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Least-cost optimisation of common energy infrastructure for multi-industry low emissions hubs: Implications of hydrogen demand

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Abstract: Multi-industry low emissions hubs will be developed as a means of reducing greenhouse gas emissions from industry and are of relevance to Australia's energy infrastructure planning (e.g., Energy Policy WA 2023). Such hubs are expected to consist of several industries sharing common energy infrastructure, which may include electricity, natural gas, hydrogen, CO_2 and steam networks. Establishing hubs will involve determining the optimal mix of energy technologies and infrastructure to reduce emissions while minimising costs to industry. Hydrogen is an emerging energy carrier that will likely play a significant role with the development of hydrogen hubs to scale up its deployment and reduce its cost being part of Australia's National Hydrogen Strategy (Commonwealth of Australia 2019). In this work, we develop a linear model to investigate the implications of electricity and hydrogen demand on the least cost optimisation of common energy infrastructure for multi-industry low emissions hubs.

Our approach is based on linear programming and mixed-integer linear programming to determine the optimal mix of energy technologies and infrastructure that meet the energy demands of the hub while minimising costs and providing the resulting emissions footprint. We consider various energy technologies such as solar PV, wind turbines, gas turbines, batteries, other energy storage systems, electricity transmission, and hydrogen production, storage, and transport.

We aim to present progress in application of our approach to a case study of a multi-industry low emissions hub and evaluate the economic benefits of different energy infrastructure scenarios. Of particular interest will be application of the model to investigate how the inclusion of hydrogen demand impacts the resulting infrastructure, and how that may differ from a more traditional build out. The integration of hydrogen production and storage technologies into the model will be presented, along with its impact on the resulting energy infrastructure under various future technology cost assumptions.

We will also evaluate the trade-offs of different hydrogen production and storage technology options, such as electrolysis, steam methane reforming, compressed hydrogen, and liquid hydrogen. Our model will incorporate the availability of renewable energy sources, and the distance to, scale, and temporal profile of the hydrogen demand.

While this paper will focus on the mathematical model, implementation, and initial results of our tool, the future application will inform policymakers and industry stakeholders on the trade-offs and benefits of hydrogen production and storage for multi-industry low emissions hubs.

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