BIFACIAL PV MODULES IN SOLAR TRACKERS AND CONCENTRATORS

Bifacial PV modules are recently delivered by several manufacturers. Because there is either no or low price difference in the price of such bifacial and monofacial modules it is reasonable to use bifacial modules which could produce 5-20% more energy (in comparison with monofacial PV module with the same nominal output power).

Polar axis solar tracker and/or tracking concentrator [1] is always mounted on high support structures (to avoid contact of the rotating PV array with the ground). It improves back side energy collection in comparison with fixed PV arrays or even roof integrated PV modules. The energy gain can be in the range 10-15% (for typical albedo 0.3). Air-flow around the modules and corresponding cooling is improved as well (especially in comparison with roof integrated modules).

Additionally solar trackers/concentrators are usually oriented to the west, before backtracking, in the morning. The bifacial modules enable to collect direct back side solar radiation before backtracking. According to local climate the resulting energy gain could be 2-5%.

It is very advantageous that bifacial PV modules (fixed), transparent for infrared radiation, has lower operating temperature against monofacial ones (about 5-9°C). It is especially advantageous by solar trackers and tracking soft (C = 1.6) concentrators where PV modules are exposed to higher solar radiation than on fixed racks. Measured temperature of bifacial c-Si PV modules on the tracker was usually lower (by 5-8°C) than that of roof integrated monofacial c-Si modules. The reduced temperature of bifacial modules can also increase the energy gain by 2-5%.

The reduced temperature is also very important for lifetime of PV modules in soft (C = 1.6) concentrators. It should help to avoid degradation of polymer encapsulants of modules cased by higher temperatures (of monofacial modules).

A synergic combination of all above effects can boost energy gain by 15-25% in comparison with the same tracker/concentrator with monofacial modules.

The polar axis solar tracker with c-Si bifacial PV modules will therefore deliver by about 50% more energy than fixed c-Si monofacial PV array with the same rated output power. The tracking bifacial soft concentrator will even double the energy gain against fixed monofacial PV array (Fig.1). Concerning the PV pumping systems there can be up to 100% and 150% pumping capacity surplus for tracks and tracking concentrators respectively.

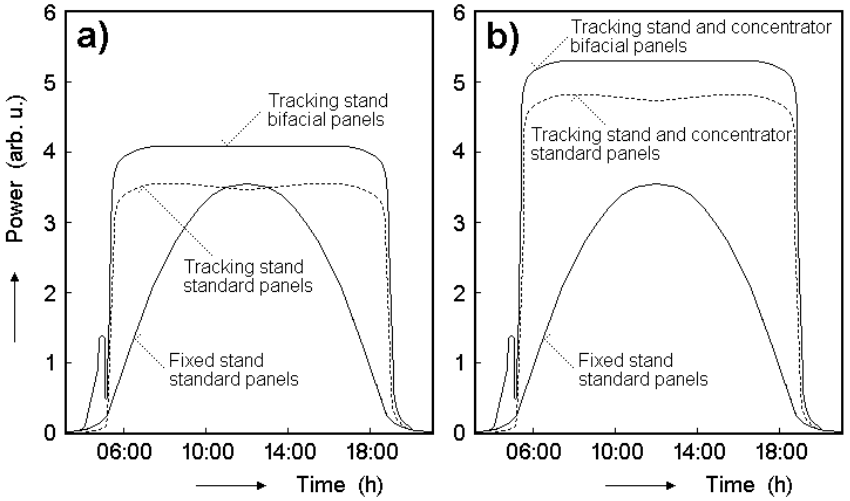

Fig.1. Idealised dependence of the power on the time

Operating temperature measurement of bifacial modules

Bifacial as well as monofacial reference PV modules were delivered by the same manufacturer. The design of both modules has been very similar. The only difference is back surface grid of bifacial cells and back surface glass encapsulant of the bifacial module. Cell temperatures were calculated using the temperature dependence of the open circuit voltage.

Our measurements of both bifacial glass/c-Si/glass and monofacial glass/c-Si/foil flat plate PV modules indicate that the operating temperature T_{op} = 41°C of bifacial modules was by 12°C lower than that of monofacial ones T_{op} = 53°C at AM 1.5 solar radiation, wind speed below 1 m.s^{-1} and ambient temperature T_{amb} = 22°C.

Another measurement indicate that bifacial PV modules at soft concentrators ($C_{geometrical}$ = 1.5, $C_{optical}$ = 1.35) are still by about 3°C less hot T_{op} = 50°C than monofacial modules at one sun radiation.

The main reasons are as follows:

1) Bifacial Si PV cells are transparent for the infrared part of the solar radiation. As the infrared radiation above 1,100 nm represents more than 20% of the solar energy a proportionally lower energy is absorbed in the bifacial module in comparison with non transparent monofacial one.

2) Opaque back surface protection foil also contributes to the higher temperature of monofacial modules. Typical packing density of c-Si PV modules is about 0.85. It means that 15% of the module area, not covered by PV cells, can absorb substantial quantity (about 50%) of the incident solar radiation while there is negligible absorption in the bifacial modules.

The experimental results are in good agreement with our calculation as well as with soft concentrator (C = 1.6 and 2.2) measurements [2] of PV modules (both glass/Si/glass and glass/Si/foil) with monofacial cells only.

In conclusion using soft concentrators ($C_{geometrical}$ = 1.5-1.7 , $C_{optical}$ = 1.35-1.45) with bifacial PV modules the over heating of modules is eliminated.