School of Systems Science and Industrial Engineering
Ph.D. Dissertation Defense

The Optimization of Solar Hydrogen Production to Enable the Decarbonization of the Industrial Sector: *A Focus on Spatiotemporal Modeling*

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1:30 - 3:00 PM, Eastern

Meeting Location (Via Zoom): Link

Abstract

Rising concentrations of greenhouse gas emissions worldwide, necessitate the need for deep decarbonization across all sectors of the economy. The use of hydrogen has emerged as a promising solution to decarbonize the hard to electrify sectors of the economy such as industrial manufacturing, shipping and heavy duty transport. The advantages of hydrogen include its potential production from electricity, ability to support long term-energy storage, and the absence of carbon-based emissions at the point of combustion. Despite these benefits, significant challenges continue to hinder its wide scale adoption, including cost effective production, a high land use intensity, and the lack of infrastructure. To address these challenges, the research described in this dissertation uses a high technical, spatial and temporal resolution multi-period optimization model to describe the system properties that emerge with the continuous production of 100% zero-carbon solar hydrogen when considering land use constraints across more than 35,000 possible locations in the continental US.

The research presented in this dissertation examines the tradeoffs between different energy storage systems (mass storage, and battery energy storage systems) supporting 100% zero-carbon solar hydrogen production plants, and assesses the resulting impacts on system design, production dynamics, and cost. In addition, this work identifies, and characterizes the properties of robust plant designs that can further insulate the natural variation of solar to ensure the continuous production of hydrogen without strong dependencies on any source of hydrogen to meet the production targets of a given plant. The results from this dissertation show that under certain conditions it is possible to produce solar hydrogen at an industrial scale at a cost that is less than $2.50 per kg, even when using more expensive aboveground hydrogen storage systems.

Overall, the work described in this dissertation serves as a valuable decision support tool for use with the planning of industrial scale solar-powered hydrogen production plants to support the decarbonization of the industrial sector.