European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23rd to 25th March, 2010

Modelling and Optimization of a Concentrating PV-Mirror System

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The paper presents results on a novel low concentration system for photovoltaic/ hybrid module [2], its geometric modelling and the optimal working parameters. The low concentration system is build up of a PV module and two mirrors, one on the left side and symmetrically on the right side along the length of the PV module. Our objective is to maximize the received direct radiation of the PV or hybrid module, maintaining an overall geometric size of the system as small as possible with a minimum number of the tracking steps. Two cases were considered: the first case when the reflected solar radiation from each mirror sweeps the whole surface of the PV module increasing by almost 2x the amount of radiation that sweeps the PV-surface; the second case when the reflected light from each mirror partially sweeps the PV-module surface, building together one cover of light on the plane and increasing the amount of radiation that falls on the module surface around 1x.
The simulations were developed considering the equatorial tracking system for the geographical location of the Brasov - Romania area, using specific regional parameters, considering the ideal meteorological conditions. Through numerical simulations the parameters that influence functionality of the assembly can be identified, making optimization possible.
The main geometric parameters of the model are: the inclination angle between the PV-module and the mirror (θ), the ratio L1/ L2 (ε) , the incidence angle [4], υ_M – maximum incidence angle (when positioned to the right, $\upsilon_M > 0$), υm- minimum incidence angle (when positioned to the left, $\upsilon_m = -\upsilon_M$), υ_{M11}, υ_{M12}, υ_{M13} – incidence angle reflected by the right mirror, M1 on the PV module, right extreme, median and left extreme and analogue υ_{M21}, υ_{M22}, υ_{M23} for the left mirror, M2. For the angle υ_M we considered the values υ_M= 15°, 7.5, 3.75°, 1,875°, knowing that the sun moves with ~15°/hour.
During the first case, ε1 depends on the θ angle as well as on the maximum incidence angle υ_M and it increases due to the θ and υ_M values; in the second case, ε2 depends only on the values of θ and not on υ_M. The overall size in the first case (described by the ratio ε1) tends to overlap the overall size of the second case system (ε2) when the tracking accuracy increases; during continuous orientation of the first case system, the overall sizes of the two cases become equal.

Table I

θ [°]	Case	Absolute tracking efficiency*	Relative tracking efficiency 1**	Relative tracking efficiency 2***
50	1	135%	137%	205%
	2	117%	120%	177%
55	1	168%	171%	255%
	2	134%	137%	203%
60	1	200%	204%	303%
	2	149%	152%	226%
65	1	229%	234%	347%
	2	164%	167%	248%

* compared to the direct available radiation
** compared to the direct radiation that falls on the PV module without concentrators
*** compared to the direct radiation that falls on a fix tilted PV module without concentrators

The results show that the maximum values of tracking efficiency are obtained for high values of θ (in these cases 65°): 2.2x in the first case and 1.6x in the second case; because this means big overall sizes, a rational compromise must be made. A reasonable compromise solution (with good efficiencies and acceptable overall sizes) is to use a system similar to the one in case 1 with high accurate tracking and mirror's angle θ contents in the range 55°-60°. Another good compromise solution can be obtained by combining a low accurate tracking with a fine discreet adjustment of the mirror's angle θ.
Further research will focus on the tracking system accuracy, using different tracking programs and tracker types (equatorial, azimuth or pseudo-equatorial).

References

[2] A. L. Luque, V. M. Andreev, Concentrator Photovoltaics, Springer-Verlag, Berlin Heidelberg, 2007.
[4] I. Visa, D. Diaconescu, V. Popa, B. Burduhos, On the Incidence Angle Optimization of the Dual-Axis Solar Tracker, 11th International Research/Expert Conference TMT Hamammet, Tunisia, September 2007, pp. 1111-1114.