

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

How many pounds of CO <sub>2</sub> are emitted <sup>c</sup> to generate a kilowatt-hour of electricity?		How many pounds of CO <sub>2</sub> are emitted <sup>c</sup> to generate electricity for one household for one month?			How many pounds of CO <sub>2</sub> are emitted <sup>c</sup> to generate electricity for 100,000 households for one month?			
Renewable <sup>b</sup> sources in italics		Average household kWh/month: <sup>4,5</sup> AZ = 1095, U.S. = 920, world = 240						
Origin	lb/kWh	Origin	AZ	U.S.	world	Origin	U.S.	world
<i>Municipal Solid Waste</i> <sup>a, d, 1</sup>	2.988	<i>Municipal Solid Waste</i>	3,272	2,749	717	<i>Municipal Solid Waste</i>	274,896,000	71,712,000
Coal <sup>a, 1</sup>	2.249	Coal	2,463	2,069	540	Coal	206,908,000	53,976,000
Oil <sup>a, 1</sup>	1.672	Oil	1,831	1,538	401	Oil	153,824,000	40,128,000
Natural Gas <sup>a, 1</sup>	1.135	Natural Gas	1,243	1,044	272	Natural Gas	104,420,000	27,240,000
<i>Biomass</i> <sup>a, d, 2</sup>	0.997	<i>Biomass</i>	1,092	917	239	<i>Biomass</i>	91,724,000	23,928,000
<i>Geothermal</i> <sup>2</sup>	0.067	<i>Geothermal</i>	73	62	16	<i>Geothermal</i>	6,164,000	1,608,000
<i>Landfill Gas</i> <sup>a, d, 2</sup>	0.043	<i>Landfill Gas</i>	47	40	10	<i>Landfill Gas</i>	3,956,000	1,032,000
<i>Solar Thermal/CSP</i> <sup>a, b, e, 1</sup>	0.000	<i>Solar Thermal/CSP</i>	0	0	0	<i>Solar Thermal/CSP</i>	0	0
<i>Nuclear</i> <sup>a, b, 1</sup>	0.000	<i>Nuclear</i>	0	0	0	<i>Nuclear</i>	0	0
<i>Hydroelectric</i> <sup>1</sup>	0.000	<i>Hydroelectric</i>	0	0	0	<i>Hydroelectric</i>	0	0
<i>Solar PV</i> <sup>f, 1</sup>	0.000	<i>Solar PV</i>	0	0	0	<i>Solar PV</i>	0	0
<i>Wind</i> <sup>1</sup>	0.000	<i>Wind</i>	0	0	0	<i>Wind</i>	0	0
<i>Micro-Hydroelectric</i> <sup>1</sup>	0.000	<i>Micro-Hydroelectric</i>	0	0	0	<i>Micro-Hydroelectric</i>	0	0
Average <sup>3</sup>	1.293	Average	1,416	1,190	310	Average	118,965,200	31,034,400

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

Approximately 7% of electricity generated in the U.S. is lost during transmission/distribution (USEIA). In 2007, the CO<sub>2</sub> emissions associated with this loss weighed 188 million tons.<sup>3</sup>

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%.<sup>6</sup>

Selected 2009 per-capita CO<sub>2</sub> emissions (tons):<sup>7</sup> Afghanistan: 0 | Jordan: 3.5 | World: 5 | China: 6.4 | France: 6.9 | Japan: 9.5 | Germany: 10.2 | U.S.: 19.5 | Australia: 21.6 | Qatar: 84

CO<sub>2</sub> = Carbon dioxide, at generation only. Data do not include climate-change potential of other greenhouse gases, or emissions associated w/ extraction of raw energy sources & lifecycle of infrastructure.

a. Thermoelectric power plants, which provide 90% of U.S. electricity, heat large quantities of 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.<sup>8</sup>

b. Some benefits of zero-carbon power generation are offset by increased nuclear & solar thermal installations, which are the most water-intensive forms of thermoelectric power generation.<sup>9</sup>

A typical nuclear plant creates 22 tons of spent nuclear fuel per year, which can take thousands of years to degrade.<sup>10</sup>

Utility-scale concentrated solar power (CSP), if situated in remote locations, requires transmission buildout to bring generated power to populated areas, which costs \$2 million to \$4 million per mile.<sup>11</sup>

In 2007, non-biomass renewable fuel sources generated 7% of U.S. electricity & produced less than 0.1% of U.S. CO<sub>2</sub> emissions.<sup>6</sup>

c. All regions' emissions are calculated based on U.S. data. In actuality, each regions' average emissions will vary based on its power-generation specifics.

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 CO<sub>2</sub> impact, as amount of CO<sub>2</sub> used by growing plants is equal to that released upon their combustion.<sup>12</sup>

This view does not account for the rate at which CO<sub>2</sub> 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 produce steam, and thus electricity via conventional thermoelectric methods.<sup>13</sup>

f. Solar PV = onsite photovoltaic solar panels, which use semiconductors to convert solar energy into direct-current electricity.<sup>14</sup>

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