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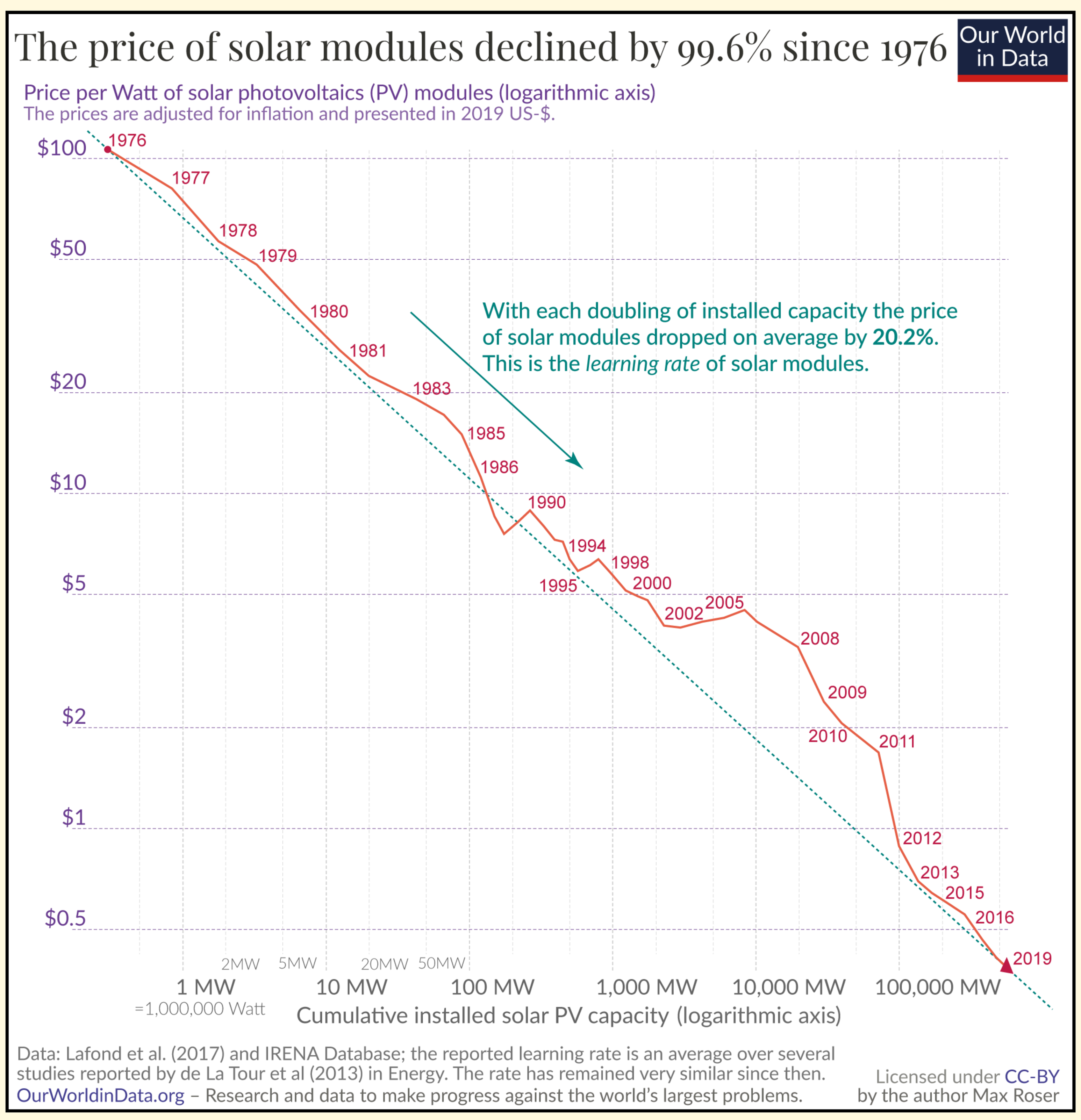
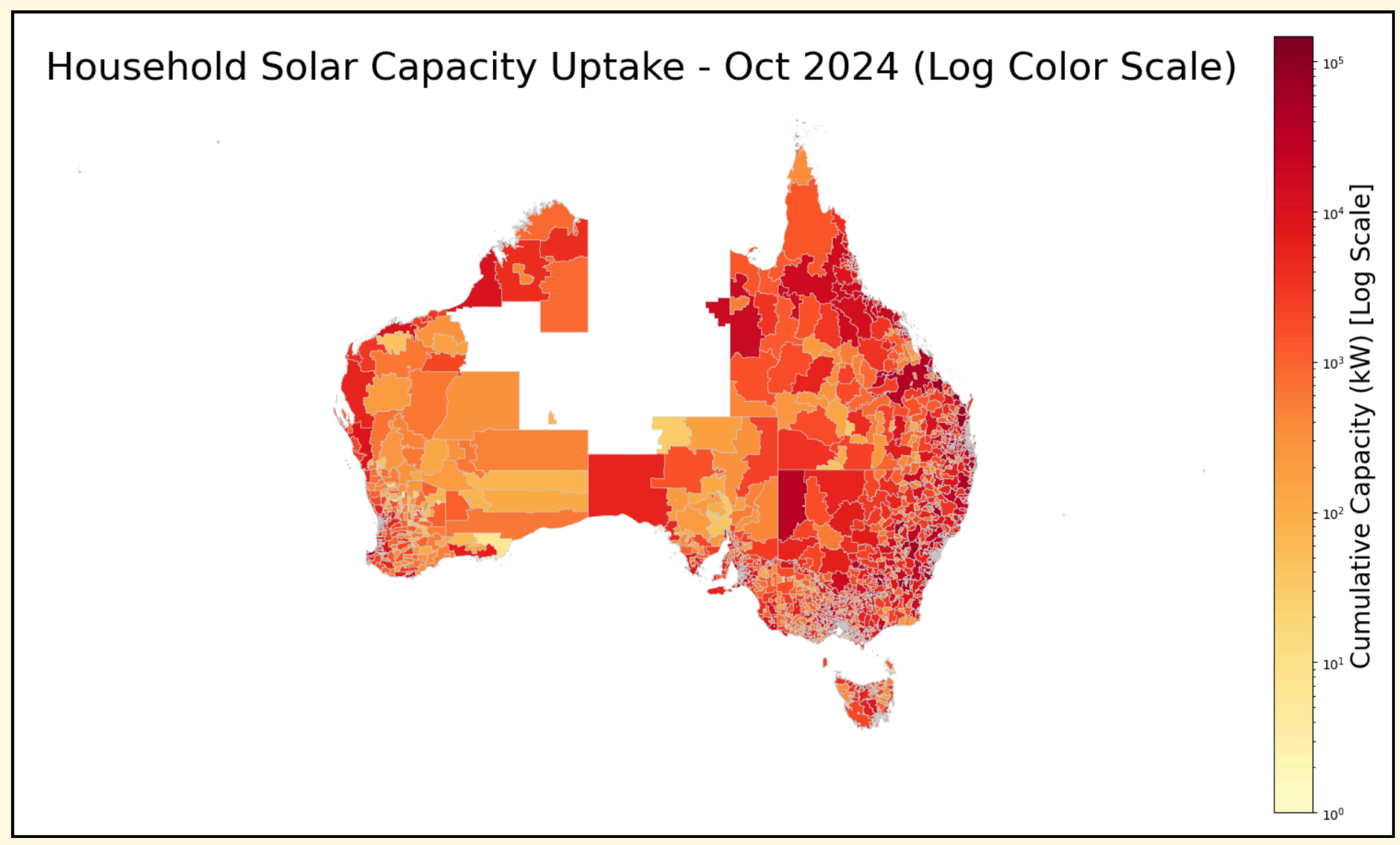
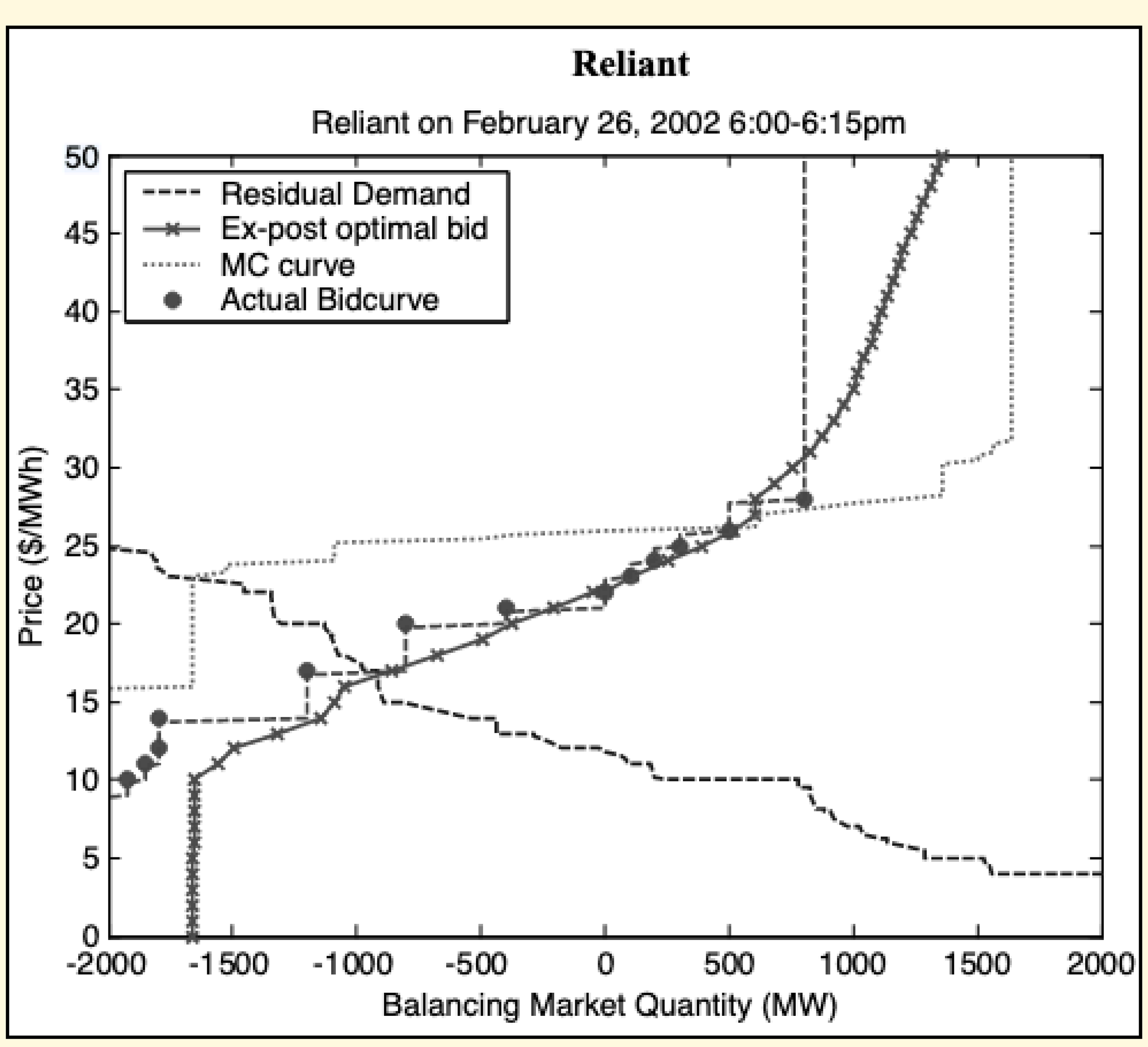
Decentralisation in electricity markets: the effect of household solar on strategic bidding in the Australian spot market

Introduction and Research Importance

1. The Australian National Electricity Market (NEM) is at the leading edge of what **electricity markets in the future** will look like. This is due to Australia's rapid adoption of renewables, extreme natural environment, and sophisticated financial markets.
2. In recent years, this has resulted in the **price of electricity** in the spot market being extremely **volatile**. The price has both spiked to over $5,000/MWh and turned negative a record number of times.
3. Traditionally, coal power stations have provided the base load of generation. However, they now face **greater uncertainty** than ever due to the inherent variability of renewable production. Coal assets remain necessary to meet the early evening demand spike, but in the middle of the day, coal generation is squeezed by the twin realities that solar generation has zero marginal cost and coal power stations face high shutdown and cold start costs.







Methodology

1. Firstly, the **degree of profit maximisation** is measured for each power station in the electricity spot market, based on a managerial optimisation model for individual power stations. The spot market operates as a uniform price auction every five minutes. Visually, the graph in the lower left corner illustrates the profit maximisation measure intuitively—it represents the distance between the ex-post optimal bid curve and the actual bid curve submitted.
2. Secondly, the extent to which firms exhibit **learning-by-doing** over time is estimated by analysing changes in the profit maximisation measure. A key focus is the **heterogeneity** among firms—for instance, do small or large firms adapt their bids more quickly in response to the uncertainty created by the surge in renewable energy sources?
3. Thirdly, a **Cognitive Hierarchy model** is applied to explain how differences in firm sophistication result in deviations from rational market equilibrium. A Level-0 firm behaves non-strategically, while a Level-1 firm acts strategically by adjusting its bid in response to unstrategic Level-0 firms. More generally, a Level-k firm formulates its bid based on the behavior of firms at Levels 0 through k-1.

Findings and Policy Implications

1. Firms operating small coal plants are the **least profit-maximising** and demonstrate the **lowest levels of learning-by-doing**. This suggests that policies aimed at phasing out these plants or encouraging their consolidation with larger firms could lead to a more efficient electricity market.
2. The strongest predictor of firm sophistication is firm size. Since greater firm sophistication contributes to a more efficient market, policies that incentivize more **sophisticated bidding strategies** could further enhance **market efficiency**.
3. The advancement of **battery technology** should be a policy priority. This is the most effective solution for addressing the "**renewable gap**" during early evening peak electricity demand and supports the transition away from coal power.

Conclusion and Future Research Directions

1. An important extension to the model in this research would be to investigate the **sequential nature** of firms' decision-making, not just the static optimisation problem. Withholding supply of electricity in one period to supply electricity in future periods may increase a firm's profits.
2. Another promising research direction is to examine the role of **battery storage** and assess the applicability of the findings to the **United Kingdom**.