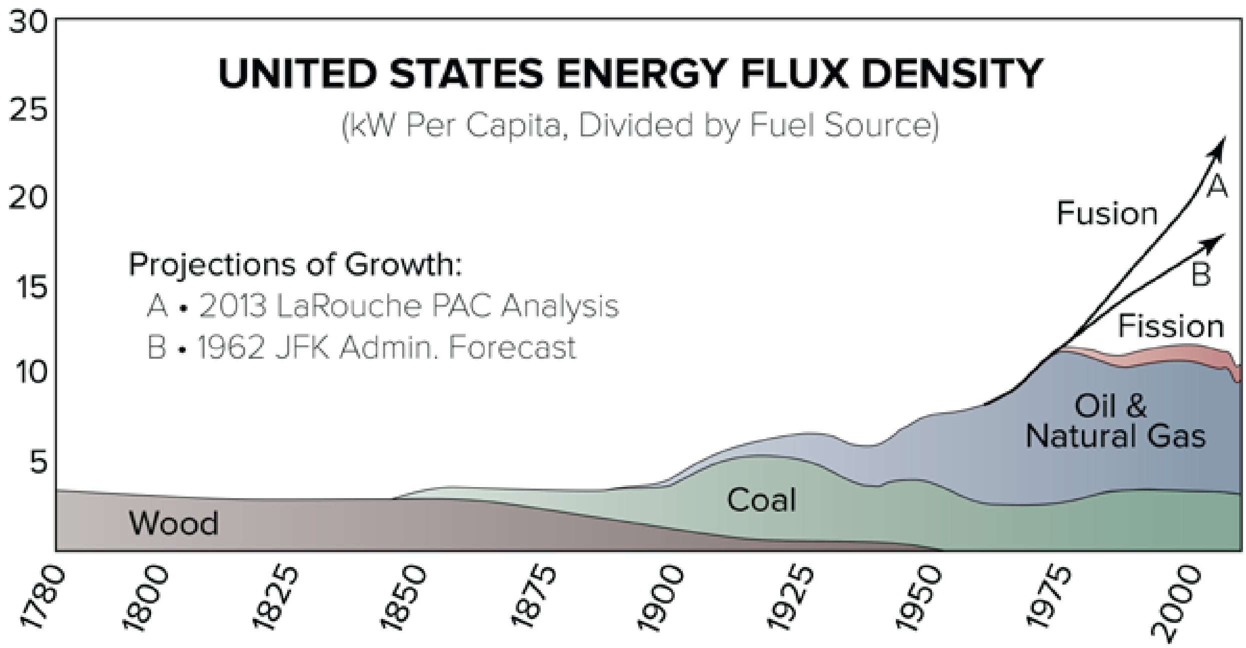
Desalination: Outdoing the Sun

by Liona Fan-Chiang and Jason Ross

Returning to our basic understanding of the water cycle, the ocean water evaporated by the Sun is presently the source of nearly all water on land. But we don't have to be dependent on this; we can out-do the sun, and create our own fresh water from the seas, setting up new water cycles. While the sun has done a good job for the past millions of years at making life on land possible by providing it with water, it is incredibly inefficient when compared to human abilities to create fresh water from the oceans, and to better distribute that water. The "natural" (solar-powered and weather-dependent) cycle based upon evaporation and precipitation is inconsistent and less productive, than it could be. Instead of relying on the sun, we can directly do what it does: separate water from salt, and bring that fresh water where it is needed to support life.

Our desalination of ocean water is around a thou-



This graphic shows per-capita power over the history of the United States, and reveals two important changes: an increase in the power per capita (until the onset of the zero-growth paradigm of the late 1960s and early 1970s), and transitions to higher sources of power. Not only did the U.S. have more power available in 1960 than in 1860, that power was of a higher quality: it could be used to make electricity, and it could be furnished by nuclear, rather than chemical changes.[1] Curves A and B on the figure show the anticipated power availability today had the post-Kennedy downshift not occurred, with fission power being fully developed and fusion power being realized. In such an economy, large-scale desalination would already be a reality, and the global water systems would be much improved under the guidance of man.

1 See "Forging Fusion: Physical, Chemical, Nuclear, Fusion!" in EIR, Feb 6, 2015.

sand times more efficient than "natural" solar-powered desalination. There are 60 million gigawatts of solar power incident on the planet's oceans, from which 413,000 cubic kilometers are evaporated, salt-free, every year. This comes out to 1,300 kWh (kilowatt-hours) of incident sunlight per cubic meter of evaporated water. Given that most of this water (90%) falls back into the oceans, rather than on land, the effective power rate for solar-desalinated ocean water precipitating on land, is 13,000 kWh per cubic meter. This is incredibly energy-intensive compared with the absolute theoretical minimum energy required: only 0.75 kWh per cubic meter. Currently mankind's most energy-efficient method of desalination, reverse osmosis, can operate at efficiencies of 3 kWh per cubic meter, or even better—over a thousand times more efficiently than the Sun.

While these efficiencies have enabled the widespread use of desalination on smaller scales, we are on the verge of being able to make a huge leap.

Current global desalination capacity is just under 30 cubic kilometers per year (equivalent to about one and a half times the flow of the Colorado River). This is a little less than 1% of the current global water use, and a little less than a tenth of a percent of the natural freshwater flow into and out of all the world's continental systems.

Since energy is still the largest determinant of cost for desalination, the widespread development of nuclear fission power and, even more importantly, a crash program for the development of fusion power can enable desalination on massive scales. By increasing the energy flux density of the economy, measured as power per capita and per square kilometer, the oceans can become an easily accessible resource for developing fresh water.

Types of Desalination

There are essentially three main techniques for removing salt from water: distillation, electrodialysis, and reverse osmosis. Distillation involves using a change in state to separate water from the salt and other materials it contains. When water turns into vapor, by heating or reducing the surrounding pressure, salt does not evaporate with the water. The water vapor can then be condensed—"distilled"—back into pure liquid water. Electrodialysis removes salt from water by setting up an electric potential across the motion of the water to be treated. The different charges attract the salt ions and pull them out of the water. Current research is studying ways of using the technique to remove other substances, such as bacteria. Reverse osmosis uses a semi-permeable membrane through which water can pass, but salt and other substances cannot. By pumping water at pressure against the membrane, pure water moves through it. Since water usually moves across such a membrane in the direction from purer water towards saltier water, it takes energy to push it in the opposite direction, putting the "reverse" in reverse osmosis.

The different techniques each have their own particular advantages and disadvantages, in such factors as electricity and heat use, maintenance needs, construction costs, and quality of power required. For example, a power plant specifically made for desalination could generate electricity to power reverse osmosis, and use the waste heat from the process of generating electricity for distillation, increasing the overall water production.

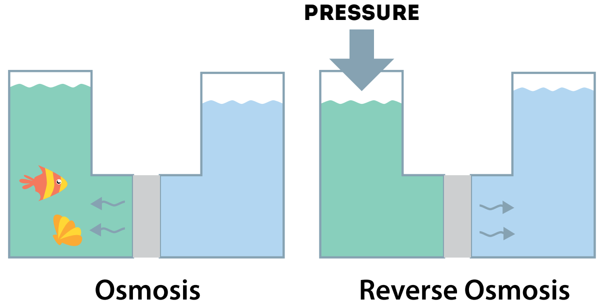
The world's largest desalination facility, the Al-Jubail plant in Saudi Arabia, produces one million cubic meters of clean water per day (0.37 cubic kilometers per year) by multi-stage flash distillation. While this technique provides half of the world's desalinated water at present, it is much more energy-intensive than reverse osmosis. Developments in membrane technology are moving the world towards reverse osmosis as the

Water Comparisons

- Gallons: the average use per Californian is 100 gallons per day.
- Cubic meter: 264 gallons—a typical California family of four uses 1.5 cubic meters per day.
- Cubic kilometer per year (cubic kilometers per year)—The discharge of the Colorado River is 20 cubic kilometers per year.

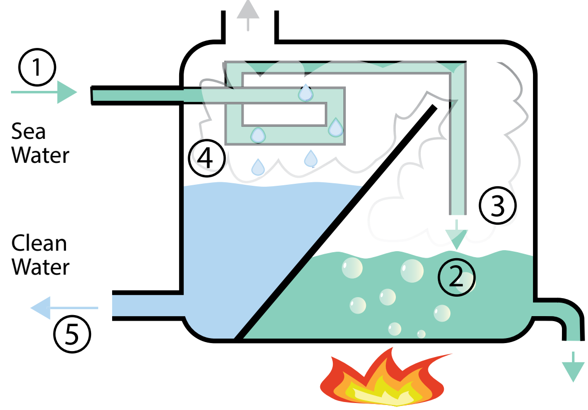
DESALINATION METHODS

Reverse Osmosis



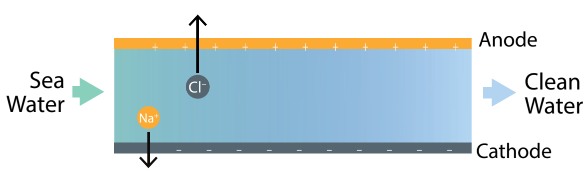
If salt water and fresh water are separated by a semipermeable membrane, osmosis occurs, whereby water flows from the fresh water reservoir to the salt water one. The process of reverse osmosis applies pressure to reverse that process, creating fresh water.

Distillation

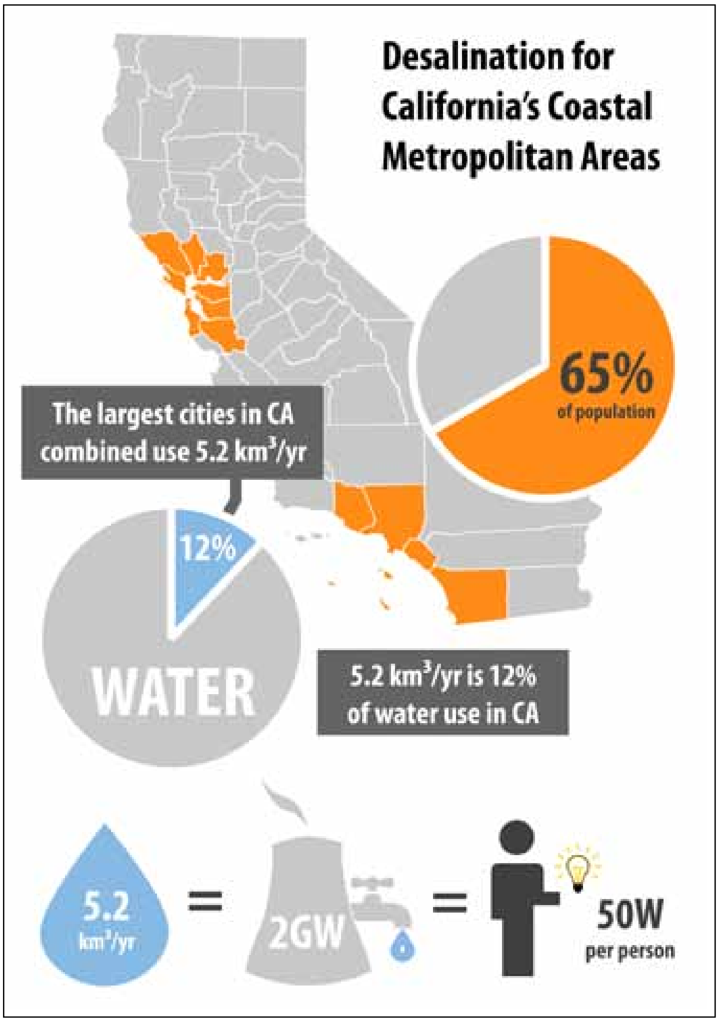


1. Seawater enters cold, 2. gets heated, and 3. turns into steam. The steam then 4. condenses on the cold pipes bringing in water, falls, and 5. is collected.

Electrodialysis



In electrodialysis, an electric potential is applied perpendicular to the water flow. As salty water flows across, the Cl^- ions are attracted to the positive electrode, while Na^+ is attracted to the negative one. They exit through a permeable membrane, leaving pure water behind.



the size of Saudi Arabia's Al-Jubail plant, two dozen plants like Israel's Sorek plant, or about eighty plants the size of the Carlsbad plant. Assuming a typical reverse osmosis energy use of 3 kWh per cubic meter, the power requirement would be on the order of two gigawatts to supply the entirety of the water needs of California's largest coastal cities.

The volume of this desalinated water would be comparable in scale to the major water transfer projects of the 1930s to the 1960s. In 1939 California opened the Colorado River Aqueduct, transferring 1.5 cubic kilometers per year from the Colorado River to Southern California. The California State Water Project and the Central Valley Project transfer 3 cubic kilometers and 8 cubic kilometers per year from the North to the South (when operating at capacity).

With desalination, two gigawatts of power can transfer another 5 cubic kilometers per year, from the Pacific Ocean directly onto land (leaving the salt behind). This wouldn't be simply transferring existing surface supplies, but accessing a new dimension of the water system by creating a new cycle, increasing the water available in the state. This would free up more water inland, as these coastal regions would no longer need to pull from the existing inland water transfer systems, leaving that water for agriculture and other inland needs.

Returning to the energy requirements, for the state of California this would be about 50 watts per

most efficient method for desalinating large volumes of water. The largest reverse-osmosis desalination facility, the Sorek plant in Israel, produces 627,000 cubic meters per day (0.23 cubic kilometers per year). Compare these with what will be the largest desalination plant in the United States (and in the western hemisphere), the Carlsbad desalination facility in California, which will have a potential output of 190,000 cubic meters per day (0.07 cubic kilometers per year).

While these and other desalination plants have demonstrated the viability of desalination technologies, it is time to expand the capacity to a new scale.

Case Study: California

California's coastal cities use 5.2 cubic kilometers of water per year, which is 65-70% of total urban water use in the state, or about 12% of the state's total water use. To produce the entirety of this coastal urban water by desalinating ocean water, would require only a dozen plants

capita to power a desalination project of this scale. This is only a small slice of the increased power per capita made available by a full scale development of a nuclear economy, and practically nothing in the energy flux density levels enabled by an advanced fusion economy.

Additional expansion of desalination could make more water available to pump further inland, providing for inland urban centers and industries, or even advance agriculture. Under a fusion driver program California could create new water cycles, emulating the effect of evaporation and precipitation with desalination and transfer systems, increasing the scale of the hydrological interaction between the Pacific Ocean and North America.

This can become a solid and reliable cycle, completely under the control of man, providing a guaranteed baseline, while weather modification can work to manage atmospheric moisture systems, and expanded water transfer can ensure the best use of what does get precipitated over land.