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Electricity procurement and storage investment for risk-averse hydrogen producers: A stochastic approach using modeling to generate alternatives

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Extended Abstract

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Abstract Summary

This paper explores the complex electricity procurement and storage investments for green hydrogen producers aiming for a constant baseload supply. Producers must meet strict EU (RED II) criteria for renewable hydrogen, typically achieved through Power Purchase Agreements (PPAs). To navigate this challenge, the authors propose a novel stochastic optimization model designed to minimize the Levelized Cost of Hydrogen (LCOH). Unlike traditional models that optimize for a single weather year, this approach incorporates multi-year weather data to ensure resilience against inter-annual meteorological risks. Furthermore, it integrates investor risk aversion through the Conditional Value at Risk (CVaR) and employs a Modeling to Generate Alternatives (MGA) framework to explore practical, near-optimal portfolio configurations rather than just a single, potentially unattainable theoretical optimum.

The findings reveal that stricter temporal matching requirements significantly increase the LCOH. This cost escalation is most pronounced when there is a substantial divergence between PPA prices and electricity market values, a situation often influenced by renewable energy support frameworks.This occurs because strict matching compels producers to over-procure expensive PPA power to guarantee supply during low-generation hours, forcing them to sell any resulting surplus electricity back to the grid at a loss due to those lower market prices. The study also highlights a clear trade-off between maximizing expected profits and securing returns during worst-case weather conditions. Risk-averse producers can effectively mitigate potential revenue losses through the spatial and technological diversification of their PPA portfolios, sacrificing only a marginal amount of overall profitability. Finally, the exploration of the near-optimal solution space demonstrates that while various structurally distinct portfolios can achieve comparable economic success, specific key technologies—namely offshore wind and hydrogen storage—remain indispensable across almost all resilient investment scenarios.

Presenting Author Biography

Felix Schaefer has been a research associate at EWI and a doctoral candidate at the University of Cologne since 2023. His research focuses on the techno-economic modeling of electricity markets and grids. Another research field is the analysis of the hydrogen market ramp-up. In consulting projects, he has advised the Federal Ministry for Economic Affairs and Energy (BMWE), RWE Gas Storage West GmbH, E.ON SE, and various industry associations and energy companies on these topics. Before joining EWI, Felix Schäfer studied economics at the University of Cologne and Boğaziçi University (Istanbul, Turkey), focusing on energy economics, markets, and institutions.