RESEARCH BRIEF

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Stanford WOODS INSTITUTE for the ENVIRONMENT

Desalination's Role in a Circular Water Economy

Applying desalination practices more broadly across water systems can help ensure resilient supplies and offer a range of solutions to address 21st century demands.

Background

Water is a linchpin of the economy and critical to the security and prosperity of our communities. In the U.S. alone, more than 1.2 billion cubic meters of water are consumed per day, primarily sourced from distant freshwater sources, treated in centralized facilities, used inefficiently and discharged back into the environment as a waste stream. These 20th century "linear" practices are not sustainable in the 21st century with climate change, population growth and depleted groundwater aquifers exacerbating supply uncertainty.

Desalination, the process of separating ions from water, is most commonly associated with producing freshwater from the sea. However, desalination processes are also integral to recycling municipal wastewater as well as reusing brackish groundwater and industrial wastewaters. While use of large seawater desalination plants will continue to be limited to coastal communities, small-scale, localized systems for distributed desalination will be essential to cost-effectively tapping and reusing many of these nontraditional water sources across the country.

POINTS FOR POLICY MAKERS

▶ **Both small-scale distributed system and centralized treatment plants will benefit from A-PRIME.** The water sector faces unprecedented challenges from climate, environmental regulations and aging infrastructure. A-PRIME technology innovations will help to address pressing issues, from precisely removing problematic contaminants like PFOS/PFOA and arsenic; to providing more robust materials that prevent infrastructure corrosion; to reducing the cost of concentrate management that exist at both small- and large-scale water treatment facilities.

▶ **Technology innovations that deliver cost-competitive, distributed desalination and water reuse must be coupled with policy innovations at the federal, state and local levels.** Creating a "Water Information Administration" modeled on the Energy Information Administration would provide robust scientific and economic information to foster a comprehensive and systemic understanding of the country's changing water needs, including supply, demand by sector and end use, and flows.

▶ **Data collection efforts must be paired with data dissemination policies.** Over the past two decades, access to location specific information about critical water infrastructure has been severely curtailed. Secure data sharing platforms and clear policies around removing identification data in publications would allow academic and national laboratory researchers to access sensitive information about water treatment sources and distribution systems without jeopardizing national security or citizen well-being.

▶ **Fostering a water research ecosystem will require prioritized and sustained R&D investment.** Past efforts to establish an interagency framework to coordinate policy and research investments at the energy-water nexus should be expanded with a focus on advancing early stage successes.

A paradigm shift in both network and system design would enhance water resiliency, minimize the environmental impacts of wastewater discharge and facilitate water use efficiency across water end users. First, we need to evolve toward a circular water economy in which water is locally treated to fit-for-purpose standards. Second, we need to replace conventional economies of scale in treatment with economies of scale in device manufacturing, installation and operation. These same technology innovations that are critical to expanding the distributed desalination and fit-for-purpose reuse of nontraditional waters will also address many of the ongoing challenges faced by centralized municipal systems that will continue to supply the majority of our clean water.

Stanford researchers examined ways to build a circular water economy that could facilitate the next revolution in distributed desalination and reuse. They identified a suite of technologies — referred to by the acronym **A-PRIME** — which are **A**utonomous, **P**recise, **R**esilient, process **I**ntensified, **M**odular and **E**lectrically powered technologies that support locally tailored treatment of nontraditional waters at a cost comparable to other sources. To be successful, any technology innovations must also go hand in hand with policy innovations at the federal, state and local levels.

Augmenting existing systems with diverse, nontraditional water sources that we currently discard and continuously using and reusing water so that "contaminants" become the feedstock for other economically valuable processes will be key to stabilizing our water supplies and reducing wastewater treatment costs incurred by both industry and the environment. A-PRIME technology innovations will help to make these non-traditional water supplies cost competitive and accelerate the evolution of a linear water economy into a circular one.

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A-PRIME Technologies

AUTONOMOUS	PRECISE
Sensor networks and adaptive process control for efficient and secure water treatment systems.	Targeted removal of trace solutes for regulatory compliance, enhanced water recovery and resource valorization.
RESILIENT	**INTENSIFIED**
Adaptable water supply networks, flexible treatment processes and robust materials.	Energy efficient concentrate management by eliminating first order phase transitions.
MODULAR	**ELECTRIFIED**
Materials, manufacturing and operational innovations that propel modular membrane systems into new treatment applications	Electrifying water treatment processes and facilitating their integration with a clean energy grid.

FOR MORE INFORMATION

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