Bifacial Photovoltaic Modules

Jazmine Boloor

Department of Electrical Engineering, University of Nevada Las Vegas

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Dr. Yahia Baghzouz

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Bifacial Photovoltaic (PV) Modules are solar panels with solar cell on both sides. This allows for the front to capture incident sunlight (as a normal panel does), while the back is capturing reflected light. Therefore, both sides of the panel are producing solar power. This is a more efficient design than common monofacial solar panels not only because they produce more power, but also because they save space. Bifacial solar panels are a large topic of discussion currently because their cost has lowered to be competitive with the industry standard (monofacial panels), making their use more widely available. They are predicted to grow in popularity immensely within the next decade because of their efficiency (SolarMag, 2020). Several photovoltaic module producing companies such as LG, LONGi, Lumos Solar, Prism Solar, Silfab, Sunpreme, Trina Solar, and Yingli Solar have already released bifacial solar panels, and the list is expected to grow in the coming years as their use becomes more widespread (Marion, MacAlpine, & Deline, 2017). The main purpose of bifacial solar panels is to turn sunlight into solar energy on both of their sides, increasing their efficiency in comparison to monofacial panels. Specific models can be analyzed to further assess these photovoltaic modules.

Bifacial photovoltaic modules are an efficient way for solar energy to be produced. According to Solar Magazine, a bifacial solar panel is a “double sided energy factory that transforms sunlight into electrical energy” (SolarMag, 2020). These modules have solar cells on both the top and bottom, making their capacity to create solar energy much larger than those with just cells on the top. The front side of the photovoltaic module, (the side facing the sun), collects sunlight and turns it into solar panel the same way competing solar panels do. However, bifacial photovoltaic modules add another path that allows for solar power to be made through its bottom side. To be more specific, these panels are designed so that light incident on their rear side due to reflection from surrounding objects/surfaces on the ground can be turned into solar power.

Furthermore, because sunlight reflects off all surfaces in different ways, a significant amount of energy can be produced even on cloudy days (SolarMag, 2020). It should be noted that placing these modules at an angle (and leaving space next to them) provides for maximum efficiency because the bottom side has room to absorb reflected light. This makes them especially useful on areas such as parking lot covers, as there is room on either side of the panel, and they can be placed on top of the structure at an angle (Johnson, Yoon, & Baghzouz, 2012). Additionally, their commercial use on houses is increasing because of their ability to work well when placed as raised mounts on flat roofs (Gambone). The image below from Solar Magazine shows bifacial solar panels installed on a patio top (SolarMag, 2020).

Overall, bifacial photovoltaic modules are usually more efficient than regular solar panels because of their ability to produce energy on both their top and bottom side.

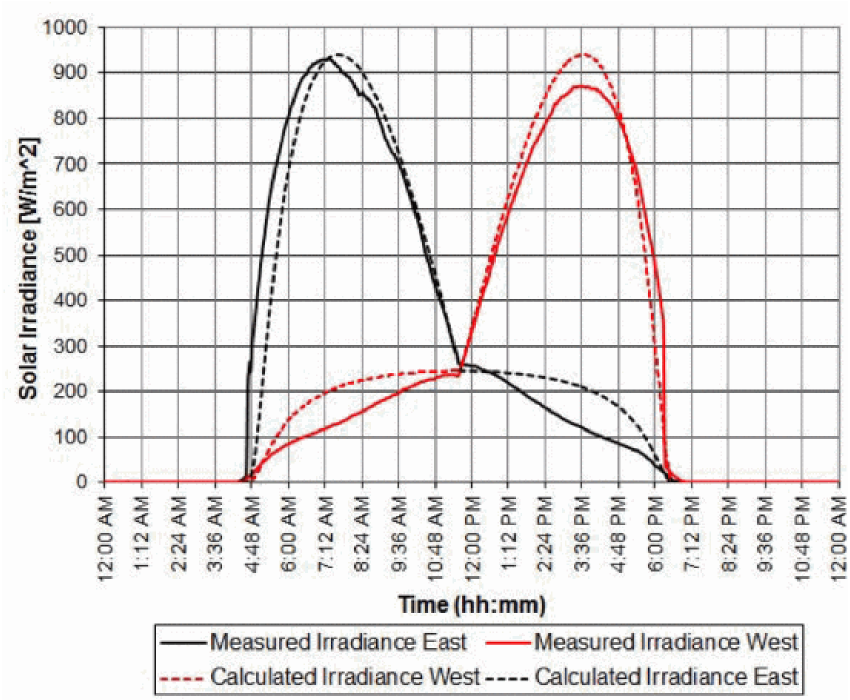
Correct placement of bifacial solar panels is crucial for maximum efficiency. Solar Magazine mentions that the solar panels should be placed so that they can have two energy peaks throughout the day (SolarMag, 2020). This can occur by facing half of the bifacials in an array east, and the other half west. This way, rays of sunshine from sunrise can be absorbed by the east facing bifacials, and rays of sunshine from sunset can be absorbed by the west facing bifacials. This means that peak times are in the morning and late afternoon (Johnson, Yoon, & Baghzouz, 2012). In addition to this, the panel will also be creating energy even when the sun is not focally shining on it, as it can take reflected light and produce energy. Alternatively, bifacials can be placed vertically, as this will also create two peak energy producing times (reflection on the other side of the panels will contribute tremendously). This vertical system method is optimal for areas with bad weather conditions, as events such as snow and sand will not stop its functioning (Pickerel, 2019). The glass covers that are on either side of the panel make them very durable. All in all, these bifacial solar panels have an optimal placement that should be utilized when installing.

Bifacial photovoltaic modules take the efficiency of monofacial solar panels and add another layer to it, both literally and figuratively. Another side of solar panel cells are added to the modules, creating an extra means of developing solar energy. Studies show that using a bifacial solar panel in place of a monofacial one can increase efficiency by eleven to twenty-seven percent (SolarMag, 2020). This is a considerable number and gives bifacial solar panels the upper hand. Not only do these bifacial panels increase efficiency in comparison to other solar panels, but they also allow for fewer panels to be used for the same amount of energy. Furthermore, this calls for a smaller area requirement, meaning that these panels allow for maximum efficiency in smaller spaces. An article by the Institute of Electrical and Electronics Engineers (IEEE) on bifacial solar panels titled “Modeling and Analysis of a Bifacial Grid-Connected Photovoltaic System” explains that there is a limited amount of modeling and simulation on bifacial solar panels currently because of their relatively new (and therefore small) market (Johnson, Yoon, & Baghzouz, 2012). The article continues to explain that though these panels have been on the market for around ten years, there is a renewed interest in their abilities due to recent cell fabrication and performance enhancements. In short, bifacial solar panels are a strong competition for widely used monofacial solar panels.

The same IEEE article mentioned previously conducted a study of the Sanyo bifacial PV modules (Model # HIP-195DA3) in 2012 that modeled their behavior. Each module contained 96 series-connected cells with four bypass diodes. The specifications that were available on the model did not include information on the power that the back side produced. Therefore, tests were done to illustrate the performance of both sides of the panel. The power-voltage curve under a solar irradiance of 950 W/m^2 was measured and drawn (at 135˚F) and concluded that the back side of the panel was around 15% less efficient than the front side (Johnson, Yoon, & Baghzouz, 2012). Five of these modules were then connected in parallel to produce a 1 KW array. This array was placed vertically, which creates two peak energy producing times. The study found that the two sides of the array did not measure the same solar irradiance, (the rate at which radiant power is incident on a surface per unit area of surface) during a clear day (Garner, 2015). It should be noted that the total solar irradiance received by a single side in the array can be calculated by the following equation:

$$S_{total} = S_{array} + S_{diffuse} + S_{reflect}$$

where S_{array} is the direct-beam radiation, $S_{diffuse}$ is the diffuse radiation, and $S_{reflect}$ is the reflected radiation. These calculations are shown on the plot (Johnson, Yoon, & Baghzouz, 2012) below by the dotted lines. Note that this plot was produced by the researchers on the IEEE study.



This plot makes it clear that the calculated values are relatively close to the measured values, and that there are two peaks of sunlight during the day. The study emphasizes the difference in solar irradiance that each side of the solar panel has. It is abundantly clear that the west side panel is measuring less solar irradiance than the east side panel. Continuing with the analysis of the Sanyo bifacial PV modules, the shading that the bifacial PV modules (and all PV modules) encounter can significantly prohibit their abilities. In the same IEEE study, the east facing modules experienced up to four centimeters of shading across their panels throughout hours of the day (Johnson, Yoon, & Baghzouz, 2012). This can account for a large portion of the discrepancy between calculated and measured values. Nonetheless and as stated previously, the panel is still much more efficient than its monofacial market counterparts because of its ability to produce energy on both sides.

Bifacial solar panels are more efficient in turning sunlight into energy than other market counterparts, such as monofacial solar panels, because they allow for energy to be produced on both sides of their panel. This is especially efficient for smaller spaces that want to utilize a system that will create the most amount of solar power possible. Additionally, their use is beneficial on places that are tilted (or can allow for a tilt), as this creates more opportunity for light to hit both sides of the panel. All in all, bifacial solar panels are production, size, material efficient.

References

Gambone, S. (n.d.). What Are Bifacial Solar Panels. Retrieved November 18, 2020, from https://www.paradisesolarenergy.com/blog/what-are-bifacial-solar-panels

Garner, R. (2015, April 03). Solar Irradiance. Retrieved November 18, 2020, from https://www.nasa.gov/mission_pages/sdo/science/solar-irradiance.html

Johnson, J., Yoon, D., & Baghzouz, Y. (2012). Modeling and analysis of a bifacial grid-connected photovoltaic system. *2012 IEEE Power and Energy Society General Meeting*. doi:10.1109/pesgm.2012.6345266

Marion, B., MacAlpine, S., & Deline, C. (2017, June 25). A Practical Irradiance Model for Bifacial PV Modules. Retrieved November 18, 2020, from https://www.nrel.gov/docs/fy17osti/67847.pdf

Pickerel, K. (2019, April 09). What are bifacial solar modules and how do they work? Retrieved November 16, 2020, from https://www.solarpowerworldonline.com/2018/04/what-are-bifacial-solar-modules/

SolarMag. (2020, March 01). Bifacial Solar Panels: Residential Uses and Trends. Retrieved November 10-20, 2020, from https://solarmagazine.com/solar-panels/bifacial-solar-panels/