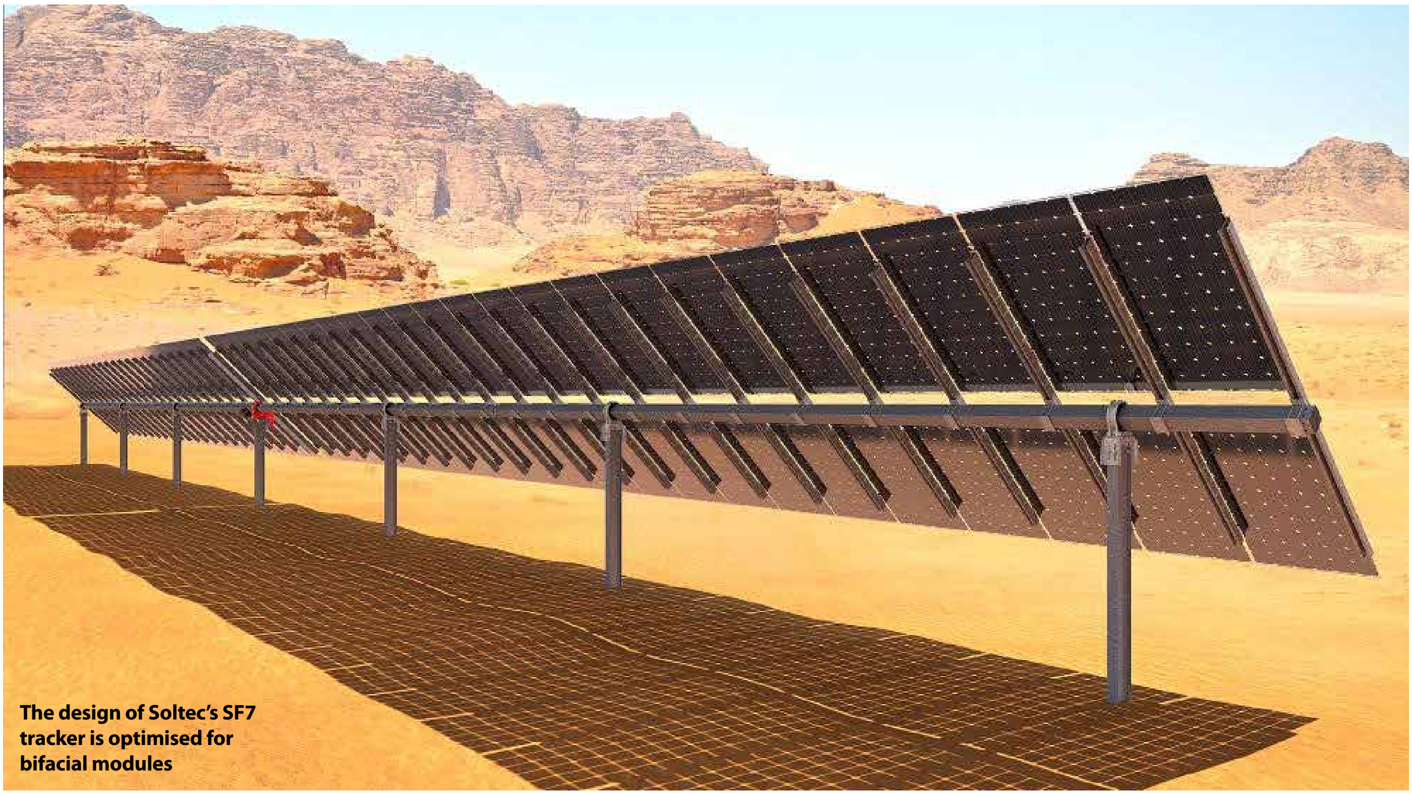
Both sides of the story

Bifacial tracking | As described in the previous pages, tracking and bifacial technologies combined offer the prospect of higher energy outputs. Javier Guerrero, R&D manager at Soltec, one of the pioneers of bifacial tracking, explains some of the lessons the company has learned about optimising tracker design for bifacial modules



The design of Soltec's SF7 tracker is optimised for bifacial modules

Credit: Soltec

Following the bifacial-tracking success at the 2015 La Silla project in Chile, the seventh generation SF7 tracker was rolled out in 2017 with standard features that provide for drop-in compatibility with, and enhanced performance of, bifacial module applications.

The mission of Soltec's Bifacial Tracker Evaluation Center (BiTEC) is to perform a rigorous assessment of the influences on bifacial-tracking performance that are attributed to tracker design, tracking algorithm and installation parameters.

BiTEC is investigating specific tracker design factors that are known to influence bifacial performance, including: module mounting height above grade, backside obstructions that cause shading and losses, inter-row spacing and tracker positioning algorithms.

Following are some BiTEC investigation results to date in terms of those attributes and specific factors known to influence bifacial performance.

The bifacial gain model

The Sankey diagram in Figure 1 exhibits the composition of bifacial gain. From it, relationships between bifacial ratio, bifacial gain and the summation of bifacial module energy performance (E) can be deduced.

Albedo is a determinant factor in bifacial gain. It is dependent on reflective surface colour, texture and extension. Maximum gain comes from smooth white surfaces and greater reflecting area free of disrupting obstructions. At La Silla, experience highlighted a measureable seasonal variability of albedo as vegetation colours change.

Mounting height

The mounting height of the bifacial module has considerable influence on the quantity of diffuse irradiation that impinges on the rear side of the module. The graphics in Figure 2 exhibit bifacial gain versus height of fixed-mount PV

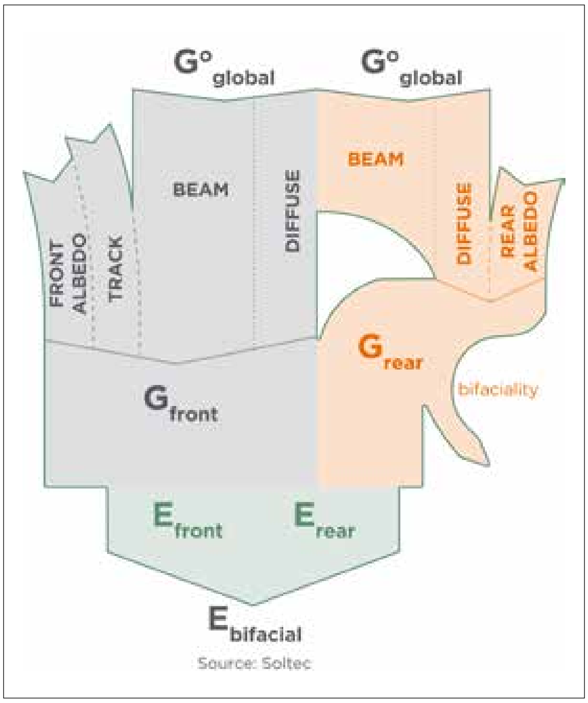


Figure 1. The composition of bifacial gain.

Source: Soltec

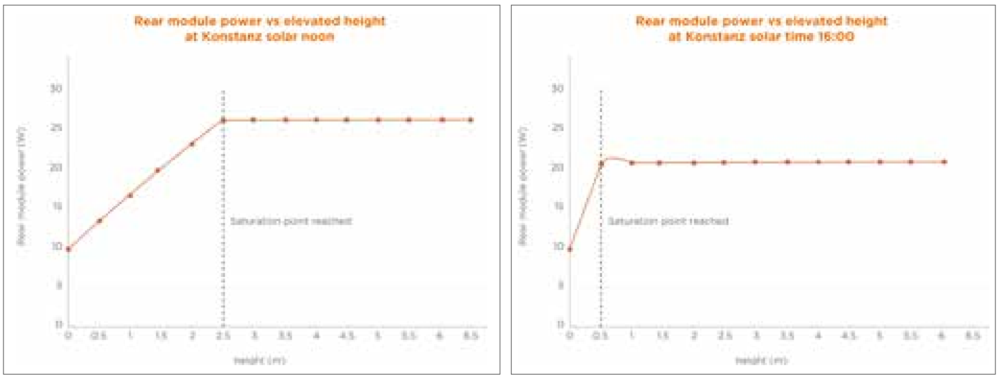


Figure 2. The effects of module mounting height on bifacial gain

that reaches a saturation point of adding value [1].

The economic considerations of module mounting height present a trade-off on increased height (for increased performance) versus increased cost of principally steel material to meet the increased structural demands including with respect to wind-design. The tradeoff analysis is highly dependent upon the albedo potential of any subject site, with greater albedo potential indicating an economic justification for pursuing increased height.

Inter-row spacing

Direct beam radiation is reflected, and greater reflected surface area free of obstructions within "view" of the backside will positively influence bifacial gain. Inter-row spacing is a function of tracker width and the design-specified GCR (ground coverage ratio) or pitch on the east-west plant layout dimension. A GCR of 33% indicates an aisle width between tracker rows equal to double the tracker width, 25% GCR indicates an aisle width triple the tracker width. A wider tracker results in wider aisles and a cleaner view from the backside, and results in the higher mounting height for greatest backside capture (Figure 3).

Both albedo and GCR are fundamental design parameters of traditional monofacial tracking applications. The bifacial application highlights the distinct and critical nature of design considerations and establishing criteria to best capture energy from both sides now.

Backside shading and losses

This aspect finds enhanced bifacial gain performance from a cleaner backside view where structural and cabling elements are obstructions to maximising capture on the backside.

The structural components include the tracker torque tube and (typically) pile-type foundation elements. The cabling components include typical PV source-circuit management of bundled and suspended cabling leading to a mounted combiner box.

Simply fewer installed parts results in less obstruction and greater bifacial gain capture. Other components that cause backside obstruction are mechanical dampers and tracker-drive links.

The ideal torque-tube imposes minimal direct obstruction on the bifacial backside thanks to the sun-facing array-gap that corresponds to torque tube width. Moreover, its top-face can be leveraged as a strongly reflecting surface impinging the bifacial backside most homogeneously.

The ideal cable management solution is embedded within the torque tube and excludes traditional combiner boxes, resulting in zero obstruction influence.

Tracking algorithms

Comprehensive tracker position control enables a bifacial tracking algorithm that maximises performance according to the conditions of the sky and diffuse radiation. Bifacial technology creates a new scenario for tracking algorithms.

Site albedo and radiation characteristics play key roles in the economic balance of "unfocusing" the tracker to favour backside production and potentially trading off front side production. Unfocusing refers to a position control modification away from standard clear-sky monofacial tracking that is typically oriented normal to the impinging direct beam radiation.

Beam radiation is captured only on the front side along with diffuse, while in the bifacial application both sides capture diffuse radiation. The Sankey diagram above exhibits the composition.

With cloud-cover, the bifacial application economic balance leans towards tracker positioning to maximise the combined diffuse components over traditionally focusing on front side beam radiation. Unfocusing algorithms are not unique to bifacial applications, but they are increasingly considered essential to them. The criteria of unfocusing are coming forward from accurate modeling and corresponding field tests at BiTEC.

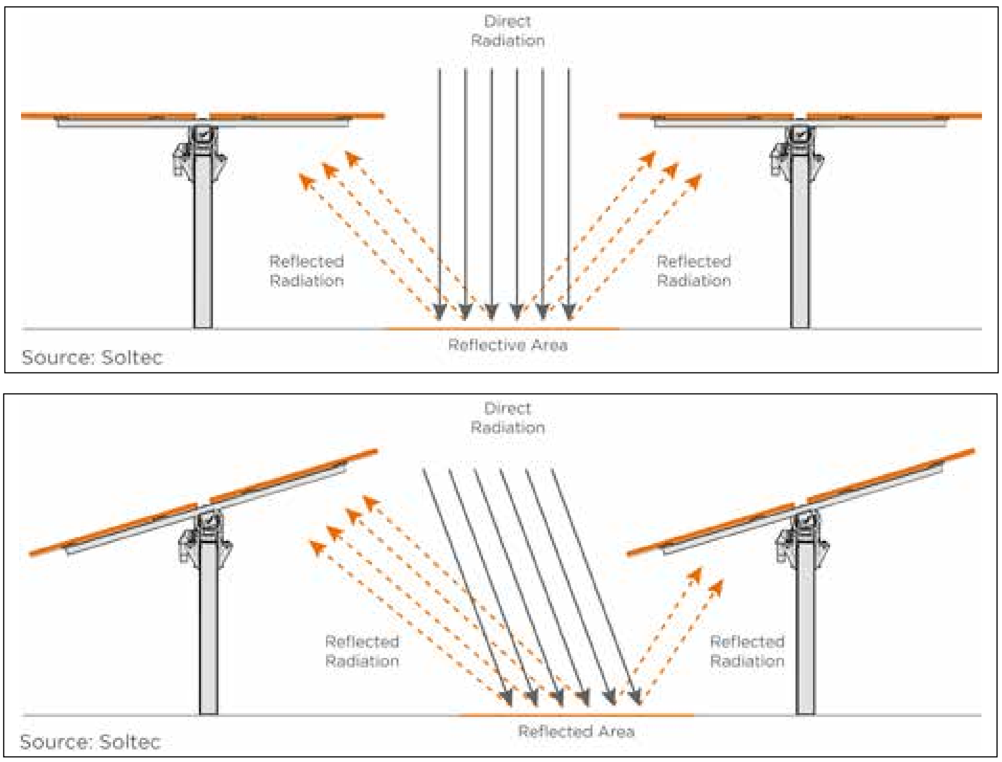
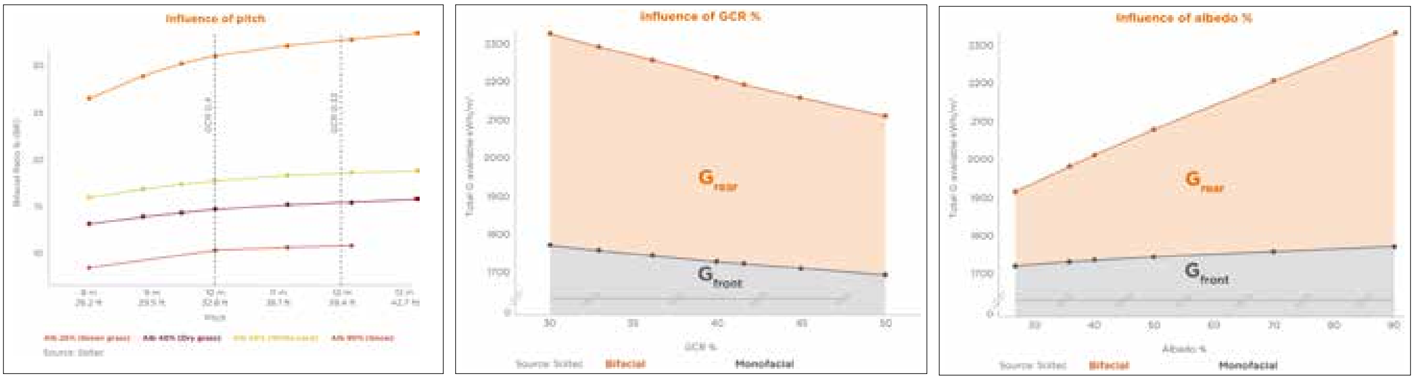


Figure 3. Direct beam radiation is reflected towards the backside as a function of site albedo (spacing not shown to scale)



Continuing BiTEC investigation

BiTEC is moving forward with industry collaborators on those topics to help quantify bifacial gain expectations considering tracker alternatives. Furthermore, it is going to greater depth on emerging evidence such as backside irradiation distribution being heterogenous versus homogenous. The latter is preferable, as in the case of torque tube and gap optimisation described above. Highly heterogenous distributions may generate hot spots on the array, and array temperature distributions are being tested.

The BiTEC tracker field is configured to test GCRs of 0.3, 0.4, and 0.44, and to test three albedo types. It will accommodate almost any module and configurations thereof. Comprehensive tracker position control is on board along with sensing of sky and irradiation conditions in order to perform tracker position response functions.

Figure 4. Wider spacing and higher albedo enhance bifacial ratio and bifacial gain

In conclusion

Soltec and BiTEC collaborators are doing diligence to help customers address the emerging bifacial tracking technology opportunity. The investigation has as its end cost-effective innovation and operational criteria to best leverage the bifacial gain opportunity.

Author

Javier Guerrero holds a Ph.D. in renewable energy with a thesis around modelling the electrical behaviour of PV module and inverter combinations. His professional involvement in the solar industry spans over 10 years. Javier joined Soltec in 2015 commissioning the bifacial trackers at La Silla, and he is currently managing Soltec's Bifacial Tracker Evaluation Center in Livermore, California.

References

[1] Wang et al 2015. "Bifacial photovoltaic systems energy yield modelling", Science Direct. Energy Procedia 77, 428 – 433.