THE *WATER* COSTS OF ENERGY (WCE) – metric units

How many liters of water are used[a] to produce ***one kilowatt-hour*** *of electricity?*		*How many liters of water are used[a] to produce electricity for* ***one household*** *for one month?*			*How many liters 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	**liter/kWh**	**Arizona**	**U.S.**	**World**	**U.S.**	**World**
Hydroelectric [b,3,4,5,6,7]	113.857	124,674	104,749	27,326	10,474,868,030	2,732,574,269
	17.034	18,653	15,672	4,088	1,567,155,600	408,823,200
Geothermal [4,6,7]	6.416	7,026	5,903	1,540	590,295,276	153,990,072
	2.271	2,487	2,090	545	208,954,080	54,509,760
Solar Thermal/CSP [c,3,4,5,6,7]	3.483	3,813	3,204	836	320,396,256	83,581,632
	2.839	3,109	2,612	681	261,192,600	68,137,200
Nuclear [3,4,5,6,7,8]	2.972	3,254	2,734	713	273,381,588	71,316,936
	1.514	1,658	1,393	363	139,302,720	36,339,840
Biomass [5,6,7]	2.517	2,756	2,316	604	231,590,772	60,414,984
	1.136	1,244	1,045	273	104,477,040	27,254,880
Natural Gas (ST) [d,6]	2.442	2,674	2,246	586	224,625,636	58,597,992
Coal [3,4,6,7,8]	2.120	2,321	1,950	509	195,023,808	50,875,776
	1.136	1,244	1,045	273	104,477,040	27,254,880
Municipal Solid Waste [5]	1.817	1,990	1,672	436	167,163,264	43,607,808
	1.136	1,244	1,045	273	104,477,040	27,254,880
Oil [5,7]	1.817	1,990	1,672	436	167,163,264	43,607,808
	1.136	1,244	1,045	273	104,477,040	27,254,880
Landfill Gas [e,3,4,9]	1.325	1,451	1,219	318	121,889,880	31,797,360
	0.038	41	35	9	3,482,568	908,496
Natural Gas (CC) [d,3,4,5,6,7,8]	0.738	808	679	177	67,910,076	17,715,672
	0.379	415	348	91	34,825,680	9,084,960
Natural Gas (GT) [d,4,6,7]	0.189	207	174	45	17,412,840	4,542,480
	0.038	41	35	9	3,482,568	908,496
Solar PV [f,3,4,5,6,7,8,9]	0.004	4	3	1	348,257	90,850
	0.000	0	0	0	0	0
Wind [f,4,5,6,7,8,9]	0.004	4	3	1	348,257	90,850
	0.000	0	0	0	0	0
Micro-Hydroelectric [b]	0.000	0	0	0	0	0
Average [4,7]	2.423	2,653	2,229	581	222,884,352	58,143,744
	2.158	2,363	1,985	518	198,506,376	51,784,272

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39% of fresh water withdrawn in the U.S. is for **thermoelectric power-generation cooling systems**.[5]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 0.038 liters/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 0.004 liters/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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