THE EFFECT OF WEATHER CONDITIONS ON ALBEDO FOR SOLAR PROJECTS

1 OBJECTIVE

In the last 5 years, bifacial technology has become common practice in the solar energy market. More than 60% of solar farm installations are constructed with bifacial modules. Most of the time, the albedo value is obtained from standardized surface types, where the project is located. With the aim of reducing the uncertainty, it is necessary to have reliable albedo data. This data can be obtained from different sources and their accuracy may vary. One of the more convenient and readily available sources for this data come from satellite imagery. However, the accuracy and fidelity of this satellite derived data is typically lower.

That is why on-site weather stations, properly equipped to measure albedo have become an important tool for assessing solar projects today. For this study, a comparison of the Albedo has been made between two sites, (Figure 1.1) where weather conditions such as temperature, humidity, irradiation were gathered to see if and how the albedo may change given a variation in these parameters. The location of both sites is in the Dominican Republic.

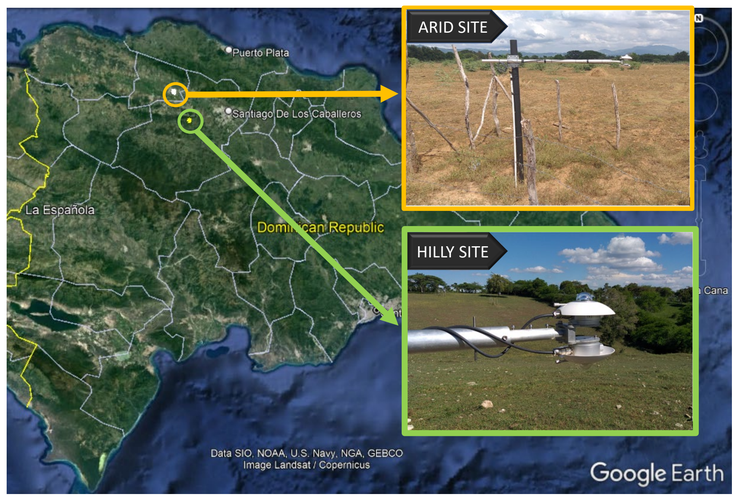

Figure 1.1: Site Locations – Arid Site and Hilly Site

2 SITE CONDITIONS & METSTATION

In each site a meteorological station was installed with the sensors mentioned in table 2.1.

The Arid Site is located between two mountain ranges. One is located 10km to the north with an elevation of 1,000 meters. The other mountain range is located 14km south with an elevation as heigh as 500 meters.

Table 2.1: Meteorological Station

TYPE	QTY	Principal Characteristic
Pyranometer	04	Secondary Standard
Anemometer	01	Resolution 0.01 m/s
Wind Vane	01	Accuracy 1°
Temp Sensor	01	Uncertainty <±1°C
Relative Hum.	01	5% to 95% H.R.

The Arid Site has a pluviometry of about 500mm per year. The surface of the terrain is arid, with spare vegetation and limited agriculture crops.

The Hilly Site is located on a plateau of about 500 meters of altitude. This site is about 20km to the southeast of the Arid Site. The Hilly Site has a pluviometry of about 650mm per year. The surface of the terrain is grassy, with wild flora used for livestock farming.

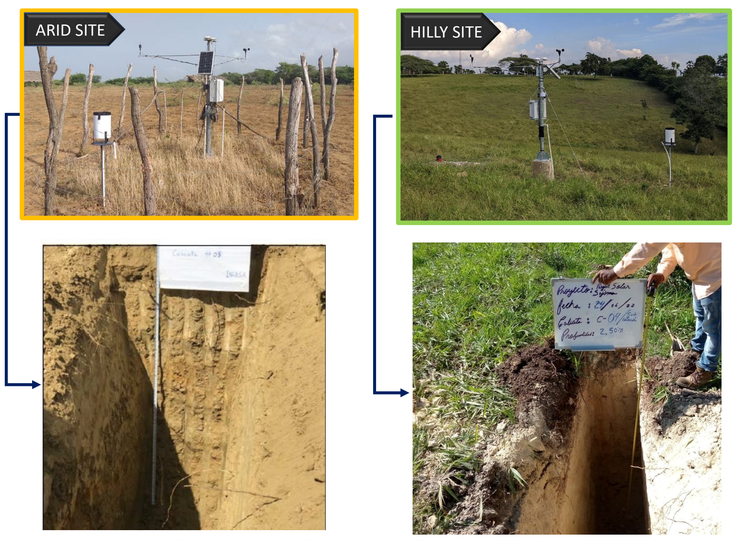

Figure 2.1: Met Station and soil type in each site

3 METHODOLOGY

- The data logger system of the met station were pre-programed to record irradiance measurements at a set time interval;
- Both meteorological stations were commissioning by internationally recognized consulting company.
- The data acquisition is from November 2020 to February 2022;
- The albedo measurements were recorded in 10-minute intervals, from 7:00 to 19:00;
- Methodology for measuring albedo: two secondary standard pyranometers were used. One sky facing and one ground facing. For the purpose of this study, the reflected irradiance is the irradiance measured by the ground facing pyranometer.
- The data was filter to eliminate night measurement, incongruent data points and missing entries.

4 SITE MEASUREMENTS STADISTIC RESULTS

The Arid site has an annual irradiation of 2,149 kWh/m². The average temperature of this site during the sunny hours is 29.4°C. The average daily irradiance is 5.88 kWh/ m² and the average daily albedo is 17.15%. The Hilly site has an annual irradiation of 2,138 kWh/ m². The average temperature of this site during the sunny hours is 26.2°C. The average daily irradiance is 5.72 kWh/ m² and the average daily albedo is 18.16%.The figure 4.1 shows a moderate positive correlation between the irradiance reflected and the temperature at both sites. The Arid site has a correlation of 0.57 and the Hilly Site of 0.49, which shows the reflected irradiance in the Arid Site has a higher dependency with the temperature than the Hilly Site.

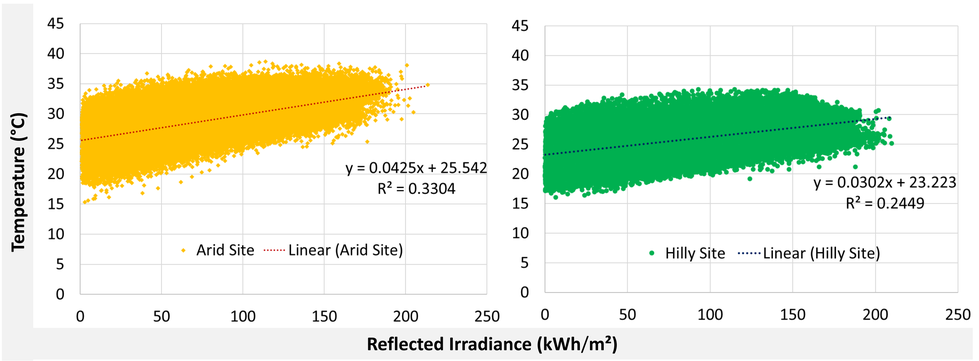

Figure 4.1: Reflected irradiance and temperature of both sites

The data was segmented based on temperature (T<20°C; T>30°C) and reflected irradiance (>86kWh/m²). At the Arid Site, 0.79% of the data below 20 °C and 45.4% are found above 30°C. Meanwhile in the Hilly site, 4.69% has a temperature below 20°C, and 10.47% are above 30°C. Above 100 kWh/m2, the Arid site is 41.42% and the Hilly Site, 43.91%.

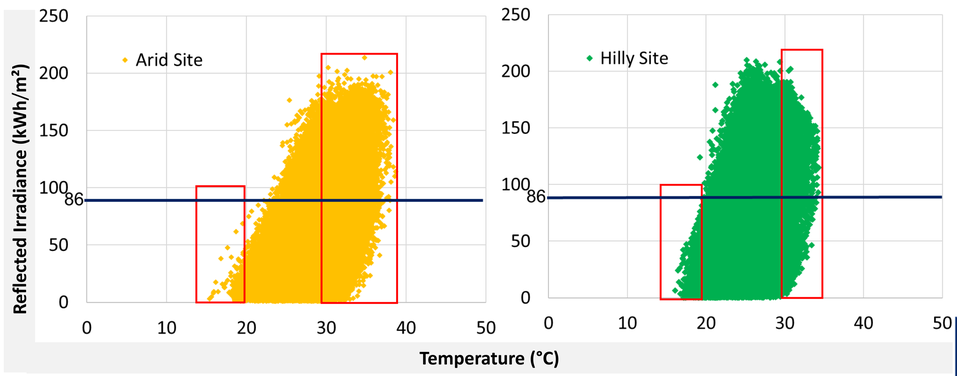

Figure 4.2: Temperature and reflected irradiance – segmented data

The correlation between the albedo and temperature in the Arid Site is weak since it is less than -0.08. The relation can be observed in figure 4.3. The Hilly site shows a moderate correlation of -0.41.

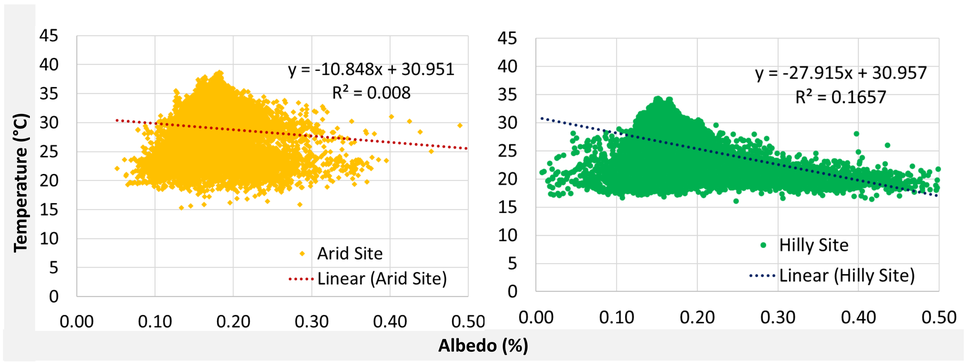

Figure 4.3: Albedo and temperature of both sites

The Arid Site data was segmented based on its average temperature (29.4°C) and average albedo (17.15%). The figure 4.4 shows that 45.54% of the data has a temperature below average and 54.46% is above average. The albedo data has 58.63% below and 41.37% above albedo average. 0.6% of the data has less than 10% of albedo and 0.5% of the data has an albedo more than 30%.

The Hilly Site data was segmented based on temperature average (26.2°C) and albedo average (18.16%). The figure 4.4 shows that 47.15% of the data has a temperature below average and 52.85% is above average. The albedo data has 64.35% below and 35.65% above albedo average. 0.87% of the data has less than 10% of albedo and 3.45% of the data has an albedo more than 30%.

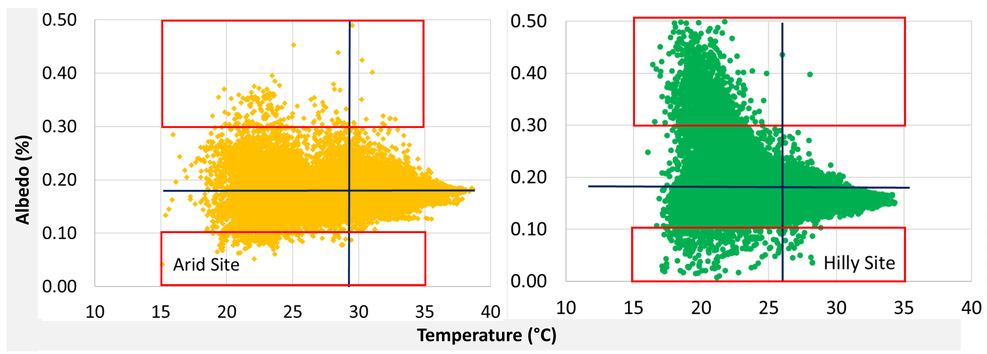

Figure 4.4: Temperature and Albedo – Segmented Data

Figure 4.5 shows the frequency distribution of the albedo in both sites. The Arid Site has a larger presence of data at the lower end of the albedo spectrum (below the average) than the Hilly Site. The Hilly Site occupies a larger distribution of data at the higher end of the albedo spectrum than the Arid Site. In the Arid Site, 98.6% of the data falls between 10% and 30% albedo while in the Hilly Site, 95% of the data falls between this range.

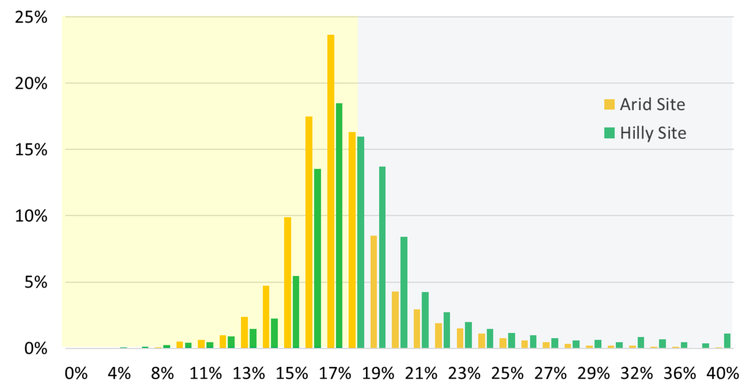

Figure 4.5: Frequency distribution of albedo for Arid Site data and Hilly Site data

5 SITE DATA & SATELLITE DATA

Adequate GHI measurements have lower uncertainties than some satellite data. The results of this comparison are shown in Table 5.1 for measured data the period is 2020–2021. SAT 1 measurement period is from 1999-2021, and SAT 2 is from 2010-2014.

Table 5.1: Site data and satellite data

PARAMETERS	ARID SITE DATA			HILLY SITE DATA		
	Site	SAT 1	SAT 2	Site	SAT 1	SAT 2
Temperature (°C)	26.5	26.2	26.1	23.8	23.9	24.4
%RH	73.0	74.41	78.9	79.1	76.79	78.7
GHI (kW/m²)	2149	2118	1873	2138	2096	1857
Albedo	17%	N/A	N/A	18%	N/A	N/A

It is important to highlight that SAT1 data has a very high correspondence with the measured data in both sides as is indicated in Figure 5.1.

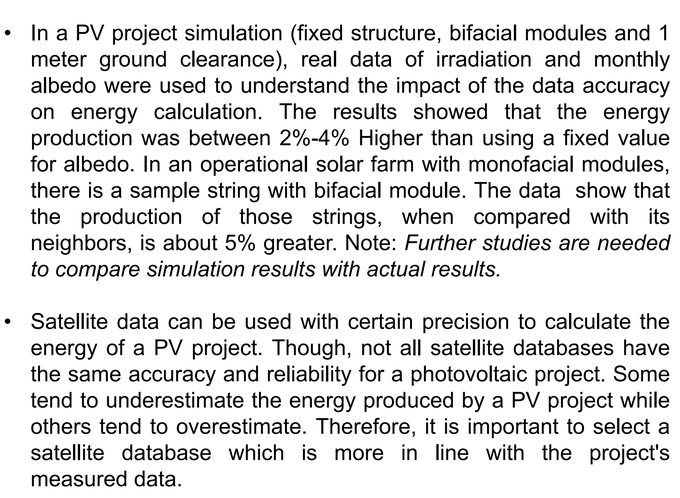

Figure 5.1: Monthly site data and monthly satellite data

6 CONCLUSION

- A default value 0.2 is commonly used for the albedo in PV performance software. This value is reasonably close for the long-term mean average of both sites.
- When considering the stations for which the ground surface is arid, the median albedo is 17.15% and 98% of the value are between 10% and 30%.
- When considering the stations for which the ground surface is vegetation, the median albedo is 18.16% and 95% of the values are between 10% and 30%.
- Due to the characteristic of the ground surface in the hotter site, it was understood that a higher albedo could be obtained. However, in this case, it does not meet this assumption, which means that obtaining data from ground measurements is necessary in order to eliminate the uncertainty in the performance of the PV system.
- In a PV project simulation (fixed structure, bifacial modules and 1 meter ground clearance), real data of irradiation and monthly albedo were used to understand the impact of the data accuracy on energy calculation. The results showed that the energy production was between 2%-4% Higher than using a fixed value for albedo. In an operational solar farm with monofacial modules, there is a sample string with bifacial module. The data show that the production of those strings, when compared with its neighbors, is about 5% greater. Note: *Further studies are needed to compare simulation results with actual results.*
- Satellite data can be used with certain precision to calculate the energy of a PV project. Though, not all satellite databases have the same accuracy and reliability for a photovoltaic project. Some tend to underestimate the energy produced by a PV project while others tend to overestimate. Therefore, it is important to select a satellite database which is more in line with the project's measured data.

Authors:

Santana Tapia, Karla Marielle
Méndez de Jesus, Priamo V.
Vicini Bonetti, Juan Enrique
Estévez Mejía, Ricardo

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