# Backgrounder: U.S. Energy Utilization for Groundwater Supply

*This summary contains a number of estimates made from assumptions, as there are few requirements for more complete public records, nonetheless it provides valuable insight into the complexity of determining the estimated energy costs per groundwater supply sector.*

**02-2017**

## Introduction

Energy use for water is a function of many variables, including water source. The energy costs for groundwater include the cost to lift the groundwater to the surface. Groundwater sources typically use about 30 percent more energy than do surface water supplies.[1]

While most water well pumps are driven by electric motors, in some end-use sectors such as agricultural irrigation, other energy types such as natural gas, propane, gasoline, or diesel fuels are used. In some remote areas, wind-powered, solar-powered, and manually powered pumps are used.

This backgrounder document does not account for groundwater pumping energy use by thermoelectric power plants (including solar energy); injection wells; bottling operations; industry; self-supplied commercial uses for nondrinking water purposes, such as car washes; dewatering; and mining, including quarry operations.

**Table 1: Estimated Energy Costs per Groundwater Supply Sector**

| Groundwater Supply Sector | Estimated Energy Costs |
|---|---|
| *Public supply well systems* | $1,312,742,940 |
| *Residential well systems* | $247,703,477 |
| *Agricultural irrigation well systems* | $2,134,773,533 |

## Public Supply

Nearly all of the energy consumed for public water supply is for electricity, about 80 percent of which is used by pump motors.[2]

University of Texas researchers concluded energy use associated with the U.S. public water supply is 4.1 percent of the nation's annual primary energy consumption.[3]

"Because of important regional differences, the United States is a difficult country to generalize for energy use by public water supply systems. For example, the lifecycle energy-intensity of water in cities nationally is estimated to be 3,300-3,600 kilowatt-hours (kWh)[4] per million gallons delivered and treated."[5]

There are different types of public supplies (community, noncommunity nontransient, and noncommunity transient), and each type may have more or less different types of well pumps and their associated motor drives. For this backgrounder document, we are assuming 100 percent of these are powered by electricity.

The U.S. Geological Survey estimates in 2010, U.S. public supply extracts were an estimated 15,700 million gallons (15.7 billion gallons) per day of groundwater.[6] Assuming 3,450 kWh per million gallons[7] delivered and treated, and assuming all of the groundwater extracted is delivered and treated, the annual national energy consumption to supply groundwater for public supply purposes is 19,770,225,000 kWh per year.

[1] *Energy-Water Nexus: The Water Sector's Energy Use*, January 24, 2017. Congressional Research Service, p. 3.

[2] *Ibid.*, p. 5.

[3] Cited in *Energy-Water Nexus*, p. 3 but attributed to K.M. Twomey and M.E. Webber, "Evaluating the Energy Intensity of the US Public Water System," *Proceedings of the ASME 5th International Conference on Energy Sustainability*, August 7–10, 2011, Washington, D.C., USA.

[4] A kilowatt is a unit of electric power equal to 1,000 watts. A kilowatt-hour is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour.

[5] *Ibid.*, p. 4.

[6] U.S. Geological Survey, Estimated Use of Water in the United States, 2010. Released 2014.

[7] The average of the range cited by Twomey and Webber.

NGWA The Groundwater Association
**Address** 601 Dempsey Road, Westerville, Ohio 43081-8978 U.S.A.
**Phone** (800) 551-7379 • (614) 898-7791 **Fax** (614) 898-7786
**Email** ngwa@ngwa.org **Websites** NGWA.org and WellOwner.org

Using a November 2016 national average electricity cost[8] of $0.0664 per kWh for industrial purposes, the energy costs to provide groundwater from community water supply systems is estimated at $1,312,742,940.

## Residential Well Systems

The National Ground Water Association calculates the estimated 13.1 million U.S. households served by their own individual water well system use a combined 2.829 billion kWh annually to power well pump motors. We assume 100 percent are electricity-powered, although it is possible in some settings alternative energy sources are used such as diesel, gasoline, propane, solar, or even human power.

To reach this estimate, we assume an average rural U.S. household size of 2.61 persons, consistent with the U.S. Census Bureau's American Community Survey. Further assumptions relate to the split between household wells supplied by submersible pumps and jet pumps, and about the percentage of these pump motor drive horsepower sizes.

Assuming a November 2016 national average residential electricity cost of $0.1275 per kWh,[9] the energy costs to provide groundwater from residential water well systems is estimated at $247,703,477.

## Agricultural Irrigation

Agricultural irrigation relies heavily upon groundwater, which requires pumping systems to move the water from the subsurface to the application. The U.S. Department of Agriculture and the U.S. Bureau of the Census conduct a *Farm and Ranch Irrigation Survey* and the 2013 report shares there are nationally 472,185 pumping agricultural water wells at an average well depth of 229 feet, with 90 feet to water and 145 feet to the pump bowls. The average pumping capacity of these pumps is 722 gpm at an operating pressure of 37 psi, an average engine horsepower of 87 operating 940 hours annually on average. The combined national energy costs to irrigate using groundwater from wells was estimated at $2.134 billion in 2013.

Table 2 identifies the major energy sources for agricultural irrigation well pumps, the number of U.S. acres irrigated by well pumps using each energy source, and the associated costs with these systems.

While some 28,104 acres of U.S. farmland are equipped with solar-powered pumps, the *Farm and Ranch Irrigation Survey* does not distinguish acreage supplied with groundwater from acreage supplied by surface water.

No estimates are available from the Association for other large-scale irrigation by water wells for uses by golf courses, sports turf, or large-scale landscape utilization.

## Other Direct Energy Consumption by the Groundwater Sector

To construct water wells requires energy to power drilling machines and other equipment, not only during transport to the construction site, but also while in use during construction. No estimates are made of that energy consumption, but most of this equipment uses either gasoline or diesel fuel, with some rare exceptions for propane-powered equipment.

## Geothermal Heat Pumps

A 2015 estimate suggests 1.2 million geothermal (ground source) heat pumps[10] are installed residentially in the United States. No good count exists for how many of these 1.2 million units rely upon groundwater, but NGWA members estimate less than 10 percent. Lund[11] reported in 2001 about 16 percent of all GSHP systems in an open-loop

**Table 2. Energy and Agricultural Irrigation Well Pumps, 2013**

| Energy Type | Number of U.S. acres irrigated by this energy type, 2013 | Average cost per irrigation acre by this energy type (wells), 2013 | Estimated annual national energy expenses consumption by agricultural well pumps, 2013 |
|---|---|---|---|
| *Electricity* | 23,800,355 | $59.59 | $1,418,263,154.45 |
| *Natural gas* | 3,931,248 | $55.38 | $217,712,514.24 |
| *LP/Propane* | 937,556 | $36.91 | $34,605,191.96 |
| *Diesel and biodiesel* | 10,079,483 | $45.61 | $459,725,219.63 |
| *Gasoline* | 92,513 | $48.29 | $4,467,452.77 |
| **TOTALS** | **38,841,155** | | **$2,134,773,533.05** |

**Source: *Farm and Ranch Irrigation Survey*, 2013, U.S. Department of Agriculture and U.S. Bureau of the Census**

[8] https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

[9] Found February 6, 2017, at https://www.eia.gov/electricity/ monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

[10] U.S. Energy Information Agency's 2015 Annual Energy Outlook data.

[11] J.W. Lund. "Geothermal Heat Pumps—An Overview." *GHC Bulletin,* March 2001, pp. 1-2.

or closed-loop configuration were using groundwater or surface water. The estimated total annual electricity use by these units is estimated to be 3,254.2 kWh per unit,[12] or a national total of 3.905 billion kWh per year.

Assuming an electricity cost of $0.1275 per kWh, the energy costs for all forms of ground source heat pumps installed in the United States is estimated at $496,515,600.

Since commercial buildings vary widely in size and principal activity, it is hard to estimate electricity use for each type of commercial building. According to latest (2012) CBECS data, total electricity consumption for space heating and space cooling in commercial buildings is about 210 trillion watt-hours per year. Assuming ground-source heat pumps are used in one percent of commercial buildings and are 30 percent more energy efficient than conventional HVAC systems, the estimated total electricity consumption for commercial ground source heat pumps could be about 1.5 trillion watt-hours per year.[13]

[12] E.C. Battacletti and W.E. Glassley. "Measuring the Costs and Benefits of Nationwide Geothermal Heat Pump Deployment." *GHC Bulletin*, November 2010, pp. 4-8. Note: NGWA believes this electricity consumption includes not only the heat pump, but the associated fans and pumps as well.

[13] Communication from Xioabing Liu, Oak Ridge National Laboratory, February 2017.