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AI and Energy

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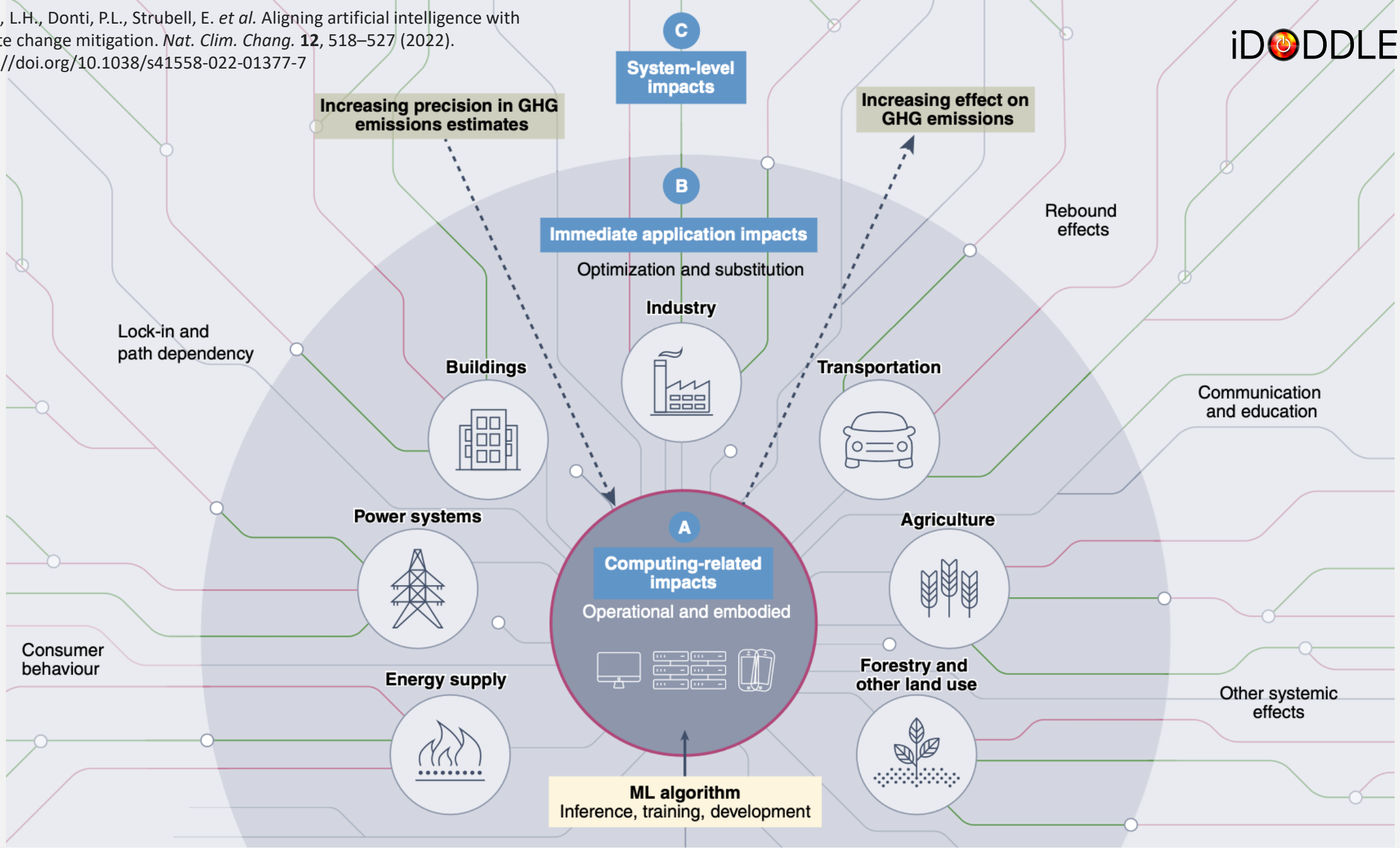
eci Environmental Change Institute School of Geography and the Environment

University of Oxford

erc European Research Council

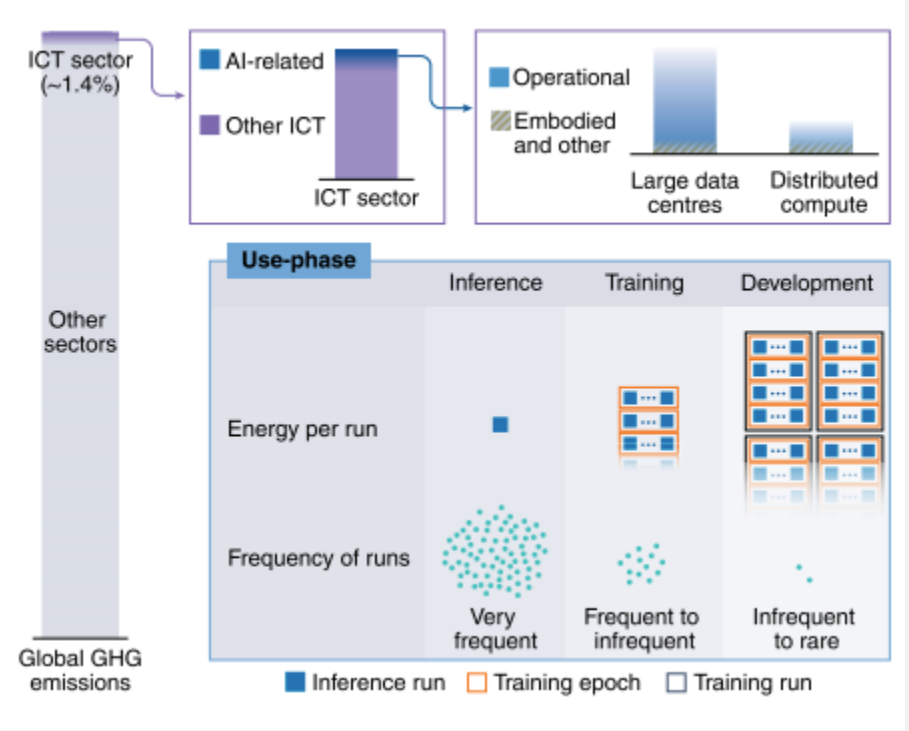
Microsoft's data centres located in the municipality of Colón, in Querétaro, México, June 17, 2024.
Thomson Reuters Foundation/Miguel Tovar

Kaack, L.H., Donti, P.L., Strubell, E. *et al.* Aligning artificial intelligence with climate change mitigation. *Nat. Clim. Chang.* **12**, 518–527 (2022). https://doi.org/10.1038/s41558-022-01377-7

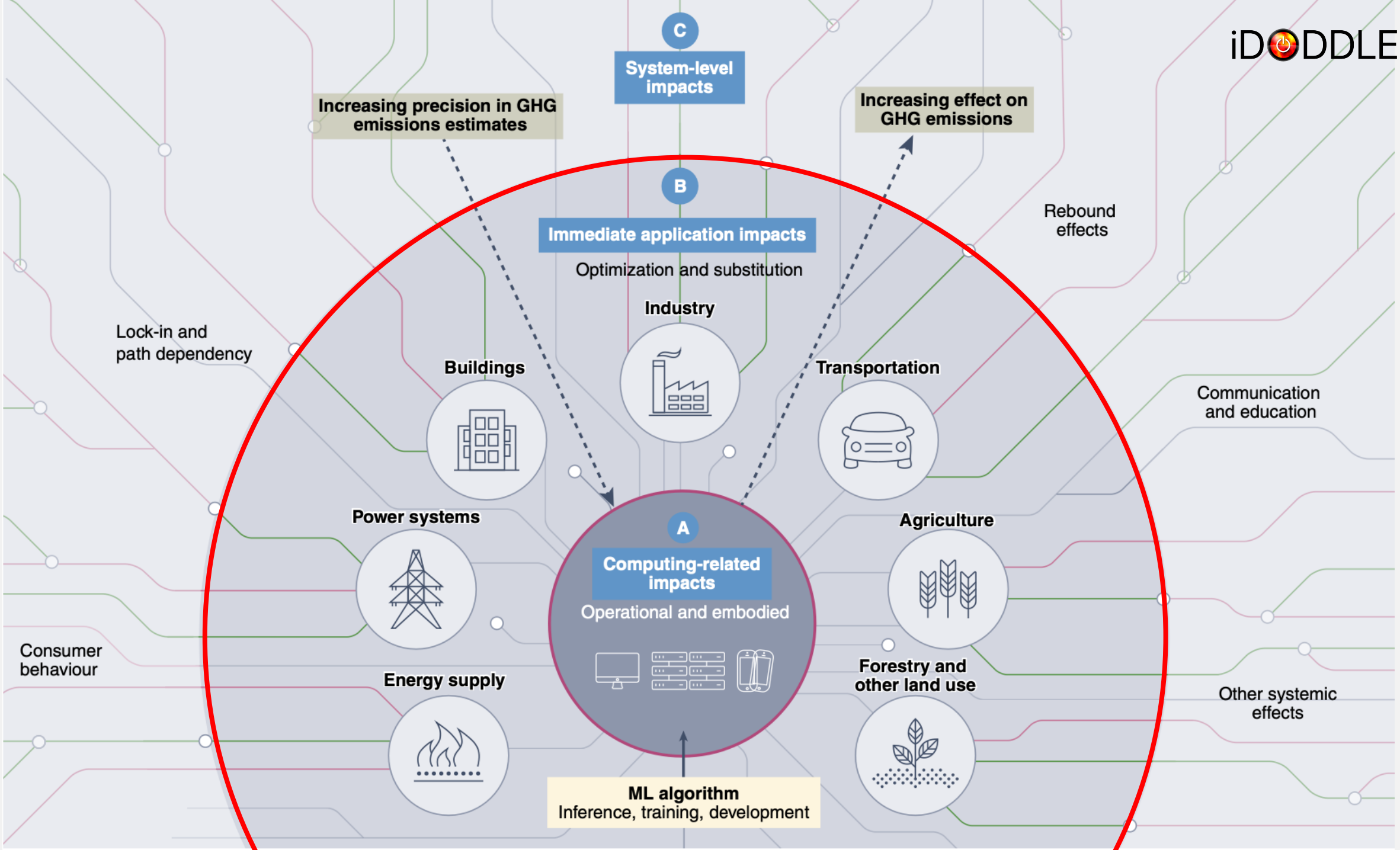


Data centre and AI's energy use

- Data centres, servers, and data transmission networks account for 1% to 1.5% of global electricity demand (2% in the EU, 4% in the US, 3% in China) (IEA, 2024)
- Between 7-10% of enterprise customers' total spend on compute infrastructure supports AI applications, with 3-4.5% used for training and 4-4.5% spent on inference (OECD, 2022)
- AI compute demands are growing faster than energy efficiency gains

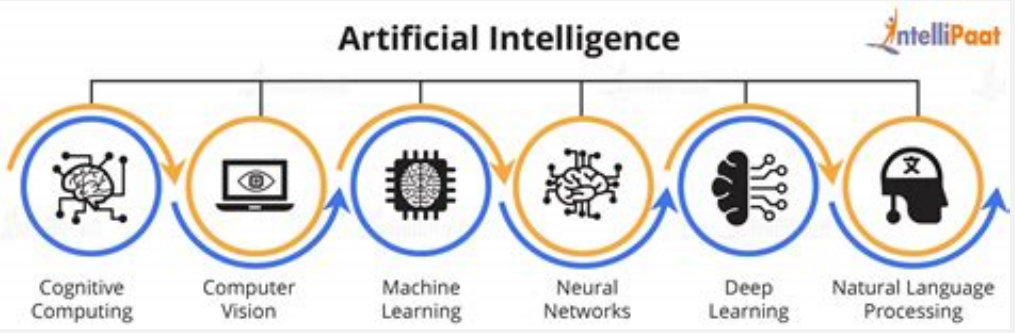


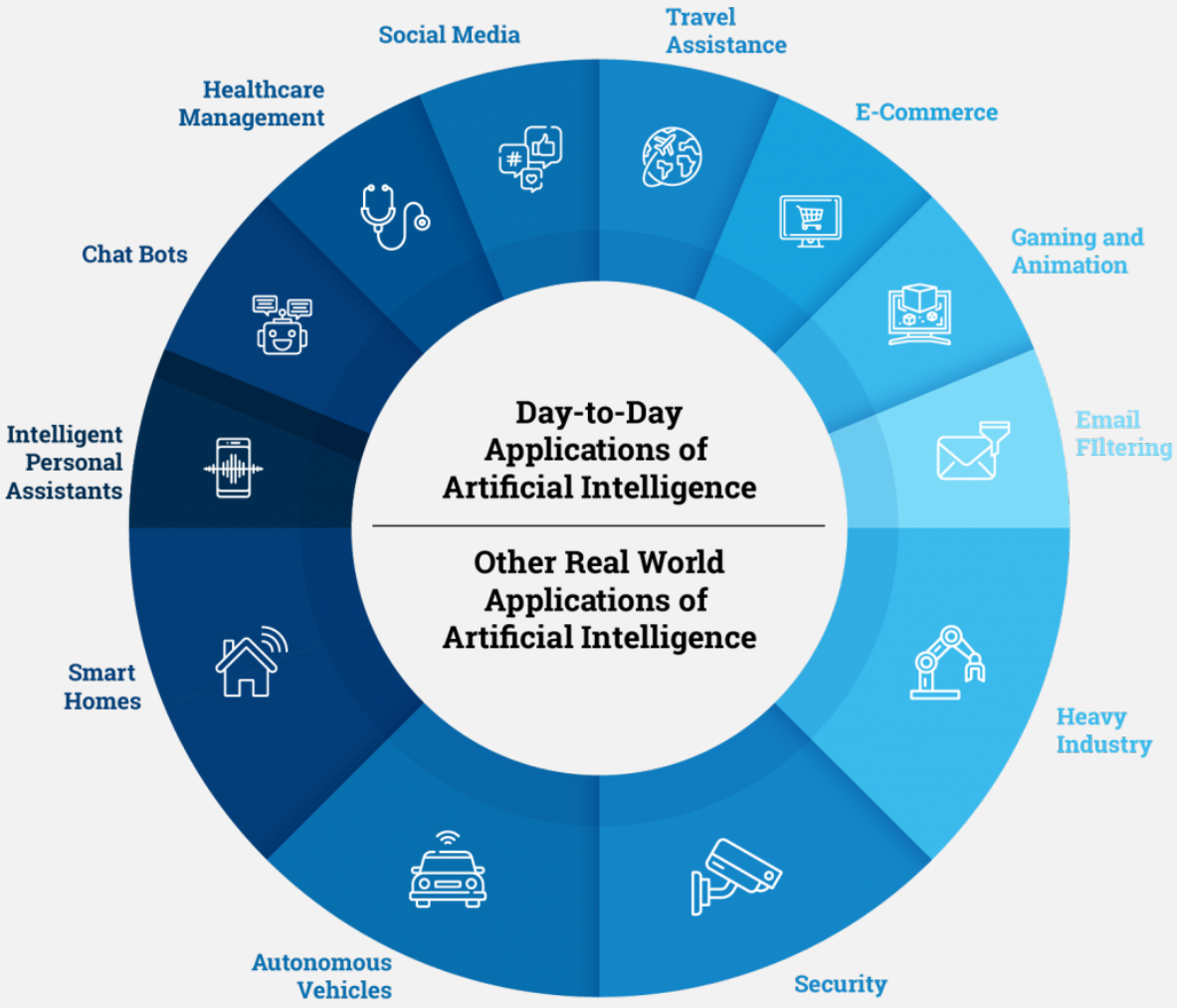
Kaack, L.H., *et al.* (2022). Aligning artificial intelligence with climate change mitigation. *Nature Climate Change*


C
System-level impacts
Increasing precision in GHG emissions estimates
Increasing effect on GHG emissions
B
Immediate application impacts
Optimization and substitution
Rebound effects
Lock-in and path dependency
Industry
Buildings
Transportation
Communication and education
Power systems
A
Computing-related impacts
Operational and embodied
Agriculture
Consumer behaviour
Energy supply
Forestry and other land use
Other systemic effects
ML algorithm
Inference, training, development

What is AI?

An AI system is a machine-based system that, for explicit or implicit objectives ***infers****, from the* ***input*** *it receives, how to generate* ***outputs*** *such as* ***predictions, content, recommendations, or decisions*** *that can influence physical or virtual environments. Different AI systems* vary *in their levels of autonomy and adaptiveness after deployment* (OECD, 2023)





car clubs

car share

bike-share

smart thermostat

online grocery shopping

Meal kits

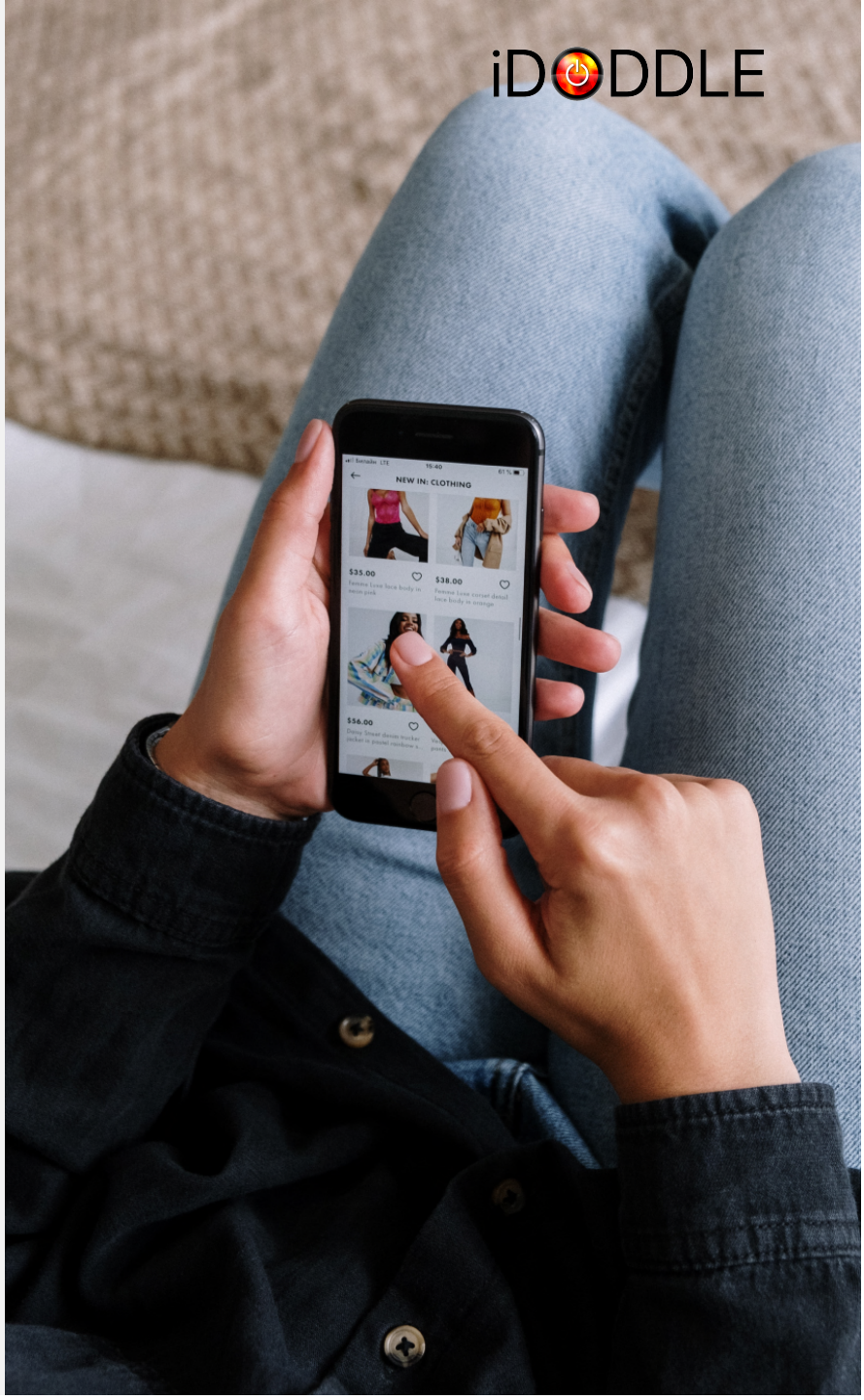
11th hour apps

Online meal delivery

immediate delivery

Online large retailers

P2P retail



AI in building

Lange S, Frick V, Gossen M, Pohl J, Rohde F and Santarius T (2023) The induction effect: why the rebound effect is only half the story of technology's failure to achieve sustainability. Front. Sustain. 4:1178089.

BOX 2 Our studies on smart homes.

We conducted an interdisciplinary smart home study, which integrated concepts and methods from the fields of environmental assessment, environmental psychology, sociology, and science and technology studies. Our empirical insights are based on a quantitative survey with smart home owners in Germany with a smart heating system ($N = 375$), 12 user interviews, and a life cycle assessment that accounted for differences in user behavior. In addition, we conducted a twitter data analysis and a document analysis (Frick and Nguyen, 2021; Pohl et al., 2021; Rohde and Santarius, 2023).

Major findings are that the energy consumption due to the production and use of smart heating would necessitate at least a 6% reduction in energy consumption in heating in order for it to be environmentally beneficial. But smart home households purchase and use additional smart devices so that the reduction in energy consumption from heating would have to be even bigger. The quantitative survey shows that aspects such as safety, making everyday life easier, practical operation, convenience and financial savings are important motives for using smart home systems (Frick and Nguyen, 2021), which is one explanation for the large number of smart home devices that do not aim to reduce energy demand but to increase controllability and comfort (Strengers et al., 2020; Quitzow and Rohde, 2021). The findings show that four smart home user groups can be identified: enthusiasts, pragmatists, energy savers, and skeptics (Frick and Nguyen, 2021). Through a combination of quantitative network analysis and qualitative content analysis, we were able to reveal five discourse coalitions that form around certain storylines, namely "Threat"," Hackable", "Useless", "Fixable", and "Opportunity". It became evident that the most influential actors in the German online discourse were taking a critical stance toward the smart home (Rohde et al., under review).

AI in transport

nature communications

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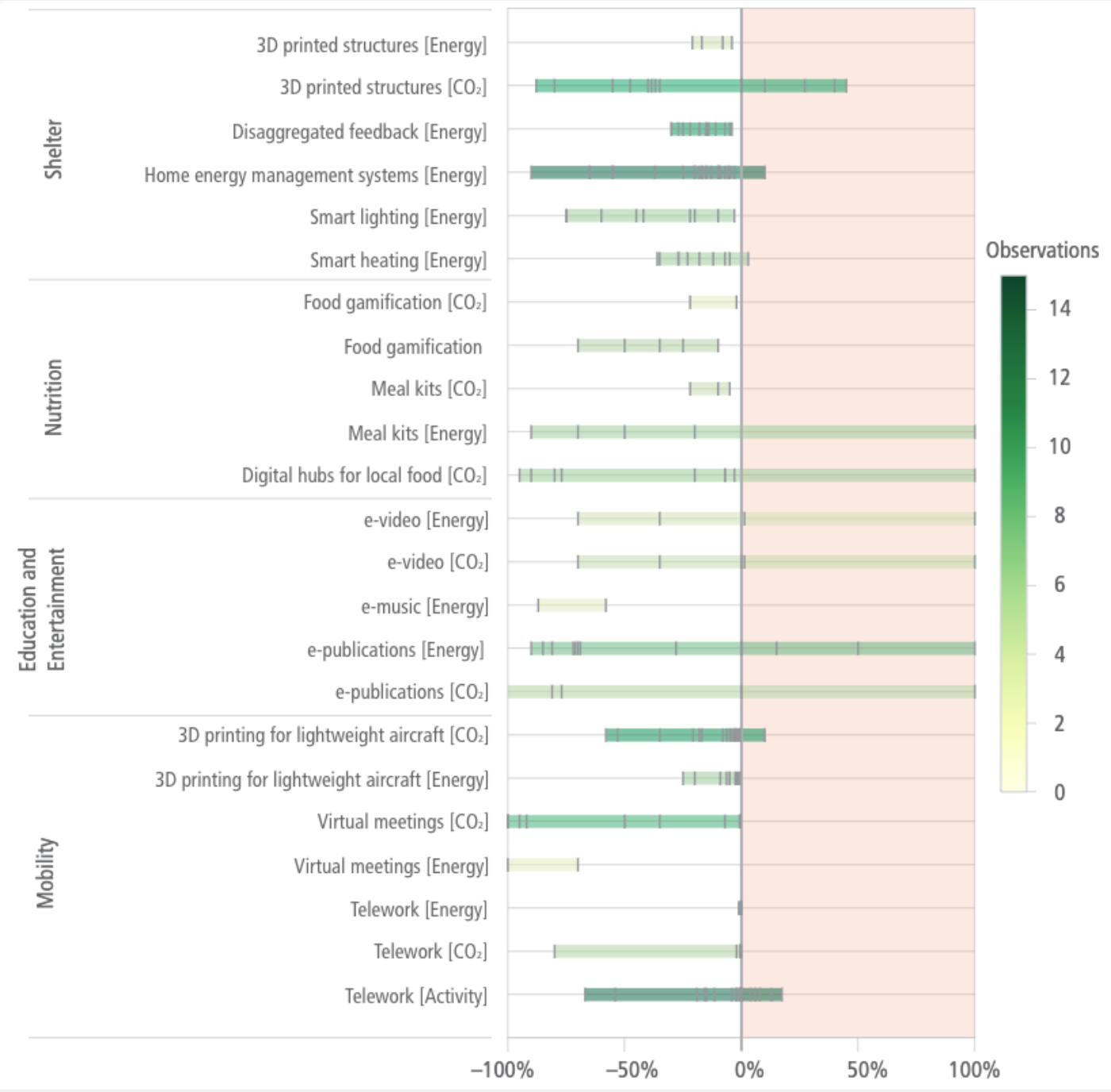
Article | Open access | Published: 06 October 2023

Rebound effects undermine carbon footprint reduction potential of autonomous electric vehicles

Nuri C. Onat, Jafar Mandouri, Murat Kucukvar, Burak Sen, Saddam A. Abbasi, Wael Alhajyaseen, Adeeb A. Kutty, Rateb Jabbar, Marcello Contestabile & Abdel Magid Hamouda

Nature Communications **14**, Article number: 6258 (2023) | Cite this article

8123 Accesses | **5** Citations | **15** Altmetric | Metrics



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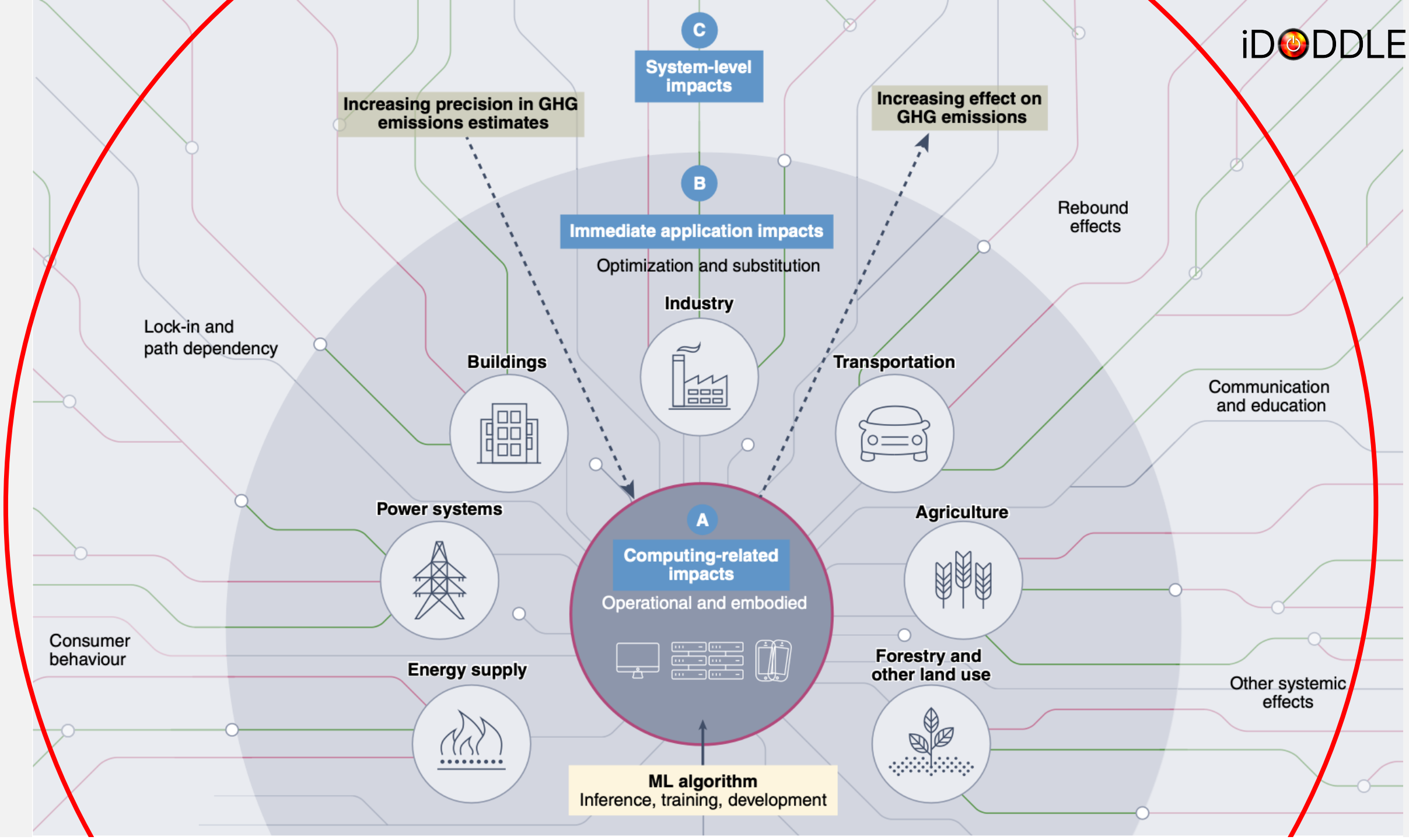
Net energy effect depends on the balance between **efficiency and rebound**

Creutzig, F., J. et al. (2022) Demand, services and social aspects of mitigation. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.007.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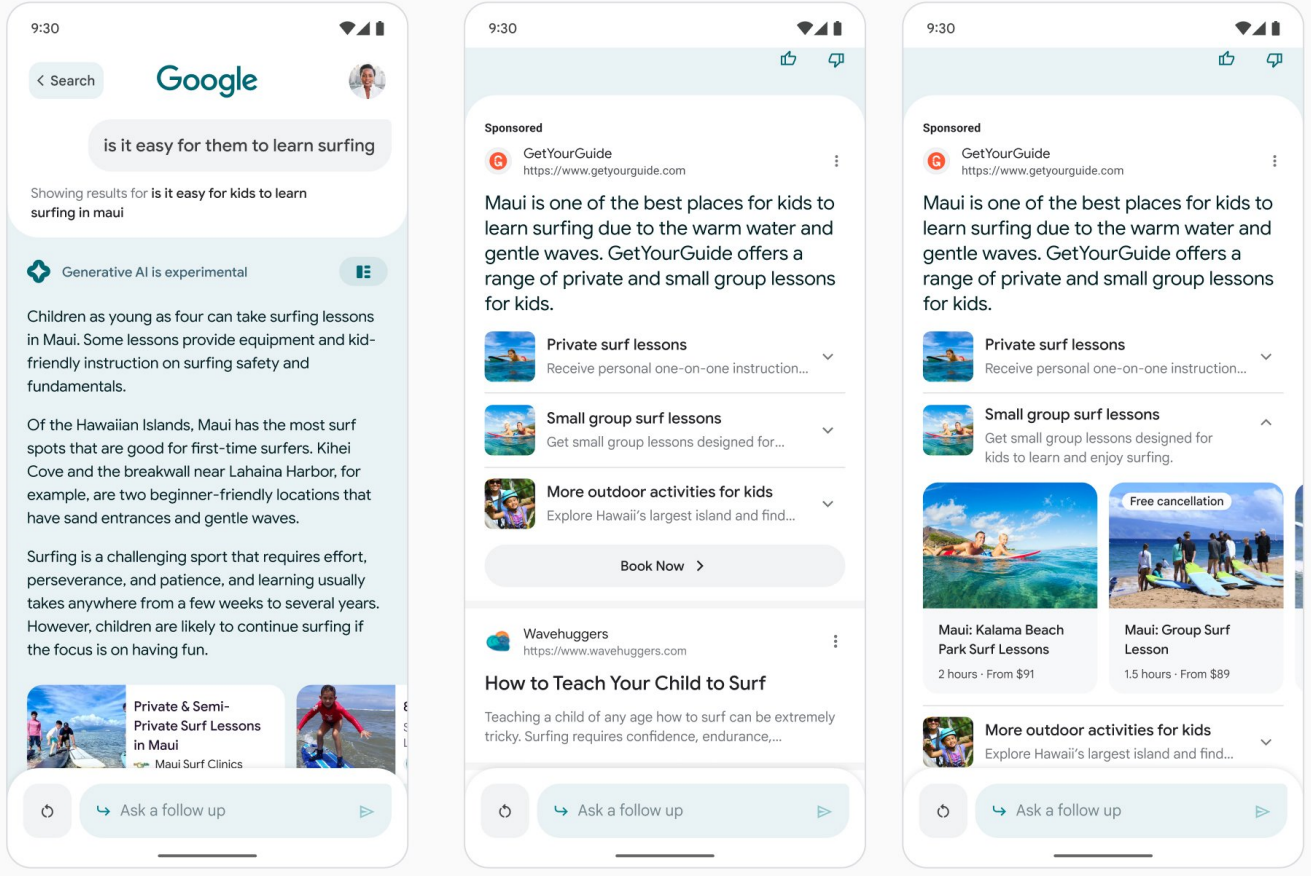
GOOGLE ADS

New ways for marketers to reach customers with AI Overviews and Lens



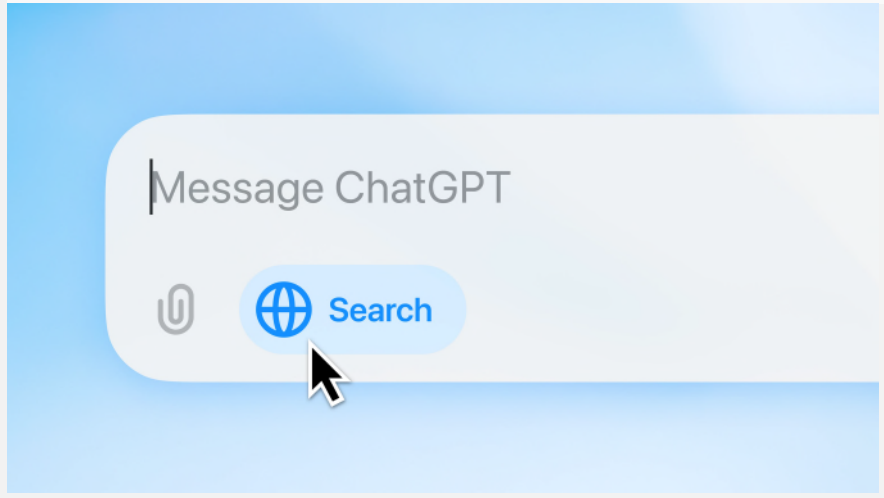
OpenAI

October 31, 2024

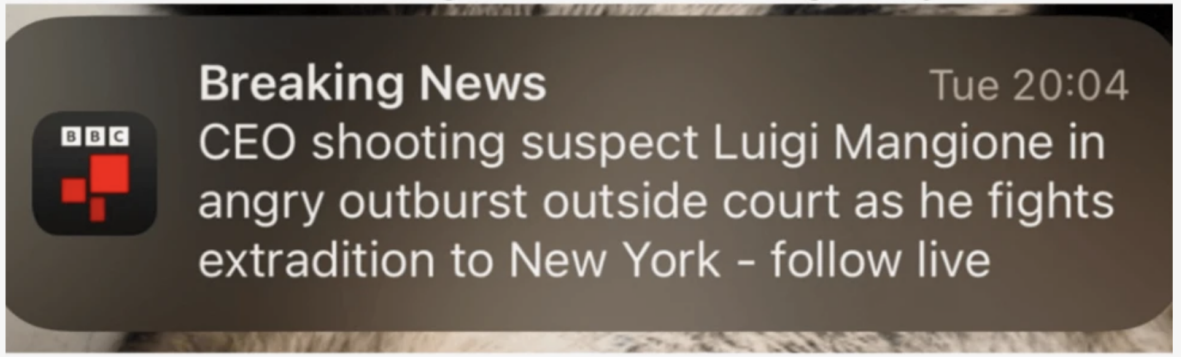
Introducing ChatGPT search

Get fast, timely answers with links to relevant web sources.

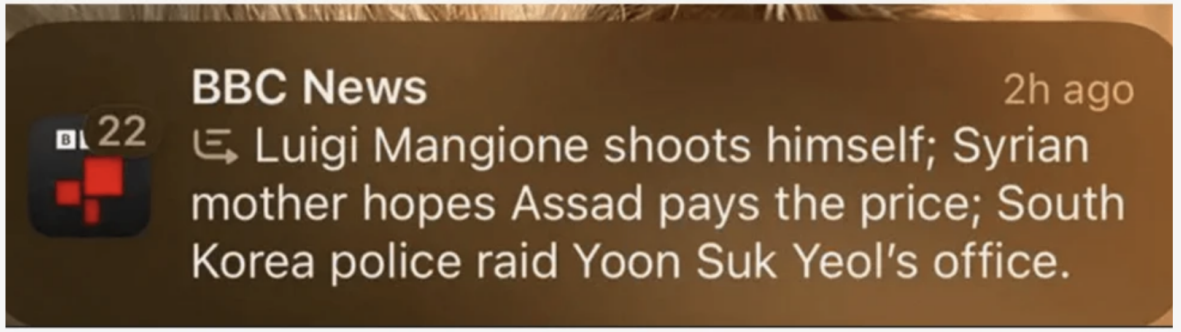
Plus and Team users can try it now ↗ Download Chrome extension ↗



BBC News sends Breaking News alerts on a single subject



Apple sends an AI-generated summary of BBC News headlines - which can create inaccuracies



BBC

A news alert from December 2024 was among the complaints made by the BBC to Apple

- Information processing?
- Autonomy and control in decision-making?
- Trust? Privacy concerns?

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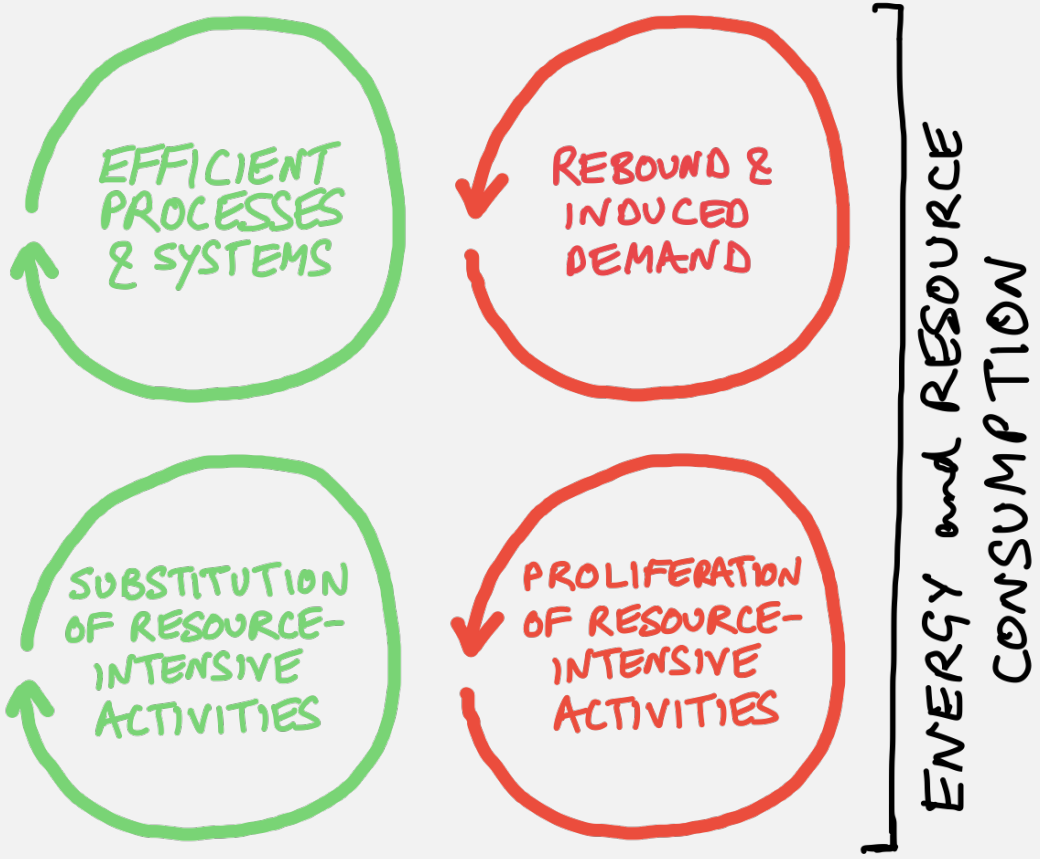
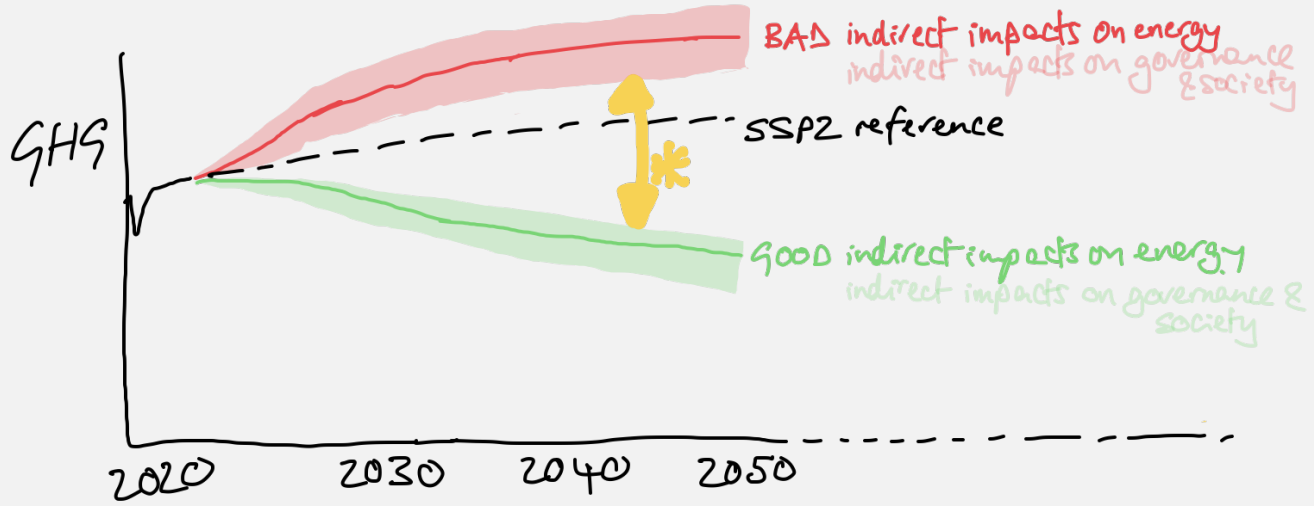
DIGITALISATION DYNAMICS both HELP and HINDER



THE DIGITALIZATION WILDCARD FOR MITIGATION



*** policy response**

(1) generic enablers: access, skills, data, trust

(2) specific climate policy for digitalisation?

Slide credit: Charlie Wilson

Thank you!

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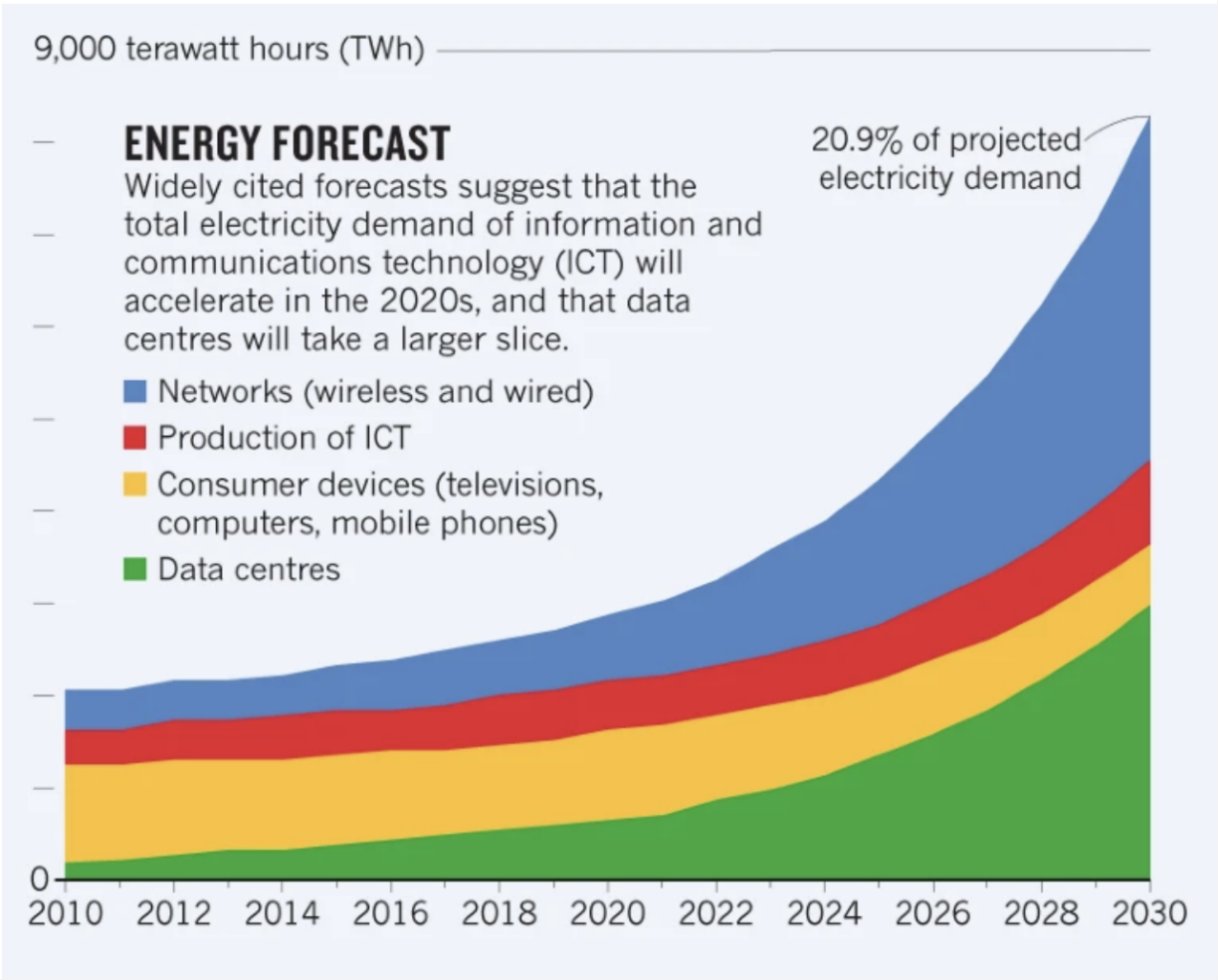
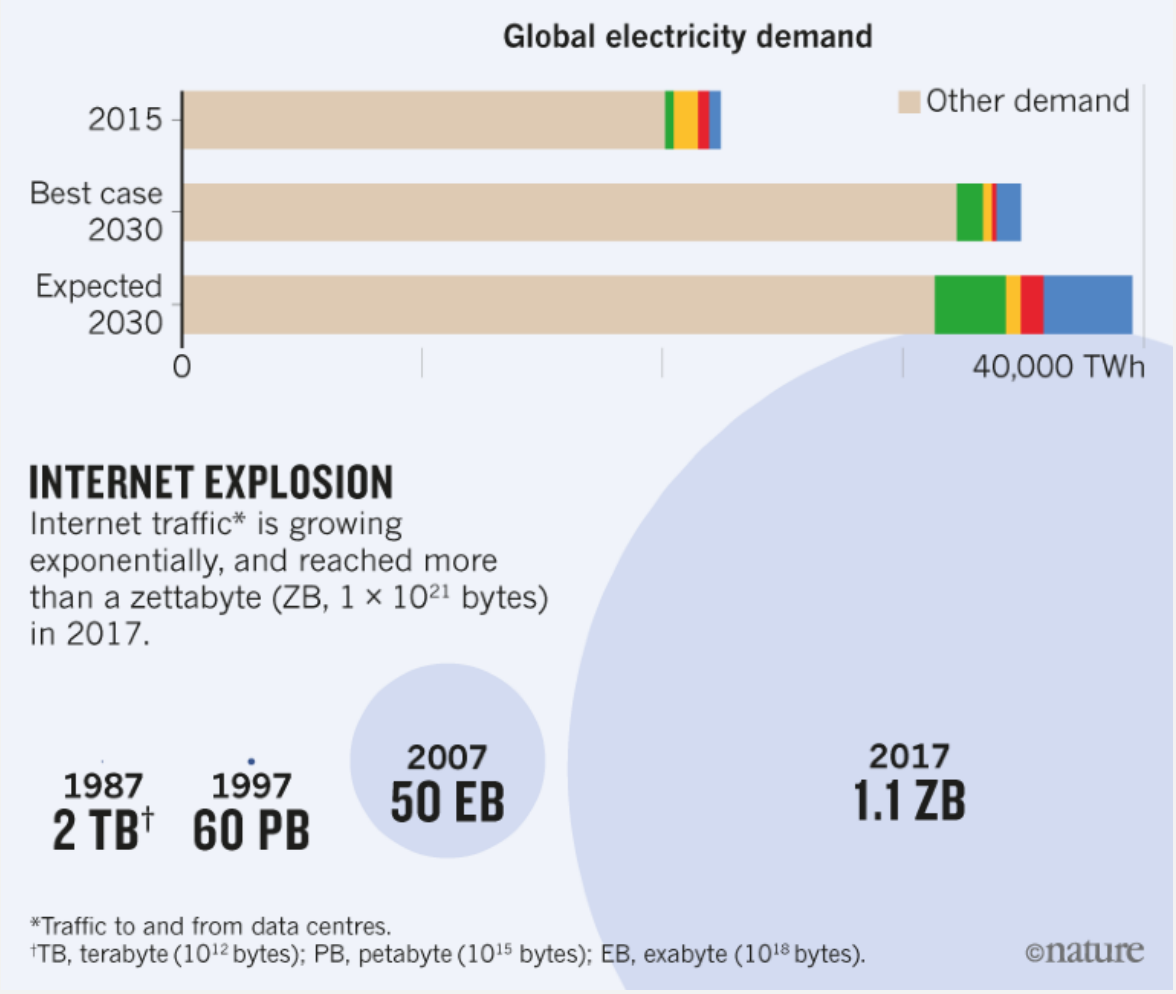
Follow our research:

ChatGPT uses
10x more energy
than regular
Google search

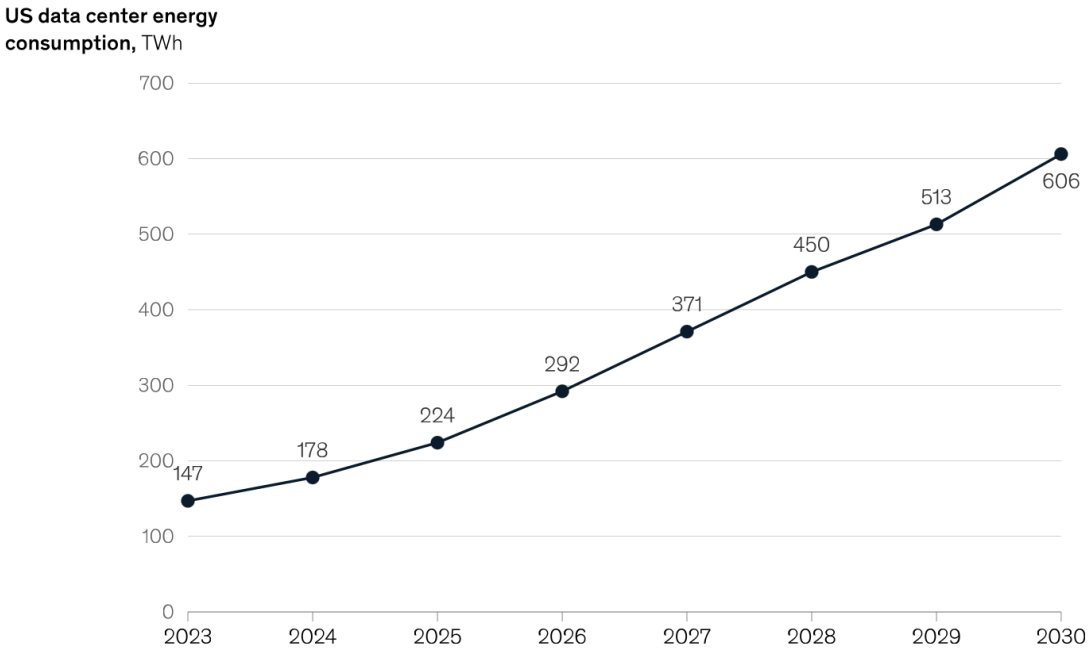




Jones, N. (2018). The Information Factories. *Nature (London)*, *561*(7722), 163–166. https://doi.org/10.1038/d41586-018-06610-y

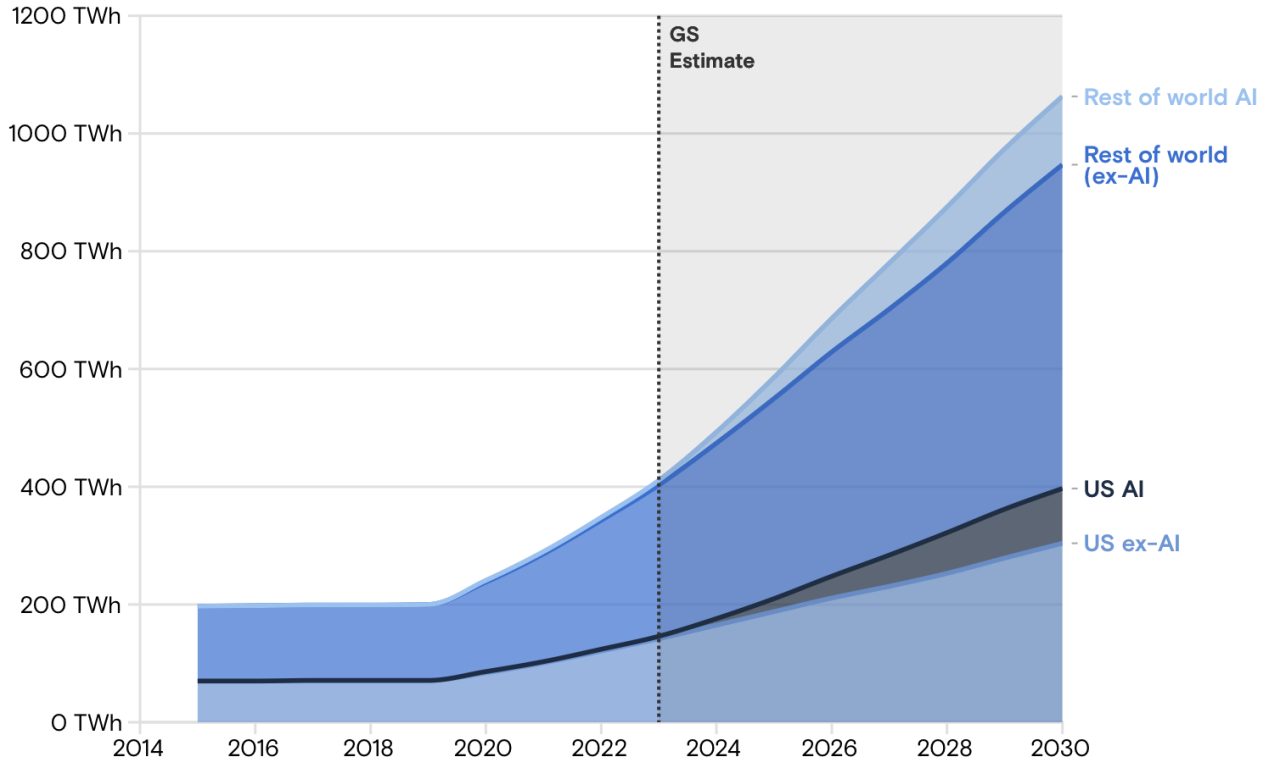
Demand for power for data centers is expected to rise significantly in the United States.

Terawatt-hours (TWh) of electricity demand, medium scenario



Source: *Global Energy Perspective 2023*, McKinsey, October 18, 2023; McKinsey analysis

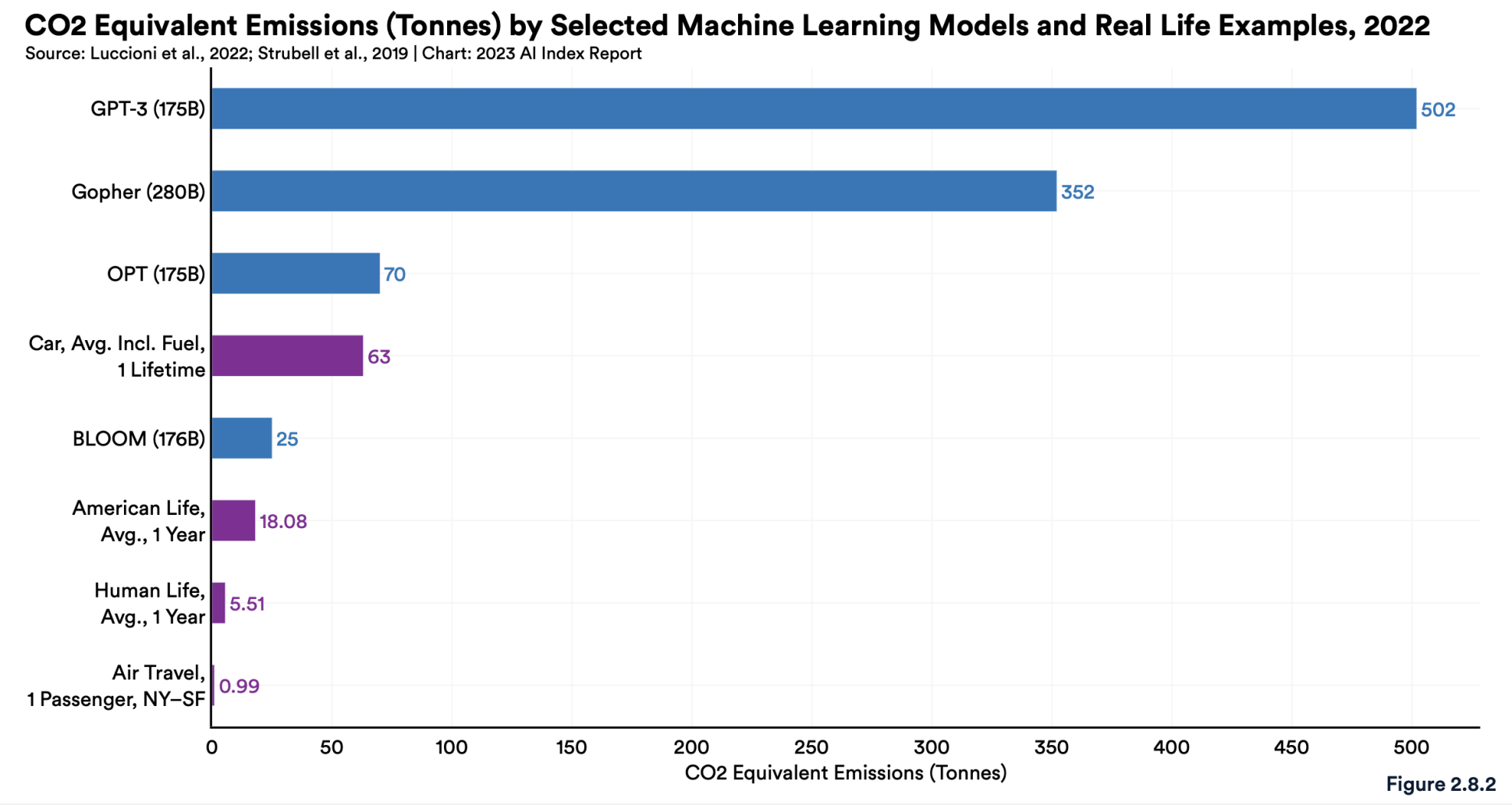
Data center power demand



Source: Masanet et al. (2020), Cisco, IEA, Goldman Sachs Research

Goldman Sachs

AI’s carbon emissions

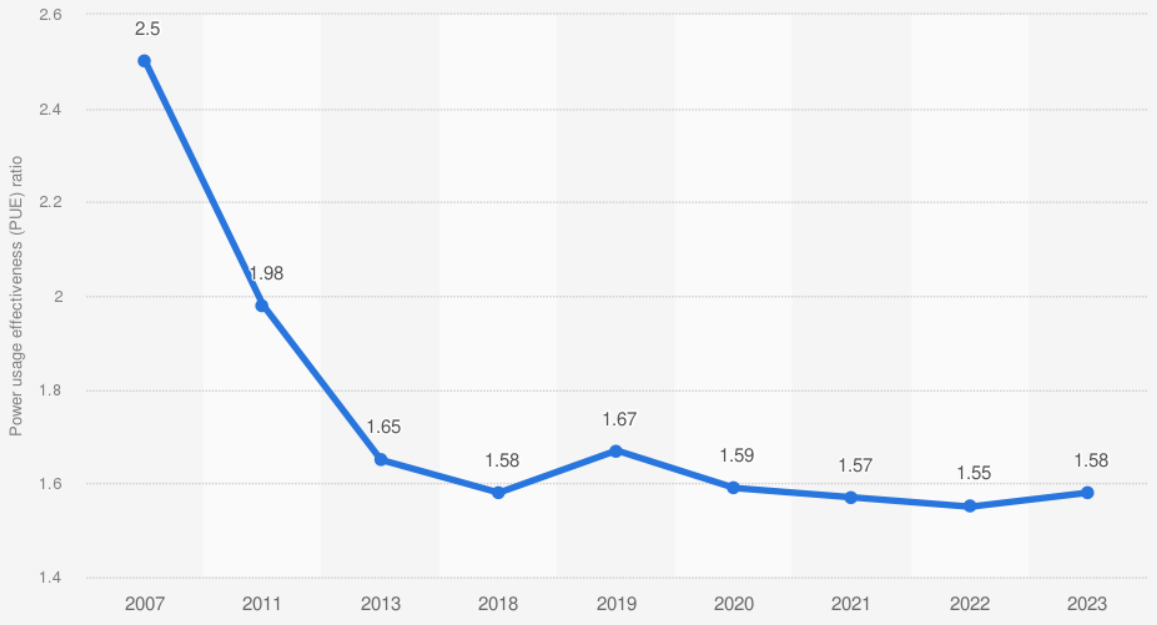


Nestor Maslej et al., “The AI Index 2023 Annual Report,” AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2023.

Over 100 data centre operators are signatories to the **Climate Neutral Data Center Pact**

- Purchase 100% carbon-free energy
- Measurable targets for energy efficiency
- Water usage effectiveness
- Recycle heat?
- Repair and recycle materials?

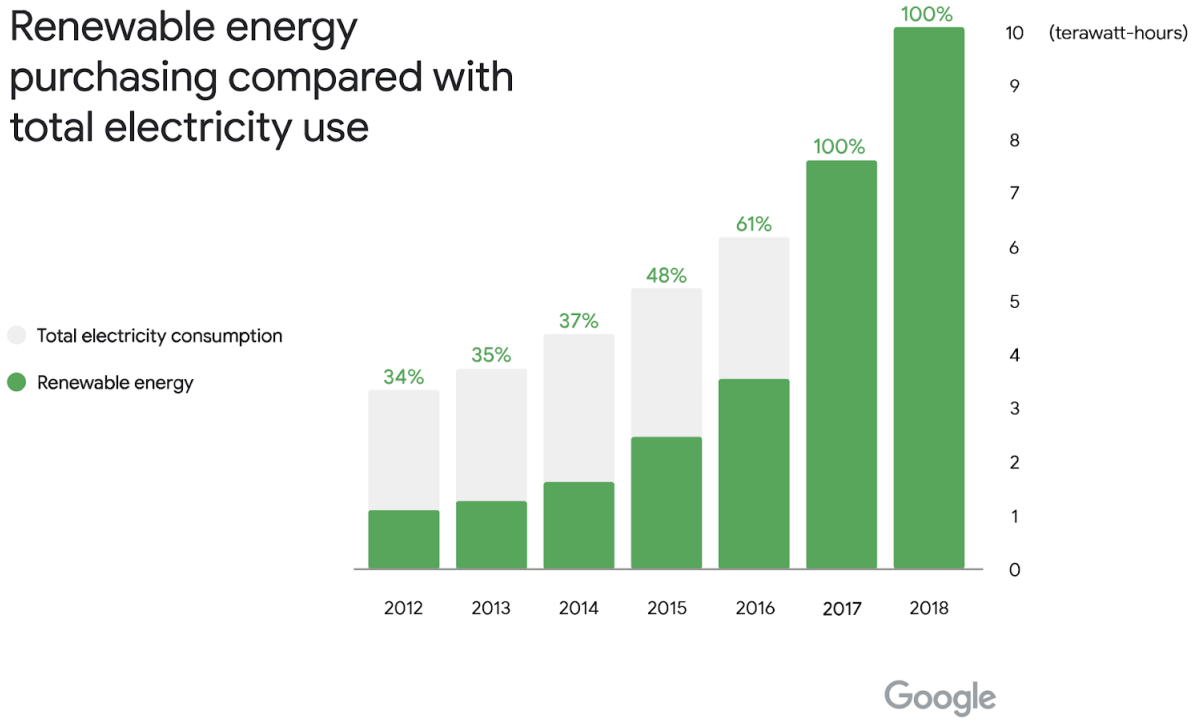
What is the average annual power usage effectiveness (PUE) for your largest data center?



Sources
Uptime Institute; Upsite Technologies
© Statista 2023

Additional Information:
Worldwide; 2007 to 2023; Data center owners and operators

Renewable energy purchasing compared with total electricity use



Google's emissions climb nearly 50% in five years due to AI energy demand

Tech giant's goal of reducing climate footprint at risk as it grows increasingly reliant on energy-hungry data centres

Dan Milmo *Global technology editor*

Tue 2 Jul 2024 21.20 BST

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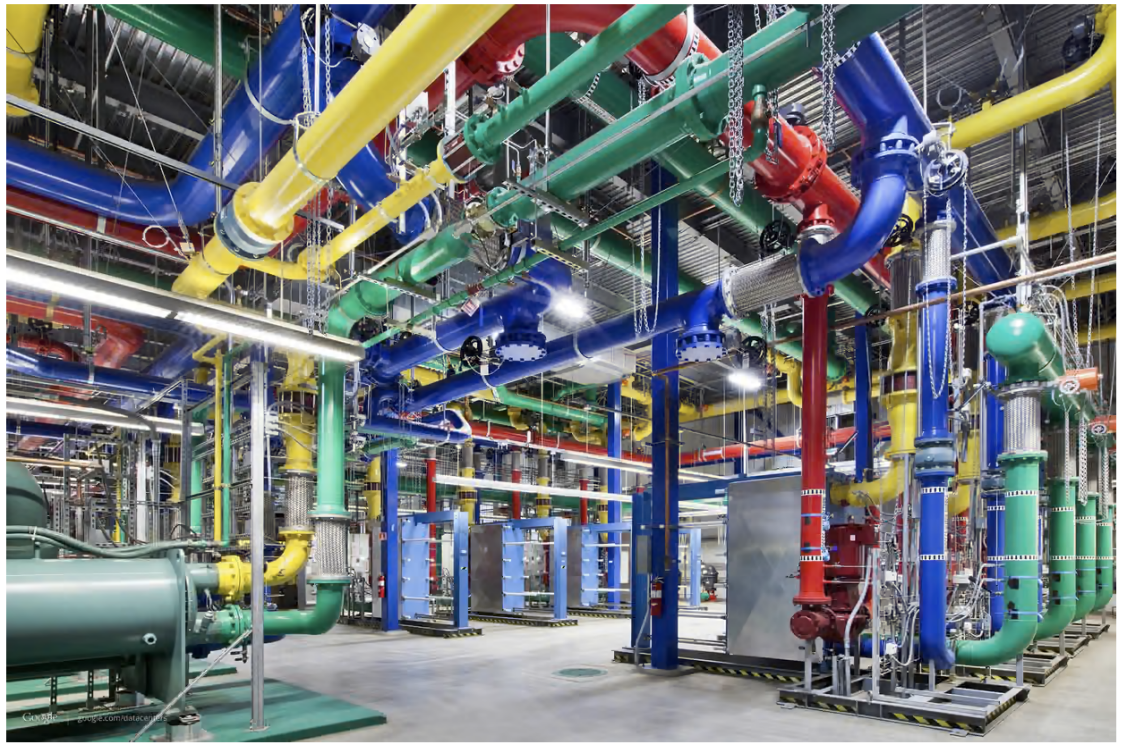


A Google data centre in The Dalles, Oregon, in 2012. Photograph: Google Handout/EPA

Google's goal of reducing its climate footprint is in jeopardy as it relies on more and more energy-hungry data centres to power its new artificial intelligence products. The tech giant revealed Tuesday that its greenhouse gas emissions have climbed 48% over the past five years.

Challenges

- Location of data centre
- Energy mix in the local energy grid
- Location of renewable energy generation

Singapore lifts data center moratorium - but sets conditions

Minister for Trade and Industry says the country will be "more selective" in future

January 12, 2022 By: **Peter Judge** Have your say

Singapore appears to have lifted its moratorium on new data center projects, according to a statement by the Trade and Industry Minister this week - but new data centers will have to meet certain conditions.

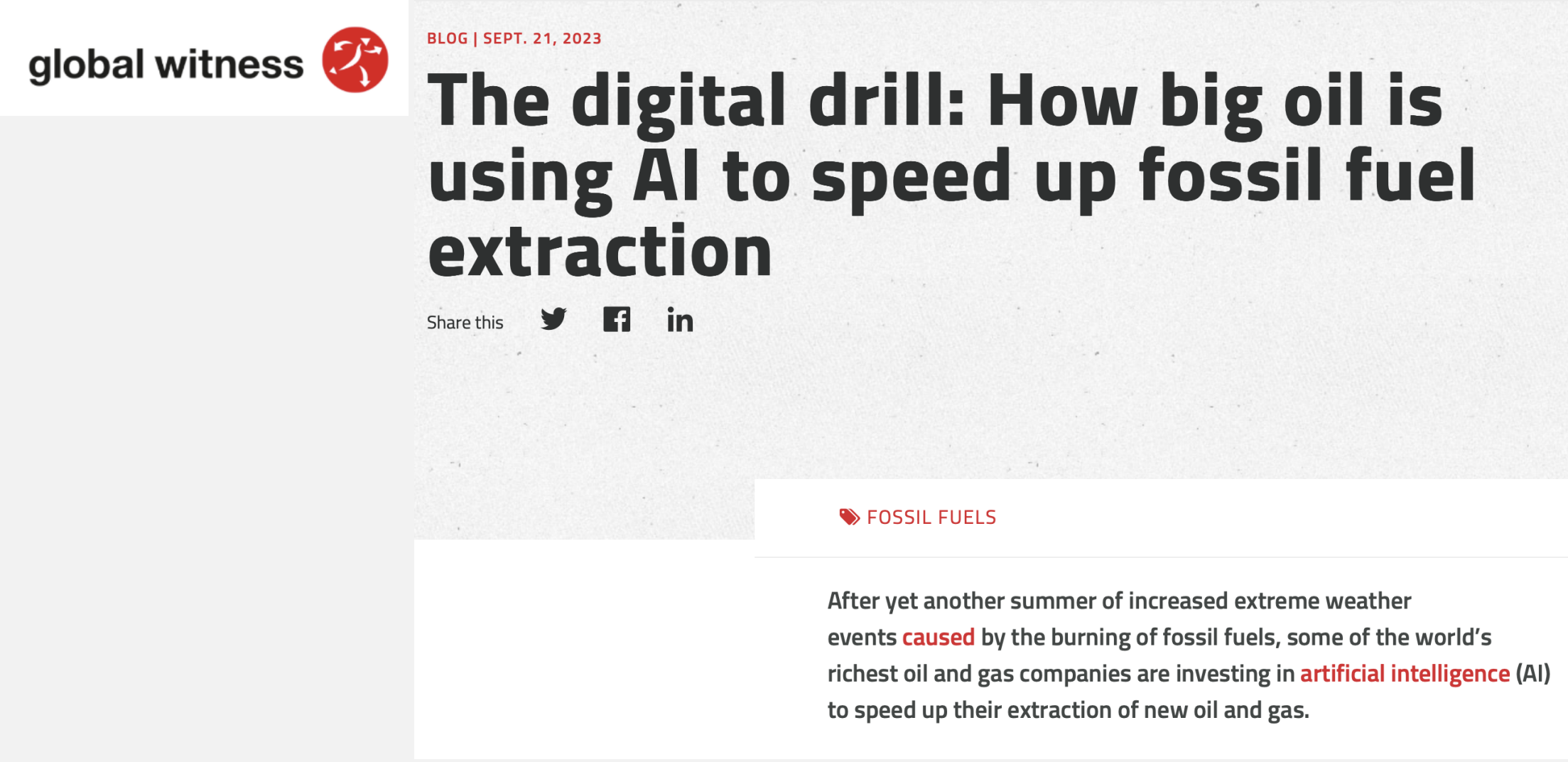
Data centers contribute to Singapore's growth, but must be sustainable, said Minister Gan Kim Yong, in a written answer to Parliament on Tuesday, Jan 11. The country has paused new data center development since 2019, but this will now resume, though the government will impose measures to make them more efficient, he said.

National Green Algorithms Program

The National Green Algorithms Program will promote the development of green algorithms to maximize energy efficiency and reduce the environmental impact of artificial intelligence models.

The program will include specific investments in the context of the calls for proposals forming part of the ENIA and in addition a series of market-driven actions in support of sustainable and environmentally responsible artificial intelligence.

AI in energy supply



global witness

BLOG | SEPT. 21, 2023

The digital drill: How big oil is using AI to speed up fossil fuel extraction

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FOSSIL FUELS

After yet another summer of increased extreme weather events caused by the burning of fossil fuels, some of the world's richest oil and gas companies are investing in artificial intelligence (AI) to speed up their extraction of new oil and gas.

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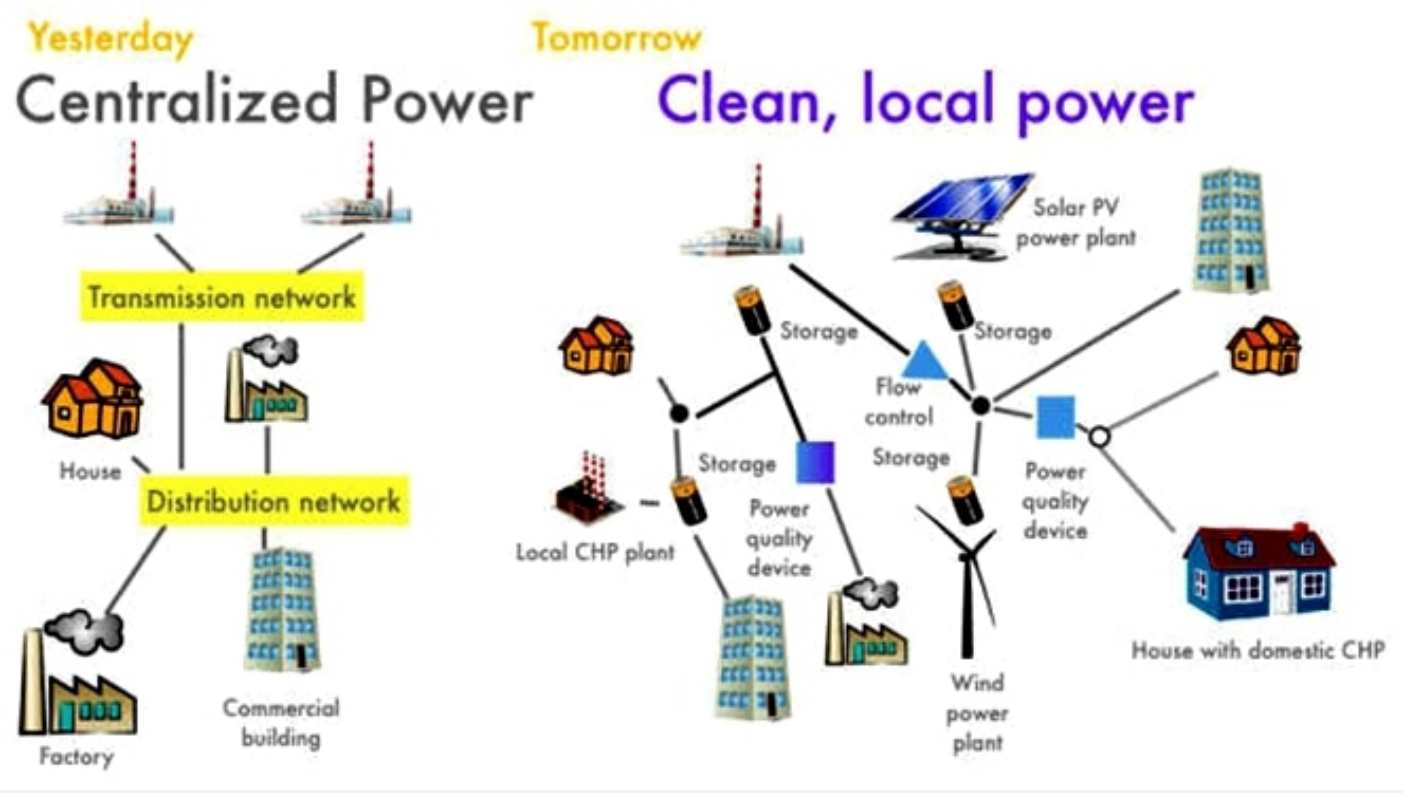
AI in power systems

- Support flexibility by forecasting supply and demand
- Prevent grid failures through predictive maintenance
- Optimise energy systems through digital twin



Policy Responses

Examination of:

- Energy consumption of the full lifecycle of AI models, hardware, data centres
- Potential environmental impacts at local scales
- Positive and negative environmental impacts of **AI applications** including rebound effects, behavioural impacts

Policy Responses – UK AI Energy Council

Clean and renewable energy solutions are needed to power the increasing energy demands of AI. To identify potential solutions, the Science and Technology Secretary of State and the Energy Secretary will co-chair a new AI Energy Council formed of industry leaders from the energy and AI sectors. The Energy Council will provide expert insight on **the energy needs of AI**, opportunities to **accelerate investment in the development of renewable and innovative energy solutions**, including Small Modular Reactors (SMRs) and the **role of AI in a modern, efficient and sustainable energy system**

iDODDLE Research

- AI hype and intention to use AI application