California's Water Challenges and Possible Solutions

By John Benson

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1. Introduction

Our climate has changed. We are experiencing extreme, sustained drought conditions in California and across the American West caused by hotter, drier weather. Our warming climate means that a greater share of the rain and snowfall we receive will be absorbed by dry soils, consumed by thirsty plants, and evaporated into the air. This leaves less water to meet our needs.

This is our new climate reality, and we must adapt.[1]

As I'm starting to write this in late August, my state has just released the Reference 1 document. Section 2 of this post will cover this. Later sections will reference other posts with information related to this subject, the latest news on the U.S. Department of Energy's Desalination Prize, and some early adopter communities that are building desalinization systems.

2. California's Strategy

During his first months in office, Governor Newsom issued an executive order calling on State Agencies to create a comprehensive Water Resilience Portfolio. The Portfolio prioritized key actions to secure California's water future. Over the last two years we've made major progress that includes: working to bring our groundwater basins into balance; updating infrastructure to move water throughout the state; restoring river systems, including the nation's largest dam removal effort on the Klamath River; and improving water management through new voluntary agreements and technology investments.

Regarding the *"…dam removal effort on the Klamath River,"* see the earlier post described and linked below.

Destructive Restoration – Part 1, The Klamath: *Every machine made by humans reaches the end of its useful life. This will be the first post in a short series on what should happen to electric generation projects when it is no longer economical to restore, repurpose, nor continue to use them for their intended purpose.*

However this first post is special. It is partially drawn from my deep past and partially an agreement to restore a natural resource and everything around it through the creative destruction of a series of old projects near the California-Oregon Border.

https://energycentral.com/c/ec/destructive-restoration-%E2%80%93-part-1-klamath

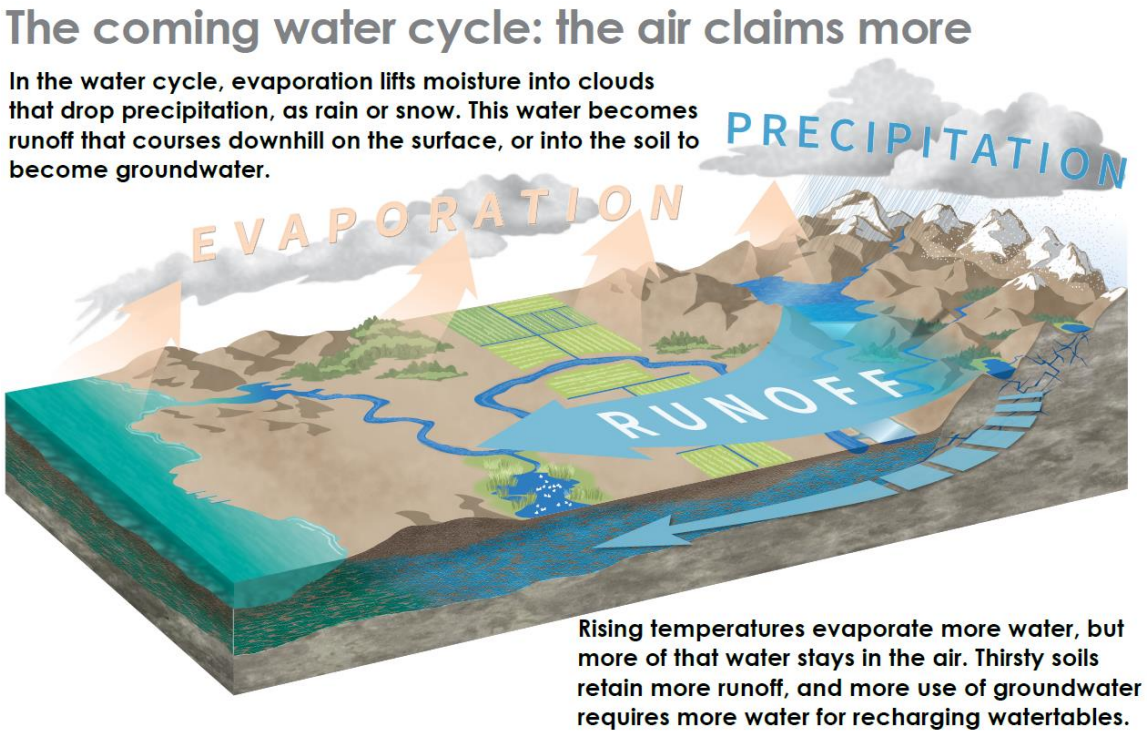
[1] California Volunteers (#CaliforniansForAll), California Natural Resources Agency, California Department of Water Resources (DWR), California Water Boards, California Environmental Protection Agency (CalEPA) and California Department of Food and Agriculture, "California's Water Supply Strategy," Aug 2022, https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Water-Resilience/CA-Water-Supply-Strategy.pdf

Over the last three years, state leaders have earmarked more than $8 billion to modernize water infrastructure and management. The historic three-year, $5.2 billion investment in California water systems enacted in 2021-22 has enabled emergency drought response, improved water conservation to stretch water supplies, and enabled scores of projects by local water suppliers to become more resilient to current and future droughts. The 2022-23 budget includes an additional $2.8 billion for drought relief to hard-hit communities, water conservation, environmental protection for fish and wildlife, and long-term projects to permanently strengthen drought resilience…

To ensure California has the water needed for generations to come, this Strategy includes:

- ***Create storage space for up to 4 million acre-feet of water,*** *allowing us to capitalize on big storms when they do occur and store water for dry periods*
- ***Recycle and reuse at least 800,000 acre-feet of water per year by 2030,*** *enabling better and safer use of wastewater currently discharged to the ocean*
- ***Free up 500,000 acre-feet of water*** *through more efficient water use and conservation, helping make up for water lost due to climate change*
- *Make new water available for use* ***by capturing storm-water and desalinating ocean water and salty water in groundwater basins,*** *diversifying supplies and making the most of high flows during storm events*

To match the pace of climate change, California must move smarter and faster to update our water systems. The modernization of our water systems will help replenish the water California will lose due to hotter, drier weather, and generate enough water for more than 8.4 million households



DWR estimates a 10% reduction in water supply by 2040. This is a planning scenario that considers increased temperatures and decreased runoff due to a thirstier atmosphere, plants, and soils. According to the California Water Plan, California's managed water supply ranges from 60-90 million acre-feet (MAF) per year so the effect of a drier climate results in a disappearance of about 6-9 MAF of water supply.

Below is a table showing the net effects of the above described actions by 2030 and 2040. For additional information see reference 1.

	2030		2040	
Increase Recycled Water	.8 MAF	About 5 MAF	1.8 MAF	About 7 MAF
Increase Desal Production	28,000 AF		84,000 AF	
Increase Stormwater Capture	.25 MAF		.5 MAF	
Increase Conservation	.5 MAF		.5 MAF	
SUBTOTAL FOR RECYCLED, DESAL, STORMWATER AND CONSERVATION	1.6 MAF		2.9 MAF	
Expand Storage Above and Below Ground*	3.7 MAF		4 MAF	
Total	4.8 MAF		6.9 MAF	

*Additional storage capacity does not equate to a similar volume of new water supply. MAF – million acre-feet.

3. Additional Resources

The following are earlier posts:

Water World *(Nov 2021): Although a large percentage of my posts are about energy, I have written about water utilities before. Energy is required to process water, pump water and otherwise make it suitable for use. Also, guess which sector is the largest user of water? The main image for this post (right) might help you.*

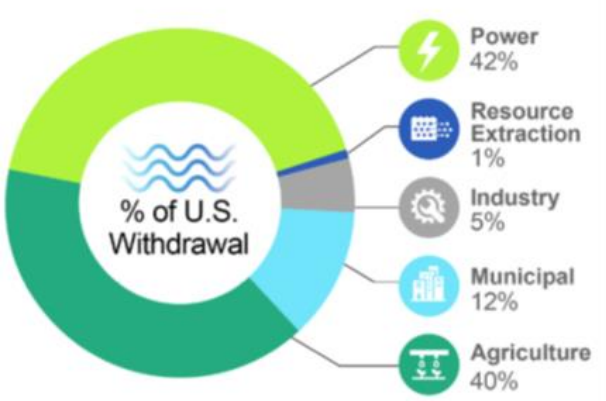


Figure 3. Overview of water withdrawals in the United States[1]

This chart is part of a roadmap created to "make nontraditional sources of water (i.e., brackish water; seawater; produced and extracted water; and power sector, industrial, municipal, and agricultural wastewaters) a cost-effective alternative."

If you look at the beginning of section 2 of "Water World", you will see that the organization that authored the roadmap was created by the U.S. Department of Energy, so I think I'm on firm ground.

This paper will focus on methods and projects to use water more sustainably.

https://energycentral.com/c/rm/water-world

Watts and Water *(Nov 2019) Electricity and water are invariably linked. Given enough inexpensive power, there will be no shortage of water.*

This post is about three technologies. One is the current state-of-the art technology for desalination, one is a potentially more efficient technology for desalinization, and a third is a technology for extracting water from the atmosphere.

https://www.energycentral.com/c/ec/watts-and-water

DOE Solar Desalination Prize *(March 2021): The Solar Desalinations Prize is a four-round completion among developers of innovative technologies that will be used in the future for less expensive and more flexible desalination system.*

Removing salt from water takes a lot of energy! Many of the largest untapped water resources in the US and around the world cannot be cost-effectively used because of high concentrations of dissolved salts.

Water treatment processes, like reverse osmosis, are efficient when salt concentrations are low, but can't treat high-salt waters like those that are produced from oil and gas wells, concentrated brines, and some industrial and agricultural wastewaters.

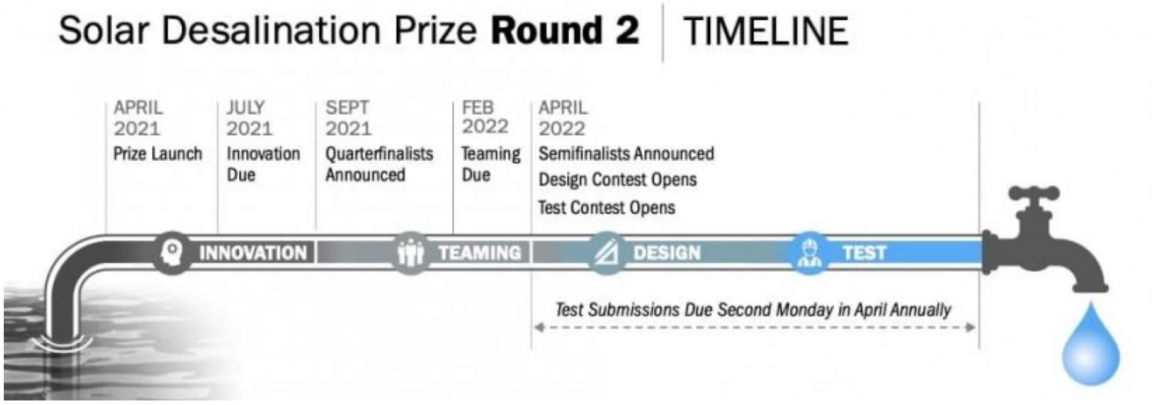
Novel thermal desalination technologies can purify water with very high salt content without dramatically increasing the amount of energy required. By using solar thermal as the energy source, desalination technologies could be used in a variety of important environments, especially in arid areas with high sun exposure, where water purification is especially important.

https://energycentral.com/c/um/doe-solar-desalination-prize

4. DOE Solar Desalination Prize Update

The six semifinalists for this prize are listed below, but first note the timeline. Also note that we are now in the final competition stages.

4.1. Timeline



Innovation: The first phase opened on April 12, 2021, and will close July 15, 2021. Quarterfinalists were announced on September 28, 2021.

Teaming: The second phase opened on September 28, 2021, and close February 9, 2022. Semifinalists were announced on April 22, 2022.

Design: The third phase opened on April 22, 2022, and will close when competitors have completed their designs and obtained the required documents, no later than April 10, 2025.

Test: The fourth phase also opened on April 22, 2022. Submissions will be evaluated every second Monday in April, starting in 2023. Winners will be determined approximately one month after visits to their newly built system sites.

4.2. Semifinalists

Below are the six semifinalist teams.[2]

4.2.1. Sunvapor: SCEPTRE - Solar Cascading Evaporation Process

Location: Pasadena, CA

Sunvapor's Solar Cascading Evaporation Process (SCEPTRE) focuses on brine management—taking in brines produced from a variety of sources, such as reverse osmosis waste, power plant cooling towers, and other waste streams with high salt content. Steam discharged from a steam accumulator provides thermal energy storage to support both low- and high-temperature desalination processes. Together, this efficient use of thermal energy from stored solar steam has the potential to provide high-efficiency, low-cost brine treatment. Sunvapor intends to demonstrate this technology at an existing saltwater disposal injection facility.

4.2.2. Planet A Energy: Solar Heat Collector With Built-in Storage

Location: Pasadena, CA

Planet A Energy has developed an innovative system concept that directly couples a low-cost solar collector with a low-cost thermal energy storage material that the solar collector can directly heat. The collector, absorber, and energy storage are all integrated into a single module, eliminating many of the system complexities associated with traditional CSP technologies. Planet A Energy has teamed with the Rosenblad Design Group and Aerometrix LLC. The team intends to couple Rosenblad's proprietary evaporator technology with their collector and thermal energy storage systems at an Aerometrix desalination plant to demonstrate how this technology can be used to reduce the volume of brine wastewater.

4.2.3. SolMem: Solar NZLD

Location: Houston, TX

SolMem has developed a concept for desalination of various wastewater streams to produce drinking-quality water. The team's membrane distillation (MD) technology simultaneously collects solar energy and desalinates water, greatly improving thermal efficiency and water recovery compared to conventional MD. SolMem has assembled a team that includes Winston Cone Optics and Rice University. The team intends to demonstrate their technology at the Brackish Groundwater National Desalination Research Facility.

[2] U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), "American-Made Challenges: Solar Desalination Prize Round 2," April 22. 2022, https://www.energy.gov/eere/solar/american-made-challenges-solar-desalination-prize-round-2

4.2.4. Artic Solar: Engineered Solar-Thermal Osmosis

Location: Jacksonville, FL

A team led by Artic Solar has designed an integrated solar-thermal desalination system. The technology uses a thermally responsive solvent, which draws water from a brine stream. The solvent is then heated using an external compound parabolic concentrator, designed by Artic Solar, which separates the solvent from the generated fresh water. The team also includes technology developers of the novel desalination process and component suppliers. The team plans to test their system at Southern Company's Water Research and Conservation Center in Georgia.

4.2.5. Team Trident: Temperature Swing Solvent Extraction for Zero Liquid Discharge (TSSE-ZLD) Treatment of Produced Water

Location: Santa Barbara, CA

Team Trident has an innovative concept to targets a reduction in the cost of treating high-salinity brines for water produced from oil and gas extraction. By using low-grade thermal heat to drive TSSE's separation and solvent regeneration processes, the technology advances a non-evaporative, non-membrane solar-thermal desalination concept, which can be implemented at a low capital and operating cost. In collaboration with Columbia University and Bechtel, the team plans to construct a prototype of their system at the Brackish Groundwater National Desalination Research Facility.

4.2.6. Winston Cone Optics: Inland Brackish Water Desalination and Brine Concentration for Agriculture

Location: Merced, CA

Winston Cone Optics (WCO) has developed an innovative solar concentrator designed to minimize system capital costs, complexity, and operations and maintenance costs of the collector system of a solar-driven desalination process. Their technology is designed to be quick to deploy and portable, allowing solar-thermal water treatment systems to gain access to niche markets where seasonal or multi-site application is needed. WCO will couple their solar collector technology with Trevi Systems' Switchable Solvent Water Softener technology, a forward-osmosis-based desalination system. The team will demonstrate their renewably powered, zero-liquid-discharge desalination prototype for the agricultural market with their partners, Global Water Innovation and Wacomet Water.

5. Early Steps

I frequently write about unpredictable consequences of climate changes. The ongoing California drought is forcing several communities to expand their water supplies through desalinization.

5.1. Antioch

The city of Antioch is experiencing one of these effects now. By the way Antioch has about the same population as my hometown (Livermore) at a around 100,000 and like Livermore it has been in existence since the early 1800s.

The city of Antioch sits right next to the largest source of fresh water in Northern California. But it's facing a water supply crisis because of changes to the Sacramento / San Joaquin River Delta, both natural and man-made.[3]

As a result, the city is taking extraordinary measures to increase supply in a way that has the rest of the state watching…

Founded in the 1800s, Antioch was established on the banks of the Delta. But the city's public works Director, John Samuelson, said it's been a while since the Delta has provided much life to the area.

"We were only able to use our river intake for 30 days this year," Samuelson told KPIX 5. "Last year, we weren't able to use our intake for a single day because of the salinity levels. Because there's no water runoff from the Sierras to push the salinity back out into the Delta."

Over the decades, more and more water has been siphoned out of the Delta to supply Southern California cities and Central Valley farmers.

Now, with even more reduced flows because of the drought, seawater from the Bay is pushing up into the system, making Antioch's historic water supply too salty to use.

"Until we get enough precipitation, enough rain upstream in the watershed, and start to fill our reservoirs and start to add more fresh water in, you're going to have issues like that," said Jacob McQuirk, principal engineer for the California Department of Water Resources.

But while the state may be praying for rain, Antioch doesn't see the situation improving anytime soon. So, they're doing what a lot of other cities have only pondered--they're building the first surface-water desalination plant in the Bay Area.

The new facility, located at the city's wastewater treatment plant, will use large reverse-osmosis filters to create 6 million gallons of fresh water per day--about a third of the city's needs--but with room for expansion.

"We're actually only building about half of this facility," said Samuelson, "so this building is large enough for us to be able to double the size of this in the future."

Because they're dealing with brackish water, which has a lower salt content than regular Bay water, they can clarify it using less energy and creating less salt-concentrated wastewater.

It's an advantage many other Bay Area cities don't have, but they're still closely watching what Antioch is doing.

"Yeah, we've received a lot of interest from other water agencies on this project," Samuelson said. "I've had several reach out to me. I do anticipate that you're going to see more of these facilities coming up here in the Bay Area and across the state."

[3] John Ramos, CBS SF Bay Area via MSN, "Desalination plant construction underway in Antioch as drought worsens," Aug 9, 2022, https://www.msn.com/en-us/news/us/desalination-plant-construction-underway-in-antioch-as-drought-worsens/ar-AA10uFgx

All told, the desalination plant will cost about $110 million, with about $82 million of that coming from state grants and loans.

Samuelson said supply chain problems have delayed the project a bit, and he predicts it will be operational sometime at the end of next year or the beginning of 2024.

5.2. Eastern Municipal Water District and Huntington Beach

California's Eastern Municipal Water District (EMWD) has opened its third groundwater desalination facility, which will provide additional local water supply reliability to its service area. [4]

The above district is about 50 miles east of Los Angeles.

Called the Perris II Desalination Facility, EMWD's new groundwater desalter will deliver enough water for over 15,000 households a year through its reverse osmosis (RO) treatment process.

Located in Menifee, it is positioned next to the Menifee I and Perris I desalination plants.

The new plant with treat roughly 5.4 million gallons of water per day with the EMWD's groundwater desalination program collectively treating approximately 14 million gallons per day.

The program will remove 65,000 tons of salt each year from the groundwater basin, helping to provide long-term improvements to water quality in the basin.

Funded partly in grants equaling $22.5 million for the State Water Resources Control Board as part of Proposition 1 - a 2014 water bond approved by voters.

"This facility and other projects funded by Prop 1 — together with Governor Newsom's historic, three-year, $5.2 billion investment in California water systems enacted last year, and the billions in funding coming from the federal Bipartisan Infrastructure Law — provide us with a generational opportunity to transform our state's water system to meet the 21st-century challenges of a changing climate," said Joaquin Esquivel, chair of the State Water Resources Control Board.

Funding also came from the United States Army Corps of Engineers which provided $10.8 million in support.

Speaking of the opening of the new plant, EMWD board president Phill Paule, said: "As we continue to face water supply challenges throughout California, this facility will further ensure that our area is prepared to meet the needs of our customers through investments in local water supply sources."

5.3. Desalinization Done Right

But if California is facing such a big challenge, why has it rejected plans to build another desalination plant?

[4] Aquatech, "One In, One Out As California Opens Third Desalination Plant," 15 Aug, 2022, https://www.aquatechtrade.com/news/desalination/third-desalination-plant-in-california/

California's regulators recently rejected a $1.4 billion desalination plant which was part of the Governor's plans to tackle the State's drought challenge.

The California Coastal Commission voted 11-0 to reject the proposal by the seawater desalination developer, Poseidon Water, to build a new desalination plant on a low-lying coastal site at Huntington Beach.

"The plant was set to have a capacity of 50 million gallons of drinking water a day."

Plans were rejected on environmental concerns after experts said the facility would destroy marine life in about 100 billion gallons of seawater per year.

While enough to supply 400,000 people, the commission said the plant would devastate marine life and expose the plant to future risk of sea level rise while producing costly water too expensive for low-income consumers.

While plans for a new plant at Huntington Beach were unanimously rejected, the commission did release a statement saying it would be willing to support other desalination projects.

"We have a dire need for more water, but we have to do it the right way," said Commissioner Effie Turnbull-Sanders, one of Newsom's four appointees on the commission.

So while this project might have been called off in the 11th hour, California is not writing desalination off altogether, with the commission approving 11 plants since 2015.