Ashesi Solar Monitoring Network (ASMONET): An IoT-Enabled Network for Ground-Based Soiling Measurements in West Africa

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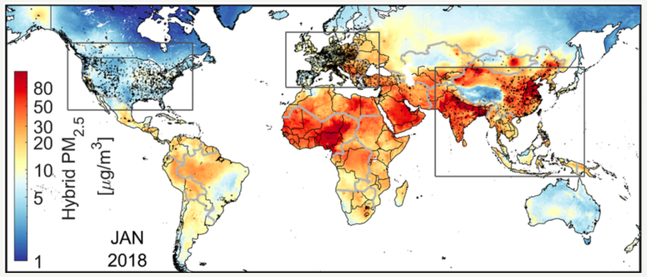
1 INTRODUCTION

- The Harmattan in West Africa can cause PV systems to lose more than 50% of power output to dust-soiling [1].



Estimates of global particulate matter concentrations [2]

This work aims to improve solar data availability in West Africa by designing a network of ground-based, IoT-enabled PV sensor systems to be installed throughout the region. Each system will provide data on solar panel performance, key environmental parameters affecting dust soiling, soiling mass accumulation, and relative loss in power output.

2 METHODS

There are three fundamental sub-systems of the Ashesi Solar Monitoring Network (ASMONET):

- A weather station. Shown in Fig. 1.
- A PV module soiling monitoring system. Shown in Fig. 1.
- Cloud-based web application.

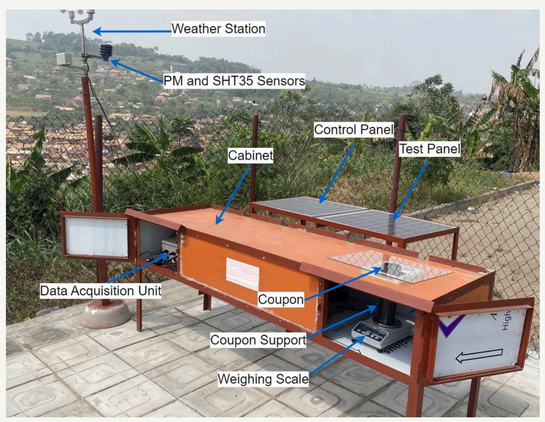


Fig. 1.

The weather station measures ambient temperature, humidity, rainfall, wind direction, wind speed, and PM concentration (PM1.0, PM2.5, PM4.0, PM10.0).

- Soiling is measured in terms of the mass of dust, and this is captured through a three-part setup comprising a control module, a test PV module, and a complementary glass coupon shown in Fig. 2.
- A weighing scale is used to measure the cumulative mass of the soiled coupon. This is used to approximate the mass of dust on the test panel.

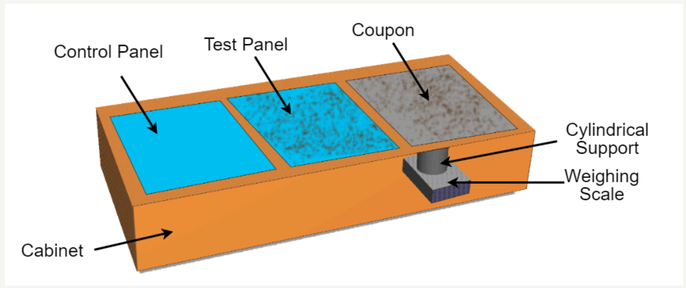


Fig. 2.

- Data is sampled every 3 minutes and uploaded to a cloud server for remote monitoring through a Wi-Fi gateway.
- A database on the cloud stores the incoming data, while a responsive web application is seamlessly interfaced to facilitate remote user interaction with the data. Fig. 3. shows this architecture.

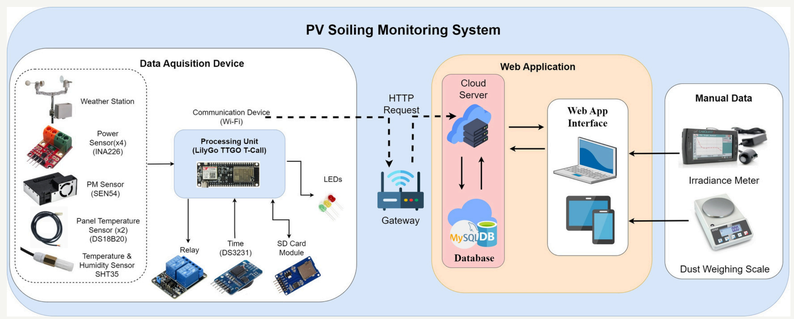
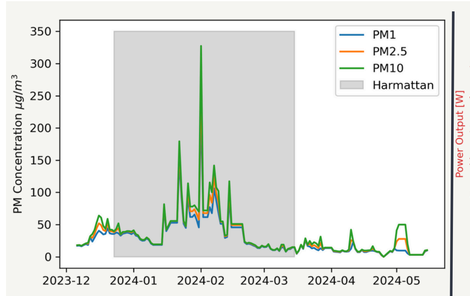


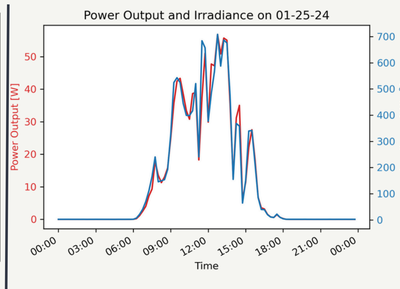
Fig. 3.

3 RESULTS

Data was collected from December 2023 to May 2024, exported from the web application, and processed. In a few cases, ASMONET was offline due to repairs, in which case a forward-filling algorithm was used to fill in missing data from these times.

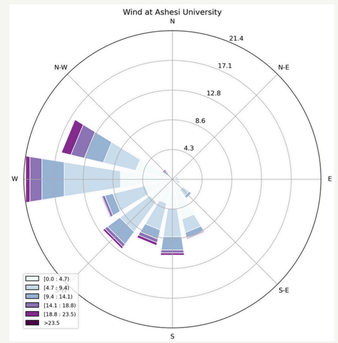


During the Harmattan season, when there is less precipitation and an influx of dust from the Sahara Desert in the region, PM concentrations for all sizes increase as expected.



There is a close association between the measured irradiance and the power output.

During this time, wind primarily originated from the West and Southwest directions. The fastest wind speeds came from the Northwest, with speeds as high as 20 m/s in some measurements.



4 CONCLUSION

- Installed a novel IoT-enabled solar monitoring system with soiling measurement capabilities and weather data collection.
- Developed a web application for real-time data viewing and historical data export.
- Future analysis will compare collected power generation, dust mass, and weather data with existing soiling estimation models.

REFERENCES

[1] S. Isaacs et al., “Dust soiling effects on decentralized solar in West Africa,” Applied Energy, 2023, [Online]. Available: https://doi.org/10.1016/j.apenergy.2023.120993.
[2] A. van Donkelaar et al., “Monthly Global Estimates of Fine Particulate Matter and Their Uncertainty,” Environ. Sci. Technol., vol. 55, no. 22, pp. 15287–15300, Nov. 2021, doi: 10.1021/acs.est.1c05309.