Resource Consumption of Data Centers and AI

Thomas Fricke

November 27, 2025
LOCOS Seminar, University of Glasgow

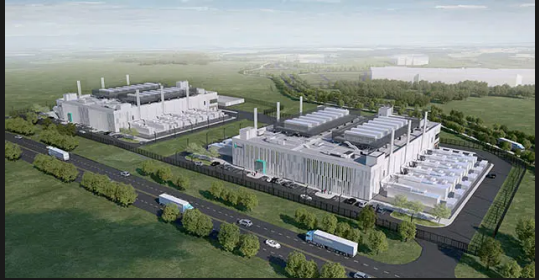
Who am I?

Thomas Fricke

- Kubernetes Cloud Security
  - critical infrastructure
  - architecture
  - examination
- Former life: Statistical Physics
- Disclaimer

  Work for the German Administration
  - Pro Bono: OpenCode, Consulting IT Planning Counsel
  - Payed: OpenDesk, FITKO

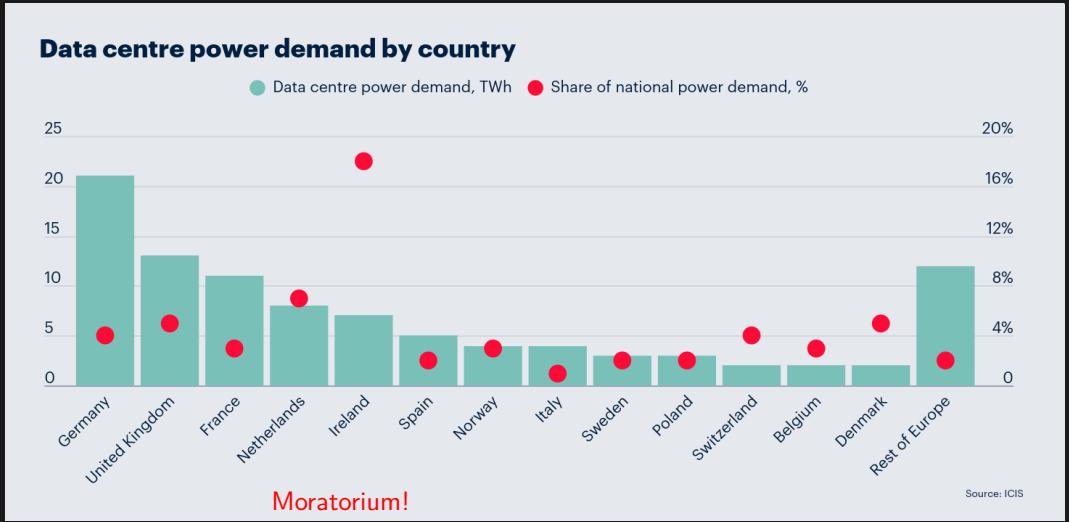
Datacenter



Datacenters are Factories

- Energy consumption
  - 12 MW small German DC
  - 40 MW state of the art German DC
  - ~~300~~ 600 MW planned in Berlin
  - ~~20~~ ~~160~~ 860 MW planned in Skien, Norway
- Diesel emergency power Generator
  - 1 day onsite
  - transport capacity for longer
  - ship
  - vans
- Access to transmission grid
  - transformer station
  - power lines 110kV
- total consumption
  - Berlin/Brandenburg planned ~~1~~ ~~2~~ 9 GW
- Water
  - cooling
  - transport
- several Billions € of servers
  - typical rack 900.000€
  - several thousand racks
- access to multiple redundant fiber lines
- German setup
  - 2 x Telekom
  - Vodafone
  - Colt
- access control
  - typical vans
  - Kalaschnikov safe amoured glass entrance
- noisy (90 dB+)
- completely unprotected roof

EU Datacenter Power Demand by Country 2024



Electric Power Research Institute – US Predictions

Electric Power Research Institute
Epoch AI Joint Report Finds Surging Power Demand from AI Model Training August 2025

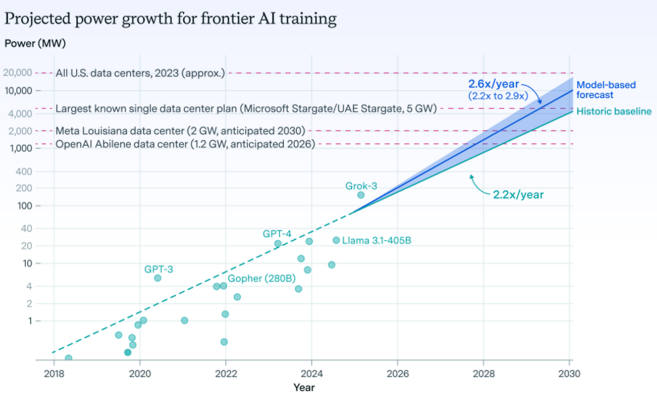


Figure 1. *Forecast for peak power demand required to train the largest frontier models, with historic frontier AI power growth and historic training runs highlighted for context. Graph prepared by Epoch AI.*

Exponential Growth

- explosives
- nuclear chain reactions
- population growth
- infections at the beginning of an epedemy SIR Model
- limited by resources

Small Modular Reactor (SMR) – Green and Safe?

Nuscale

- 77 MW / unit
- 4 - 12 units
- too expensive
- now solar and wind power

X-Energy XE 100

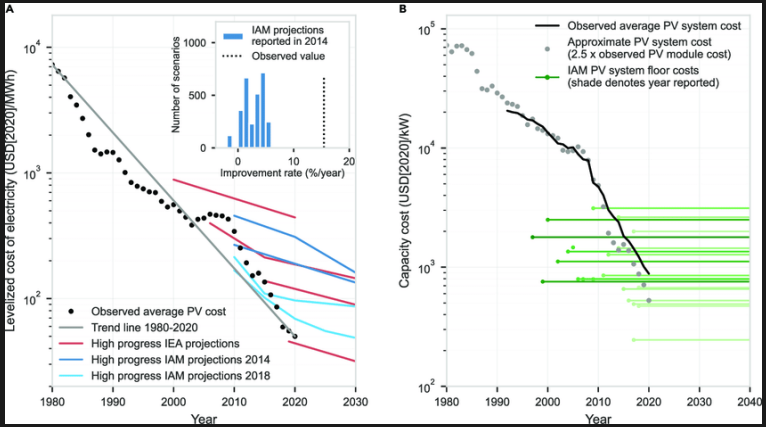
- Gen-IV High-Temperature Helium-cooled Reactors (HTGR)
- U^{235} 15% enriched Pebbles
- can be shipped by trucks
- 60 years of usage
- 4 x 80 MW

- Uranium under Russion control
- hard to mine
- final repository
- proliferation

Fact Sheet

- Bloomberg: Sam Altman's Energy 'New Deal' Is Good for AI. What About Americans?
- Demand per Hyperscaler 5GW (roughly 8-10 power station blocks)
- Total 47GW($>$ 150 reactors of 300 MW)
  - 3 prototypes (1 Russia, 1 China)
  - none in the US or EU
  - Uranium mostly under Russian control
  - Reopen Wismut???
- Small ... Reactors Have A Big Problem
- PG&E: Pacific Gas & Electric Company
  - PG&E Launches First Commercial Deployment of On-Site Generative AI Solution for the Nuclear Energy Sector at Diablo Canyon
  - Utility giant PG&E agrees to $45 million settlement related to California's second-largest wildfire
  - PG&E fined $1.7 million over 2021 power shutoff lapses
- Illinois: $468 million in subsidies for only 339 jobs ($1.4 million per job)
- Nebraska: costs for Google and Meta passed onto residents, estimated rate increase 2.5% to 3% per year
- Datacenters are extremely unequally distributed (Chicago, Texas, Virginia)
- Washington Post: Biden plan would encourage AI data centers on federal lands
- Europe
  - Ireland: 20% of electricity consumption
  - Energy Consumption in Data Centres and Broadband Communication Networks in the EU

Nuclear Fusion – Remote 149 Mio km Distance – needs storage



Rupert Way, Matthew C Ives, Penny Mealy University of Oxford, J. Doyne Farmer:

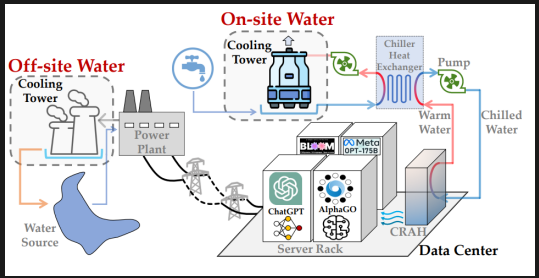
Empirically grounded technology forecasts and the energy transition, September 2022

Comparison nuclear power – PV + Wind + Batteries

Topic	Nuclear	Sun + Tides + Wind + Batteries
Costs	Exploding	Falling
Fuel	U^{235}	free
Stock predictions	12-130 years	*what?*
Size	300 MW	5 MW
Number	4	several hundred
Cooling	Water	*none*
Problems	radioactive waste, no final repositories, proliferation	several days of dark doldrums, recycling
Solutions	*none*	transmission grids, local buffer

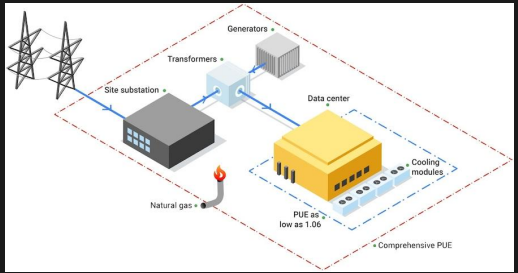
Water

Data Center Dynamics: **How to cut water usage in cloud data centers**

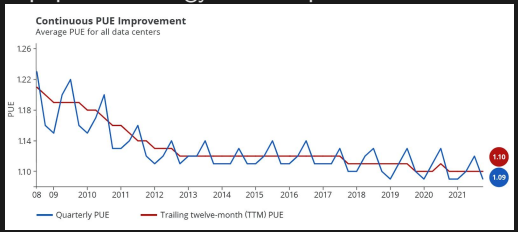


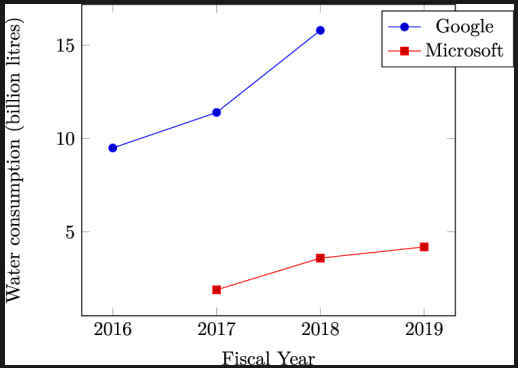
- Its complicated
- 1 – 9 l of water per kWh
- first post
  1 MW consumes 26 Million litres a year
  $\approx$ 3 l/kWh
- variations of efficiency
- weather conditions

Google Power Usage Effectiveness – PUE Greenwashing



Centre Total Energy Consumption PUE= ICT Equipment Energy Consumption

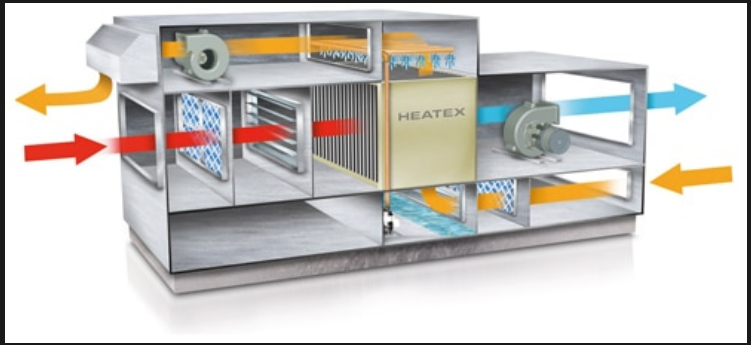


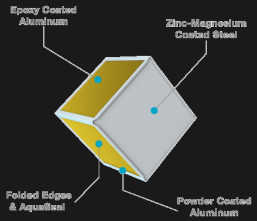


$$\text{PUE} = \frac{\text{Data Centre Total Energy Consumption}}{\text{ICT Equipment Energy Consumption}}$$

Source: Google(left), Nature (right)

Cooling





Source: Heatex

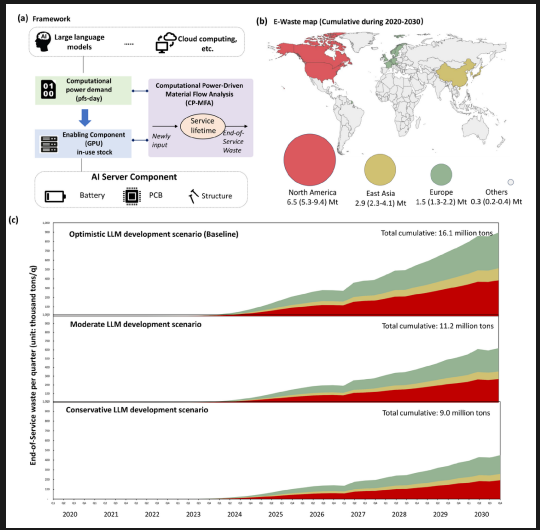
Warning

Wired

The Trump Administration's Data Center Push Could Open the Door for New Forever Chemicals

AI-Waste

- Life of Data Center Hardware: **3 – 5 years**
- Peng Wang, Chinese Academy of Sciences, Lingyu Zhang, Institut National des Sciences Appliquées de Lyon, Asaf Tzachor, Eric Masanet, University of California, Santa Barbara:
  E-waste Challenges of Generative Artificial Intelligence
  also in **Nature**
- Deutsche Welle
  E-waste from AI computers could 'escalate beyond control'
  - Nature
    E-waste challenges of generative artificial intelligence
    - 1.2-5.0 million metric tons in 2030
- **1,000** fold increase of waste



E-Waste

Chip Production – Taiwan drought 2021

- Phys.org

Taiwan imposes water rationing as drought worsens

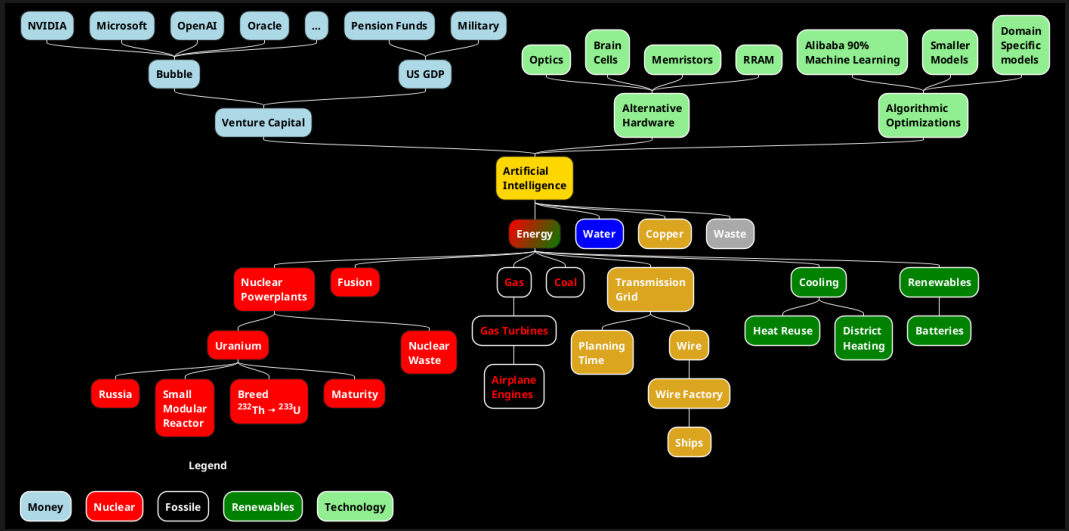
- resource conflict
- rice or 2nm factories

- truthdig

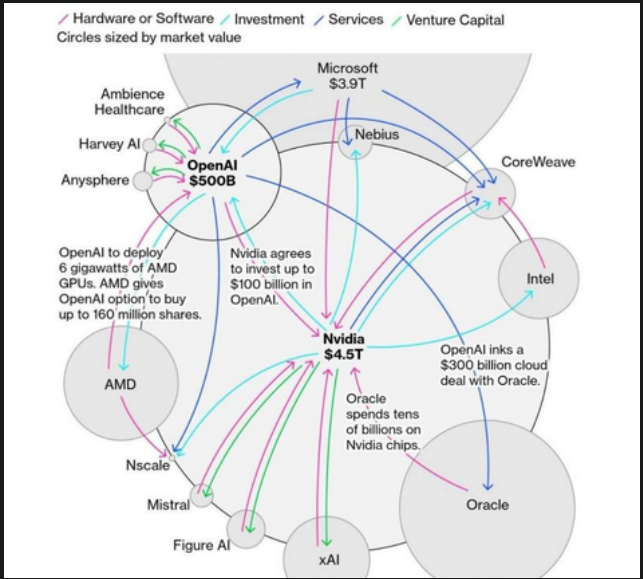
The Ecological Cost of AI Is Much Higher Than You Think

- "acutely carcinogenic, reproductive-toxic and neurotoxic substances."
- 1000 applications of PFAS
- union busting

Bottlenecks



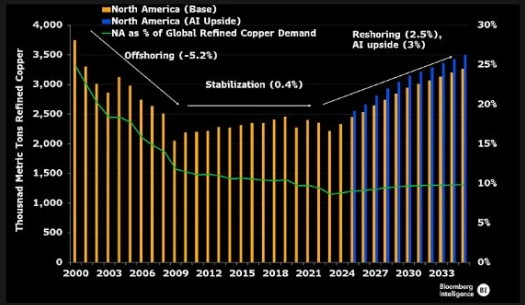
AI Bubble



- 2 Trillion $ needed till 2030
- only 800 Billion $ in return
- circular business
- bilance make up
- Financial Times
  Oracle is already underwater on its ‘astonishing’ OpenAI deal
- Macromicro
  Behind NVIDIA’s Stellar Earnings: Five Financial Indicators to Evaluate the AI Bubble
  - including NVIDIA’s inventory turnover 91 ↗ 103 days
  - slower-than-expected growth in automotive and robotics
  - end-user AI applications showing a clear deceleration over the past four quarters

Copper in US data centers

North American Refined-Copper Demand



Source: Data Center Knowledge, Wakefield & Cushman, Wood Mackenzie, ICSG, Bloomberg Intelligence

- 3% increase every year
- 1.1 million tons in 2030

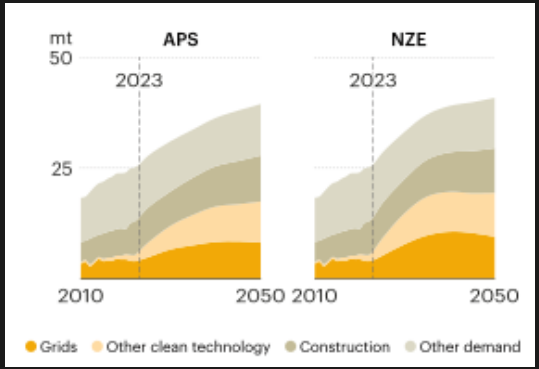
North American Data-Center Copper Demand by 2030

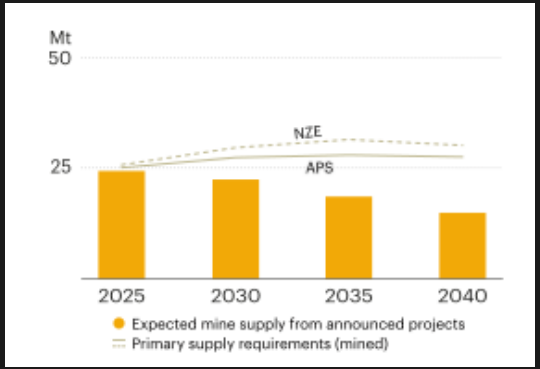
Source: US Department of Energy, US Energy Information Administration, IDC, eMarketer, Data Center Knowledge, Navigant Research, Cushman & Wakefield, Bloomberg Intelligence

- 1 MW $\approx$ 27 -33 metric tons
- Data Centre Magazine
  How the AI Data Centre Boom Could Threaten Global Copper

International Energy Agency (IEA): Copper

Copper Outlook for key energy transition minerals





- 3% increase every year
- 1.1 million tons in 2030
- 1 MW $\approx$ 27 metric tons

Environmental Impact – British Geological Survey

Rare earth elements	REE	9.5	China	China	Rhenium	Re	7.1	Chile	Chile
Antimony	Sb	9.0	China	China	Selenium	Se	6.9	Japan	China
Bismuth	Bi	8.8	China	China	Mercury	Hg	6.9	China	
Germanium	Ge	8.6	China		Fluorine	F	6.9	China	South Africa
Vanadium	V	8.6	China	China	Niobium	Nb	6.7	Brazil	Brazil
Gallium	Ga	8.6	China		Zirconium	Zr	6.4	Australia	Australia
Strontium	Sr	8.3	China	China	Chromium	Cr	6.2	South Africa	Kazakhstan
Tungsten	W	8.1	China	China	Tin	Sn	6.0	China	China
Molybdenum	Mo	8.1	China	China	Manganese	Mn	5.7	China	South Africa
Cobalt	Co	8.1	DRC	DRC	Nickel	Ni	5.7	Indonesia	Australia
Indium	In	8.1	China		Thorium	Th	5.7		USA
Arsenic	As	7.9	China		Uranium	U	5.5	Kazakhstan	Australia
Magnesium	Mg	7.6	China	Russia	Lead	Pb	5.5	China	Australia
Platinum group elements	PGE	7.6	South Africa	South Africa	Iron	Fe	5.2	China	Australia
Lithium	Li	7.6	Australia	Chile	Carbon (Diamond)	C	5.2	Russia	Australia
Barium	Ba	7.6	China	China	Titanium	Ti	4.8	Canada	China
Carbon (Graphite)	C	7.4	China	China	Copper	Cu	4.8	Chile	Chile
Beryllium	Be	7.1	USA		Zinc	Zn	4.8	China	Australia
Silver	Ag	7.1	Mexico	Peru	Aluminium	Al	4.8	Australia	Guinea
Cadmium	Cd	7.1	China		Gold	Au	4.5	China	Australia
Tantalum	Ta	7.1	Rwanda	Australia					

Low hanging fruits

- Recycling of components can save $>$ 80% of minerals

  Rich Kenny

  Understanding Data Centre IT Efficiency – The Hidden Power Source by Rich Kenny – Interact

- Software production generates more emissions than software operations

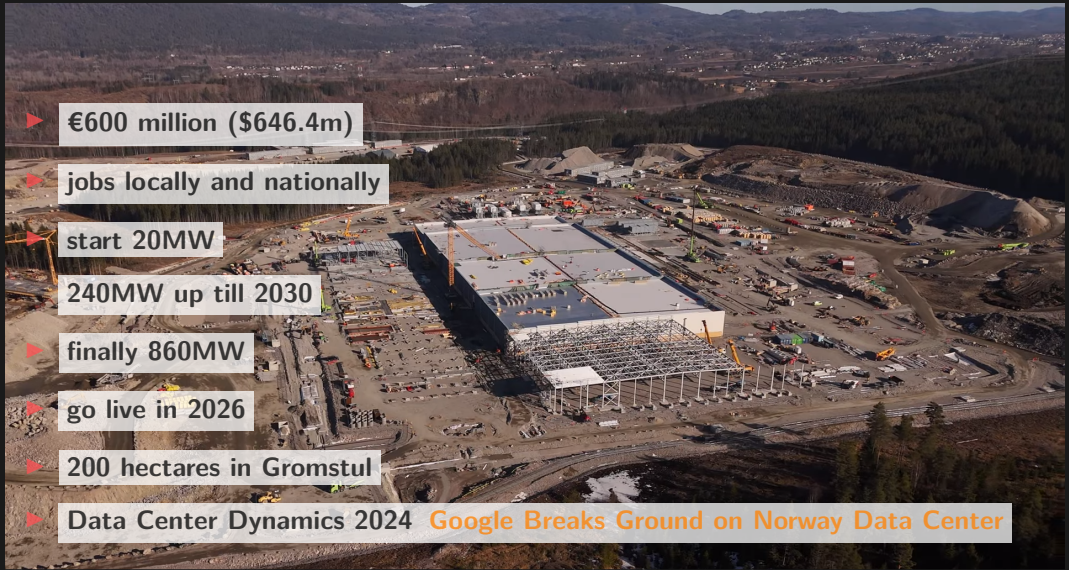
  Aydin Mir Mohammadi

  One year of the CO2-challenge – insights and lessons learned

Thumb Rules

Resource	Unit	Source	Main competition	Impact Blast Radius
Power	1 MW	power plants	industry, households	earth
Transmission		power lines	landscape	
Copper	27 t		mining industry, electric cars	indigenous communities in the mining area
Water	1000 – 9000 l/h	ground water, rivers	farms, households	local to the datacenter

Skien – Gromstulskogen



- €600 million ($646.4m)
- jobs locally and nationally
- start 20MW
- 240MW up till 2030
- finally 860MW
- go live in 2026
- 200 hectares in Gromstul
- Data Center Dynamics 2024 Google Breaks Ground on Norway Data Center

Google in Germany

- **Clandestine behavior meets sycophantic politicians**
- **Absolutely intransparent**
  - Heise

    Amazon Reforestation: Google Deal with Brazilian Startup

    5.5 billion euros: Google's "GDP booster" for AI in Germany

    How Green Are Google Data Centers Really?

    "high-voltage power has been exclusively laid for operators," including nine 110 kV lines.

    . . . figures for Germany from 2024 show, according to AlgorithmWatch, only 68 percent coverage when viewed hourly; the rest, it claims, came from fossil sources.
  - Algorithmwatch

    Investitionspläne von Google: Nachhaltigkeit und Transparenz in den Blick nehmen
  - Google

    Google . . . €5.5 Billion Investment in Germany, including AI . . . , through 2029

Google Kubernetes

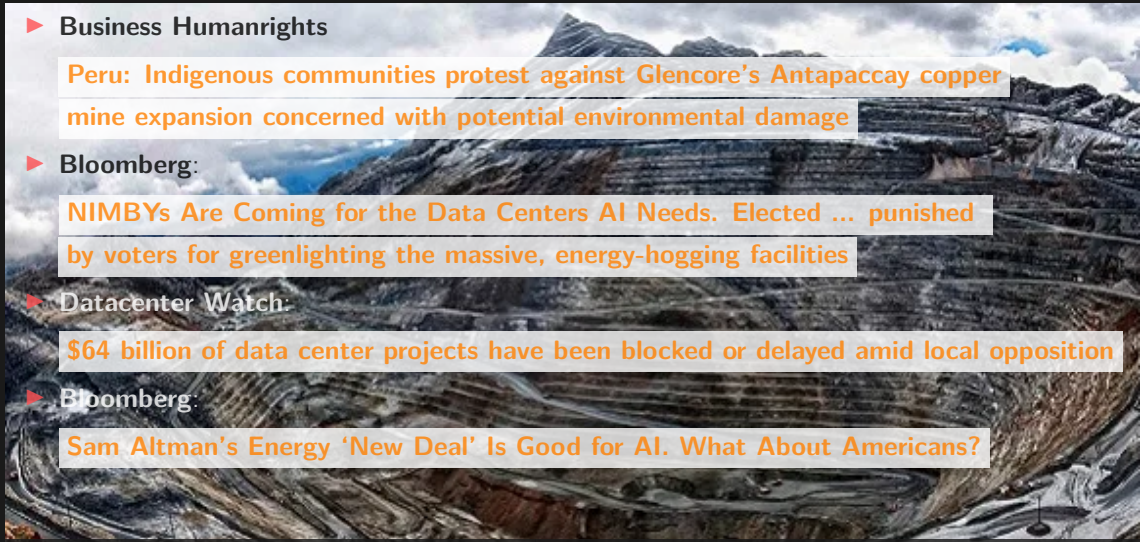
How Google Does It: Building the largest known Kubernetes cluster, with 130,000 nodes

- A single NVIDIA GB200 GPU needs 2700W of power.
- $>$ some 10K
- single cluster power footprint $>$ 100s MW
- ideally distributed across multiple data centers
- for AI platforms exceeding 100K
  - robust multi-cluster solutions
  - significant challenge
- *If your workloads require this level of scale, reach out to us to discuss your specific needs!*
- utilization still 25% ?

```
gcloud container node-pools create burn \
    --zone eu-north-666 \
    --cluster burn-the-planet \
    --num-nodes=100000 \
    --machine-type a4x-highgpu-4g \
    --accelerator type=nvidia-gb200,count=4,gpu-driver-version=DRIVER_VERSION \
    --additional-node-network network=GVNIC_NETWORK_PREFIX-net,subnetwork=GVNIC_NETWORK_PREFIX-sub \
    --additional-node-network network=GVNIC_NETWORK_PREFIX-net,subnetwork=GVNIC_NETWORK_PREFIX-sub-0 \
    --additional-node-network network=GVNIC_NETWORK_PREFIX-net,subnetwork=GVNIC_NETWORK_PREFIX-sub-1 \
    --additional-node-network network=GVNIC_NETWORK_PREFIX-net,subnetwork=GVNIC_NETWORK_PREFIX-sub-2 \
    --additional-node-network network=GVNIC_NETWORK_PREFIX-net,subnetwork=GVNIC_NETWORK_PREFIX-sub-3 \
    --scopes "https://www.googleapis.com/auth/cloud-platform" \
    --reservation-affinity=specific \
    --reservation=RESERVATION_NAME/reservationBlocks/BLOCK_NAME
    --placement-policy=WORKLOAD_POLICY_NAME
```

Create a GW cluster with a single line

Resistance



- **Business Humanrights**

  Peru: Indigenous communities protest against Glencore's Antapaccay copper mine expansion concerned with potential environmental damage

- **Bloomberg**:

  NIMBYs Are Coming for the Data Centers AI Needs. Elected ... punished by voters for greenlighting the massive, energy-hogging facilities

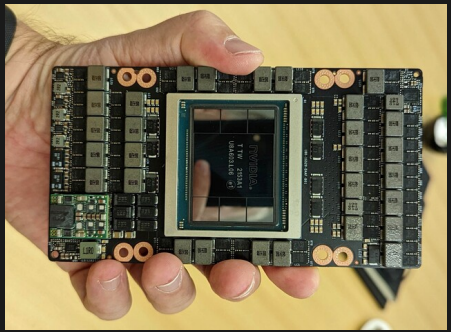
- **Datacenter Watch**:

  $64 billion of data center projects have been blocked or delayed amid local opposition

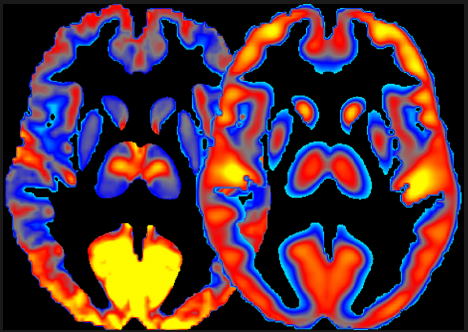
- **Bloomberg**:

  Sam Altman's Energy 'New Deal' Is Good for AI. What About Americans?

Comparison NVIDIA Hopper H100 vs Homo Sapiens[2]



700 Watts



20 Watts

Energy Consumption

- Single Graphics Card
- 700 Watts = 0.7kW
- ~ ~~30~~ 100 kW / rack
- instead of 3 to 6 KW / rack

New method for combining measures of brain activity (left) and glucose consumption (right) . . .

**Dr. Ehsan Shokri Kojori, NIAAA

Misalignement – How to Kill One Industry After the Other

- Maskulinity
  - Rittal 1MW cooling
  - 2 sportcar equivalents
- All money into old technology
- Trillions of Venture Capital
  - Graphic Cards
  - Nuclear
  - **Exhaustion of VC**
- Fewer Billions could trigger **real** innovation
  - Funding for alternative AI technologies
  - Integration into existing Infrastructure
  - Decentralisation to save Ressources

Prediction Recap and FOMO

- never seen before 5 fold increase
- from 3.7% to 5-15% of the 2030 prediction
- adding 10% to the US grid
  - unprepared
  - instable
- FOMO (fear of missing out) propaganda
  - China will lead in 2030
  - at the brink of World War III
  - Retain US leadership in AI
  - US Gov: AI linchpin of our economy
  - AI New Deal
- nuclear power to the rescue – SMR

Touching Limits: Energy, Water, Metal CO_2

- Ireland: AI Data Center Moratorium until 2028 because of Blackout fears
- Netherlands: Inside the data centre moratorium movement
- Tech HQ: Heating up: how much energy does AI use? *What we do know is that training ChatGPT used 1.287 gigawatt hours, roughly equivalent to the consumption of 120 US homes for a year.*
- Moomoo: Chicago data center electricity demand increased by 900%! AI continues to detonate global energy challenges
- Cleanroom Technology: data centers run out of power
- Business Today: OpenAI might go bankrupt by end of 2024
- Business Insider: The AI boom will push America's shaky power grid to its limit
- Wired: AI's Energy Demands Are Out of Control. Welcome to the Internet's Hyper-Consumption Era
- OECD: How much water does AI consume? The public deserves to know
- Substack: The Great Salt Lake is Disappearing. So, Utah Banned the Rights of Nature.
- Straight Arrow News: AI tools consume up to 4 times more water than estimated
- Substack: Material Sacrifices To tackle climate chaos, decolonize the labor movement
- The Driller: Growing Demand for Copper Drives Need for Increased Domestic Mining, Experts Suggest
- Generative AI is reportedly tripling carbon dioxide emissions from data centers
- Odessa American Online: AI to boom natural gas market
- Arabian Gulf Business Insight: Aramco partners with US startup Groq for AI data centre

Impact on the Environment

Neo Colonialism

- Reporter Brasil

  Documents link Amazon and Google to companies investigated for illegal gold mining

- Tucson

  Arizona opinion: Data centers redefine the Copper State

- Dan Watch

  Impacts of copper mining on people and nature

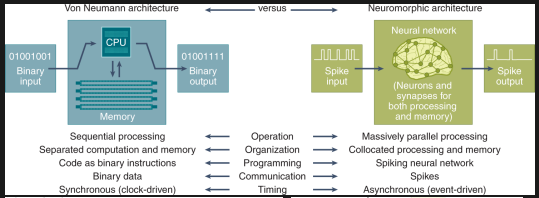
- Monga Bay

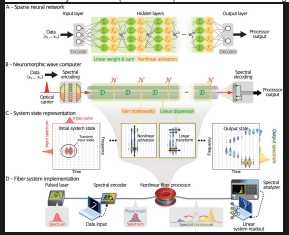
  Renewables won't save us from climate catastrophe, experts warn; what will?

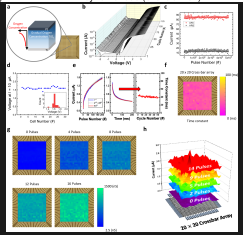
- The Guardian

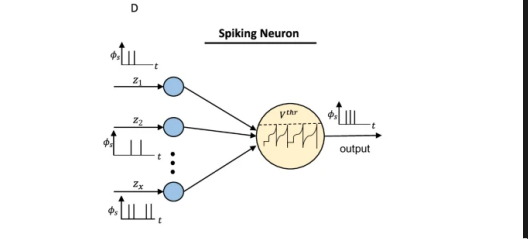
  How the rise of copper reveals clean energy's dark side

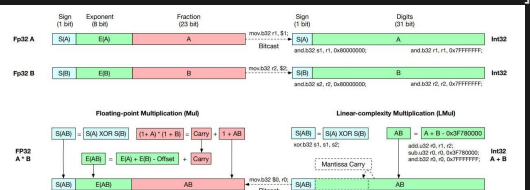
Neuromorphic Computing – Can Tech Save us?







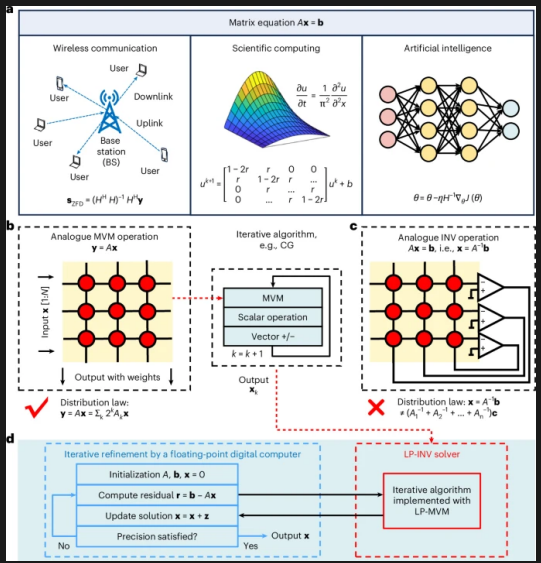




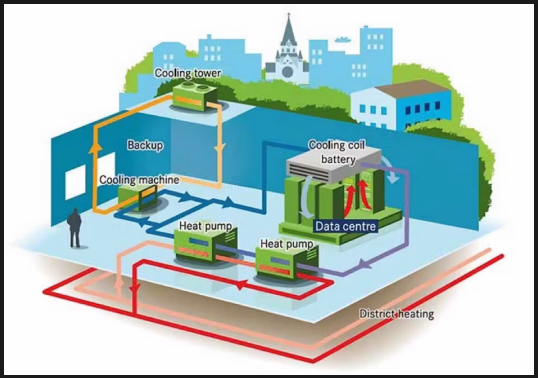
Could save 95% of the energy needed

China FOMO – The Right Way

- Wikipedia
  Solar power in China
- Bloomberg
  Alibaba's Shares Soar After Investors Buy Into Big AI Moves
- Alibaba
  New AI Training Method Cuts Search Costs by Nearly 90%
- Nature
  Precise and scalable analogue matrix equation solving using resistive random-access memory chips
  - NumPy
  - SciPy
  - on an analogue chip



Reusing the heat



- Cloud and Heat Vattenfall
- Integration into district heating
- NTT Berlin 2 – Gasag
  - district heating does not really fit
  - must be planned and implemented together

Reusing the heat – Schwäbische Alp

- Integration into district heating
- Small scale J-H Computers
- better than Geothermal energy
- works from 40kW
- nice from $>$ 240kW

Europe

- Start investing into the **right** technologies
- Cheaper than a single Gigafactory
- Supports local strength
- Decentralisation
  - Resilience
  - Low Latency
  - Robots
  - Technology advantage
- Ecology
- AItad

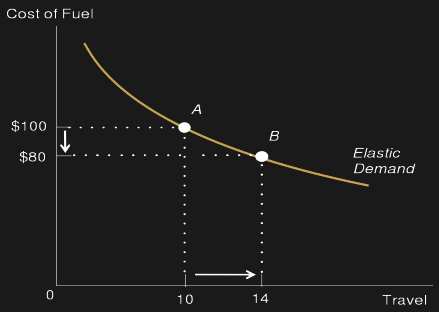
  KI in Mikrochips: Der Blick in den Abgrund bringt Innovationen hervor
- OpenFlexure

  50$ self printed microscope
  - Europe / Africa
  - AI on a tablet
  - Leukemia
  - Malaria

Conclusion: Optimization

- Increasing efficiency
- Focus on the right part of economy
- But beware
- Factor of 10: buys us 10 years
- Factor of 1000: buys us 30 years
- Insufficient on the long run
- **Degrowth**

Jevons Paradoxon



Jevons Paradox

Experts are skeptical about Google's AI water consumption claims

- *Google's five drops per query is just the tip of the iceberg*
- individual user problem now
- get over it – don't look up

Jevons Paradoxon

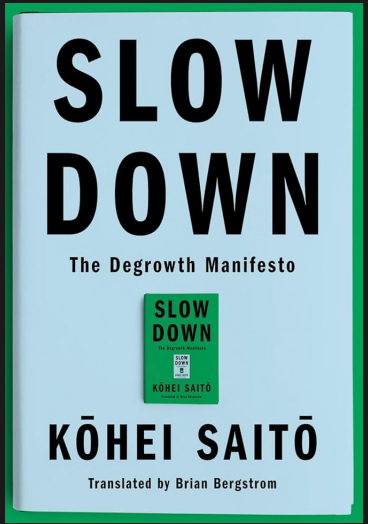
- first described for steam engines
- example is for travelling costs
- Rebound Effects in Cloud Computing: Towards a Conceptual Framework

Personal observations

- provisioning times are hidden costs
- self provisioning
- cloud enabling
- virtualisation
- containers
- Kubernetes
- CI/CD pipelines

Conclusion: Degrowth

- Wikipedia
  Degrowth is an *academic and social* movement aimed at the planned and democratic reduction of production and consumption as a solution to social-ecological crises
- Must become imperative in engineering
- Optimization $\neq$ Degrowth
  - buys time
  - but only a few years



Question? Remarks?

Further reading

- Gerry McGovern
- Paris Marx
- Halloween Talk at SreCon Emea 2024
- Kohei Saito on archive.org: Marx in the Anthropocene

Some Answers

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