On the Dependence between the Step Orientation and the Received Direct Solar Radiation of a PV Panel. Part II: The Step Pseudo-Equatorial Orientation

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1. Interest of the Work:

This second part of the paper approaches a problem that is referring to the energetic efficiency maximization of a tracked PV panel, which consists in maximizing the received solar radiation and minimizing the driving energy. The objective is to optimize the "received direct solar radiation" – "number of daytime tracking steps" correlation for a pseudo-equatorially tracked PV panel (Fig. 1). The solution presented is a graphical one and an analytic model will be developed in the future

Keywords:
PV panel, incidence angle, direct solar radiation, pseudoequatorial tracker, steps' orientation.

2. Objectives of the Paper:

The optimization problem is divided in two sub-problems:

a) maximization of the received direct solar radiation by optimizing the correlation between the daytime (active) steps' number and the direct received solar radiation

b) minimization of the driving energy by optimizing the tracking actuators.

This paper objective is referring only to the first aspect of the problem. For better understanding, the paper presents the graphical maximization of the received direct solar (see. Fig. 2,3).

A. Unit Vectors Modelling

First objective of this second part of the paper is to model the *pseudo-equatorial* tracker incidence angle. Using Fig. 1, are modelled the sun-ray unit vector and the solar panel normal unit vector.

B. Sun-Panel Incidence Angle

Using the modelled unit vectors, there is obtained the incidence angle and some numerical simulations are made considering the input data corresponding to *Brasov/Romania* location (latitude $\varphi = 45.65°$ N).

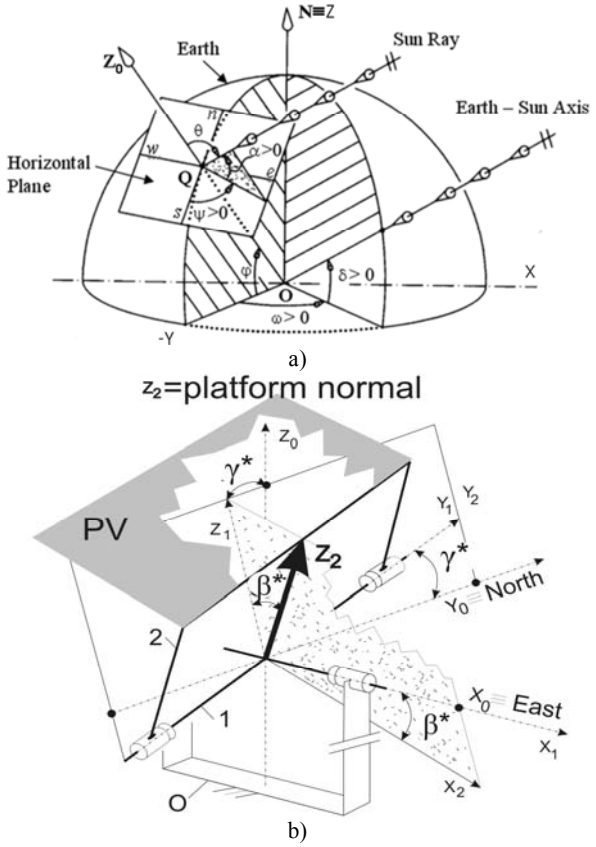

Fig. 1 Relative geometry Earth-Sun (a); Geometrical scheme of the *pseudo-equatorial* tracker (b)

C. *Step (discontinuous) Orientation*

In order to establish the step orientations there are considered the following requirements:

a) minimization of the extreme tracking angles
b) achievement of an optimum received direct radiance on the solar panel with the minimum number of steps.

D. *Received Direct Solar Radiance*

By means of the numerical simulations (for Brasov/Romania location), there are analysed the variations of the received direct solar radiance and the surfaces under these diagrams (see Fig. 2, 3). The obtained areas are then compared with the reference surface under the diagram of the available direct solar radiance.

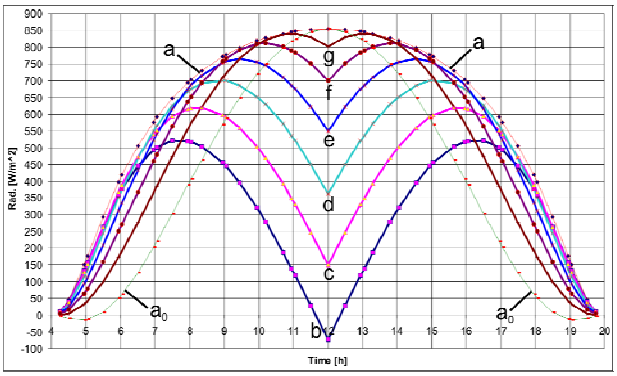

Fig. 2. Nomographic chart with variations of the received direct solar radiation during the Summer Solstice (δ =+22,5º): a – total available; a_0 – for a tilted fixed panel (ω*= 0)º ; b –for panel with ω*=±95º; c –for ω*=±80º ; d –for ω*=±65º ; e –for ω*=±50º ; f – for ω*=±35º; g –for ω*=±20º.

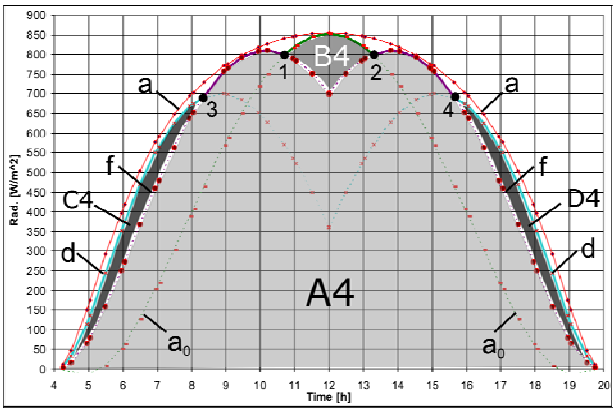

Fig. 3. Summer solstice variations of the *received direct solar radiation* of a *pseudo-equatorial* tracked PV panel, for *four* tracking steps (1, 2, 3 and 4): a - available radiation, a_0 - for a tilted and fixed PV panel, d - for a PV panel with ω*=±65º and f - for ω*=±35º.

By means of the obtained models, some nomographic charts are generated trough numerical simulations (see Fig. 2); for the pseudo-equatorial tracking, these charts allow graphical establishment of the parameters that assure the optimization of the correlation between the daytime (active) steps' number and the direct received solar radiation (see Fig.3).

3. Main Contributions of the Paper

The main conclusions that can be stated taking into account the previous radiation diagrams are:

a) the received radiation gain, brought by every step decreases with its order number;
b) the optimal steps' number is the one, for that the energetic gain can be compared with the energetic consumption of the actuators;
c) considering the previous conclusion, it results that the choosing of the minimum number of steps, respectively of the optimum orientation program depends on the energetic performances of the actuators used for tracking;
d) in the design of the tracking program it is necessary to model the optimization for a big enough number of steps, determining so the best values of the (ω_j and $(\varphi-\delta)_j$) parameters, which assure the maximum energy for each considered step;
e) the analytical development of this aspect, using the MatLab software, will be presented in a future paper.

References

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