Water in the American West – Supply-Side Management

Climate models predict a continuation of the trends we've been seeing in many countries: heat waves happening more often and more intensely, longer and more severe droughts owing to decreased precipitation, wildfires as a consequence of long-term dry spells, and water stress for both urban and rural populations as well as for agriculture. Nowhere are these trends more in evidence than in the American West. The extraordinary engineering that has gone into making the West prosperous is at risk. (I blogged about the landmark history of water policy and politics in the West, *Cadillac Desert*, here in September.)

How to survive the coming decades? I wrote the other day about the pressing need to reduce demand and the ways to do that. There have been many highly successful initiatives in the West but much more **must** happen in residential, commercial, and agricultural water conservation.

But even with increasingly effective programs to reduce demand, there will still be a shortfall in available water as demographic trends remain as they've been and economic activity grows as expected. California, it should not be forgotten, has a gross state product of over $3 trillion, putting it behind only the US, the PRC, Japan, and Germany, and ahead of India, the UK, and France. California accounts for nearly 15% of the US economy.

Water supply thus becomes an existential issue for the American West in a climate-stressed world. Much of the West has relied on the Colorado River for decades but that once-seemingly inexhaustible resource has become an iffy proposition. Phoenix, for instance, the fifth-largest city in the US, has been thinking ahead to when the Colorado's water won't be enough. As *Cadillac Desert* recounts, the Central Arizona Project, a diversion from the Colorado River, became the lifeline for Phoenix and Tucson and Arizona farmers. It was created by federal legislation in 1968. In 1970, Phoenix had 582,000 people; Tucson had 263,000. By 2021, Phoenix's population was 1.74 million; Tucson, 555,000. Phoenix, though, knows the score. Arizona has been building innovative water-saving infrastructure like the water banks, begun in 1996, that store 3.6 million acre-feet in 28 sites using empty aquifers. That's about 1.2 trillion gallons! Phoenix uses some of that system as well as its own aquifers, recharged naturally and

some with water that is pumped into them. Those local sources alone can supply the city for years.

Recycling wastewater is another key strategy with 20 billion gallons a year going to a nuclear power plant and another 10 billion going to local farms. So-called "toilet-to-tap" tech, treating sewage effluent to make it drinkable, is being researched, and so is desalination, drawing on hundreds of millions of gallons of brackish water in Arizona and possibly from the Gulf of Mexico, 200 miles south of Phoenix.

Those technologies, it turns out, are well advanced in San Diego as well as in neighboring Orange County. The Groundwater Replenishment System (GWRS) in Orange County is an impressive, technologically advanced infrastructure project, producing 100 million gallons a day of clean water. One third of that is used to buttress the seawater intrusion barrier that keeps the Pacific from infiltrating into Orange County's groundwater. The other two-thirds go to replenishing the groundwater aquifers. It's an amazing process and one that is going to proliferate around the world.

San Diego recycles water for non-potable uses such as irrigation and manufacturing. They also have 11 projects in the works to produce 30 million gallons a day of drinking water, a "toilet-to-tap" system. The goal is to have 83 million gallons flowing by 2035.

The crown jewel in San Diego's water supply system is the Claude "Bud" Lewis Carlsbad Desalination Plant that produces 50 million gallons a day. You can see how they do it here. (Their video is missing, but you can watch a quick explanation here, as well as an overview of the project and various worthies explaining its many virtues here.)

It's been my sense for a while that we're not going to overcome the looming problems of water shortages and, for that matter, desertification, in much of the world without a huge reliance on "non-conventional water resources." That means both water-reuse and desalination plants. Capacity for reuse in particular has been growing steadily over the past decade. The International Desalination Association (IDA) has documented "explosive growth" as "climate change bites" and predicts the further build-out of capacity. There were nearly 16,000 desalination plants in 177 countries as of 2018. This infrastructure is critical for meeting SDG6, "Ensure availability and sustainable management of water and sanitation for all."

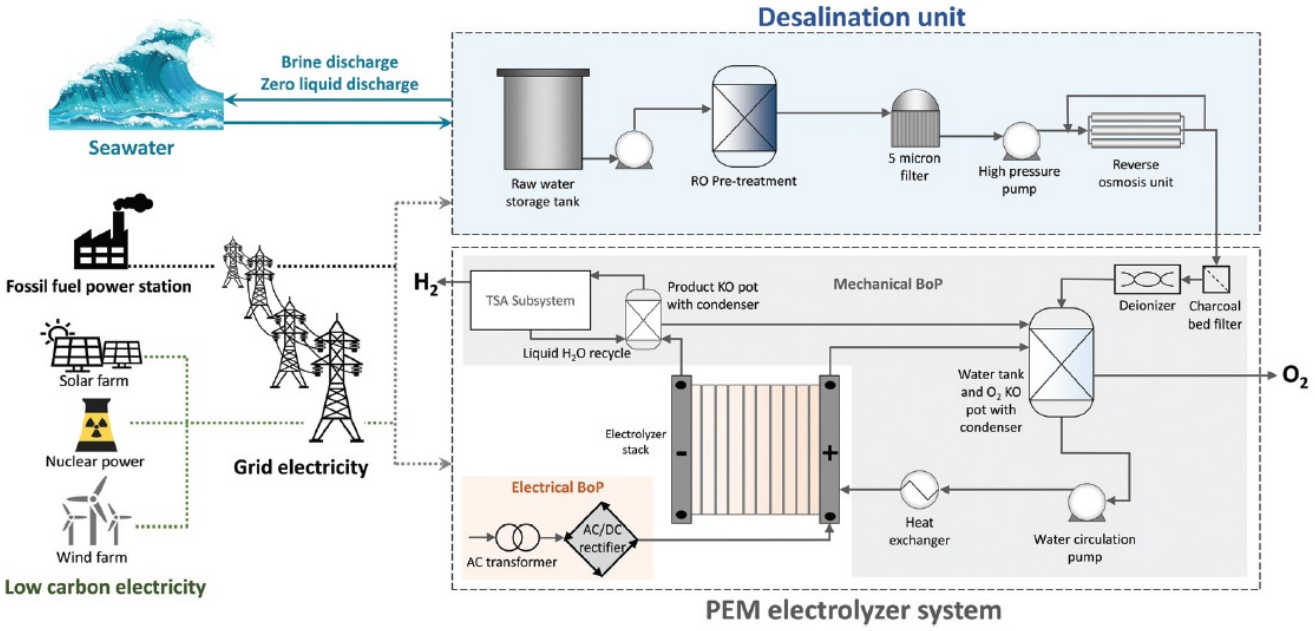
The key to it all, though, is renewable power. The IDA notes that solar power may be the silver bullet, particularly for desalination. The Saudis have a project that produces water for $\$0.50/m^3$ and the UAE is bringing in a project for $\$0.27/m^3$. Solar power (both PV and CSP), wind power, and, eventually, marine energy, are all viable options.

I am bullish about hydrogen. (See The Hydrogen Economy and Hydrogen Rising.) A fascinating paper from earlier this year poses the question of how to make "green" hydrogen **and** desalinated seawater at the same time. "Seawater electrolysis for hydrogen production: a solution looking for a problem?" (You can buy the article or access it through your local library. In any event, you can see the abstract at the link.) There has been a lot of time and effort expended trying to find a cost-effective approach to using seawater directly

for producing hydrogen through electrolysis. There are, as you might imagine, a lot of barriers to making that easy and cheap enough to justify the work. What this paper does is, for all intents and purposes, identify how to kill two birds with one stone. Here's how the paper puts it:

The choices we make today as we transition towards a net-zero emissions energy system will determine the future of our planet. 'Green' hydrogen produced via water electrolysis and renewable electricity is being explored as an enabler to this transition. The requirement of high purity water for electrolysis as well as the widespread availability of seawater have led to decades of research in developing direct seawater electrolysis technology; however, with limited success. On the other hand, desalination particularly via seawater reverse osmosis has seen tremendous technological advancements and reduction in cost. Here we present a critical assessment of an industrially mature pathway i.e., desalination coupled electrolysis technology to provide a bird's-eye view of its economic feasibility and climate impacts over direct seawater electrolysis for hydrogen production.

Pretty convincing. Here's a simple schematic:



Returning to the immediate question of water in the American West, we should also flag the heroic path that Los Angeles is choosing to take. Saying that LA's Green New Deal is ambitious is an understatement. By 2050, they're aiming for "a zero carbon grid, zero carbon transportation, zero carbon buildings, zero waste, and zero wasted water." The water component of the Green New Deal is compelling: aggressive water conservation efforts, capturing and storing nearly 50 billion gallons of stormwater a year by 2035, and reusing 100% of all wastewater by the same year.

On November 15, President Biden signed the Infrastructure Investment and Jobs Act into law. It has a significant water component: $82.5 billion for a series of important initiatives. The

Pacific Institute has produced a comprehensive analysis of it. One of the highlights they identify is that "The Act provides a shift away from the 20th century primary focus on building major dams and water diversions toward a more sustainable and resilient approach." (See Cadillac Desert!) Water reuse has a big role to play. The new law requires EPA to convene an interagency working group "to develop and coordinate actions, tools, and resources to advance water reuse" and implement the Water Reuse Action Plan. The Bureau of Reclamation has $1 billion allocated for water recycling and reuse projects. They are also responsible for using $1.15 billion for water storage projects, plus another $250 million for desalination studies and construction.

How we deal with water stress in the coming years, not only of course in the American West but globally, will go a long way toward determining the ecological and economic health of our cities, our farms, and our wild lands and waters. We've got many tools available, and many brilliant engineers, scientists, policy makers, public officials, and activists pushing us in the right directions. It's always gratifying to see how many hard lessons have been learned, how much progress has been made, and the hopeful indications for the future.