FIPSE-6 Short Presentation 1b

Design and Capacity Planning Challenges in Green Hydrogen Supply Chains: A PSE Perspective

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ABSTRACT

This presentation provides a detailed exploration of the design and planning aspects of green hydrogen supply chains, focusing on the perspective of process systems engineering (PSE). *Green hydrogen, produced from renewable energy sources such as solar and wind*, is emerging as a key player in the shift towards sustainable energy, offering a zero-carbon energy solution. Despite its clear environmental advantages, there remain significant challenges, including high production costs and insufficient infrastructure. These issues underscore the importance of precise economic evaluations and the optimization of supply chain designs. In addressing these challenges, several complex factors come into play:

- Multi-time Scale Complexity: The development and operation of green hydrogen supply chains involve intricate links between various elements, compounded by the unpredictable and fluctuating nature of renewable energy sources (RESs). Conducting analyses on a granular, hourly basis is crucial to accurately capturing the volatile and time-sensitive characteristics of RESs, while planning for capacity might extend over many years. Optimizing such expansive systems can result in enormous mathematical programming challenges, which become even more daunting when uncertainties are factored in.
- Global Scope: The international scope of green hydrogen supply chains adds layers of complexity, encompassing diverse countries and legal frameworks.
- Technological Variability: The wide range of technological choices available for production, storage, transport, and distribution adds further complexity to the planning and design process, presenting a myriad of potential pathways.

The presentation delves into the **modeling and computational hurdles** presented by these factors, particularly focusing on the multi-time scale nature. It discusses how PSE and artificial intelligence (AI) tools can be used in tandem to overcome these challenges. In particular, the integration of mathematical programming methods like Mixed-Integer Linear Programming (MILP) and AI techniques such as Bayesian optimization and reinforcement learning should be explored to solve complex *multi-stage stochastic optimization problems* that span various time and spatial scales.

Fusing PSE methodologies with AI capabilities can provide a robust framework to navigate the

complexities of designing and planning green hydrogen supply chains. The combination of mathematical precision and the adaptability of machine learning has the potential to offer promising solutions and insights, aiming to advance the progress and implementation of sustainable energy systems.

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