PEARL PV

Dynamic simulation of the shading cast by a wind farm on an adjacent photovoltaic plant

Jesús Robledo Bueno

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Background

- *Starting point:* Already existing wind farm - Wind turbine locations fixed

- *Goal* - Install as many 1 axis trackers as possible but there were limitations…
  - Topography
  - Available power output

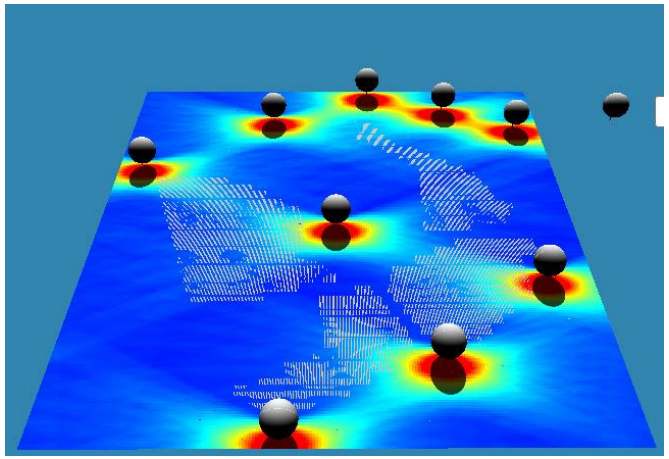
- *Challenge* - Different trade offs needed to evaluate the electrical losses depending on the relative position between each turbine and the PV modules

- *Not simulated (yet)* - Instantaneous effect of shading over modules and impact on the inverters (time characteristic of blade movement) - Only interest in overall yearly figures

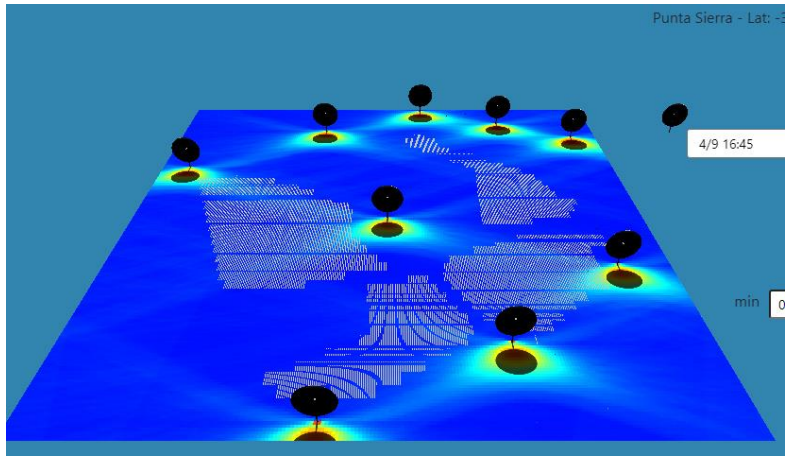
Methodology - 1) Critical shading areas identification

Typical shadow flicker analysis gives a big dispersion depending on assumptions:

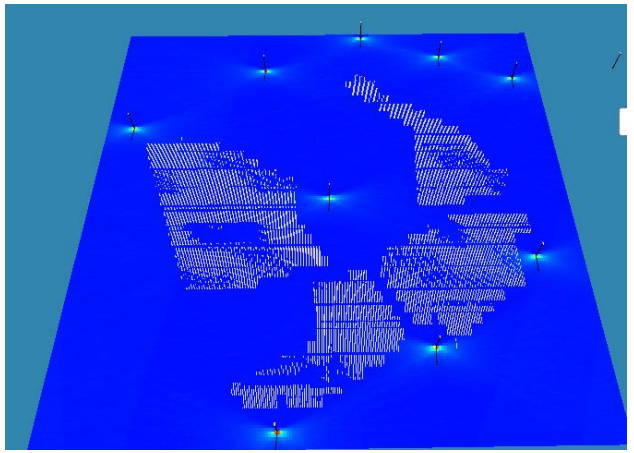
- If no wind direction is known, a sphere approach is too convervative
- If a predominant direction is known, more realistic estimation can be done, but still too conservative
- If only towers are considered, the problem is undersized



Spheres approach - No predominant wind direction



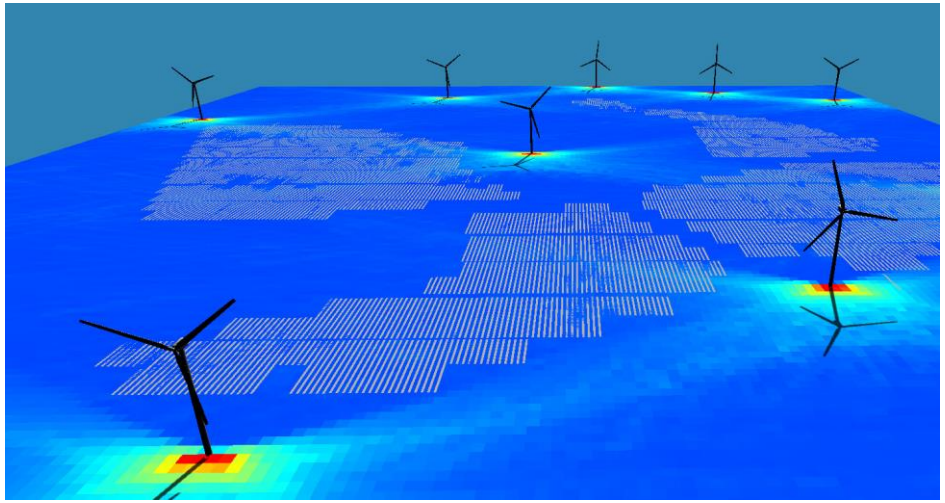
Disks approach - Predominant wind direction



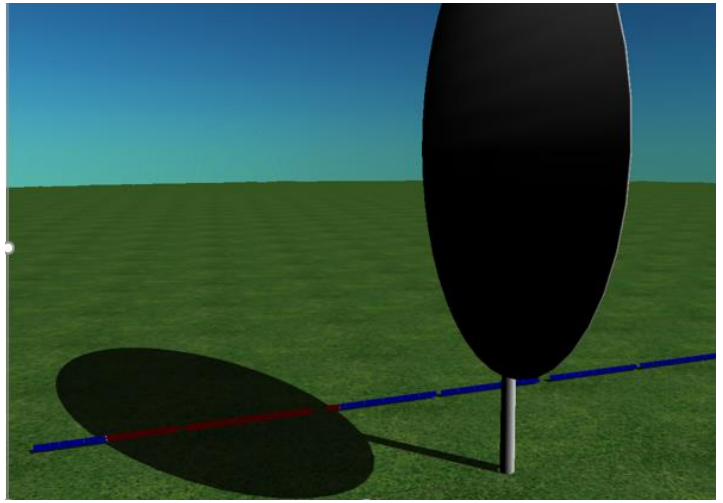
Tower approach - Understimation

Methodology - 2) Dynamic shading implementation (I)

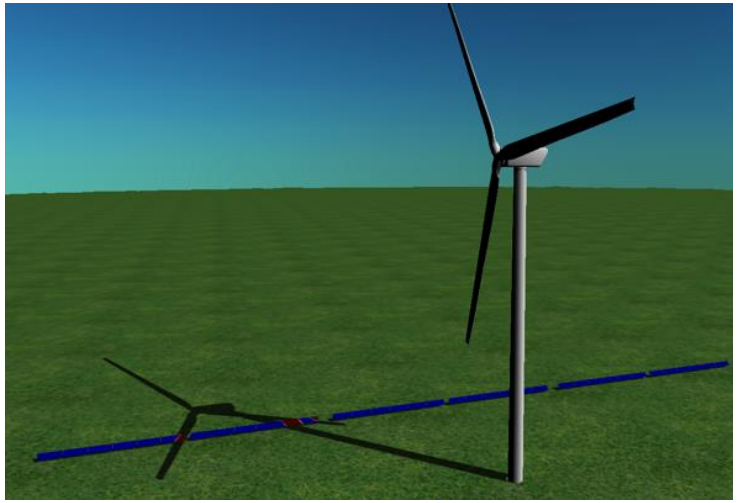
- Simulation applied to a system where the wind turbine tower is fixed and the blades rotate
- Blade rotation is considered random and a set of several simulations are performed to perform a Monte Carlo analysis
- Geometric shading results provides a more realistic shadow flickering, but does not take into account electrical loses…
- New methodology using GPU for computing the electrical losses (1)



Adapted shadow flicker for geometric shading



Details for shading oversizing

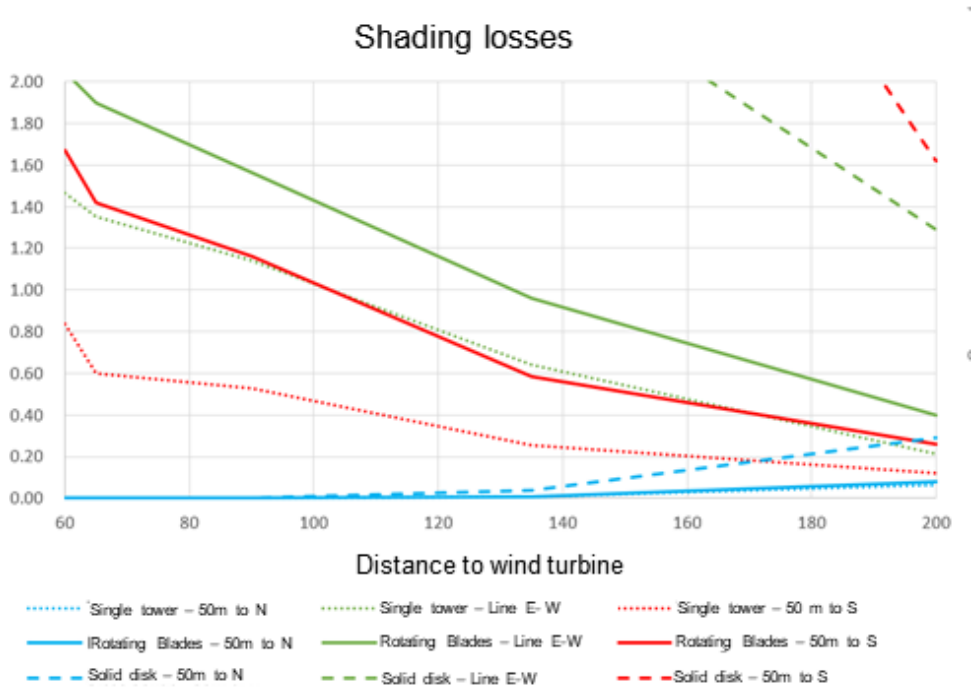


Instant blade shading evaluation

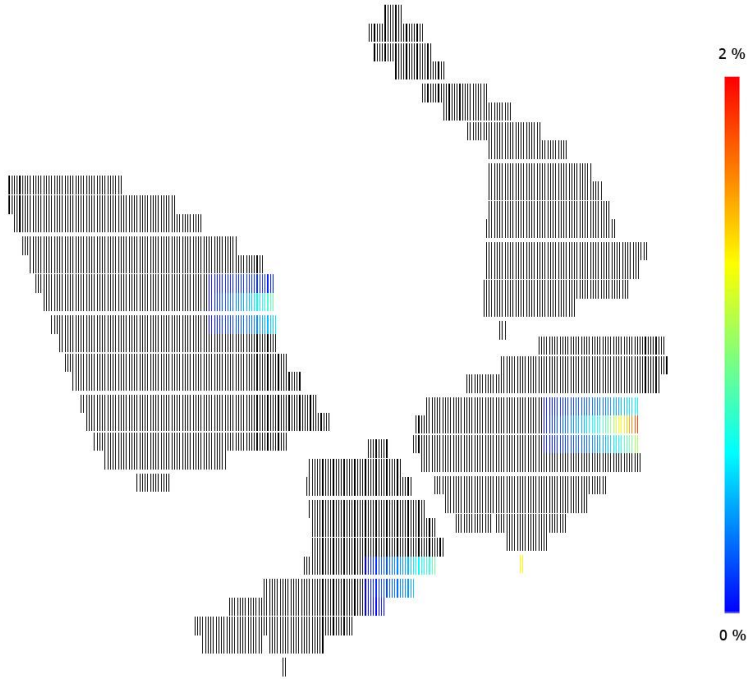
(1) Jesús Robledo, Jonathan Leloux, Eduardo Lorenzo, Christian A. Gueymard, - From video games to solar energy: 3D shading simulation for PV using GPU, Solar Energy, Volume 193, 2019, Pages 962-980, ISSN 0038-092X https://doi.org/10.1016/j.solener.2019.09.041

Methodology - 2) Dynamic shading implementation (II)

- Several simulations per tracker are performed depending on relative possition to a particular wind turbine
- Results provide a "losses heat map" depending on tracker location for the complete field

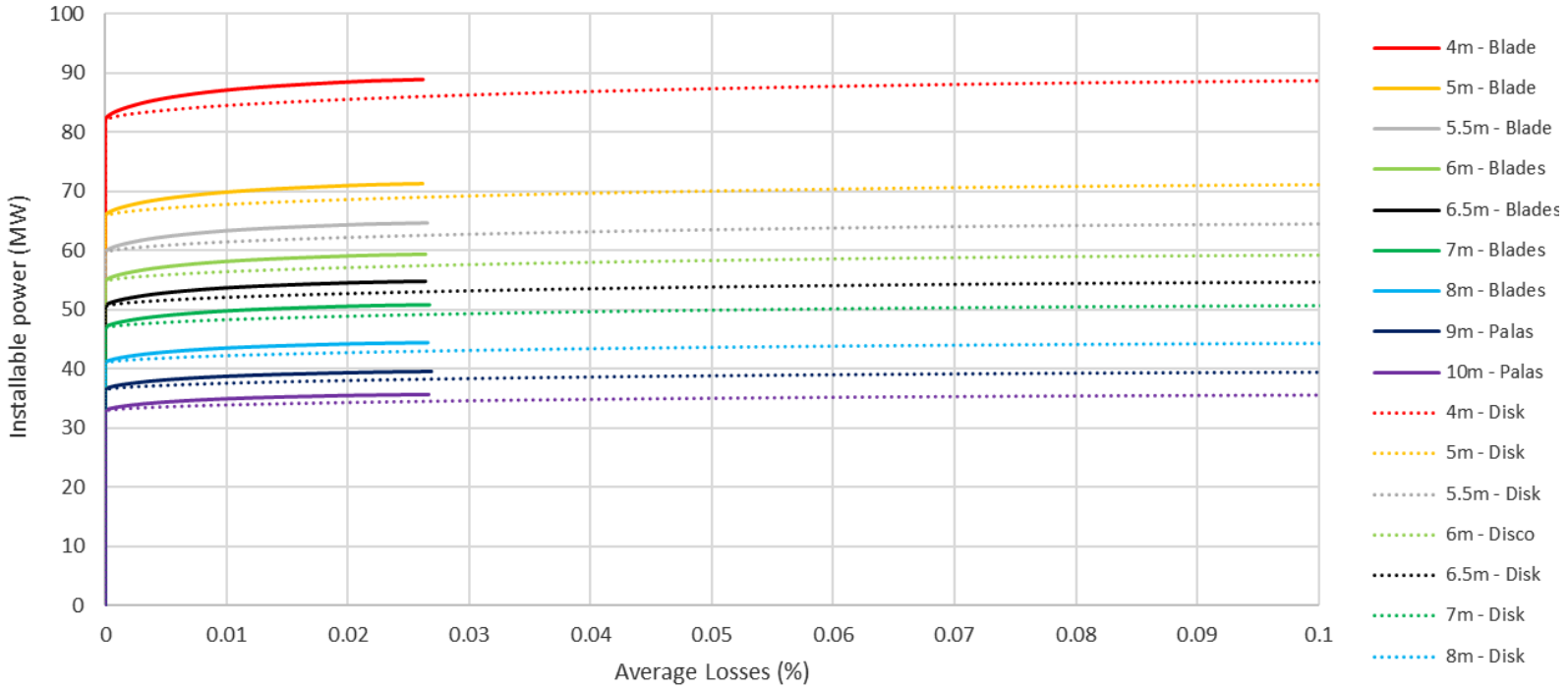


Electrical losses analysis as a function of distance and position



Overall potential losses heat map

Results - Prefered locations installation



- Separated study about balance between CGR (decreasing distance between trackers) and energy production
- Gains corrected based in the "losses heatmap" obtained before
- Allows to identify the preferences about where a tracker would be too "costly" to be installed
- Real limitation due to topography and MW output available

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Thanks for your attention!