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Predictive Power: Unlocking Grid Stability Through Solar Forecasting

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Abstract: The energy transition is changing the way that power flows through the grid. In the past, most power came from a few large power sources and flowed one way to homes and businesses. Now, with the increase in consumer energy resources such as rooftop solar, electricity is also being produced at many smaller, distributed sources and can flow in both directions. This means that the power system can no longer be operated at the transmission level alone by the Transmission System Operator (TSO). To deal with this, actions have been taken by Distribution Network Service Providers (DNSPs) around the country to actively manage the power flows on their networks, and these actions in turn impact the predictability of demand and supply on the overall energy system.

DNSPs are increasingly managing dynamic bidirectional flows of energy and associated market interactions. This evolution of function is known as a Distribution System Operator (DSO). In the case of SA Power Networks, the 'Flexible Exports' program allows the network to dynamically adjust a customer's rooftop solar exports to the electricity grid based on the real-time network capacity. These solar exports are adjusted in cases where excess solar generation has the potential to exceed network limits, causing local or system-wide issues. Other DNSPs (including Ausnet in Victoria and Endeavour Energy in New South Wales) have implemented similar programs.

The project aims to address how our TSO - the Australian Energy Market Operator (AEMO) could anticipate and respond to changes that emanate from the DNSPs, to maintain system security and manage minimum system load conditions. In the case of SA Power Networks' actions, AEMO would like to be able to anticipate the flexible export limits enacted to turn down solar generation.

There are also rare situations where the network experiences extreme low system load conditions, making it necessary to remotely switch off solar generation entirely, in accordance with emergency backstop arrangements. To support greater coordination between DNSPs and AEMO, there is a growing need for a well-defined DSO/TSO interface. At present, much of this coordination is still managed manually – for example, some solar backstop events are triggered through phone calls between operators.

The project seeks to create a better understanding of AEMO and SA Power Networks' operational requirements and current capabilities, by working collaboratively to identify and bridge gaps. New processes and systems are required to ensure that changes in solar generation due to DNSP activation of flexible export limits and/or emergency backstops are visible and predictable to AEMO. In the future, we also aim to collaborate with other DNSPs to share learnings and inform their work programs as they implement similar actions.

From a mathematical and data modelling perspective, this project represents a significant uplift in forecasting capability, particularly in the context of integrating weather-dependent variables into energy system predictions. The model that we use to forecast flexible export limits and curtailment will need to account for the inherent variability and uncertainty of weather conditions, such as solar irradiance, temperature, and cloud cover. One of the key challenges lies in balancing the trade-off between short-term accuracy and long-term forecasting horizons, as weather forecasts tend to lose precision over time.

The desired outcome is for AEMO to have visibility and predictability of when flexible export limits and emergency backstop measures are being applied. This will be crucial for AEMO's operational forecasts and planning. We aim to develop automated infrastructure and data exchange protocols to provide AEMO with visibility and predictability of DNSP operational actions. This should also enable transmission and/or supply-side constraints to trigger DNSP operational actions.

Keywords: *Energy transition, distribution system operator, solar forecasting*

