



RESEARCH BRIEF

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Optimizing Decentralized Water Recycling Systems

A new framework for identifying energy-optimal locations for deploying smaller, decentralized water reuse systems can change the equation for effective water supply in water-stressed regions.

Background

Evaluating the cost and energy tradeoffs of new water supply sources in water-stressed regions, whether seawater desalination plants, long-distance water transfer, or wastewater reuse facilities, requires a robust understanding of the full lifecycle costs of water supply from source acquisition through treatment and distribution for a specific location. The reliability of the urban wastewater stream has made recycling and reusing wastewater an attractive strategy for enhancing water supply resiliency, offering suppliers the ability to quickly recover from disruptions and withstand persistent or severe drought while also reducing costs in water-stressed regions.

As a result, most urban areas have focused their efforts on developing large, centralized water reuse systems for direct and indirect drinking water and other treatment standards of water reuse. However, shifts in both technology and policy are beginning to motivate the adoption of decentralized water recycling systems also known as DWRS. These smaller, localized systems are true ‘marginal’ sources that can be deployed quickly and in stages, often at individual end-user sites such as corporate office campuses. In contrast, new centralized supply systems have fixed design volumes, large capital expenditures, and lengthy permitting, design, construction, and start-up phases which can delay implementation.

POINTS FOR POLICYMAKERS

► **Evaluating the cost and energy tradeoffs of new water supply sources such as decentralized water recycling systems (DWRS) would improve water utility decision-making.** Understanding the full lifecycle costs of water supply from source acquisition through treatment and distribution for a specific location is necessary to optimizing water supply systems.

► **A marginal energy intensity (MEI)-based framework offers a convenient and reliable tool for relevant stakeholders such as water utilities to make more energy-aware decisions regarding DWRS deployment.** If utilities incorporate an MEI-based framework as one module in their multi-objective decision-making, there is significant potential to augment and diversify water supply via DWRS deployment with lower additional energy consumption. Additionally, without insight into the MEI as a function of location in each system, an operator might inaccurately assume that DWRS unit deployment would increase the total energy consumption.

► **Eligibility and priority of incentives, such as consumer rebates, for DWRS by water utilities in water-stressed regions are often determined without a full understanding of tradeoffs.** For example, eligibility for onsite water reuse grant programs in San Francisco require that applicants replace at least 450,000 gallons per year with recycled water. This excludes participation from smaller water users that, in aggregate, could reduce water consumption by the same volume while decreasing the energy intensity of that water supply.



To better understand water recycling system cost-benefit tradeoffs, Stanford researchers developed a marginal energy intensity or MEI framework that quantifies the full cost of sourcing, treating and transporting water from its origin(s) to a specific consumer at a specific time. Using case studies, the researchers evaluated and compared the energy consumption for three different DWRS deployment strategies and found that their MEI-based decision framework not only effectively identified the energy-optimal locations for DWRS implementation but could also help decision-makers assess the energy tradeoffs related to siting at various locations. Most critically, their findings highlighted the importance of accounting for both distribution and treatment energy intensity when evaluating new water sources and demonstrated the viability of DWRS as an energy efficient tool for augmenting water supply, suggesting that this technology will play an increasingly important role in securing the nation's urban water supply.

ABOUT THE AUTHOR



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This brief is based on the papers “**Energy-optimal siting of decentralized water recycling systems**” published in the journal *Environmental Science & Technology* and “**Marginal energy intensity of water supply**” published in *Energy & Environmental Science*.



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