At the Crossroads:

Energy Demands for Water Versus Water Availability

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Water is an integral part of energy development, production, and generation. Water is used directly in hydroelectric power generation and is used extensively for thermoelectric power plant cooling and air emissions control. It is also widely used in energy-resource extraction, refining, and processing, as well as for energy resource transportation. As shown below, the U.S. energy sector now withdraws about 140 billion gallons per day (Bgal/day) of fresh water and 60 Bgal/day of saline water, accounting for 39 percent of daily fresh water withdrawals and 50 percent of total water withdrawals (Hutson and others, 2004).

Energy sector water withdrawals are currently dominated by cooling water for thermoelectric power generation, though many current power plants return the cooling water to the source for reuse downstream. Therefore, while total water *withdrawals* for energy are high, fresh water *consumption* in 1995—the last year data were collected—was only about 4.3 Bgal/day (Solley and others, 1998). Still, this accounts for more than 25 percent of all daily nonagricultural fresh water consumption in the United States.

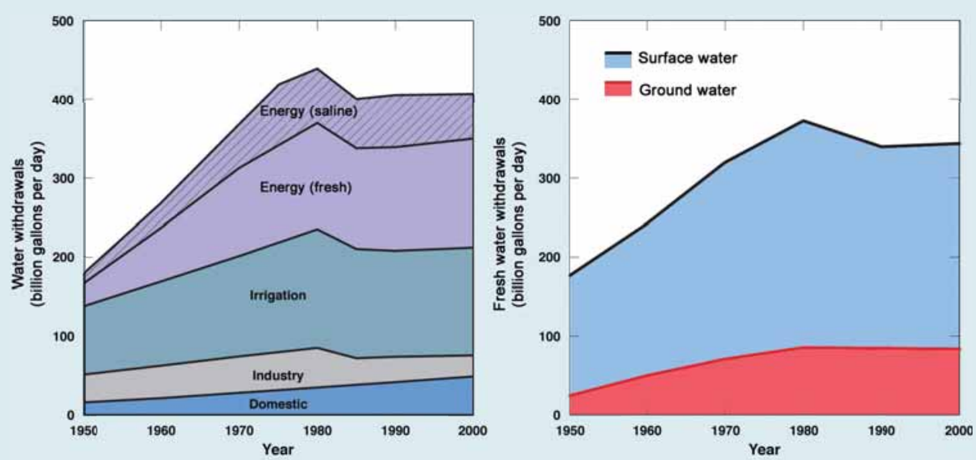
Growing Energy Demands for Water

In its reference case for 2006, the Energy Information Administration (EIA) projects the U.S. population to grow by 70 million by 2030, increasing electric power demands by 50 percent and transportation fuel demands by 30 percent. Much of this growth is expected in the Southeast, Southwest, and West, significantly increasing water demands for energy growth in regions with already-stressed water supplies. EIA projects major growth in coal-fired power plants, modest growth for natural gas and renewable power, and a slight growth in nuclear power. Also, traditional domestic petroleum supplies are projected to remain constant at about 10 million barrels per day, while alternative domestic petroleum supplies are projected to grow substantially.

By 2030, EIA projects that the United States will produce almost 5 million barrels per day of ethanol and biodiesel fuels, and as much as 3 to 5 million barrels per day of alternative fuels from oil shale. Beyond 2030, hydrogen production from steam reforming of natural gas, the use of concentrating solar and wind resources for the electrolysis of water, and construction of new hydrogen producing nuclear power plants could also provide alternative transportation fuels (DOE, 2007).

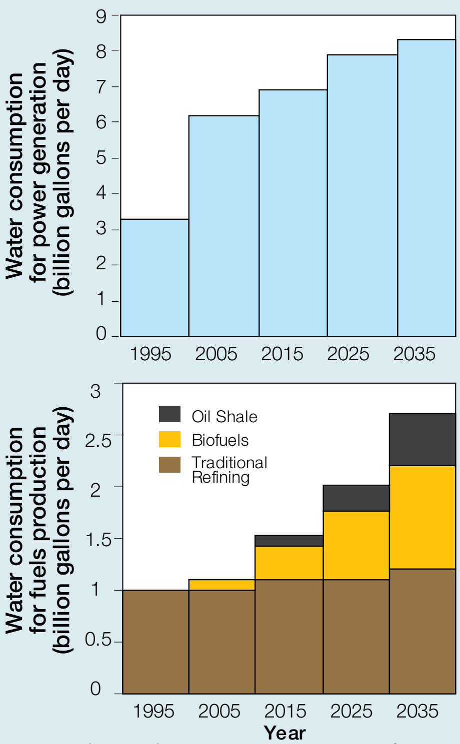
The increased water needed to meet this growth in electric power generation and fuel production will depend on the type and number of power plants built, cooling technologies used, air and carbon emission requirements, and the type and quantity of alternative fuels produced. The figures at right show estimates of the increased water consumption for energy development projected from 1995, based on these assumptions: 1) current trends in evaporative power plant cooling will continue; 2) carbon emission requirements will not be imposed; and 3) projected petroleum, oil shale, and biofuels development will occur (Cameron, 2006). The estimates include the significant growth in gas-fired power plants and biofuels production that have occurred since 1995, but have yet to be quantified through water consumption assessments by the U.S. Geological Survey.

Not included in the charts are two potentially significant water requirements that must be considered. If carbon



U.S. water withdrawal trends, 1950-2000 (from Hutson and others, 2004).

emission caps are implemented, water consumption for electric power generation could increase an additional 25 percent, or an additional 1 to 2 Bgal/day, by 2030. Also, irrigation of biofuel feedstocks will depend on crop market conditions, oil prices, and incentive policies. Much of the biomass feedstock is expected to come from areas with high rainfall, but even small amounts of irrigation to stabilize yields will substantially increase water consumption. Irrigation of only two percent of grain and cellulose-based biofuel production



Projected growth in water consumption for power generation (top) and fuels production (bottom).

would consume an additional 5 Bgal/day by 2030. While some of this water demand could be transferred from agricultural uses, the volumes of water required warrant serious consideration.

Therefore, water consumption for the energy sector, including power generation plus fuels production, could grow from the 4.3 Bgal/day used in 1995 to somewhere between 11 and 17 Bgal/day by 2035. Other alternatives, such as hydrogen production as proposed in the Hydrogen Posture Plan (DOE, 2004), could require as many as 300 new high-efficiency nuclear power plants. While the hydrogen from these power plants could replace alternative fuels and reduce associated water demands, with evaporative cooling they would consume over 3 Bgal/day of fresh water.

Water Availability Challenges

The projected growth in water demands for future energy development is occurring at a time when the nation's water supplies are seeing increasing stress from surface-water storage limitations, depletion of groundwater, instream ecological needs, and uncertainty about climate variability impacts on water resources. From 1920 to 1980, the United States tripled its surface water storage capacity by building many large dams, which supported significant increases in surface water withdrawals as shown in the chart on page 24, right. But since 1980 few new reservoirs have been built, and without expansion of dams or changes in operations, fresh surface-water withdrawal rates will remain fixed. If

see Crossroads, page 37

Because iron is well known for its ability to bind arsenic, Colvin's group repeated the experiments in arsenic-contaminated water and found that the particles reduce the amount of arsenic to levels well below the EPA's drinking water standard.

Preliminary calculations indicate the method could be practical for settings where traditional water treatment technologies are not possible. The cost of the materials could be quite low if manufacturing methods are scaled up. The primary raw materials used to prepare the iron oxide are rust and fatty acids, which can be obtained from olive oil or coconut oil.

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New Mexico's First Artificial Recharge Project Planned

Having observed its neighboring states artificially recharging aquifers for decades, the first such project in New Mexico has appeared on the horizon. The Albuquerque-Bernalillo County Water Utility Authority is planning a $1 million study to test the feasibility of diverting water from the Rio Grande into an arroyo, which will serve as a natural recharge basin, according to an *Associated Press* report in the *Albuquerque Tribune*.

Although the project must first be approved by the state, the utility hopes to begin the project this fall, using about 1,000 acre-feet of river water to measure the recharge rates that can be achieved, said the *AP* report. Monitoring wells and instrumentation will be used to track its progress to the aquifer 300-500 feet below the surface.

AP interviewed John Stomp, manager of the city-county water utility, who said underground storage and recovery is "part of the utility's long-range plan." Eventually the utility hopes to bypass the recharge basin and use recharge wells to inject river water treated to drinking water standards directly into the aquifer.

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Crossroads, continued from page 25

major dams are removed, surface-water withdrawal rates would likely decrease.

Groundwater resources will not be the answer: impacts to aquifers from excessive pumping in the latter half of the 20th century will limit new groundwater development and future use. Furthermore, climate variability is expected to affect snowfall and precipitation, the timing of spring runoff, and streamflow volumes, resulting in many regions experiencing significant reductions in reservoir storage, and surface-water and groundwater availability.

These limitations on fresh water supplies are forcing expansion of the use of nontraditional waters such as brackish water, seawater, and wastewater to supplement supplies in many areas. The growth in nontraditional water use over the past decade has been remarkable as water treatment technologies have matured. Wastewater reclamation and reuse and desalination are growing at rates of 15 and 10 percent per year, respectively. As shown in the chart below left, nontraditional water consumption is predicted to equal fresh water consumption for nonagricultural needs by 2035.

Addressing Energy and Water Resource Challenges

The chart below right shows that projected growth in water consumption for energy is the major driver for future water demands. These new water demands will increasingly be met by the use of nontraditional water resources. Energy demands for water alone could outstrip available nonagricultural fresh water supplies by 2035. These interdependencies between energy and water and their impact on future economic growth are being recognized by energy officials and energy and water managers. For example, in mid-2005, Congress funded the Department of Energy to develop an energy-water report to Congress to help identify and quantify emerging energy and water challenges and issues (DOE, 2007). Congress also funded a series of regional workshops to help identify research and development efforts to address these emerging challenges and issues (see *www.sandia.gov/energy-water*). These efforts are the first steps in improving and coordinating energy and water resource planning and development to ensure future energy and water reliability and sustainability.

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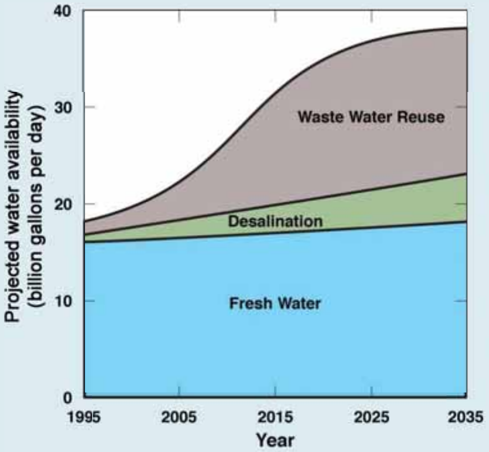

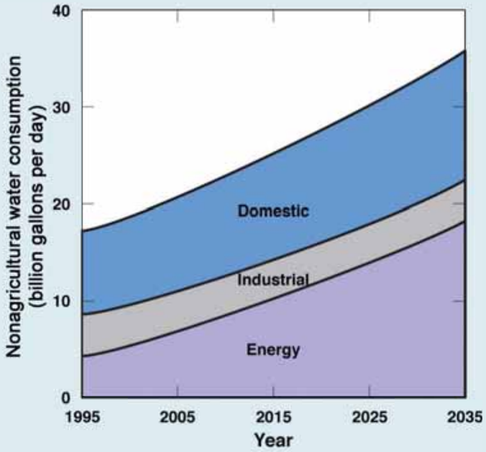

Nonagricultural water consumption and water supply trends for the United States, 1995-2035.