THE *ENERGY* COSTS OF WATER (ECW): U.S. units

How many kWh of energy are used to source & treat **one gallon of water?***			*How many kWh of energy are used to source & treat water for **one U.S. household** for one month?* *Average U.S. household water use: 7,686 gal/month[8]*			*How many kWh of energy are used to source & treat water for **100,000 U.S. households** for one month?*		
Ranges of averages are shown from low (lighter) to high (darker). Overall averages are not necessarily the medians of the extremes.								
Origin	*kWh/gal range*		*Origin*	*kWh/month range*		*Origin*	*KWh/month range*	
On-site rainwater [a] ➔✚	0.0000	0.0007	**On-site rainwater**	0	5	**On-site rainwater**	0	538,020
On-site greywater [b] ➔✚	0.0000	0.0002	**On-site greywater**	0	2	**On-site greywater**	0	153,720
On-site blackwater [c] ➔✚	0.0000	0.0011	**On-site blackwater**	0	8	**On-site blackwater**	0	845,460
On-site AC condensate [d] ➔✚	0.0000	360.0000	**On-site AC condensate**	0	2,766,960	**On-site AC condensate**	0	276,696,000,000
Stormwater [e,18] ➔✚	0.0000	0.0034	**Stormwater**	0	26	**Stormwater**	0	2,613,240
Surface water [1,2] ➔✚	0.0002	0.0014	**Surface water**	2	11	**Surface water**	169,092	1,080,652
Colorado River Aqueduct [5] ➔✚	0.0062	0.0063	**Colorado River Aqueduct**	48	48	**Colorado River Aqueduct**	4,765,320	4,842,180
Central Arizona Project [f,3,4] ➔✚	0.0125	0.0152	**Central Arizona Project**	96	117	**Central Arizona Project**	9,607,500	11,682,720
Groundwater [1,2] ➔✚	0.0006	0.0020	**Groundwater**	5	15	**Groundwater**	476,532	1,537,200
Brackish groundwater [g,1,2,6,7] ➔✚	0.0032	0.0379	**Brackish groundwater**	25	291	**Brackish groundwater**	2,459,520	29,129,940
Desalinated seawater [1,2,7] ➔✚	0.0087	0.0882	**Desalinated seawater**	67	678	**Desalinated seawater**	6,686,820	67,790,520
Wastewater [1,2] ➔✚	0.0010	0.0030	**Wastewater**	8	23	**Wastewater**	768,600	2,305,800
Recycled water [2,5] ➔✚	0.0011	0.0041	**Recycled water**	8	31	**Recycled water**	845,460	3,132,416
Average municipal water [2] ⟳	**0.0013**	**0.0065**	**Average municipal water**	**10**	**50**	**Average municipal water**	**960,750**	**4,995,900**

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

The **average U.S. residential water usage** is 98 gallons per capita per day (gpcd).[9]

The **virtual water footprint** of each **U.S.** citizen is 1,146 gallons per day.[10] The **virtual water footprint** of each **world** citizen is 366 gallons per day.[11]

Democratic Republic of Congo's virtual gpcd is lowest: 9 | **Jordan:** 120 | **Germany & China** ~290 | **France:** 371 | **Japan:** 517 | **Australia:** 834 | **Iraq**'s is highest: 1,894.[10]

Of **all water withdrawn** (2005) for use in the U.S., **5% was for industry/mining, 12% for public supply, 34% for agriculture, 49% for thermoelectric power generation.**[h, 9]

***Sourcing** (➔) includes pumping from aquifer, surface source, ocean, wastewater facility, etc, to treatment plant only. **Treatment** (✚) includes raw-water treatment to potable standards, or wastewater to discharge standards. **Lifecycle** (⟳) means ➔ & ✚, **plus** distribution to end-user, **&** wastewater collection, treatment, & discharge.

Energy costs of infrastructure (tank & pump manufacture, canal & building construction, etc.) relevant to water sources are beyond intended scope of this resource, & are not included herein.

Range in kWh/gal is due to pumping distance, depth, & quality of source water, &/or variations in equipment/processes (e.g., 0.0040–0.0080 kWh is used to lift 1 gallon of water 1,000 feet).[2]

a. Energy use is zero for gravity-fed untreated rainwater systems. High end is calculated with Flotec 3/4-HP shallow-well jet pump lifting water 0–5' at 14.4 gpm[12] & UV system treating to NSF/EPA standards using a Sterilight Silver S12Q-PA[13] or a Trojan UV Max IHS12-D4.[14]

b. Energy use is zero for gravity-fed greywater systems. High end was calculated based on EcoVort 650W dirty-water pump lifting water 5' at 56 gpm.[15]

c. Energy use is zero for gravity-fed & -discharged septic tanks & leachfields. The high end of range is for lagoons or ponds with oxidation.[16]

d. Energy use is zero for passive harvest (secondary to normal operation of air conditioner (AC)). Cost rises dramatically for active harvest (if AC is installed or run primarily to harvest condensate). Energy intensity = energy use ÷ condensate yield. Energy use for 2- to 3-ton central AC system: 1.4–3.6 kW/hour.[17] Dry-air condensate yield 0.01–0.02 gal/hour; humid air: 0.1–0.2 gal/hour.[18] Range includes dry air: 7–36 kWh/gal, humid air: 70–360 kWh/gal. Values are for AC, not cooling tower. Indoor & outdoor humidity & temp, SEER rating, etc, affect kWh/gal.

e. Zero value is for gravity-fed stormwater in separated storm & sewer systems (MS4). High value is for combined storm & sewer overflow systems (CSO), where stormwater is treated at wastewater treatment plant & often pumped from deep underground storage. Values for MS4 in low-lying areas prone to flooding & requiring stormwater pumping stations would fall within given range.[19]

f. Central Arizona Project (CAP) diverts water from Colorado River near Lake Havasu to supply central & southern Arizona. The given statistic for southern Arizona is 4–5 times higher than energy intensity of water delivered to central Arizona, due to more treatment & pumping.[3] Higher value includes small kWh usage to distribute treated water to end-users.[4]

g. Meaning of brackish groundwater varies by source. Broadly, it is groundwater containing 500–30,000 mg/liter of TDS (total dissolved solids)—more salty than freshwater, less salty than seawater.[20]

h. A large percentage of water withdrawn for power generation is typically returned to its source, but the volume of withdrawal matters: If the quantity of water isn't available, the power plant will have to shut down. Also when water is withdrawn for one use, it is then unavailable for others, such as municipal water supply & environmental needs.[2]

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REFERENCES

1. Energy-Water Nexus in TX, Stillwell et ali, UT Austin & Environmental Defense Fund. Accessed 4/25/2011, edf.org/documents/9479_Energy-WaterNexusinTexasApr2009.pdf.
2. The Carbon Footprint of Water (2009), River Network. Accessed 7/20/2011, cumberlandrivercompact.org/pdf/Carbon%20Footprint%20of%20Water%20-%20TN%2009.pdf.
3. Water & Energy Sustainability with Rapid Growth & Climate Change in the Arizona-Sonora Border Region, Scott et ali, 2009. Accessed 1/5/2012, azwaterinstitute.org/media/Scott%20final%20report%2008.
4. Protecting the Lifeline of the West, Western Resource Advocates & Environmental Defense Fund, 2010. Accessed 1/4/2012, westernresourceadvocates.org/water/lifeline/lifeline.pdf.
5. LADWP's Draft 2010 Urban Water Management Plan, January 2011. Accessed 7/28/2011, from ladwp.com/ladwp/cms/ladwp013956.pdf.
6. Report to Congress: Energy Demands on Water Resources. Accessed 7/18/2011, sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf.
7. Energy Needs, Consumption, & Sources, Journal of Contemporary Water Research & Educ, 12/2005, Younos & Tulou. Accessed 7/21/2011, ucowr.org/updates/132/5.pdf.
8. 98 gpcd (USGS, see note 7) * 30.4 days/month * 2.58 people/household (census.gov) = 7,686 gallons/household/month
9. pubs.usgs.gov/circ/1344/pdf/c1344.pdf, pp 4-5, 19, accessed 11/2/2011
10. Total national water use ÷ population. Per fao.org/nr/water/aquastat/data/query/index.html, in 2007, 1583m^3/U.S. person/yr x 264.17 gal/m^3 ÷ 365 days/year = 1,146 gpcd.
11. Chartsbin.com/view/1455, accessed 8/17/2011
12. HomeDepot.com, accessed 11/5/2012
13. Mark Ragel, Water Harvesting International, via email 11/7/2011
14. Jeremiah Kidd, San Isidro Permaculture, via email 11/8/2011
15. Paul James, BestHomeWaterSavers.com, via email 10/28/2011
16. Water & Wastewater Industries: Characteristics & DSM Opportunities, Report TR-102015s, Burton, Electric Power Research Institute (EPRI), 1993.
17. Cec.net/tips/brochures/heatcool.pdf, accessed 1/18/2012
18. Rainwater Harvesting for Dylands and Beyond, Volume 2, p 301.
19. Brandy Lellou, Nature's Voice – Our Choice (NV-OC.org), via email 1/18/2012
20. Brackish water, en.wikipedia.org, accessed 8/11/2011