Optimisation of energy supply to industry hub with multi-criteria selection and techno-economic assessment

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Abstract: Transitioning the energy supply for heavy industry to net-zero emissions requires new planning tools and decision-making frameworks. This study presents an integrated optimisation framework combining multi-criteria analysis with a hybrid energy supply model to determine optimal infrastructure for electricity, heat, and hydrogen provision in a generic industrial process. The framework is applied to a case study in South Australia, generating spatially resolved maps of Levelised Cost of Energy (LCOE) and identifying optimal hub configurations for generation, production, storage, and transport components. The methodology supports strategic energy system design and is adaptable for application in other industrial regions.

1. INTRODUCTION

The heavy industry sector is responsible for around one-third of global energy use and a quarter of greenhouse gas emissions, making it a key target for decarbonisation. Designing energy infrastructure for industrial hubs requires balancing renewable resource availability, land use, and proximity to transmission, while ensuring cost and reliability. This study proposes an optimisation framework combining multi-criteria site selection with techno-economic assessment. Geospatial and infrastructural factors are used to score potential sites, and a hybrid energy supply system is modelled to deliver electricity, heat, and hydrogen. The framework is applied to South Australia's Whyalla region to optimise energy infrastructure planning.

2. METHODOLOGY AND RESULTS

As part of the multi-criteria selection process, a spatial grid with cells measuring 4 km × 4 km was generated to cover the entirety of South Australia. Each grid cell was evaluated and assigned a score for multiple constraints, generally following the approach proposed in [1]. Table 1 summarises the constraints, their data sources, and weights. The overall score for each grid cell was calculated as a weighted sum of these individual constraint scores. Following the generation of the final score map, the highest-ranking locations within the designated Renewable Energy Zones (REZs) were identified. Specifically, the top 30% of scoring sites within the REZ boundaries were selected and carried forward into the hybrid energy supply model for further techno-economic assessment.

Table 1: Data source and weight of constraints.

Constraint	Data source	Weight
Wind resource	BOM BARRA-C2 [2]	18%
Solar resource	BOM Himawari-8/9 [3]	12%
Electrical network	Digital Atlas Australia [4]	10%
Cadastral parcel density	Land use Generalised [5]	10%
Land cover	Geoscience Australia [6]	10%
Roads	Geoscience Australia	5%
Terrain complexity	Geoscience Australia	10%
Airports	Geoscience Australia	Exclusion
Population density	Australian population grid [7]	10%
Protected areas	Digital Atlas Australia [8]	10%

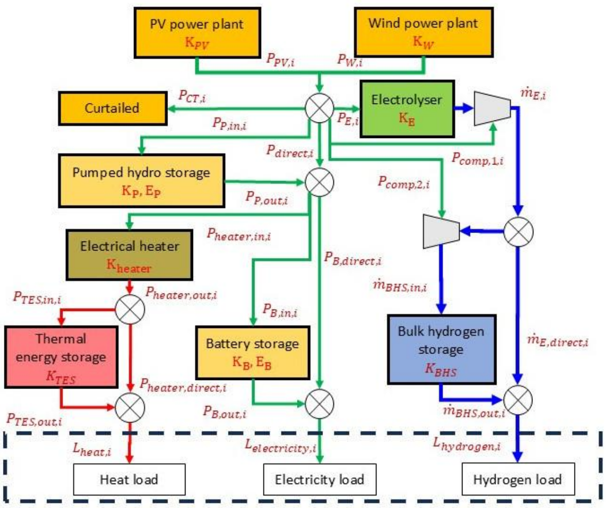

Figure 1: Diagram of the hybrid energy supply system

The hybrid energy supply system, illustrated in Figure 1, sources its electricity from solar PV and wind generation. Hydrogen and heat production are enabled through the use of an electrolyser and electric heater. A range of storage technologies are incorporated, including pumped hydro and battery storage, thermal energy storage, and hydrogen storage. The system is designed to meet a continuous demand of 100 MW each for electricity, heat, and hydrogen. The model is developed using a linear programming implemented in MiniZinc [9]. Cost assumptions are primarily drawn from established sources, such as GenCost [10]. The objective function is to minimise the LCOE.

Figure 2 presents the resulting LCOE map, with values ranging from 94.5 USD/MWh to 190 USD/MWh. The lowest LCOE regions are predominantly located near the end-user site in Whyalla. This is largely attributed to the favourable renewable energy resources and lower locational cost factors in nearby REZs. Additionally, proximity to the end user reduces the cost of transmission lines and hydrogen pipelines compared to more distant REZs. Figure 3 illustrates the system configuration for the optimal case. In this scenario, both power generation and hydrogen production are located in REZ S3, with the generated electricity and hydrogen delivered to Whyalla via transmission infrastructure and hydrogen pipelines. The resulting LCOE for this configuration is 94.5 USD/MWh.

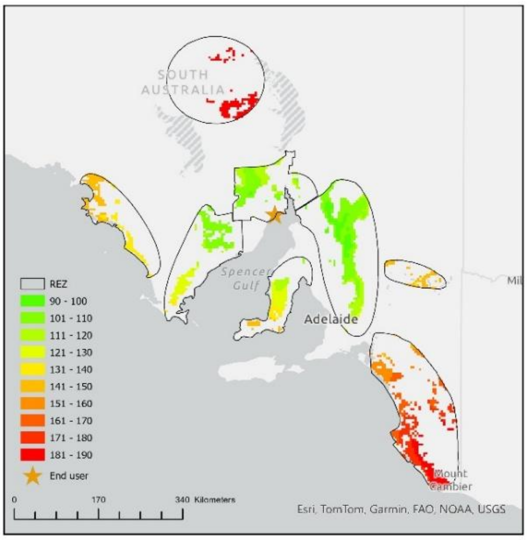

Figure 2: LCOE map across South Australia

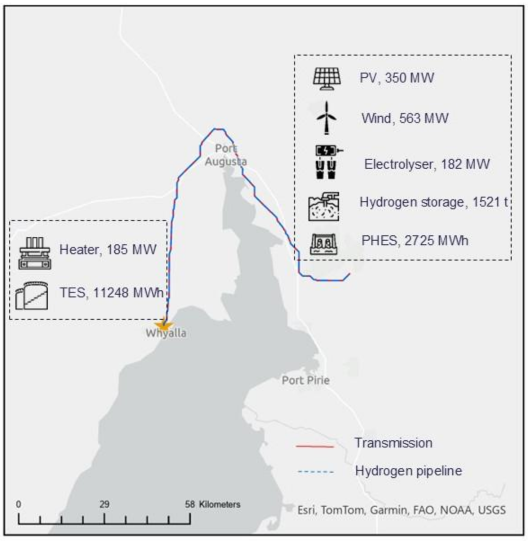

Figure 3: Hub configuration of the optimal case. Heater and thermal energy storage (TES) are located at end user. PV, wind, electrolyser, hydrogen storage and pumped hydro (PHES) are co-located in the production site.

3. CONCLUSIONS

This study presents an integrated framework combining multi-criteria site selection and techno-economic optimisation to inform energy infrastructure planning for industrial decarbonisation. Applied to Upper Spencer Gulf region, the framework identifies optimal locations and configurations for a hybrid energy supply system delivering electricity, heat, and hydrogen. The optimal case achieved a minimum LCOE of 94.5 USD/MWh. Across the state, LCOE values ranged up to 190 USD/MWh, highlighting the strong spatial dependence of energy supply costs. The framework offers a robust and adaptable tool to support net-zero industrial transitions.

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REFERENCES

[1] AEMO (2018). Multi-Criteria Scoring for REZ Identification.
[2] Su, C.-H., Rennie, S., Torrance, J. (2022). BARRA-C2 Atmospheric Reanalysis. BoM.
[3] BoM (2025). Himawari-8/9 Solar Irradiance Dataset.
[4] Digital Atlas Australia (2024). Electricity Transmission Lines.
[5] DCCEEW (2023). Land Use Generalised Dataset.
[6] Geoscience Australia (2023). Land Cover, Roads, Terrain & Infrastructure Datasets.
[7] ABS (2025). Australian Population Grid, 2023–24.
[8] CAPAD (2024). Collaborative Protected Areas Database – Terrestrial and Marine.
[9] Nethercote, N. et al. (2007). MiniZinc: A Standard CP Modelling Language. CP 2007.
[10] Graham, P., Hayward, J., Foster, J. (2024). GenCost 2024–25 Consultation Draft. CSIRO.

