THE *WATER* COSTS OF ENERGY (WCE) – U.S. units

How many gallons of water are used[a] to produce ***one kilowatt-hour*** *of electricity?*		*How many gallons of water are used[a] to produce electricity for* ***one household*** *for one month?*			*How many gallons of water are used[a] to produce electricity for* ***100,000 households*** *for one month?*	
Renewable sources in italics		*Average household* ***kWh/month****:*[1,2] ***Arizona*** *= 1,095,* ***U.S.*** *= 920,* ***World*** *= 240*				
Ranges of averages are shown: high (darker) & low (lighter). Overall means are not necessarily the means of the given extremes.						
Origin	**gal/kWh**	**Arizona**	**U.S.**	**World**	**U.S.**	**World**
Hydroelectric [b,3,4,5,6,7]	30.078	32,935	27,672	7,219	2,767,176,000	721,872,000
	4.500	4,928	4,140	1,080	414,000,000	108,000,000
Geothermal [4,6,7]	1.695	1,856	1,559	407	155,940,000	40,680,000
	0.600	657	552	144	55,200,000	14,400,000
Solar Thermal/CSP [c,3,4,5,6,7]	0.920	1,007	846	221	84,640,000	22,080,000
	0.750	821	690	180	69,000,000	18,000,000
Nuclear [3,4,5,6,7,8]	0.785	860	722	188	72,220,000	18,840,000
	0.400	438	368	96	36,800,000	9,600,000
Biomass [5,6,7]	0.665	728	612	160	61,180,000	15,960,000
	0.300	329	276	72	27,600,000	7,200,000
Natural Gas (ST) [d,6]	0.645	706	593	155	59,340,000	15,480,000
Coal [3,4,6,7,8]	0.560	613	515	134	51,520,000	13,440,000
	0.300	329	276	72	27,600,000	7,200,000
Municipal Solid Waste [5]	0.480	526	442	115	44,160,000	11,520,000
	0.300	329	276	72	27,600,000	7,200,000
Oil [5,7]	0.480	526	442	115	44,160,000	11,520,000
	0.300	329	276	72	27,600,000	7,200,000
Landfill Gas [e,3,4,9]	0.350	383	322	84	32,200,000	8,400,000
	0.010	11	9	2	920,000	240,000
Natural Gas (CC) [d,3,4,5,6,7,8]	0.195	214	179	47	17,940,000	4,680,000
	0.100	110	92	24	9,200,000	2,400,000
Natural Gas (GT) [d,4,6,7]	0.050	55	46	12	4,600,000	1,200,000
	0.010	11	9	2	920,000	240,000
Solar PV [f,3,4,5,6,7,8,9]	0.001	1	1	0	92,000	24,000
	0.000	0	0	0	0	0
Wind [f,4,5,6,7,8,9]	0.001	1	1	0	92,000	24,000
	0.000	0	0	0	0	0
Micro-Hydroelectric [b]	0.000	0	0	0	0	0
Average [4,7]	0.640	701	589	154	58,880,000	15,360,000
	0.570	624	524	137	52,440,000	13,680,000

Available at: HarvestingRainwater.com/water-energy-carbon-nexus

WCE FACTS

39% of fresh water withdrawn in the U.S. is for **thermoelectric power-generation cooling systems**.[5]

Most thermoelectric power plants are only **33% efficient**, which means **2/3 of heat-energy potential is lost**.[5]

The country with the **lowest per-capita monthly kWh usage** is **Haïti**: 2 kWh. **Iceland**'s is highest: 4,172 kWh.

Jordan: 174 kWh, **China**: 205 kWh, **France, Germany, & Japan**: ~625 kWh, & **Australia**: 935 kWh.[2]

Of the **total kWh usage** for the United States, 37% goes to **residential**, 36% to **commercial**, and 27% to **industrial** purposes.[1]

WCE NOTES

Data do not include water used in association with extraction or production of raw energy sources or with lifecycle of power-generating infrastructure (construction of facilities, manufacture & transport of equipment, etc).

- These water-for-energy data are for wet-cooled power generation *only*. Wet cooling is a method of transferring waste heat to the atmosphere from water used in power generation. The water is cooled by its reduction to a fine spray, allowing the discharge of heat through evaporation.[10]

a. Regions' monthly water-for-energy quantities are calculated based on U.S. water-for-energy data and region-specific average energy usage. However, each region's actual water-for-energy quantities will vary based on local power-generation specifics, including type of cooling system.

b. Unlike hydroelectric power generation, in which the movement of water flowing over large dams turns turbines to generate power, micro-hydro's turbines are placed in-stream and do not require creation of reservoirs from which large amounts of water are lost to evaporation.

c. CSP = concentrated solar power, a form of solar-thermal energy that uses solar-tracking mirrors or lenses to focus a large area of sunlight onto a small area. The light energy is converted to heat, which is applied to water to create steam to turn turbines, and thus generate electricity via conventional thermoelectric methods.[11]

d. ST = steam turbine. Fuel is combusted to heat water to create steam to turn turbines.

CC = combined cycle. Exhaust of one heat engine is used as heat source for another. This dual use of heat increases system's overall efficiency, but water consumption is higher than in a gas-turbine natural-gas system.[12]

GT = gas turbine (a.k.a., combustion turbine, or single cycle). Force from combustion of fuel turns turbine.

e. As with all power generation, the water costs of landfill gas-generated energy depend on the technology used. We use the same low-end figure of 0.010 gal/kWh that is cited for Natural Gas (GT); other technologies use more water. Despite attempts to contact the authors of reference 3, we were unable to confirm the technology behind their Landfill-Gas figure.

f. Solar PV and wind systems consume water if rainfall is not sufficient to wash panels or turbine blades, and if the systems store power in water-filled batteries.

The 0.001 gal/kWh figure for Solar PV, given by Kevin Koch, owner of Technicians for Sustainability, was carried over as an estimate for Wind, as the sources that consider wind power to consume water[5,9] state only that it is used in minimal quantities.

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