Energy yield of a Next2Sun Agri-PV system compared to conventional bifacial vertical PV systems

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SUMMARY

This report summarizes the results of a study conducted at ISC Konstanz on the energy yield of vertically bifacial PV systems. The aim of the study was to compare the expected annual energy yield of a Next2Sun PV system with that of a typical commercially available vertical bifacial PV system, using an east-west-oriented PV system as an example at a location in southern Germany. The yield simulation was carried out using the MoBiDiG simulation model developed at ISC since 2015. In particular, the different influence of shading caused by the module frame and the mounting system was quantified for both systems and taken into account in the calculation of the energy yield. The result of this analysis clearly confirms the advantages of the Next2Sun system: thanks to an intelligent selection of the PV modules used and the optimized design, the Next2Sun system generates 24% more energy compared to the alternative system with the same installed module nominal power.

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1. MOTIVIATION

Agri-PV systems, especially when designed as vertical bifacial PV systems, allow for the effective utilization of synergies between agriculture and renewable energy generation. Such vertical PV systems enable dual use of the available field area, where solar modules generate renewable, emission-free electricity while the land between the rows of modules can still be used for agricultural purposes. Additionally, depending on the location, the presence of solar modules can have a positive impact on the microclimate and, consequently, the productivity of the agricultural area. To maximize the overall value of such Agri-PV systems, the system design ideally optimizes energy yield while considering the agricultural use of the land. With this objective, a corresponding study was conducted at ISC Konstanz. This report summarizes the results of this study. The aim of the investigation was to quantify the differences in energy yield for Agri-PV systems based on the vertical Next2Sun concept compared to a typical vertical bifacial system from competitors.

2. DESCRIPTION OF THE PV SYSTEMS

To enable an objective comparison between the Next2Sun system and the competitor's system (referred to as 'alternative vertical bifacial'), it was assumed that both systems are installed at the same location. The municipality of Aasen near Donaueschingen in Baden-Württemberg (Germany) has been chosen as the location. The reason for this selection is that Next2Sun already operates an Agri-PV system at this site.

Figure 1: Tractor during mowing at a Next2Sun Agri-PV system in Donaueschingen (Germany) (Image source: Next2Sun)

2.1 System site Aasen: Geographical Location and Weather Data

Aasen is located in Baden-Württemberg within the municipality of Donaueschingen (Germany). The geographic coordinates are as follows:

- Latitude: 47° 59' North
- Longitude: 8° 33' East
- 679 m above sea level.

The weather data for the Aasen location has been obtained from the Meteonorm database (Version 8.0). This database provides values for solar irradiation, temperature, and wind speed for every time stamp throughout the year (with an hourly resolution). These values are used as input parameters for calculating the respective instantaneous electrical power output of the two PV systems. The annual values for Aasen are as follows:

- Global horizontal irradiance (GHI): 1175 kWh/m^2
- Diffuse horizontal irradiance (DHI): 575 kWh/m^2
- Average ambient temperature: 8.5°C
- Average ambient temperature: 2.9 m/s

To ensure comparability, it was also assumed that both PV systems were installed on a flat horizontal surface without any shading from trees or nearby terrain features. For the typical grass-covered ground in Aasen, an average albedo of 20% was assumed throughout the year.

2.2 Orientation and row-to-row pitch

For both vertically bifacial PV systems, an east-west orientation was assumed, with the module front side facing east. The height of the bottom edge of the module above the ground is set to 0.8 meters for both systems. The row spacing was chosen in a way that ensures the same row shading angle for both systems. By doing so, the losses in annual energy yield due to mutual shading between rows are identical for both system configurations, thus not affecting the comparison between the two systems

Figure 2: Next2Sun Agri-PV System *(image source: Next2Sun)*

2.3 Alternative vertical-bifacial system (system of competitor)

The alternative system is built using commercially available framed PERC modules. The module-specific parameters have been verified by TÜV Süd and incorporated into the calculations and simulations by ISC Konstanz.

For both systems, a uniform row shading angle of 12 degrees was assumed. In the case of the alternative system, which typically uses vertically (portrait) oriented modules and has a collector height of 2.4 meters, this results in a row spacing of 11.5 meters. For the Next2Sun system with two horizontally oriented modules stacked on top of each other, the row spacing is 10 meters.

Furthermore, the frame geometry of the reference solar modules was analyzed and compared with the scenario investigated in [i]. Next2Sun also conducted a field study in which the energy yield of various vertically bifacial systems has been monitored over a time period of 12 months. The recorded data from this study were provided for this analysis, analyzed by ISC, and incorporated into the calculation of the energy yield.

2.4 Simulation of yearly energy yield using MoBiDiG

Since the choice of inverter model and, in general, the design of the AC side of the PV system is independent of the actual technology and configuration of the vertically bifacial PV system, the yield simulations were conducted for the DC values of the system.

The simulation of the annual DC energy yield was performed using the input parameters mentioned above and the .pan-files provided by the module manufacturers. The simulation was conducted using the MoBiDiG (*Modeling of Bifacial Distributed Gain*) simulation model, which has been specifically optimized by ISC Konstanz for bifacial vertical bifacial PV systems ([ii],[iii],[iv]). In these simulations, the findings described in section 2.3 were taken into account. The results are presented in Table 1. Taking into consideration the row spacing requirements mentioned earlier to achieve the same shading angle, the Next2Sun system has a higher occupancy density of 6.5% in addition to its higher system yield. As a result, the annual specific energy yield per square meter of field area is 32% higher than that of the comparison system.

Tabelle 1: Annual specific energy yield (DC) considering shading elements and percentage increase in yield of the Next2Sun system compared to the alternative system

System Configuration	kWh/kWp/year	Power per m² land area [Wp/m2]	yearly kWh/m2 land area
Alternative	**977**	38.7	**37.8**
Next2Sun	**1208** (+24%)	41.2	**49.7** (+32%)

2.5 Conclusion

The aim of this study was to compare the expected annual energy yield of a conventional vertically bifacial PV system with that of the Next2Sun system. It was assumed that both systems are installed at the same location and with comparable geometry (orientation, shading angle, height above the ground, etc.). ISC Konstanz collected all the necessary data and information about the location, PV modules, and mounting systems and conducted a literature study as well as an analysis of field data provided by Next2Sun. Based on this data, ISC calculated the annual energy yield for both PV systems using its proprietary simulation model MoBiDiG and evaluated the respective influence of shading caused by module frames and mounting systems. The comparison of the expected annual energy yield (kWh/kWp/year) between the Next2Sun system and the alternative bifacial vertical system shows a 24% increase in yield for the Next2Sun system. When considering the specific annual yield per unit area of the land (kWh/kWp/m²), the Next2Sun system exhibits a 32% advantage. The analysis of both systems revealed that the significantly higher yield of the Next2Sun system can be achieved due to the fundamentally optimized design and construction of the entire system.

Literature

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