Labstart

Your Launchpad for Impact

The Opportunity: Building the Next Generation of Sustainable AI Infrastructure

A White Paper

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Andrew Bray

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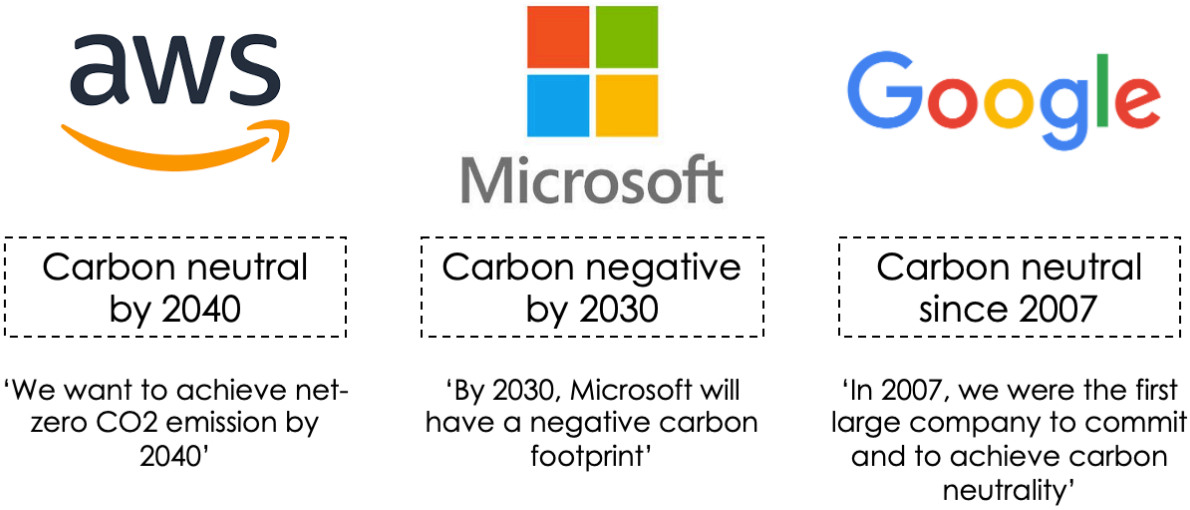
Introduction

AI faces a sustainability problem. LabStart aims to address this sustainability problem with its Data Center Sustainability cohort.

The fierce race to build data centers currently supersedes the need to build them sustainably. McKinsey estimates that 298 GW of data center capacity will be needed by 2030 in their upper scenario, which is five times the 60GW that exists today ("AI data center growth: Meeting the demand"). They anticipate that $5.2 trillion of investment will need to be deployed to build this capacity ("The cost of compute: A $7 trillion race to scale data centers"). S&P Global predicts that these data centers will require 150 to 200 TWhs of additional energy per year through 2030 ("Data Centers: Rapid Growth Creates Opportunities And Issues"). This growth necessitates turning to natural gas generation, resulting in 40 million to 67 million tons of additional $CO2_e$ per year by 2030. This intense growth of data center energy demand puts hyperscalers' and data center owners' climate and sustainability commitments at risk.



Hyperscalers' climate commitments ("Cloud carbon footprint: Do Amazon, Microsoft and Google have their head in the clouds?")

Sustainability concerns go beyond energy and emissions. There are sustainability concerns around water use, biodiversity, critical minerals, and building materials. These challenges not only pose a threat to companies meeting their environmental and sustainability goals, but also can affect their financial credit ratings. S&P shows a case

study of how poor water management could affect a technology company's credit rating by as much as 10% ("Sustainability Insights: TSMC And Water: A Case Study Of How Climate Is Becoming A Credit-Risk Factor").

The industry needs innovative solutions for these sustainability problems. The need for innovation in the data center industry is recognized by innovation leaders. Y Combinator has issued a call for data center innovation, stating, "we need new companies and more innovative solutions to accelerate this buildout—whether in power infrastructure, cooling, material procurement, or project management".[1] Solutions can not only ensure that AI has a low environmental impact but even allow for a net negative impact, according to Microsoft ("2025 Environmental Sustainability Report"). Sustainability solutions ensure that data center owners operate their facilities efficiently, grid operators maintain electricity reliability, and tech companies stay at the forefront of AI.

There are many innovations ready to make an impact on all the areas of a data center's footprint. Five areas where we need breakthrough solutions to align AI infrastructure with climate goals include:

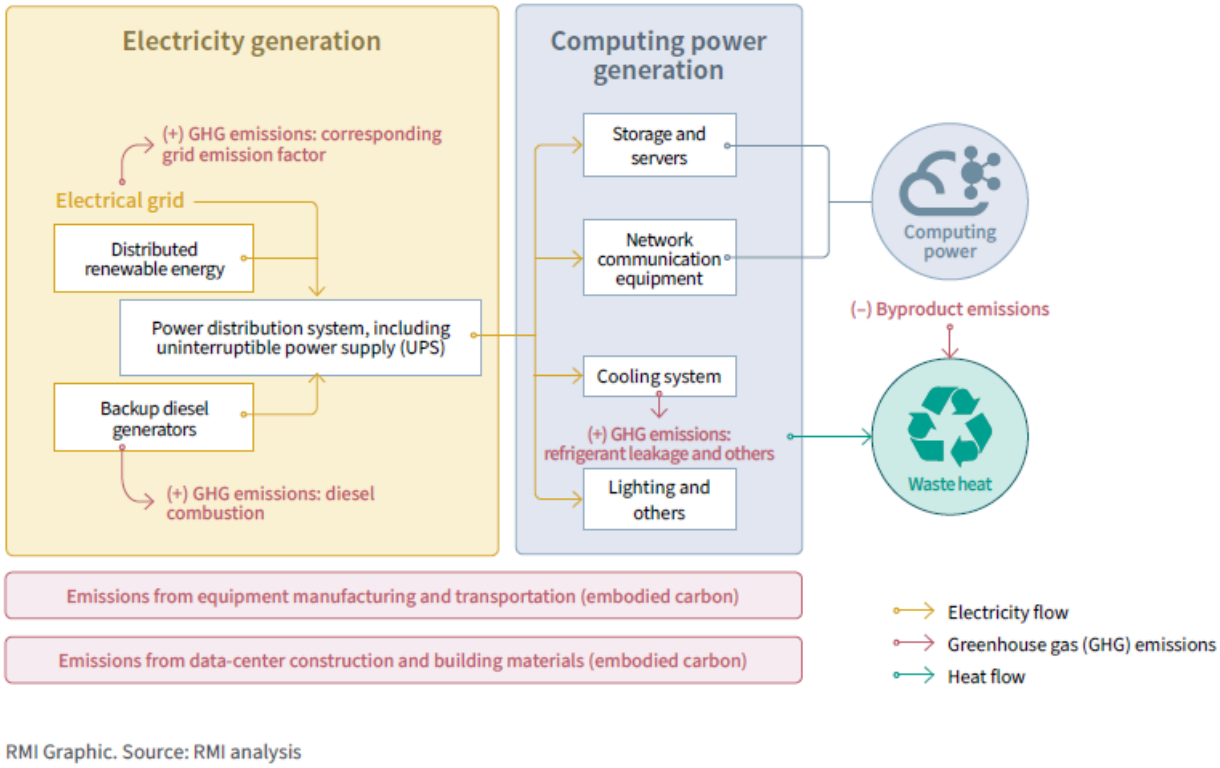
1. **Repurposing heat** to recover energy instead of wasting it
2. **Aligning operations with the electric grid** to enable flexibility and carbon-aware computing
3. **Improving cooling** to reduce water use, an overlooked stress point
4. **Siting data centers more strategically** to incorporate climate, clean energy, and environmental impact factors
5. **Designing better compute** to avoid more capacity by using hardware and software that can do more with less

Data centers are ripe for innovation in sustainability. LabStart recognizes this opportunity in its latest cohort, focusing a subset of its incoming fellows on data center sustainability innovation and offering them exclusive mentoring to develop their ideas. Read more about LabStart's Data Center Sustainability cohort in its 2025 fellowship.

[1] 2025 Requests for Proposals. Y Combinator. https://www.ycombinator.com/rfs

Innovation Areas Ready for Data Center Sustainability

Data centers are a complex system of heat, energy, electricity, and resource management. Each subsystem represents an opportunity to mitigate emissions and resource consumption. The Rocky Mountain Institute outlines the basic structure of energy management within a data center system that is then used as a framework to identify sustainability opportunity areas (Li et al.).



RMI Graphic. Source: RMI analysis

Data center energy flows, Rocky Mountain Institute (Li et al.)

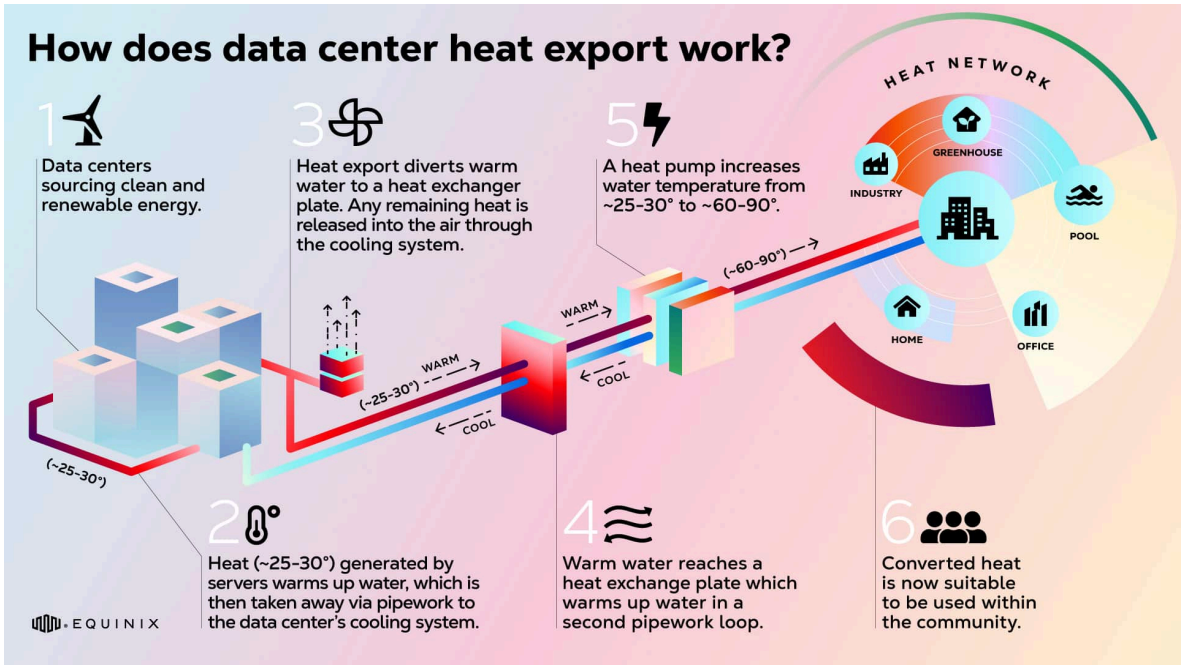
We review the five identified opportunity areas, including the startups already making them happen.

1. Repurposing heat to recover energy instead of wasting it

Data centers require energy for computing, cooling, and operations. They measure their energy use effectiveness with the power usage effective (PUE) metric, which measures how much energy is used for computing compared to used overall (total energy /

computing energy). High performing data centers can typically reach PUEs of 1.2 to 1.4x (Judge).

However, even energy used for computing ultimately is dissipated as heat energy. So, operators use the energy reuse factor (ERF) metric to define how much heat energy is reused, defined as a percentage. Microsoft has been able to reuse up to 69% of its heat in winter and 86% during summer ("Modern datacenter heat energy reuse").



Heat management of data centers (Nkonge)

Innovators are coming up with new ways to reuse heat energy and increase the ERF of a data center. Examples of innovations include:

- Deep Green places data centers next to locations with an energy demand. This colocation offers a mutual benefit, providing sites such as swimming pools with heat while providing data centers with cooling.
- Infinity Turbine is a company that turns waste heat into electrical energy. They do this by using organic rankine cycle turbines connected in a mesh configuration similar to connecting small battery cells to form a larger battery system.
- Hestiia is placing chips directly into homes to heat them while running computations. This dual-purpose use saves money and reduces maintenance.

Future advances in heat recapture could include operating servers at higher temperatures. Higher temperature heat is useful for a broader range of applications and makes for more efficient heat transfer.

Other opportunities may also lie in turning waste heat to electricity using solid state devices. Thermoelectric generators are able to turn heat into electricity via the Seebeck effect, which could avoid the mechanical operations of using the rankine cycle.

2. Aligning operations with the electric grid to enable flexibility and carbon-aware computing

Hyperscalers have high computational needs, but there is some flexibility in when computations can be completed. Operators can use this flexibility to optimize operations. Data center operators can better manage competing factors of operations by employing innovative software. Examples include:

- Verrus is building data centers that adjust to grid, carbon, and computing inputs. This flexibility is made possible with batteries that not only provide power to the data center, but also have the capability to send power back to the grid (Giacobone).
- DCFlex is an industry initiative of over 40 participants by the Electric Power Research Institute to demonstrate how data centers can serve the electric grid. It is a three-year project that covers three workstreams: data center design, utility programs, and grid planning. The initiative will carry out 10+ demonstration projects that will showcase how data centers can better integrate with the grid.

Syncing data centers with the electric grid can ensure that the data centers get the energy and interconnection they need.

3. Improving cooling to reduce water use, an overlooked stress point

U.S. data centers are estimated to consume 400 million gallons of water per day (1.7 billion litres per day = ~449 million gallons per day) (Mytton 1). Water is used for cooling, humidity control, fire suppression systems, and facility maintenance (Zhang). Data centers' high water use creates an environmental challenge when drawn from critical areas. Data centers draw 20% of their water from moderately to highly stressed water

areas (Ahmad). Water savings solutions reduce water demands and impacts on environmentally sensitive areas.

Many data center operators don't even yet measure their data centers' water use. The first step, according to Lawrence Berkeley Laboratory's best practices report, is simply for operators to start monitoring their data centers' water use.[2] The water usage effectiveness (WUE) is an underused metric to disclose a center's water use. The lab has provided best practices and recommendations for addressing data center water efficiency.

Google Data Center in The Dalles, Oregon, Releases Steam and Water into the Air (Zhang)

One of the most promising areas for water conservation is in liquid cooling. Liquid cooling offers a solution that creates a closed loop cooling system to make sure water is not wasted. It is becoming a necessity as higher performance servers required for AI create more heat (Beauvilian et al.). Examples of technologies addressing the water use problem include:

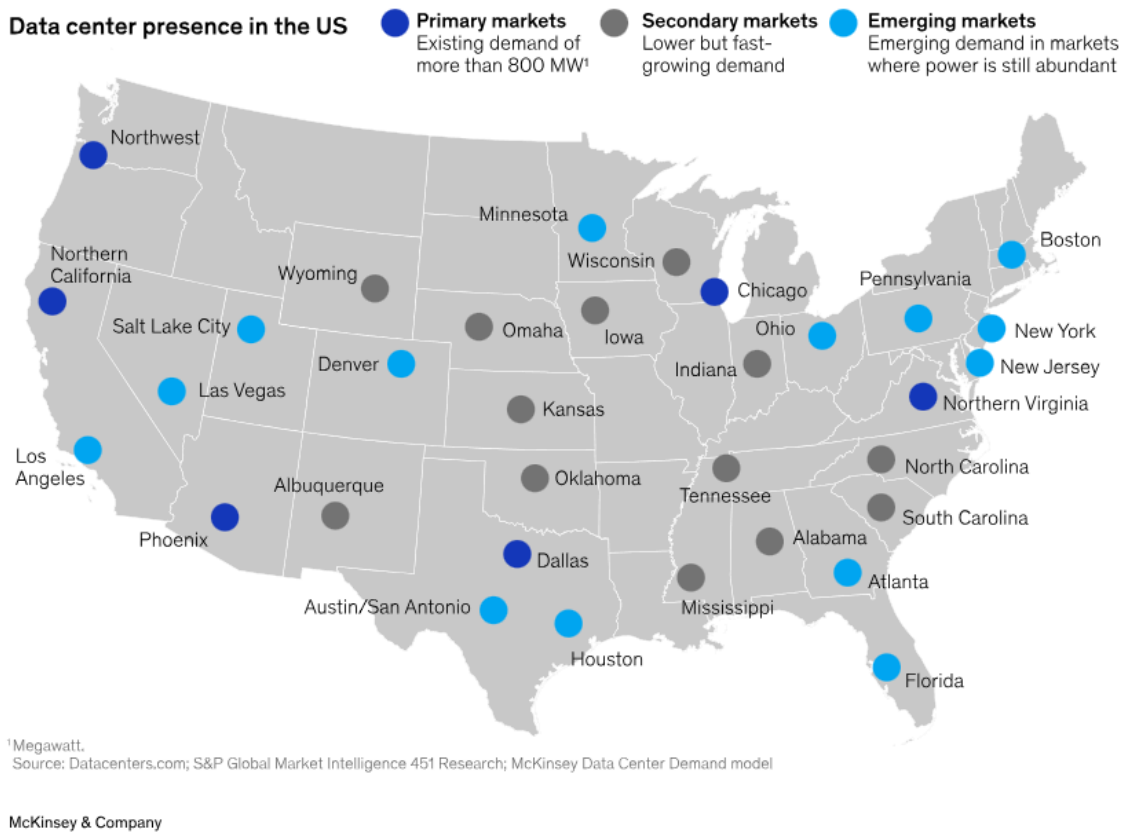
- ZutaCore has a direct-to-chip cooling technology that reduces water needs, increases performance, and decreases the carbon footprint.
- Vertiv's portfolio of cooling and computing offerings includes technologies with low-global warming potential cooling refrigerants. These advanced refrigerants ensure regulatory compliance while increasing energy efficiency in a safe and sustainable manner.

[2] *Water Efficiency*. Lawrence Berkeley National Laboratory. https://datacenters.lbl.gov/water-efficiency

The goal is not simply to use less water, but to replenish more water than consumed. Microsoft and Google have the goal to attain a net-negative water intensity by 2030 by supporting a range of water replenishment activities ("2025 Environmental Sustainability Report").

4. Siting data centers more strategically to incorporate climate, clean energy, and environmental impact factors

Data center developers face conflicting factors when deciding where to site data centers, including land availability, network connectivity, power availability, environmental conditions, seismicity, security, compliance, and talent (Ahmad). As data center growth increases, data centers will have to expand outside the traditional primary markets ("How data centers and the energy sector can sate AI's hunger for power"). These primary markets include Virginia, where the top five hyperscalers own or lease 116 data centers that are online or in development. New data centers will have to look elsewhere to meet their needs, especially their needs for resources such as power and land.



Data center hubs across the United States ("AI data center growth: Meeting the demand")

A number of companies are thinking critically about where to site data centers:

- VIRTUS has strategically placed its largest data center to use 300MW (in Phase 1) of onshore wind energy and also be close enough to the nearby city of Wustermark outside of Berlin to be able to deliver heat via a district heating network. These siting considerations will help the data center achieve net-zero emissions by 2030.
- Elementl is a nuclear project developer working with Oak Ridge National Laboratory and Google to site nuclear facilities taking into consideration data center demand ("Oak Ridge National Laboratory and Elementl Power Partner to Accelerate Siting of Nuclear-Powered Data Centers"). The project uses "multi-criteria siting framework to assess dozens of candidate locations for advanced reactor deployment across the United States—enabling faster, lower-risk project development."

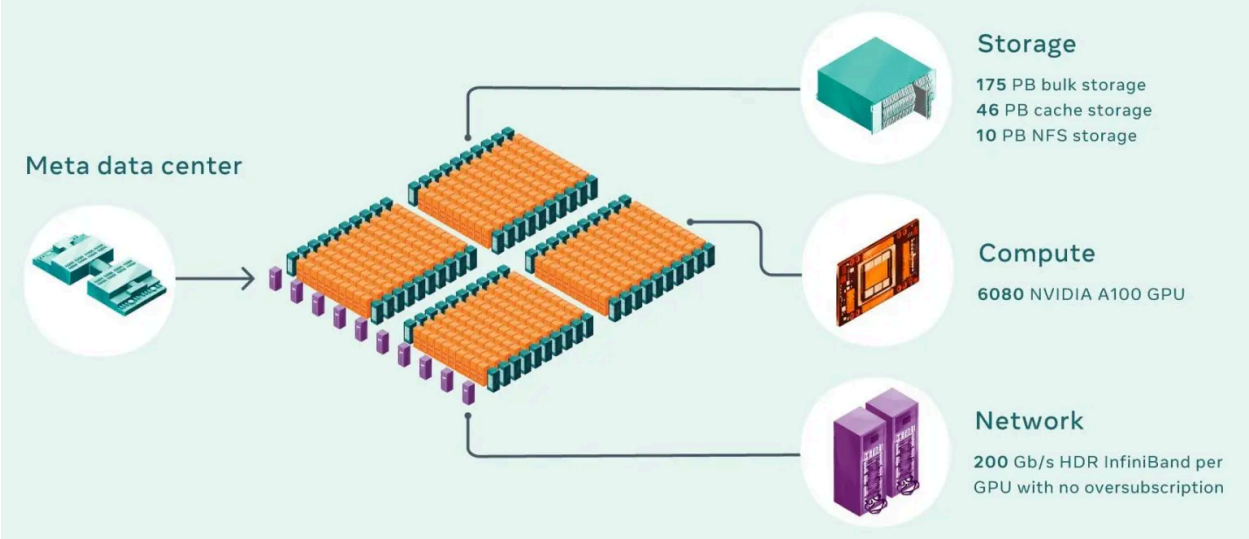
The continued dispersion of data centers and siting them in more diversified locations is feasible with the management of running them in ways that fit this location strategy. For example, smaller, on the edge data centers can meet the need for low latency computing for a region. This spread of data centers can also help alleviate the stress on grid interconnection queues in certain regions.

5. Designing better compute to avoid more capacity by using hardware and software that can do more with less

One way of reducing the resource use of data centers is to improve the hardware and software used in computation. Hardware improvements can increase the number of calculations per time and decrease the power needed for them. Software improvements can lead to models that require less training and therefore less computation time.

- Flower Labs and Vana have teamed up to create the distributed training model, Collective-1 (Knight). The model disburses the tasks across hundreds of computers, saving the need for data center computations. This approach not only uses underutilized compute resources, but also allows for a distributed, lower risk model as it is spread across more computers.
- InfiniLink is a company focused on the hardware connectivity of chips. They are using high-speed chiplets that utilize silicon and sci-photonics to increase

connection speeds of chips, which ultimately lowers the amount of resources needed. The result is lower latency and lower power needs (Jackson).



Infinity's connectivity of chips (Zhang)

Other opportunities include inferencing engines that use learning from model training in an application without needing to frequently retrain the model itself. Inference engineer techniques could reduce data center component needs by over 80% compared to standard data centers, while having the added benefit of running cooler ("Data Centers: Rapid Growth Creates Opportunities And Issues").

Conclusion

These opportunity areas cover only a part of what's possible. Microsoft details further opportunities in their Sustainable by Design blog, which also covers topics such as critical minerals. More moonshot innovative thinking includes Y Combinator investing in companies that are working on putting data centers in space or at the bottom of the ocean.

In addition, AI can be a tool to solve climate change problems. Climate Change AI is an organization composed of volunteers from academia and industry who seek to use machine learning and artificial intelligence to reduce and respond to climate change. They present ideas on how AI can address topics of mitigation, adaption, climate science, and tools for action.

LabStart recognizes that the next generation of technologies are sitting in national laboratories, at universities, or in the minds of industry professionals. We need creative and resilient innovators to help bring technologies out into the world and drive innovation forward. LabStart is supporting the next generation of innovators in energy, computing, and resource management to help ensure AI has a net-negative environmental impact. A subset of its latest cohort will be focused specifically on sustainability in data centers, receiving specialized industry mentoring and support.

Innovations in data center sustainability will be required for technology companies to deliver the promises of AI while meeting their climate commitments.

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