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Quasi-Horizontal Arrangement of Solar Panels in Equatorial Zones: Problems and Proposed Solutions

Bello Pierre Ngoussandou[1], Oumarou Hamandjoda[2] and Djongyang Noël[1]

1. The Higher Institute of the Sahel, University of Maroua, Maroua P.O. Box 46, Cameroon

2. The National Advanced School of Engineering, University of Yaounde, Yaounde P.O. Box 8390, Cameroon

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Abstract: Solar panels are oriented to the North (South) when the site is in the South (North) with a tilt angle close to the latitude. In the equatorial zone, the panels are quasi-horizontally arranged. This situation caused some problems: the panel is more rapidly covered with dust or salty mud that decreases its performance and degrades the protective glass. To overcome these difficulties, we evaluated theoretically and practically the energy lost by an incorrect tilt. The results are rather encouraging. Just 1.5% of total energy is lost when we tilted the panel at 10.0°. In practice, we realized that the loss of energy is fewer than we calculated it because of the reflected solar rays.

Key words: Solar panel tilt, equatorial zone, auto cleaning of panel, energy loss, salt effect on glasses.

1. Introduction

A solar panel converts sunlight into electrical energy. The electrical energy produced in a time interval is proportional to the flux of sun rays which arrive on the surface of the panel [1]. That is why people always seek to orient the solar panels so that they receive throughout the day, the greatest stream of sunlight.

In general, the panels must be oriented to the North (South) when the site is in the South (North) and with an inclination angle close to the latitude [2]. Thus, the tilt angle is theoretically zero at the equator.

We observed some solar installations in the equatorial region of Cameroon where actually the panels are quasi-horizontally arranged. We studied two typical cases that allowed us to make some observations:

- The installation performed on the ground in Ekona by the Geophysical and Volcanological Research Antenna;
- That carried on the roof of the IbolykaNzabo Foundation building in Limbe.

The two installations have been performed by two different teams of technicians who came from Europe and went back immediately.

From the testimony of users, our own observations and some measurements we made it emerges that:

- The cleaning timetable of the solar panels required by the engineers is not effective;
- The panels are covered with dust or mud;
- Salt crystals are deposited on the panels and are likely to degrade the protective glass.

2. Problems

2.1 Difficulty of Cleaning the Surface of the Panels

The cleaning schedule of the solar panels is rarely respected wherever the panels are situated. But in the equatorial zones, its consequence is more accelerated because of the lack of inclination of the panels. This cleaning is more difficult on the roof of the IbolykaNzabo Foundation building.

Corresponding author: Bello Pierre Ngoussandou, Ph.D. student, research fields: energy storage, renewable energy.

2.2 Rapid Accumulation of Dust or Dirt on the Surface

Far from the equator, the inclination is a determining factor in the cleaning of surfaces. Much of the dust which is deposited slides on the smooth wall of the panel surface [3]. The rain water also leaches the surface. Where there is no inclination, dust and rain water are retained and cover the surface.

2.3 Degradation of the Protective Glass

Due to the proximity of the Atlantic Sea, the salt crystals are visible on the surface of the panels on the roof of the IbolykaNzabo Foundation building in Limbe. These crystals degrade the protective glass of the panels [4], making the surface rough and therefore more likely to trap dust and water.

3. Solutions

To overcome these difficulties, one aspect is to realize solar installations in prominent places easily accessible to users. Thus, they can occasionally clean the surface of the panels.

The second aspect is the voluntarily incorrect inclination of the panels to promote the sliding of the dust and water.

The evaluation of the theoretical part and practical energy lost by this incorrect tilt gives rather encouraging results.

3.1 Determination of Theoretical Energy Lost by Improper Tilt

Theoretically, when a panel is not well tilted, the energy produced is not optimal.

Consider $\emptyset_1$ is the radiation flux received when the panel is horizontal, $\emptyset_2$ the flux received when the panel makes an angle α of inclination. These flows represent a linear relationship to both E_1 and E_2 energy produced per day [5]. They are also linearly related to the two surfaces S_1 and S_2 (Fig. 1) defined by:

$$S_1 = L_1 \times D \text{ and } S_2 = L_2 \times D \quad (1)$$

Finally, daily energies E_1 and E_2 are related to the lengths L_1 and L_2.

Furthermore

$$L_2 = L_1 \cos \alpha \quad (2)$$

Hence,

$$\cos \alpha = \frac{L2}{L1} = \frac{S2}{S1} = \frac{E2}{E1} \quad (3)$$

By tilting slightly (α = 10°, for example) the part of the energy lose is:

$$E_0 = E_1 - \mathrm{E}_2 = E_1 - \cos \alpha \, E_1$$
$$= (1 - \cos \alpha) \times E_1 = 0.015 \times E_1 \quad (4)$$

Just 1.5% of the total energy that means a solar panel of 100 Wp would behave like one of 98.5 Wp.

To lose an acceptable part 10% of total energy, we must tilt the panel at an angle of 25.8°. With such tilt, the result is acceptable. Dimensioning of solar field in

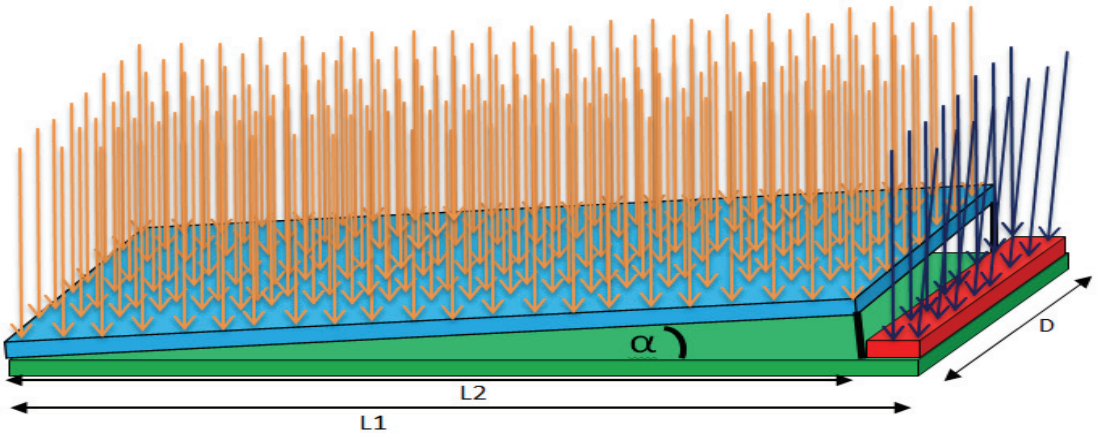

Fig. 1 Flux of sunrays lost by wrong tilt of a panel.

those areas must take account of a minimum inclination.

3.2 Practical Study of the Loss due to the Wrong Tilt

In practice, we have used two identical panels of 60 Wp arranged side by side for few hours of time during rain-free days. One is quasi-horizontal and the other is inclined with a 10° angle.

The first work consisted to get the maximum dust mass that each panel could retain. We sprinkled 1,000 g of flour on each panel by the same way. The first panel has retained 537 g while the second retained 297 g.

In a second time, study the speed of dust accumulation by disposing the same panels near a dusty road frequently used by motorcycles. Table 1 and Fig. 2 present the data.

At least, we made a comparative study of the power generated by each of the two systems. Each panel is connected to charge a battery of 8 Ah/12 V. We repeated the experience three times and we got the following results resumed in Table 2.

Indeed, the global solar radiation that reaches the panels is the result of three components: direct radiation, diffuse radiation and the reflected radiation

Table 1 Mass of dust accumulated on the panels as function of the time.

Duration (hrs)	0	1	2	3	4	5	6	7	8	9	10
Mass (g) of dust for horizontal panel	0	9	18	27	36	45	53	62	71	80	89
Mass (g) of dust for tilted panel	0	7	14	22	29	36	43	51	58	65	72

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
98	107	116	125	134	142	151	160	169	178	187	196	205	214	223	231	240	249	258	267
80	87	94	101	109	116	123	130	137	145	152	159	166	174	181	188	195	203	210	217

31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
276	285	294	303	312	320	329	338	347	356	365	374	383	392	401	409	418	427	436	445
224	232	239	246	253	261	268	275	282	289	294	294	294	294	294	294	294	294	294	294

51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
454	463	472	481	490	498	507	516	525	534	534	534	534	534	534	534	534	534	534
294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294

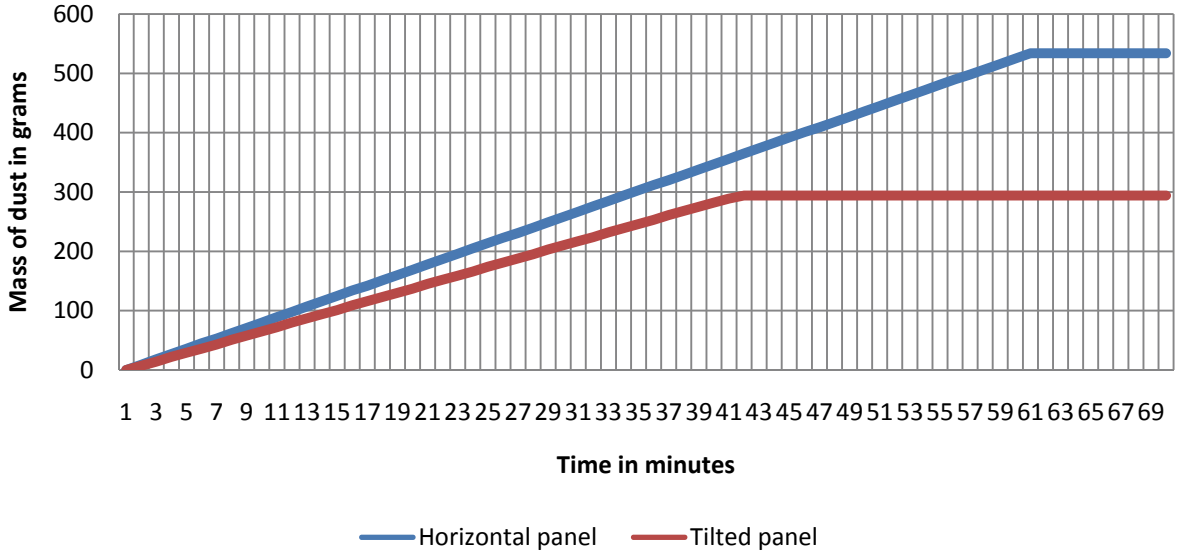

Fig. 2 Evolution of the mass of dust accumulated on the panels.

Table 2 Comparison of the performances of the dusty panels.

	1st day	2nd day	3rd day	Average
Complete charging time by horizontal panel (TH) in minutes	129	132	124	128.33
Complete charging time by inclined panel (TI) in minutes	125	129	120	124.67
Difference (TH-TI) in minutes	4	3	4	3.67

[6]. However, by disposing the panel horizontally, the reflected component is nil. Moreover, the rapid accumulation of dust on the surface of the horizontal panel reduces its performance over the day [7]. We realized that the theoretical loss due to the slight tilt is compensated by the reflected radiation.

4. Conclusions

Our works demonstrate clearly that the horizontal arrangement of the panels in equatorial areas is not practically advisable for two reasons. Dust and rain water form a sludge that limits the productivity of the panels. The salt crystals that are deposited with dust damage the protective glass at an alarming speed.

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