit is Wm^{-2})
3. Import the Swiss boundaries file (*TLM_LANDESGEBIET*) that is within the geo-database called *swissBOUNDARIES3D_1_3_LV95_LN02.gdb*
4. Remove the areas outside Switzerland by performing an extraction operation in the raster using the Swiss boundaries as a mask layer.
5. Perform a reclassification of the solar irradiation values using the new raster.
6. Convert the new raster into a vector layer using the processing toolbox. The final result should look like the one shown in figure 1.
7. Compute the area corresponding to each solar irradiation value in the new vector layer using the *Field Calculator* tool.
8. Export the solar irradiation and the area to a text file and compute the total irradiation in Switzerland (using matlab, excel, etc.).

You can use a python script to perform these steps for the whole year. It will easier for you to use the python environment inside QGIS. Also note that many of the operations are saved in the history which will be very useful when writing the python scripts.