

**Data Centers
are growing.**

**How can we
make them
sustainable?**



Impact stats

Operation Impact

In the U.S., data centers are projected to drive **half of all electricity demand growth** through 2030 and to surpass the combined demand of the cement, steel, aluminum, and chemical industries⁶.

Manufacturing Impact

Wafer production for chips relies on **fluorinated gases with high global warming potential** to etch circuits and clean deposition chambers. 10–80% of these gases enter the atmosphere unreacted^{31,32}.

Resource Impact

AI data centers alone could consume **4.2–6.6 billion cubic meters of freshwater** annually by 2027, about half of the UK's water use⁹.

Server **replacement cycles of one to five years** add to material waste, with most discarded hardware ending up in landfills, incinerators, or untracked streams¹¹.



AI can also reduce emissions...

and its projected power use remains **modest** compared to other sectors³.

- Globally, electrifying transport, buildings, and industry could increase electricity demand by 20–30% by 2030, while even a doubling of data center demand would account for **only 2% of new power needs**³.
- If applied at scale for sustainability, AI could **cut 2.6–5.3 gigatons of emissions** across economic sectors, outweighing the 14–15 million tons emitted annually by hyperscalers such as Google and Microsoft³ (*best case scenario estimate from BCG*).



Bottlenecks



Limited grid capacity

Reconductoring with advanced materials could increase transmission capacity by **2.5 times** while using less material, money, and time³⁹. Instead, utilities often build new corridors with less efficient lines and steel towers, which cost more but allow for higher returns recouped from ratepayers.

Resource scarcity and supply chains

1/5 of servers' direct water footprint comes from moderately to highly **stressed watersheds**¹⁵

GPUs depend on **critical materials vulnerable to supply disruptions**. With short server replacement cycles, Rising demand will intensify pressure on finite resources, and **low recovery rates** amplify the risk.



Solutions



Efficiency

Reduce demand through software, hardware, and infrastructure optimization.

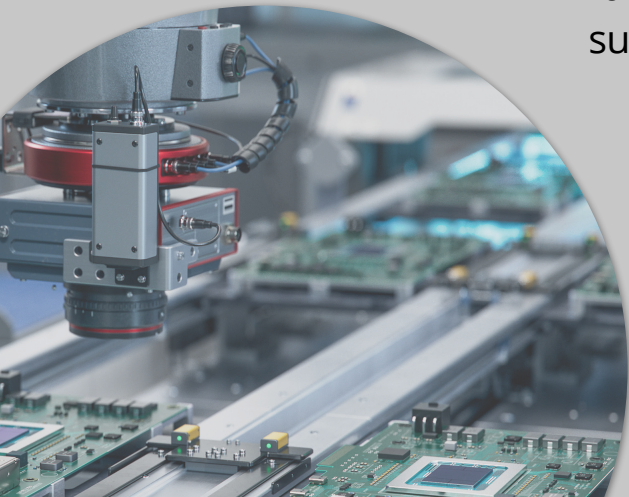
Clean energy

Secure 24/7 renewable power and site workloads near low-carbon grids.



Circularity

Extend hardware life, recover raw materials, and reform supply chain logistics.



Efficiency



Software

- Compression & deduplication
- Data tiering & archiving
- Virtualization & containerization
- Application modernization

Hardware

- Multicore processors
- Variable-speed fans
- High-density CPUs, GPUs, and TPUs
- Solid-state drives vs HDDs
- NVMe SSDs, which connect directly to the motherboard

Infrastructure

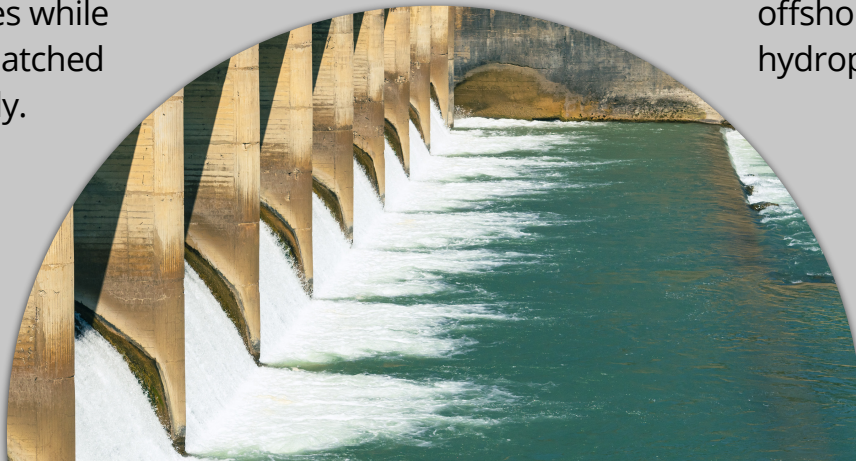
- Real-time virtual sub-metering
- Medium-voltage microgrids
- Immersive cooling
- Battery energy storage systems

Clean energy

24/7 renewable power purchase agreements (PPAs)—long-term contracts that typically secure electricity at lower rates than utilities while ensuring time-matched renewable supply.

Co-locating facilities near low-carbon grids or clean energy generators

Shift energy-intensive workloads such as AI training to regions with abundant or stranded clean power, such as offshore wind or remote hydropower²²



Circularity



Design and Logistics

- Design IT equipment for simple disassembly for refurbishment or recycling
- Keep inventory of decommissioned server parts for repairs, upgrades, & resale

Manufacturing

- Gas abatement to destroy gases
- Alternative chemistry for etching gases
- Temperature & pressure adjustments
- Membrane separation, cryogenic recovery, adsorption, & desorption to recycle gas

Digital Technology

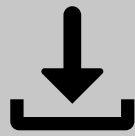
- Apps, sensors, & robots for sorting
- Machine learning for lifetime prediction & optimizing design
- IoT sensors & online databases for traceability
- Blockchain to verify responsibly sourced & recycled materials

Implementation



Generally, an effective sequence begins with reducing demand, then cleaning supply, and finally modernizing hardware and infrastructure—all while integrating circular economy practices and policy engagement to sustain long-term impact.

However, alternative implementation sequences may prove more effective depending on project-specific needs, grid interconnection delays, and resource constraints.



Full report available

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Data Centers, Decarbonization, and the Circular Economy

Strategies for Sustainable Operations

