

THE CARBON COSTS OF ENERGY (CCE) – U.S. units

How many pounds of CO ₂ are emitted ^a to generate a kilowatt-hour of electricity?		How many pounds of CO ₂ are emitted ^a to generate electricity for one household for one month?			How many pounds of CO ₂ are emitted ^a to generate electricity for 100,000 households for one month?	
<i>Renewable^b sources in italics</i>		Average household kWh/month: ^{4,5} Arizona = 1,095, U.S. = 920, World = 240				
Origin	lb/kWh	Arizona	U.S.	World	U.S.	World
<i>Municipal Solid Waste</i> ^{c,d,1}	2.988	3,272	2,749	717	274,896,000	71,712,000
Coal ^{c,1}	2.249	2,463	2,069	540	206,908,000	53,976,000
Oil ^{c,1}	1.672	1,831	1,538	401	153,824,000	40,128,000
Natural Gas ^{c,1}	1.135	1,243	1,044	272	104,420,000	27,240,000
<i>Biomass</i> ^{c,d,2}	0.997	1,092	917	239	91,724,000	23,928,000
<i>Geothermal</i> ²	0.067	73	62	16	6,164,000	1,608,000
<i>Landfill Gas</i> ^{c,d,2}	0.043	47	40	10	3,956,000	1,032,000
<i>Solar Thermal/CSP</i> ^{b,c,e,1}	0.000	0	0	0	0	0
<i>Nuclear</i> ^{b,c,1}	0.000	0	0	0	0	0
<i>Hydroelectric</i> ¹	0.000	0	0	0	0	0
<i>Solar PV</i> ^{f,1}	0.000	0	0	0	0	0
<i>Wind</i> ¹	0.000	0	0	0	0	0
<i>Micro-Hydroelectric</i> ¹	0.000	0	0	0	0	0
Average ³	1.293	1,416	1,190	310	118,965,200	31,034,400

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

CCE FACTS

Approximately **7% of electricity generated in the U.S. is lost** during transmission/distribution (U.S. EIA).
In 2007, the **CO₂ emissions** associated with this loss **weighed 188 million tons**.³

Of the **total United States greenhouse-gas emissions, electric power generation accounts for 34%, transportation 28%, industry/commerce 26%, agriculture 8%, and residential use 5%**.⁶

Selected 2009 **per-capita CO₂ emissions**, in tons:⁷ **World average: 5**

Afghanistan: 0 | Jordan: 3.5 | China: 6.4 | France: 6.9 | Japan: 9.5 | Germany: 10.2 | U.S.: 19.5 | Australia: 21.6 | Qatar: 84

CCE NOTES

CO₂ = Carbon dioxide, at generation only. Data do not include climate-change potential of other greenhouse gases, or emissions associated with extraction of raw energy sources & lifecycle of infrastructure.

- a. All regions' emissions are calculated based on U.S. carbon-emissions data and region-specific energy-consumption data. However, each region's actual average emissions will vary based on its own power-generation specifics.
- b. Some of the zero-carbon benefits of nuclear and solar-thermal power generation are offset by their high water intensity. A typical nuclear plant creates 22 tons of toxic spent nuclear fuel per year, which can take thousands of years to degrade.⁸ Utility-scale concentrated solar power (CSP), if situated in remote locations, requires transmission buildout to bring generated power to populated areas. Such buildout typically costs between \$2 million and \$4 million per mile.⁹ In 2007, non-biomass renewable fuel sources generated 7% of U.S. electricity & produced less than 0.1% of U.S. CO₂ emissions.⁶
- c. Thermoelectric power plants, which provide 90% of U.S. electricity, heat water to create steam to turn turbines that generate power. The heat comes from burning municipal solid waste, coal, oil, natural gas, biomass, or landfill gas; concentrated sunlight; or a nuclear reactor.¹⁰
- d. Biomass is a fuel category whose subtypes include landfill gas, agricultural byproducts, plant-based component of municipal solid waste (estimated at 2/3 of total materials), wood/wood waste, etc. EPA considers biomass to have zero net atmospheric CO₂ impact, as amount of CO₂ used by growing plants is equal to that released upon their combustion.¹¹ This view does not account for the *rate* at which CO₂ is released via combustion vs. gradual decomposition.
- e. 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 used to generate electricity via conventional thermoelectric methods (see note c, above).¹²
- f. Solar PV = on-site photovoltaic solar panels, which use semiconductors to convert solar energy into direct-current electricity.¹³

CCE REFERENCES

1. EPA.gov, "Air Emissions," www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html (accessed 3 Nov. 2011).
2. Emissions calculated with data from EPA.gov, "eGRID," eGRID2010V1_1_year07_PLANT.xls, www.epa.gov/cleanenergy/energy-resources/egrid/index.html (accessed 4 Nov. 2011), as advised via personal telephone communication with Art Diem, Environmental Engineer at U.S. EPA, 4 Nov. 2011.
3. EPA.gov, "eGRID2010 Year 07 Summary Tables," www.epa.gov/cleanenergy/energy-resources/egrid/index.html (accessed 26 July 2011).
4. EIA.gov, "Table 5. Residential Average Monthly Bill by Census Division, and State," www.eia.gov/cneaf/electricity/esr/table5.html (accessed 14 July 2011).
5. Worldbank.org, "Electric power consumption (kWh per capita)," data.worldbank.org/indicator/EG.USE.ELEC.KH.PC (accessed 21 Aug. 2011).
6. Alan W. Hodges and Mohammad Rahmani, "Fuel Sources & Carbon Dioxide Emissions by Electric Power Plants in the United States," University of Florida IFAS Extension Publication #FE796, Mar. 2009. Available online at edis.ifas.ufl.edu/fe796.
7. ChartsBin.com, "Current Worldwide Carbon Dioxide Emissions Per Person," chartsbin.com/view/1519 (accessed 8 Nov. 2011).
8. NEI.org, "Nuclear Waste: Amounts and On-Site Storage," nei.org/resourcesandstats/nuclear_statistics/nuclearwasteamountsandonsitestorage (accessed 9 Dec. 2011).
9. GigatonThrowdown.org, "Concentrating Solar Power," gigatonthrowdown.org/files/Gigaton_ConSolPow.pdf (accessed 9 Dec. 2011).
10. Personal communication via email correspondence with Brandy Lellou, Executive Director, Natures' Voice – Our Choice, 19 Jan. 2012.
11. EPA.gov, "eGrid2007TechnicalSupportDocument.pdf," epa.gov/cleanenergy/energy-resources/egrid/index.html (accessed 19 Sep. 2011).
12. Wikipedia.org, "Concentrated solar power," en.wikipedia.org/wiki/Concentrated_solar_power (accessed 21 Jan. 2012).
13. Wikipedia.org, "Photovoltaics," en.wikipedia.org/wiki/Photovoltaics (accessed 21 Jan. 2012).