AI, environment & climate change: The sustainability paradox

Weighing AI’s environmental footprint against its environmental & climate value

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AI as the solution: environmental & climate innovations

Energy Systems

Advanced grid optimization, accurate demand forecasting, and seamless integration of volatile renewables.

Climate Science

Processing massive structural datasets for complex climate modeling and hyper-accurate extreme weather prediction.

Smart Agriculture

Continuous soil health monitoring, automated irrigation optimization, and targeted pest management.

Ecosystem Protection

Real-time satellite and drone image analysis to detect localized deforestation and manage active conservation.

The core paradox

AI is simultaneously an environmental burden and a critical tool for environmental and climate action

The environment & climate action tool

- ***Opportunities:*** *AI can optimize energy grids, predict extreme weather patterns, and scale ecosystem conservation globally*.

The environmental burden

- ***Physical reality****: heavily relies on data centers, grids, cooling systems, and rare minerals.*
- ***Hidden footprints****: heavy lifting isn't just in model training-everyday inference and deployment drive massive ongoing resource demands.*

The strategic question: Under what conditions does AI's environmental & climate value exceed its lifecycle footprint?

Beyond digital: the lifecycle of AI

To evaluate AI's green and carbon footprint, we need to look into 4 operational core phases:

1 **Materials**

Heavy reliance on critical minerals and highly complex semiconductor supply chains.

2 **Infrastructure**

Building physical data centers, expanding localized utility grids, and manufacturing advanced hardware.

3 **Operation**

Continuous electricity consumption and massive liquid or air cooling demands during daily use.

4 **End-of-life**

Managing the growing wave of hazardous, hard-to-recycle e-waste.

Powering AI: electricity pressures

A single query to a generative AI model such as ChatGPT (GPT-4) can consume about 0.0034 kWh. ChatGPT processes 2.5 billion to 2.8 billion queries and messages per day globally. (KWh 8.5 million daily)

~ 415 TWh

Global data center electricity (2024 baseline)

~ 945 TWh

Projected data center demand by 2030.

~ 3%

Global electricity share (but local grid strain will be significantly higher)

Key growth drivers:

- AI is the most critical structural driver of projected growth in global data centers.
- Accelerated servers alone account for almost half of the net increase in global data center power consumption

The hidden cost: water scarcity

Cooling

Direct/indirect water demand

Electricity

Water embedded in power generation

312.5-764.6 bn L

Operational AI-related water estimate

4.2-6.6 km^3

Projected global AI-related cooling water demand in 2027

2030

Water consumption expected to rise strongly

The hidden cost: e-waste

- **1.2 to 5 million metric tons**
- Projected global generative AI-related e-waste by 2030.

- **395 to 617 million tons**
- Projected global cumulative e-waste between 2025 and 2050

MIT Technology Review

Overall, only 22 per cent of e-waste is recycled and disposed of in an environmentally sound manner

Footprint formula: where, when, & how

Same AI workload ≠ same environmental footprint

Where

Grid carbon intensity
Renewables/gas/coal
Local capacity constraints

When

Peak demand
Load shifting
Seasonal stress

How

Model efficiency
Hardware efficiency
Cooling & PUE

Mandate for governance

- **Measure:** Mandate public disclosure of energy, water, carbon, land, and lifecycle impacts.
- **Site:** Integrate regional water stress, local grid capacity, and land constraints into data-center planning.
- **Design:** Enforce efficiency by design: smaller models, optimal hardware utilization, and smarter workloads.
- **Lifecycle:** Prioritize hardware repair, reuse, cross-industry recycling, and fully responsible mineral sourcing.
- **Distributional effects:** Who receives benefits, and where are energy, water, land, and waste burdens located?

Usage management?

Initiatives to mitigate the impact of AI energy consumption

- Amazon has matched 100% of its operations' global energy consumption with electricity generated by renewable energy systems.
- Microsoft established a supplier code of conduct, requiring suppliers to transition to 100% carbon-free electricity by 2030, and has committed to doing the same.
- Google remains committed to its goal to rely on carbon-free electricity by 2030 and has launched efforts to improve its AI model efficiency and data-centre energy consumption.
- OpenAI founder Sam Altman invested $20 million in Exowatt, which uses solar power to help meet the needs of OpenAI data centers.
- Salesforce announced that it is lobbying for new regulations to compel companies to report AI emissions data and efficiency standards as part of its Sustainable AI Policy Priorities initiative.

- *AI is neither inherently green nor naturally harmful.*
- *The environmental footprint is real, expanding, and highly multidimensional.*
- *True value depends entirely on how systems are designed, powered, located, and used.*
- *Sustainability must be treated as a systemic governance challenge—not merely a tech-efficiency puzzle.*

Questions?