26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Optimisation of renewable electricity supply for brackish groundwater desalination in Western Australia

Helen Wu, Sam West and Jenny Hayward

Commonwealth Scientific and Industrial Research Organisation (CSIRO) Energy Centre, Newcastle 2300, NSW Australia
Email: jenny.hayward@csiro.au

Abstract: This study has explored the potential for brackish groundwater desalination in Western Australia (WA) to be powered by standalone hybrid renewable energy power systems, which include solar photovoltaics (PV), onshore wind, battery energy storage and diesel generators for backup power. The detailed optimisation analysis was conducted across the Perth Basin, Carnarvon Basin, West Canning in the Canning Basin, the Alluvial Fan region in East Pilbara, the Karratha Hinterland region in West Pilbara, and selected palaeovalley regions such as Murchison. Additionally, specific locations associated with remote communities were included in the analysis.

Keywords: *Renewable energy, desalination, optimisation, techno-economics*

1. INTRODUCTION

Brackish groundwater resources across Australia and their suitability for desalinisation are poorly understood. Using brackish groundwater resources can improve security of water supply to local communities and existing agricultural or other industrial uses in areas with a scarcity of freshwater supplies, further supporting regional development and water security. Brackish water desalination offers several advantages over desalination of highly saline water, including higher water recovery rates, lower energy requirements, and reduced brine stream volumes. Desalinated water is more expensive than sourcing water from conventional sources however, due to the lower salinity of brackish groundwater compared to seawater it should be lower in cost than seawater desalination.

Barron et al. (2025) have identified and characterised brackish groundwater resources in several basins across the whole of WA with the potential for beneficial use once the water has been desalinated. However, the energy required for desalination is high, and can represent up to 50% of the total cost of desalinated water (excluding brine disposal). There are two isolated electricity networks in WA: the South West Interconnected System (SWIS) and the North West Interconnected System (NWIS). There is limited overlap between these networks and potential groundwater basins. In addition, when powered by fossil fuels, desalination also produces significant greenhouse gas emissions.

2. METHODOLOGY

The Bureau of Meteorology Atmospheric high-resolution Regional Reanalysis for Australia (BARRA) data from 1990 to 2019 were used to develop solar PV and wind farm electricity production profiles in 12 km grids across the groundwater regions and remote communities. Integrated with this were battery storage systems and diesel generators required to meet demand for a desalination electricity load which was supplied from a reliability level of 60% up to 99.9%. A range of reliability levels were explored due to the potential for variability in the operation of desalination plants, which is typical for small-scale plants powered by renewable energy. Larger plants with more than one desalination "train" can turn trains on and off to vary their load in response to changes in prices and/or the availability of renewable electricity. However, there can be issues with membrane fouling and thus increased operations and maintenance costs when turning desalination plants off and on.

Wu et al. (2025b) conducted a bi-objective optimisation at each of the more than 2,500 sites over all BARRA dataset years to minimise the levelised cost of electricity (LCOE) and maximise reliability. The capital cost data was sourced from Graham et al (2023). Remoteness factors were not applied to the cost data to simplify the optimisation process. The results for selected reliability levels have been summarised and presented.

3. RESULTS

The results show that a hybrid system combining solar PV, wind turbines, battery storage, and diesel generators for backup can supply a constant 100 kW load with 99.9% reliability across the modelled locations in WA. The LCOE for these hybrid systems ranges between \$0.12/kWh and \$0.38/kWh, depending on the location.

The locations with the lowest LCOE are the Carnarvon Basins, the Karratha Hinterland in the West Pilbara, West Canning in the Canning Basin, and the northern parts of the Murchison Palaeovalleys. The highest LCOEs are found in remote communities in the northern parts of WA and the southwestern parts of the Perth Basin. The differences in LCOEs at the same level of reliability are due to differences in renewable energy resources.

Wu et al. (2025a) and Wu et al. (2025b) also revealed that the LCOE increases substantially at reliability levels of over 90%. This increase is due to the need for larger amounts of battery storage and/or the operation of the diesel generator to maintain a consistent electricity supply.

When comparing renewable energy hybrid systems to diesel-only generators, the study found that the hybrid systems are generally the most cost-effective. The LCOE for the renewable hybrid systems, at a reliability level of 99.9%, ranges from \$0.12/kWh to \$0.38/kWh. In contrast, diesel-only systems with the same mode of operation have an LCOE ranging from \$0.45/kWh to \$0.74/kWh, depending on fuel costs.

Wu et al. (2025a) examined the impact of LCOE on the energy cost of desalinating water, which varies depending on the salinity of the water. Sites with higher salinity levels (greater than 14,000 mg/kL total dissolved solids) face energy costs that are up to three times higher than those with low salinity levels (less than 3,000 mg/kL total dissolved solids). For sites with a mean LCOE at a reliability level of 90%, the cost of desalinated water ranges from \$0.15/kL to \$0.45/kL, depending on the salinity level.

4. CONCLUSION

The study shows that hybrid renewable energy systems, combining solar, wind, battery storage, and diesel backup generators, offer a cost-effective and sustainable solution for powering off-grid desalination plants in WA.

The results highlight the importance of site selection for renewable energy generation. The most affordable hybrid systems can cost less than a third of the most expensive systems, depending on local renewable resource conditions. Diesel-only systems were found to be more expensive than all hybrid renewable energy options, reinforcing the practicality of hybrid systems. As renewable energy and storage technologies improve and reduce their capital cost, the cost of hybrid systems is expected to decrease further, making off-grid projects even more economical.

Salinity levels also play a crucial role in desalination costs, as higher salinity requires more energy. The study found that energy consumption for desalination is about three times higher at high-salinity sites compared to low-salinity sites. Selecting sites with lower salinity can reduce energy use and costs, while also minimising the amount of brine, which is costly to treat.

ACKNOWLEDGEMENTS

The CSIRO Brackish Groundwater Desalination in WA project leadership team: Olga Barron, David Lemon, Andrew Taylor and Ramesh Thiruvenkatachari and the National Water Grid for financing this project.

REFERENCES

Barron OV, Taylor AR, Donn MJ, Reid N, Hodgson G, Raiber M and Wu J (2025) Brackish groundwater characterisation across Western Australia. A technical report from the CSIRO Brackish groundwater characterisation project for the National Water Grid. CSIRO, Australia.

Graham PW, Hayward J, Foster J and Havas L (2023) GenCost 2022-23 Final Report. CSIRO, Australia

Wu H, West S and Hayward J (2025a) Energy options for brackish groundwater desalination in Western Australia. A technical report from the CSIRO Brackish groundwater characterisation project for the National Water Grid, CSIRO, Australia.

We H, West S and Hayward J (2025b) Energy options for brackish groundwater desalination in Western Australia. Desalination 600, 118446-118458. https://doi.org/10.1016/j.desal.2024.118446