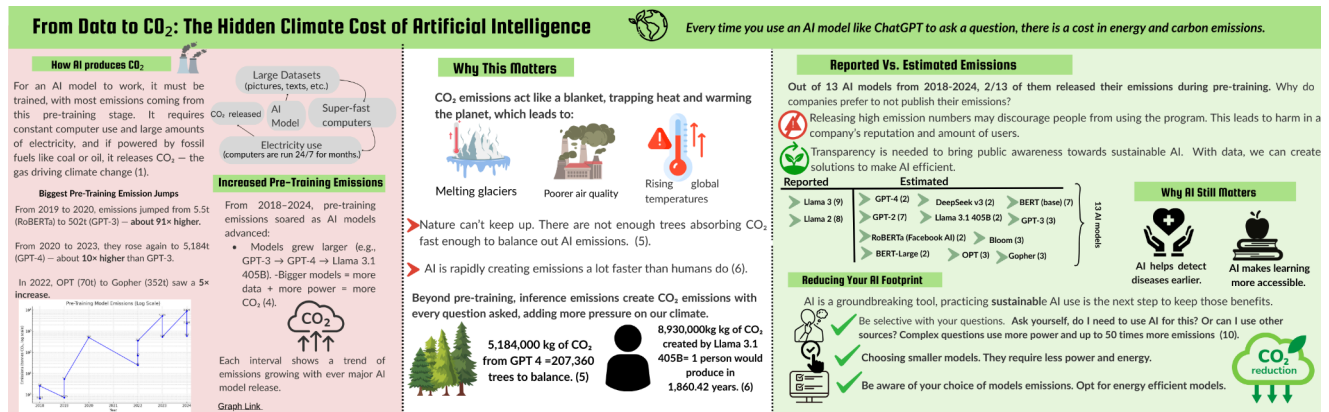


From Data to CO₂: The Hidden Climate Cost of Artificial Intelligence

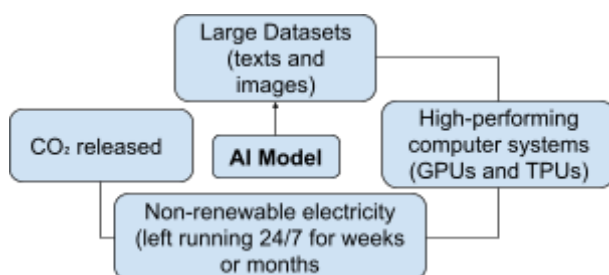


Generative AI tools like ChatGPT are becoming part of everyday life for students, teachers, and the public. They can help us learn, create, and solve problems — but every AI conversation comes with an invisible price: the electricity used and the carbon dioxide (CO₂) released into the atmosphere. By exploring the environmental cost of AI through measurements and comparisons we can move toward sustainable practices to reduce emissions and help our planet.

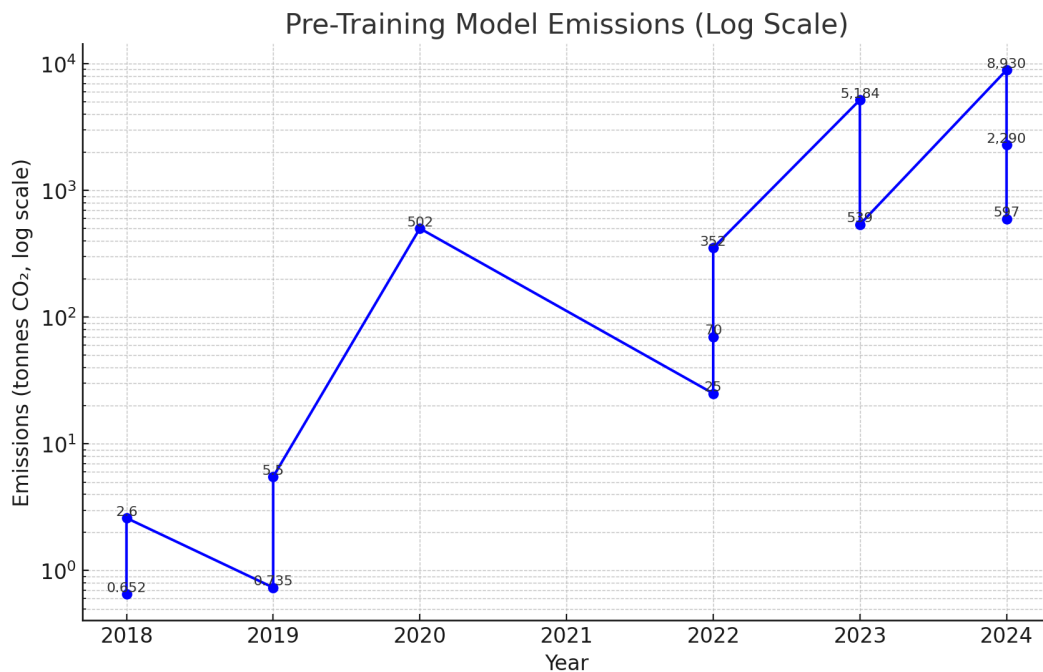
How AI Produces CO₂

Before an AI model can answer questions, it must go through *training*, learning patterns from huge collections of text, images, and other data. This *pre-training* stage is where most emissions are produced. This can take weeks or months of nonstop work on powerful computer processors. These processors use a lot of electricity, and if that power comes from fossil fuels like coal or oil, large amounts of CO₂ are released into the atmosphere.

Once trained, AI models also produce emissions during everyday use, especially for harder questions that require more computing power.



A Rising Trend in AI Emissions



The chart above shows the pre-training emissions from 13 major AI models released between 2018 and 2024. The pattern reflects a growing trend with emissions increasing as bigger models are released.

Some of the biggest jumps in CO₂ have been estimated in tonnes (t):

- **2019 to 2020:** RoBERTa's estimated 5.5 tonnes of CO₂ jumped to GPT-3's estimated 502 tonnes. **About 91 times higher.**
- **2020 to 2023:** GPT-3's estimated 502 tonnes grew to GPT-4's estimated 5,184 tonnes. Roughly **10 times higher.**
- **Within 2022:** OPT's estimated 70 tonnes rose to DeepMind Gopher's estimated 352 tonnes. About **five times higher.**

So why do these models produce so many pre-training emissions?

Emissions from training AI models grew rapidly as models got bigger. Moving from GPT-3 to GPT-4 to Llama 3.1 405B meant using more data and more electricity to improve these models, which led to much higher CO₂ emissions. These figures are estimates, and actual emissions also depend on factors like hardware efficiency and the energy source used.

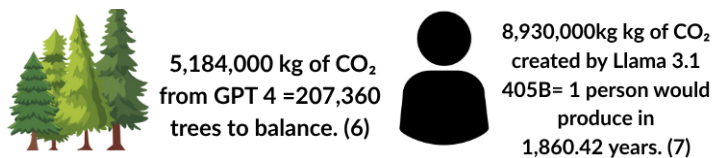
Why This Matters

CO₂ acts like an invisible blanket around Earth, trapping heat and warming the planet. High emissions contribute to global issues like:

- Melting glaciers
- Poorer air quality
- Rising global temperatures

The problem with AI emissions is that nature can't keep up. A single mature tree can absorb about 25 kg of CO₂ in a year — far less than what AI systems emit. This is just pre-training emissions too, daily use produces continuous emissions. This leaves huge amounts of CO₂ going towards the atmosphere at a higher rate than we can control.

Looking at these emissions comparisons, we can begin to fully understand the extent of the damage of these AI model emissions.



Model Name	Year	CO ₂ Emissions (kg) (R for reported, E for estimated)	Equivalent amount of CO ₂ Absorbed by trees /year 25kg	Equivalent to 1 Human CO ₂ Footprint: 4800kg/yr
BERT (base)	2018	E (652kg CO ₂) [1]	26.08 trees	0.14 years (~1.7 months)
BERT-Large	2018	E 2600kg CO ₂ [6]	104.00 trees	0.54 years (~6.5 months)
Open Ai GPT-2	2019	E (735 kg of CO ₂) [1]	29.4 trees	0.15 years (1 month and 25 days)
RoBERTa (Facebook AI)	2019	E (5500 kg CO ₂) [6]	220.00 trees	1.15 years
Open AI GPT-3	2020	E (502000 kg CO ₂) [2]	20,080 trees	104.6 years

Bloom (Big Science Initiative) (176B)	2022	E (25,000 kg CO ₂) [2]	1,000 trees	5.21 years
OPT (175B)	2022	E (70,000 kg CO ₂) [2]	2,800 trees	14.58 years
DeepMind Gopher (280B)	2022	E (352,000 kgCO ₂) [2]	14,080 trees	73.33 years
OpenAI GPT-4	2023	E (5,184,000kg of CO ₂ [6]	207,360 trees	1,080.00 years
Meta Llama 2 (70B)	2023	R (291,420 kg CO ₂) [3]	12,670 trees'	60 years.
Llama 3.1 405B	2024	E (8,930,000kg CO ₂) [6]	388,261 trees'	1,853 years.
Meta Llama 3 (70B)	2024	R (1,900,000 kg CO ₂ (kg) of CO ₂ [4]	82,609 trees	394 years.
DeepSeek v3	2024	E 597000kg of CO ₂ [6]	23,880 trees	124.38 years

Reported vs. Estimated Emissions

Most AI model emissions are **estimated** because companies rarely share exact figures. This lack of transparency makes it harder for researchers to find ways to reduce emissions. Companies may worry that high numbers could hurt their reputation, but reporting pre-training data is essential for accountability and innovation in sustainable AI.

Why AI Still Matters

AI brings enormous benefits: helping detect diseases, supporting education worldwide, and enabling new scientific discoveries. The challenge is to ensure these benefits don't come at an unsustainable environmental cost. That means innovating in ways that reduce emissions while keeping AI's positive impact strong.

Reducing Your AI Footprint

An individual's AI footprint reflects both their patterns of AI use and the resulting carbon emissions. By adopting sustainable practices, users can reduce their footprint, thereby lowering overall emissions and helping to maintain a cleaner atmosphere.

1. Be selective with your questions. **Ask yourself, do I need to use AI for this? Or can I use other sources? Every use produces emissions, and complex queries can produce up to 50× more emissions than simple ones.**
2. Choosing smaller models. **They require less power and energy.**
3. Prioritizing efficient systems – **Look for AI tools that are transparent about their emissions and energy efficient.**