Journal of Energy Systems

2022, *6*(4)

2602-2052 DOI: 10.30521/jes.1105348 Research Article

Analysis of albedo effect in a 30-kW bifacial PV system with different ground surfaces using PVSYST software

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Submitted: 18.04.2022
Accepted: 18.09.2022
Published: 31.12.2022

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Abstract: Today, electrical energy is used extensively worldwide, increasing importance in almost all business sectors. For this reason, how to produce electrical power from earth sources is so important. Renewable energy sources that do not damage the environment and do not cause greenhouse gas emissions are increasingly used in electrical energy production. Solar energy, also renewable energy, is an excellent choice for the world's future because it is durable, abundant, low cost, recycling, and clean. Efficiency in solar energy is essential in terms of reducing resource use. The efficiency of solar PV modules depends on their structure, irradiance, and temperature. The albedo effects are significant in the bifacial modules because of the reflection of direct and diffuse irradiances. In this paper, the Albedo effect, and the surface's reflective power, are analyzed in a 30-kW bifacial PV system making simulations with PVsyst software. With different ground models and albedos, the PV system is simulated under given conditions using the PVsyst software. After results are compared, it is understood that the albedo effect brings about a severe power increase in bifacial PV systems compared to mono facial PV systems.

Keywords: *Albedo effect, Bifacial module, Lowering LCOE, PV efficiency, PVsyst software*

Cite this paper as: Türkdoğru, E., & Kutay, M., Analysis of albedo effect in a 30-kW bifacial PV system with different ground surfaces using PVsyst software. *Journal of Energy Systems 2022; 6*(4): 543-559, DOI: 10.30521/jes.1105348

Nomenclature			
LCOE	Levelized Cost of Energy [USD/kWh]	*MPPT*	Maximum Power Point Tracking [-]
DiffHorr	Horizontal Diffuse Irradiation [kWh/m^2]	*PERC*	Passivated Emitter and Rear Contact [-]
Earray	Effective Energy at the Output of the Array [MWh]	*Pitch*	Distance Between Rows of Modules [m]
E_Grid	Energy Injected into Grid [MWh]	*Pnom Ratio*	Installed Power (DC)/Output Power (AC)
GCR	Ground-Coverage Ratio [%]	*PR*	Performance Ratio [-]
GlobEff	Effective Global Irradiation [kWh/m^2]	*PV*	Photovoltaic [-]
GlobHor	Global Horizontal Irradiation [kWh/m^2]	*STC*	Standard Test Conditions [-]
GlobInc	Global Incident in Collector. Plane [kWh/m^2]	*T_Amb*	Ambient Temperature [^{o}C]
Isc	Current at Short Circuit [A]	*Voc*	Voltage at Open Circuit [V]
Lc	Normalized Collection Losses [kWh/kWp/day]	*Yf*	System Yield [kWh/kWp/day]
Ls	Normalized System Losses [kWh/kWp/day]	*Yr*	Reference System Yield [kWh/kWp/day]

1. INTRODUCTION

Albedo is the portion of incident radiation reflected by a surface. Albedo plays a vital role in the energy balance of the earth's surface since it defines the rate of absorbed solar radiation**.** The Albedo is formulated as the proportion of the radiation reflected from the surface to the incoming radiation. Many PV simulations systems only provide the option for a changeless albedo - or occasionally make a different solution for the snow-covered periods. Commonly, this is a sensible estimation for traditional low angle tilted PV systems simulation. The albedo value extends from 0 to 1. A zero value refers to a blackbody, an academic environment that absorbs 100% of the incident radiation. A 0.1–0.2 indicates dark-colored, rough soil surfaces, while 0.4–0.5 represents smooth, light-colored soil surfaces. The albedo of snow, remarkably fresh, deep snow, can reach as high as 0.9. The value 1 refers to an ideal reflector surface (a white, absolute surface) in which all the energy falling on it is reflected [1]. Albedo can be determined with Eq. (1) general formula and seen in Fig. 1 [2]:

$$\text{Albedo} = \frac{Reflected\ Light}{Incident\ Light} \qquad (1)$$

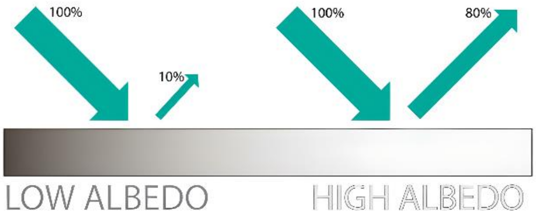

Figure 1. Low reflection on dark surfaces (low Albedo) and high reflection on light surfaces (high Albedo).

A surface's Albedo, or ground reflectance, is a unitless quantity that describes the fraction of incident sunlight that it reflects. In most PV system demands, assuming a changeless albedo is acceptable, but in other circumstances, a more exact description of the albedo is greatly significant. Simulation of the gain of the tilted bifacial PV modules is one instance because the energy produced on the backside will primarily originate from reflected irradiance. Albedo on the bifacial gain ranges from 5 to 15% for an albedo range of 0.2 to 0.4, according to bifacial PV module simulations of a large-scale plant [3]. The direct, diffuse, and ground-reflected radiation of a bifacial PV module is shown in Fig. 2.

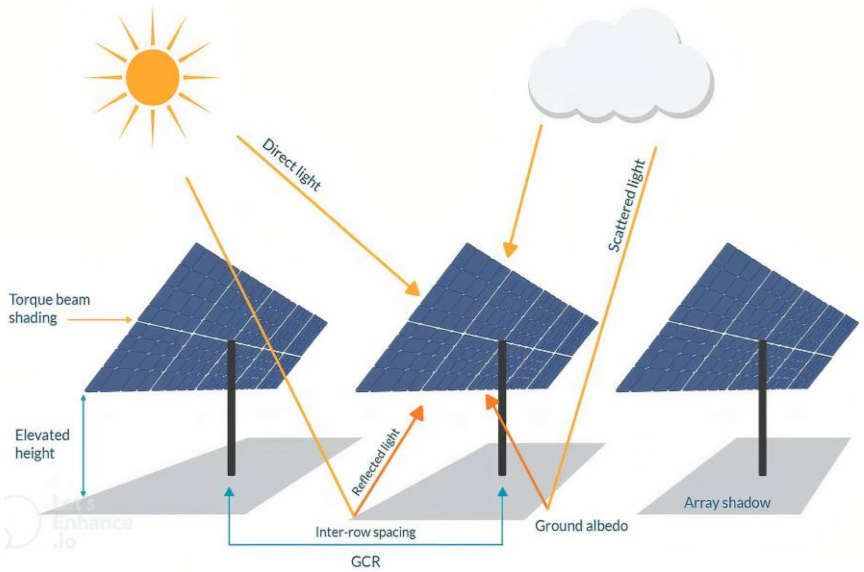

Figure 2. Irradiation components that affect bifacial efficiency.

By processing sunlight on the front and reflected light on the rear, the bifacial PV Module can produce energy from both the front and back, unlike conventional modules. The bifacial PV module offers greater power output when compared to conventional monofacial PV modules due to its ability to harvest light reflected onto the backside. The bifacial PV Module doesn't use a white backsheet but uses a transparent backsheet (or glass) on the back. The reflected light can come from various sources, such as reflection from the ground or a neighboring row of PV modules. In the matter of irradiance received by the module, the bifacial gain is strongly tied to the direct sunlight, diffuse light, and reflected light acquired by the rear side. Albedo, ground coverage, and mounting characteristics also impact these calculations. Moreover, the bifacial gain is also affected by the module quality and other factors, including Albedo, height to the ground, ground cover ratio, and potential in world regions [4]. Bifacial gain is determined by the ratio of supplementary rear side energy production (kWh) and front side energy production (kWh) by Eq. (2) [2]. Two typical and bifacial solar cell structures are seen in Fig. 3 [5].

$$\text{Bifacial Gain (BG)}= \frac{Energy\ (Rear)}{Energy\ (Front)} \tag{2}$$

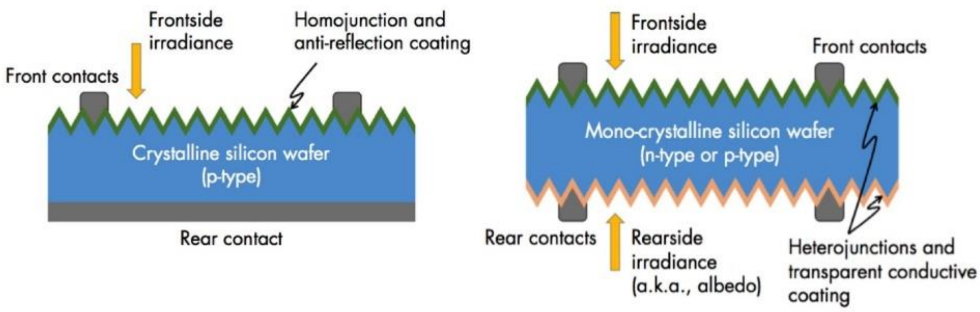

Figure 3. The contrast between the typical and bifacial solar cell (from Ref. [6]).

In today's world conditions, fossil energy prices are rising so fast that the only solution to solve this energy crisis is to use renewable energy. Therefore, using the most efficient way of renewable energy has become very important. After the costs of modules and solar system parts decreased, obtaining electricity from the sun has become the cheapest electricity generation method. Research and tests have shown that bifacial panels will come to the fore with albedo gain and will offer more efficient electricity production for the future. This study aims to compare the gains obtained on different albedo surfaces in a 30 KW solar plant based on bifacial panels that offer high-efficiency gain from the sun and to reveal the importance of bifacial panels for efficiency and economy in the obtained results.

2. BIFACIAL PV MODULES AND ALBEDO

The ground-reflected irradiance related to its albedo value possesses only a little influence on a typical PV system. Nevertheless, for a bifacial PV plant, albedo is critical. Figs. 4 and 5 demonstrate the correlative benefactions of the various components of the irradiances collected on the front and rear surfaces of a module.

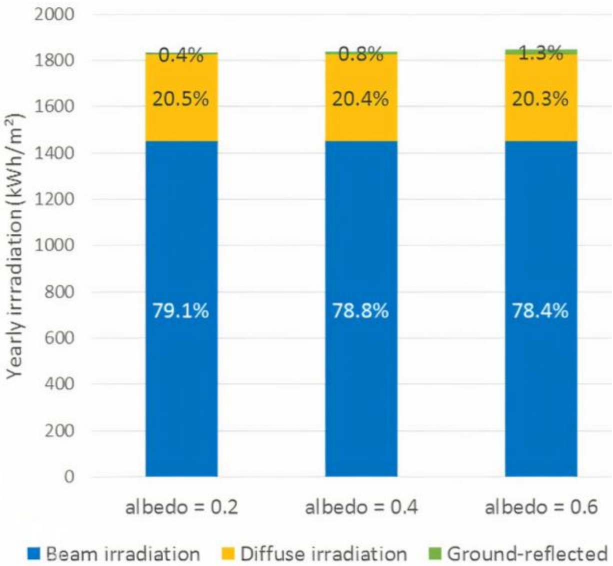

Figure 4. For different albedo values, the relative additions of light in the different components come to the front surface of the PV module.

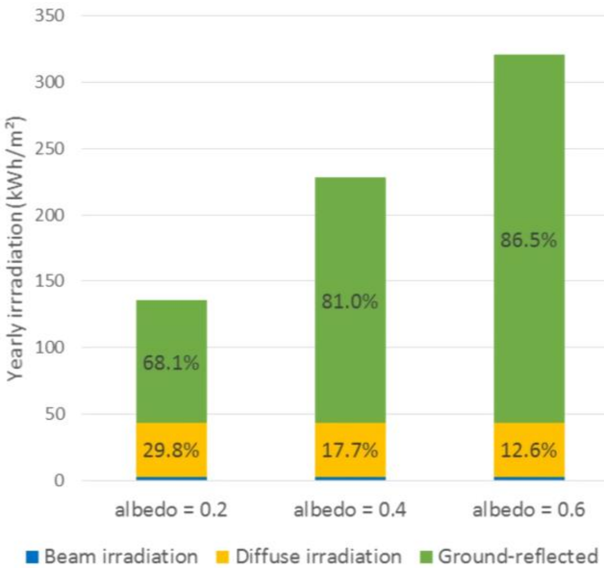

Figure 5. For different albedo values, the relative additions of light in the different components come to the rear surface of the PV module.

Although in a standard PV plant, direct and diffuse components cancel out reflected irradiation, reflected irradiation is the predominant contributor to the irradiation gathered by the backside of the bifacial module [3].

As well as pure climate-related factors such as solar radiation, temperature, wind speed, and precipitation (appearing as rain and snow), other site-specific factors will play a role in bifacial performance. One of the essential site-specific terms for bifacial modeling is ground reflectivity or albedo. Ground-reflected light is a need rather than an addition for bifacial applications. Albedo is critical even with monofacial PV when the tilt angle allows reflected light to contribute remarkably to the absorbed power inside the array's front-side surface. This is critical in snowy high-latitude continental climates where sharp tilt angles are found. Because most natural surfaces absorb more light than they reflect, albedos typically vary from 15 to 30 percent, and natural materials have moderate to high reflection (e.g., water, white stone, snow). The constructed surfaces, such as crushed white stone, can be utilized to increase reflectivity. The albedo of a location can change dramatically throughout the year, owing to seasonal changes in soil moisture and vegetation, as well as occasional brilliantly reflecting snow cover. Due to variable rock and soil forms, as well as vegetation development, the Albedo at multi-MW sites can vary considerably, making it critical to measure the albedo within the design to reach a bankable conclusion [7].

2.1. The Future of Bifacial PV Modules

Based on the International Technology Roadmap for Photovoltaics (ITRPV) report, research predicted that the market share of bifacial solar modules will expand from 20% in 2020 to 70% by 2030. According to market forecasts, the bifacial PV market will be triple by 2030 in Fig. 6. Depending on installation and location conditions, they will gain between 5% to 30% more power than monofacial modules. The majority of PV modules on the market consist of monofacial solar cells, but bifacial solar cells can be used for both mono and bifacial PV modules. According to ITRPV, between 50% and 60% of bifacial solar cells will be assembled into bifacial modules, while the remaining 40% to 50% will be put into monofacial modules [8].

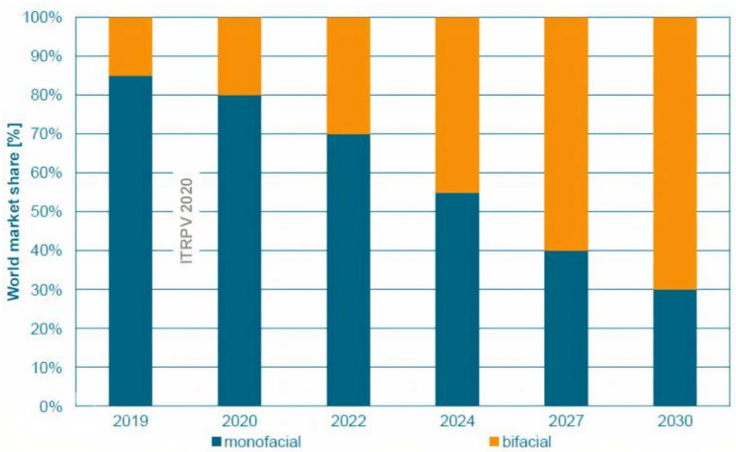

Figure 6. The ratio of solar cells in the PV market from the ITRPV 2020.

One of the primary projected causes for the bifacial module market share to continue to grow is seen in Fig. 7. The higher costs associated with generating the backside of bifacial modules can be balanced when bifacial production increases (with more data reachable and better designs obtainable). The issue is establishing how to properly assess the cost of the bifacial plant and predict the power generated while taking all of the variables into consideration. Bifacial modules can produce extra power between 10-and 20% over monofacial panels. The increased capacity can be around 30-40% more if circumstances are improved and single-axis trackers are used. [9].

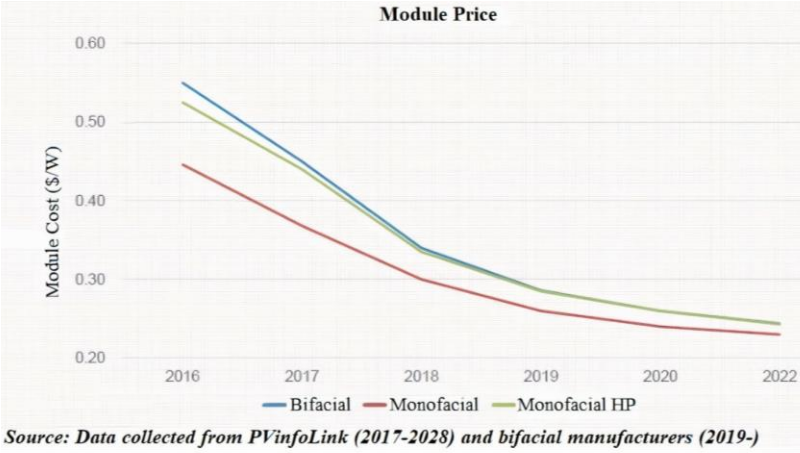

Figure 7. The price gap between bifacial and monofacial modules.

3. PHOTOVOLTAIC POWER POTENTIAL OF TÜRKİYE

Türkiye is located in a unique position in the Middle East and Southeast Europe for solar energy. Solar energy is a rapidly growing part of renewable energy in the country, with almost 10 GW of solar panels generating about 5% of its electricity by 2022. Solar potential is excessive in Türkiye, particularly in the South Eastern Anatolia and Mediterranean provinces in Fig. 8 [10].

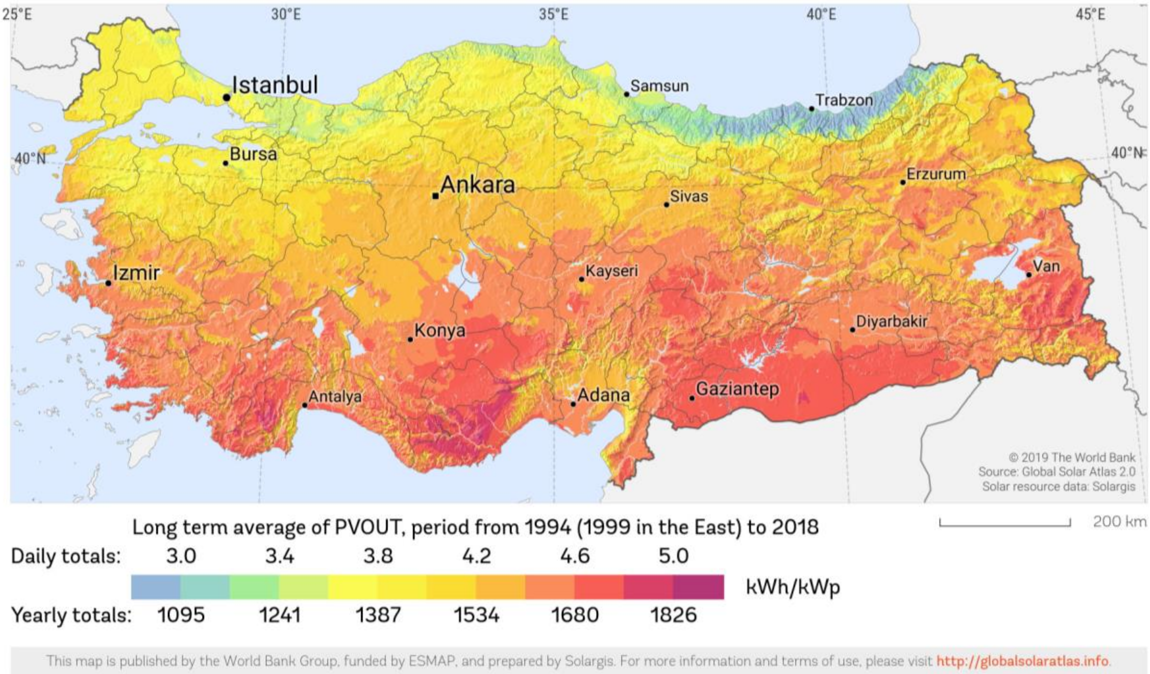

Figure 8. The PV power potential of Türkiye.

4. WHAT IS PVSYST SOFTWARE

PVsyst is an international standard for PV system design and simulation, created by A. Mermoud and M. Villoz. The developers claim this software is designed and simulated to be used by architects, engineers, researchers, and students. PVsyst is the most commonly used solar simulation program for estimating power generation and optimizing solar power plant design. It includes a detailed contextual Help menu that explains the procedures and models used and offers a user-friendly method with a guide to constructing a project. PVsyst employs extensive knowledge of PV Technology, Meteorological irradiation resources data, and PV system parts. Thus, it will help understand the PV system components and thus help optimize the system design. There are a lot of solar design simulation software on the market, such as Helioscope, Aurora, etc. However, PVSyst is accepted almost globally and is one of the oldest softwares. It is quite comprehensive and provides excellent results for larger utility-scale projects**.** PVSyst as a solar design software is exceptionally feature-loaded and complex [11].

5. 30-KW BIFACIAL PV SYSTEM DESIGNING WITH PVSYST

A 30-kW bifacial PV system was designed and simulated with PVsyst software to see the albedo effect in a bifacial photovoltaic system. 30 kW solar covered area can give enough data for analyzing and evaluating the results of the albedo effect. We should also know that a 30 kW PV system provides sufficient operating power for many individuals and small businesses.

5.1. Geographical Site Parameters and Horizon Line Drawing for Caferbey, Salihli, Manisa

The meteorological data is the first step in the consideration of a project. The project's geographic coordinates are taken from Meteonorm 8.0 database for Caferbey, Salihli, Manisa, Türkiye, which is located at a latitude of 38.4772 N and longitude 28.0972 E at an altitude of 126 meters. This geographical area is chosen because it is suitable for setting up the project. The geographic area parameters are seen in Fig. 9.

	Global horizontal irradiation	Horizontal diffuse irradiation	Temperature	Wind Velocity	Linke turbidity	Relative humidity
	kWh/m²/mth	kWh/m²/mth	°C	m/s	[-]	%
January	68.2	31.7	6.6	2.19	3.269	77.6
February	77.2	39.7	8.3	2.41	3.710	74.1
March	125.6	61.2	11.6	2.39	4.355	66.3
April	164.8	74.6	15.6	2.19	4.930	60.9
May	209.4	77.5	21.1	2.30	4.501	54.5
June	229.4	73.0	25.8	2.70	3.851	47.5
July	240.1	64.8	29.5	3.10	3.735	42.6
August	215.0	59.1	29.2	3.10	3.790	44.9
September	163.9	50.1	23.9	2.39	3.689	52.5
October	115.7	46.0	18.4	2.10	3.719	62.0
November	76.9	33.1	12.7	1.90	3.469	73.0
December	59.9	24.6	8.1	2.00	3.301	76.4
Year	**1746.1**	**635.4**	**17.5**	**2.4**	**3.860**	**61.0**

Global horizontal irradiation year-to-year variability 5.4%

Figure 9. The geographic area parameters for Caferbey, Salihli, Manisa, Türkiye.

The horizon of the far shadings section is the uncomplicated way of defining shadings in PVsyst. However, this is only suitable for considering shadings of objects that are adequately far away, since we may consider them to operate on the PV field in a global manner: the sun is either visible or not visible on the field at any one time. Typically, the spacing between these shading objects should be greater than 10 times the size of the PV field in Fig. 10.

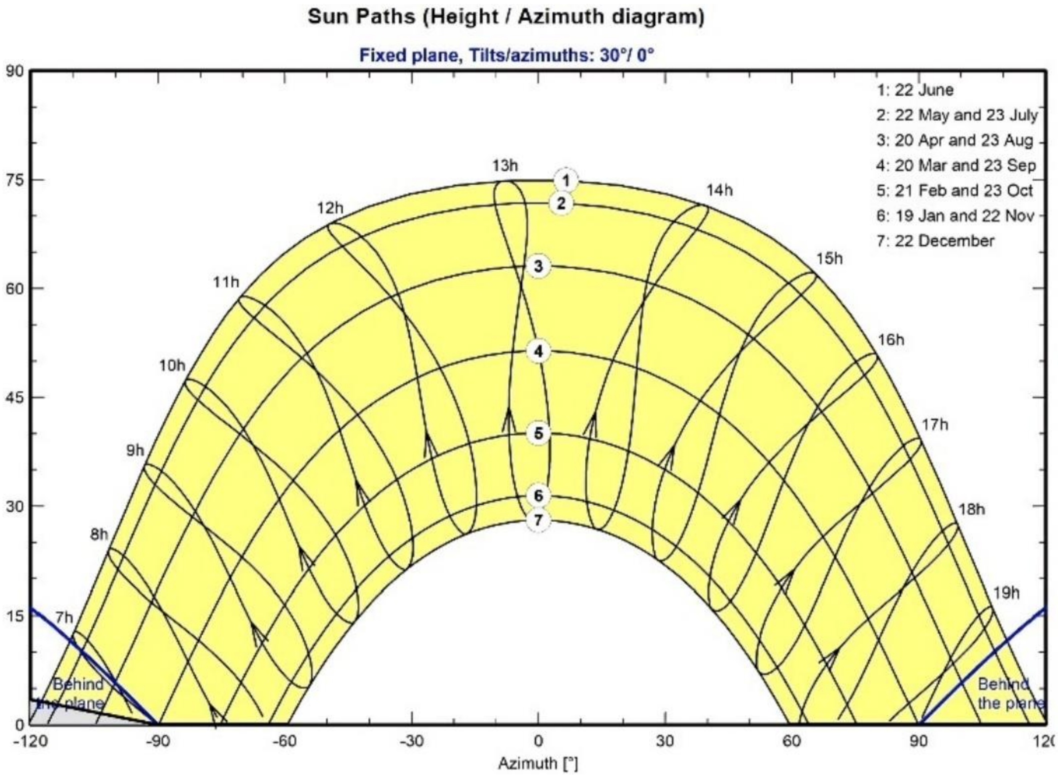

Figure 10. Horizon line at Caferbey, Salihli, Manisa, Türkiye.

5.2. Design and Shading Scene Construction

Initially, we need to define the PV system mounting system. There are three different solar PV mounting systems: Fixed-mount type, single-axis tracking, and dual-axis tracking. We chose the fixed mount type for this project because the costs of investment, maintenance, and application are easy to handle for others way. For stationary mount type, the tilt angle is taken as the optimum value of 30^o for obtaining maximum irradiance seen in Fig. 11. And also, for the same reason, the azimuth angle is taken at 0^o degrees.

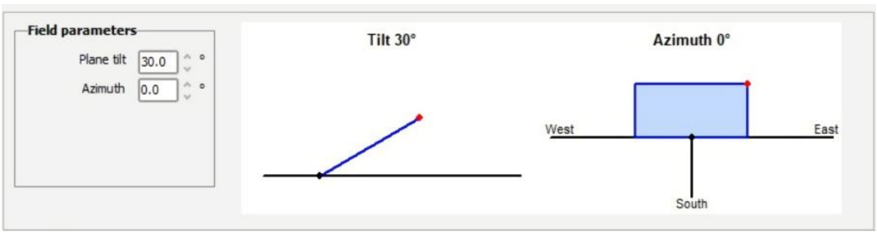

Figure 11. The orientation and direction of bifacial PV system.

While designing a 30 kW PV system, 80 units of 425-watt PV modules were used. Eighty modules were used in 4 rows, 20 of which are in each row. The pitch value (inter-row spacing) was taken at 5 m. Also, the panel's elevated height was taken at 1.35 m. These parameters were taken for the optimum values for covering fewer spaces but gaining a high yield. Shading scene construction is shown in Fig. 12.

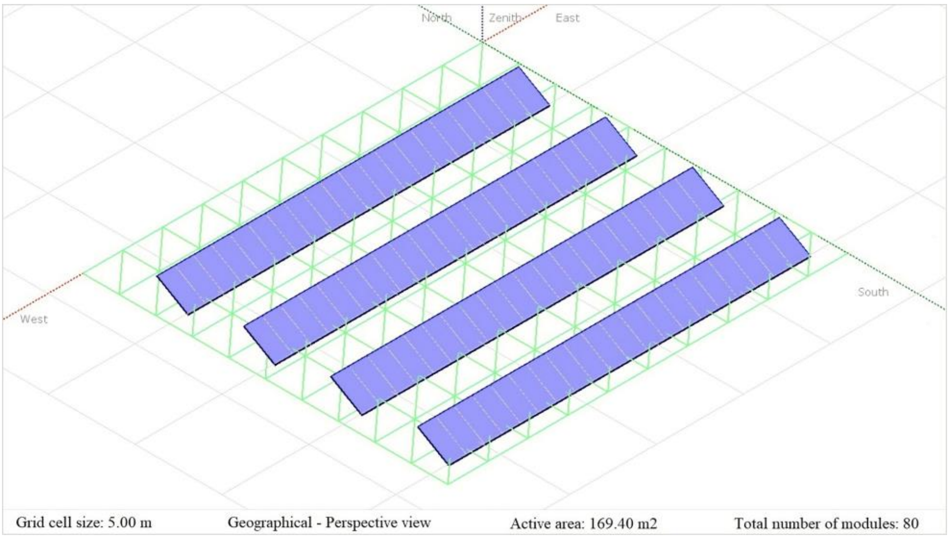

Figure 12. Shading scene construction.

5.3. Selecting the PV Module

Bifacial modules are used to analyze the albedo effect on the PV system in this project. There are many types of PV modules with different characteristics. Among these modules, a highly efficient, widely available, affordable, and the local product was selected. Selecting a high power and efficiency PV module ensures less use of the surface area The selected PV module is seen in Fig. 13.

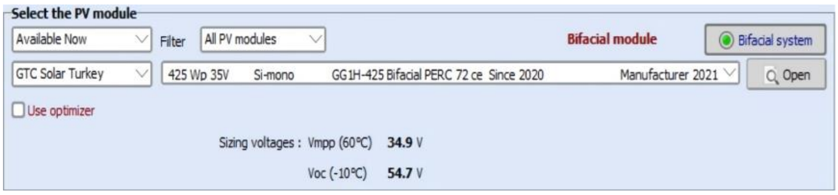

Figure 13. Selecting the PV module.

The graph of efficiency against the incident solar radiation under varying temperature conditions is shown in Fig. 14, which demonstrates that as the temperature of the PV module increases, the efficiency decreases at a specific radiation level. The efficiency of the solar panel is 20.47% at STC. It is clear from Fig. 15, that as the incident solar radiation level increases, the maximum current for a PV array also increases and has no significant effect on the voltage when the temperature remains stable.

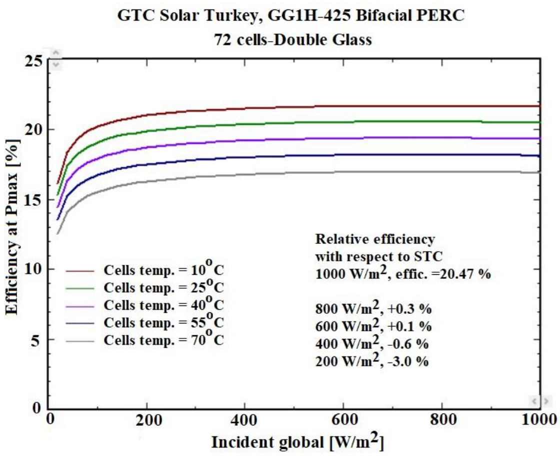

Figure 14. Efficiency at Pmax [%] vs. incident global [W/m^2] graph of selected PV module.

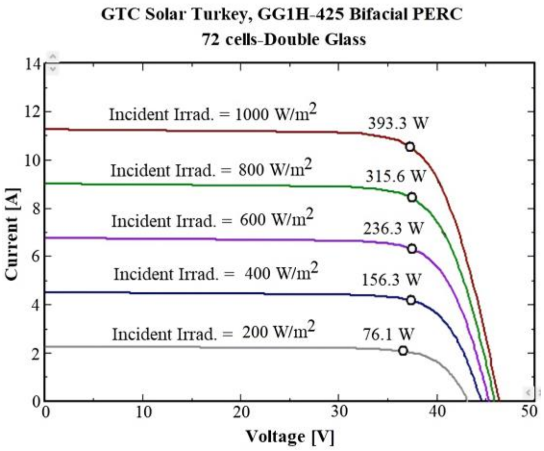

Figure 15. Current [A] vs. voltage[V] graph of selected PV module.

5.4. Selecting the Inverter

An inverter is one of the essential equipment in a solar energy system. Our sample 30 kW PV system uses two inverters of 15 kW AC output power and two MPPT input. The inverters' operating points and electrical conditions must be consistent with the PV system, as the operating DC voltage of the inverter should not exceed minimum and maximum operating values. The selected inverter is shown in Fig. 16.

Figure 16. Selecting the inverter.

The PNom ratio is the ratio between the installed PV power (DC) (nominal at STC) and the nominal AC power of the inverter. This is truly a widely-used reference when sizing the inverter. It is often determined to get an insignificant overload loss. Pnom ratio was taken at 1.13 in this project. The other important parameter in this section is V_{oc} (-10 °C). It should be lower than the maximum dc voltage of the inverter. The designed array is shown in Fig. 17 [12].

Figure 17. Designing the array.

5.5. Schematic of PV System

A grid-connected system is depicted in Fig. 18 as a clarified block diagram with three primary components: the PV array, inverters, and the ultimate user loads. In the first stage, a PV array collects solar radiation and converts it into electricity with a DC current that flows through the system. In the second stage, an inverter is used to convert the DC current into AC current that can be used by the system's instruments. In the third stage, any surplus power is sent to the grid [13].

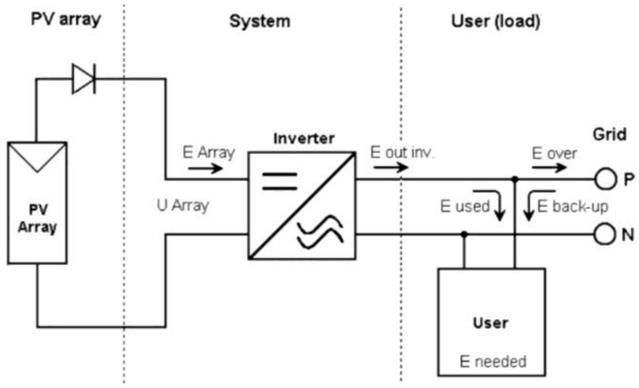

Figure 18. Schematic of 30 kW bifacial PV system

5.6. Beam and Diffuse on the Ground with Sheds

The beam and diffuse on the ground with sheds graphics are shown in Fig. 19. On the left side, there are design parameters. Ground Albedo is chosen at 0.65. This value can be achieved easily with white paint or white portland cement.

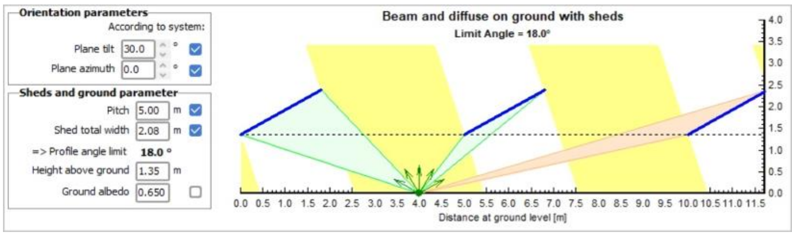

Figure 19. Beam and diffuse on the ground with sheds.

6. BIFACIAL PV SYSTEM SIMULATION RESULTS AT PVSYST

The 30-kW bifacial PV system, for which initial definitions and designs are made above, is simulated in the next section. Simulations for critical parameters were made with PVsyst software and the results were obtained in the table form. As a result of the simulations, the correlation of the albedo effect with the bifacial modules is examined in Table 2. In today's conditions, the use of bifacial modules will be discussed in the conclusion section considering the Albedo effect.

6.1. Optimization Tool Results

The PVsyst software is also used to determine the appropriate azimuth and tilt angle established on the system orientation and to ensure that it is acceptable and efficient for this system using software simulation. The optimum tilt angle is 30º and the azimuth angle is 0º to the south, as seen in Fig. 20 below. The maximum power capacity of our system can be produced at this tilt and azimuth angle. Also, PVsyst's software helps us to find optimum values of Height, GCR, and Pitch step by step graphics using an optimization tool. E_Grid and Elevation height graphics are shown in Fig. 21. Elevation height is taken at 1.35 m. E_Grid and GCR graphics are shown in Fig. 22. GCR is taken 41.6%. E_Grid and Pitch graphics are shown in Fig. 23. Pitch is taken 5 m.

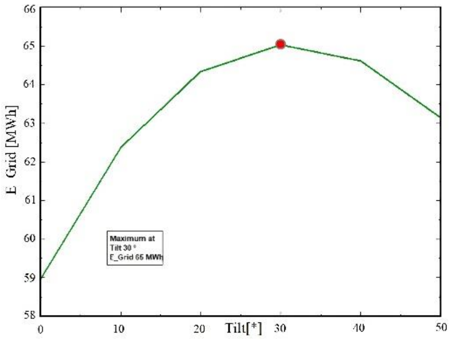

Figure 20. E_grid vs. Tilt

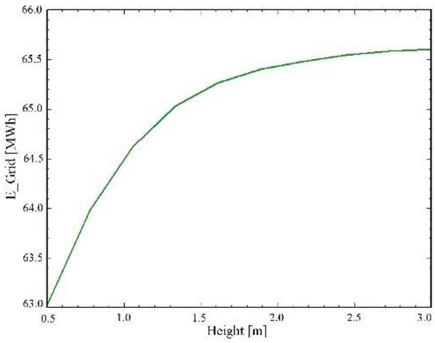

Figure 21. E_Grid vs. Elevation height

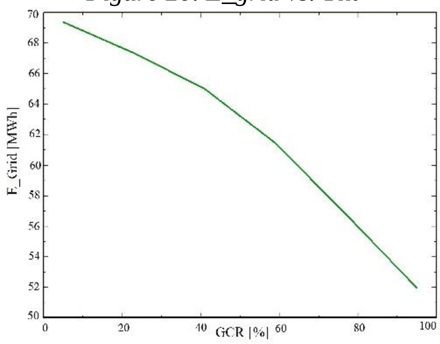

Figure 22. E_Grid vs. Ground coverage ratio

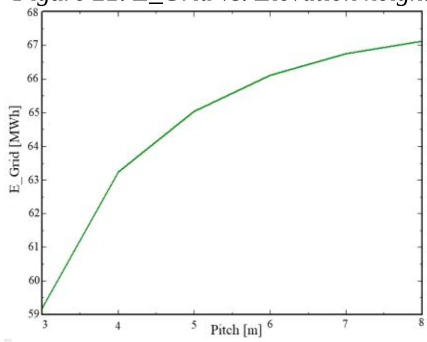

Figure 23. E_grid vs. Pitch

6.2. Simulation Results

Performance ratio (PR) is the ratio of the final PV system yield (Y_f) and the reference yield (Y_r). Our PV system performance ratio (PR) graphic is shown in Fig. 24. The performance ratio value is quite high in our PV system because of the bifacial module gains. The normalized power production and loss factors yielded annually are seen in Fig. 25.

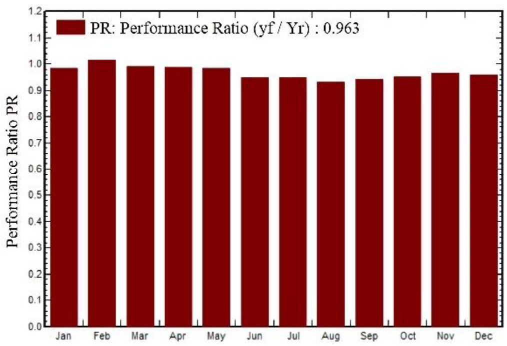

Figure 24. Performance ratio PR

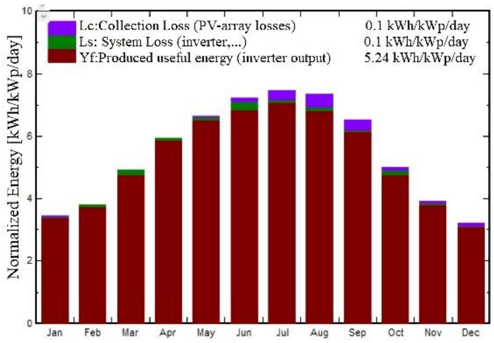

Figure 25. Normalized productions

Fig. 26 shows the system loss diagram. After subtracting all system losses, the final power fed to the grid is 65 MWh. In Fig. 27, the daily system output energy graph demonstrates how energy fed to the grid changes by months. Also, the incident irradiation distribution graphic tells us about changing incident irradiation in collector planes over the year in Fig. 28.

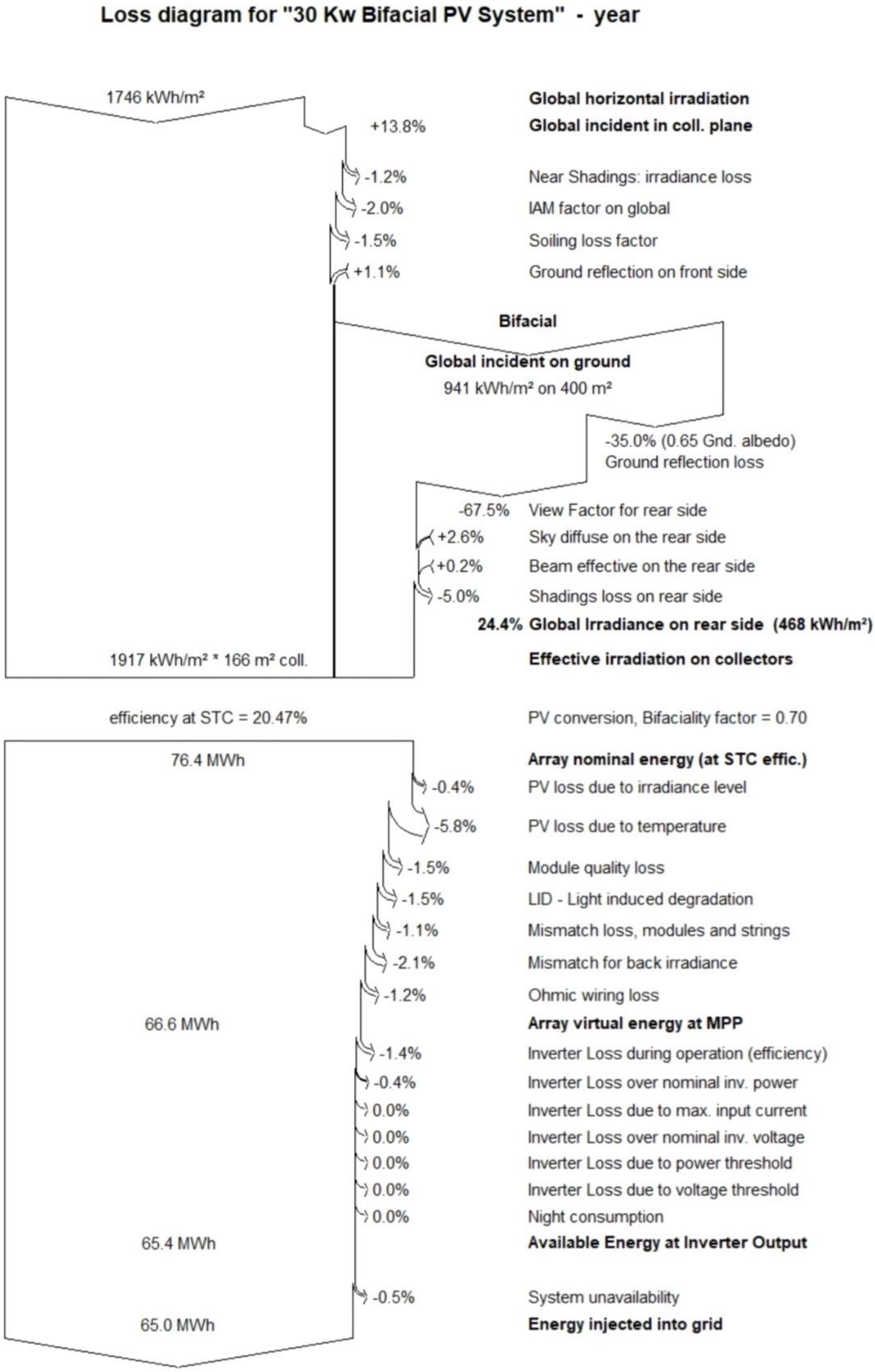

Figure 26. Loss diagram

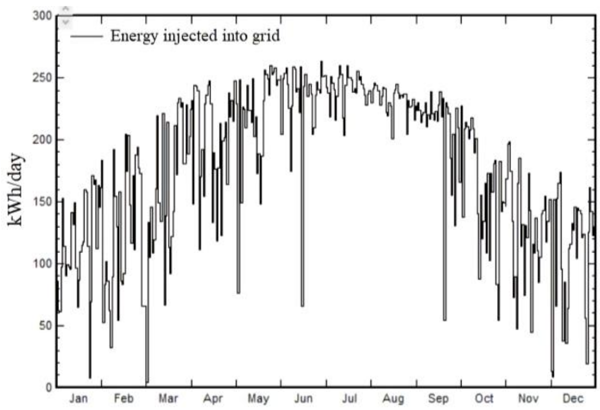

Figure 27. Daily system output energy

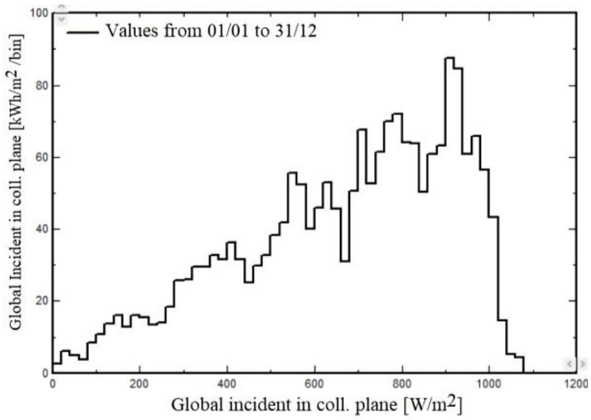

Figure 28. Incident irradiation distribution

6.3. Comparisons and Fundamental Results

Table 1 shows the comparisons and fundamental results for variables like irradiations, temperatures, system energies, and PR ratio. Irradiances are thought about with soiling and shading losses in table 1. For our location, the annual global irradiance on a horizontal plane is 1746.3 kWh/m^2. Annual, energies per square meter of the global incident on the plane and effective global irradiance are 1987.2 kWh/m^2 and 1916.9 kWh/m^2, respectively. Based on this effective irradiance, yearly DC energy generated from the PV array and yearly AC energy fed to the grid are respectively 66.30 MWh and 65 MWh. A PV array's yearly mean yield is determined to be 20.10 percent, while the system's yearly mean yield is calculated to be 19.07 percent.

Table 1. Comparisons and fundamental results.

Month	GlobHor (kWh/m^2)	DiffHor (kWh/m^2)	T_Amb (ºC)	GlobInc (kWh/m^2)	GlobEff (kWh/m^2)	EArray (MWh)	E_Grid (MWh)	PR
January	68.2	31.68	6.64	106.5	102.4	3.611	3.561	0.984
February	77.2	39.65	8.25	103.5	99.8	3.617	3.566	1.014
March	125.6	61.22	11.57	149.6	144.2	5.170	5.030	0.989
April	164.8	74.58	15.60	178.1	171.5	6.068	5.985	0.988
May	209.4	77.53	21.08	206.0	198.4	6.979	6.882	0.983
June	229.4	72.96	25.84	216.4	208.8	7.261	6.971	0.948
July	240.1	64.83	29.46	231.3	223.4	7.566	7.462	0.949
August	215.0	59.06	29.16	227.5	219.9	7.296	7.194	0.930
September	163.9	50.07	23.85	195.7	189.0	6.339	6.253	0.940
October	115.7	45.96	18.37	155.2	150.0	5.170	5.015	0.951
November	76.9	33.11	12.66	117.7	113.5	3.924	3.868	0.967
December	59.9	24.61	8.06	99.8	96.0	3.297	3.250	0.958
Year	1746.3	635.26	17.60	1987.2	1916.9	66.299	65.038	0.963

6.4. Simulation Results and Analysis

For analyzing the influence of the albedo effect on the power in bifacial panels, simulations were made on surfaces with different albedo. By taking dark surfaces with a low albedo and light surfaces with a high albedo, the power and gain delivered to the grid were calculated. PVsyst simulation made closed the bifacial panel feature, and the power injected into the grid was just 56.4 MWh. The reference surface with an albedo value of 0.65 underlined in Table 2. was taken as a reference albedo point in the PVsyst base calculations. According to this albedo, the system injected 65.0 MWh of energy into the grid. It can be clearly from here that the 15.25% gain is obtained from the reference albedo value of 0.65. As seen from the table, the higher the Albedo value, the higher the power supplied to the grid. The power gain corresponding to each albedo value was calculated as a percentage. As a result of the calculation, the gain of the PV system varies between 1% and 20% in average albedo values. The last calculation was made for white paint of the high-value albedo. The power injected into the grid is as much as 67.9

MWh, and the power gained is 20.39%. As you can see, the gain exceeds 20%. All the results obtained are shown in Table 2. With the title of typical albedo values of different kinds of surfaces and E_Grid and gain results [14].

Table 2. Typical albedo values of different kinds of surfaces and simulation results.

Surface	Albedo	Albedo (Avg.)	E_Grid (MWh)	Gain (%)
Oceans	0.05 - 0.10	0.075	57.6	1.02
Asphalt	0.05 - 0.20	0.125	58.3	3.37
Corrugated roof	0.10 - 0.15	0.125	58.3	3.37
Trees	0.15 - 0.18	0.165	58.8	4.26
Red/Brown roof tiles	0.10 - 0.35	0.225	59.6	5.67
Colored paint	0.15 - 0.35	0.25	60.0	6.38
Gray portland cement concrete	0.20-0.30 (weathered)	0.25	60.0	6.38
Grass	0.25 - 0.30	0.275	60.3	6.91
Brick/Stone	0.20 - 0.40	0.30	60.6	7.44
Gray portland cement concrete	0.35-0.40 (new)	0.375	61.6	9.22
Ice	0.30 - 0.50	0.40	61.9	9.75
White portland cement concrete	0.40-0.60 (weathered)	0.50	63.2	12.06
Reference Surface	0.65 (ref. value)	0.65	65.0	15.25
White paint	0.50 - 0.90	0.70	65.6	16.31
Old snow	0.65 - 0.81	0.73	66.0	17.02
White portland cement concrete	0.70-0.80 (new)	0.75	66.2	17.38
Fresh Snow	0.81-0.88	0.845	67.3	19.33
White paint (high value)	0.90	0.90	67.9	20.39

Intending to compare, the views of some surfaces with different albedo values are given at the white concrete in Fig. 29, white paint in Fig. 30, snow in Fig. 31, and soil-grass in Fig. 32.

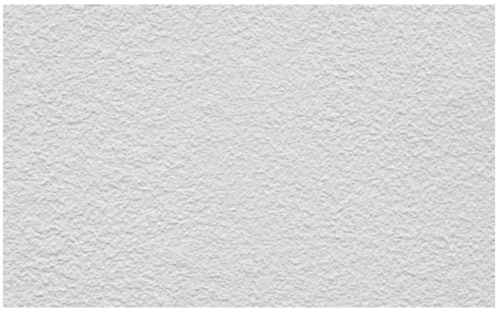

Figure 29. White concrete

Figure 30. White paint

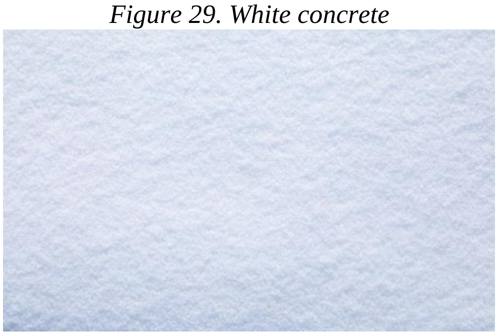

Figure 31. Snow

Figure 32. Soil-grass

7. CONCLUSION

Using PVsyst V7.2 simulation software, an analysis of the Albedo effect in a 30-kW bifacial PV system with different ground surfaces was performed at the Caferbey, Salihli, Manisa, Türkiye, which is located at a latitude of 38.4772 N and longitude 28.0972 E at an altitude of 126 meters. PVsyst simulations were made firstly by taking the reference albedo value of 0.65, which is the optimum big value that is practically applicable in the solar fields. Horizontal global irradiation is found at 1746.3 kWh/m^2 and the performance ratio is found about 96.3%. The energy at the inverter output, which is fed to the grid, is 65.0 MWh with a specific power production of 1913 kWh/kWp/year. Thus, the performance analysis is done using PVsyst software, which gives a normalized production of 5.24 kWh/kWp/day. For the reference 0.65 albedo value, the power supplied to the grid is 65.0 MWh. When the bifacial panel features are closed in the PVsyst simulation, the power supplied to the grid falls to 56.4 MWh. Thus, the gain was calculated at 15.25%. This high gain from the albedo effect alone can be considered quite good despite using a fixed-mounted solar field. Moreover, bifacial panel costs have decreased considerably, and the price gap between monofacial and bifacial modules has closed. Albedo value at 0.65 can be achieved without hard by using white concrete or white paint on the ground, as shown in Table 2. Nowadays, solar PV areas occupy less space as the new technologies help more power gain by the panel module surface area. Financial gain from bifacial PV system production is much higher than the cost of covering the ground with a thin thickness of white concreting or white painting at a high albedo. In addition, the solar panels will be prevented from soiling loss. Covering the ground with white concrete may not be possible in all areas such as agricultural lands. However, different solutions can be found that provide high albedo value without concreting the soil. The important thing is to see that bifacial panels have a very high potential in terms of gain and efficiency and to benefit from it as much as possible to lower an LCOE.

Acknowledgement

I would like to express my gratitude to Yasar University faculty member Dr. Mahir Kutay, whose valuable information I have benefited greatly from while writing this article, and to my family for all their support during my university education.

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