

## Comparison of Fuels Used for Electric Generation in the U.S. 2016 Update – Study Details

### Emissions (see end of page for bracketed footnote items)

#### Natural Gas – Combined Cycle

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
0.05	737	0.01

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg [20]
77	900,267	58	38	38	8	-	0	0.00

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
0.2	2,518	0.2	0.11	0.11	0.02	-	-	-

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
0.03	369	0.02	0.02	0.02	0.00	0.00	0.00	0.00

#### Coal – APC

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
0.5	1813	0.9

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
3,006	4,128,833	1,203	200	60	2,004	160	140	0.03

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
5.6	7,622	2.2	0.37	0.11	3.70	0.30	0.26	0.0001

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
0.66	906	0.26	0.04	0.01	0.44	0.04	0.03	0.00001

## Coal – APC with CCS

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
0.6	1406	0.2

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
-	3,202,192	1,332	222	67	444	178	155	0.03

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
-	5,912	2.5	0.41	0.12	0.82	0.33	0.29	0.0001

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
0.00	703	0.29	0.05	0.01	0.10	0.04	0.03	0.00001

## Biomass – MSW [13-14] [15-17]

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
4.86	3,600	1.26

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
473	630,720	851	95	0	221	-	0	0.20

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
11.35	15,137	20.4	2.27	-	5.30	-	-	0.00

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
1.35	1,800	2.43	0.27	0.00	0.63	0.00	0.00	0.00

## Biomass – BFB [7-8] [19]

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
1.08	2,633	0.00

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
333	432,388	177	22	4	-	13	0	0.00

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
8.0	10,377	4.3	0.53	0.11	-	0.32	-	-

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
1.01	1,316	0.54	0.07	0.01	0.00	0.04	0.00	0.00

## Geothermal [6] [12]

Emissions [lbs/MWh] [5] [10]

NOx	CO2	SO2
-	120	0.20

Emissions [tons/year] [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
-	22,338	-	0	0	37	-	0	0.00

Emissions in tons per year per thousand households [1-4] [18]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
-	536	-	-	-	0.89	-	-	-

Emissions in tons per thousand MWh per year [1-4]

CO	CO2	NOx	PM	VOC	SO2	HCl	NH3 [5]	Hg
0.00	60	0.00	0.00	0.00	0.10	0.00	0.00	0.00

## No significant emissions noted for **Nuclear, Hydro, Solar** [15] or **Wind** fuel sources

### Legend

Coal APC - standard coal burning operations using advanced pollution control (APC) technology; currently in wide use  
Coal CCS - coal plant using carbon capture & sequestration (CCS) technology; several demo projects underway, but not yet commercially viable

Biomass MSW (waste) - burns municipal solid waste

Biomass BFB (wood) - utilizes bubbling fluidized bed technology - typical biomass consists of wood chips, construction and demolition wood, bark, residual logging debris, saw dust, paper rejects, and paper and/or sewage sludge

### Notes

1. Approximate, using typical applicable facility availabilities and capacity factors.
2. On the basis of facility size indicated.
3. On the basis of electric power generation.
4. Sources: various industry and proprietary database sources.
5. On the basis of expected regulatory limit (i.e., typical permit limits)
6. Geothermal can range in CO<sub>2</sub> output between negligible to 0.7 ton/MWh depending on the trapped gases and technology type.
7. Biomass CO<sub>2</sub> output varies depending on the fuel. However, since biomass is considered renewable, it can be considered CO<sub>2</sub> neutral.
8. BFB -Assuming 0.5% sulfur biomass at 5,000 btu/lb and a 99.5% sulfur removal rate
9. Assuming 2 ppmvd corrected to 15% O<sub>2</sub> for F-Class engine. Assumes development of SCR for IGCC with CCS
10. From DOE Voluntary GHG Reporting
11. Geothermal SO<sub>2</sub> - 0.02 Reported as pounds per MWh and as H<sub>2</sub>S - actual will vary with resource
12. Geothermal CO<sub>2</sub> - 120 Reported as pounds per MWhr - actual will vary with resource
13. MSW SO<sub>2</sub> - Based on 30 ppmvd @ 7% Oxygen - 5,000 Btu per pound HHV of MSW
14. MSW NO<sub>x</sub> - Based on 150 ppmvd @ 7% Oxygen - 5,000 Btu per pound HHV of MSW
15. Assumes solar operation only - operations will vary with use of fossil fuels as supplemental fuel
16. MSW PM - Based on 24 mg/dscm @ 7% Oxygen - 5,000 Btu per pound of HHV of MSW
17. MSW VOC - Based on 0.080 mg/dscm @ 7% Oxygen - 5,000 Btu per pound of HHV of MSW
18. Based on 10,837 KWh of electricity consumed per household in the United States in 2012 (Source: EIA)

19. Assuming the CO<sub>2</sub> emissions from burning wood is neutral due to the lifecycle emissions

20. In natural gas, mercury exists almost exclusively in its elemental form and at concentrations far below saturation suggesting that no liquid mercury phase exists in most reservoirs. A 2001 EPA study indicates that natural gas has no suspended mercury compounds (mercuric sulfide and selenide), which in contrast to elemental mercury, may be present as suspended solid particles of very small particle size and are the dominate mercury compounds in coal

**Source:**

**Comparison of Fuels Used for Electric Generation in the U.S., 2016 Update**

Leidos

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