The Wind/Water Nexus

Wind Powering America Fact Sheet Series

Nobel laureate Richard Smalley cited energy and water as among humanity's top problems for the next 50 years as the world's population increases from 6.3 billion to 9 billion.[1] The U.S. Department of Energy's Wind and Hydropower Program has initiated an effort to explore wind energy's role as a technical solution to this critically important issue in the United States and the world. This fact sheet outlines five areas in which wind energy can contribute.

In 2000, the national U.S. average freshwater withdrawal per capita was approximately 1464 gallons per day, which includes 190 gallons per day for domestic and commercial use, 673 gallons per day for industrial use, and 600 gallons per day for agricultural use.[2] As the U.S. population increases, the demand for clean water will also increase—but the supply is finite.

In many regions, the water supply is shrinking because of drought and non-sustainable pumping of aquifers. Drought impacts in the West reduce the amount of available water for existing and planned thermal power production, urban and agriculture use, and hydropower production. According to Bennett Raley, Department of the Interior's former Assistant Secretary for Water and Science, "The demands for water in many basins of the West exceed the available supply even in normal years."[3] Water managers in 36 states surveyed by the GAO said they anticipate water shortages in the next 10 years even under "normal conditions."[4] Forty-six state water managers predicted water shortages in the next 10 years under drought conditions; these shortages "may be accompanied by severe economic, environmental and social impacts."[5]

Drought impacts in the West reduce the amount of available water for existing and planned thermal power production, urban and agriculture use, increased pumping requirements, and hydropower production.

Implementing wind energy is a means to address the national and global challenge of water resource management. The U.S. Department of Energy has identified five water application areas in which wind energy could contribute: thermoelectric power plant/water processes, irrigation, municipal water supply, desalination, and wind-hydropower integration.

Thermoelectric Power Plant/Water Processes

In 2000, the largest category of water withdrawals was thermoelectric power, accounting for 48% of total withdrawals[6] in the United States.[7] The primary use of water at plants is for condensing steam, or cooling steam back into water. Water is also used in thermoelectric power plants to generate electricity, purge boilers, and wash stacks. Although newer plants recirculate water or use dry cooling, once-through cooling methods are the most common technology in use.[8]

The Facts

- In 2000, an estimated 195,000 Mgal/d, or 219 million acre-feet per year, were withdrawn for thermoelectric power.[9]
- The least efficient water-cooled plants use as much as 50 gallons of water per kilowatt-hour (kWh).[10]
- Water quality is affected by water use at power plants because of the effects of the temperature of discharged cooling water and the conditioning agents used to treat cooling water.[11]

Coal power plant smokestacks emitting steam. In 2002, fossil fuel and nuclear plants withdrew nearly 225 billion gallons of water per day.

- The National Energy Technology Laboratory (NETL) estimates that over the next 20 years, the majority of new generation plants will use recirculating, closed-loop cooling technology, which will result in a 10% reduction in withdrawals but a dramatic increase in water consumption.[12]

How Can Wind Energy Help?

Wind energy does not use or consume water during electricity generation. Greater additions of wind to offset fossil, hydropower, and nuclear assets in a generation portfolio will result in a technology that uses no water, offsetting water-dependent technologies. By diversifying the generating portfolio energy mix, a utility can manage its water supply risks.

Table 1. Estimated Water Saved Annually by Wind Energy Installations in the Interior West[13]

Megawatts of Wind Energy	Water Savings: Gallons WITHDRAWN	Water Savings: Gallons CONSUMED
3,000	7.88 billion	4.73 billion
4,000	10.51 billion	6.31 billion

Irrigation

Irrigation is the second largest water user in the United States.

The Facts

- In 2000, irrigation accounted for 34% of water withdrawals and 137 billion gallons per day.[14]
- About 14% of U.S. farms are irrigated, representing 55 million acres of irrigated land.[15]

Irrigation is the second largest water user in the United States.

- Irrigation systems use diesel, gasoline, electricity, propane, or natural gas, depending on the local economics, availability, and pump size. For example, 75% of irrigation in Colorado is powered by electricity, while 75% of irrigation in Kansas is powered by propane/natural gas. Irrigation in Texas is powered almost equally by electricity, diesel, and propane/natural gas. Most smaller on-farm pumps are electric.[16]

How Can Wind Energy Help?

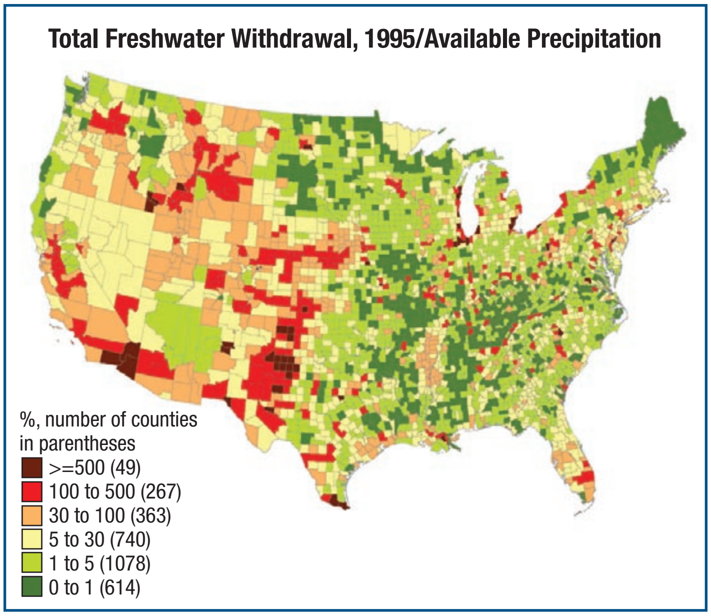
- Nine of the top 10 irrigation states (California, Texas, Idaho, Arkansas, Colorado, Nebraska, Arizona, Kansas, Washington, and Oregon[17]) have good to excellent wind resources.[18]
- The rising and uncertain future costs of diesel, natural gas, and even electricity increase the opportunity for wind energy and its predictable and competitive cost.
- Hybrid wind-gas or wind-diesel systems provide another option.

Municipal Water Supply

Many municipalities face rising and variable energy prices, increasing water demand, and increasing competition for declining water supplies. In the United States, 80% of the U.S. population lives in urban areas[19], and that percentage is increasing. Increasingly, water rights are purchased from rural areas to satisfy the urban demand.

The Facts

- In 2000, total freshwater withdrawals for public supply were 43.3 billion gallons per day.[20]
- The states with the largest public supply withdrawals are (in descending order) California, Texas, New York, Florida, Illinois, Ohio, Pennsylvania, Georgia, Michigan, and Arizona.[21]



Many U.S. areas experience non-sustainable freshwater withdrawals.
Source: EPRI 2003.

How Can Wind Energy Help?

- Twelve of the 15 fastest-growing states (1995–2025)[22], eight of the 10 states with the largest public water supply withdrawals[23], and nine of the 10 states with the highest per capita water consumption[24] have good to excellent wind resources.[25]
- Offshore (including the Great Lakes) wind resources are particularly robust[26] and close to large and growing metropolitan areas.
- Municipalities with air quality requirements may favor wind solutions.[27] Water pumping often involves storage, so the intermittency of wind may be somewhat mitigated.
- Wind energy is relatively economically competitive, predictable, and renewable—all benefits to municipal electricity/water providers.

Desalination

One strategy to address impending water shortages is the development of new water sources, such as brackish aquifers and sea water. Desalination is utilized by coastal cities as well as inland municipalities with access to brackish water sources.

The Facts

- Desalination requires a constant power supply, and electricity is the major cost for these plants: for brackish water, electricity use is 11% of total cost, and for seawater, it is 44% of operating costs for the plant.[28]

How Can Wind Energy Help?

- Many growing coastal cities with high energy costs are located in good wind resource areas.[29]
- Desalination systems can be installed off-grid, powered by wind or hybrid systems (such as wind-diesel).

Wind/Hydropower Integration

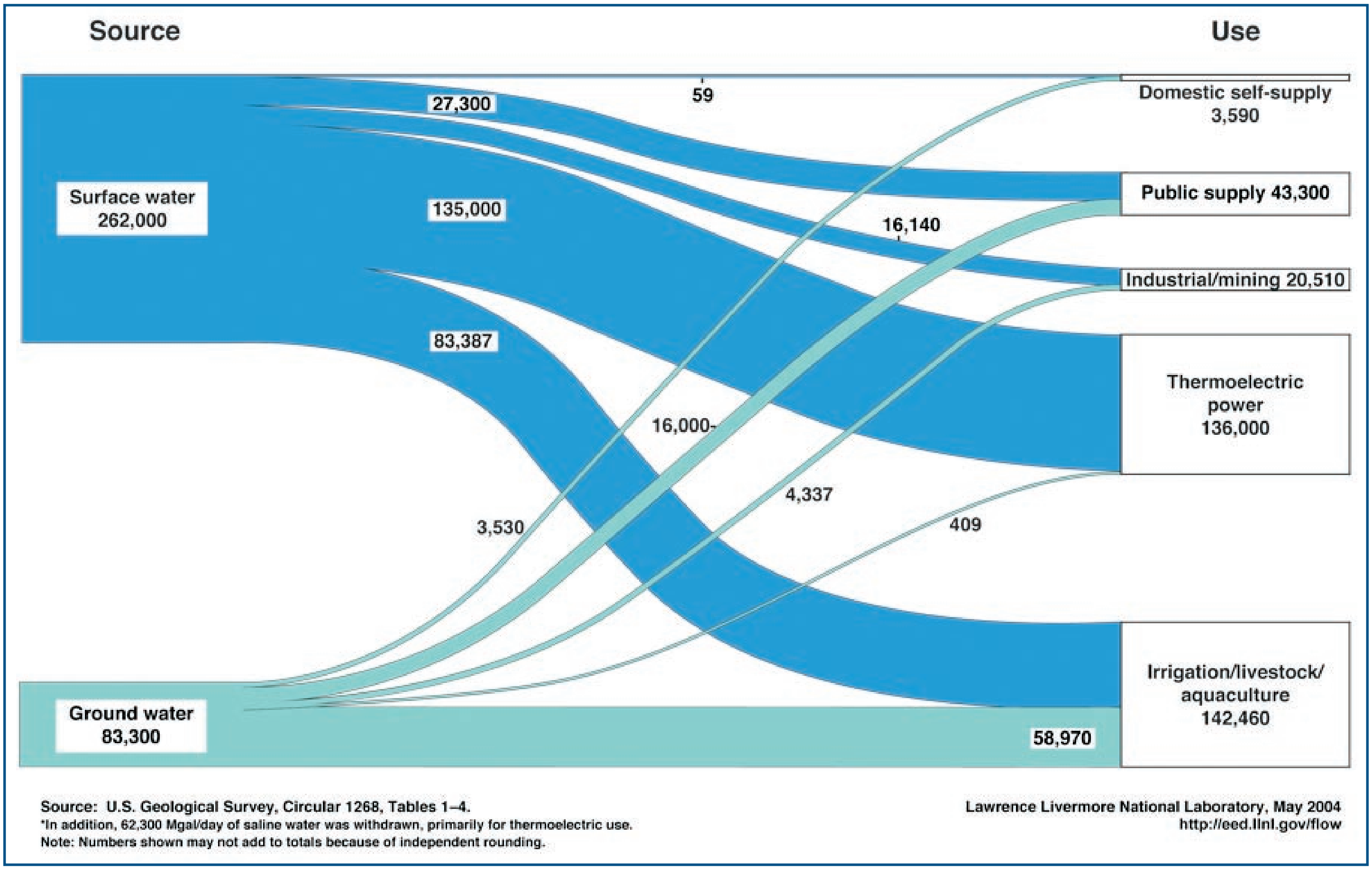
Hydropower, the most established of the renewable energy technologies, offers significant benefits. It is a reliable, domestic resource that emits no harmful greenhouse gases. Hydropower projects also provide other benefits, such as water supply, flood control, irrigation, navigation, and recreation.

The Facts

- About 10% of U.S. electricity comes from hydropower.[30]
- More than 75% of the nation's renewable energy is generated from hydropower.[31]

How Can Wind Energy Help?

- Hydroelectric generating plants can "store" energy and then release water to generate electricity when it is needed. This ability to store energy is an asset that can be combined with wind energy to enable larger-scale use of renewable energy.



Estimated U.S. freshwater* withdrawals in 2000: ~345,000 Mgal/day.

Other Benefits of Wind Energy

- With today's rising coal and gas prices, new wind plants compete favorably against any new electricity generation source. In fact, when the Colorado Public Service Commission issued a ruling on the 161-MW wind project in Lamar, Colorado, the commission determined that wind energy provided the lowest cost of any generation resource submitted to a solicitation bid by Xcel Energy. The commission also noted that unlike the other generation resources considered, the Lamar project avoided a future risk of increased fuel prices.[32]

- Wind energy boosts rural economic development and is a valuable crop of the future for farmers and ranchers. Wind farms are located in rural areas where they provide well-paying jobs, as well as land lease revenue for farmers and ranchers (as much as $4,000 per turbine per year). Wind energy also provides an increased local tax base (Prowers County, home to the Lamar project, increased its local tax base by $32 million). Wind turbines are compatible with rural land uses—crops can be grown and livestock can be grazed up to the base of the turbine.[33]

- Wind energy is clean energy that produces no emissions, which means it doesn't contribute to acid rain and snow, global climate change, smog, regional haze, mercury poisoning, water withdrawal, or before related chemical and thermal alterations.

Footnotes

[1]1 R.E. Smalley. (April 3, 2005). *Our Energy Challenge*. 27th Illinois Junior Science and Humanities Symposium. *http://cohesion.rice.edu/NaturalSciences/Smalley/emplibrary 040305%20Illinois%20Science%20Symposium.ppt*

[2]Gleick, P. (2004). *The World's Water 2004–2005: The Biennial Report on Freshwater Resources*. Island Press, p. 267.

[3]Statement before the Senate Energy and Natural Resources Committee Oversight Hearing on Water in the West. March 9, 2004. *www.doi.gov/water2025/raley3-9-04.doc*

[4]United States General Accounting Office. (2003). *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages*. GAO Highlights, July. *www.gao.gov/new.items/d03514.pdf*

[5]United States General Accounting Office. (2003). *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages*. GAO Highlights, July. *www.gao.gov/new.items/d03514.pdf*

[6]Water withdrawals are returned to the local surface or groundwater and are available for subsequent use; the term consumption is used to denote water that is consumed and not available for subsequent use.

[7]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[8]EIA, 2002 and 2000. Form 767. *Steam-Electric Plant Operation and Design Report. Schedule V. Cooling System Information. Section A. Annual Operations. www.eia.doe. gov/cneaf/electricity/forms/eia767/eia767.pdf*

[9]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[10]Clean Air Task Force and Western Resource Advocates. (2003). *The Last Straw: Water Use by Power Plants in the Arid West. www.westernresourceadvocates.org/media/pdf/ WaterBklet-Final.pdf*

[11]Clean Air Task Force and Western Resource Advocates. (2003). *The Last Straw: Water Use by Power Plants in the Arid West. www.westernresourceadvocates.org/media/pdf/ WaterBklet-Final.pdf*

[12]Hoffman, J., et al. (2004). *Estimating Freshwater Needs to Meet 2025 Electricity Generating Forecasts*. U.S. Department of Energy/National Energy Technology Laboratory. *www.netl.doe.gov/coal/E&WR/pubs/ Estimating%20Freshwater%20Needs%20to%202025.pdf*

[13]Based on "The Last Straw" (see *www.westernresourceadvocates.org/media/pandp.php*), the regional average for seven western states (AZ, CO, MT, NV, NM, UT, and WY) for water withdrawals is roughly 1 gallon/kWh and for consumption is 0.6 gallons/kWh. Since wind energy uses essentially no water, the water withdrawal and consumption numbers, using the formula below, reflect how much would be saved annually by using wind to generate that same amount of energy:
3000 MW x 0.30 (capacity factor) x 8760 (hours/year) x 1000 gallons/MWh (Last Straw seven-state average) = 7.88 billion gallons/yr withdrawn.
3000 MW x 0.30 x 8760 x 600 = 4.73 billion gallons/year consumed.
4000 MW x 0.30 x 8760 x 1000 gallons/MWh = 10.51 billion gallons/year withdrawn.
4000 MW x 0.30 x 8760 x 600 = 6.31 billion gallons/year consumed.
Note also that because once-through cooling systems are much more common in the rest of the United States, water withdrawals per kWh are many times higher, creating even greater estimated savings from wind power.

[14]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[15]USDA National Agricultural Statistics Services. *www.nass.usda.gov/census/census02/ volume1/us/st99_1_009_010.pdf*

[16]Clark, R.N. Irrigation. A presentation to the National Wind Coordinating Committee, Business Meeting #34, January 19, 2005. *www.nationalwind.org/events/business/ 34/presentations/Irrigation.pdf*

[17]Clark, R.N. Irrigation. A presentation to the National Wind Coordinating Committee, Business Meeting #34, January 19, 2005. *www.nationalwind.org/events/business/ 34/presentations/Irrigation.pdf*

[18]State Wind Resource Maps. *www.eere.energy.gov/windandhydro/windpoweringamerica/ wind_maps.asp*

[19]Federal Highway Administration Web site. Census 2000 Population Statistics, U.S. Population Living in Urban vs. Rural Areas. *www.fhwa.dot.gov/planning/census/ cps2k.htm*

[20]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[21]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/htdocs/table05.html*

[22]Campbell, P. Population Projections, States, 1995–2025. U.S. Census Bureau. P25-1131 May 1997. *www.census.gov/prod/2/pop/p25-1131.pdf*

[23]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[24]Hutson, S.S., et al. (2004). *Estimated Use of Water in the United States in 2000*. USGS Circular 1268. *http://water.usgs.gov/pubs/circ/2004/circ1268/index.html*

[25]*State Wind Resource Maps. www.eere.energy.gov/windandhydrowindpoweringamerica/ wind_maps.asp; New England Wind Map. www.truewind.teamcamelot.com/ne/*

[26]*Michigan Wind Resource Map*. www.eere.energy.gov/windandhydro/ windpoweringamerica/maps_template.asp?stateab=mi

[27]*Improving Regional Air Quality with Wind Energy. www.nrel.gov/docs/fy05osti/38071.pdf*

[28]U.S. Bureau of Reclamation, Sandia National Laboratories. (2003). *Desalination and Water Purification Technology Roadmap—A Report of the Executive Committee. www.usbr.gov/pmts/water/media/pdfs/roadmapreport.pdf*

[29]*State Wind Resource Maps. www.eere.energy.gov/windandhydro/ windpoweringamerica/wind_maps.asp*

[30]*www.eere.energy.gov/windandhydro/about.html*

[31]*www.eere.energy.gov/windandhydro/about.html*

[32]Lehr, R.L., et al. (2001). *Colorado Public Utility Commission's Xcel Wind Decision. www. eere.energy.gov/windandhydro/windpoweringamerica/pdfs/xcel_wind_decision.pdf*

[33]*Wind Energy for Rural Economic Development. www.eere.energy.gov/windandhydro/ windpoweringamerica/pdfs/wpa/33590_econ_dev.pdf*

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