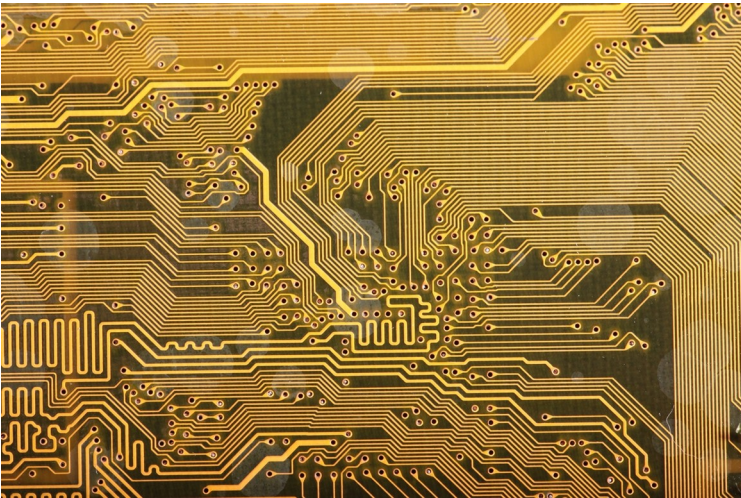


KI und Nachhaltigkeit



Kathrin Braungardt

Agenda

- Nachhaltigkeit
- Stromverbrauch
- Ökologischer Fußabdruck
- Datenzentren
- Modelle & Energieverbrauch
- Wasserverbrauch
- Widerstand
- Maßnahmen & Konsequenzen

Is this worse than boiling the kettle?

„...the information and communications technology (ICT) sector accounts for a quite significant 2%-4% of all GHG emissions globally,

with a total of 1 to 2 billion tonnes CO₂e per year...“

APPLIANCE	USAGE	ASSUMPTIONS	kWh/YEAR	KG CO ₂ e/ YEAR
Kettle	1,542 uses/year	0.11 kWh/use based on heating 1 liter of water	170	73
Electric oven	135.1 uses/year	1.56 kWh/use	211	91
Primary TV (plasma, 34-37 inches)	6.5 hours/day	263.9 w	626	269
Low-energy light bulb	4 hours/day	18 w	18	11
Using ChatGPT	Once/day	Each conversation has 20 queries; .00396 kWh/query	29	11
Google search	20 searches/day	.0003 kWh/search	2.19	<1
Email/messaging/voice/etc.	20/day	Average technological progress, average carbon intensity for Canada	Not reported	<1
Video streaming	2 hours/day	Average technological progress, average carbon intensity for Canada	Not reported	26
Flight from NY to SF	Once/year		Not reported	1,000
Bitcoin mining	219 million people with Bitcoin	Average/Bitcoin owner	Not reported	96-242
Average emissions/ person globally				~6,000

Sources: Carbon Footprint, Medium, Full Fact, Luciano Rodrigues et al., *The Guardian*, Crypto News, Our World in Data

<https://www.cutter.com/article/environmental-impact-large-language-models>

Nachhaltigkeit

„Wir sollten mit den begrenzt zur Verfügung stehenden Ressourcen sorgsam umgehen und nicht auf Kosten der Menschen in anderen Regionen der Erde und auf Kosten zukünftiger Generationen leben. Nachhaltigkeit betrifft unsere Umwelt, alle Bereiche unseres Lebens und Wirtschaftens.“ (

<https://www.bundesumweltministerium.de/themen/nachhaltigkeit/ueberblick-nachhaltigkeit>)

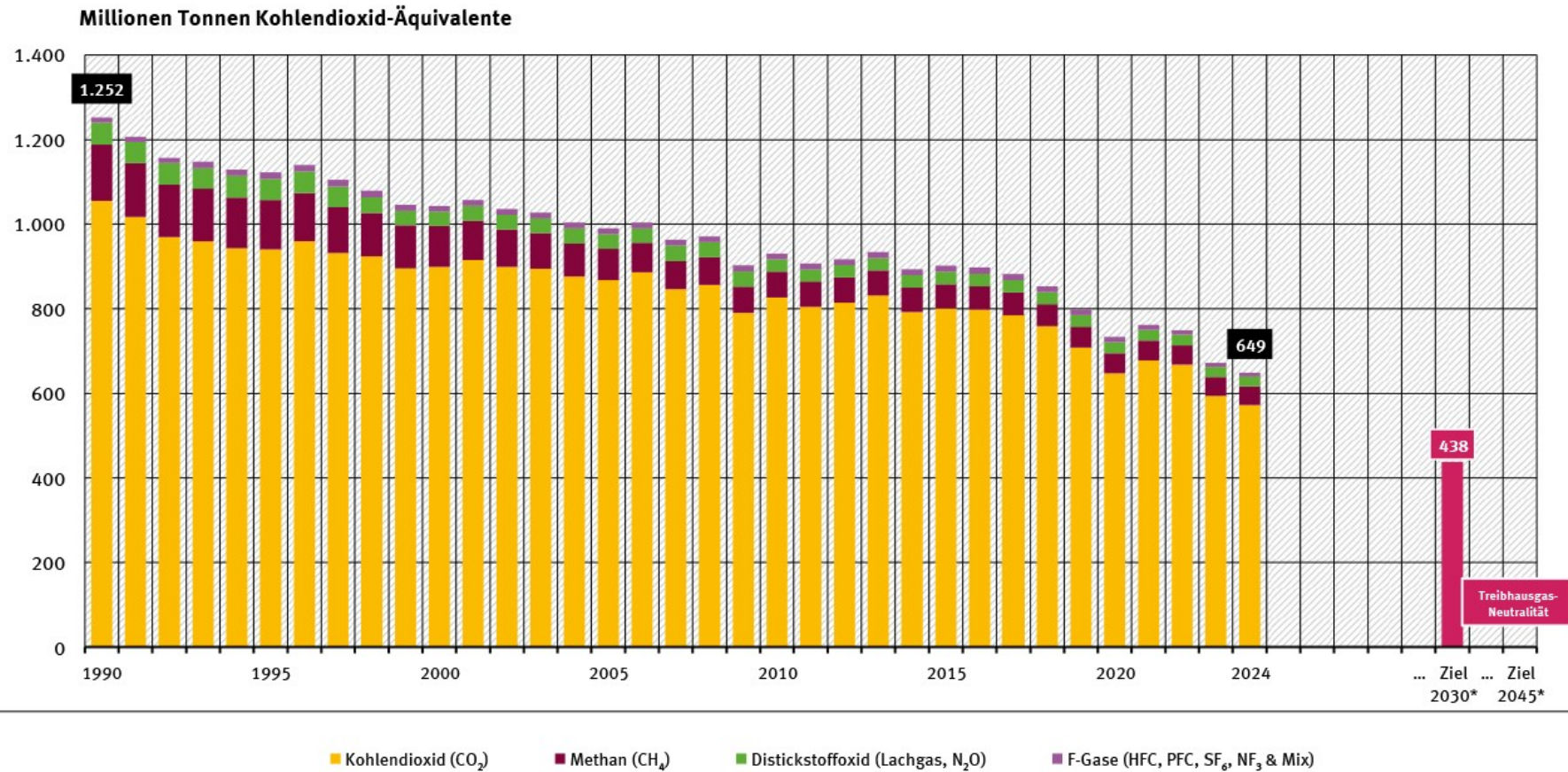


Weg in eine treibhausgasneutrale Wirtschaft und Gesellschaft

2030: Reduktion der Treibhausgasemissionen um 55% im Vergleich zu 1990

2045/50: Klimaschutzziele sind erreicht

Treibhausgas-Emissionen seit 1990 nach Gasen



Emissionen ohne Landnutzung, Landnutzungsänderung und Forstwirtschaft
 * angepasste Ziele 2030 und 2045: entsprechend der Novelle des Bundes-Klimaschutzgesetz (KSG) vom 12.05.2021

Quelle: Umweltbundesamt, Nationale Treibhausgas-Inventare 1990 bis 2023 (Stand 03/2025), für 2024 vorläufige Daten (Stand 15.03.2025)

KI: ökologischer Fußabdruck

- Hardware: e.g. Chips: Herstellung
- Rechenkapazität: Datacenter: Server, Speicher, Netzwerkausrüstung, Strom & Wasser
- Training
- Inferenz

„Pro Kilowattstunde des in Deutschland verbrauchten Stroms wurden im Jahr 2025 bei der Erzeugung durchschnittlich 344 Gramm CO₂ ausgestoßen.“

Quelle: Bundesumweltamt: <https://www.umweltbundesamt.de/themen/co2-emissionen-pro-kilowattstunde-strom-2024>

Stromverbrauch

Stromverbrauch der privaten Haushalte nach Haushaltsgrößenklassen¹

Merkmale	2015	2016	2017	2018	2019	2020	2021	2021 zu 2020 in %	2021 zu 2015 in %
Petajoule									
Strom insgesamt	467	464	464	461	457	466	499	7,2	6,9
Gigawattstunden									
Strom insgesamt	129 703	129 027	129 000	128 032	126 932	129 324	138 629	7,2	6,9
Anzahl in 1 000									
Haushalte	40 256	40 397	40 721	40 805	40 902	40 540	40 974	1,1	1,8
Kilowattstunden									
Strom je Haushalt	3 222	3 194	3 168	3 138	3 103	3 190	3 383	6,1	5,0
1-Personen-Haushalt	2 105	2 072	2 057	1 974	1 945	1 978	2 105	6,4	0,0
2-Personen-	3 305	3 261	3 242	3 225	3 188	3 252	3 470	6,7	5,0

ca. 140 GWh / Jahr
ca. 48 Mio. t CO₂

<https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/UGR/private-haushalte/Tabellen/stromverbrauch-haushalte.html>

1 Gigawatt= 1 Mio. Kilowattstunden

Data Center

Data Center Map: <https://www.datacentermap.com/datacenters/>





At Amazon's Biggest Data Center, Everything Is Supersized for A.I.

On 1,200 acres of cornfield in Indiana, Amazon is building one of the largest computers ever for work with Anthropic, an artificial intelligence start-up.

- 2.2 gigawatts of electricity — enough to power a million homes

- millions of gallons of water

https://www.nytimes.com/2025/06/24/technology/amazon-ai-data-centers.html?unlocked_article_code=1.SU8.2JRa.e3Ju6r_pL1Im

1 Gallon = 3,785 Liter

1 Gigawatt= 1 Mio. Kilowattstunden

Meta: 2 GW Data center in Louisiana

<https://www.datacenterdynamics.com/en/news/meta-announces-4-million-sq-ft-louisiana-data-center-campus/>

Bau eines Gaskraftwerks:

<https://www.datacenterdynamics.com/en/news/entergy-propose-s-15gw-natural-gas-plant-to-directly-power-adjacent-data-center-in-louisiana/>

„Several US utilities have indicated that fossil fuels are increasingly being considered a viable energy source due to the insatiable energy demand of data centers.“

Nuklarenergie: Prometheus AI data center: New Albany, Ohio,

<https://apnews.com/article/facebook-meta-zuckerberg-ai-vistra-oklo-terrapower-0eb051a9a11d96f7ce200e186ad13476>

Stargate: joint venture OpenAI, Or

<https://www.nytimes.com/2025/01/21/technology/trump-openai-stargate-artificial-intelligence.html>

acle and SoftBank: 100 Mrd. Dollar über vier Jahre:

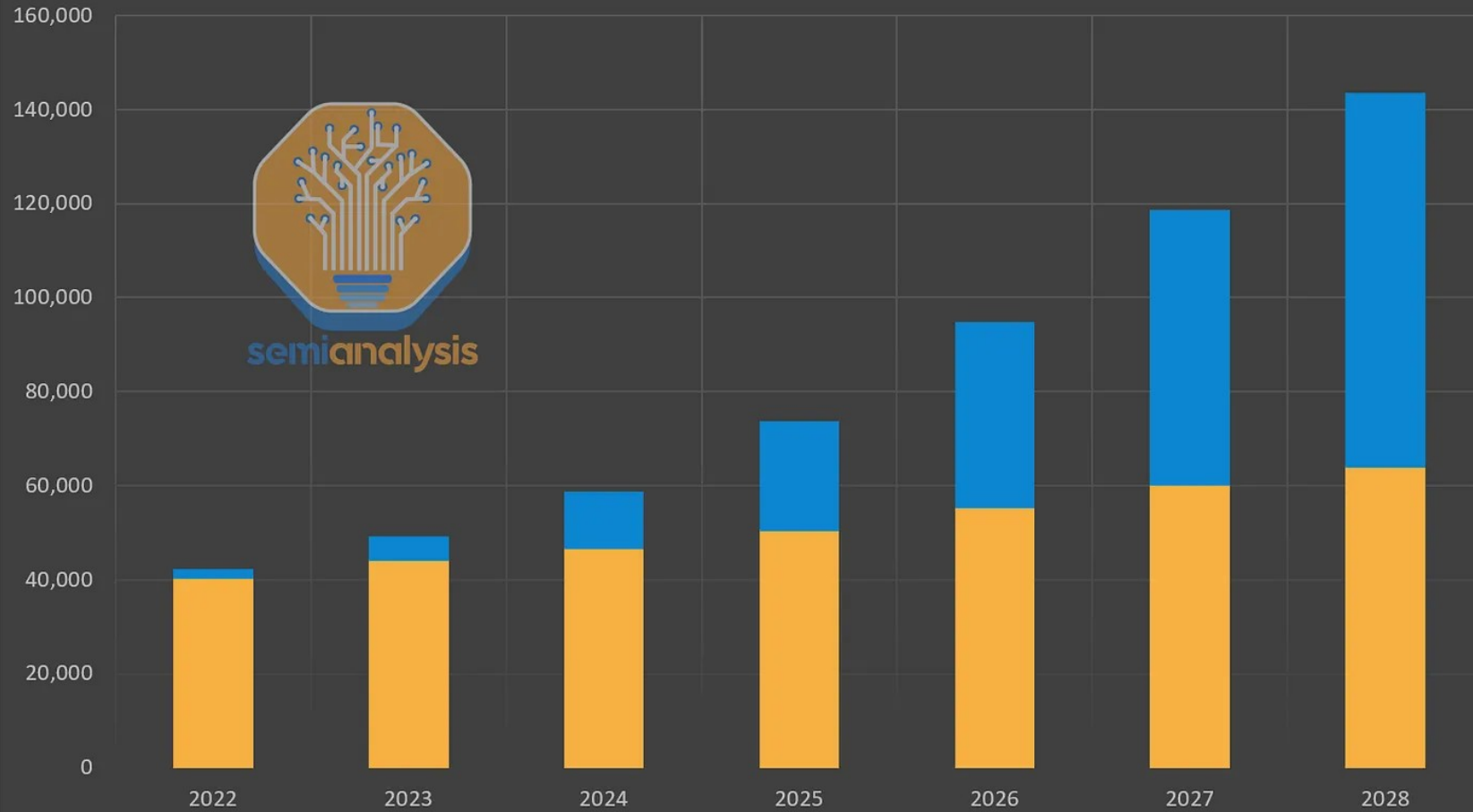
Data Center in den Vereinigte Arabische Emirate: joint venture mit Oracle, Nvidia, t SoftBank, Cisco und G42 im Auftrag von OpenAI

https://www.nytimes.com/2025/06/24/technology/amazon-ai-data-centers.html?unlocked_article_code=1.SU8.2JRa.e3Ju6r_pL1Im

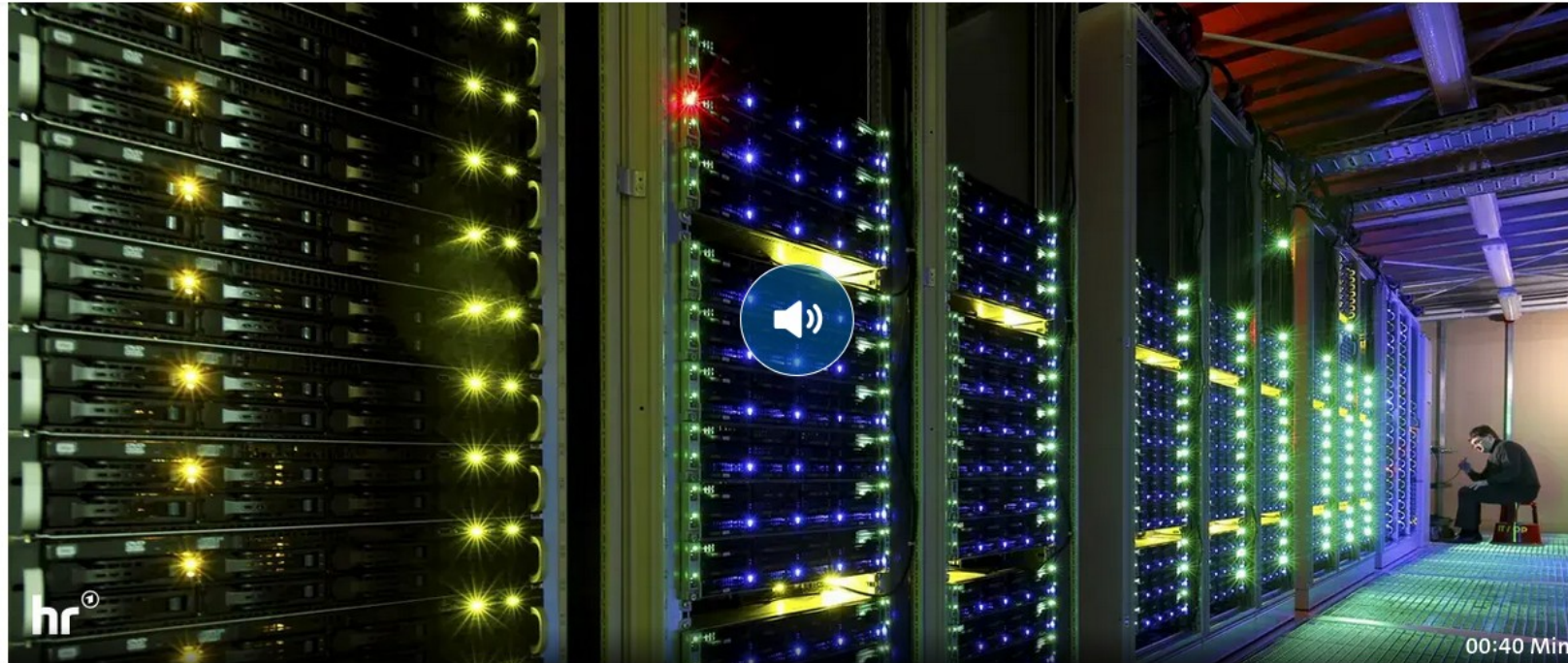
https://www.nytimes.com/2025/06/24/technology/amazon-ai-data-centers.html?unlocked_article_code=1.SU8.2JRa.e3Ju6r_pL1Im

Global Data Center Critical IT Power (Megawatts - MW)

■ Non-AI Data Center Critical IT Power ■ AI Data Center Critical IT Power



Startseite ▶ Inland ▶ Regional ▶ Hessen ▶ Hessen: Rechenzentrum in Maintal: Proteste bringen Projekt ins Stocken



Hessen

Rechenzentrum in Maintal: Proteste bringen Projekt ins Stocken

Stand: 12.05.2026 • 10:51 Uhr

Milliardenschwer sollte das Rechenzentrum werden, das ein US-Konzern in Maintal plante. Weil es mit einem eigenen Gaskraftwerk betrieben werden sollte, schlugen Anwohner Alarm. Nun stockt das Projekt.

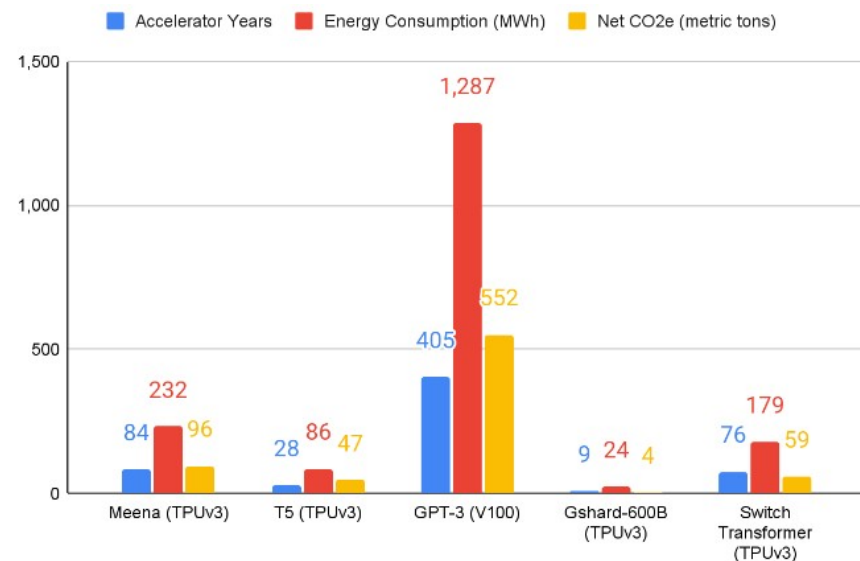
Modelle

Estimating the Carbon Footprint of BLOOM, a 175B Parameter Language Model

Model name	Number of parameters	Datacenter PUE	Carbon intensity of grid used	Power consumption	CO ₂ eq emissions	CO ₂ eq emissions × PUE
GPT-3	175B	1.1	429 gCO ₂ eq/kWh	1,287 MWh	502 tonnes	552 tonnes
Gopher	280B	1.08	330 gCO ₂ eq/kWh	1,066 MWh	352 tonnes	380 tonnes
OPT	175B	1.09 ²	231 gCO ₂ eq/kWh	324 MWh	70 tonnes	76.3 tonnes ³
BLOOM	176B	1.2	57 gCO ₂ eq/kWh	433 MWh	25 tonnes	30 tonnes

Table 4: Comparison of carbon emissions between BLOOM and similar LLMs. Numbers in *italics* have been inferred based on data provided in the papers describing the models.

<https://arxiv.org/pdf/2211.02001>



Single passenger round trip SF-NY (1.2t CO₂e)

<https://arxiv.org/pdf/2104.10350>

Power Hungry Processing: Watts Driving the Cost of AI Deployment?

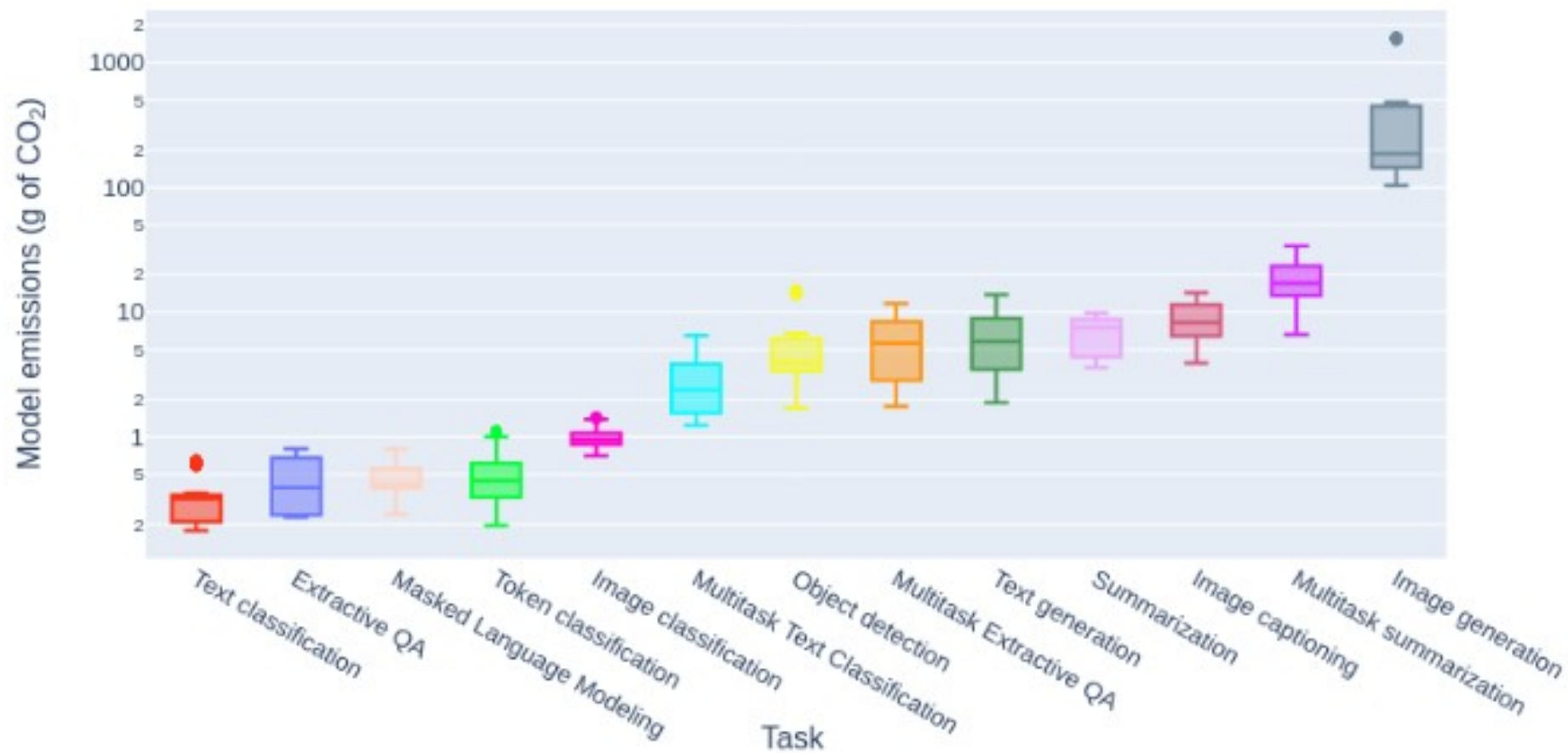


fig. 1. The tasks examined in our study and the average quantity of carbon emissions they produced (in g of CO₂e_q) for 1,000 queries. N.B. The y axis is in logarithmic scale

Energy Consumption Calculations

Total Yearly Energy Consumption

Daily energy use per user:

$$350 \text{ W} \times 1.5 \text{ h} = 525 \text{ Wh} = 0.525 \text{ kWh} \quad (1)$$

Daily energy use for 10 million users:

$$0.525 \text{ kWh} \times 10,000,000 = 5,250,000 \text{ kWh} \quad (2)$$

Yearly energy use for 10 million users:

$$\begin{aligned} 365 \times 5,250,000 \text{ kWh} &= 1,916,250,000 \text{ kWh} \quad (3) \\ &= 1.92 \text{ TWh} \end{aligned}$$

Based on our assumption that the 10 million users of Stable Diffusion (as confirmed by StabilityAI) run the system for approximately 1.5 hours per day on a RTX 3090, will lead to a yearly energy consumption of approximately 1.92 TWh. This level of energy consumption is similar to the total electricity consumption of the West African nation Mauritania in 2021, which has been estimated to be 1.9 TWh according to the US Energy Information Administration (eia.gov n.d.).

(https://computationalcreativity.net/iccc23/papers/ICCC-2023_paper_60.pdf)

AI Energy Leaderboard

LLM Problem Solving Text Conversation Code Completion | **MLLM Image Chat** Video Chat | Diffusion Text to Image Text to Video

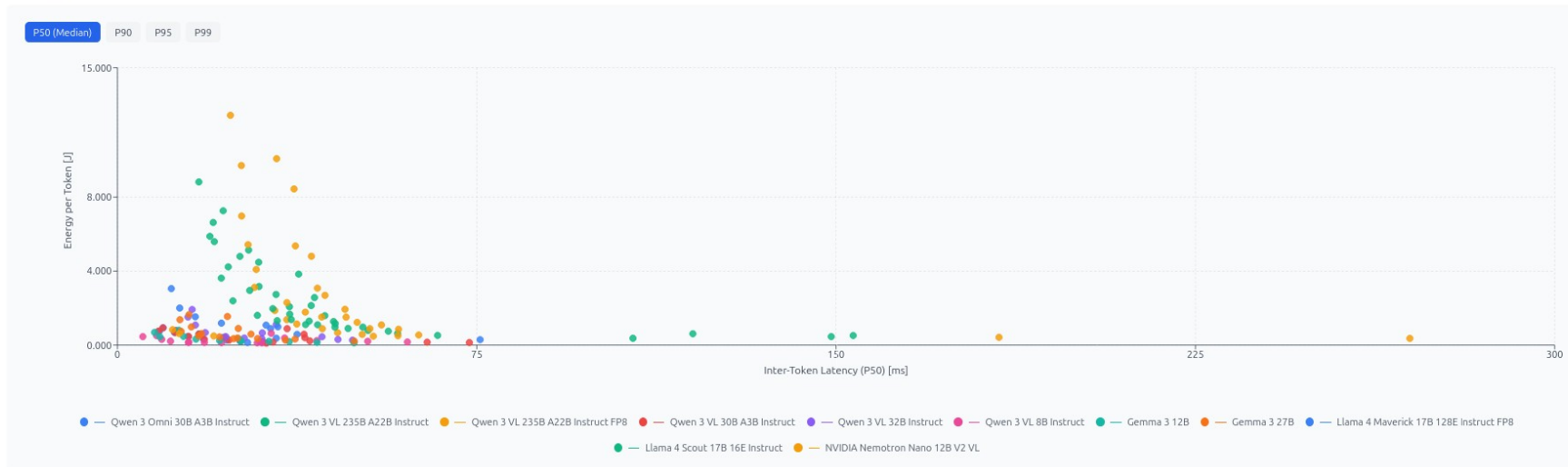
Conversational AI Chatbot with Image Understanding [About](#)

Median ITL deadline: 300 ms Per token energy budget: 12.43 J GPU Models

B200 H100 Reset

All configurations

173 configurations



Energy-optimal points for each model

11 models satisfy the given constraints (click row for model details).

Advanced columns

<input type="checkbox"/> Compare	Model	Precision \uparrow	Total Params (B) \uparrow	Active Params (B) \uparrow	GPU \uparrow	# GPUs \uparrow	Energy/Token (J) \uparrow	Energy/Response (J) \uparrow	Median ITL (ms) \uparrow	Perf/Watt (tokens/s) \uparrow
<input type="checkbox"/>	Qwen 3 VL 30B A3B Instruct	bfloat16	30	3	B200	1	0.1051	107.68	31.1	9.51

https://ml.energy/leaderboard/?__theme=light

Making AI Less “Thirsty”: Uncovering and Addressing the Secret Water Footprint of AI Models: <https://arxiv.org/pdf/2304.03271>

Table 1: Estimate of GPT-3’s operational water consumption footprint. “*” denotes data centers under construction as of July 2023, whose PUE and WUE are projected by Microsoft.

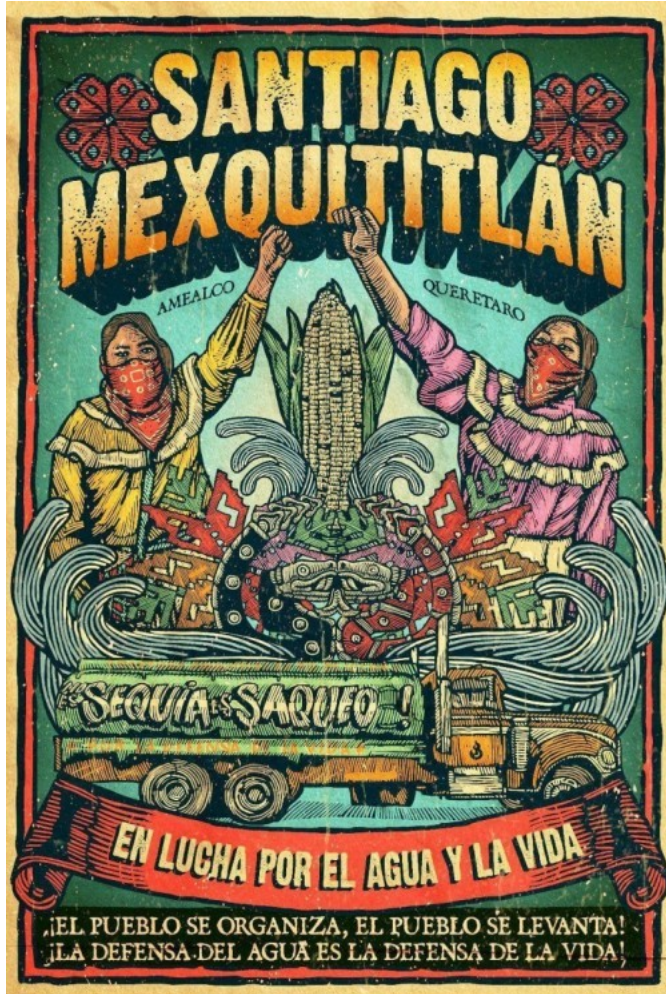
Location	PUE	On-site WUE (L/kWh)	Off-site EWIF (L/kWh)	Water for Training (million L)			Water for Each Request (mL)			# of Requests for 500ml Water
				On-site Water	Off-site Water	Total Water	On-site Water	Off-site Water	Total Water	
U.S. Average	1.170	0.550	3.142	0.708	4.731	5.439	2.200	14.704	16.904	29.6
Arizona	1.180	1.630	4.959	2.098	7.531	9.629	6.520	23.406	29.926	16.7
Georgia*	1.120	0.060	2.309	0.077	3.328	3.406	0.240	10.345	10.585	47.2
Illinois	1.350	0.740	2.233	0.952	3.880	4.833	2.960	12.060	15.020	33.3
Iowa	1.160	0.140	3.104	0.180	4.634	4.814	0.560	14.403	14.963	33.4
Texas	1.280	0.250	1.287	0.322	2.120	2.442	1.000	6.590	7.590	65.9
Virginia	1.140	0.140	2.385	0.180	3.499	3.679	0.560	10.875	11.435	43.7
Washington	1.150	0.950	9.501	1.223	14.063	15.285	3.800	43.706	47.506	10.5
Wyoming	1.110	0.130	2.574	0.167	3.677	3.845	0.520	11.429	11.949	41.8
Australia*	1.120	0.012	4.259	0.015	6.138	6.154	0.048	19.078	19.126	26.1
Denmark*	1.160	0.010	3.180	0.013	4.747	4.760	0.040	14.754	14.794	33.8
Finland*	1.120	0.010	4.542	0.013	6.548	6.561	0.040	20.350	20.390	24.5
India*	1.430	0.000	3.445	0.000	6.340	6.340	0.000	19.704	19.704	25.4
Indonesia*	1.320	1.900	2.271	2.445	3.858	6.304	7.600	11.992	19.592	25.5
Ireland	1.190	0.020	1.476	0.026	2.261	2.287	0.080	7.027	7.107	70.4
Mexico*	1.120	0.056	5.300	0.072	7.639	7.711	0.224	23.742	23.966	20.9
Netherlands	1.140	0.060	3.445	0.077	5.054	5.131	0.240	15.708	15.948	31.4
Sweden	1.160	0.090	6.019	0.116	8.986	9.101	0.360	27.927	28.287	17.7

medium-sized request, each with approximately ≤800 words of input and 150 – 300 words of output

Power usage effectiveness (PUE)
Water usage effectiveness (WUE)
energy water intensity factor (EWIF)

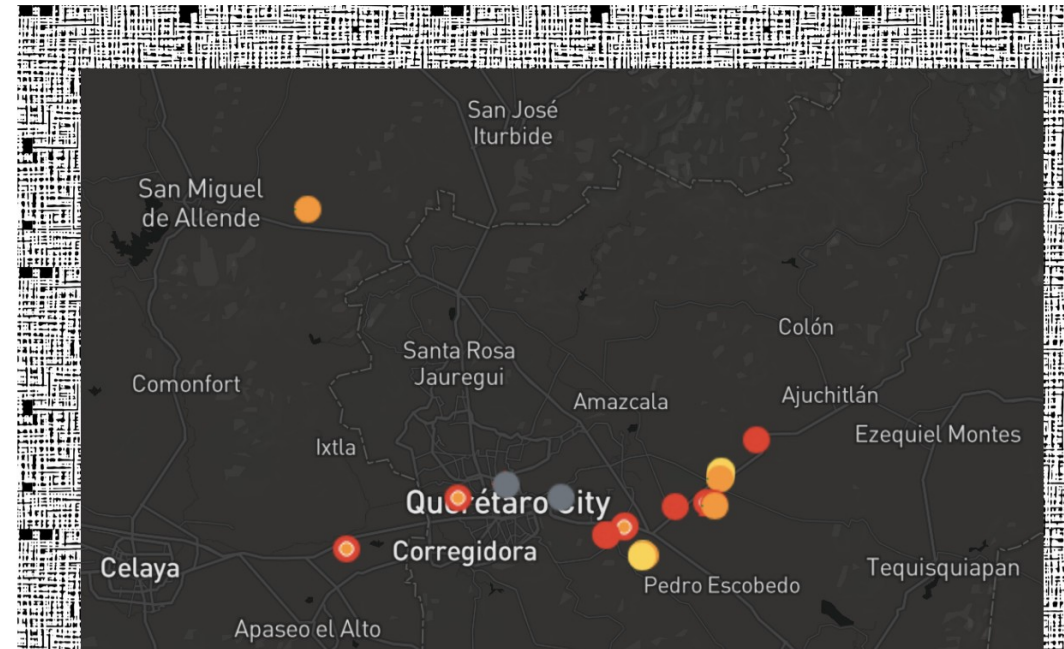
<https://journal.uptimeinstitute.com/dont-ignore-water-consumption/>

Widerstand



Querétaro: "The valley of data centers"

Querétaro has firmly established itself as Mexico's leading data center hub, controlling 65% of the national capacity and attracting more than 80% of all current and planned investments for the years to come. With 27 data center projects (Figure 2), conservative estimates place the total investment at approximately \$15 billion (Opportimes, 2025).



<https://tramas.digital/en/cases/queretaro/>

Maßnahmen



Klimaschutzbericht Google 2025: <https://sustainability.google/google-2025-environmental-report/>

Konsequenzen?