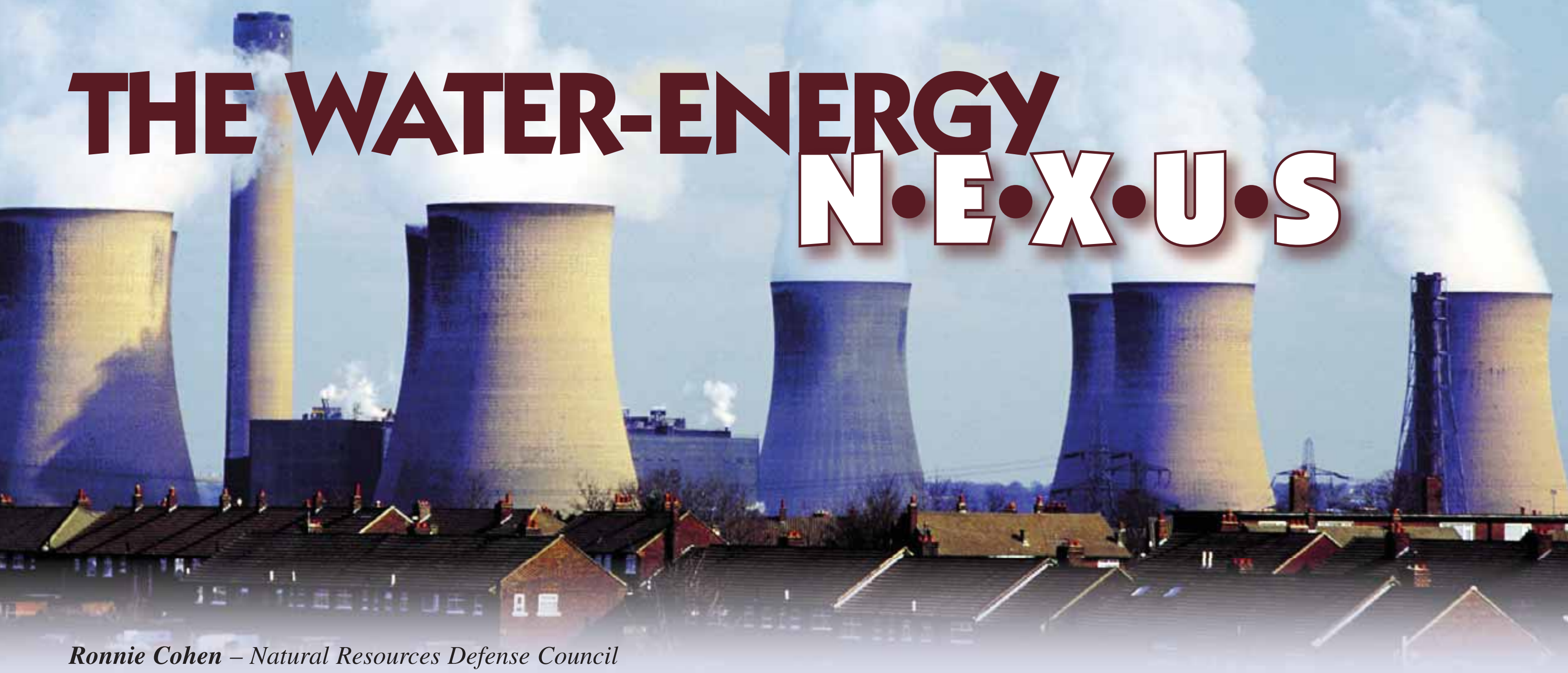
THE WATER-ENERGY N•E•X•U•S



Ronnie Cohen – *Natural Resources Defense Council*

It's not a secret, but most people don't think about it. Water uses a tremendous amount of energy. It is not just a matter of the gas and electricity required to heat, cool, or pump water in our homes and businesses. It takes large amounts of energy before that to extract, convey, treat, and deliver water. Additional energy is required to collect, treat, and dispose of wastewater. While the total energy required for water use is highly location-specific, overall, the California Energy Commission (CEC) has estimated that almost 20 percent of California's electricity demand, and over 30 percent of California's natural gas demand, are associated with water use.

Energy in the Water Use Cycle

Energy is used at five stages of the water use cycle:

Extracting and conveying water: Most water used in the United States is diverted from rivers and streams or pumped from aquifers. Conveying water often means pumping it over hills or into storage facilities—a process that can be highly energy intensive. Smaller amounts of fresh water are extracted from salt, brackish, or recycled water using desalination or other energy-consuming technologies.

Treating water: Water treatment facilities use energy to pump and process water, and this energy demand is expected to increase over the next decade as treatment capacity expands, new water quality standards are adopted, and new treatments are developed to improve the taste and color of drinking water.

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Distributing water: Energy is usually needed to pump and pressurize water, but gravity pressurization and distribution are possible when reservoirs are sufficiently higher than the locations of water use.

Using water: End users consume additional energy by treating water with softeners or filters, circulating and pressurizing water with circulation pumps and irrigation systems, and heating and cooling water.

Collecting and treating wastewater: Energy is used to pump wastewater to the treatment plant, and to aerate and filter it at the plant. On average, wastewater treatment in California uses 500 to 1,500 kilowatt-hours per acre-foot.

Water Options from an Energy Perspective

To keep up with growing demand, water agencies are seeking new sources—generally a mix of surface water, groundwater, recycled water, and desalinated water. How do these alternatives compare when their energy costs are considered?

Surface water: The energy intensity of surface water depends on the source and destination of the water. In much of the West, water is pumped over long distances. Delivering water from Northern to Southern California, for example, requires 3,000 kilowatt hours per acre-foot, because the water is pumped over the 2,000-foot Tehachapi Mountains—the highest lift of any water system in the world. But even gravity-fed water is frequently pumped into and out of reservoirs.

Groundwater: The energy required to extract and deliver groundwater depends on the depth to groundwater and the efficiency of the pumps. In California, energy demands for groundwater pumping range from an average of 292 kilowatt-hours per acre-foot along California's central coast to 740 kilowatt-hours per acre-foot for the Westlands Water District in the Central Valley.

Recycled water: The CEC estimates that the energy required for water recycling—additional treatment of wastewater and transport to the point of use—ranges in California from 325 to 1,000 kilowatt-hours per acre-foot. Depending on the energy costs for surface or groundwater supplies in a certain area, water recycling may be an energy-efficient alternative.

Orange County, California, is constructing a water-recycling system that will use half the energy required to import the same amount of water from Northern California. The project will produce 70 million gallons of water per day for less than the cost of imported water, and save an estimated 140 million kilowatt-hours annually.

Desalinated water: Desalination has been limited in the United States because of its high cost, directly tied to high energy consumption: energy accounts for approximately 40 percent of total desalination costs. The amount varies widely depending on the method used and the quality of the source water. Estimates of energy demand for seawater desalination plants proposed or planned in California range from about 4,400 to 5,500 kilowatt-hours per acre-foot. Desalination of brackish groundwater may require less energy; two such facilities in Southern California require just 405 and 1,700 kilowatt-hours per acre-foot.

Efficiency As a Water Source

Forward-thinking water agencies are also considering efficient use as an "alternative" source of water. These agencies compare efficiency or "demand-side" alternatives to traditional supply-side alternatives for meeting a community's future water needs.

A recent analysis by the Natural Resources Defense Council (NRDC) and the Pacific Institute found that for the San Diego region, end use represents the single largest component of water-related energy costs. If this is true for regions like San Diego, where the energy cost of conveyance is unusally high, it is likely to be even truer for other regions, suggesting potentially enormous energy savings from using water more efficiently.

Residential water use accounts for 50 percent to 85 percent of urban water use. Using water more efficiently may be the single best way to reduce water-related energy costs, because, in addition to saving the on-site energy, efficiency reduces the upstream energy required to extract, convey, treat, and distribute water, as well as the downstream energy needed to treat and dispose of wastewater.

Efficiency measures that reduce indoor water use include installing efficient toilets, showerheads, dishwashers, and clothes washers. Outdoor landscape irrigation, which typically does not require end-use energy nor wastewater treatment, is still a highly promising area for reducing water and energy use, due to the sheer magnitude of water required for landscape use. More than 50 percent of residential use goes to landscape irrigation. This percentage may be even higher in hot, inland areas. According to the CEC, the cumulative energy consumed for outdoor water use (including conveyance, treatment, and distribution) averages 3,500 kilowatt-hours per acre-foot in Northern California and over 11,000 kilowatt-hours per acre-foot in Southern California. Recently, water agencies have begun to focus conservation programs on outdoor use, using such tools as "smart" controllers that adjust landscape irrigation based on weather conditions.

Agencies Taking Strides

Water agencies and energy utilities alike are becoming more aware of the energy-water connection, implementing ways to reduce energy and water consumption.

The Inland Empire Utilities Agency of Southern California adopted an integrated water management strategy to reduce dependence on high-energy water supplies by establishing aggressive efficient-use programs and developing water-recycling and groundwater- and stormwater-recapture programs. The water-recycling program is expected to produce approximately 100,000 acre-feet per year, replacing the same amount of imported water and saving 34 megawatts of electricity a year.

A recent CEC report suggested that conserving water might be a more cost-efficient approach for energy utilities to save energy than traditional programs. Preliminary estimates showed that by conserving water, California could save 95 percent of the energy saved by implementing the usual energy efficiency programs at only 58 percent of the cost.

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Just the Numbers: Energy Consumed for CA Water

(all in kilowatt-hours per acre-foot)

- Transport from Northern to Southern California: 3,000
- Groundwater pumping, Central Coast: 292
- Groundwater pumping, Central Valley: 740
- Planned seawater desalination: 4,400 to 5,500
- Existing brackish water desalination: 405 and 1,700
- Wastewater treatment: 500-1,500
- Water recycling: 325-1,000
- Outdoor water use, Northern California: 3,500
- Outdoor water use, Southern California: more than 11,000

Putting Kilowatt-Hours into Perspective

A kilowatt-hour (kWh) is a unit of energy (power used over time) commonly used with electricity and natural gas. A 100-watt lightbulb left on for 10 hours will consume one kWh of electricity.

According to the U.S. Department of Energy, the average household in the West used 8,300 kilowatt-hours of electricity per year in 2001. Average 2001 electrical consumption for common items includes:

- Refrigerator: 1,239 kWh/year
- Personal computer: 300 kWh/year
- Color TV: 137 kWh/year
- Coffee maker: 116 kWh/year

A typical 10 million-gallon-per-day surface water treatment plant consumes close to 15,000 kWh per day.

The U.S. water and wastewater sector annually consumes around 75 billion kWh.

The average retail price of residential electricity in 2007 is about $0.10/kWh. Commercial and industrial prices are slightly less.

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Climate Concerns

Any evaluation of new water supplies or re-examination of existing supplies must factor in the predicted impacts of climate change. The most energy-conserving approaches—efficient-use programs and recycling—are also likely to be the best performers in the uncertain conditions created by climate change. Water conservation and recycling can help water agencies meet the demand for water under a variety of climate change scenarios, while simultaneously saving them energy and reducing the emissions that contribute to climate change.

As the water-energy nexus gains attention, more people will recognize the role that improved conservation, recycling, and other water management alternatives can play in saving energy. When it comes to saving energy, turning off the tap is like turning off the lights.

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