

AI, Infrastructure, Energy

G. Urvoy-Keller

1 Introduction

- Data centers
- Where is my precious AI?

2 Data centers

- Why focusing on DC?
- What does it look like?
- Where do they live?

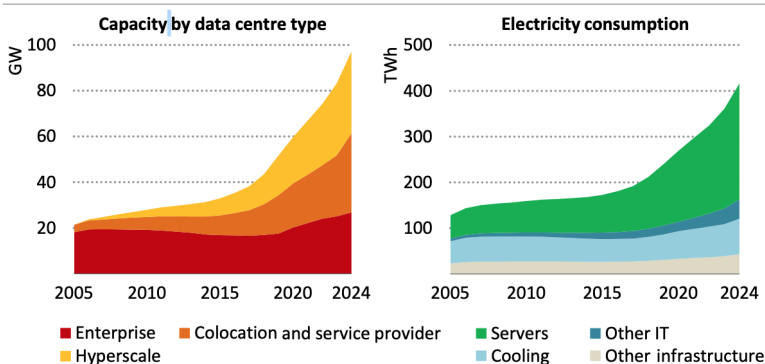
3 Data Centers and Energy

4 Future trajectory

5 Is it really a problem?

6 Conclusions

Figure 2.3 ▶ Total data centre electricity consumption by equipment type and data centre type, 2005-2024



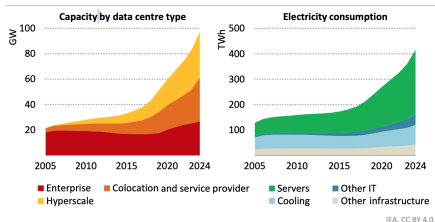
IEA. CC BY 4.0.

After a decade of limited growth, data centre electricity consumption began to accelerate again after 2015



- Capacity (Power) is the maximum electricity flow while Energy is capacity *used* over time
 - Ex : the "toaster challenge" → need to generate 700 W of power for a long enough period
 - Here 700 W for 3 min → $700W \times 3/60h = 35Wh$

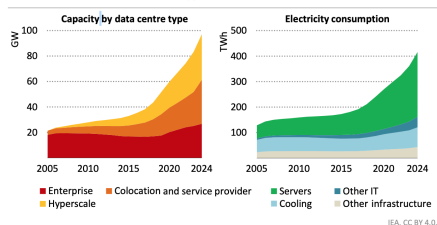
Figure 2.3 ➤ Total data centre electricity consumption by equipment type and data centre type, 2005-2024



After a decade of limited growth, data centre electricity consumption began to accelerate again after 2015

- Installed capacity is ≈ 100 GW and consumed energy ≈ 400 TWh
- 100 GW used continuously over 1 year :
 $100GW \times 24h \times 365days = 876 TWh$
- \rightarrow average utilization is $\approx 45\%$

Figure 2.3 Total data centre electricity consumption by equipment type and data centre type, 2005-2024

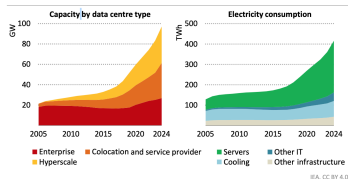


After a decade of limited growth, data centre electricity consumption began to accelerate again after 2015

- 100 GW to be compared to a typical nuclear reactor of 1 GW¹
- 400 TWh to be compared to the French electricity consumption 450 TWh, in 2024

1. For instance, EDF, in France, operates 58 nuclear reactors rated between 0.9 and 1.45 GW.

Figure 2.3 - Total data centre electricity consumption by equipment type and data centre type, 2005-2024



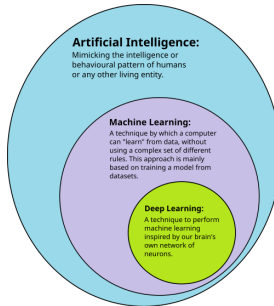
After a decade of limited growth, data centre electricity consumption began to accelerate again after 2015

- \approx stable in the period 2005-2015 \rightarrow energy efficiency
- increase since 2018 \rightarrow traditional services + crypto-currencies (not represented in figure)

Global trends in digital and energy indicators, 2015-2022

	2015	2022	Change
Internet users	3 billion	5.3 billion	+78%
Internet traffic	0.6 ZB	4.4 ZB	+600%
Data centre workloads	180 million	800 million	+340%
Data centre energy use (excluding crypto)	200 TWh	240-340 TWh	+20-70%
Crypto mining energy use	4 TWh	100-150 TWh	+2300-3500%
Data transmission network energy use	220 TWh	260-360 TWh	+18-64%

Sources: Internet users [ITU (2023)]; Internet traffic [IEA analysis based on Cisco (2015), TeleGeography (2022)].



- Machine learning (extracting knowledge from data) is opposed to symbolic AI (set of rules)
- Classical machine learning : SVM, forest tree, kmeans, neural networks
- Modern AI
 - with the advent of deep learning (2010)
 - lot's of applications : classification of feelings, automatic translation, image classification, object detection
 - ... and then came the generative AI with Chatgpt in Nov. 2022

Current share of AI

"The International Energy Agency (IEA) estimated that AI systems accounted for 15% of total data center electricity demand (excluding cryptocurrency mining) in 2024," [de Vries 2026]

Future Share

Shift project anticipates AI will be the new kid in the block

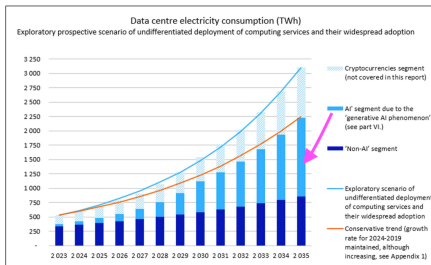


Figure 10 - Electricity consumption of data centres in the use phase (TWh) in our exploratory forward-looking scenario of undifferentiated computing capacity deployment and widespread adoption, compared with a conservative trend. Source: (The Shift Project, 2025a)

D	Electricity use reporting?		PUE reporting?		WUE reporting?	
	Total company	Data centers	Company average	Individual data centers	Company average	Individual data centers
Alibaba	Yes	No	Yes	No	No	No
Amazon	Yes	No	No	No	Yes	No
Apple	Yes	Yes	No	No	No	No
Baidu	Yes	No	Yes	No	No	Yes
ByteDance	No	No	No	No	No	No
CoreWeave	No	No	No	No	No	No
Google	Yes	No	Yes	Yes	No	No
Lambda Labs	No	No	No	No	No	No
Meta	Yes	Yes	Yes	No	Yes	No
Microsoft	Yes	No	Yes	No	Yes	No
Oracle	Yes	No	Yes	Yes	No	No
Tencent	Yes	No	Yes	No	No	No
Tesla	Yes	No	No	No	No	No

From : Masanet, Eric, Nuoa Lei, and Jonathan Koomey. "To better understand AI's growing energy use, analysts need a data revolution." Joule 8.9 (2024) : 2427-2436.

impact of data centers is growing rapidly, the urgency for transparency in the tech sector is also increasing. The carbon footprint of AI systems alone could be between 32.6 and 79.7 million tons of CO₂ emissions in 2025, while the water footprint could reach 312.5–764.6 billion L. To put this into perspective, this is in the same range as the carbon footprint of New York City (52.2 million tons of CO₂ emissions in 2023²⁷). Similarly, the water footprint of AI systems may be in the same range as the entire global annual consumption of bottled water (446 billion L²⁸). This assessment can be made only by using the wider data center

6.

7.

8.

From : de Vries-Gao, Alex. "The carbon and water footprints of data centers and what this could mean for artificial intelligence." Patterns 7.1 (2026).

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Why focusing on DC ?

- Data centers are the physical substrate of AI
- Characterizing supply (DC) is easier than demand (AI services)

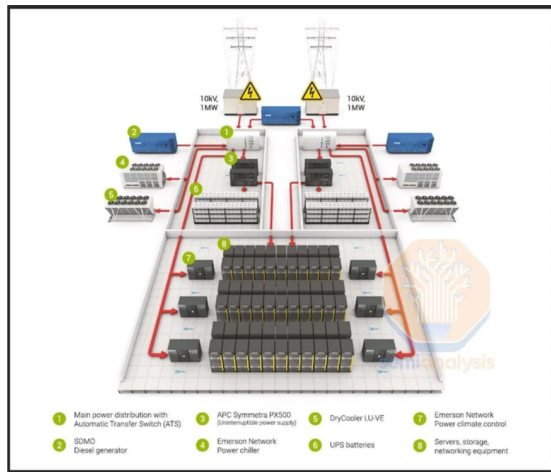


Schéma des éléments composants couramment un centre de données. Source : DEAC et Semi Analysis

■ Power supply

■ Switch gear (1)

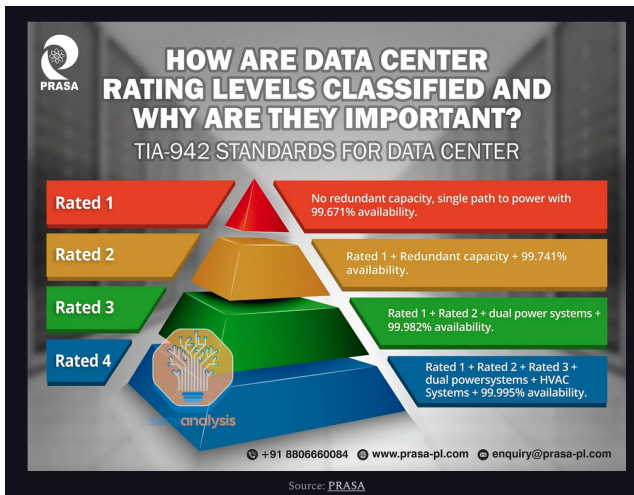
- main grid ;
- fossil fuel power generator (2) ;
- UPS (3) with batteries (6).

■ Cooling : (4),(5) and (7)

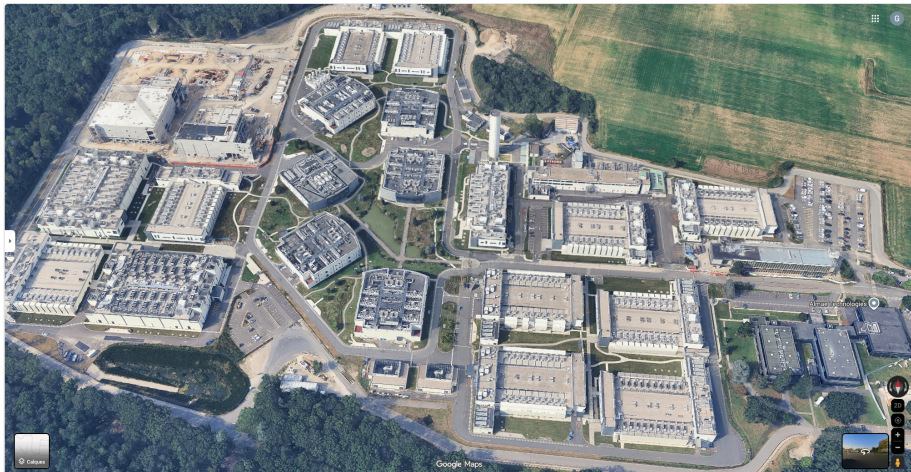
■ IT room : (8)

Case of 112 8th Avenue in New York with 600,000-liter fuel oil tanks



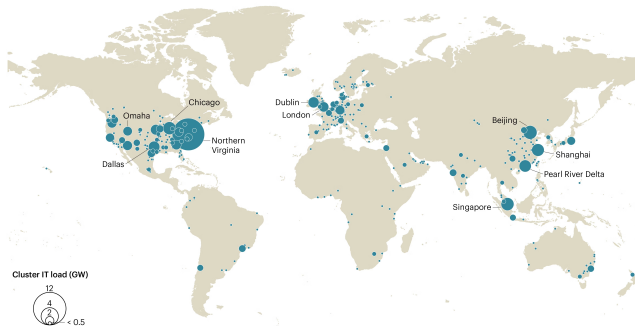


(source : <https://newsletter.semianalysis.com/p/datacenter-anatomy-part-1-electrical>)



■ 420 GWh consumed in 2023

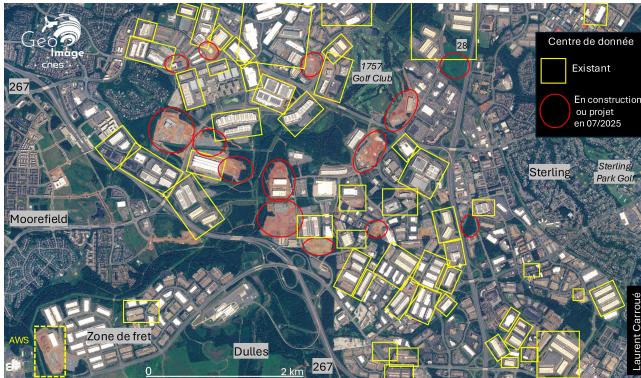
DCs live in clusters :



The unit of measurement is electrical power \Rightarrow **energy availability is a key factor**

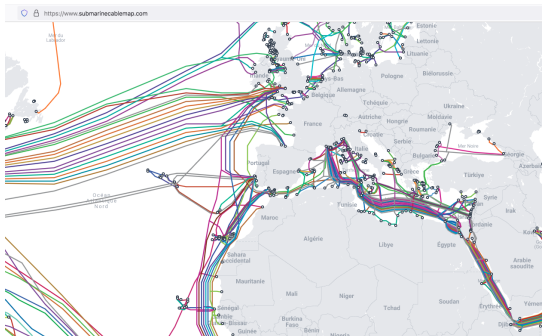
(source : telegeography)

Zoom on Asburn, Virginia - the largest concentration of DCs in the world



SOURCE : <https://cnes.fr/geoimage/etats-unis-virginie-data-center-alley-1er-pole-mondial-de-centres-de-donnee>

- International Internet highways \Rightarrow submarine cables (e.g. Marseille)
- National Internet highways
 - motor highways \approx Internet highways



<https://www.submarinecablemap.com/>

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- The electricity distribution network requires a constant balance between producers and consumers on a minute-by-minute timescale.
- The basic rules for grid access
 - "first come, first served"
 - **the operator has an obligation to provide the access.**
- It takes long to install a new sub-station (grid access for companies)
⇒ up to several years in France
- Hence the temptation to do things differently...

C'est la directrice du réseau français de distribution de gaz (GRDF), Laurence Poirier-Dietz, qui l'a partagé à une poignée de journalistes le 1^{er} avril. « *Nous sommes régulièrement sollicités par des opérateurs de data centers. Ils viennent vers nous pour explorer des solutions de raccordement au réseau gazier. Parce que les délais annoncés sur le réseau électrique – parfois cinq à sept ans – ne sont pas compatibles avec leurs calendriers. Il ne s'agit pas d'un phénomène marginal.* »



- At the national level, data centers can become major energy consumers.
- The emblematic case of Ireland

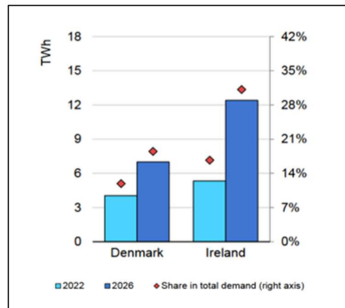
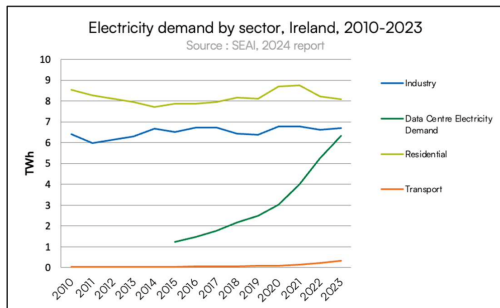
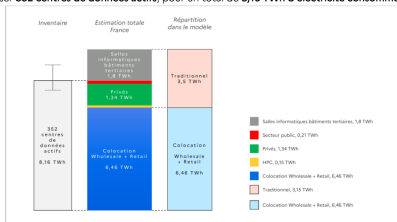


Figure 25 - Demande d'électricité par secteur entre 1990 et 2023 en Irlande (à gauche). Source : (SEAI, 2024) et estimation de la consommation d'électricité des centres de données et de sa part dans la demande totale d'électricité en Irlande. Source : (IEA, 2024a)

Pour l'année 2024, les résultats de notre travail d'inventaire des centres de données en France a permis de recenser **352 centres de données actifs**, pour un total de **8,16 TWh d'électricité consommés**.⁵



8 TWh \Rightarrow 1.52% of annual production

Source : Ademe 2026 report "Prospect for the evolution of data center consumption in the short, medium and long term 2024 to 2060"



The screenshot shows a news article from RTE (Réseau de Transport d'Électricité) titled "La production d'électricité française a atteint son plus haut niveau depuis 5 ans" (French electricity production reaches its highest level in 5 years). The article is dated 29/01/2025. The text states that in 2024, France returned to important levels of electricity production, setting several records with 536.5 TWh, which is the highest level since 2019, matching the average of 2014-2019 (537.5 TWh).

- **Marseille** : a data center booked 90 MW and the city had to negotiate 7 MW for its electric buses²
- **Meta** data center : training of the LLama 3.220 model. With "only" 30 MW of installed power for IT (24,000 H100 GPUs),
 - Training disturbed the electrical grid
 - Basically, 0 MW – 30 MW – 0 MW
 - Solution : **At the end of training, launch unnecessary jobs to gradually reduce power demand**
 - "pytorch-no-powerplant-blowup=1"

2. **20 MW is the power needed for a city of 50 000 inhabitants.**

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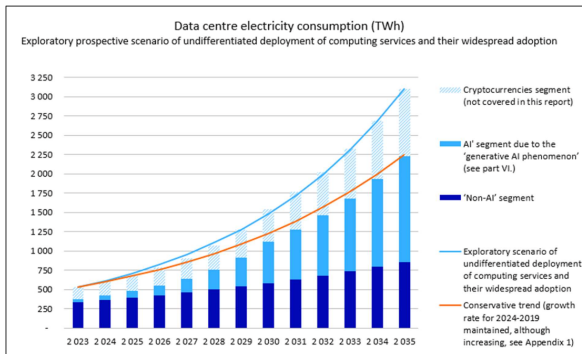


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2030

- Global : between 1250 and 1500 TWh
- AI : \approx 500 TWh

IEA

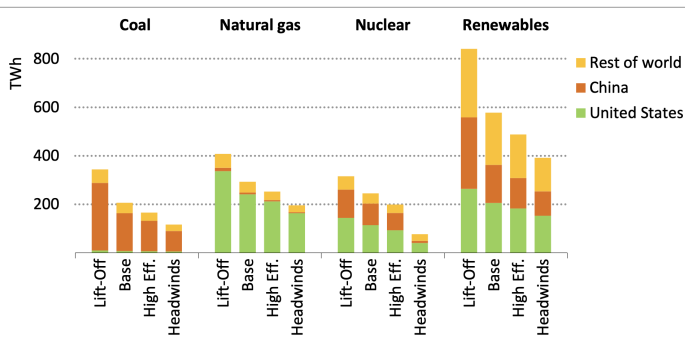
- 4 scenarios (Lift-off, Base, High Efficiency, Headwinds)
- between **670 and 1265 TWh in 2030**(excluding cryptocurrencies) (IEA, 2025a)

Schneider

- 4 scenarios (Abundance, Sustainable AI, Energy Crunch, Limits to Growth)
- AI consumption alone of **510 to 880 TWh in 2030** (Schneider Electric, 2024)

- Electricity demand from DC \Rightarrow increasing pressure on the energy sector.
- Big tech companies desperately seek for low-carbon electricity :
 - Amazon is exploring the deployment of 0.3 GW of small modular reactors (SMRs)
 - Google is conducting a deep geothermal experiment targeting a capacity of 0.1 GW
 - Microsoft made a deal to restart Three Mile Island

- A total of 85 gas-fired power plants are under development worldwide for data centers (Financial Times, 2025)
- First Energy has canceled the planned closure of two coal-fired power plants, which it now plans to operate until 2035-2040 (Financial Times, 2024).



IEA. CC BY 4.0.

In all cases, fossil fuels remain an important element of the data centre electricity supply mix by 2035

- US plans to rely on gas, China on coal
- Renewable energy \Rightarrow 20 MtCO₂e
- Fossil fuels \Rightarrow 500 MtCO₂e.

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<https://doi.org/10.1038/s44168-025-00252-3>

Green and intelligent: the role of AI in the climate transition



Nicholas Stern¹, Mattia Romani^{1,2}, Roberta Pierfederici¹✉, Manuel Braun², Daniel Barraclough², Shajeeshan Lingeswaran², Elizabeth Weirich-Benet² & Niklas Niemann²

Artificial Intelligence (AI) can play a powerful role in supporting climate action while boosting sustainable and inclusive economic growth. However, limited research exists on the potential influence of AI on the low-carbon transition. Here we identify five areas through which AI can help build an effective response to climate threats. We estimate the potential for greenhouse gas (GHG) emissions reductions through AI applications in three key sectors—power, food, and mobility—which collectively contribute nearly half of global emissions. This is compared with the increase in data centre-related emissions generated by all AI-related activities.

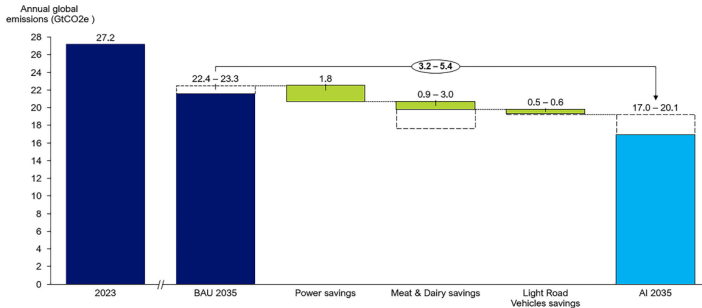


Fig. 1 | Total emissions and emissions savings from AI in 2035 for the sectors in scope (Power, Meat and Dairy, Light Road Vehicles). Note, the 2023 bar is the total 2023 GtCO₂e emissions of power (15.3 GtCO₂e), meat and dairy (8.7 GtCO₂e), and light road vehicles (3.2 GtCO₂e) sectors.

- Maybe AI can bring some benefits for the society
- But is it the case of all types of AI ?

David Rolnick

- Rolnick, David, et al. "Tackling climate change with machine learning." ACM Computing Surveys (CSUR) 55.2 (2022) : 1-96.
 - 2186 citations (Google Scholar)
 - "I'm so tired of this sales pitch : "AI is using a lot of energy but it's also helping the climate". The AI that helps the climate is generally very different from the AI that uses a lot of energy (e.g. LLMs like ChatGPT). We can have the former without the latter"

The AI Climate Hoax: Behind the Curtain of How Big Tech Greenwashes Impacts



Ketan Joshi is an analyst, writer and communicator specialising in clean energy, corporate accountability and advocacy.

3

3. Luccioni, Alexandra Sasha et al. "From efficiency gains to rebound effects : The problem of jevons' paradox in AI's polarized environmental debate." ACM Facct 2025.

- 1 Collect a number of statements supporting the *AI for Green* paradigm from a set of publicly and recognized sources :
 - "IA and Energy" report from IEA
 - Stern, Nicholas, et al. "Green and intelligent : the role of AI in the climate transition." *npj Climate Action* 4.1 (2025) : 56.
 - Luers, Amy. "Net zero needs AI—five actions to realize its promise." *Nature* 644.8078 (2025) : 871-873.
 - Microsoft sustainability playbook (2023)
 - Microsoft - Corporate website (2025)
 - Microsoft - Sustainability report (2025)
 - Google - Sustainability Report (2025)
 - 'AI for a planet under pressure' (2025) - excluded from analysis
 - Climate Change AI project (2019)
<https://www.climatechange.ai/summaries>
- 2 Check both :
 - the type of AI referenced ;
 - the type of evidence referenced

AI category	AI type	Definition	Example
Traditional	Predictive	"Predictive AI refers to the use of AI models to predict future outcomes" - IEA	Improved wind predictions using machine learning
Traditional	Computer vision	"Computer vision focuses on enabling machines to interpret and understand visual data, such as images and videos, in a way that mimics human vision" - IEA	Detecting vegetation regrowth in satellite imagery
Traditional	Physical	"Physical or embodied AI refers to systems that physically interact with the real world, such as autonomous cars, robots and drones" - IEA	Automated laboratories producing experimental materials for solar panels
Traditional	Unclear	Insufficient information, overlapping categories	
Traditional	Generative narrow	Generation of text or search retrieval for a narrow, constrained input and a narrow set of outputs	A chatbot trained only on IPCC reports
Generative	Generative consumer	Generative AI refers to applications that focus on generating new content, such as text, images, audio and video	A chatbot marketed as general use and trained on vast amounts of digital information

Characteristic	Definition
No evidence	Whether primary evidence is cited for the claim that the AI technology is an effective climate solution, and if so, what type of evidence
Corporate website	The website of a private corporation
Corporate report	A report published by a private corporation
Academic (unpublished)	An academic report not yet published in a peer reviewed publication
Academic (published)	An academic report published in a peer reviewed publication
NGO, Government, Other	Reports, analyses and websites published by non-governmental organisations, governments and other similar institutions
Newsmedia	Journalistic outlets

97% of claims relate to Traditional AI

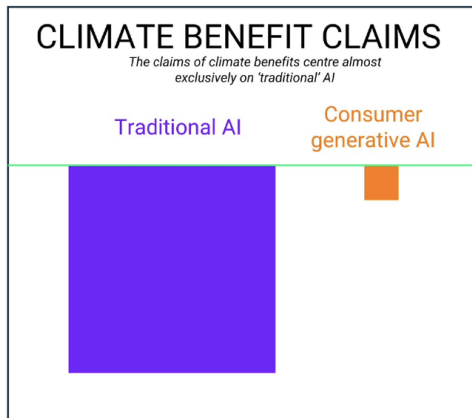
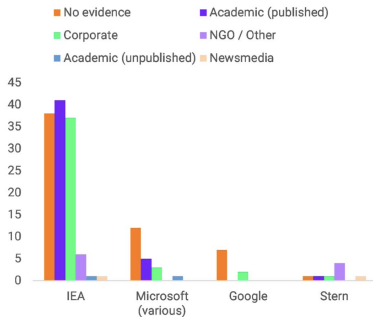


FIGURE 6 - NUMBER OF CLAIMS BY AI TYPE

"Of 154 climate benefit claims assessed, only 26% cited published academic papers. 36% did not cite any evidence at all."



Conclusion of K. Joshi

By muddling these two types of AI^a into one umbrella term, purported climate solutions are coupled to extreme pollution and presented as a package deal.

a. Traditional vs generative AI

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- 6** Conclusions

- Data centers are energy intensive objects
 - Increasing stress on electricity grid at the local level \Rightarrow power issue
 - Increasing stress on electricity grid at the national level \Rightarrow energy issue
- The gen AI moment leads to an energy wall that :
 - might request a partial return to fossil energy
 - might compromise the energy transition of other sectors (transport, food and agriculture, building)
- Modern AI is not **only** large scale generative AI

- Why the IT industry is an extractivist industry
- The micro-workers behind AI



Portraits of micro-workers

The real people behind AI in France

PAOLA TUBARO, National Center of Scientific Research (CNRS)
ANTONIO A. CASILLI, Telecom Paris



Washing copper ore, Kolwezi, DRC. Photo by Fairphone/Flickr.

- Ideologies behind AI



The TESCREAL bundle: Eugenics and the promise of utopia through artificial general intelligence
by Timnit Gebru and Émile P. Torres

- AI in the academic (research) domain
- AI for Sustainability report from The Stockholm Resilience Centers



AI for a planet under pressure

Editors: Victor Galaz & Maria Schewenius



Google DeepMind

Google.org

**Urban
Systems
Lab**

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