UniStar NUCLEAR ENERGY

WATER FOR ENERGY, ENERGY FOR WATER

A UniStar Issue Brief

"When the well is dry, we learn the worth of water."

Benjamin Franklin

Water and energy are fundamental to life, and easy access to both is critical to prosperity. Water and energy have a complicated, interdependent relationship in human civilization. Huge quantities of water are used in the production of electricity. In turn, much of that electricity goes to move even greater quantities of water over many miles to locations where it's needed. Water and energy are everywhere, simultaneously supporting each other, consuming each other, and sustaining all of the other activities that makeup the complex ecology of contemporary human society.

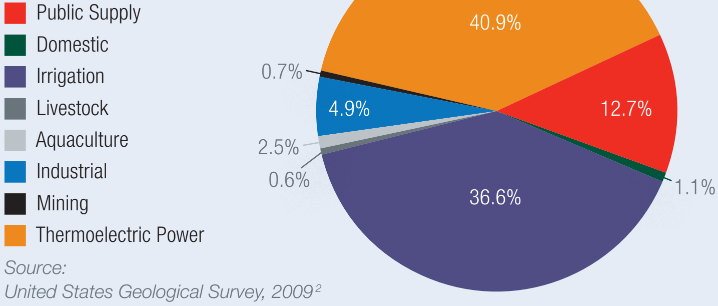
WATER USE IN THE U.S.

To understand water-use issues, one must first understand that there are two types of water use: withdrawal and consumption. These two usage types differ in their effects on the water source and on the other users of that water source.

Water that is removed from the source is said to be withdrawn, but much of that withdrawn water can be used and returned to the original source, essentially unchanged or even improved in quality. Water that is consumed is water that has been evaporated as steam, incorporated into a product, degraded in terms of its usable quality, or not returned to the original source for some other reason. Consumed water is, therefore, no longer available to other users of that source. Water consumed by a user can range from a small fraction to virtually 100 percent of the withdrawn water.

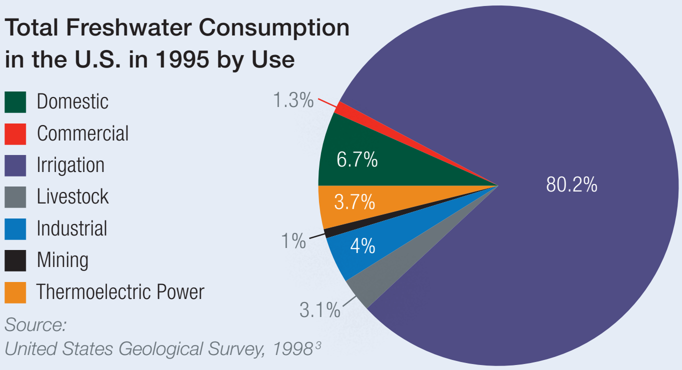
The quantities of water used in the U.S. are immense. In 2005, total withdrawals were 410 billion gallons per day, 85 percent of which were freshwater withdrawals.[1]

Total Freshwater Withdrawals in the U.S. in 2005 by Use



Source: United States Geological Survey, 2009[2]

Total Freshwater Consumption in the U.S. in 1995 by Use

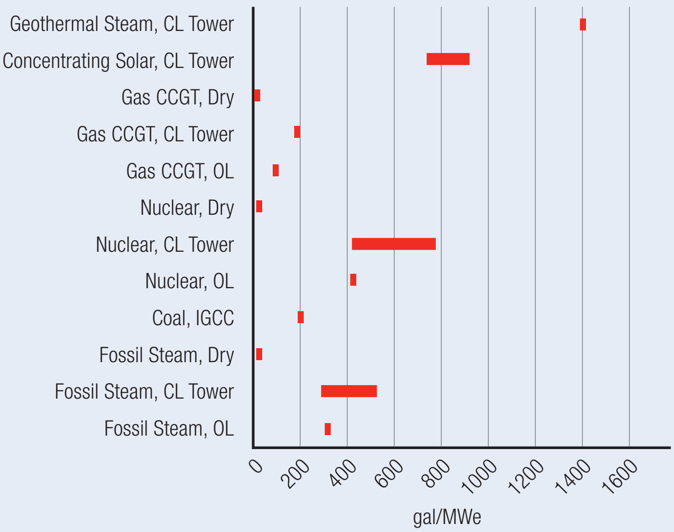


Source: United States Geological Survey, 1998[3]

The differences between the statistics for water withdrawal and consumption are striking. Thermoelectric power plants are the largest category of water withdrawal in the U.S., making up 41 percent of all water withdrawn in 2005. Thermoelectric plants are facilities that generate electricity by using a heat source to create steam to spin turbine-generator systems. This type of facility includes nuclear, coal, gas, oil, geothermal, and concentrating solar generating plants.

However, most of the water used for cooling at thermoelectric plants today is simply returned to its source at a slightly higher temperature, so actual consumption by thermoelectric plants is very low. Agriculture is, by far, the largest category of water consumption in the U.S., accounting for 80 percent of consumption in 1995, the last year for which consumption data were reported. Thermoelectric plants, on the other hand, were responsible for only 3.3 percent of actual water consumption that year, less than half of household use.

Water Consumption for Power Generation



CL: Closed Loop Cooling; OL: Open Loop Cooling; CC: Combined Cycle; IGCC: Integrated Gasification Combined Cycle

Source: U.S. Department of Energy, 2006[4]

WATER AND ENERGY

The relationship of water and energy is complicated. Our current methods of energy production require water for cooling, as well as for the mining and processing of fuels, the manufacturing of hardware, and the construction of the plants.

Likewise, the availability of clean water is dependent on inexpensive, reliable energy. Water must be pumped, treated, and distributed to users, sometimes many miles away from the source. Nationwide, water supply and treatment accounts for about four percent of U.S. electrical consumption. Conveyance of water can be even more energy-intensive. In California, pumping, treating, transporting, heating, cooling, and recycling water account for about 19 percent of the state's electrical consumption (California Energy Commission, 2005).[6]

Water issues never occur in isolation. When supplies are adequate, water is a multi-user resource with the same water source simultaneously meeting the needs of many users. A single water source may provide domestic water to a population center, cooling water for electrical generation, process water for industries, irrigation water for agriculture, habitat for fisheries, vacation destinations for tourism, and recreational opportunities for nearby residents, all at the same time.

When there is a supply shortage, competition among the usual beneficiaries of a water resource can be fierce. Withdraw too much for farming, and there may be power cutbacks; prioritize power or drinking water, and a crop fails; drain a reservoir below critical levels, and a fishery doesn't survive the winter. A water shortage will quickly become a shortage of something else, if not everything else.

Many Water Costs are Indirect

• Generating the electricity at a coal-fired plant to burn a 60-watt light bulb for 30 minutes requires about two quarts of water (Virginia Tech, 2008).[6]	• Producing a 150-gram (1/3 lb.) hamburger before cooking requires 634 gallons of water for raising cattle and irrigating feed (UNESCO, 2004).[7]	• Making one gallon of fuel alcohol from corn requires 788 gallons of process and irrigation water (USDA, 2004).[8]

GEOGRAPHY

Water issues and solutions are generally local or regional issues. With enough energy, we can divert, store, and move water reasonable distances. But given the weight and quantity of water used, we can't harvest it in one locale and ship it all over the world as we do with other commodities.

Water resources and possible shortages vary by region. But population growth doesn't reflect this; in fact it seems to fly in the face of it. Populations are growing fastest where freshwater supplies are already strained.

Population Growth Trends & the Availability of Fresh Water[9]

- During the 1990's, regional population growth was highest (25 percent) in the most water-deficient region of the country—the mountain West.
- Growth was also high in the Southeast (14 percent), where water availability was becoming an issue.
- Growth was only two percent in the Northeast, where fresh water was relatively abundant.
- Increased population growth is expected to continue in regions where fresh water supply is an issue, the arid West and the Southeast, especially Florida.
- The population shift toward warmer climates will result in disproportionate growth in electrical demand for cooling and increased competition for dwindling supplies of fresh water.

Most irrigation for crops occurs in the West, a region with chronic, long-term water supply isues. Although only 17 percent of cropland in the West is irrigated, irrigated crops account for 50 percent of the dollar value of all crops raised.[10]

"Water is like our gold, and we have to treat it like that."

California Governor Arnold Schwarzenegger, June 2008

NUCLEAR GENERATION AND WATER

Spray irrigation of crops.

About 60 percent of the nuclear generating facilities in the U.S. use a once-through cooling system. These systems withdraw the most water but return virtually all of it to the original source. The other 40 percent use closed loop or recirculating cooling systems. These systems withdraw far less but consume most of the water through evaporation. No nuclear facilities in the U.S. use air or dry cooling. If used, dry cooling would consume no water, but would result in higher internal energy consumption to drive cooling fans.

Once-through cooling is the least expensive method of cooling. Closed loop, wet cooling systems have higher capital costs and come with an operating penalty of a two to five percent reduction in plant efficiency. Dry cooling systems cost even more—three to five times the cost of wet cooling systems. Their operating penalties are also higher, from two percent in cold climates to 20 to 25 percent on hot days in warmer climates. Hybrid systems can be designed to use minimal amounts of water for cooling to prevent plant efficiency losses on the hottest days.

Cooling Technologies and Water Use in Nuclear Electrical Generation (gal/MWhe)

Cooling Process	Withdrawal	Consumption
Once-Through Cooling	25,000–60,000	~400
Closed Loop with Cooling Tower	500–1,100	400–720
Closed Loop with Cooling Pond	800–1,100	~720
Dry Cooling	0	0

Source: USDOE, 2006

NUCLEAR SOLUTIONS

Since water issues are local, opportunities may be available to provide unique cooling solutions for specific new nuclear energy facilities. In fact, some existing nuclear facilities have already championed such innovative uses for non-potable or lower-quality water supplies such as gray water, waste water, or saline aquifers. Palo Verde Nuclear Generating Station in Arizona uses 100 percent reclaimed wastewater for cooling and has no liquid discharge to fresh water bodies. Limerick Nuclear Generating Station in Pennsylvania qualifies for greater cooling water withdrawal from the Schuylkill River by augmenting the upstream river flow with water pumped from a non-acid, mine drainage pool. The project maintains flow and water quality in times of otherwise low river flow.

Calvert Cliffs 3—the U.S. EPR™ project being considered by UniStar Nuclear Energy for Maryland—will use several innovative approaches to minimize the impacts of its water use. While Calvert Cliffs 1 and 2 use open-loop, once-through cooling, Calvert Cliffs 3 will use a closed-loop cooling tower, cutting its withdrawal from the Chesapeake Bay to less than two percent of the once-through design. To preserve the aesthetic low profile of the site, Calvert Cliffs 3 will use an innovative, low-profile, mechanical-draft cooling tower that rises only to about a quarter of the height of a natural draft cooling tower. In addition, since only one low-profile tower will be required instead of two natural draft towers, the space needed is significantly reduced.

Incorporation of plume abatement in the design ensures there will be no visible steam plume under most conditions.

The Calvert Cliffs 3 plans also include a unique feature to avoid any need for groundwater from the local freshwater aquifer once the plant becomes operational. Its design incorporates a desalination plant capable of producing up to 1.25 million gallons of fresh water per day from the brackish water of the Chesapeake Bay. This desalination plant will satisfy all of the facility's freshwater needs.

Needless to say, these features add cost to the facility and will consume some of the plant electrical output. But the reliability of base load nuclear energy and the low production cost of its electricity, make it economical to incorporate these water-saving design features. Calvert Cliffs 3 thus provides an excellent example of how the 24/7 availability of electricity from nuclear energy facilities, coupled with the willingness to design innovative cooling solutions, positions new nuclear energy to be an integral part of solving our energy-water dilemma.

"Water efficiency is the wave of the future."

Benjamin Grumbles, asst. administrator for water at the Environmental Protection Agency

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This UniStar Issue Brief is a publication of UniStar Nuclear Energy, a joint venture of Constellation Energy and EDF Inc. It is one in a series of Issue Briefs presenting information and interpretation on important issues surrounding the growth of electrical generation in the United States. UniStar and its partners are working to meet future energy needs with a new generation of nuclear generating facilities, the most effective combination of clean, reliable, and environmentally-friendly electrical production. We have confidence that an informed public armed with the facts behind our energy options will support increasing the role of nuclear generation for meeting the nation's future electricity demand. The Issue Briefs series is just one part of UniStar's efforts to keep the public fully informed.

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