NAWI National Alliance for Water Innovation

Project 3.23: Evaluating the Value of Grid-Responsive Flexible Desalination

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Project Objectives

This project aims to determine whether enabling temporally flexible operation of desalination facilities can potentially reduce the cost of desalinated water by taking advantage of time-varying electricity prices and the provision of services for the electric grid. Further, this project investigates what conditions need to be in place for reductions in the cost of desalinated water to be realized, accounting for real-world operational considerations.

Current Practice and State-of-the-Art

Conventional brackish and seawater desalination facilities are typically designed for steady-state operation, resulting in relatively constant electricity demand. This limits their ability to participate in electricity arbitrage or provide grid services—opportunities that could reduce operational costs and lower the selling price of desalinated water. In this study, we advance current practice by examining:

- The flexibility of existing brackish desalination plants to shift the timing and scale of electricity consumption, given their process dynamics and operational constraints;
- The potential for additional revenue from enabling time-varying electric loads through price-responsive operation and grid service participation;
- The added costs associated with implementing flexible operation, including process modifications or on-site energy storage deployment.

Approach and Novelty

We developed a dynamic process model of a brackish water desalination facility using Dynamizu (Figure 1), capturing the relevant process timescales that govern how electric loads can respond to varying electricity price signals. The model explores the facility's responsiveness to different types of price signals and assesses how design changes—such as equipment sizing—affect operational flexibility.

The novelty of this work lies in explicitly incorporating process dynamics to evaluate load flexibility and in providing design insights for future desalination facilities aiming to capitalize on electricity market opportunities.

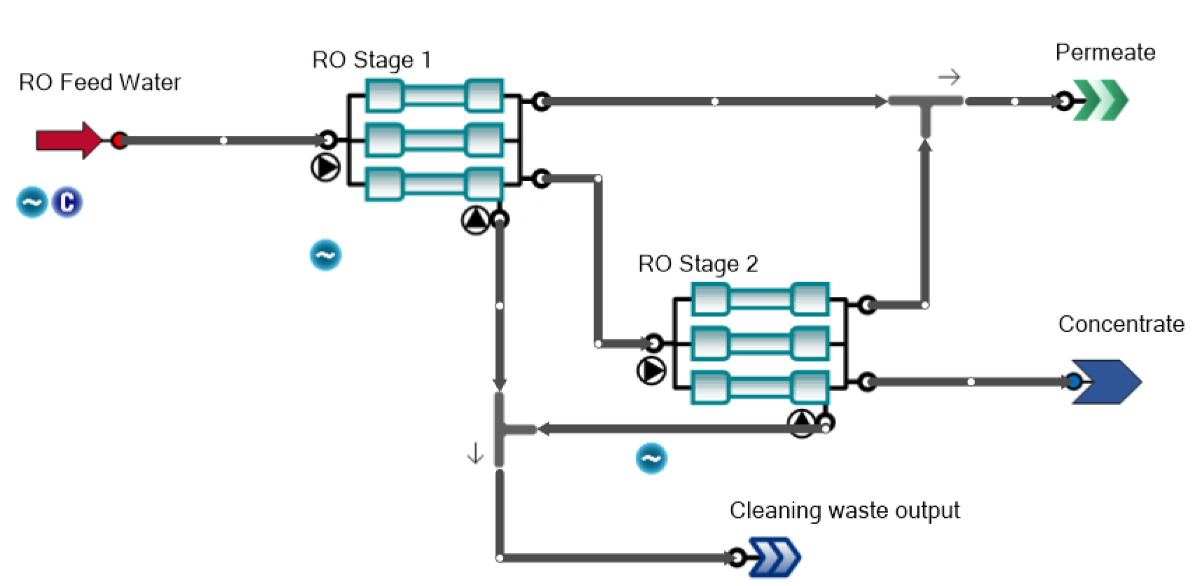

Figure 1. Dynamic process model of Chino Desalter Authority (CDA) Facility treatment train #5, including 2 stages of reverse osmosis systems using Dynamizu.

Highlighted Results

The energy cost saving of flexible desalination operation depends on the electricity tariff structure. Under the SCE TOU-8 Summer tariff, flexible operation yields no cost savings, as reductions in energy charges are offset by increased demand charges.

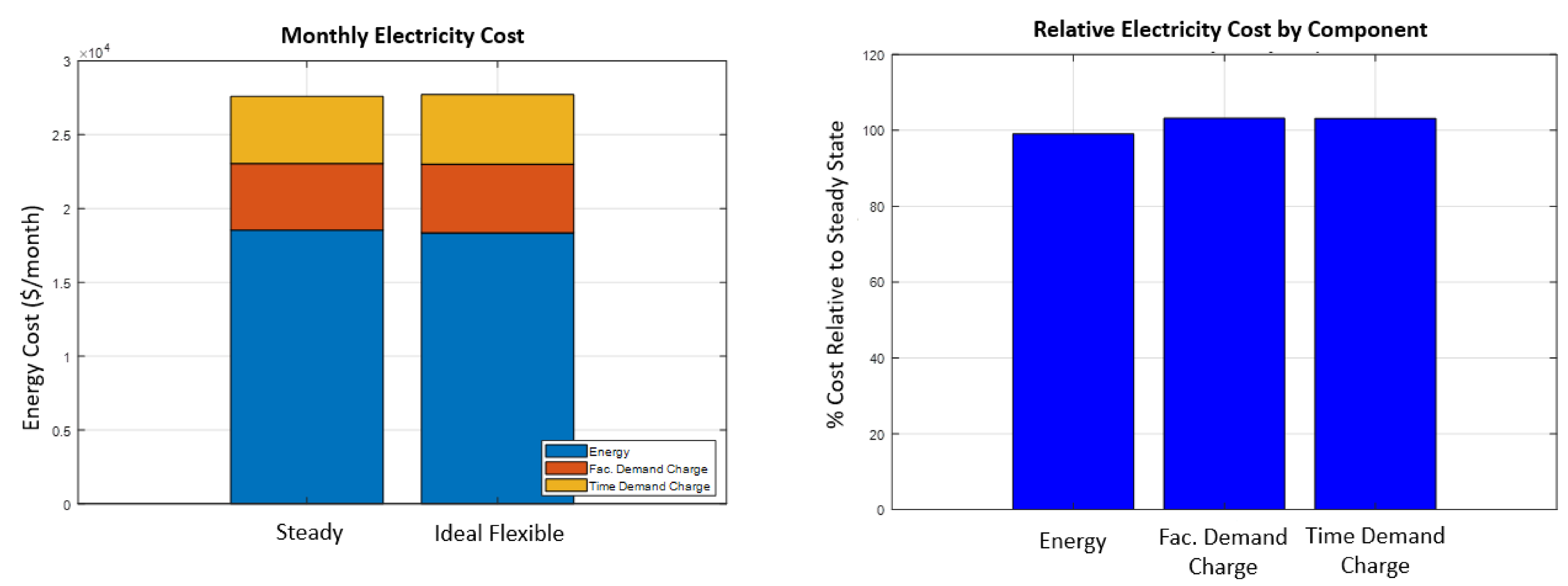

Figure 2. Energy cost saving of desalination operation under the SCE TOU-8 Summer tariff

In contrast, under the SCE TOU-8-RTP Summer High tariff—characterized by larger on-peak/off-peak price differentials— cost savings are observed (Figure 3). Here, the reduction in energy charges outweighs the increase in demand charges, demonstrating the potential for meaningful economic gains through time-varying operations when high varying tariffs are in place.

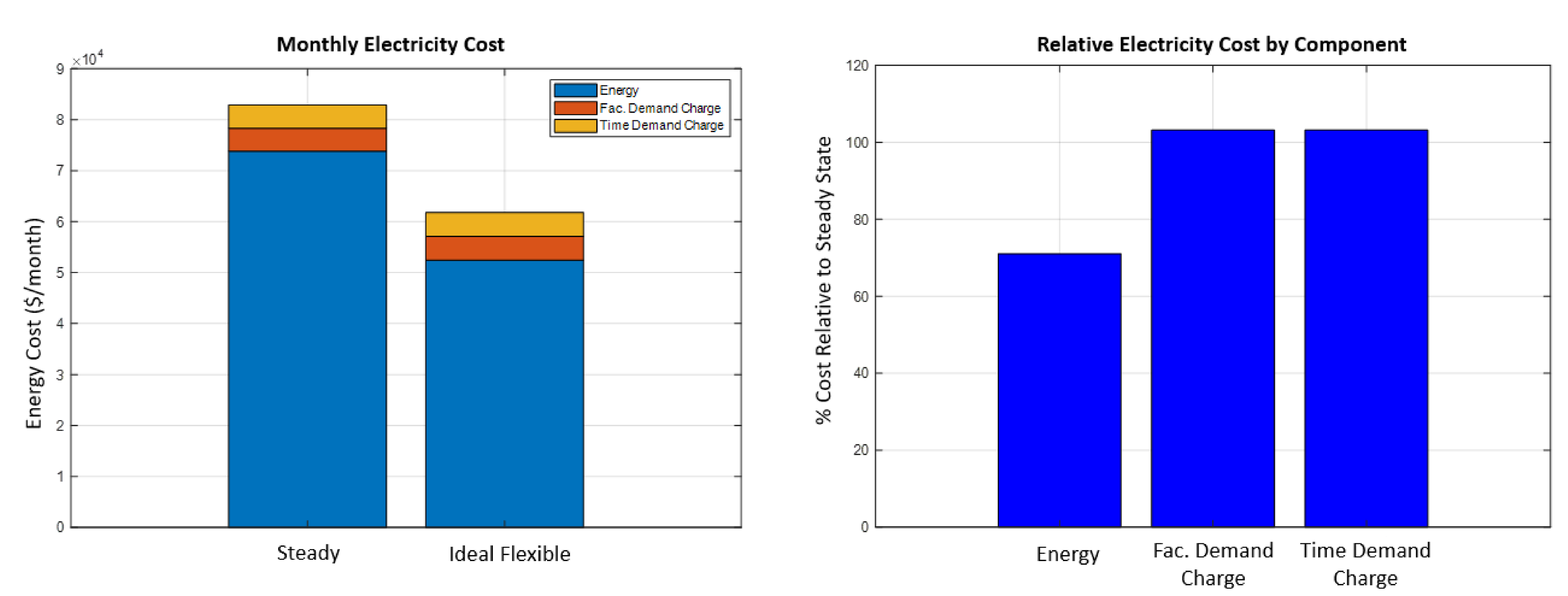

Figure 3. Energy cost saving of desalination operation under the SCE TOU-8 Summer High tariff

Next Steps

Future work will focus on quantifying the operational costs associated with increased ramping and cycling of pumps and RO units, including wear and tear and impacts on the balance of the plant. Additionally, we will compare the potential revenue gains from a flexible operation against the costs of increased equipment sizing and the additional wear from frequent cycling. Finally, the cost-benefit tradeoffs of flexible operation will be evaluated relative to the alternative strategy of installing on-site battery storage to respond to electricity tariffs.

NAWI CONNECTIONS

Period of Performance: October 2023 – September 2025

Challenge Area/Topic Area: Topic Area 3: Data Modeling and Analysis

This project explores a potential means for improving the business case for desalination and better integration of electrified water treatment with an evolving electricity system.

NAWI Leverage:

This project is complimentary to NAWI 5.09 but focuses in more detail on the potential for electric load flexibility in desalination facilities. However, dynamic modeling capabilities through the use of Dynamizu, comparison with WaterTAP, and know-how from applying these tools are shared between 3.23 and 5.09.

KEY FINDINGS AND CONCLUSIONS

Effect of Flexible Operation on Energy Costs

- The potential energy cost saving depends on which tariff structure the treatment train is assumed to follow.
- If tariffs have a larger difference between on-peak and off-peak pricing, more potential for savings compared to operating at a steady state at that same tariff.

Effect of Oversizing Pumps on Energy Costs with Flexible Operation

- Oversizing the pumps can yield more flexibility to take advantage of tariffs under a fixed water delivery constraint.

Conclusions:

Flexible operation of desalination facilities can increase revenue for facility operators when the tariffs have a larger difference between on-peak and off-peak pricing.

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