Assessment of PV Systems Performance in the Madeira Island Using Typical Meteorological Year Data

Edgar F.M. Abreu[a], Paulo Canhoto[a,b], Victor Prior[c], R. Melício[b,d]

[a]Instituto de Ciências da Terra, Universidade de Évora, Portugal
[b]Departamento de Física, Escola de Ciências e Tecnologia, Universidade de Évora, Portugal
[c]Observatório Meteorológico do Funchal, IPMA – Instituto Português do Mar e da Atmosfera, Funchal, Portugal
[d]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Portugal

Contents

I. Introduction

- What is a Typical Meteorological Year?
- How is the TMY generated?
- What are the main advantages of using TMY data in renewable energy systems modelling?
- How can a PV system be modelled?
- What is the Performance Ratio (PR) and the Weather Corrected Performance Ratio (WCPR)?
- What is the annual number of equivalent hours at peak power?

II. TMY Generation

- Hourly measurements of:
  - Air temperature
  - Relative humidity
  - Wind speed
  - Global solar irradiation
- Minimum of five years of data ending in 2014 in eight locations

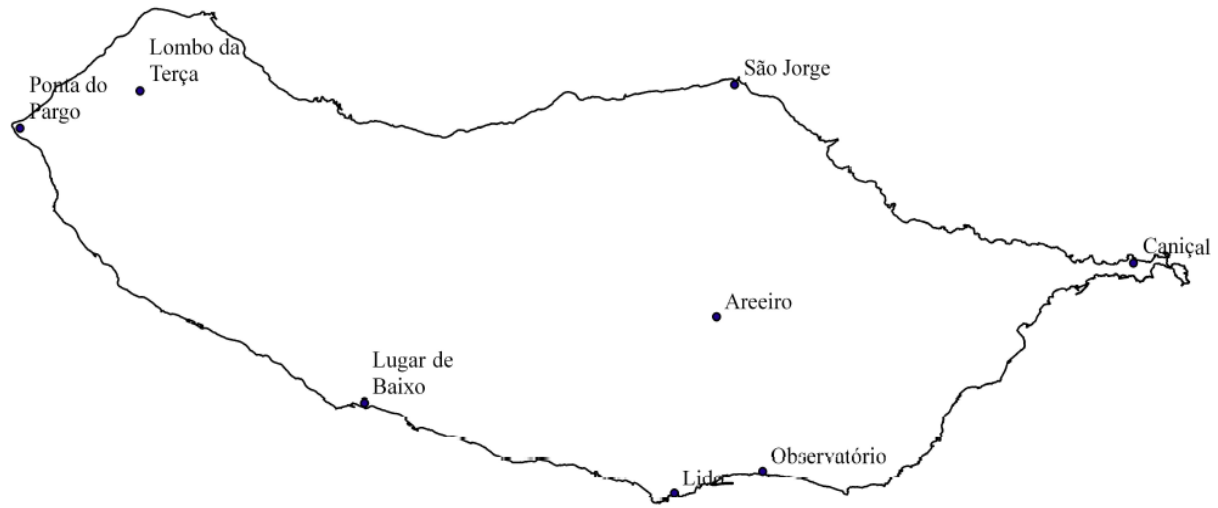

Figure 1 – Distributions of the locations analysed.

II. TMY Generation

- Sandia method [2]
- Cumulative Distribution Function ($S_n(x)$)
- Finkelstein-Schafer statistics (*FS*)
- Weighted Sum (*WS*)
- Root Mean Square Difference (*RMSD*)

$$S_n(x) = \begin{cases} 0 \; for \; x < x_{(1)} \\ \dfrac{c - 0.5}{n} \; for \; x_{(k)} \leq x \leq x_{(k+1)} \\ 1 \; for \; x \geq x_{(k)} \end{cases}$$

$$FS = \frac{1}{n}\sum_{p=1}^{n} D_p$$

$$WS = \sum_{k=1}^{9} w_k * FS_k$$

$$RMSD = \left(\frac{1}{m}\sum_{a=1}^{m} d_a^2\right)^{1/2}$$

II. TMY Generation

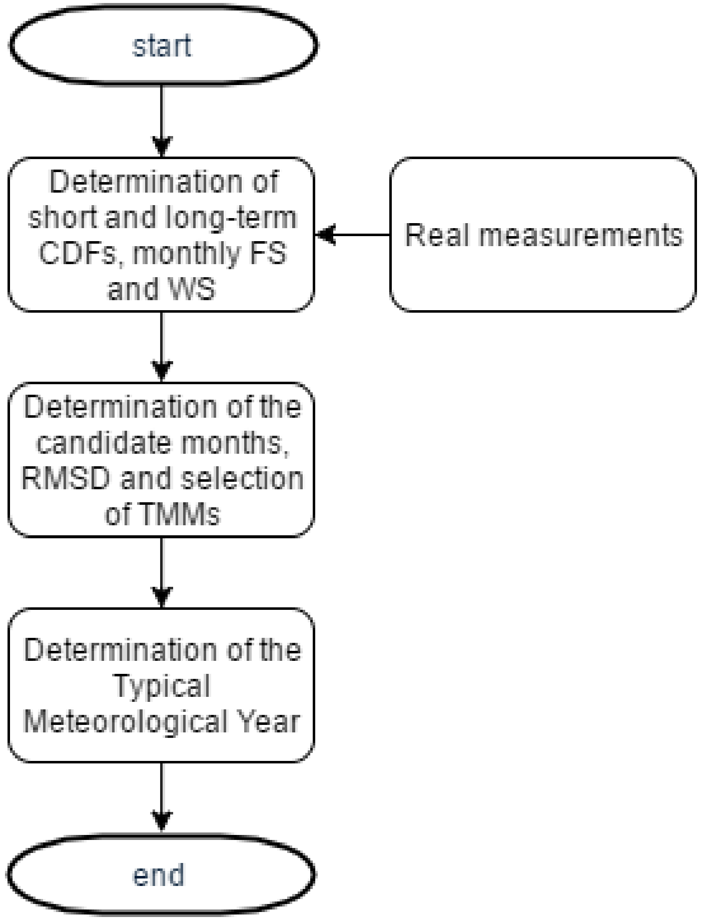

Figure 2 – Flowchart of the TMY generation algorithm.

II. TMY Generation

- TMY validation

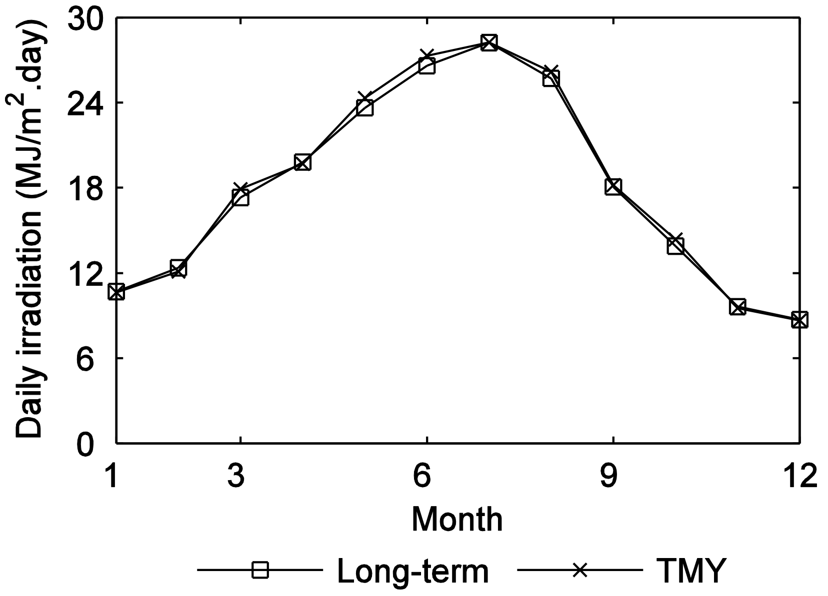

Figure 3 – Comparison between the long-term and the TMY monthly mean values for the daily global solar radiation.

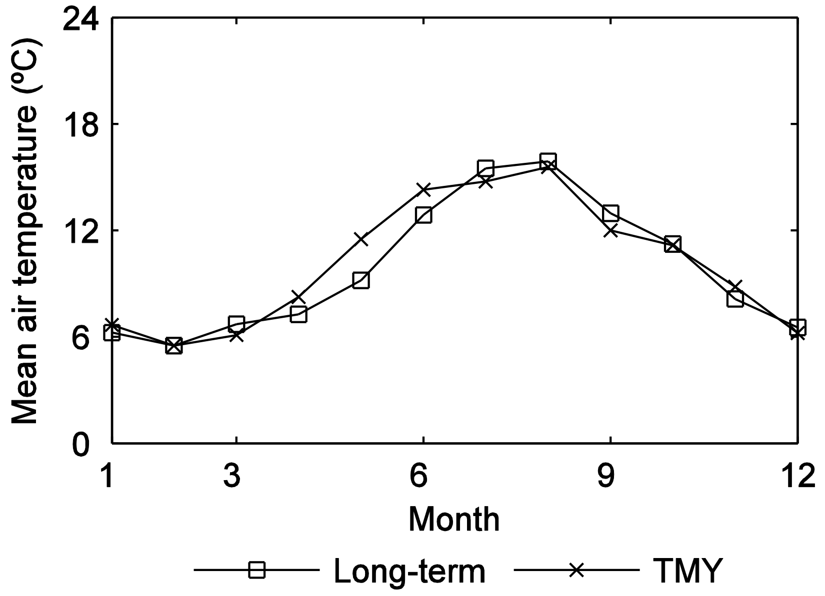

Figure 4 – Comparison between the long-term and TMY monthly mean values for the daily mean air temperature.

III. PV System Modelling

- One diode and five parameters model

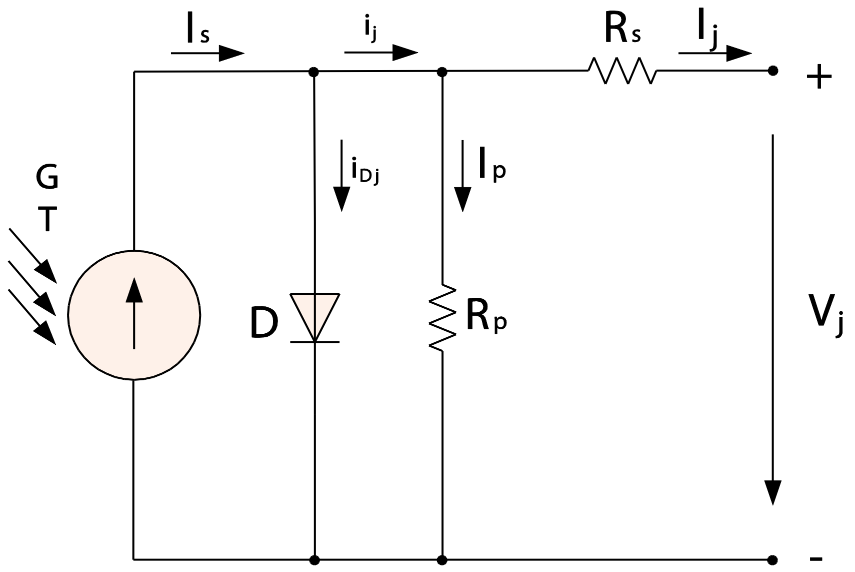

Figure 5 – Equivalent circuit of a solar cell.

$$R_p = \frac{V_{OC}}{i_{OC}}$$

$$R_S = \frac{R_p\left(i_j - I_j\right)}{I_j} - \frac{V_j}{I_j}$$

$$I = I_S - I_0\left(e^{\gamma(V+IR_S)} - 1\right) - \frac{V + IR_S}{R_p}$$

III. PV System Modelling

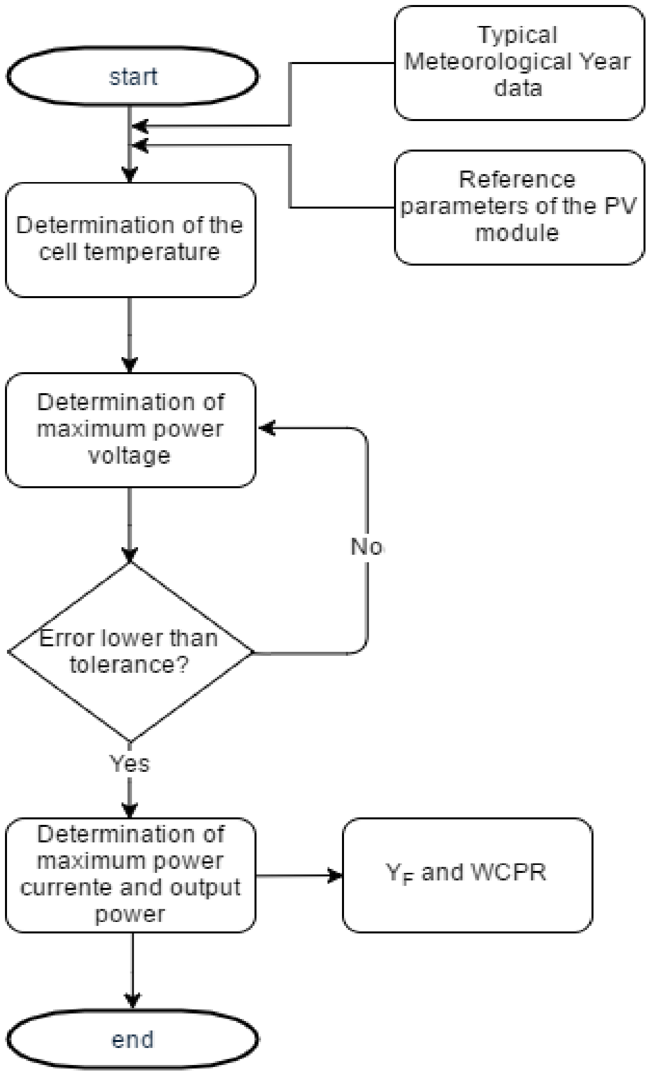

Figure 6 – Flowchart of the PV modelling algorithm.

III. PV System Modelling

- Effect of the temperature

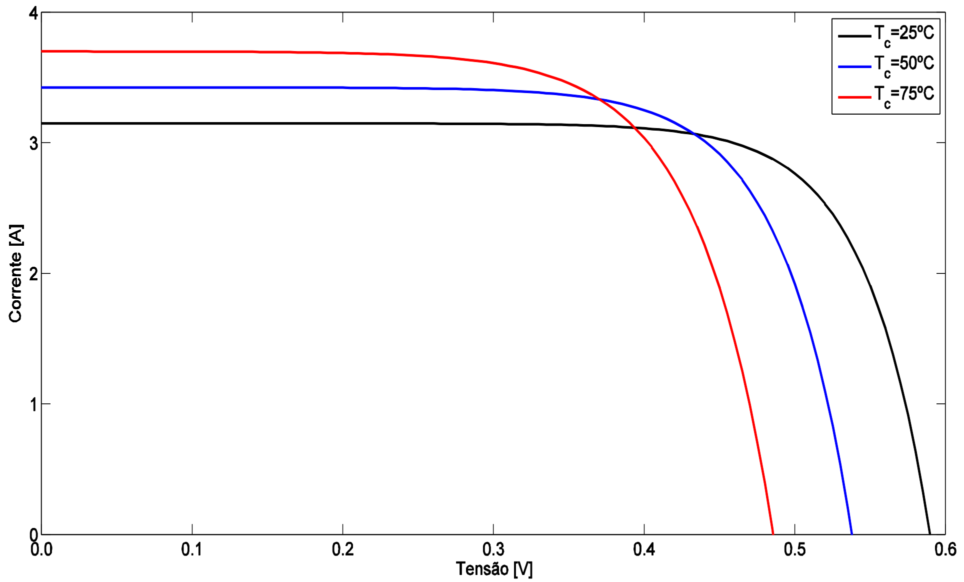

Figure 7 – Effect of the cell temperature on the energy output.

- Effect of the incident irradiation

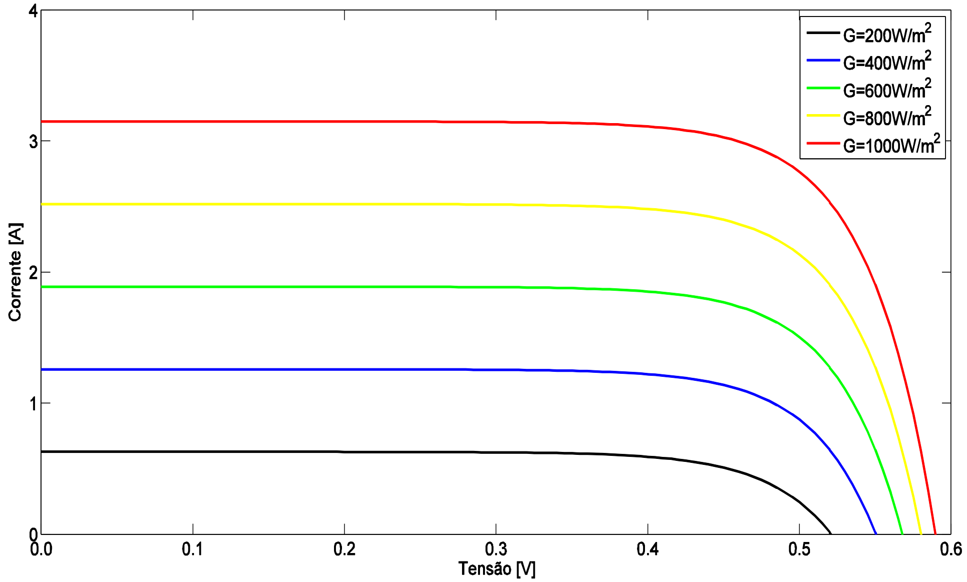

Figure 8 – Effect of the solar irradiation on the energy output.

IV. Results and Discussion

- TMY global solar irradiation

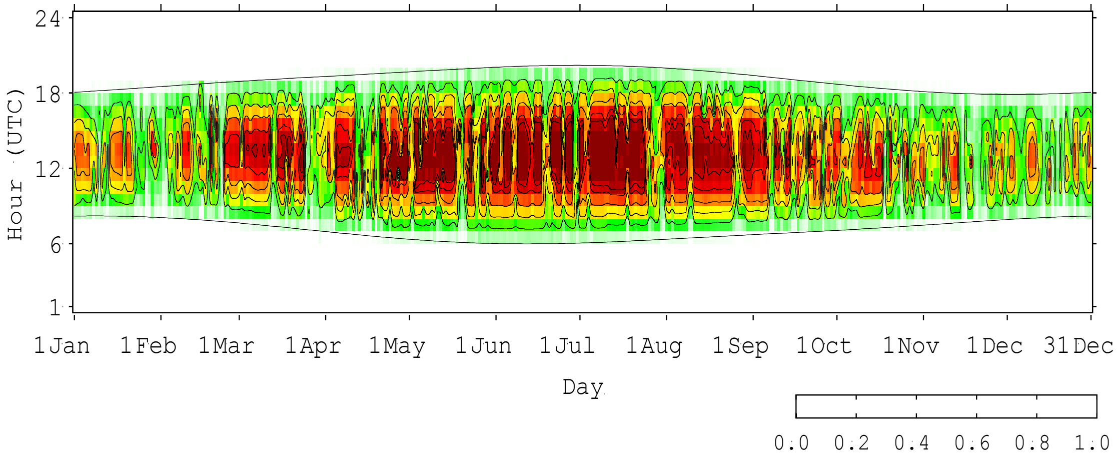

Figure 9 – Hourly global solar irradiation in Areeiro for the TMY (kWh/m^2).

- TMY PV system yield

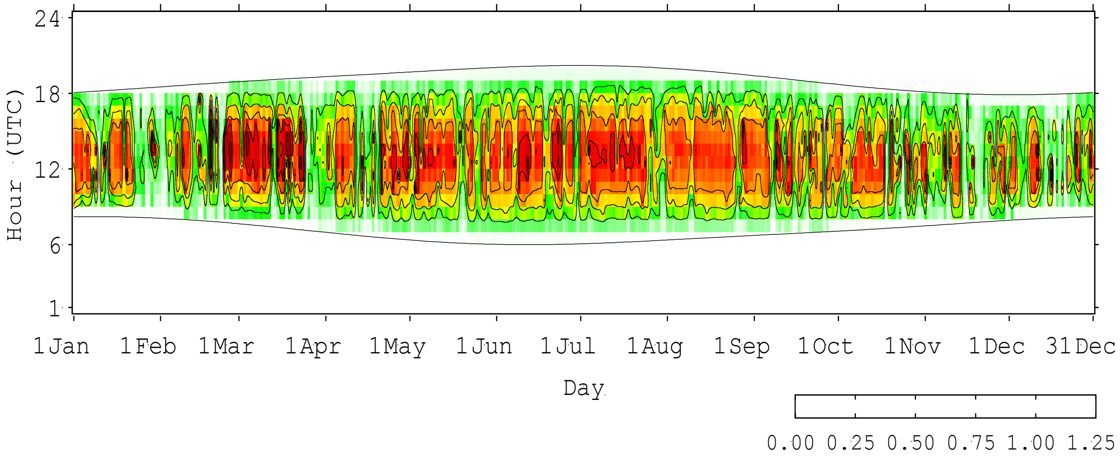

Figure 10 – Hourly PV system yield in Areeiro for the TMY (kWh/kWp).

IV. Results and Discussion

- Performance Ratio (PR)

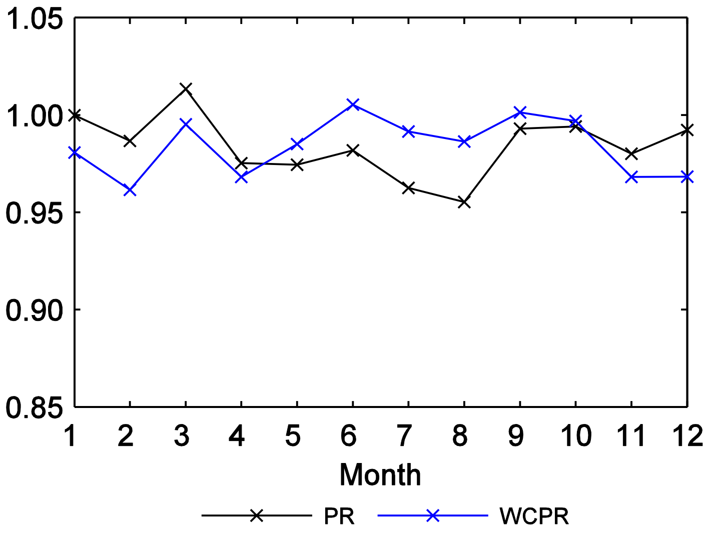

Figure 11 – Monthly values of PR and WCPR for Areeiro.

- Weather Corrected Performance Ratio (WCPR)

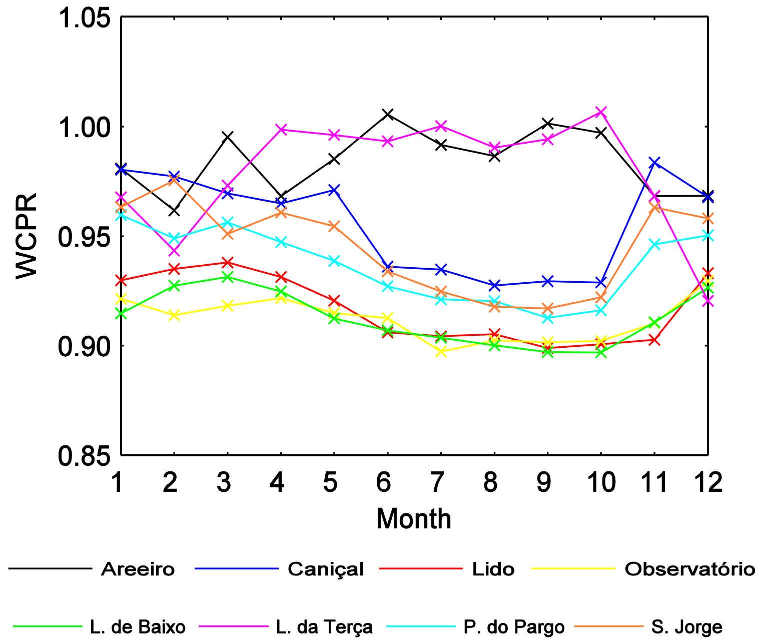

Figure 12 – Monthly values of WCPR.

IV. Results

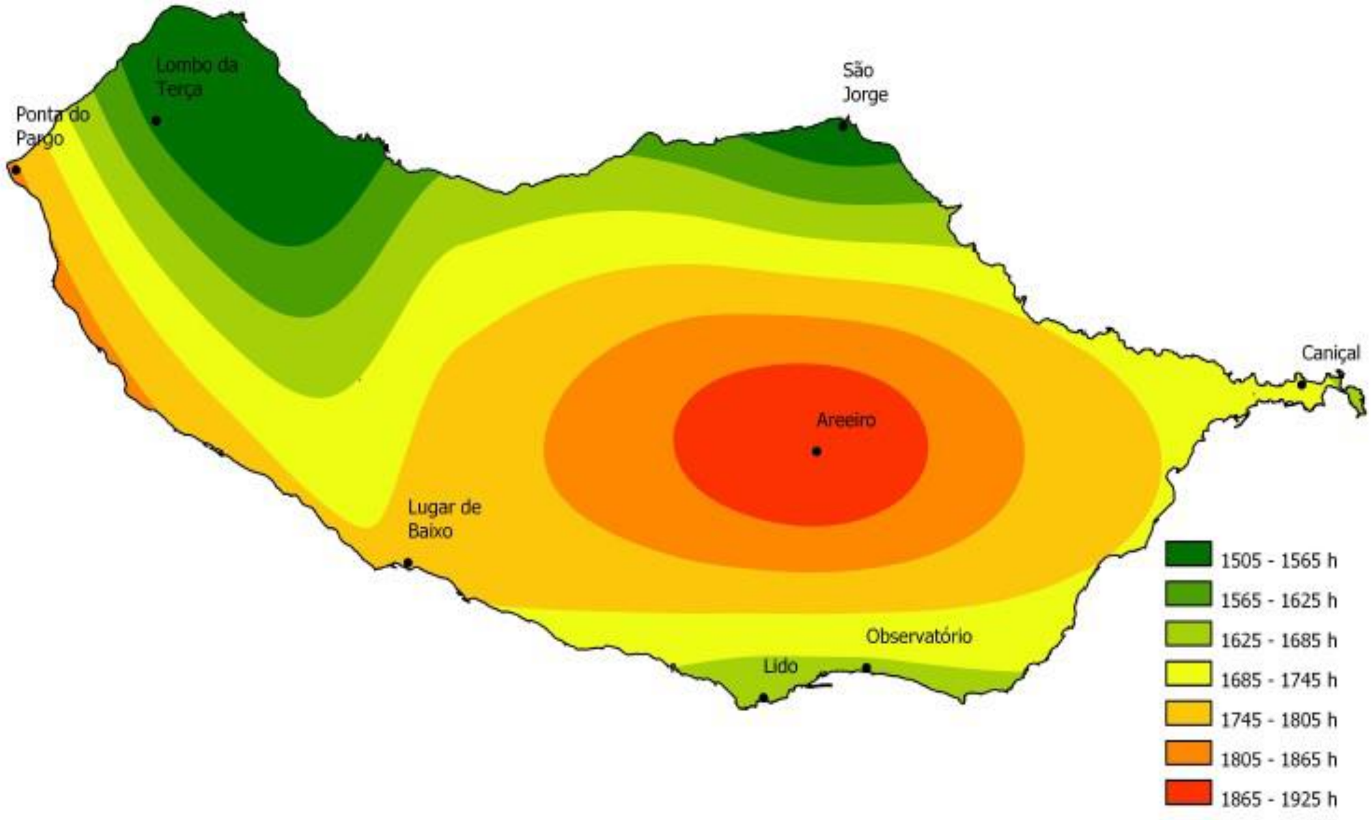

Figure 13 – Number of annual equivalent hours at peak power in Madeira Island.

V. Conclusions

- TMY Generation
- TMY validation
- PV System Modelling
- Effect of the cell temperature and of the solar irradiation
- PR and WCPR
- Spatial interpolation of number of equivalent hours at peak power

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