# Project Instructions

# Operational research for urban solar development

# “PV failure detection based on operational time series”



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**Project summary:**

The project aims at modeling a PV system and detecting underperformances to, eventually, correct them.

The first objective relies on the estimation of the operating variables such as POA irradiance, module temperature, DC and AC power from in-situ data while the second objective is to quantify the losses from three underperformances categorized as shading, inverter clipping, and module short-circuit.

**Groups:** Groups of 2 people, working alone is also an option (and highly recommended).

**Deadline:** Friday 22/12/2024 9h30

If 15mins late: - 10%

If 1h late: - 25%

If 3h late: -50%

If more than 3h late: -50%

**Deliverables:**

* One jupyter notebook as html file.
* 6 csv files.

**Input datasets of the project:**

* project\_xtrain.csv: Data to use as inputs for models with irradiance data, air temperature, wind\_speed and sun\_path.
* project\_ytrain.csv: Data to compare with the outputs of the models. It contains the irradiance in the plane of array, module temperature, DC power and AC power.  
  The ac power is simulated from data-driven technics to account for error and noise.
* project\_shading.csv: Data which includes shading effect.
* project\_clipping.csv: Data which includes inverter clipping effect.
* project\_sc\_clipping.csv: Data which includes module short-circuit effect.

The three last files contain the pdc and pac variables with the default effects included on pdc, pac.

# Tasks

## AC Power modelling

1. Estimate the irradiance in the plane of the array.
2. Estimate the module temperature.
3. Estimate the DC power.
4. Estimate AC power.
5. Calculate the performance of the installation at the AC level through two indicators:
   1. Performance Ratio
   2. Energy Performance Index

### Expected outputs:

* 1 CSV file with 4 columns [“gpoa\_estimated”, “t\_mod\_estimated”, “dc\_power\_estimated”, “ac\_power\_estimated”] and Datetime index with the estimated POA irradiance, module temperature, DC power and AC power.
* The notebook with the explained approach and the performance metrics (PR, EPI) calculated and printed.

## Underperformance detection

Detect when the following underperformances occur and quantify the losses:

1. Inverter shutdown.
2. Inverter clipping.
3. Shading.
4. String open-circuit.
5. Bypass diode failure.
6. ***Bonus***: All failures combined – to dissociate.

### Expected outputs

1 csv file for each underperformance which contains a pandas DataFrame (one column) with its values that corresponds to the energy losses from the underperformance.

For the 6., the csv file should contain 5 columns, 1 for each underperformance.s

# Grading scale

Score distribution:

* 45% A. AC power modeling

10% for each task for the first 4 tasks.

5% for the last 5th task.  
For the first 4 tasks, the following points will be assessed:

* + - Relevance of the estimation method
    - RMSE accuracy of the estimation  
      (3/5 for the accuracy is the same as the most basic method  
      5/5 if the accuracy is the same as the teacher’s method)

For the 5th task: The correctness of the calculation is assessed.

* 50% B. Failure detection  
   10% for each failure, the following points will be assessed:
  + - Relevance and originality of the approach
    - Accuracy of the estimation  
      (3/5 if the accuracy is the same as the most basic method  
      5/5 if the accuracy is the same as the teacher’s method)
* 5% for the overall structure and the ease of reviewing the notebook.
* ***Bonus*** 10%: All failure signals are combined together. Correctly dissociate them and estimate their energy losses.
  + Relevance and originality of the approach
  + Accuracy of the estimation  
    (3/5 if the accuracy is the same as the most basic method  
    5/5 if the accuracy is the same as the teacher’s method)

### Potential bonus/penalty points:

* + Relevant data treatment on the inputs for estimations
  + Better accuracy than the teacher’s benchmark.
  + Illustrations to explain the approach/the results.

#### Advice:

* Refer to the course formulas.
* Make concise explanations.
* Illustrate your approach with some relevant plots.
* Comments to explain your code with “#”  
  For example,

# Check when the inverter efficiency is under 60%  
filter = (ac\_power / dc\_power) < 0.6

ac\_power.loc[filter]

# Consider that a failure occurs when the inverter efficiency < 60% and quantify the losses  
loss = ac\_power\_estimated.loc[filter] - ac\_power.loc[filter]  
print(loss.sum())