PROJECT: Layout planning and optimization of high density PV power plants
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Context:

The design of small, medium or large PV plants is always dependent on the available budget. Their costs are not only affected by the type of technology and the number of required PV systems to satisfy the power needs but are also dependent on land-related costs, such as land, wiring, fencing, civil works, etc. Besides economic issues, the land area availability can be a limiting factor for the design of a PV plant, for example, in small islands or in mini-generation systems in urban context, which can become an important parameter in the new context of smart grids design for smart cities.

Small land area per PV system increases the probability of mutual shading, leading to severe reductions on the energy yield. Thus, in PV power plants planning, the ground cover ratio requires careful optimization.

This project aims to optimize the layout arrangement of high-density PV power plants using Linear and Genetic algorithms, considering land availability, type of technology, costs and energy yield.

Objectives:

This work presents an optimization land occupation model considering shading effects, PV plant design and financial assessment. The main goals of the tool under development are to provide to the final user, the following decision key points:

- Graphical layout arrangement output;
- Energy yield prediction;
- Best match technology;
- Cost analysis;

The presented model will be implemented on a web platform (GIS kind), where the final user can explore several input options, to better meet it needs, as: location, land topography, time frame analysis… and get a first project layout fully integrated in the local policy and economic frameworks.

Description of the project:

The model is a result of the iteration of two distinct analyses:

(1) determination of the energy yield expressed in terms of ground cover ratio (GCR – represents the PV systems density)

(2) determination of a maximum value for return on investment indicator for a certain land area.

This iteration results in the maximization of the installed power on the new PV plant, minimizing the levelized cost and maximizing the return on investment. Simultaneously one or a set of layouts are generated and purposed as optimal solutions for each terrain.

The model workflow is shown on the following flux diagram (figure 1). Firstly, a linear model was implemented where it is possible to test several PV plants densities (GCRs) arranged as simple regular matrixes with no topography (inner block in figure1). Currently, a new model generation evolved into a genetic algorithm based analysis that uses the linear algorithm as multi-objective function for the selection of layout arrangements. In this step, an incremental GCR study is abandoned in favour of an exploration of non-regular layouts where topography information is valorised.

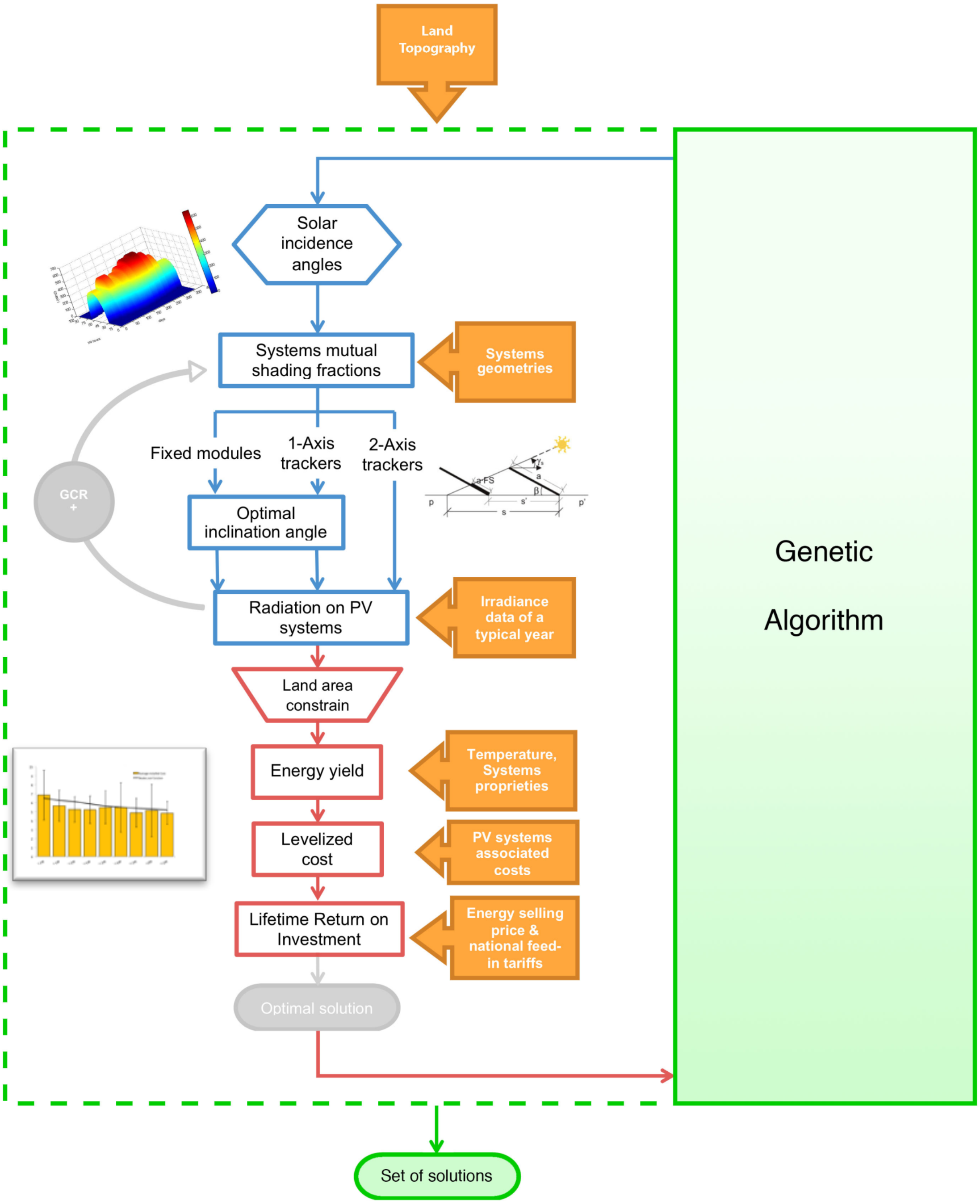

Figure 1 - Model workflow flux diagram.

Results:

A simple exemplary result [1] is the case study of a small power plant to be installed in Tagus Park, Industrial Park near Lisbon, for a non-constrained situation in terms of layout arrangement.

Location: N 38.74°; W 9.30°
Area restriction: 500 m^2 PV plant
Evaluation time: 20 years
National feed-in tariff: 34 c€/kWh

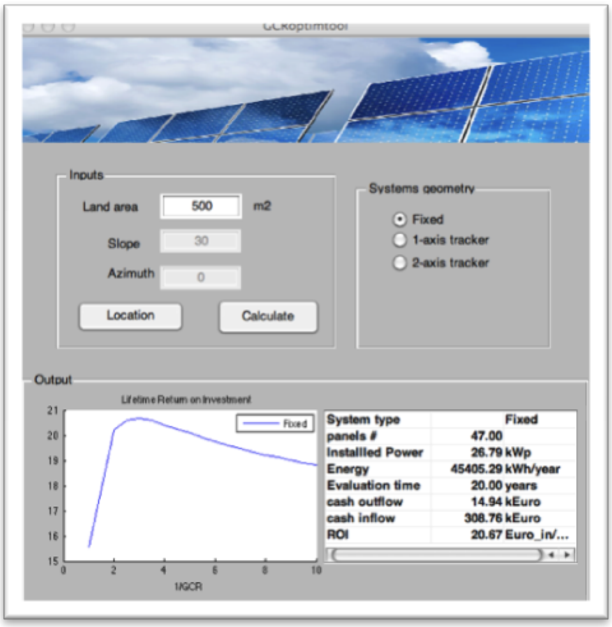

Figure 2 – Graphical user interface.

Systems type	ROI ($€_{IN}/€_{OUT}$)	Number of systems	Installed power (kWp)	Energy yield (MWh/yr)
Fixed	20.67	47	26.8	45.40
1-axis trackers	**21.75**	**57**	**32.5**	**63.90**
2-axis trackers	20.26	47	26.8	55.3

References:

[1] Pera D., Brito M.C., Alves J. M., Serra J.M., Silva C., Vallêra A.M., “Optimization Model For High Density Photovoltaic Power Plants by Maximization of the Return on Investment”, in 26th European Photovoltaic Solar Energy Conference proceedings, Hamburg, Germany, September 2011