The Sustainability of AI

Environmental Impact, Challenges, and Solutions

Technology   Sustainability   Balance

The Environmental Toll of Artificial Intelligence

- Rapid advancement of AI raises **significant environmental concerns**
- **Substantial energy and water consumption** across AI systems
- Full extent of impact remains **uncertain** due to lack of transparency
- Available data points to a **growing problem with far-reaching consequences**

> *"The challenge we face is balancing AI's transformative potential with its environmental footprint."*

Log Scale

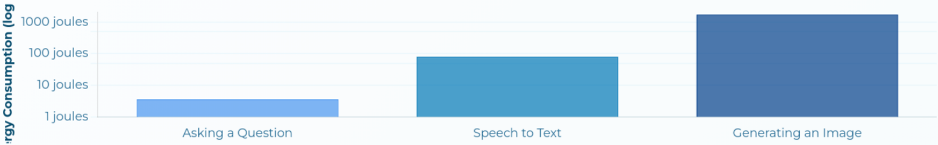
Energy Consumed by Various AI Tasks

3.6
joules
Asking a question

79
joules
Speech to text

1,700
joules

Daily Energy Footprint of ChatGPT Queries



ChatGPT alone handles over ***1 billion queries daily****, translating into a massive energy footprint*

Wait a second...

Wait a second...

YOU use ChatGPT every day?!

Wait a second...

YOU use ChatGPT every day?!

Hypocrisy much?

Enough to power your laptop for 30 seconds while you try to think of a better prompt than 'An Anime Girl doing Programming '.

Don't Worry I got you bro!

Figure: BTW do note that I know your history!

Energy Consumption

- **Large language models** like ChatGPT require vast amounts of electricity
- Energy consumption of **data centers** has been steadily increasing
- Both **training and operation** phases consume significant power

Data centers in Ireland consume

17%

of the country's total electricity

I want to ask:

I want to ask:

What is the total environmental impact of these AI tools?

I want to ask:

What is the total environmental impact of these AI tools?

What damage are they doing in various ways,

I want to ask:

What is the total environmental impact of these AI tools?

What damage are they doing in various ways, but also, what benefits do they bring to our fight against climate change?

And most importantly,

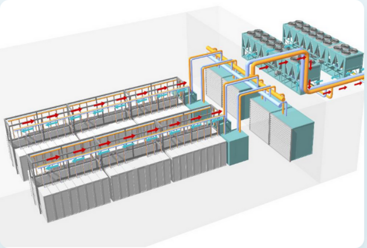
what does all this have to do with you, how you use artificial intelligence, and how you feel about it?

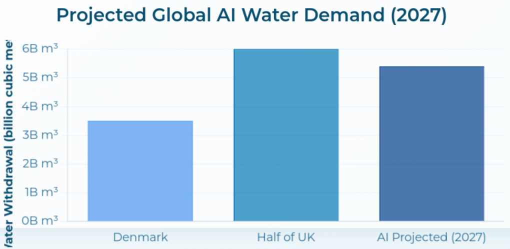
Dramatic much? Let's start the main show.

Water Consumption!!

Water Consumption

- AI's **thirst for water** is another major environmental concern
- Data centers use **vast quantities of fresh water** for cooling servers
- Training GPT-3 evaporated **700,000 liters** of clean freshwater





4.2-6.6B

cubic meters of water withdrawal projected for AI in 2027

Exceeds **Denmark's total annual water withdrawal** or **half of the UK's**

Semiconductor Industry Water Use:

Semiconductor Industry Water Use: 1.2 **billion m^3 / year**

AI and Water Usage

Semiconductor Industry Water Use: 1.2 **billion m^3 / year**

Apple: 99% of water in supply chain for chips

Semiconductor Industry Water Use: 1.2 **billion m^3 / year**

Apple: 99% of water in supply chain for chips

To put it in perspective:

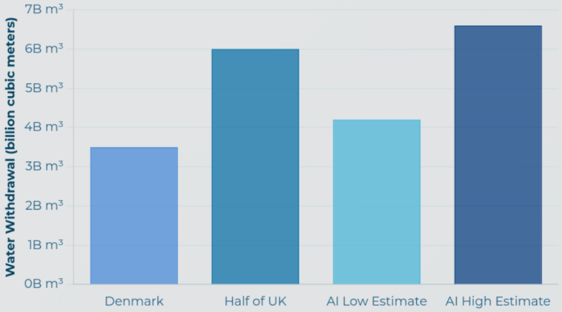
Semiconductor Industry Water Use: 1.2 **billion m^3 / year**

Apple: 99% of water in supply chain for chips

To put it in perspective:

Less than 0.1% of global agricultural water use!

Projected Water Demand



Global AI Water Demand

Projected to require **4.2 to 6.6 billion cubic meters** of water withdrawal in 2027

- More than **Denmark's total annual** water withdrawal
- Equal to **half of the United Kingdom's** annual water withdrawal

⚠ Freshwater scarcity is becoming an increasingly pressing global issue

Before we move on, we need to talk about the making of AI or LLMS

The Lifecycle of an AI Tool: A Drain on Resources

1 Hardware

Manufacturing requires **significant resources** and causes pollution

2 Training

Energy-intensive process consuming vast amounts of electricity and water

3 Usage

Ongoing use by billions contributes to **continuously growing** energy demand

4 End of Life

Disposal contributes to growing **e-waste problem**

AI tools cause environmental impacts at **every stage** of their lifecycle, across energy use, water use, resource consumption, and pollution

You bought a new tablet last year. Don't act superior!

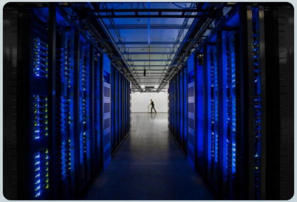
Lifecycle Stage 1: Hardware

Manufacturing Impact

- Silicon chips require **significant resources** for production
- Extraction of **rare minerals** like gallium and germanium
- Production process generates **pollution and waste**

Water Usage

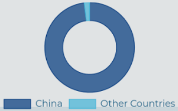
- Semiconductor industry uses **ultrapure water** for chip manufacturing
- **99%** of Apple's water usage is in its supply chain



1.2B

cubic meters of water used by semiconductor industry annually

Mineral Production Distribution



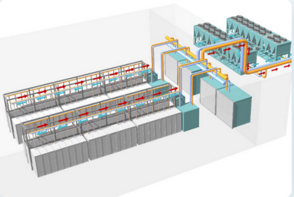
Lifecycle Stage 2: Training

Energy-Intensive Process

- Training requires **massive computational power** in data centers
- **Vast amounts of electricity** consumed during model training
- Processing **enormous datasets** requires extensive computing resources

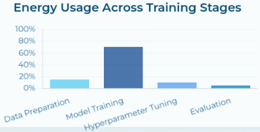
Water Consumption

- Data centers use water for **cooling hardware** during training
- Water usage **scales with model size** and training duration



700K

liters of clean freshwater evaporated to train GPT-3



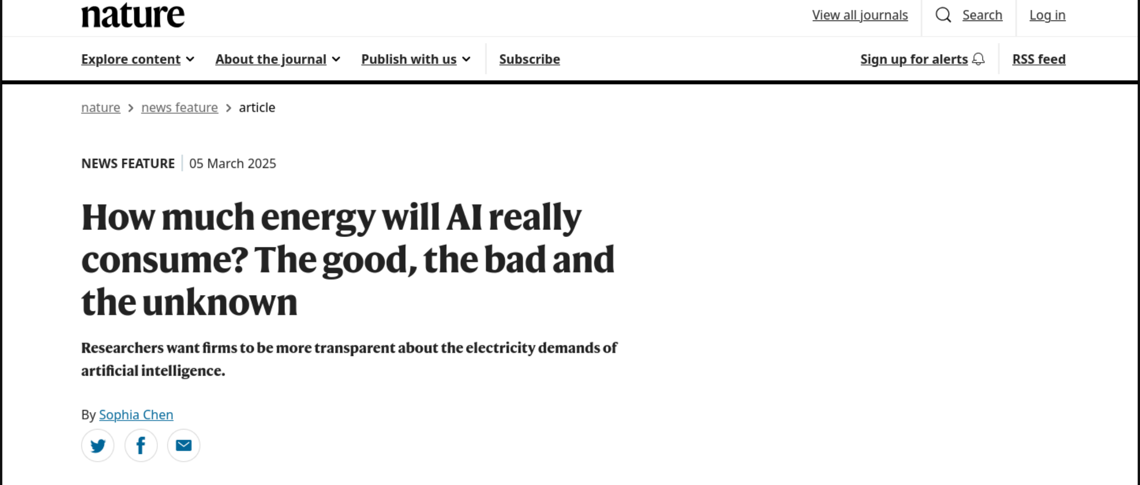
BTW, don't forget about the data.

— **we had a deal, right?

Stolen? I'm a data pirate! Arrr, matey!

Stolen? I'm a data pirate! Arrr, matey!

— But I am the victim here!!! I hate you!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How much energy will AI really consume? The good, the bad and the unknown
Researchers want firms to be more transparent about the electricity demands of artificial intelligence.
By Sophia Chen

How much energy will AI really consume? The good, the bad and the unknown

in Virginia, where they account for more than one-quarter of the state's electricity use, according to a report by EPRI, a research institute in Palo Alto, California[2]. In Ireland, data centres account for more than 20% of the country's electricity consumption — with most of them situated on the edge of Dublin. And the facilities' electricity consumption has surpassed 10% in at least 5 US states.

Complicating matters further is a lack of transparency from firms about their AI systems' electricity demands. "The real problem is that we're operating with very little detailed data and knowledge of what's happening," says Jonathan Koomey, an independent researcher who has studied the energy use of computing for more than 30 years and who runs an analytics firm in Burlingame, California.

"I think every researcher on this topic is going crazy because we're not getting the stuff we need," says Alex de Vries, a researcher at the Free University of Amsterdam and the founder of Digiconomist, a Dutch company that explores the unintended consequences of digital trends. "We're just doing our best, trying all kinds of tricks to come up with some kind of numbers."

Working out AI's energy demands

Lacking detailed figures from firms, researchers have explored AI's energy demand in two ways. In 2023, de Vries used a supply-chain (or market-based) method[3]. He examined the power draw of one of the NVIDIA servers that dominates the generative AI market and

Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models

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UC Riverside

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UT Arlington

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UC Riverside

Abstract

The growing carbon footprint of artificial intelligence (AI) has been undergoing public scrutiny. Nonetheless, the equally important water (withdrawal and consumption) footprint of AI has largely remained under the radar. For example, training the GPT-3 language model in Microsoft's state-of-the-art U.S. data centers can directly evaporate 700,000 liters of clean freshwater, but such information has been kept a secret. More critically, the global AI demand is projected to account for 4.2 – 6.6 billion cubic meters of water withdrawal in 2027, which is more than the total annual water withdrawal of 4 – 6 Denmark or half of the United Kingdom. This is concerning, as freshwater scarcity has become one of the most pressing challenges. To respond to the global water challenges, AI can, and also must, take social responsibility and lead by example by addressing its own water footprint. In this paper, we provide a principled methodology to estimate the water footprint of AI, and also discuss the unique spatial-temporal diversities of AI's runtime water efficiency. Finally, we highlight the necessity of holistically addressing water footprint along with carbon footprint to enable truly sustainable AI.

Rapid groundwater decline and some cases of recovery in aquifers globally

https://doi.org/10.1038/s41586-023-06879-8

Received: 8 April 2023

Accepted: 14 November 2023

Published online: 24 January 2024

Open access

Scott Jasechko[1,11]✉, Hansjörg Seybold[2,11], Debra Perrone[3,11], Ying Fan[4], Mohammad Shamsudduha[5], Richard G. Taylor[6], Othman Fallatah[7,8] & James W. Kirchner[2,9,10]

Groundwater resources are vital to ecosystems and livelihoods. Excessive groundwater withdrawals can cause groundwater levels to decline[1–10], resulting in seawater intrusion[11], land subsidence[12,13], streamflow depletion[14–16] and wells running dry[17]. However, the global pace and prevalence of local groundwater declines are poorly constrained, because in situ groundwater levels have not been synthesized at the global scale. Here we analyse in situ groundwater-level trends for 170,000 monitoring wells and 1,693 aquifer systems in countries that encompass approximately 75% of global groundwater withdrawals[18]. We show that rapid groundwater-level declines (>0.5 m year^{-1}) are widespread in the twenty-first century, especially in dry regions with extensive croplands. Critically, we also show that groundwater-level declines have accelerated over the past four decades in 30% of the world's regional aquifers. This widespread acceleration in groundwater-level deepening highlights an urgent need for more effective measures to address groundwater depletion. Our analysis also reveals specific cases in which depletion trends have reversed following policy changes, managed aquifer recharge and surface-water diversions, demonstrating the potential for depleted aquifer systems to recover.

Lifecycle Stage 3: Usage

Global Scale Impact

- **Billions of users** worldwide accessing AI tools daily
- **Continuously growing** energy demand from usage
- Energy consumed in **data centers**, not on user devices

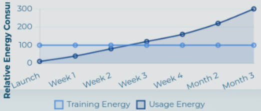
Shifting Energy Balance

- For popular models like ChatGPT, **usage energy** exceeds training energy within weeks
- Data centers in Ireland consume **17%** of country's electricity

1B+

daily queries processed by ChatGPT alone

AI Usage Energy vs. Training Energy Over Time




Every Investor to AI companies
BIJLEE KA BILL TERA
BAAP BHAREGA


When the investor sees the stocks of AI companies go up

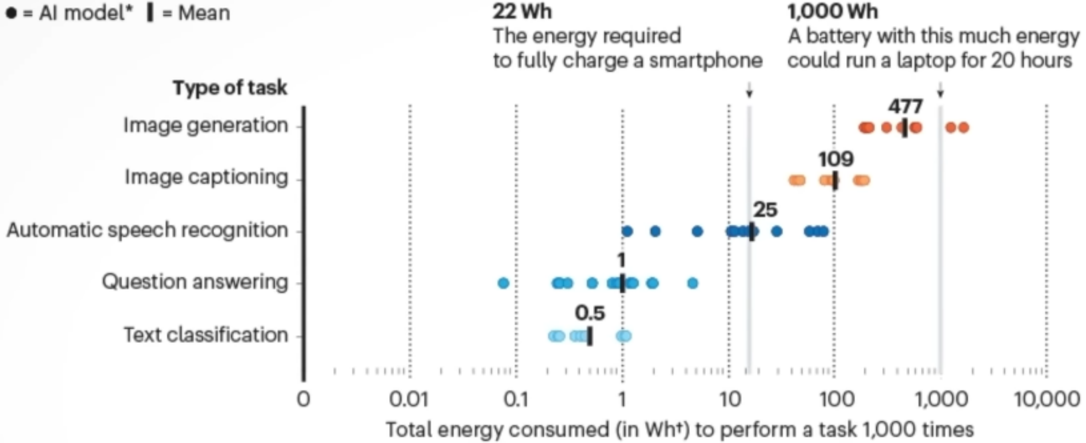
BTW this guy used NanoBaNaNa to make the images.

BTW this guy used NanoBaNaNa to make the images.

He got no editing skills!!

AI'S ENERGY FOOTPRINT

The power consumed by artificial intelligence (AI) tools varies greatly depending on the task. An AI model that provides answers to queries is much less energy-intensive than one that generates images from text prompts, for example. And the data show that even AI models of the same type can vary widely in energy consumption.

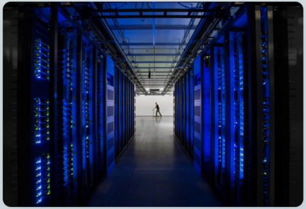


*Tests conducted on 20 popular open-source models. Each dot represents one model;
†1 Watt-hour represents power consumption of 1 W extended over 1 hour.

Lifecycle Stage 4: End of Life

E-waste Challenge

- **Obsolete AI hardware** contributes to growing e-waste problem
- **Rapid evolution** of AI technology shortens hardware lifespan
- E-waste **leaches heavy metals** into soil and groundwater



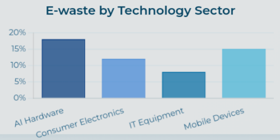
Recycling Reality

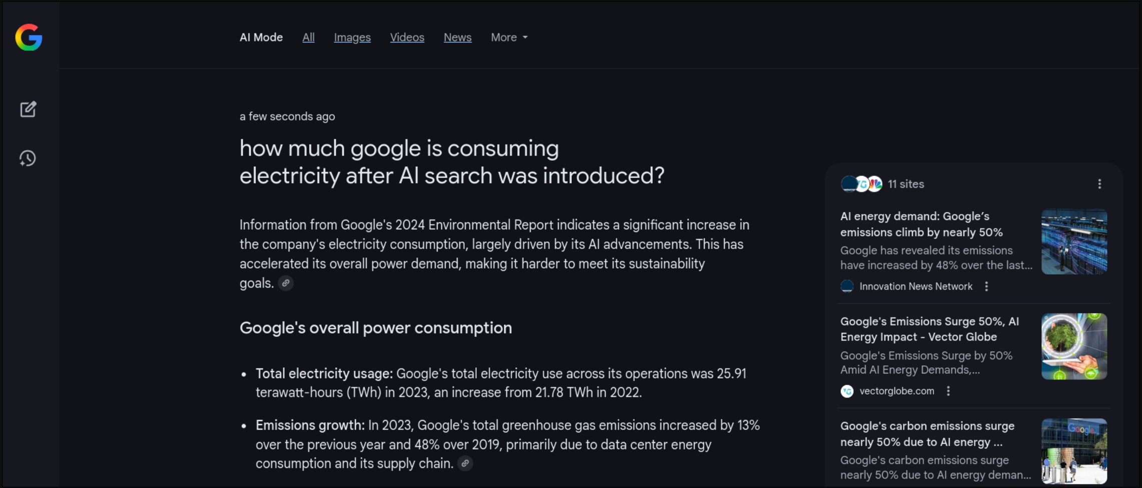
- Only **20%** of hardware actually gets recycled
- **Complex components** make specialized AI hardware difficult to recycle

> ⚠ Future environmental cost of AI hardware disposal is significant

20%

of AI hardware gets recycled





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a few seconds ago

how much google is consuming electricity after AI search was introduced?

Information from Google's 2024 Environmental Report indicates a significant increase in the company's electricity consumption, largely driven by its AI advancements. This has accelerated its overall power demand, making it harder to meet its sustainability goals.

Google's overall power consumption

- **Total electricity usage:** Google's total electricity use across its operations was 25.91 terawatt-hours (TWh) in 2023, an increase from 21.78 TWh in 2022.
- **Emissions growth:** In 2023, Google's total greenhouse gas emissions increased by 13% over the previous year and 48% over 2019, primarily due to data center energy consumption and its supply chain.

11 sites

AI energy demand: Google's emissions climb by nearly 50%
Google has revealed its emissions have increased by 48% over the last...
Innovation News Network

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FORBES DIGITAL ASSETS

Why Big Corporations Are Quietly Abandoning Their Climate Commitments?

By Jemma Green, Contributor. ⓘ Dr Jemma Green is cofounder and chairman ... Follow Author

Published Aug 29, 2024, 12:40am EDT, Updated Sep 03, 2024, 06:40am EDT

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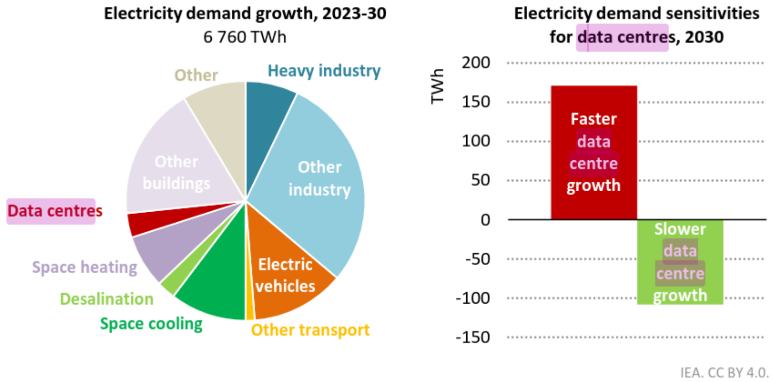
Figure 4.11 ▷ Electricity demand growth by end-use in the STEPS, 2023-2030, and data centre sensitivity cases



Data centres account for a small share of global electricity demand growth to 2030, and plausible high and low sensitivities do not change the outlook fundamentally

Note: Other includes electricity demand from agriculture. Electricity demand does not include any own use for generation, nor transmission or distribution losses.

Figure: Source: World Energy Outlook 2024


Am I really that bad?

Something Weird

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The carbon emissions of writing and illustrating are lower for AI than for humans

Bill Tomlinson[1,2]✉, Rebecca W. Black[1], Donald J. Patterson[1,3] & Andrew W. Torrance[4,5]

As AI systems proliferate, their greenhouse gas emissions are an increasingly important concern for human societies. In this article, we present a comparative analysis of the carbon emissions associated with AI systems (ChatGPT, BLOOM, DALL-E2, Midjourney) and human individuals performing equivalent writing and illustrating tasks. Our findings reveal that AI systems emit between 130 and 1500 times less CO2e per page of text generated compared to human writers, while AI illustration systems emit between 310 and 2900 times less CO2e per image than their human counterparts. Emissions analyses do not account for social impacts such as professional displacement, legality, and rebound effects. In addition, AI is not a substitute for all human tasks. Nevertheless, at present, the use of AI holds the potential to carry out several major activities at much lower emission levels than can humans.

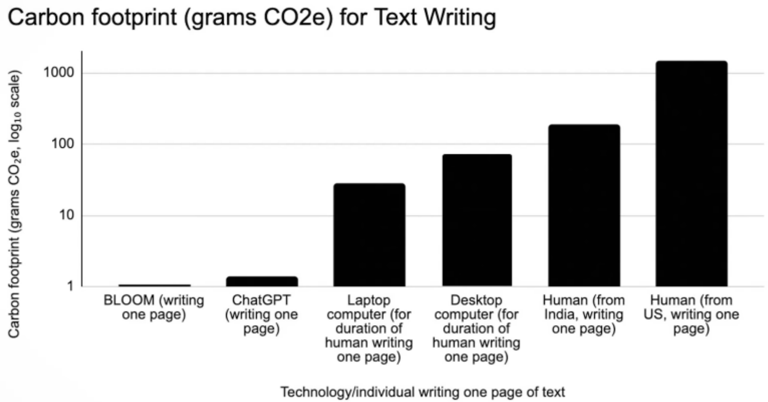


Figure 1. This figure compares the CO2e emissions of AI and humans engaged in the task of writing one page of text. AI writing (via BLOOM or ChatGPT) produces 130–1500 times less CO2e per page than a human author. AI also produces substantially less CO2e than the computer usage to support humans doing that writing.

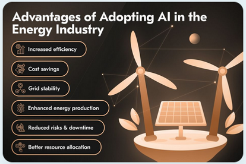
The Double-Edged Sword: AI's Role in Climate Change

Environmental Challenges

- **Energy-intensive** data centers prolong coal power plant lifespans
- **Massive water consumption** for cooling systems
- **E-waste** from rapidly obsolete hardware
- AI used to **optimize fossil fuel extraction**

Environmental Solutions

- **Smart grids** for efficient energy distribution
- **Agricultural optimization** to reduce resource use
- **Enhanced climate modeling** with faster predictions
- Google's goal: **1 billion tons** carbon emissions avoided by 2030



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IoT in UK smart grids: Powering a reliabl[e] energy-efficient future

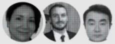
Reading time 13 mins

Key Points

- The UK has one of the world's most ambitious climate change targets: to reduce greenhouse gas emissions to net zero by 2050.
  To reach this target, there is increased pressure to decarbonise high-emitting sectors such as residential and commercial buildings (e.g., the UK gas boilers ban on all newly built buildings from 2025), which account for approximately 30% of the UK's total energy usage.
- Technologies like the Internet of Things (IoT) are crucial to meeting these targets as they significantly enhance energy efficiency, improve reliability (due to predictive and preventative maintenance capabilities), conserve energy, reduce waste, and create more flexible/adaptable energy systems.
- IoT in UK smart grids consists of meters (to measure energy consumption in real-time), sensors (to monitor the condition of grid infrastructure), communications networks, and data analytics platforms (to exchange information between devices and central control systems).
- These devices work together to provide comprehensive monitoring and management capabilities, e.g. smart meters that enable utility companies to manage demand and supply more efficiently and sensors that detect faults/anomalies in the grid, prompting automatic or manual interventions to prevent outages.
- Successful implementation of smart grids nationwide will require strategic partnerships, creative collaboration, and increased investment focused on renewable energy, innovative energy storage solutions, decentralisation of energy systems, digitisation, and regulatory support.

iea

Why AI and energy are the[...] power couple



Vida Rozite, Energy Policy Analyst
Jack Miller, Energy Efficiency Policy Analyst
Sungjin Oh, Energy Analyst
Commentary — 02 November 2023

Managing the grids of the future will re[...] powerful analytical tools, with a critical [...]

Power systems are becoming vastly more complex as [...] grows and decarbonisation efforts ramp up. In the past [...] energy from centralised power stations. Now, power sy[...] need to support multi-directional flows of electricity be[...] generators, the grid and users. The rising number of gr[...] devices, from electric vehicle (EV) charging stations to [...] installations, makes flows less predictable. Meanwhile, [...] between the power system and the transportation, buil[...] sectors. The result is a vastly greater need for informati[...]

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High tech, high yields? The Kenyan farmers deploying AI to increase productivity

AI apps are increasingly popular among small-scale farmers seeking to improve the quality and quantity of their crop

Musau Mutisya uses the PlantVillage app to diagnose a maize plant on his farm in Machakos county, Kenya. Photograph: Stephen Mukhongi/The Guardian

Carlos Mureithi *in Kericho and Machakos*
Mon 30 Sep 2024 05.00 BST

Share

S ammy Selim strode through the dense, shiny green bushes on the

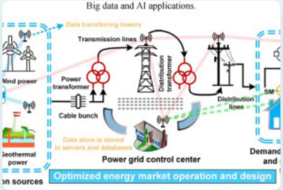
AI's Potential Benefits: Improving Energy Efficiency

Smart Grid Technology

- AI-powered **smart grids** optimize electricity distribution
- **Real-time adjustments** to balance supply and demand
- **Reduced energy waste** through predictive maintenance

Energy Optimization

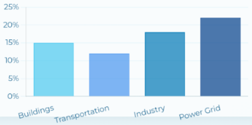
- **Building management systems** that adapt to usage patterns
- **Industrial processes** with optimized energy consumption



1B

tons of carbon emissions Google aims to avoid by 2030 using AI

Energy Savings Potential with AI



AI's Potential Benefits: Optimizing Agricultural Practices

Resource Optimization

- **Reduce fertilizer use** through precision application
- **Optimize water usage** with smart irrigation systems
- **Minimize pesticides** through targeted application

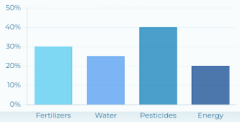
30%

potential reduction in fertilizer usage with AI-optimized farming

AI Agricultural Models

- **Virtual Agronomist** provides real-time crop advice
- **Satellite imagery analysis** for crop health monitoring

Resource Reduction Potential with AI



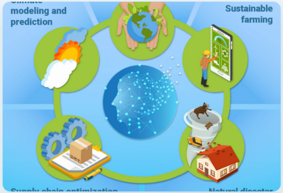
AI's Potential Benefits: Enhancing Climate Modeling

Advanced Climate Predictions

- **More accurate models** of Earth's climate systems
- **Detailed predictions** for regional climate impacts
- **Faster processing** on basic hardware compared to supercomputers

AI Weather Models

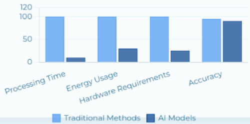
- **Minutes vs. hours** for comparable forecast accuracy
- **Lower energy consumption** than traditional methods



100×

faster climate predictions with AI compared to traditional methods

Computational Efficiency Comparison



Risks Associated with AI in Climate Context

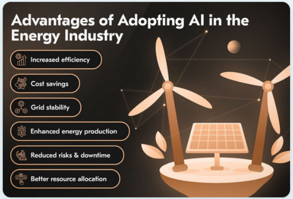
Climate Misinformation

- AI can **spread false information** about climate change
- **Deepfakes and synthetic media** can undermine climate science
- **Algorithmic bias** can skew climate-related information

Fossil Fuel Optimization

- AI used to **optimize extraction** of fossil fuels
- **Increased efficiency** in carbon-emitting industries

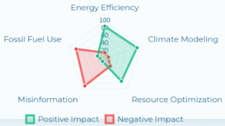
> Microsoft-ExxonMobil partnership increased oil production by 50,000 barrels/day



Double-Edged Sword

AI's capabilities can be used for both **environmental benefits** and **harm** depending on implementation

AI Impact on Climate Action



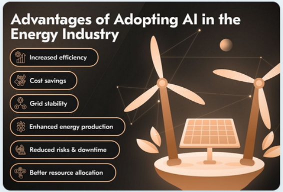
Case Study: Microsoft-ExxonMobil Partnership

AI for Fossil Fuel Extraction

- Microsoft AI tools used to **optimize extraction** processes
- **Increased efficiency** in identifying oil reserves
- **Enhanced production** through AI-driven drilling techniques

Environmental Impact

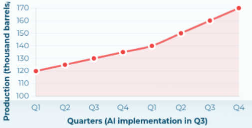
- Partnership resulted in **increased fossil fuel production**
- **Contradicts climate goals** despite technological innovation



50K

additional barrels of oil produced per day through AI optimization

Production Increase After AI Implementation



Parallels Between AI Boom and Climate Crisis

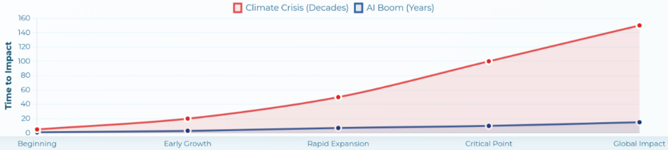
AI Boom

- **Energy-intensive** infrastructure
- **Water consumption** for cooling
- **Resource extraction** for hardware
- **E-waste** from rapid obsolescence

Climate Crisis

- **Fossil fuel** dependency
- **Global warming** and extreme weather
- **Resource depletion** and biodiversity loss
- **Waste management** challenges

Timeline Comparison: Crisis Development

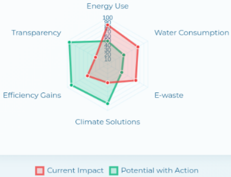


"The recent AI boom has an awful lot in common with the climate crisis, just in super-fast motion"

Key Takeaways

- AI has **significant environmental impacts** across its entire lifecycle
- **Energy and water consumption** are growing concerns as AI usage expands
- **Hardware production and e-waste** add to AI's environmental footprint
- AI presents both **challenges and opportunities** for climate change
- Addressing AI's sustainability requires **transparency, innovation, and collective action**
- **Individual choices matter**, but **systemic change** is essential
- We must **balance AI's benefits** with its environmental costs

AI Environmental Impact vs. Potential Benefits



Collective action is key to creating sustainable AI systems

A Small Question

Question time!!

But is that really the case? Are you using the time freed up by these tools to do nothing, or are you now doing more and using more energy because of these tools?

Why are we being forced into the moral choice of participating in a system that we know has profound negative impacts in terms of energy use, water use, intellectual property theft, and spreading misinformation, or not?

Q&A

Q&A – Let's Chat (Without Draining the Grid!)