Introduction to System76's Sustainability Reporting

At **System76**, we are driven by the belief that technology should be open, accessible, and sustainable. Our commitment to **technology freedom** is reflected in everything we create—from premium Linux laptops, desktops, and servers to our operating system, **Pop!_OS**. Located in Denver, Colorado, our factory manufactures **open source products** that empower creators, innovators, and builders to shape the future on their own terms.

As part of our mission to **reduce environmental impact** and promote **sustainability**, we design our products with longevity and repairability in mind. Our efforts to minimize waste are grounded in our core principles of **Reduce, Reuse, Recycle**. We incorporate **recycled materials** into our designs, encourage customer-driven repairs, and offer **lifetime support** to ensure that our products have extended life cycles. When a product reaches the end of its life, we facilitate its recycling at no cost to the customer.

This report has been prepared in reference to the **Global Reporting Initiative (GRI) Standards**, specifically focusing on disclosures related to **energy consumption (GRI 302)**, **water and effluents (GRI 303)**, and **emissions (GRI 305)**. These disclosures reflect our efforts to transparently communicate the environmental impacts of our operations and to demonstrate our ongoing commitment to sustainability.

Below, we provide the **GRI Content Index**, which outlines the specific disclosures covered in this report, the pages where they can be found, and any relevant explanations.

GRI Index

GRI Standard	Disclosure Number	Disclosure Title	Page Number	Omissions
GRI 2: General Disclosures		Organization and Reporting Practices		
GRI 2	2-1	Organizational details	Page 2	None
GRI 2	2-2	Entities included in sustainability reporting	Page 3	None
GRI 2	2-3	Reporting period, frequency, and contact point	Page 4	None
GRI 2	2-4	Restatements of information	Page 4	None
GRI 2	2-5	External assurance	Page 5	None

GRI 302: Energy		Energy		
GRI 302	302-1	Energy consumption within the organization	Page 5	None
GRI 303: Water and Effluents		Water Management		
GRI 303	303-3	Water withdrawal	Page 7	Water data includes the entire building's use, and it was not possible to separate System76's water use from another business or irrigation. No immediate plans for sub-metering. Located in an area of extreme water stress.
GRI 303	303-5	Water consumption	Page 8	
GRI 305: Emissions		Emissions		
GRI 305	305-1	Direct (Scope 1) GHG emissions	Page 10	None
GRI 305	305-2	Energy indirect (Scope 2) GHG emissions	Page 14	None
GRI 305	305-7	Nitrogen oxides (NO_x), sulfur oxides (SO_x), and other significant air emissions	Page 16	None

GRI 2-1: Organizational Details

Legal Name:
System76, Inc.[1]

Primary Activities, Products, and Services:
System76, Inc. is a leading manufacturer of open-source hardware, including Linux-based laptops, desktops, servers, and accessories. The company also develops and maintains Pop!_OS, a Linux operating system that empowers creators, innovators, and builders to achieve their potential by providing a highly customizable and secure platform. System76 advocates for user freedom, including the right to repair and modify the technology they purchase.

Headquarters Location:
System76, Inc. is headquartered in Denver, Colorado, USA.

Ownership and Legal Form:
System76, Inc. is a privately held corporation.

Countries of Operation:
System76 operates primarily within the United States, with global product distribution through its online sales platform. Additionally, some of the remote software developers the company employs, who contribute to the development of Pop!_OS, are based in Europe.

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GRI 2-2: Entities Included in Sustainability Reporting

This sustainability report covers **System76, Inc.**, including its headquarters in **Denver, Colorado**, where the company designs, manufactures, and distributes its Linux-based laptops, desktops, servers, and accessories.

The reporting boundaries for this sustainability report are consistent with those used for financial reporting. There are no significant differences between the entities considered in financial reporting and those included in this sustainability report.

System76 does not control or have ownership in any other operational entities beyond those included in this report. Sustainability impacts associated with our **remote employees**, including remote developers located in Europe, are considered immaterial due to their small number and the nature of their work, which is entirely digital and remote. As such, their environmental impact (such as energy use and emissions) is excluded from this report.

This report covers the sustainability impacts of the following:

- The **Denver manufacturing facility**, where the primary environmental impacts include **energy consumption**, **water use**, and **emissions** from production processes.
- The remote activities of employees contributing to **Pop!_OS** from various locations, with sustainability reporting focused on operational practices within our Denver headquarters.

No other entities are included in this report as System76, Inc. does not have operational control or significant sustainability impacts in other regions.

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GRI 2-3: Reporting Period, Frequency, and Contact Point

Reporting Period:
This sustainability report covers the period from **January 1, 2023, to December 31, 2023**. This period aligns with our financial reporting cycle and reflects System76's sustainability performance during the calendar year 2023.

Reporting Frequency:
System76, Inc. intends to issue its sustainability reports on an **annual** basis. This report is the first in a series of annual sustainability reports that will document the progress of our environmental and social initiatives, focusing on our energy consumption, water use, and emissions.

Contact Point for Questions Regarding the Report:
For any questions or inquiries regarding this sustainability report or our sustainability initiatives, please contact:

Jacob Kaulike
Sustainability Lead
System76, Inc.
Email: **sustainability@system76.com**
Phone: **+1 (720) 226-9269**
Address: **4240 Carson St Suite 101, Denver, Colorado, 80239, USA**

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GRI 2-4: Restatements of Information

This report marks the first sustainability report published by **System76, Inc.**, covering the period from **January 1, 2023, to December 31, 2023**. As this is the inaugural report, there are no restatements or revisions of previously reported information.

In future reports, any material changes to previously disclosed data, including revisions to methodologies, data corrections, or adjustments in reporting boundaries, will be transparently disclosed in this section.

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GRI 2-5: External Assurance

System76, Inc. has obtained third-party assurance to verify the accuracy and reliability of the data presented in this sustainability report. The assurance engagement was conducted by ISOS Group, Inc., an independent assurance provider, in accordance with the AccountAbility 1000 Assurance Standard v3 ("AA1000AS").

The assurance process included an evaluation of the following key disclosures:

- **Energy consumption** (GRI 302)
- **Greenhouse gas emissions** (GRI 305)

Additionally, ISOS Group, Inc. provided observations and recommendations related to water withdrawal and consumption (GRI 303). They noted that System76 reports whole building water withdrawal, which includes other tenant spaces not relevant to its operations, and recommended pursuing an allocation methodology to better represent System76's portion of water withdrawal.

ISOS Group, Inc. assessed the completeness, accuracy, and consistency of the reported data, applying recognized assurance standards to ensure the credibility and transparency of System76's sustainability reporting practices. The final assurance statement, which outlines the methodology, findings, and recommendations, is available as an appendix to this report and on our website.

System76's commitment to third-party assurance underscores our dedication to transparency, accuracy, and accountability in our sustainability practices.

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GRI 302-1: Energy Consumption within the Organization

In 2023, System76's total energy consumption comprised electricity and natural gas used at our headquarters and manufacturing facility in **Denver, Colorado**. The data below represents all energy consumed within the organization, converted into gigajoules (GJ) for consistency.

Energy Consumption from Non-Renewable Sources:

- **Natural Gas**: We consumed a total of **6,838 therms** of natural gas during the reporting period, which was primarily used for heating purposes. Using a conversion factor of **1 therm = 0.1054804 GJ**[2], this translates to **721.275 GJ** of energy.

- **Electricity**: System76 purchased **246,960 kWh** of electricity from the local grid in the **Colorado** eGRID subregion[3]. Using a conversion factor of **1 kWh = 0.0036 GJ**[4], this equals **889.056 GJ** of energy consumed.

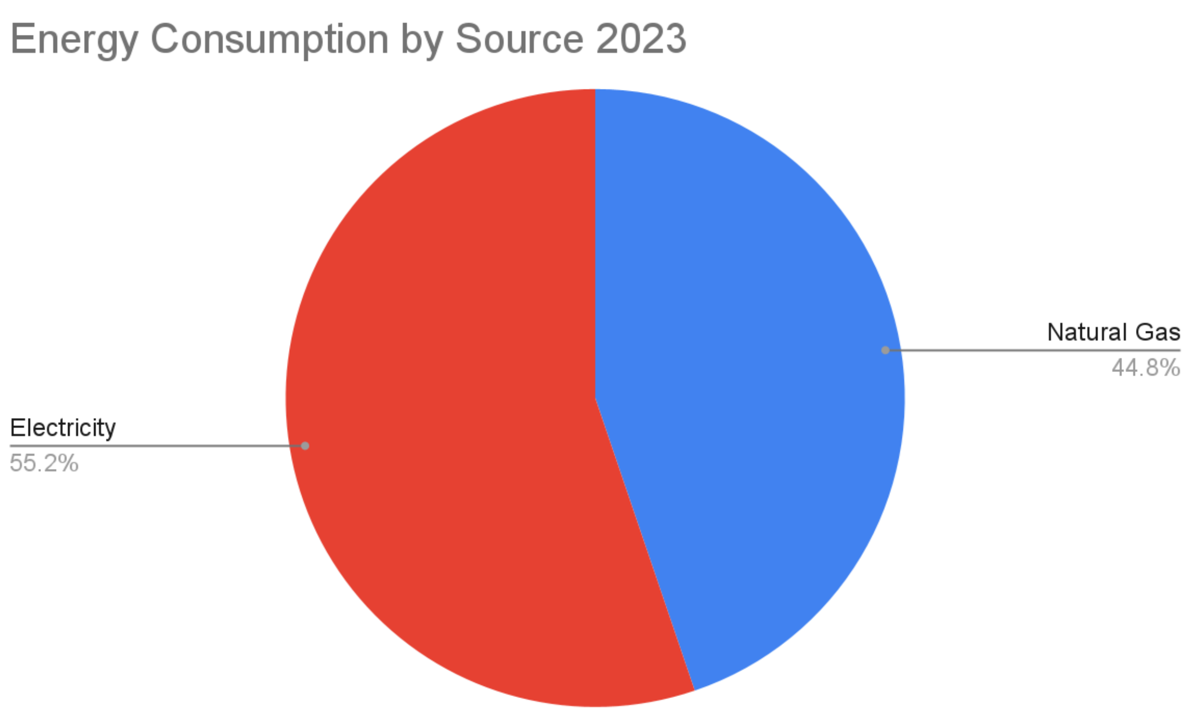
Total Energy Consumption:

- The combined total energy consumption from both natural gas and electricity was **1,610.331 GJ** for the reporting period.
- No renewable energy was purchased or self-generated during the reporting period.
- System76 does not generate or sell electricity, heating, cooling, or steam.

Energy Conversion Factors:

The following standard conversion factors were used to convert energy consumption data into gigajoules (GJ):

- **Natural Gas**: 1 therm = 0.1054804 GJ[5].
- **Electricity**: 1 kWh = 0.0036 GJ[6].

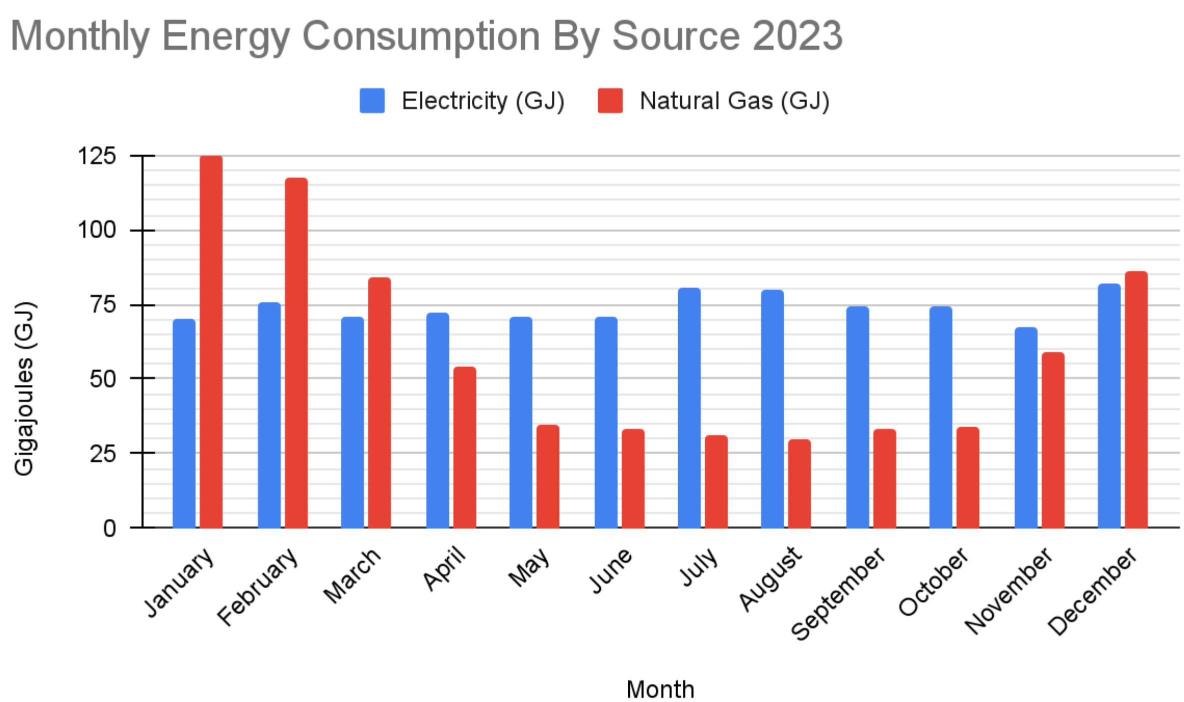


Energy Source	Unit	Amount	Gigajoules (GJ)
Natural Gas	Therms	6,838	721.275 GJ
Electricity	kWh	246,960	889.056 GJ

Total Energy	-	-	1,610.331 GJ

Monthly Energy Consumption:

We tracked energy consumption on a monthly basis to observe any seasonal trends and ensure continuous monitoring of energy use.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Electricity	69.98	75.74	71.14	72	70.56	70.56	80.93	80.06	74.02	74.59	67.1	82.37
Natural Gas	124.95	117.29	84.19	54.32	34.34	33.2	31.15	29.47	33.10	33.63	59.25	86.41

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GRI 303-3: Water Withdrawal

In 2023, System76's water withdrawal totaled **187,000 gallons (≈0.71 megaliters)**, based on metered data provided by our property manager. This data covers the entire building at 4240 Carson St—which System76 shares with another business—and includes water used for irrigation, over which System76 has no control. Due to the lack of sub-metering, it is not possible to accurately determine System76's specific water usage.

Conversion Details:

- **NIST Conversion Factor:**
  1 US gallon = 3.785412 liters[7]
  1 Megaliter = 1,000,000 liters[8]
- **Calculation:**
  $187,000\ gallons \times 3.785412\frac{liter}{gallon} = 707,872\ liters$
  $707,872\ liters \times (\frac{1}{1,000,000}(\frac{megaliter}{liter})) = 0.70787\ megaliters$
  (Rounded, this is approximately **0.71 ML**)

Water Withdrawal by Source:

Source	Unit	Amount
Municipal Water Supply	ML	0.71
Total Water Withdrawal	ML	0.71

Water Source:
All water withdrawn is sourced from the municipal water supply. No water is withdrawn from surface water, groundwater, seawater, or other third-party sources.

Water Stress Context:
System76 operates in Denver, Colorado, an area classified as having high water stress (with water stress levels between 40% and 80%)[9]. This classification underscores the importance of responsible water management in System76's operations to reduce unnecessary water consumption.

Limitations and Future Reporting:
Since the total water usage data includes another business and irrigation, it is not possible to separate System76's operational water use. At present, there are no plans to install water monitoring systems or sub-meters that would allow for more precise data collection in the near future. As a result, similar limitations are expected for future reporting periods, including 2024.

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GRI 303-5: Water Consumption

System76's operations at 4240 Carson St, Denver, Colorado, involve water consumption for both operational and employee use. While the total building-wide water withdrawal was 187,000 gallons in 2023 (including irrigation and water for an unrelated business), only a portion of this water is consumed (i.e., not returned to the municipal system). Based on our operational processes, we estimate the following annual water consumption:

- **Water for powder coating (etch and rinse tanks):**
  System76's powder coating process uses two 300-gallon tanks, an Etch tank and a Rinse tank.
  - These tanks:
    - Are **completely refilled 3 times per year**, using **600 gallons per refill** (300 per tank).
    - Are **topped off 3 times between refills**, using **1.5 gallons per tank per top-off**.
    - **Water from these tanks is never returned to the water supply**, as it is collected and **sent away for safe disposal**.
  - **Annual powder coating water consumption**:
    $(3\ refills \times 600\ gallons) + (3\ top\ offs \times 1.5\ gallons \times 2\ tanks)$
    $1,800\ gallons + 27\ gallons = 1,827 gallons\ per\ year$
- **Employee drinking water consumption:**
  - Estimated per worker daily drinking water consumption: 0.34375 gallons[10]
  - Workers in factory: 34[11]
  - Working days: 251[12]
  - **Calculation**:
    $$Estimated\ Annual\ Drinking\ Water\ Consumption = Workers \times Days \times 0.34375 \frac{gallons}{day}$$
    $$34\ workers \times 251\ days \times 0.34375 \frac{gallons}{day} = 2,933.56\ gallons$$
- **Swamp coolers (weekdays, July–October):**
  System76 uses two swamp coolers to cool its factory. Each swamp cooler consumes an estimated 20 gallons of water per hour[13].
  - Average daily hours operating: 6.5287[14]
  - Weekdays in operating months: 87[15]
  - **Calculation**:
    $$Est.\ Annual\ Swamp\ Cooler\ Consumption = Average\ Daily\ hours \times 20 \frac{gallons}{hour} \times Weekdays$$
    $$6.5287 \frac{hours}{weekday} \times 20 \frac{gallons}{hour} \times 87\ weekdays = 11,360\ gallons$$
    $$11,360\ gallons \times 2\ swamp\ coolers = 22,720\ gallons$$

Conversion Details:

- **NIST Conversion Factors:**
  1 US gallon = 3.785412 liters[16]
  1 ML = 1,000,000 liters[17]
  To convert gallons to megaliters:
  $ML = (gallons \times 3.785412 \frac{liter}{gallon}) \times (\frac{1}{1{,}000{,}000} (\frac{megaliter}{liter}))$

Using this conversion:

- **Powder Coating:**
  $1,827\ gallons \times 3.785412 \frac{liter}{gallon} \times (\frac{1}{1{,}000{,}000} (\frac{megaliter}{liter})) \approx 0.00692\ ML$
- **Employee Consumption:**
  $2,933.56\ gallons \times 3.785412 \frac{liter}{gallon} \times (\frac{1}{1{,}000{,}000} (\frac{megaliter}{liter})) \approx 0.011105\ ML$
- **Swamp Coolers:**
  $22,720\ gallons \times 3.785412 \frac{liter}{gallon} \times (\frac{1}{1{,}000{,}000} (\frac{megaliter}{liter})) \approx 0.086005\ ML$
- **Total Water Consumed:**
  $(1,827 + 2,933.56 + 22,720)\ gallons = 27,480.56\ gallons$
  $27,480.56\ gallons \times 3.785412 \frac{liter}{gallon} \times (\frac{1}{1{,}000{,}000} (\frac{megaliter}{liter})) \approx 0.104025\ ML$
  (rounded to approximately **0.104 ML**)

Water Consumption by Source:

Water Use	Unit	Amount
Water for powder coating (etch and rinse tanks)	ML	0.007
Employee drinking water consumption	ML	0.011
Swamp coolers (weekdays July–October)	ML	0.086
Total Water Consumed	ML	0.104

Water Stress Context:
System76 operates in Denver, Colorado, an area classified as having high water stress (with water stress levels between 40% and 80%)[18]. This underscores the importance of responsible water management in our operations.

Limitations:
Since System76 operates in a shared building without sub-metering, it is not possible to fully separate our water consumption from the building's total water withdrawal. The data provided here is based on estimates for known operational usage, including the etch and rinse tanks, swamp coolers, and general employee consumption.

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GRI 305-1: Direct (Scope 1) GHG Emissions

In 2023, System76's operations generated direct (Scope 1) greenhouse gas emissions primarily from the combustion of **natural gas** used for heating—including for our powder coating oven and water heating systems—at our facility in **Denver, Colorado**.

Natural Gas Consumption:

- **Natural gas consumed**: 6,941 ccf.

Emission Calculation Methodology:

System76 calculated its Scope 1 GHG emissions from natural gas combustion using a volume-based approach, leveraging emission factors for **CO_2**, **CH_4**, and **N_2O** expressed in tonnes per cubic meter (m³). This method aligns with regulatory and industry-standard methodologies, such as the **GHG Protocol Stationary Combustion Guide**[19]. Below is a detailed breakdown of the methodology and calculation steps:

1. **Conversion of Natural Gas Volume to Cubic Meters**:
    - The initial volume of natural gas was recorded in **ccf** (hundred cubic feet)[20]. To convert this to cubic meters (m³)[21] for consistent unit usage in the calculation:

      $$Natural\ gas\ in\ ft^3 = ccf \times 100 = 6,941 \times 100 = 694,100\ ft^3$$

      $$Natural\ gas\ in\ m^3 = 694,100\ ft^3 \times 0.02831685 = 19,654.73\ m^3$$
2. **Calculation of Emission Factor per m³**:
    - Initial CO_2 energy basis: 53.06 kg/mmBTU[22]
    - Conversion factor from mmBTU to TJ: 0.001055056[23]
    - CO_2 energy basis converted to kg/TJ with this formula:

      $$Emission\ basis\ (\frac{kg}{TJ}) = Emission\ basis\ (\frac{kg}{mmBTU}) \times (\frac{1}{0.001055056}\ (\frac{TJ}{mmBTU}))$$

      $$= 53.06 \frac{kg}{mmBTU} \times (\frac{1}{0.001055056}\ (\frac{TJ}{mmBTU})) = 50291.16938\ \frac{kg}{TJ}$$
    - The emission factor was calculated by considering the **Energy basis value (50291.16938 kg/TJ)**, **Net Calorific Value (NCV) of 48.0 TJ/Gg**[24], and **density of natural gas (0.7 kg/m³)**[25]. The formula[26] applied was:

      $$Emission\ factor\ (\frac{tonne}{m^3}) = Energy\ basis\ (\frac{kg}{TJ}) \times (\frac{NCV\ (\frac{TJ}{Gg})}{1,000,000 \frac{kg}{Gg}}) \times Density\ (\frac{kg}{m^3}) \times 0.001 \frac{tonne}{kg}$$

      where the 0.001 factor at the end is to convert the units from kg to tonnes[27].
    - This calculation yielded an emission factor of **0.00169 tonnes CO_2 per m³**.
3. **CO_2 Emissions Calculation**:
    - Using the calculated emission factor, CO_2 emissions were determined by multiplying the total volume of natural gas in m³ by the CO_2 emission factor:

      $$CO_2\ Emissions\ (tonnes) = 19,654.73\ m^3 \times 0.00169 \frac{tonne}{m^3} = 33.22\ tonnes\ CO_2$$
4. **CH_4 and N_2O Emissions Calculations**:

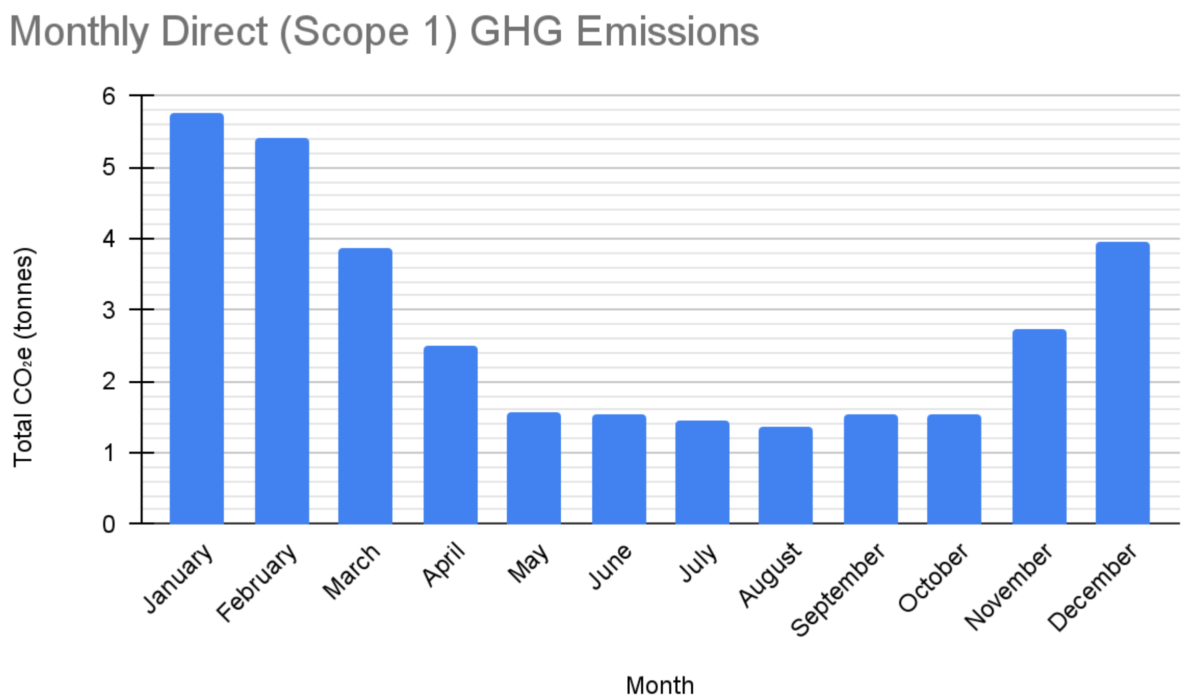
- CH_4 and N_2O emissions were calculated using similar volume-based emission factors, derived from industry standards.
- **CH_4 Emissions**:
  - Initial energy basis: 0.001 kg/mmBTU[28]
  - Energy basis in kg/TJ: 0.9478 kg/TJ
  - Emission Factor: 0.000000032 tonnes CH_4 per m^3
  - Calculation: $19,654.73\, m^3 \times 0.000000032 \frac{tonne}{m^3} = 0.000629\, tonnes\ CH_4$
- **N_2O Emissions**:
  - Initial energy basis: 0.0001 kg/mmBTU[29]
  - Energy basis in kg/TJ: 0.09478 kg/TJ
  - Emission Factor: 0.0000000032 tonnes N_2O per m^3
  - Calculation: $19,654.73\, m^3 \times 0.0000000032 \frac{tonne}{m^3} = 0.0000629\, tonnes\ N_2O$

5. **Conversion to CO_2e using Global Warming Potentials (GWP)**:
   - **CH_4 GWP**: $25 \frac{tonnes\ CO_2e}{tonnes\ CH_4}$ [30]
   - **N_2O GWP**: $298 \frac{tonnes\ CO_2e}{tonnes\ CH_4}$ [31]
   - Final values were calculated in terms of **CO_2e** by applying these GWPs.
     - **CH_4 CO_2e:**
       $0.000629\, tonnes\ CH_4 \times 25 \frac{tonnes\ CO_2e}{tonnes\ CH_4} = 0.016\, tonnes\ CO_2e$
     - **N_2O CO_2e:**
       $0.0000629\, tonnes\ N_2O \times 298 \frac{tonnes\ CO_2e}{tonnes\ CH_4} = 0.019\, tonnes\ CO_2e$

CO_2e Explanation:

- **CO_2e**, or **carbon dioxide equivalent**, is a metric used to express the impact of different greenhouse gasses (GHGs) in a common unit. Since gasses like **CH_4** and **N_2O** have different warming impacts, **CO_2e** allows emissions to be reported in terms of the equivalent amount of **CO_2** that would produce the same warming effect, facilitating clearer comparisons and reporting.

Monthly Direct (Scope 1) GHG Emissions:



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tonnes CO_2e	5.76	5.41	3.88	2.50	1.58	1.52	1.44	1.37	1.53	1.55	2.72	3.97

Scope 1 GHG Emissions by Source:

Emission Source	Unit	Amount Consumed	CO_2 Emissions (metric tons)	CH_4 Emissions (metric tons CO_2e)	N_2O Emissions (metric tons CO_2e)
Natural Gas	ccf	6,941	33.216	0.016	0.019
Total Scope 1 Emissions	-	-	**33.251 metric tons CO_2e**	-	-

Justification of Calculation Method:

This approach was chosen for its compatibility with industry-standard methods, as it uses volume-based emission factors, which are directly applicable to the natural gas consumption volume in cubic meters. This avoids the need for complex recalculations of energy content per mass and ensures consistent unit alignment across all values. Additionally, the method aligns with recommendations in the **GHG Protocol** for emissions calculated based on fuel energy properties, ensuring accuracy and regulatory compliance.

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GRI 305-2: Indirect (Scope 2) GHG Emissions

In 2023, System76's operations produced indirect (Scope 2) greenhouse gas emissions due to the use of purchased electricity at our facility in **Denver, Colorado**.

Purchased Electricity Consumption:

- **Electricity consumed**: 246,960 kWh.

Emission Calculation Methodology:

System76 calculated its Scope 2 GHG emissions from electricity consumption using **regional emission factors** provided by the **EPA's eGRID power profiler**[32]. Below is a detailed breakdown of the methodology and calculation steps:

1. **Application of eGRID Emission Factors**:
    - Using eGRID's **regional emission factors**, System76 applied the specific emission factor for **CO_2**, **CH_4**, and **N_2O** emissions associated with the regional grid supplying our facility. These factors are:
        - **CO_2 eGRID Factor**: 1,166.201 lb CO_2/MWh[33]
        - **CH_4 eGRID Factor**: 0.103 lb CH_4/MWh[34]
        - **N_2O eGRID Factor**: 0.015 lb N_2O/MWh[35]
2. **Calculation of CO_2e Emissions**:
    - Conversion factor from lbs to kg: 0.45359237[36]
    - Conversion factor from kWh to MWh: 0.001[37]

Each greenhouse gas was calculated using this formula:

$$(Electricity\ Consumption\ (kWh)\ \times\ 0.001\frac{MWh}{kWh})\ \times\ eGRID\ Factor\frac{lb}{MWh}\ \times\ 0.45359237\frac{kg}{lb}\ =\ Emissions\ (kg)$$

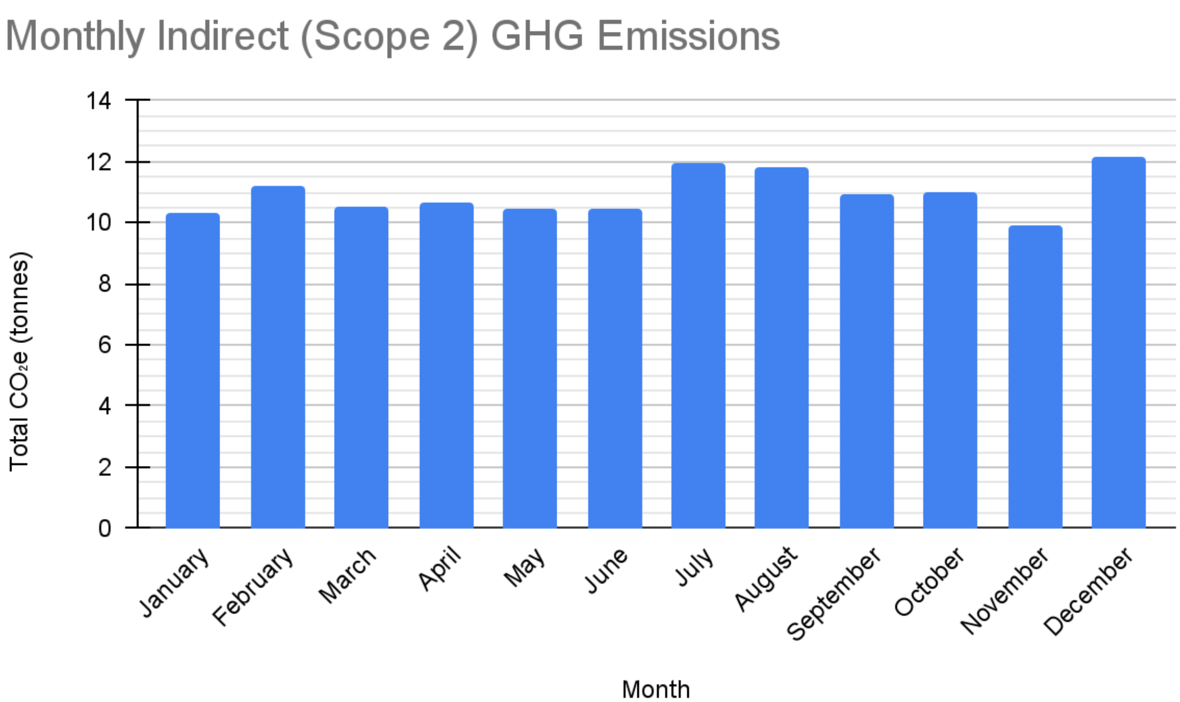
- **CO_2 Emissions**:
  $(246,960\ \times\ 0.001)\ \times\ 1,166.201\ \times\ 0.45359237\ =\ 130,636.87\ kg$

- **CH_4 Emissions**:
  $(246,960 \times 0.001) \times 0.103 \times 0.45359237 = 11.54\ kg$
- **N_2O Emissions**:
  $(246,960 \times 0.001) \times 0.015 \times 0.45359237 = 1.68\ kg$

- **Conversion to CO_2e**:
  - **CH_4 CO_2e**: $11.54 \times 25 \frac{tonnes\ CO_2e}{tonnes\ CH_4} = 288.5\ kg$
  - **N_2O CO_2e**: $1.68 \times 298 \frac{tonnes\ CO_2e}{tonnes\ N_2O} = 500.64\ kg$
- The total Scope 2 emissions are presented in **metric tons of CO_2e** by summing these values and multiplying by a conversion factor of 0.001[38]:

  $Scope\ 2\ CO_2e = (130,636.87\ kg + 288.5\ kg + 500.64\ kg) \times 0.001 \frac{tonne}{kg} = 131.43\ tonnes$

  Monthly Indirect (Scope 2) GHG Emissions:



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tonnes CO_2e	10.35	11.2	10.52	10.64	10.43	10.43	11.96	11.84	10.94	11.03	9.92	12.18

Scope 2 GHG Emissions Summary:

Emission Source	Unit	Amount Consumed	CO_2 Emissions (metric tons)	CH_4 Emissions (metric tons CO_2e)	N_2O Emissions (metric tons CO_2e)
Purchased Electricity	kWh	246,960	130.637	0.2885	0.50064
Total Scope 2 Emissions	-	-	**131.43 metric tons CO_2e**	-	-

Justification of Calculation Method:

This approach is based on the GHG Protocol's Scope 2 Accounting and Reporting Standard and utilizes EPA's eGRID power profiler data for Colorado.

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GRI 305-7: Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x), and Other Significant Air Emissions

In 2023, System76's operations generated air emissions primarily from the use of purchased electricity and the combustion of natural gas at our facility in **Denver, Colorado**.

Sources of Air Emissions

System76's air emissions were largely indirect (Scope 2) and included the following pollutants:

- **Nitrogen Oxides (NO_x)**
- **Sulfur Oxides (SO_x)**

Emissions were calculated using **regional emission factors** provided by **EPA's eGRID**[39] for purchased electricity and **emissions factors for natural gas combustion**[40] in our stationary equipment.

Emission Calculation Methodology

1. **Purchased Electricity (Scope 2)**:
    - Using eGRID's emission factors from Colorado for NO_x and SO_x (typically in **lb/MWh**), we calculated the associated emissions for each pollutant:
        - **NO_x Factor:** 0.636 lb/MWh[41]
        - **SO_2 Factor:** 0.36 lb/MWh[42]
        - Conversion factor lb to kg: 0.453592[43]
        - Conversion factor kWh to MWh: 0.001[44]

- **NO_x Emissions**:
  $(246,960 \times 0.001 \frac{MWh}{kWh}) \times 0.636 \frac{lb}{MWh} \times 0.453592 \frac{kg}{lb} = 71.24\ kg$
- **SO_2 Emissions**:
  $(246,960\ kWh \times 0.001 \frac{MWh}{kWh}) \times 0.36 \frac{lb}{MWh} \times 0.453592 \frac{kg}{lb} = 40.33\ kg$

2. **Combustion of Natural Gas (Scope 1)**:
   - For natural gas, we used emissions factors in **kg/m³** for each pollutant. These factors are derived from national averages for stationary combustion sources.
   - **Natural gas consumed (ccf)**: 6,941
   - Natural gas consumed in m³ is obtained by multiplying by 100 to convert from ccf to ft³[45], then multiplying the result by the conversion factor of 0.02832 get from ft³ to m³[46]:

$$Natural\ Gas\ (m^3) = (Gas\ consumed\ (ccf) \times 100 \frac{ft^3}{ccf}) \times 0.02831685 \frac{m^3}{ft^3}$$
$$= (6,941\ ccf \times 100 \frac{ft^3}{ccf}) \times 0.02831685 \frac{m^3}{ft^3}$$
$$= 19,654.73\ m^3$$

   - **NO_x and SO_2 Emissions** for natural gas were calculated as:
     - **NO_x Emission factor:** 100 lb/10⁶ scf[47]
     - **SO_2 Emission factor:** 0.6 lb/10⁶ scf[48]
     - Conversion factor lb to kg: 0.453592[49]
     - Conversion factor 10⁶ scf to m³: 28316.85[50]
     - Formula from lb/10⁶ scf to kg/m³:
       $(Emission\ factor \frac{lb}{10^6\ scf} \times 0.453592 \frac{kg}{lb}) \times (\frac{1}{28316.85} (\frac{m^3}{10^6\ scf}))$
     - **NO_x Emission factor (kg/m³):**
       $(100 \frac{lb}{10^6\ scf} \times 0.453592 \frac{kg}{lb}) \times (\frac{1}{28316.85} (\frac{m^3}{10^6\ scf})) = 0.001602 \frac{kg}{m^3}$
     - **SO_2 Emission factor (kg/m³):**
       $(0.6 \frac{lb}{10^6\ scf} \times 0.453592 \frac{kg}{lb}) \times (\frac{1}{28316.85} (\frac{m^3}{10^6\ scf})) = 0.00000961 \frac{kg}{m^3}$
     - **NO_x Emissions (natural gas)**:
       $19,654.73\ m^3 \times 0.001602 \frac{kg}{m^3} = 31.49\ kg$
     - **SO_2 Emissions (natural gas)**:
       $19,654.73\ m^3 \times 0.00000961 \frac{kg}{m^3} = 0.1889\ kg$

Air Emissions Summary Table

Emission Source	NO_x Emissions (kg)	SO_2 Emissions (kg)
Purchased Electricity	71.24	40.33
Natural Gas	31.49	0.1889

Justification of Calculation Method

System76 used **EPA eGRID** emission factors for Scope 2 pollutants and national emission factors for natural gas combustion (Scope 1). These standardized factors allow for consistent and regionally relevant reporting of NO_x, SO_x, and other pollutants in alignment with GRI and regulatory requirements.

[Back to Index]

References

[1] - https://www.system76.com

[2], [5] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 12 has the conversion factor from therm to MJ as 105.4804. 1 MJ is 1/1000th of 1 GJ, so multiplying 105.4804 by 0.001 gets 0.1054804 for therm to GJ.

[3] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

Within the egrid2022_data.xslx workbook, worksheet ST22, row 8 for Colorado specific data.

[4], [6] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 12 has the conversion factor from kWh to MJ as 3.6. 1 MJ is 1/1000th of 1 GJ, so multiplying 3.6 by 0.001 gets 0.0036 for kWh to GJ.

[7], [16] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 9 has the conversion factor from Gallons to liters

[8], [17] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Table 2 on Page 3 shows common SI Prefixes.

[9], [18] -
https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=false&basemap=hydro&geoStore=0c5fadaa7caaa473b38b30dff910a16e&indicator=w_awr_def_tot_cat&lat=39.77882630492905&lng=-104.81497764587404&mapMode=analysis&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&threshold&timeScale=annual&year=baseline&zoom=14

[10] - https://www.cdc.gov/nutrition/php/data-research/fast-facts-water-consumption.html

Taken from Table 2, all adults, the CDC's mean daily water intake for adults is 44 ounces. Since there are 128 ounces in a gallon, 44/128 comes to 0.34375 gallons per day.

[11] - Average estimated number of employees working in the factory per work day.

[12] - Working days in 2023, excluding weekends and company holidays.

[13] - https://piec.com/how-much-water-does-an-evaporative-cooler-use/

[14] - https://weatherspark.com/h/y/3709/2023/Historical-Weather-during-2023-in-Denver-Colorado-United-States#Figures-ColorTemperature

The 6.53 hour estimate comes from historical weather data from Weatherspark for the Denver area from 2023. Taking the average number of hours at temperatures at or above 75°F up to 7PM, when the swamp coolers are scheduled to shut off, during the months of July, August, September, and October.

[15] - The number of weekdays in the months of July, August, September, October was arrived at by a direct count of the days on a calendar.

[19] - https://ghgprotocol.org/sites/default/files/2023-02/Stationary_Combustion_Guidance_final_1_0.pdf

[20], [45] - 1 ccf is equal to 100 cubic feet.

[21], [46] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 9 has the conversion factor from cubic feet to cubic meters as 0.02831685.

[22] - https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

[23] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 12 has the conversion factor from BTU to kJ as 1.055056. mmBTU is equal to 1,000,000 BTUs so 1 mmBTU is equal to 1,055,056 kJ. 1 kJ is equal to 0.000000001 TJ, so the conversion factor from mmBTU to TJ is 0.001055056.

[24] - https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

Page 1.18, Table 1.2, we used the Net Calorific Value for Natural Gas, which is 48 TJ/Gg.

[25] - https://ghgprotocol.org/sites/default/files/2024-10/Stationary_combustion_tool_Version4-2.xlsx

This workbook from the Greenhouse Gas Protocol uses a density value of 0.7 kg/m^3 in the "2. Settings" worksheet in cell C44. My use of this value was taken from here.

[26] - https://ghgprotocol.org/sites/default/files/2024-10/Stationary_combustion_tool_Version4-2.xlsx

The formula used here was reverse engineered by analyzing the formula used in this workbook, within the ghostSpreadsheet_CO2 worksheet. Additionally, within the formula, the Net Calorific Value is divided by 1,000,000 in order to convert from TJ/Gg to TJ/kg.

[27], [38] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Footnote 24 at the bottom of page 10 states: "*The metric ton (referred to as "tonne" in many countries), equal to 1000 kg, is accepted for use with SI.*" If 1 tonne is equal to 1000 kg, then 1 kg is equal to 0.001 tonnes.

[28], [29], [30], [31] - https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

In Table 1 for Stationary Combustion next to Natural Gas, the emission basis for CH_4 is in grams per mmBTU. Because 1 gram is equal to 0.001 kg it was fairly straightforward to convert this value from 1 g/mmBTU to 0.001 kg/mmBTU. Likewise the emission basis for N_2O was 0.1 g/mmBTU which I converted to 0.0001 kg/mmBTU.

[32], [39] - https://www.epa.gov/egrid/power-profiler#/

[33] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

From this workbook, within the worksheet for states (ST22), the annual CO_2 total output emission rate is in cell V8.

[34] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

From this workbook, within the worksheet for states (ST22), the annual CH_4 total output emission rate is in cell W8.

[35] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

From this workbook, within the worksheet for states (ST22), the annual N_2O total output emission rate is in cell X8.

[36], [43], [49] -
https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 11 has the conversion factor from pounds (lbs) to kilograms (kg) as 0.45359237.

[37], [44] - 1 kilowatt hour is one one-thousandth of 1 megawatt hour, so the conversion factor from kWh to MWh is 0.001.

[40] - https://gaftp.epa.gov/ap42/ch01/s04/final/c01s04_oct1996.pdf

Page 1.4-5, Table 1.4-1

[41] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

From this workbook, within the worksheet for states (ST22), the annual NO_x total output emission rate is in cell S8.

[42] - https://www.epa.gov/system/files/documents/2024-01/egrid2022_data.xlsx

From this workbook, within the worksheet for states (ST22), the annual SO_2 total output emission rate is in cell U8.

[47], [48] - https://gaftp.epa.gov/ap42/ch01/s04/final/c01s04_oct1996.pdf

Page 1.4-5, Table 1.4-1, we're using the value for a commercial boiler (<10 mmBTU/hr) with no CH_4 controlled burners, so 100 lb/10^6 scf, and the value for SO_2 is 0.6 lb/10^6 scf.

[50] - https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication1038.pdf

Page 9 has the conversion factor from cubic feet to cubic meters at 0.02831685. 10^6 scf is equal to 1,000,000 cubic feet (scf stands for standard cubic feet). This makes 1 10^6 scf equal to 28,316.85 cubic meters.