Water-Energy Nexus: *Solutions to Meet a Growing Demand*

Executive Summary
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Credit: U.S. Geological Survey

Water and energy are vital to the prosperity of the United States. We describe intimate but easily overlooked connections between the two resources: energy production relies on enormous amounts of water, and developing and delivering water supplies consumes large amounts of energy. As demand for both water and energy is expected to increase with population growth, we describe the challenges to addressing limited water and energy supplies. Obstacles exist at all scales and demand involvement of stakeholders, experts, and policymakers. In particular, we argue that because of the ubiquitous nature of the nexus between water and energy, a large-scale or system view is required to address both resource supplies together. This report will highlight some of the challenges we face in securing our energy and water resources, important steps to drive solutions, and the role of federal government to help us achieve a sustainable future.

Challenges to addressing vital societal implications include the following:

- Difficulty in finding and synthesizing information concerning the intersection of water and energy
- Coordination between energy and water managers
- Water prices often not reflecting the economic cost of supplying the water
- Competing demands for energy and water
- Changing supplies for energy and water
- Sharing information between scientific community, policymakers, and other stakeholders

Water and energy managers, stakeholders, and consumers can benefit greatly from the following:

- Enhanced data coverage, accessibility, and transparency
- Improved coordination between stakeholders and government agencies
- Investments in technology
- Anticipating supply changes due to climate change
- Policies to encourage suitable utility and consumer conservation

The federal government can play a major role by taking the following steps:

- Providing improved data collection and management
- Improving coordination and communication between stakeholders

- Investing in technology that promotes efficiency
- Support easily accessible user tools including better modeling and forecasting
- Offering financial support to resource managers to improve infrastructure, develop alternative supplies, and encourage conservation
- Diversifying a fuel portfolio by replacing existing fuels with less water-intensive ones

The relationship between water and energy is intricate, strong, and far-reaching. Americans depend heavily on reliable supplies of both water and energy for their social and economic well-being. These codependent resources are in high demand from many competing uses, which restricts their availability. Demand for both is expected to increase in the near future, which will further limit their supplies for an increasing population. Areas like the Southwest, where water availability is low and energy and water demands are high and rising, are increasingly vulnerable to shortages. Additionally, communities are impacted when a shortage of water requires power plants to curb energy generation or when high electricity costs prohibit the feasibility of desalinization plants or other infrastructure to provide clean water. Scarcity will be further exacerbated by the growing influence of climate change on both demands and supplies. Both water and energy impact nearly every aspect of American livelihood, from food supply to transportation to industry. Despite these challenges, America has the foresight and resources to begin resolving the issues related to the water-energy nexus on a national scale.

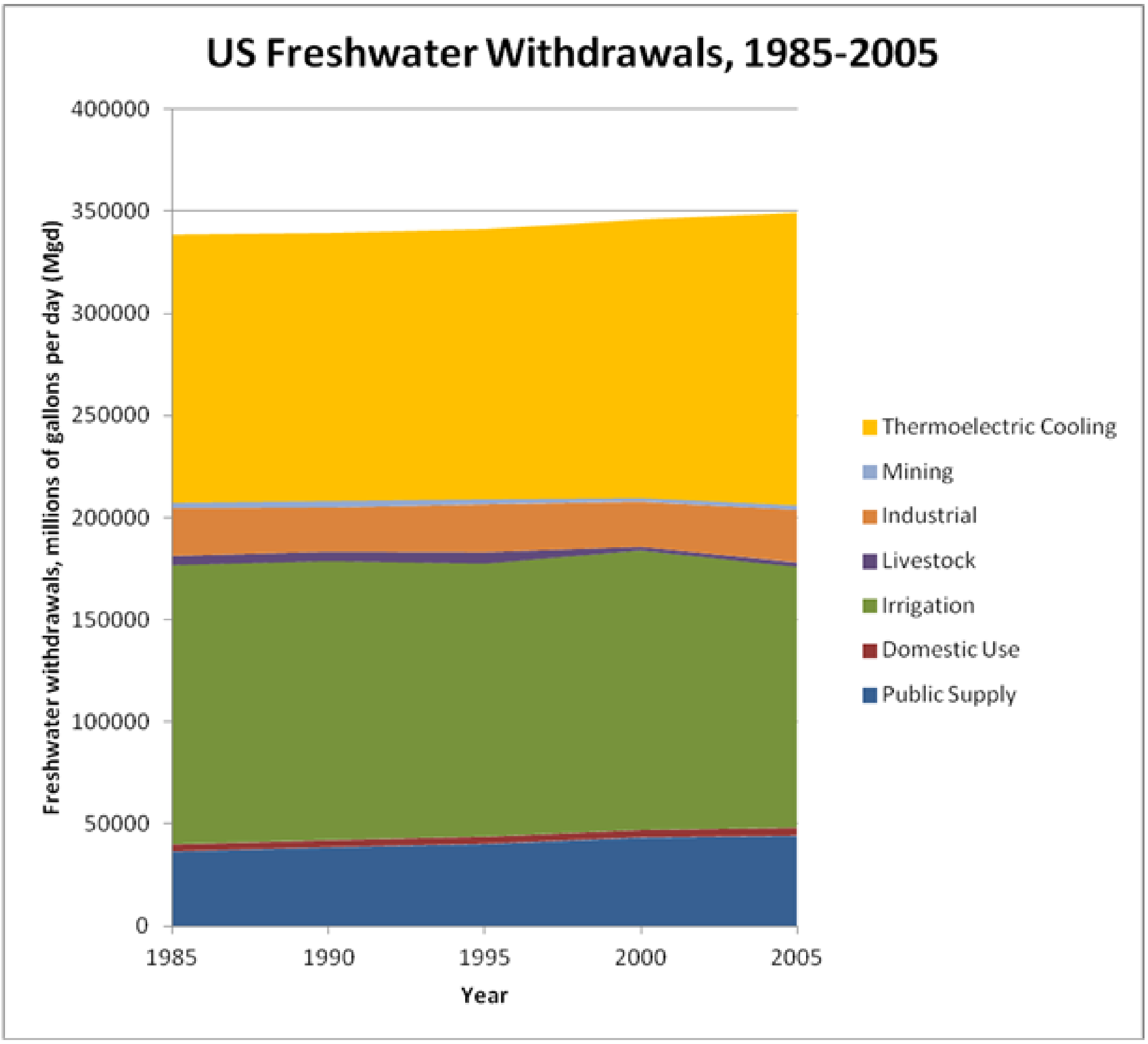

Figure 1. US Freshwater Withdrawals, 1985-2005. Total withdrawals have increased slightly since 1985. Much of this increase has come from increasing demand for public supplies and thermoelectric cooling [Kenney et al., 2009].

Water Consumption for Transportation Fuels

Fuel Type and Process	Relationship to Water Quality	Relationship to Water Quality	Water Consumption	
			Water consumed per-unit-energy [gal/MMBTU]†	Average gal water consumed per gal fuel
Conventional Oil & Gas -Oil Refining	Water needed to extract and refine; water produced from extraction	Produced water generated from extraction; Wastewater generated from processing	7 – 20	~ 1.5
-NG extraction/Processing			2 – 3	~ 4
Biofuels -Grain Ethanol Processing	Water needed for growing feedstock and for fuel processing	Wasterwater generated from processing; Agricultural irrigation runoff and infiltration contaminated with fertilizer, herbicide, and pesticide compounds	12 – 160	~ 4
-Corn Irrigation for EtOH			2500 – 31600	~ 980*
-Biodiesel Processing			4 – 5	~ 1
-Soy Irrigation for Biodiesel			13800 – 60000	~ 6500*
-Lignocellulosic Ethanol and other synthesized Biomass to Liquid (BTL) fuels	Water for processing; Energy crop impacts on hydrolic flows	Wastewater generated; Water qulaity benefits of perennial energy crops	24 – 150 ‡ʃ (ethanol) 14 – 90 ‡ʃ (diesel)	~ 2 – 6 ‡ʃ ~ 2 – 6 ‡ʃ
Oil Shale -In situ retort	Water needed to Extract/Refine	Wasterwater genergated; In-situ impact uncertain; Surface leachate runoff	1 – 9 ‡	~ 2 ‡
-Ex situ retort			15 – 40 ‡	~ 3 ‡
Oil Sands	Water needed to Extract/Refine	Wasterwater generated; Leachate runoff	20 – 50	~ 4 – 6
Synthetic Fuels -Coal to Liquid (CTL)	Water needed for synthesis and/or steam reforming of natural gas (NG)	Wastewater generated from coal mining and CTL processing	35 – 70	~ 4.5 – 9.0
-Hydrogen RE Electrolysis			20 – 24 ‡	~ 3 ‡
-Hydrogen (NG Reforming)			40 – 50 ‡	~ 7 ‡

†Ranges of water use per unit energy largely based on data taken from the Energy-Water Report to Congress (DOE, 2007)
*Conservative estimates of water use intensity for irrigated feedstock production based on per-acre crop water demand and fuel yield
‡Estimates based on unvalidated projections for commercial processing; ʃ Assuming rain-fed biomass feedstock production

Table A-1. A comparison of water consumption demands from various transportation fuels by *Pate et al.* [2007]. Since vehicles engines are not steam turbines that require water withdrawals, there are no water cooling demands for these fuels. Water intensity is indicated by the amount of water consumed to produce a given amount of energy from a fuel, in gallons per million British thermal units (gal/MMBTU). Water intensity is also indicated by the amount of water consumed for a given amount of fuel, in gallons of water per gallon of fuel. Note that estimates for biofuels are based on the potential for high irrigation requirements. If biofuel feedstock is grown where irrigation needs are low, consumption can be significantly reduced. In addition, the ranges seen here reflect the variable amounts of water needed for specific locations and fuel sources.

The full-length document, including references, is available online:

www.agu.org/WENreport