

Gas or Electric?

An Inquiry into Greenhouse Gas Emissions

March 2023

last update and expansion December 2023

posted at <http://tomsager.org/GasOrElectric-2022.pdf>

Disclaimer: I am not an expert in these matters, however, the following analysis is performed on data from known sources (mostly the US Energy Information Administration) and could probably be done by anyone with a scientific background.

Most important finding: Whether gas or electric is more climate friendly depends strongly on where you live. In all but six states more carbon dioxide is emitted per unit of electric energy generated than would be emitted in generating the same unit of thermal energy by simply burning natural gas.

Note: I find it strange that with all the publicity on electricity versus gas, the results of this analysis are not better known.

Further disclaimer: I own stock in funds that specialize in renewable energy and other funds that may contain various energy holdings. I also own stock in some electric utilities.

When I wrote the [first version of this article](#) in late winter of 2022-23, the “Go Electric” craze seemed to be at its height. I have continued to receive exhortations about the joys of electricity, however they don't ring any truer now than they did nine months ago. Many of them, it seems, could have been written by used-car salesmen.

A little research showed that, except for a very few states like Washington and Vermont that rely heavily on non-polluting renewable sources, per unit of energy generated, electricity produces far more carbon dioxide emissions than simply burning natural gas. Taking the United States as a whole, in 2021, 2.23 times as much.

In this update, we find that the electric power industry in the United States has made some progress, decreasing its CO₂ emissions by a little more than 3% from 2021 to 2022, while producing almost 3% more electricity. However, at this rate, it will still be producing more CO₂ emissions per unit of energy generated than would be produced by simply burning natural gas through 2046.

If your electricity is generated mostly from coal, as it is here in Missouri, natural gas wins hands down emitting far less greenhouse gases than electricity generated from coal. Coal generated electricity produced 5.78 times more CO₂ emissions per unit of energy than burning natural gas. (United States average in 2022)

Electricity generated from natural gas produces 2.44 times more CO₂ emissions per unit of energy than burning natural gas. The average gas powered electricity generating plant in the United States in 2022 had an efficiency of 41%.

On the other hand, electricity produced mostly from non-polluting renewable sources (wind, solar, geothermal, hydro-electric) emits virtually no carbon dioxide.

Suppose you are an “average” Estadounidense (inhabitant of the United States of America). Your electricity in 2022 came from:

coal, 20%,
natural gas, 40%,
non-polluting renewable sources (geothermal, hydroelectric, solar and wind), 19%,
nuclear, 18%
and other sources, 3%.

However, the carbon dioxide (CO₂) you generate came from:

coal, 53%,
natural gas, 45%
non-polluting renewable sources (geothermal, hydroelectric, solar and wind), 0%,
nuclear, 0%,
and other sources, 2%.

Note: Nuclear energy is neither renewable nor non-polluting. A nuclear power plant requires uranium fuel which must be mined, smelted and refined. While the generation phase does not produce greenhouse gases, the mining, smelting and refining of nuclear fuel requires vast energy inputs, as does the building of the nuclear power plant itself. In addition, a nuclear power plant gives off radioactive pollutants, particular during accidents such as occurred at Three Mile Island, Chernobyl and Fukushima.

So check into where your distributor gets its electricity. It makes a huge difference, although the “Go Electric” cheerleaders are unlikely to tell you this.

Now let's discuss three individual states: Missouri, New York and Washington. I chose Missouri because it has been my home for 40 years. It is also among the states that produce the highest CO₂ emissions per kWh of electricity generated. I chose Washington because a good friend lives there and it is among the states with the lowest CO₂ emissions per kWh of electricity generated. I added New York because of its controversial law forbidding gas hookups in new construction, a law which is [currently being challenged in court](#).

I have also added [Rolla Municipal Utilities](#) because they provide me with my electricity.

Missouri has reduced its reliance on coal by around 11% over the last year from 75 to 67% of electricity generated. However, Missouri still produced almost 4 times as much CO₂ emissions per unit of energy generated in 2022 as would be produced by simply burning natural gas.

Washington State has been endowed with abundant water resources. 68% of the electricity generated in Washington in 2022 was hydro-electric. Washington produces only slightly more than half as much CO₂ emissions per unit of energy generated in 2022 than would be produced by burning natural gas.

In spite of generating virtually no electricity from coal, New York appears to be backsliding. In 2019 the electric power industry's CO₂ emissions per unit of energy generated were 4% above what would be produced by simply burning natural gas. By 2022, New York jumped to 36% above burning natural gas, an increase of 31%. Perhaps, if their law forbidding gas hookups in new construction were made contingent upon the electric power industry reaching and remaining at or below par with burning natural gas, it would be more palatable.

Note: These figures refer to generation rather than consumption. Electric energy is often transmitted from one state to another and not consumed in the state where it was generated.

The section on Rolla Municipal Utilities (RMU) suffers from a dearth of data, particularly data on CO₂ emissions. RMU belongs to Missouri Public Energy Pool (MoPEP) which includes 35 cities. MoPEP claims to have generated its electricity from coal (66%), natural gas (19%), wind (9%), solar (2%), hydro-electric (2%) and landfill gas (2%) in 2022. For want of specific emissions data, I have used state figures instead. MoPEP's CO₂ emissions per kWh generated may have been around 5% above Missouri State emissions in 2022. (see estimate below)

These comparisons are laid out in Table 1 below.

Links to data sources are provided below.

The spreadsheet used in making these calculations is posted at:
<http://tomsager.org/OpenOfficeDocs/Spreadsheet-GasOrElectric-2022.ods>

This analysis is incomplete. I have neglected the climatic and environmental costs of mining and drilling, building infrastructure, transportation and transmission and the efficiency of the appliances installed in your home. I've also neglected other greenhouse gasses such as methane, sulfur dioxide and nitrogen oxides. However, I leave this more complete analysis to those more knowledgeable than I am.

An additional factor is the by-products of combustion within one's home, which can be detrimental to one's health. Exposure to one such by-product, [nitrogen dioxide](#), can cause respiratory problems.

If your electricity generation relies heavily on fossil fuels, particularly coal, one merely passes these toxic by-products back to those who live near locations where fossil fuels are mined, drilled, refined or burned. Since folks who live in these locations are often poor and under-privileged, this is a matter of environmental justice.

After the closure of one coal-fired plant in Pennsylvania, [emergency room visits for heart problems immediately plummeted by 42%](#). Indeed, [over 20,000 people are estimated to have died](#) annually from the air pollution from coal-fired plants.

Living close to a fracked gas site is also detrimental to one's health. One study found that children living near a fracking site were five to seven times more likely to develop lymphoma than children living over five miles from a fracking site.)

However, in the case of non-polluting renewables, these detrimental health effects are mostly avoided.

So to sum up: Before jumping on the "Go Electric" bandwagon, find out where your electricity comes from. Unless you live in Vermont, Washington, Oregon, New Hampshire, Idaho or South Dakota, you may be walking backwards by switching from natural gas to electricity.

In fact, you may be better off getting involved with an organization like Great Rivers Environmental Law Center than spending your money on new electric appliances. Great Rivers is working to retire the most polluting coal-fired electric generation plants and forcing electric utilities to transition to non-polluting renewable sources.

Table 1 below gives information on electricity generation and CO₂ emissions in the United States, Missouri, New York State, Washington State and Rolla Municipal Utilities for each year from 2015 to 2022.

2015 was chosen for the base year because it was the year the Paris Climate Accords were agreed upon.

Except for Rolla Municipal Utilities (RMU), the data for the tables below come from the US Energy Information Administration, specifically:

https://www.eia.gov/electricity/data/state/annual_generation_state.xls.

https://www.eia.gov/electricity/data/state/emission_annual.xlsx.

RMU supplied me with data on generation by source and year for Missouri Public Energy Pool to which it belongs. For want of emissions data, I used Missouri emissions data disaggregated by source and year to arrive at a rough estimate.

Using the following formula: $a = bx + cy$, where

$b = 5.52$ = 2022 average CO₂ emissions from generating one kWh of electric energy in Missouri from coal divided by the average CO₂ emissions from generating one kWh of thermal energy by simply burning natural gas;

$c = 2.95$ = 2022 average CO₂ emissions from generating one kWh of electric energy in Missouri from natural gas divided by the average CO₂ emissions from generating one kWh of thermal energy by simply burning natural gas;

$x = 0.66$ = % of electricity generated from coal in 2022 (MoPEP) divided by 100;

$y = 0.19$ = % of electricity generated from natural gas in 2022 (MoPEP) divided by 100;

And

$a = 4.20$ = a rough estimate of 2022 average CO₂ emissions from generating one kWh of MoPEP electric energy from all sources divided by average CO₂ emissions from generating one kWh of thermal energy by simply burning natural gas.

Other MoPEP sources did not produce significant amount of CO₂ emissions.

For the purpose of this article non-polluting renewable sources are limited to wind, solar, geothermal and hydro-electric.

[Burning natural gas produces on average 0.398 pounds of CO₂ per kWh of thermal energy generated](#)

So how is your state doing? To find out: Look it up in Table 2 below. If CO₂ emitted relative to burning natural gas is greater than 1.00, then you may be walking backwards by switching from natural gas to electricity.

For historical comparisons::

1. Choose a state and a year
2. Look up electricity generated from all sources by the total electric power industry on the file: https://www.eia.gov/electricity/data/state/annual_generation_state.xls . Call this number x.
3. Look up CO₂ emissions from all sources by the total electric power industry on the file: [Data on emissions from electricity generation by state and year](#) Call this number y.
4. Divide y by x and multiply by 2.20462 (pounds per kilogram) and divide by 0.398 (emissions from burning natural gas in pounds CO₂ per kWh generated). Call this number z.
5. z is your CO₂ emissions relative to burning natural gas.

If you wish to compare electricity to propane, use the figure 0.473 instead of 0.398, but be careful, liquefied petroleum gas (LPG) is not pure propane.

This is far from the last word on the matter. However, I think the following conclusion will hold:

The electric power industry must make a lot more progress in switching from fossil fuels to non-polluting renewables before switching home appliances from gas to electric will make sense in general. Nevertheless, in locations where the electric power industry has made exceptional progress in switching to renewables, switching home appliances to electric makes immediate sense now.

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Table 1: Data on Electricity Generated and CO2 Emissions for the United States, Missouri, New York State, Washington State and Rolla Municipal Utilities: Years 2015-2022.

US, State or Utility	year	million mWh generated	CO2	CO2 emissions	Lbs of CO2	emissions	% electric energy generated from					
			emissions in million tonnes	as % of 2015 emissions / 100	emissions per kWh generated	relative to natural gas	Coal	Natural Gas	* Non-polluting renewables	nuclear	other	
United States	2022	4,230.7	1,650.4	0.81	0.86	2.16	20	40	19	18	3	
		4,109.7	1,651.9	0.81	0.89	2.23	22	38	18	19	3	
		4,009.8	1,553.6	0.76	0.85	2.15	19	41	17	20	3	
	2019	4,130.6	1,724.9	0.85	0.92	2.31	23	38	16	20	3	
		4,181.0	1,872.3	0.92	0.99	2.48	27	35	16	19	3	
		4,035.4	1,849.7	0.91	1.01	2.54	30	32	14	20	4	
	2015	4,077.6	1,928.4	0.95	1.04	2.62	30	34	14	20	2	
		4,078.7	2,031.5	1.00	1.10	2.76	33	33	12	20	2	
	Missouri	2022	79.4	57.1	0.84	1.59	3.99	67	10	11	11	1
			76.9	59.7	0.88	1.71	4.29	75	8	10	6	1
72.6			54.1	0.80	1.64	4.13	71	10	8	11	0	
2019		78.3	57.5	0.85	1.62	4.07	71	10	7	12	0	
		85.1	65.6	0.97	1.70	4.27	74	8	4	13	1	
		84.6	68.6	1.01	1.79	4.49	80	6	3	10	1	
2015		78.6	62.7	0.92	1.76	4.42	77	8	3	12	0	
		83.6	68.0	1.00	1.79	4.50	78	5	3	12	2	
New York State		2022	125.2	30.8	0.94	0.54	1.36	0	48	27	21	4
			124.8	28.4	0.87	0.50	1.26	0	45	27	25	3
	129.4		26.8	0.82	0.46	1.15	0	41	27	30	2	
	2019	131.6	24.8	0.76	0.42	1.04	0	36	26	34	4	
		132.5	27.9	0.85	0.46	1.17	1	38	25	32	4	
		128.0	25.6	0.78	0.44	1.11	1	37	27	33	2	
	2015	134.4	31.3	0.96	0.51	1.29	1	42	23	31	3	
		138.6	32.7	1.00	0.52	1.31	2	41	22	32	3	
	Washington State	2022	116.7	10.8	0.93	0.20	0.51	3	12	75	8	2
			110.8	11.0	0.95	0.22	0.55	3	15	72	8	2
116.1			12.0	1.04	0.23	0.57	4	12	74	8	2	
2019		106.5	14.6	1.26	0.30	0.76	7	15	68	8	2	
		116.8	10.7	0.92	0.20	0.51	5	9	76	8	2	
		115.9	11.0	0.95	0.21	0.53	5	9	77	7	2	
2015		114.1	10.2	0.88	0.20	0.50	4	10	76	8	2	
		109.3	11.6	1.00	0.23	0.59	5	12	73	7	3	
Rolla Mun. Util. (RMU)		2022					** 4.20	66	19	13	0	2
		2021					** 4.36	73	15	10	0	2

* non-polluting renewables are limited to geothermal, hydro-electric, solar and wind
** very rough estimate

Table 2: Ranking States by CO2 Emitted per kWh Generated

year	50 states + US & DC	mWh generated	CO2 emitted in metric tons	CO2 emitted relative to burning natural gas	rank
2022	AK	6,894,128	3,591,503	2.97	42
2022	AL	144,788,893	52,252,066	2.00	24
2022	AR	65,905,030	31,302,599	2.63	36
2022	AZ	104,698,773	32,947,964	1.74	18
2022	CA	203,383,857	44,448,299	1.21	7
2022	CO	58,044,009	29,739,147	2.84	40
2022	CT	43,054,099	10,757,018	1.38	11
2022	DC	160,237	63,630	2.20	30
2022	DE	5,308,370	2,682,437	2.80	39
2022	FL	258,910,413	97,615,231	2.09	25
2022	GA	126,484,633	43,771,910	1.92	22
2022	HI	9,337,434	6,426,621	3.81	47
2022	IA	72,982,198	26,162,584	1.99	23
2022	ID	16,278,410	2,287,346	0.78	5
2022	IL	185,223,322	53,795,909	1.61	13
2022	IN	98,054,905	70,489,713	3.98	48
2022	KS	62,197,529	23,880,964	2.13	28
2022	KY	69,147,329	55,011,766	4.41	50
2022	LA	105,504,849	48,266,082	2.53	35
2022	MA	21,026,161	9,098,431	2.40	33
2022	MD	37,139,365	11,240,348	1.68	15
2022	ME	12,763,920	2,791,705	1.21	8
2022	MI	117,497,052	58,509,877	2.76	37
2022	MN	58,966,891	22,326,558	2.10	27
2022	MO	79,361,031	57,146,959	3.99	49
2022	MS	67,781,240	27,307,997	2.23	31
2022	MT	27,088,740	13,655,699	2.79	38
2022	NC	134,257,088	41,254,913	1.70	16
2022	ND	44,400,956	28,813,456	3.59	45
2022	NE	40,692,718	22,173,534	3.02	44
2022	NH	18,764,393	2,543,145	0.75	4
2022	NJ	65,060,636	15,891,394	1.35	9
2022	NM	40,889,036	18,112,408	2.45	34
2022	NV	42,591,838	13,509,369	1.76	19
2022	NY	125,185,363	30,788,229	1.36	10
2022	OH	135,810,459	71,710,160	2.92	41
2022	OK	84,634,922	26,606,682	1.74	17
2022	OR	61,317,617	7,873,594	0.71	3
2022	PA	239,261,130	77,554,826	1.80	20
2022	RI	7,819,451	2,948,937	2.09	26
2022	SC	98,709,501	24,856,695	1.39	12
2022	SD	17,900,462	2,825,260	0.87	6
2022	TN	78,036,045	26,585,960	1.89	21
2022	TX	525,562,940	213,620,917	2.25	32
2022	US-Total	4,230,672,233	1,650,366,513	2.16	28
2022	UT	39,386,043	26,261,522	3.69	46
2022	VA	89,477,325	26,092,777	1.62	14
2022	VT	2,183,829	12,751	0.03	1
2022	WA	116,690,498	10,786,642	0.51	2
2022	WI	61,244,310	32,977,847	2.98	43
2022	WV	56,665,360	50,375,921	4.92	52
2022	WY	46,347,492	38,619,211	4.62	51