Climate change may cause disruptions to solar generation in the future, modeling suggests

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Climate change may affect the future stability of grid-connected solar power systems—something that needs to be considered in the planning of Australia's renewable energy transition.

Modeling conducted by researchers from UNSW Sydney shows the magnitude, frequency and duration of disruptive solar generation events, called ramps, will significantly change over the next century. The findings, published in *Scientific Reports*, could help inform the development of future solar power infrastructure in Australia.

Grid-connected solar power systems—sometimes called large-scale photovoltaics (PV)—are Australia's fastest-growing renewable energy technology.

As solar energy relies on the direct conversion of sunlight into electricity, there is inherent variability in power generation due to factors like cloud cover, time of day, seasonal cycles, and location. Sudden variability can lead to mismatches between electricity supply and demand, which, if unmanaged, can cause power outages or complete grid failures.

"Solar PV generation is affected by climate factors, which makes it susceptible to climate change," says Shukla Poddar, lead author of the study and a Ph.D. Candidate at the School of Photovoltaics and Renewable Energy Engineering. "For example, changes to the way clouds pass over solar panels could cause sudden decreases (ramp-downs) or increases (ramp-ups) that can cause voltage fluctuations and blackouts."

In 2022, 35.9% of the total electricity generated in Australia was from renewables, with solar being the highest renewable energy contributor to the grid. With notable large-scale PV deployment planned, including the world's largest solar farm in Powell Creek, Australia, modeling future ramps is crucial for ensuring stable power generation as Australia increases its reliance on large-scale solar.

"Using more variable renewables like solar can impact the stability of the electricity grid as they can provide power intermittently as clouds pass over," says Associate Professor Merlinde Kay, co-author of the study and lecturer in the School of Photovoltaic and Renewable Energy Engineering. "So, this work is essential for grid operators, who are responsible for managing and maintaining a reliable electricity network, to understand how these ramp events will change with climate change so they can plan this adoption accordingly."

Managing solar power ramps

For the research, the team used regional climate projections to model solar ramps across Australia to 2100 under an intermediate and high emission scenario. They found ramp events are likely to become longer and more frequent across the east coast and parts of Northern Australia, though their magnitude will likely shrink. The changes are more significant under high emissions—a scenario Australia is currently headed towards.

"Overall, it means that we should expect solar ramps to become more common over the next century with climate change, though this does differ between locations and future emissions," Poddar says. "For grid operators, it means they need to be prepared with the proper technologies and strategies to manage more regular intermittency issues."

Managing the fluctuations caused by solar ramps is possible through mass storage technology and diversifying the renewable energy mix in the grid.

"During ramp-up events, large batteries can store excess solar to help reduce the strain on the grid," Kay says. "In a ramp-down event, the stored energy can be fed back into the grid to help compensate for the loss in solar power and maintain grid stability.

"Combining this with renewable energy technologies like wind, which can operate at night, is also essential, and is already working quite well in places like South Australia at The Hornsdale Power Reserve with the Tesla battery powerpack."

Building solar farms in optimal locations is another strategy for mitigating against power ramps. The researchers hope the findings of their study will help inform future solar farm developments worldwide, something they will look to identify further in future research.

"The framework we've developed here to study future ramp events spatiotemporally using climate modeling can be applied to different places around the world to ensure optimum grid operations in the future as the climate changes," Poddar says.

More information: Shukla Poddar et al, Assessing Australia's future solar power ramps with climate projections, *Scientific Reports* (2023). DOI: 10.1038/s41598-023-38566-z

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