25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Assessing the impact of Australian bushfires on rooftop photovoltaic energy production

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Abstract: In 2022 in Australia, 2.7GW of new rooftop solar photovoltaic (PV) installations led the growth of renewable energies (RE) capacity additions, accounting for 25.8% of total Australian renewable generation (Clean Energy Council, 2023). As the number of PV systems increases, it becomes more important to understand how the solar resource varies in different spatio-temporal scales and the factors that modulate the PV energy production. During clear-sky days, atmospheric aerosols are one of the main solar radiation modulators, as they can attenuate the incoming solar radiation (Ali et al., 2022). Extensive regions of eastern Australia were affected by the bushfires during the “Black Summer” of 2019–2020, resulting in significant health impacts, animal deaths, and destruction of infrastructure. Furthermore, the remarkable bushfires injected smoke-related aerosols into the atmosphere, which also affected the PV energy production. In this study, we assess the impacts of high particulate matter (PM) concentrations in PV energy production in New South Wales (NSW), from November 2019 to January 2020, during the Black Summer bushfires. We use in-situ measurements of 20 air quality stations from the NSW Air Quality Monitoring Network and the Schools Weather and Air Quality Network, and energy generation data from more than 100 commercial rooftop PV systems. We also incorporate satellite data from Himawari-8 (including the Level 1 bidirectional reflectance factor for Channel 1, and Level 2 aerosol optical depth (AOD) at 500nm and shortwave solar radiation). We only analyse clear-sky days, to eliminate the impact of clouds and focus solely on the impact of aerosols. We compare the energy generated by rooftop PV systems during clean and polluted conditions, by performing a diurnal cycle conditional analysis. We also analyse the wind, temperature and relative humidity conditions during the period of interest.

Results show that most stations exhibit a similar behaviour, with PV generation reductions in polluted conditions compared to clean environments. As expected, the air quality impacts are more pronounced in locations near bushfire burning areas, such as in Katoomba, where the mean reductions in PV energy during high PM episodes could reach up to 20%. But even stations located several tens of kilometres away from the bushfires were affected, due to high-speed westerly winds that transported the smoke and reduced the air quality and PV energy generation in most stations across Sydney. On a particular day of high bushfire activity (10 December 2019), we use satellite information to show how smoke caused increases in aerosol levels, increased PM concentrations, attenuated radiation and produced up to 65% reductions in hourly PV energy. We suggest that Himawari-8 AOD is a good predictor of PV energy production during clear-sky conditions, due to the high degree of linear correlation between the two variables. Therefore, further studies will incorporate Himawari-8 AOD in the modelling of solar resources and PV energy generation in Australia. The methodology used in this study could be replicated in other bushfire-prone areas with high integration of solar energy to understand the factors that influence PV energy production and contribute to the clean energy transition.

REFERENCES

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Keywords: *Rooftop solar photovoltaics, solar energy, bushfires impacts, atmospheric aerosols*