# Gas or Electric?

## An Inquiry into Greenhouse Gas Emissions

Last update and expansion: November 2024 (includes 2023 data)

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### Most Important Finding

*Whether gas or electric is more climate destructive 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.*

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

### Abstract

*The choice between electricity and natural gas can be inflenced by many factors This paper analyzes just one factor: the environmental cost of carbon dioxide ($CO_2$) emissions from energy generation.*

*$CO_2$ emissions from electricity generation are compared to the $CO_2$ emissions from burning natural gas. It is found that, except for in six states, burning natural gas emits less $CO_2$ per unit of energy produced than electricity generation, in the United States as a whole, less than half as much, in Missouri, around 26% as much.*

*Some limitations of this study and other environmental factors that might affect the choice between natural gas and electricity are mentioned, although not analyzed.*

### Acknowledgement

*I wish to thank the US Energy Information Administration for their data on the generation of electric energy in the United States and the emissions of carbon dioxide and other pollutants. I also wish to thank Rodney Bourne, general manager of Rolla Municipal Utilities, for data on sources of electricity for cities belonging to the Missouri Public Energy Pool.*

## Disclaimers

*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.*

*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 and natural gas utilities.*

## Introduction:

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 almost two years ago. Many of them, it seems, could have been written by lobbyists or used-car salesmen.

So which is less harmful to the environment? Natural Gas or Electricity? There is no one clear answer to this question. Here we look at one and only one aspect of this question: The environmental cost of the carbon dioxide emitted while generating electricity versus the environmental cost of the carbon dioxide emitted while simply burning natural gas.

A little research shows 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 2023, over twice as much. (see Table 1 below)

While the electric power industry in the United States has made significant progress since the adoption of the Paris Climate Accords in 2015, they still have a long way to go before they can say that electricity is less destructive of our climate than natural gas.

## What's New with Electricity Generation in the United States in 2023?

In this update, we find that the electric power industry in the United States has made progress, decreasing its $CO_2$ emissions by around 25%, while producing around 2.6% more electricity over the eight year period from 2015 to 2023. However, at this rate, it will still be producing more $CO_2$ emissions per unit of energy generated than would be produced by simply burning natural gas through 2041.

If your electricity is generated mostly from coal, as it is here in Missouri, burning natural gas wins hands down, emitting far less greenhouse gases than electricity generated from coal. Coal-generated electricity emits 5.82 times more carbon dioxide ($CO_2$) emissions per unit of energy than burning natural gas. (United States average in 2023)

Electricity generated in the United States from natural gas produces 2.42 times more $CO_2$ emissions per unit of energy generated than burning natural gas. In other words, the average gas-powered electricity generating plant in the United States in 2023 had an efficiency of 41%.

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

Suppose you are an “average” Estadounidense (inhabitant of the United States of America). Your electricity in 2023 came from:

coal, 16%,
natural gas, 43%,
non-polluting renewable sources (geothermal, hydroelectric, solar and wind), 20%,
nuclear, 19%
and other sources, 2%.

However, the $CO_2$ emissions you generated came from:

coal, 46%,
natural gas, 52%
non-polluting renewable sources (geothermal, hydroelectric, solar and wind), 0%,
nuclear, 0%,
and other sources, 2%.

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.

**Three Individual States and a Municipal Utility:**

Now let's discuss three individual states: Missouri, New York and Washington. I chose Missouri because it has been my home for over 40 years. It is also among the states that produce the highest $CO_2$ emissions per kWh of electricity generated. Only three states: West Virginia, Wyoming and Kentucky emit more $CO_2$ per unit of electric energy generated than Missouri.

I chose Washington because a good friend lives there and it is among the states with the lowest $CO_2$ emissions per kWh of electricity generated. Only Vermont and New Hampshire emitted less $CO_2$ per unit of electric energy produced in 2023 than Washington.

I added New York because of its controversial law forbidding gas hookups in new construction, a law which is set to be phased in starting in 2026 and is currently being challenged in court.

I have also added Rolla Municipal Utilities because they provide me and my neighbors with electricity.

Missouri has reduced its reliance on coal by around 23% over the last eight years from 78% to 60% of electricity generated. However, Missouri still emits over 3.8 times as much $CO_2$ per unit of energy generated in 2023 as would be produced by simply burning natural gas. If and when the Grain Belt Express Transmission Line is finally built, bringing wind-power generated electricity from the Great Plains to Missouri, it is likely that Missouri will be able to replace aging fossil-fuel generated power plants with non-polluting renewable energy from the Grain Belt Express.

Washington State has been endowed with abundant water resources. 60% of the electricity

generated in Washington in 2023 was hydro-electric. Unfortunately, 2023 was a bad year for hydro-electric power. In 2023, Washington produced only 61.4 million mWh of hydro-electric energy, as opposed to 78.9 mWh in 2022. In 2023, per unit of energy, Washington emitted only 74% of the $CO_2$ emissions that would have been emitted by burning natural gas. In 2022, the figure was 51%. 2022 was a more typical year than 2023 for the Washington electric-power industry. (See table 1 below.)

In spite of generating virtually no electricity from coal, New York State appears to be backsliding. In 2019, New York's electric power industry's $CO_2$ emissions, per unit of energy generated, were 4% above what would be produced by simply burning natural gas. By 2023, New York.'s $CO_2$ emissions jumped to 31% above burning natural gas, an increase of 26%. New York was the first, and perhaps the only, state to enact a gas hookup ban, which is set to be phased in on new construction starting in 2026. This ban is subject to a law suit. Perhaps, if New York's law forbidding gas hookups was 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 $CO_2$ emissions. RMU belongs to Missouri Public Energy Pool (MoPEP) which includes 35 cities. MoPEP claims its electricity was generated from coal (61%), natural gas (25%), wind (8%) , solar (2%), hydro-electric (2%) and landfill gas (2%) in 2023. For want of specific emissions data, I have used state figures instead. MoPEP's $CO_2$ emissions per unit of energy generated may have been around 8% above Missouri State emissions in 2023. (see estimate below)

These comparisons are laid out in Table 1 below.

Links to data sources are also provided below.

The spreadsheet used in making these calculations is posted at:
http://tomsager.org/OpenOfficeDocs/Spreadsheet-GasOrElectric-2023.ods

**Some Caveats**

1. 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.

2. According to a recent study by Robert Howarth, fracked natural gas from shale, which accounts for an increasing portion of our natural gas, requires large quantities of energy and, if these environmental costs are included, shale gas may be as destructive of our climate as coal. However, these upstream costs are beyond the scope of this article.

3. This article does not compare electric vehicles to gas or diesel powered vehicles. The internal combustion energy is notoriously inefficent and likely could not compete on a level playing field with electric power.

4. 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 one's home. An air-source heat pump or an induction stove will likely compensate, and perhaps overcompensate, for some or all of the environmentally destructive emissions in electricity generation. However, I leave this more complete analysis to those more knowledgeable than I am.

5. I've also neglected other greenhouse gasses such as methane, sulfur dioxide and nitrogen oxides.

6. If one is considering replacing gas appliances by electric appliances, one should consider the environmental cost of producing the new appliances.

7. One should also consider that long electric outages due to extreme weather are becoming increasingly more common as planet Earth heats up.

8. An additional factor is that by-products of combustion within one's home 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 were 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 injustice.

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 then children living over five miles from a fracking site.)

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

9. Discussion of these factors above has been mostly avoided here. I leave this to those more knowledgeable than I am.

**Major Conclusion**

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 able to do far more for planet Earth by getting involved with an organization like Great Rivers Environmental Law Center than spending your money on new home 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.

**Sources and Methodology**

Table 1 below gives information on electricity generation and $CO_2$ emissions in the United States, Missouri, New York State and Washington State for each year from 2015 to 2023 and for Rolla Municipal Utilities from 2021 to 2023.

2015 was chosen as 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, files:

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

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

as downloaded on 23 November 2024.

RMU supplied me with data on electricity generation by source and year for the Missouri Public Energy Pool (MoPEP) 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 formula: $a = bx + cy + dz$, where

b = 5.62 = 2023 average $CO_2$ emissions from generating one kWh of electric energy in Missouri from coal divided by the average $CO_2$ emissions from generating one kWh of thermal energy by simply burning natural gas;

c = 2.95 = 2023 average $CO_2$ emissions from generating one kWh of electric energy in Missouri from natural gas divided by the average $CO_2$ emissions from generating one kWh of thermal energy by simply burning natural gas;

d = 0.05 = 2023 average $CO_2$ emissions from generating one kWh of electric energy in Missouri from all other sources divided by the average $CO_2$ emissions from generating one kWh of thermal energy by simply burning natural gas;

x = 0.61 = portion of MoPEP electricity generated from coal in 2023

y = 0.25 = portion of MoPEP electricity generated from natural gas in 2023

z = 0.14 = portion of MoPEP electricity generated from all other sources in 2023,

one finds that

a = 4.11 is a rough estimate of 2023 average $CO_2$ emissions from generating one kWh of MoPEP electric energy from all sources divided by the average $CO_2$ emissions from generating one kWh of thermal energy by simply burning natural gas.

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 $CO_2$ per kWh of thermal energy generated.

**Other Results**

So how is your state doing? To find out: look it up in Table 2 below. If $CO_2$ 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 $CO_2$ emissions from all sources by the total electric power industry on the file: https://www.eia.gov/electricity/data/state/emission_annual.xlsx. 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 $CO_2$ per kWh generated). Call this number z.
5. z is your $CO_2$ 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.

**Final Discussion**

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

The electric power industry in the United States must make a lot more progress in switching from fossil fuels to non-polluting renewables before switching home appliances from gas to electric will, in general, be a climate friendly choice for planet Earth. Nevertheless, in locations where the electric power industry has made exceptional progress in adopting renewables, switching home appliances to electric makes immediate sense now.

This is not to belittle the progress the electric power industry in the United States has made. However, it is inadequate to the crisis we now face and more progress must be made quickly as we are already feeling the disastrous impacts of extreme weather emgendered by climate change.

Finally, I wish to point out that the conclusions drawn here are only as good as the data supplied by the United States Energy Information Administration.

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**Table 1: Data on electricity generated and $CO_2$ emssions for The United States, Missouri, New York State, Washington State and Rolla Municipal Utilities for years 2015 to 2023**

| | | | CO2 | CO2 | Lbs of CO2 | Emissions | ------- % electric energy generated from ------- | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Million | emissions | emissions | emissions | relative to | | | * Non-polluting | | |
| US, State | | mWh | in million | relative | per kWh | burning | | | renewable | | |
| or Utility | Year | generated | tonnes | to 2015 | generated | natural gas | Coal | Nat. Gas | sources | Nuclear | Other |
| United | 2023 | 4,183.3 | 1,531.6 | 0.75 | 0.81 | **2.03** | 16 | 43 | 20 | 19 | 2 |
| States | | 4,230.7 | 1,650.4 | 0.81 | 0.86 | **2.16** | 20 | 40 | 20 | 18 | 2 |
| | 2021 | 4,109.7 | 1,651.9 | 0.81 | 0.89 | **2.23** | 22 | 38 | 19 | 19 | 2 |
| | | 4,009.8 | 1,553.6 | 0.76 | 0.85 | **2.15** | 19 | 41 | 18 | 20 | 2 |
| | 2019 | 4,130.6 | 1,724.9 | 0.85 | 0.92 | **2.31** | 23 | 38 | 16 | 20 | 2 |
| | | 4,181.0 | 1,872.3 | 0.92 | 0.99 | **2.48** | 27 | 35 | 15 | 19 | 3 |
| | 2017 | 4,035.4 | 1,849.7 | 0.91 | 1.01 | **2.54** | 30 | 32 | 15 | 20 | 3 |
| | | 4,077.6 | 1,928.4 | 0.95 | 1.04 | **2.62** | 30 | 34 | 13 | 20 | 3 |
| | 2015 | 4,078.7 | 2,031.5 | 1.00 | 1.10 | **2.76** | 33 | 33 | 12 | 20 | 3 |
| Missouri | 2023 | 66.7 | 45.9 | 0.68 | 1.52 | **3.81** | 60 | 14 | 12 | 14 | 0 |
| | | 79.4 | 57.1 | 0.84 | 1.59 | **3.99** | 67 | 10 | 11 | 11 | 1 |
| | 2021 | 76.9 | 59.7 | 0.88 | 1.71 | **4.29** | 75 | 8 | 11 | 6 | 0 |
| | | 72.6 | 54.1 | 0.80 | 1.64 | **4.13** | 71 | 10 | 7 | 11 | 0 |
| | 2019 | 78.3 | 57.5 | 0.85 | 1.62 | **4.07** | 71 | 10 | 7 | 12 | 1 |
| | | 85.1 | 65.6 | 0.97 | 1.70 | **4.27** | 74 | 8 | 4 | 13 | 0 |
| | 2017 | 84.6 | 68.6 | 1.01 | 1.79 | **4.49** | 80 | 6 | 4 | 10 | 0 |
| | | 78.6 | 62.7 | 0.92 | 1.76 | **4.42** | 77 | 8 | 3 | 12 | 1 |
| | 2015 | 83.6 | 68.0 | 1.00 | 1.79 | **4.50** | 78 | 5 | 3 | 12 | 1 |
| New York | 2023 | 124.0 | 29.4 | 0.90 | 0.52 | **1.31** | 0 | 47 | 29 | 22 | 2 |
| State | | 125.2 | 30.8 | 0.94 | 0.54 | **1.36** | 0 | 48 | 27 | 21 | 3 |
| | 2021 | 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 | 27 | 34 | 2 |
| | | 132.5 | 27.9 | 0.85 | 0.46 | **1.17** | 1 | 38 | 26 | 32 | 3 |
| | 2017 | 128.0 | 25.6 | 0.78 | 0.44 | **1.11** | 1 | 37 | 27 | 33 | 3 |
| | | 134.4 | 31.3 | 0.96 | 0.51 | **1.29** | 1 | 42 | 23 | 31 | 2 |
| | 2015 | 138.6 | 32.7 | 1.00 | 0.52 | **1.31** | 2 | 41 | 22 | 32 | 3 |
| Washington | 2023 | 103.0 | 13.7 | 1.18 | 0.29 | **0.74** | 4 | 19 | 67 | 8 | 2 |
| State | | 116.7 | 10.8 | 0.93 | 0.20 | **0.51** | 3 | 12 | 75 | 8 | 1 |
| | 2021 | 110.8 | 11.0 | 0.95 | 0.22 | **0.55** | 3 | 15 | 73 | 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 |
| | 2017 | 115.9 | 11.0 | 0.95 | 0.21 | **0.53** | 5 | 9 | 77 | 7 | 2 |
| | | 114.1 | 10.2 | 0.88 | 0.20 | **0.50** | 4 | 10 | 76 | 8 | 2 |
| | 2015 | 109.3 | 11.6 | 1.00 | 0.23 | **0.59** | 5 | 12 | 74 | 7 | 2 |
| Rolla. | 2023 | | | | | ** **4.11** | 61 | 25 | 12 | 0 | 2 |
| Municipal | 2022 | | | | | ** **4.21** | 66 | 19 | 13 | 0 | 2 |
| Utilities (RMU) | 2021 | | | | | ** **4.38** | 73 | 15 | 10 | 0 | 2 |

* non-polluting renewables are limited to geothermal, hydro-electric, solar and win

** very rough estimate

**Table 2: Ranking States by $CO_2$ emitted per unit of electrical energy generated in 2023**

| 50 states + US & DC | Million mWh generated | Million tonnes $CO_2$ emitted | Emissions relative to burning nat. gas | Rank | 50 states + US & DC | Million mWh generated | Million tonnes $CO_2$ emitted | Emissions relative to burning nat. gas | Rank |
|---|---|---|---|---|---|---|---|---|---|
| AK | 6.72 | 3.60 | 2.97 | **44** | MT | 26.90 | 13.77 | 2.84 | **42** |
| AL | 139.44 | 46.08 | 1.83 | **22** | NC | 126.55 | 36.77 | 1.61 | **16** |
| AR | 63.20 | 28.36 | 2.49 | **37** | ND | 42.07 | 27.04 | 3.56 | **46** |
| AZ | 111.84 | 34.79 | 1.72 | **20** | NE | 39.45 | 19.77 | 2.78 | **41** |
| CA | 216.63 | 43.36 | 1.11 | **8** | NH | 16.82 | 2.06 | 0.68 | **2** |
| CO | 57.54 | 27.58 | 2.65 | **39** | NJ | 64.23 | 15.11 | 1.30 | **9** |
| CT | 40.67 | 10.65 | 1.45 | **14** | NM | 39.27 | 13.54 | 1.91 | **24** |
| DC | 0.17 | 0.07 | 2.36 | **35** | NV | 42.16 | 12.54 | 1.65 | **18** |
| DE | 4.77 | 2.37 | 2.76 | **40** | NY | 124.04 | 29.42 | 1.31 | **10** |
| FL | 259.80 | 93.73 | 2.00 | **27** | OH | 133.22 | 63.23 | 2.63 | **38** |
| GA | 129.22 | 43.04 | 1.85 | **23** | OK | 89.24 | 26.30 | 1.63 | **17** |
| HI | 9.19 | 6.03 | 3.64 | **47** | OR | 61.69 | 9.64 | 0.87 | **4** |
| IA | 69.84 | 24.59 | 1.95 | **26** | PA | 235.92 | 70.21 | 1.65 | **19** |
| ID | 17.84 | 3.00 | 0.93 | **6** | RI | 10.43 | 4.01 | 2.13 | **31** |
| IL | 177.74 | 42.19 | 1.31 | **11** | SC | 100.85 | 25.60 | 1.41 | **12** |
| IN | 90.05 | 61.25 | 3.77 | **48** | SD | 17.44 | 2.93 | 0.93 | **5** |
| KS | 58.46 | 20.28 | 1.92 | **25** | TN | 77.79 | 25.30 | 1.80 | **21** |
| KY | 63.22 | 50.04 | 4.38 | **50** | TX | 547.29 | 212.77 | 2.15 | **32** |
| LA | 97.78 | 42.94 | 2.43 | **36** | US-Total | 4,183.27 | 1,531.55 | 2.03 | **29** |
| MA | 19.70 | 8.26 | 2.32 | **34** | UT | 33.50 | 20.62 | 3.41 | **45** |
| MD | 36.00 | 9.14 | 1.41 | **13** | VA | 91.06 | 24.59 | 1.50 | **15** |
| ME | 12.51 | 2.43 | 1.08 | **7** | VT | 2.48 | 0.01 | 0.02 | **1** |
| MI | 120.66 | 50.02 | 2.30 | **33** | WA | 102.96 | 13.67 | 0.74 | **3** |
| MN | 57.28 | 20.84 | 2.02 | **28** | WI | 62.55 | 32.65 | 2.89 | **43** |
| MO | 66.70 | 45.92 | 3.81 | **49** | WV | 52.29 | 45.74 | 4.85 | **52** |
| MS | 72.93 | 27.10 | 2.06 | **30** | WY | 43.18 | 36.58 | 4.69 | **51** |