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Analysis of deviations in electricity demand forecasts

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Abstract: The Australian Energy Market Operator (AEMO) operates and manages energy markets across Australia, including the National Electricity Market (NEM) which spans five eastern and southern states and the ACT. AEMO plays a critical role in maintaining system reliability by making scheduled forecasts of total electricity demand and providing price signals to market participants for up to 39.5 hours in advance of dispatch through the pre-dispatch process.

AEMO's demand forecasting process uses historical and real-time data, forecasts of weather conditions—particularly temperature and humidity—and estimates of rooftop solar generation, also known as small-scale distributed photovoltaic (PV), as core inputs to the Demand Forecasting System (DFS**)**. While these forecasts provide valuable insights into general market trends, they can differ from the actual demand. Understanding the magnitude, direction, and root causes of these deviations is essential for improving system reliability. However, key features like weather conditions remain sources of uncertainty, while PV output introduces more challenges due to its independence from the NEM.

This project is conducted as part of the University of South Australia's 2025 Mathematics Clinic, a year-long sponsored research program that provides final-year mathematics undergraduates with experience applying mathematical methods to real-world industry problems, mentored by academic advisors. The work is supported by AEMO and carried out in collaboration with its Operational Forecasting (OPF) team**.**

As a third-party evaluation of AEMO's forecasting, the process begins with developing a thorough understanding of the datasets and establishing a robust data processing pipeline. Visualisation techniques are applied to detect patterns in forecast errors, including their direction, magnitude, and anomalies, using appropriate metrics. Influencing factors such as forecast horizon, day type, time of day, and season are examined to determine whether they are adequately addressed in the forecasting process. The analysis also considers the impact of uncertain variables on forecast accuracy, as well as the potential influence of price deviations or any other contributors.

To identify key trends in forecast deviation magnitudes across these factors, polar plots, treemaps, heatmaps and time-bucketed charts are developed. The analysis shows that in south–southeast regions, error patterns become more consistent with longer lead times, generally increasing in magnitude and shifting toward overestimation. Midday hours show the largest deviations, notably reaching 15–25% of average demand in South Australia. Seasonal effects show a tendency toward overestimation in summer, shifting to underestimation in winter across most times of the day. Weekly demand cycles are present but are captured by the forecasts, resulting in no significant error.

The visualisations we have developed provide insights into systematic patterns in forecast deviations. By identifying when, where and under what conditions these errors occur, we present opportunities to refine AEMO's forecasting models. These improvements may enhance AEMO's forecast transparency, supporting more efficient market operations, reducing costs, and enabling better-informed decision-making by market participants.

Keywords: *AEMO, electricity demand data analysis, electricity markets, forecast accuracy*