THE EFFECT OF SAHARAN DUST ON ENERGY PRODUCTION FOR SOLAR PROJECTS

1 OBJECTIVE

Saharan dust is a fine, dry powder that is blown from the Sahara Desert into the atmosphere that can travel long distances. The strong and constant winds that blow over the desert can stir up huge amounts of sand and dust, which can reduce the amount of irradiation received and affect weather conditions and air quality in areas as far as Europe, the Caribbean, and the United States. Dust particles can scatter and absorb sunlight which reduces the amount of energy that solar panels can collect. Interference of solar energy production due to dust storms is likely to increase in the future, as an increase in global temperatures makes the Sahara Desert more arid. That is why it is crucial to study and understand the impacts of Saharan dust today in order to better prepare for the future.

Figure 1.1: Saharan Dust arriving to Dominican Republic on June 2022, 2020. Credit: NOAA

Satellite images like the one in figure 1.1 show the vast impact that Saharan dust can have on Islands in the Greater and Lesser Antilles. For this study, we compared energy production on project site at times where a Saharan Dust Layer (SAL) was not present, to analyze its effects. The data acquisition phase of the study was from June 2020 and July 2023, during SAL season. The results of the analysis will help to verify the correlation between the presence of Saharan dust and the solar energy production.

Figure 1.2: Site Location

2 METHODOLOGY

Irradiation Measurements

The data logger system of the met station was pre-programed to record irradiance measurements at a set time interval. The Records are from June to July 2020.

The irradiance measurements were recorded in 10-minute intervals, from 00:00 to 23:50h.

The met station data was filtered to eliminate night measurements, incongruent data points, missing entries, cloudy and raining days.

Energy Production Data

Energy generation data was downloaded from Girasol´s PV plant SCADA system.

The Girasol PV Plant energy, power, and irradiation measurements were recorded in 1-minute intervals

Saharan Dust Layer Data

For SAL research, we used the GOES16 satellite image database to obtain meteorological and positional information from June to July of 2020. For images from July 2023, we used the CIMSS Tropical Cyclone Team, Cooperative Institute for Meteorological Satellite Studies / University of Wisconsin-Madison

UV Aerosol Index confirmation was obtained from Giovanni application of NASA EarthDATA services.

3 ON SITE MEASUREMENTS

The project site had a meteorological station with a set of sensors depicted in figure 3.1 and detailed in figure 3.2.

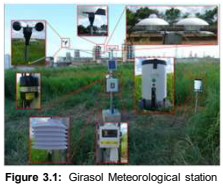

Figure 3.1: Girasol Meteorological station

Sensor type	Height above ground[m]
Anemometer	2.6
Rain Gauge	1.1
Wind Vane	2.6
Barometer	1.27
Temp Sensor	1.35
Relative Humidity	1.75
Pyranometer	2.55
Pyranometer	2.55

Figure 3.2: Meteorological Sensors

The most relevant sensors for this report are the pair of pyranometers, which measure global horizontal irradiance.

Figure 3.3: Girasol Meteorological station

Figure 3.4: Class A secondary standard pyranometers.

4 MET STATION IRRADIATION VS SAL 2020

Figure 4.1 shows a comparison between the irradiation measurements obtained from the pyranometers of the met station and the Geos16 satellite imagery obtained from CIMSS during June - July 2020. The irradiation is represented as daily average (blue line) vs the Saharan dust layer presence that is reported from 0 to 1, were 1 means strong dust layer (orange bars).

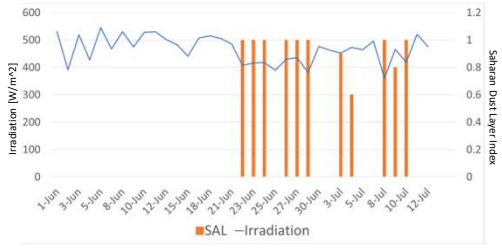

Figure 4.1: SAL Strong Presence Vs Average irradiation (W/sqm) June - July 2020

The daily average irradiation from **June 1st to June 21st in 2020** was **over 470 w/sqm to 520 w/sqm.** As soon as the Saharan dust cloud arrives, the irradiation is reduced drastically to 400 w/sqm. This massive African dust intrusion into the Caribbean Basin and Southern US, was nicknamed **the "Godzilla" dust plume**, due it´s size. (Observation and modeling of the historic "Godzilla" African dust intrusion into the Caribbean Basin and the southern US in June 2020)

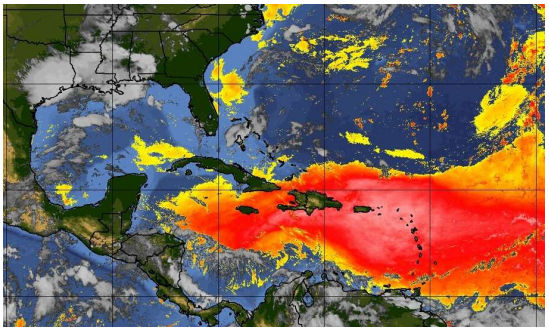

Figure 4.2: SAL or Godzilla over Dominican Republic on June 22nd, 2020

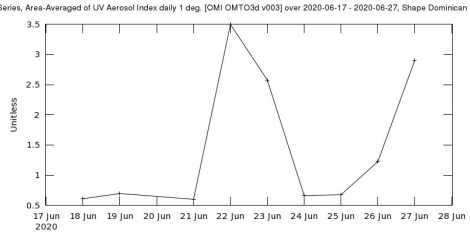

Figure 4.3: The UV Aerosol Index confirms the presence of SAL over Dominican Republic during June 21st to 24th 2020, been the 22nd the one with the strongest presence.

5 ENERGY PRODUCTION VS SAL 2023

In order to calculate the effects of SAL over energy production of a solar farm, we used the energy production reports of **Girasol PV plant**. A 120 MWdc project **developed, built, and operated** in the same place as the Metmast by **EGE Haina.** This park features 268,200 photovoltaic modules of 445/450 Wp and 28 inverters of 3.8 MW each. Its approximate annual production is **240,000 MWh**. It has a 150 MVA power substation and a 10 km long transmission line at 138 kV to inject the energy produced into the National Power Grid (SENI).

Figure 5.1: Girasol PV Plant

Comparing the daily energy production registered in Girasol PV plant during July 2023, while a strong Saharan Dust Layer was over the project area show an underperformance of energy generation.

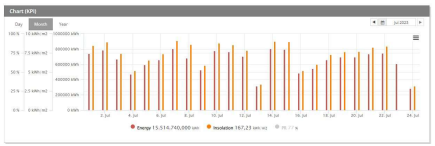

Figure 5.2: Daily energy production and insolation registered in Girasol PV plant during July 2023. **A SAL** was over Girasol PV Plant **on July 21st and 22nd 2023**, the energy output was around 7% to 8% smaller than a normal. Smaller data reported on the other days were caused by strong clouds and rainy days.

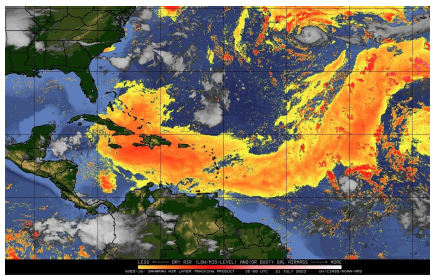

Figure 5.3: SAL over Dominican Republic, July 21st, 2023

In order to perform a fair comparison, 2 days with similar weather conditions were selected. The energy production during **July 7th** was **801,940 KWh, no presence of SAL was detected** whereas on **July 21st** the energy generated was **735,520 KWh. The Saharan dust layer** on this day **reduced** the energy production by **8.28% compared to July 7th.** the energy production was underperforming, raising alerts due low irradiation levels during non-cloudy and/or-non rainy days.

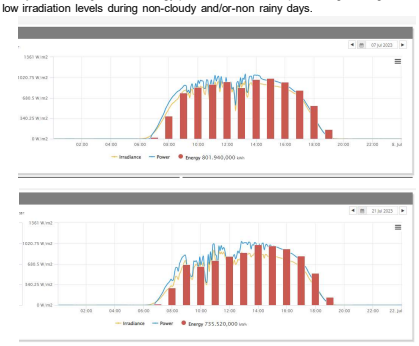

Figure 5.4: Daily energy production, irradiance and power registered in Girasol PV plant during July 2023. On the top July 7th, 2023. On bottom July 21st, 2023.

6 CONCLUSION

- Overall, there is ample evidence that suggests a link between the presence of Saharan dust in the region and the amount of solar irradiation received. It is evident that when there is an influx of Saharan dust, solar irradiation decreases. The sand particles act as a barrier, reducing the direct sunlight that can reach the Earth's surface therefore negatively impacting the solar energy generation potential.
- The SAL reduces global horizontal irradiation during peak hours by up to 20%, depending on the layer strength, as was shown during the measurements recorded in June 2020 of the Godzilla cloud, the biggest SAL to affect the Dominican Republic.
- This naturally affects energy production is by lowering irradiation and raising temperatures. As the particles in the atmosphere absorb light, they heat up creating a greenhouse effect that reduces a solar panels efficiency. Losses in energy generation can reaching up to 8%.
- Surprisingly, if the amount of SAL is classified as small, it provides a cloudless day and has a positive impact in energy production, by reducing the shadows generated by clouds, knowing that solar panels perform better under a clear sky conditions. Due the cyclical presence of Saharan Dust in the Caribbean, it is necessary to continue making observations and evaluations of the dust's effects on solar projects and should be considered for long term energy production assessments.

References

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Authors:

Méndez de Jesús, Príamo Virgilio
Rivera, Orlani
Lulo Abinader, Michel
Vicini Bonetti, Juan Enrique
Santana Tapia, Karla Marielle
Estévez Mejía, Ricardo

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