

Main

The Energy Cost and Environmental Effects of Artificial Intelligence

Research project done by Arabella Doetzel, Ailin Guo

John G. Diefenbaker, Grade 10

Teacher: Kata E. Mayer

Calgary Youth Science Fair 2026

Table of contents of logbook

1. Project Overview
2. Research Question
3. Problem Statement
4. Purpose
5. Hypothesis
6. Method/Research process
7. Background Research
8. Visual Data
9. Organizing/concluding research
10. Final Conclusion's
11. Limitations + Future Research Suggestions
12. Bibliography
13. Daily/weekly log entries

Project overview

This research project examines the energy consumption and environmental impacts of artificial intelligence systems. As the use of AI models continues to increase, concerns have emerged regarding the large amounts of electricity required for model training, daily operation, and data-center maintenance, which can lead to increased carbon emissions. This investigation uses a research-based approach by reviewing scientific studies, government reports, and industry sustainability data in order to explore just how much AI impacts the planet's health. The goal of the project is to evaluate whether the current growth of artificial intelligence is environmentally sustainable by identifying the key factors contributing to its environmental footprint and exploring how AI affects the different components of our planet's health.

Research question

In what ways does the increasing use of artificial intelligence impact our environment?

Problem

Artificial intelligence systems require extremely high computational power for both training and everyday use. This leads to high electricity demand and significant carbon emissions, especially when the energy is sourced from fossil fuels. As AI becomes more widely adopted, its total energy consumption is increasing rapidly, but the full environmental impact remains poorly understood. This creates uncertainty about whether current AI technologies are environmentally sustainable.

Purpose

Because the environmental impacts of artificial intelligence remains poorly understood and lacks the proper precautions of sustainability measures, we build our project for the purpose of properly studying this missing information. Through researching and analyzing scientific studies and industry data, this project aims to assess whether the current growth of AI technologies is environmentally sustainable and to identify the key factors contributing to its environmental footprint.

Hypothesis

If the usage of AI models continues to expand rapidly without proper sustainability measures, then overall energy demand and associated greenhouse gas emissions will increase, resulting in significant negative impacts on the environment.

Method/Research process

This research project was completed by reviewing existing scientific studies, official AI company reports and data graphs, and public legal documents, and backed articles on the sustainability of AI. These online resources were collected from reliable articles published by university studies and reports done by news organizations.

The following information obtained on electricity consumption, carbon emissions, pollution of water sources/nearby environments, harmful impacts on nearby human populations, and data-center energy use was identified and organized, before being compared the reported statistics and values of AI companies, AI model, and data centers. The cross-checked information was then analyzed to assess and determine the trend of AI's energy demand and environmental impact.

No experiments were performed. All conclusions were drawn from existing and official published data, statistics, measurements and studies.

Background research

Project trifold sections:

1. Background

- a. Generative ai LLMs how they work (energy/water usage)
- b. Data centers and how generative ai drive their energy consumption (electricity/water usage)

2. ENVIRONMENTAL IMPACTS (main focus)

- a. Oceans animals land
- b. Effects on soil toxicity
- c. Effects on water contaminant concentration
- d. Effects on Ecosystems (Whole web)
- e. Entry points for pollutants into environment from data centres
- f. Effects on human health nearby (noise pollutions)
- g. Supply strains

3. Conclusionary sections

- a. Sustainability---are these current regulations enough?
- b. What we can do!!!
 - i. Where different renewable energies come in
 - ii. Main solution; how can we use ai to help climate change?

Visual data

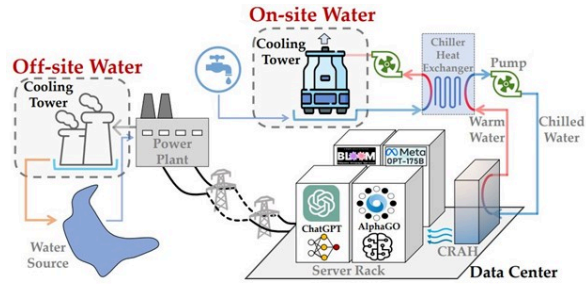
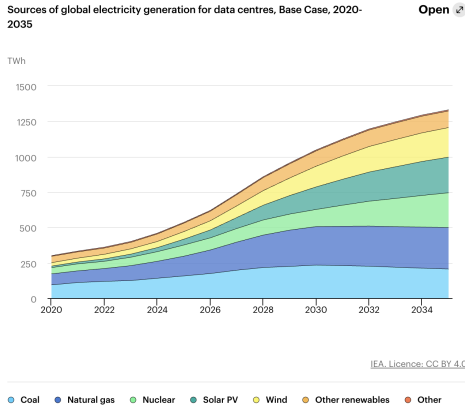


Figure 1: An example of data center's operational water usage: on-site scope-1 water for server cooling (via cooling towers in the example), and off-site scope-2 water usage for electricity generation. The icons for AI models are only for illustration purposes.

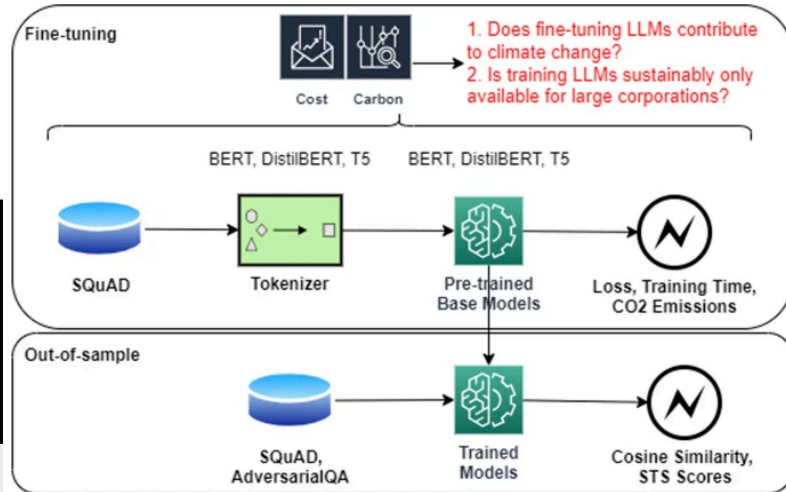
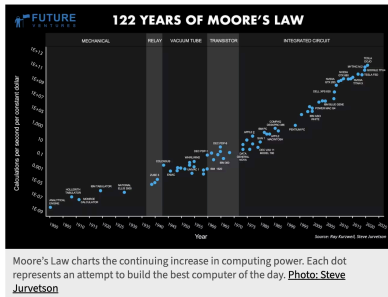
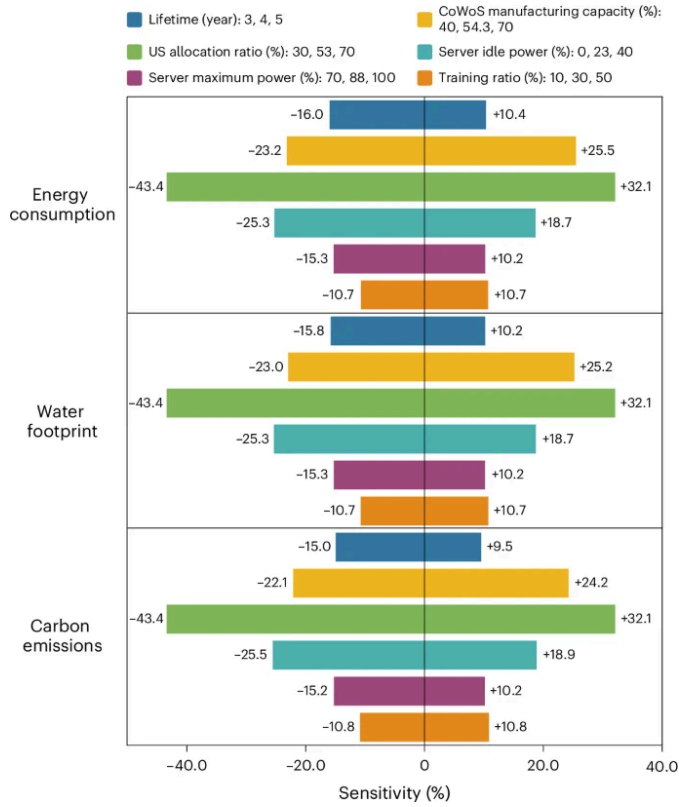
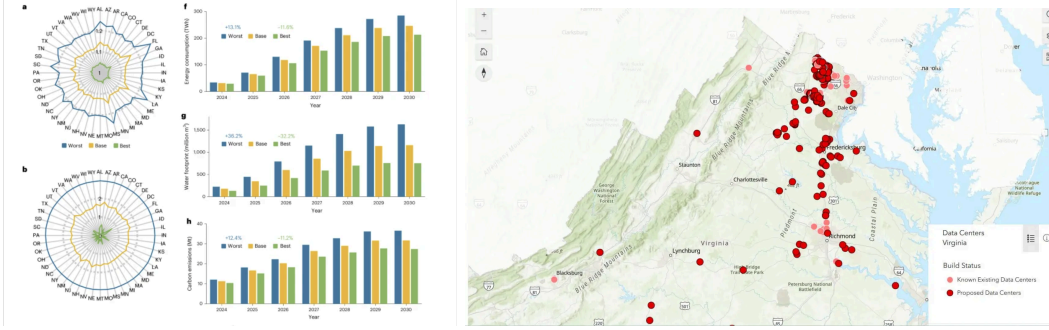


Fig. 2: Assessment of industry efforts aimed at reducing the environmental impact of AI servers.



Final conclusion

In conclusion, the information obtained from our research indicates that artificial intelligence focused data centers are currently consuming electricity and water at levels that raise extreme concerns for environmental sustainability. As AI technologies continue to expand rapidly, the energy required for model training, daily operation, and cooling systems is increasing at a significant rate. Much of this energy is still supplied by fossil fuels, contributing to rising greenhouse gas emissions and intensifying climate change. In addition, the heavy reliance on water-based cooling systems places strain on local water supplies, potentially leading to the depletion of water basins, disruptions to ecosystems, and long-term environmental damage.

Our research supports the hypothesis that if AI usage continues to grow without stronger sustainability measures, its environmental footprint will overstep sustainable limits. This could result in irreversible consequences, including increased carbon dioxide emissions, public health risks from pollution, habitat disruption, and permanent changes to wildlife migration patterns.

However, it is not too late to fix this. We have identified several possible solutions to reduce the environmental impact of AI data centers. These include the development of alternative backup power systems that rely on renewable energy sources, the implementation of hybrid and non-conductive liquid cooling technologies, the use of closed-loop cooling systems to reduce water waste, and improved noise-reduction infrastructure to limit ecosystem disruption. Additionally, increasing the use of renewable energy sources such as solar and wind power could significantly lower carbon emissions associated with AI operations.

Finally, we recommend that more comprehensive research should be completed regarding the environmental costs of AI operations and related data centers. While certain aspects of AI development are widely studied and discussed, the environmental impact of data centers and infrastructure has not received the same level of attention. Greater regulation, improved efficiency standards, and continued innovation in sustainable technology will be critical in ensuring that artificial intelligence develops in a way that benefits society without causing long-term harm to the planet.

Overall, artificial intelligence has the potential to drive progress and innovation, but its growth must be balanced with responsible environmental stewardship. Sustainable development practices will determine whether AI becomes a tool for positive change or a significant environmental challenge for future generations.

Limitations + Future Research Suggestions

hmm

Bibliography:

All references/articles used must be listed in the proper format

APA 7 (Author/organization. (date published). *Title of the article*. website name. (URL)

Adam Zewe (January 17, 2025) *Explained: Generative AI's environmental impact*.

news.mit.edu

<https://news.mit.edu/2025/explained-generative-ai-environmental-impact-0117>

Climate impact partners (October 28, 2025) *The Carbon Footprint of AI*

[climateimpact.com](https://www.climateimpact.com)

<https://www.climateimpact.com/news-insights/insights/carbon-footprint-of-ai/>

contact@uasdf.org, U. S.-A. S. D. F., *1Cambridge, MA, USA*Corresponding author. Email:, & Tong, Y. (March 7,2025) *White Paper on Global Artificial Intelligence Environmental Impact . AI and Sustainability*.

ai-sustainability.pubpub.org

<https://ai-sustainability.pubpub.org/pub/fz5j9nzu>

Hanley, Steve (2 Dec, 2025) *Massive Data Centers May Make Groundwater Pollution Worse*.

cleantechnica.com.

<https://cleantechnica.com/2025/12/02/massive-data-centers-may-make-groundwater-pollution-worse/>

International Energy Agency (April 10, 2025) *Energy and AI*

[iea.org](https://www.iea.org)

<https://www.iea.org/reports/energy-and-ai/energy-supply-for-ai>

International Energy Agency. (April, 2025) *Energy supply for AI*

[iea.org](https://www.iea.org).

<https://www.iea.org/reports/energy-and-ai/energy-supply-for-ai>

José Pablo Ortiz Partida (June 25, 2025) *What Are the Environmental Impacts of Artificial Intelligence?*

blog.uscs.org

<https://blog.uscs.org/pablo-ortiz/what-are-the-environmental-impacts-of-artificial-intelligence/>

https://news.cornell.edu/stories/2025/11/roadmap-shows-environmental-impact-ai-data-center-bloom?utm_source=chatgpt.com

Liou, Joanne (13 Dec, 2023) *What are Small Modular Reactors (SMRs)?*

[iaea.org](https://www.iaea.org)

<https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs>

Miguel Yañez-Barnuevo (June 25, 2025) *Data Centers and Water Consumption*
[eesi.org](https://www.eesi.org)
<https://www.eesi.org/articles/view/data-centers-and-water-consumption>

Pengfei Li, Jianyi Yang, Mohammad A. Islam, Shaolei Ren (March 26, 2025) *Making AI Less “Thirsty”: Uncovering and Addressing the Secret Water Footprint of AI Models*
arxiv.org
<https://arxiv.org/pdf/2304.03271>

Peng Gao and Yu Tao (5 July, 2025) *Global data center expansion and human health: A call for empirical research*
[sciencedirect.com](https://www.sciencedirect.com)
<https://www.sciencedirect.com/science/article/pii/S2772985025000262>

Renee Cho (June 9, 2023) *AI’s Growing Carbon Footprint*
www.climate.columbia.edu
<https://news.climate.columbia.edu/2023/06/09/ais-growing-carbon-footprint/>

Richardson, Kelly (3 Dec, 2024) *Understanding the impact of data center noise pollution.*
[techtarget.com](https://www.techtarget.com).
<https://www.techtarget.com/searchdatacenter/tip/Understanding-the-impact-of-data-center-noise-pollution>

Tianqi Xiao, Francesco Fuso Nerini, H. Damon Matthews, Massimo Tavoni & Fengqi You (November 10, 2025) *Environmental impact and net-zero pathways for sustainable artificial intelligence servers in the USA*
[nature.com](https://www.nature.com)
<https://www.nature.com/articles/s41893-025-01681-y>

Vivian Liu and Yiqiao Yin (July 8, 2024) *Green AI: exploring carbon footprints, mitigation strategies, and trade offs in large language model training*
[hlink.springer.com](https://link.springer.com)
<https://link.springer.com/article/10.1007/s44163-024-00149-w>

Vancouver Island Water Watch Coalition (November 4, 2025) *Artificial intelligence (AI) infrastructure, particularly the data centres required to power it, poses several contamination risks in Canada through its intense use of water, massive energy consumption, and contribution to electronic waste*
[vancouverislandwaterwatchcoalition.ca](https://www.vancouverislandwaterwatchcoalition.ca)
https://www.vancouverislandwaterwatchcoalition.ca/artificial-intelligence-ai-infrastructure-particularly-the-data-centres-required-to-power-it-poses-several-contamination-risks-in-canada-through-its-intense-use-of-water-massive-energy-consumption/?utm_source=chatgpt.com

Log entries: Month/day/year

11/29/2025: Project approved

11/30/2025: Started basic draft of the problem statement and basic method outline

12/4/2025: Edits to method formula

12/6/2025: Organized logbook by creating a chronological order of different sections, created hypothesis

12/15/2025: Drafted the project overview paragraph

12/22/2025: Drafted the research question and the project's purpose while refining the hypothesis and project overview

12/27/2025: Began looking for reliable sources to derive information from such as university articles and studies on how hungry AI really is. Began organizing research tables. Began deriving and analyzing provided info on articles on data centers. Researched the relationship between data centres with energy consumption and what energy is being generated and CO2 releases. Nuclear energy generative alternatives.

12/29/2025: researched from MIT article about how much power data centers use because of generative ai, obtained clear and well estimated numbers such as how much energy ai uses

12/30/2025: Through the article by climate impact partners; obtained the different factors that AI contributes to damaging our environment such as resource extraction, land use, model size, algorithm complexities and the efficiency of data centers

12/31/2025: read through old article from 2023 (before GPT-5 and the numbers of GPT-4 were unknown then) by columbia climate school on how language models work, article also made predictions for the future and we have analyzed how these predictions were right or not, this article also explored several ways of how AI can HELP combat climate change.

1/2/2026: Read a case report on worsening health complications from pollution, and the possible correlation with new data centres in the area.

1/3/2026: Narrowed down and refined research points and how we aim for it to fit together on the final product. Read an Article of why Empirical research is required for data centres (reasons).

1/30/2026: Read an article on noise pollution generated by Data centres, the impacts, and possible solutions. I worked on APA citation building.

2/6/2026: worked on laying out info for thingy mc bobber

2/8/2026: worker more on info inlaying. Started reading an article on AI data centres in relation to land policy and impact.

2/14/2026: began making comparisons between different ai models and company brands

2/16/2026: read an article about a roadmap on environmental effects through ai data centers

2/22/2026: worked on revising, reviewing, and comparing research as well as translating it over to the CYSF website from the Log book document.

2/23/2026: More comparisons and reviewing extra articles. Organization onto the CYSF platform.

3/1/2026: completion of CYSF platform

2/26/2026: trifolds acquired

3/4/2026: Starting plans for physical presentation

Research

Format

Source:	Credibility:
Synopsis	Summary: Parties: Time range and location:
Direct quotes we can use	
Data	
	topics
Energy and water usage (any kind of numbers)	
sustainability	
Legal & governmental	
Leakage/environmental impact	

	<p>Source: Data Centers and Water Consumption Article EESI FOCUSES ON DATA CENTERS (not much ai) Environmental and Energy Study Institute (EESI) by Miguel Yañez-Barnuevo June 25, 2025</p>
Synopsis	<ul style="list-style-type: none"> • explores how water use is tied to data centers including the same data centers that serve AI. • cooling systems used for high-performance computing and AI workloads and provides reliable numbers taken from other official studies (such as the Washington post or university studies) to show how these data centers consume huge amounts of water daily • It also provides a real world effect that large consumptions of water can cause within the region • highlights Water Usage Effectiveness (WUE) as a key metric for assessing data center water efficiency and notes potential environmental stress on local freshwater resources, particularly in water-scarce regions. • In the end of the article, it also suggests alternatives for cooling computers such as Closed-loop cooling systems, free cooling, air cooling, immersion cooling and also bringing up the idea of powering data centers with renewable energy.
Direct quotes we can use	<p>“Collectively, all data centers in Northern Virginia consumed close to 2 billion gallons of water in 2023, a 63% increase from 2019. Loudoun County, with approximately 200 operational data centers, used around 900 million gallons of water in 2023” “Approximately 80% of the water (typically freshwater) withdrawn by data centers evaporates, with the remaining water discharged to municipal wastewater facilities. The</p>

	<p>large volume of wastewater from data centers may overwhelm existing local facilities, which were not designed to handle such a high volume.”</p> <p>“A medium-sized data center can consume up to roughly 110 million gallons of water per year for cooling purposes, equivalent to the annual water usage of approximately 1,000 households. Larger data centers can each “drink” up to 5 million gallons per day, or about 1.8 billion annually, usage equivalent to a town of 10,000 to 50,000 people. Together, the nation’s 5,426 data centers consume billions of gallons of water annually. One report estimated that U.S. data centers consume 449 million gallons of water per day and 163.7 billion gallons annually (as of 2021). A 2016 report found that fewer than one-third of data center operators track water consumption.”</p> <p>“According to scientists at the University of California, Riverside, each 100-word AI prompt is estimated to use roughly one bottle of water (or 519 milliliters). This may not sound like much, but billions of AI users worldwide enter prompts into systems like ChatGPT every minute.”</p>
Energy and water usage	<p>medium-sized data center can consume up to roughly 110 million gallons of water https://www.npr.org/2022/08/30/1119938708/data-centers-backbone-of-the-digital-economy-face-water-scarcity-and-climate-ris)</p> <p>Larger data centers can each “drink” up to 5 million gallons per day, or about 1.8 billion annually, usage equivalent to a town of 10,000 to 50,000 people. https://www.washingtonpost.com/climate-environment/2023/04/25/data-centers-drought-water-use/)</p> <p>According to scientists at the University of California, Riverside, each 100-word AI prompt is estimated to use roughly one bottle of water (or 519 milliliters). https://www.washingtonpost.com/technology/2024/09/18/energy-ai-use-electricity-water-data-centers/)</p> <p>Approximately 80% of the water (typically freshwater) withdrawn by data centers evaporates https://arxiv.org/pdf/2304.03271)</p> <p>56% of the electricity used to power data centers nationwide comes from fossil fuels, a significant portion of data center water consumption is derived from steam-generating power plants https://arxiv.org/pdf/2411.09786)</p> <p>As data centers are expected to consume up to 1,050 TWh annually by 2030, water usage will increase in parallel. https://www.eesi.org/articles/view/data-center-energy-needs-are-upending-power-grids-and-threatening-the-climate)</p> <p>Collectively, all data centers in Northern Virginia consumed close to 2 billion gallons of water in 2023, a 63% increase from 2019. Loudoun County, with approximately 200 operational data centers, used around 900 million gallons of water in 2023. https://www.ft.com/content/1d468bd2-6712-4cdd-ac71-21e0ace2d048 and https://vcnva.org/agenda-item/responsible-data-center-development/)</p>
sustainability	<p>This article concludes that because data centers consume such large amounts of water, it creates high sustainability concerns. It also explains how because data centers lose so much due to evaporation and are not returned to local ecosystems, our current operations will not be environmentally safe in the future. The article also suggests alternative cooling systems for water recycling within facilities and alternative power sources for these facilities such as:</p> <p>“Closed-loop cooling systems enable the reuse of both recycled wastewater and freshwater, allowing water supplies to be used multiple times. A cooling tower can use external air to cool the heated water, allowing it to return to its original temperature. These systems can reduce freshwater use by up to 70%.</p>

	<p>Free cooling is a method where outside cold air is drawn into the data center to cool the equipment. Data centers must be located in cooler climates for this strategy to be effective.</p> <p>Air cooling involves air conditioning vents and tubes that remove heat generated by chips as they process data and AI requests. This method is most effective in areas where electricity is cheaper and water resources are limited.</p> <p>Immersion cooling in data centers involves bathing servers, chips, and other components in a specialized dielectric (or non-conductive) fluid. Hardware is submerged in specially designed tanks filled with the coolant. The non-conductive liquid absorbs the heat from the chips and transfers it to a heat exchanger, where it is cooled down before flowing back into the tank. Immersion cooling is a novel process that entails higher upfront costs than conventional direct liquid cooling, but provides significant energy savings and space-optimization benefits for data center developers. Since the technology uses synthetic fluids, it requires significantly less water than other approaches.”</p> <p>But, the article still emphasizes that these measures are not yet sufficient to fully offset the environmental impacts caused by rapid growth in data center workloads.</p>
--	--

	<p>Source: Explained: Generative AI's environmental impact MIT News Massachusetts Institute of Technology “rapid development generative AI comes with environmental consequences” by MIT news, Adam Zewe published on January 17, 2025.</p>
<p>Synopsis</p>	<ul style="list-style-type: none"> ● AI drives the energy consumed by data centers and how this power usage has grown exponentially over the years from 2021/2022. ● focus the extreme amounts of energy AI has used by showing numbers of how training AI alone takes tons of energy and produces loads of CO2. The article also mentions the fact that building AI needs loads of raw materials that can ALSO harm the environment through trying to obtain these minerals/metals. <p>(Numbers are mostly provided through other research studies and a reliable lead author of the impact paper, who is a Computing and Climate Impact Fellow at MIT Climate and Sustainability Consortium (MCSC) and a postdoc in the Computer Science and Artificial Intelligence Laboratory (CSAIL), Noman Bashir.</p>
<p>Direct quotes we can use</p>	<p>“When we think about the environmental impact of generative AI, it is not just the electricity you consume when you plug the computer in. There are much broader consequences that go out to a system level and persist based on actions that we take,” says Elsa A. Olivetti, professor in the Department of Materials Science and Engineering and the lead of the Decarbonization Mission of MIT’s new Climate Project.</p> <p>A data center is a temperature-controlled building that houses computing infrastructure, such as servers, data storage drives, and network equipment. For instance, Amazon has more than 100 data centers worldwide, each of which has about 50,000 servers that the company uses to support cloud computing services.</p> <p>“...generative AI training cluster might consume seven or eight times more energy than a typical computing workload,” says Noman Bashir, lead author of the impact paper, who is a Computing and Climate Impact Fellow at MIT Climate and Sustainability Consortium (MCSC) and a postdoc in the Computer Science and Artificial Intelligence Laboratory (CSAIL).</p> <p>Scientists have estimated that the power requirements of data centers in North America increased from 2,688 megawatts at the end of 2022 to 5,341 megawatts at the end of</p>

2023, partly driven by the demands of generative AI. Globally, the electricity consumption of data centers rose to 460 terawatt-hours in 2022. This would have made data centers the 11th largest electricity consumer in the world, between the nations of Saudi Arabia (371 terawatt-hours) and France (463 terawatt-hours), according to the Organization for Economic Co-operation and Development.

By 2026, the electricity consumption of data centers is expected to approach 1,050 terawatt-hours (which would bump data centers up to fifth place on the global list, between Japan and Russia).

In a 2021 research paper, scientists from Google and the University of California at Berkeley estimated the training process alone consumed 1,287 megawatt hours of electricity (enough to power about 120 average U.S. homes for a year), generating about 552 tons of carbon dioxide.

Power grid operators must have a way to absorb those fluctuations to protect the grid, and they usually employ diesel-based generators for that task.

ChatGPT query consumes about five times more electricity than a simple web search.

“But an everyday user doesn’t think too much about that,” says Bashir. “The ease-of-use of generative AI interfaces and the lack of information about the environmental impacts of my actions means that, as a user, I don’t have much incentive to cut back on my use of generative AI.”

Plus, generative AI models have an especially short shelf-life, driven by rising demand for new AI applications. Companies release new models every few weeks, so the energy used to train prior versions goes to waste, Bashir adds. New models often consume more energy for training, since they usually have more parameters than their predecessors.

A GPU’s carbon footprint is compounded by the emissions related to material and product transport.

There are also environmental implications of obtaining the raw materials used to fabricate GPUs, which can involve dirty mining procedures and the use of toxic chemicals for processing.

Market research firm TechInsights estimates that the three major producers (NVIDIA, AMD, and Intel) shipped 3.85 million GPUs to data centers in 2023, up from about 2.67 million in 2022. That number is expected to have increased by an even greater percentage in 2024.

“Due to the speed at which there have been improvements, we haven’t had a chance to catch up with our abilities to measure and understand the tradeoffs,” Olivetti says

Energy and water usage

- Data centers power usage grew from 2688 megawatts at the end of 2022 to 5341 megawatts at the end of 2023
- Globally data centers power usage grew to 460 terawatt-hours in 2022
 - Made data centers the 11th largest electricity consumer in the world (more than saudi arabia!!)
- Consumption predicted to reach 1050 terawatt-hours by 2025 (more than russia/japan)
- 2021 research paper from google and u of cali estimated AI training alone used 1287 megawatt hours of electricity -- enough to power 120 average US homes for a year --- and generated about 552 tons of carbon dioxide
- kilowatt hour of energy a data center consumes, it would need two liters of water

	<p>for cooling</p> <ul style="list-style-type: none"> Market research firm TechInsights estimates that the three major producers (NVIDIA, AMD, and Intel) shipped 3.85 million GPUs to data centers in 2023, up from about 2.67 million in 2022. That number is expected to have increased by an even greater percentage in 2024.
sustainability	<ul style="list-style-type: none"> Article addresses sustainability by: <ul style="list-style-type: none"> Industry is still on unsustainable oath We need to carefully study/research environmental/societal costs of AI vs the value of the benefits of AI “Due to the speed at which there have been improvements, we haven’t had a chance to catch up with our abilities to measure and understand the tradeoffs,” Olivetti says

	<p>Source: The Carbon Footprint of AI Climate Impact Partners October 25, 2025</p>
Synopsis	<ul style="list-style-type: none"> Climate impact partners: An organization that creates projects that help reduce the release of CO2 through things like improved cookware, water purification and forest restoration. Their trusted team and reliable members work with leading global companies and governments. <p>Climate impact partners research on the carbon footprint of AI through power/energy demand, water use, habitat/land disruption. Suggests ways that we can make AI greener with more environmentally based factors.</p>
Direct quotes we can use	
AI’s contribution to the damage of the environment through carbon footprint and more	<ul style="list-style-type: none"> Training AI: It involves feeding enormous datasets into algorithms and letting them “learn” patterns over many cycles of computation Training large AI models such as Large Language models (LLMs) and generative AI systems is where most of the energy gets used They take so much energy because they require large data centers packed with GPU’s and TPU’s (made of hard to mine raw materials) that work without rest and consumes energy that come mostly from non-renewable sources AI systems still require power even after it has been deployed and trained <ul style="list-style-type: none"> Power is used every time you send a message/prompt or generate an image Factors that affect how much carbon emissions AI produces: <ul style="list-style-type: none"> Algorithm complexity: <ul style="list-style-type: none"> AI training requires heavier computation than others. A more complex algorithm can mean more cycles, more servers, more energy. Model size: <ul style="list-style-type: none"> The size of the dataset and the number of model parameters directly affect training time and energy use. GPT-5, for example, is orders of magnitude larger than models from just a few years ago. Data center efficiency: <ul style="list-style-type: none"> Not all server farms are created equal. A data center powered by Icelandic geothermal energy has a much smaller footprint than one powered by coal in West Virginia. Cooling systems and energy efficiency make a difference too. Hardware and infrastructure: <ul style="list-style-type: none"> Specialized chips like TPUs are designed to accelerate AI training

more efficiently than general-purpose hardware. As hardware improves, the energy cost per calculation drops—but overall demand keeps rising. (the mining of these materials can also damage the environment)

- How AI affects the environment beyond carbon footprint:
 - Water use
 - Data centers require HUGE amounts of water for cooling; can put a strain on the region's already scarce water source
 - Electronic waste
 - AI relies on specialized hardware with relatively short lifespans like GPUs, TPUs, and high-performance servers
 - Frequent upgrades and disposal of these devices create large amounts of e-waste
 - difficult to recycle
 - may release harmful chemicals into the environment
 - Resource extraction
 - Manufacturing AI hardware requires mining metals such as:
 - lithium
 - cobalt
 - and rare earth elements.
 - These extraction processes contributes to long term ecological harm:
 - habitat destruction
 - water pollution
 - soil degradation
 - Land use
 - Building large-scale AI data centers requires significant land and maintenance of these facilities that disrupts
 - natural habitats
 - local biodiversity
 - local landscapes
 - contribute to urbanization pressures

Energy and water usage

Training a single large model like GPT-3 can use over 1,200 MWh - enough electricity to power around 120 U.S. homes for a year. And that is just for training the model. More energy is consumed every time someone submits a query.

For perspective, the International Energy Agency (IEA) estimates that global data center electricity demand will nearly double by 2030, driven largely by AI workloads.

As just one illustrative example of the CO₂ consumption of AI, researchers estimated that training GPT-3 emitted roughly 500 metric tons of carbon dioxide (CO₂)—the equivalent of driving a car from New York to San Francisco about 438 times.

Many tech companies do not publicly disclose the carbon costs of their models, and reporting is currently voluntary, not mandated. This lack of transparency means we have only snapshots from research studies or occasional disclosures—not a full picture of AI's environmental impact.

Data centers currently consume about 1–2% of global electricity. Of that, AI is responsible for about 15%.

Energy demand will double by 2030 because of AI.

about 17.5 billion gallons of fresh water was consumed directly by U.S. data centers in 2023. This is approximately equivalent to 26,500 Olympic-size swimming pools, or the

annual water use of a mid-sized American city such as South Bend, Indiana or Fort Collins, Colorado

sustainability

- Sustainability initiatives:
 - AI companies going green (These tech giants are illustrating the operational reality that data centers are massive energy sinks):
 - Google has committed to running entirely on carbon-free energy by 2030.
 - Microsoft has pledged to become carbon negative by 2030
 - Amazon is investing billions in renewable projects
 - Efficient algorithms:
 - Researchers are exploring ways to design algorithms that achieve the same performance with less computation. “Green AI” is a growing movement focused on balancing accuracy with efficiency.
 - AI for good:
 - Ironically, AI can also help solve the very climate problem it contributes to
 - For example: AI is being used to optimize power grids for renewable energy, predict wildfires, monitor deforestation, and model future climate change scenarios. It’s even helping design new materials for batteries and carbon capture. In this sense, AI is both part of the problem and part of the solution.
 - Carbon credits:
 - Many AI companies are now exploring carbon credits as a way to offset the emissions generated by their models. By purchasing verified credits, they can support projects that reduce or remove CO₂ from the atmosphere, helping to balance out the carbon footprint of AI training and operation while continuing to innovate
- Individuals can also help reduce by:
 - Choose the right companies with the right goals, transparent about their power usage
 - Support new policies that push for greener AI like government regulations and research programs on sustainable AI
 - Choose the right AI models
 - Running GPT-5, a massive large language model, to summarize a few emails is like using a jet engine to power a bicycle. In many cases, smaller models like GPT-2, which are designed to be lighter and more efficient, can deliver similar results with a fraction of the energy use.
- Developments and incentives we can take:
 - Better hardware
 - Chips designed specifically for AI are getting more energy efficient every year.
 - Greener data centers
 - Using renewable energy sources and creating better ways to cool computers using better water recycling within the facility
 - Smarter algorithms
 - Streamlined large language models that use less training data to reduce energy consumption without losing performance
 - Quantum computing
 - More efficient than traditional binary computing

Source: [AI's Growing Carbon Footprint – State of the Planet](#)

Synopsis	<ul style="list-style-type: none">• Short explanation on how LLM's work and suggests a variety of solutions on how to make AI greener
Direct quotes we can use	
LLM's	<p>LLM's are powerful learning systems trained to understand and respond to human-like text</p> <ul style="list-style-type: none">• Training:<ul style="list-style-type: none">○ Exposing the ai model to huge amounts of data with billions of words (can come from the internet such as articles, books, social media and etc)○ AI eventually learns how to identify patterns and relationships in the given data and weighs the different features in the data to accomplish the given task○ Parameters: internal settings that it learns from the data which represent the relationships between different words and are used to make predictions○ To process and analyze the vast amounts of data, large language models need tens of thousands of advanced high-performance chips for training and, once trained, for making predictions about new data and responding to queries<ul style="list-style-type: none">■ Graphics processing units (GPUs), specialized electronic circuits, are typically used because they can execute many calculations or processes simultaneously; they also consume more power than many other kinds of chips.○ AI mostly takes place in the cloud—servers, databases, and software that are accessible over the internet via remote data centers. The cloud can store the vast amounts of data AI needs for training and provide a platform to deploy the trained AI models.
Water and energy usage	<p>Each generation of large language models has many more parameters than the previous one; the more parameters, the more accurate and flexible they can be. In 2018, a large language model had 100 million parameters. GPT-2, launched in 2019, had 1.5 billion parameters; GPT-3 at 100 times larger, had 175 billion parameters; no one knows how large GPT-4 is. Google's PaLM large language model, which is much more powerful than Bard, had 540 billion parameters.</p> <p>training a single AI model can emit over 626,000 pounds of CO2, equivalent to the emissions of five cars over their lifetimes.</p> <p>A more recent study reported that training GPT-3 with 175 billion parameters consumed 1287 MWh of electricity, and resulted in carbon emissions of 502 metric tons of carbon, equivalent to driving 112 gasoline powered cars for a year.</p> <p>Once models are deployed, inference—the mode where the AI makes predictions about new data and responds to queries—may consume even more energy than training. Google estimated that of the energy used in AI for training and inference, 60 percent goes towards inference, and 40 percent for training. GPT-3's daily carbon footprint was been estimated to be equivalent to 50 pounds of CO2 or 8.4 tons of CO2 in a year.</p> <p>single request in ChatGPT can consume 100 times more energy than one Google search, according to one tech expert.</p>

	<p>the training of AI startup Hugging Face’s large language model BLOOM with 176 billion parameters consumed 433 MWh of electricity, resulting in 25 metric tons of CO2 equivalent. It was trained on a French supercomputer run mainly on nuclear energy. Compare this to the training of GPT-3 with 175 billion parameters, which consumed 1287 MWh of electricity, and resulted in carbon emissions of 502 metric tons of carbon dioxide equivalent.</p> <p>2.5 to 3.7 percent of global greenhouse gas emissions, exceeding even those of the aviation industry.</p> <p>In 2021, global data center electricity use was about 0.9 to 1.3 percent of global electricity demand.</p> <p>One study estimated it could increase to 1.86 percent by 2030.</p> <p>As the capabilities and complexity of AI models rapidly increase over the next few years, their processing and energy consumption needs will too.</p> <p>One research company predicted that by 2028, there will be a four-fold improvement in computing performance, and a 50-fold increase in processing workloads due to increased use, more demanding queries, and more sophisticated models with many more parameters.</p> <p>It’s estimated that the energy consumption of data centers on the European continent will grow 28 percent by 2030.</p> <p>Experts say this could increase the computing power needed—as well as the energy used—by up to five times per search.</p> <p>the training of AI startup Hugging Face’s large language model BLOOM with 176 billion parameters consumed 433 MWh of electricity, resulting in 25 metric tons of CO2 equivalent. It was trained on a French supercomputer run mainly on nuclear energy. Compare this to the training of GPT-3 with 175 billion parameters, which consumed 1287 MWh of electricity, and resulted in carbon emissions of 502 metric tons of carbon dioxide equivalent</p>
sustainability	<p>How can AI be made greener?</p> <ul style="list-style-type: none"> ● Renewable energy use <ul style="list-style-type: none"> ○ ● Better management of computers <ul style="list-style-type: none"> ○ ● More efficient hardware <ul style="list-style-type: none"> ○ ● The right algorithms <ul style="list-style-type: none"> ○ ● The appropriate model <ul style="list-style-type: none"> ○ ● Modifying the models <ul style="list-style-type: none"> ○ ● New cooling methods <ul style="list-style-type: none"> ○ ● Government support for sustainable AI <ul style="list-style-type: none"> ○
How AI can HELP combat climate change	<ul style="list-style-type: none"> ● Can narrow down and predict uncertainties in the climate systems ● Improve climate models ● Help businesses anticipate disruptions due to climate change ● Can use ai to develop stronger/lighter materials <ul style="list-style-type: none"> ○ Making wind turbines/aircrafts more efficient = consuming less energy ● can design new materials that use less resources, enhance battery storage, or improve carbon capture

	<ul style="list-style-type: none"> • manage electricity from a variety of renewable energy sources • monitor energy consumption • identify opportunities for increased efficiency in smart grids, power plants, supply chains, and manufacturing • AI systems can detect and predict methane leaks from pipelines • monitor floods, deforestation, and illegal fishing in almost real time • agriculture more sustainable by analyzing images of crops to determine where there might be nutrition, pest, or disease problems • AI robots have been used to collect data in the Arctic when it is too cold for humans or conduct research in the oceans
Comparisons between the past (when this article was written) vs the present	<p>Northeastern University and MIT researchers estimated that inference consumes more energy than training, but there is still debate over which mode is the greater energy consumer. What is certain, though, is that as OpenAI, Google, Microsoft, and the Chinese search company Baidu compete to create larger, more sophisticated models, and as more people use them, their carbon footprints will grow. This could potentially make decarbonizing our societies much more difficult.</p> <p>Microsoft is committed to running on 100 percent renewable energy by 2025, and has long-term contracts for green energy for many of its data centers, buildings, and campuses. Google's data centers already get 100 percent of their energy from renewable sources.</p>

	<p>Source: Making AI Less “Thirsty”: Uncovering and Addressing the Secret Water Footprint of AI Models</p> <p>March 26, 2025 -Pengfei Li; UC Riverside -Jianyi Yang; UC Riverside -Mohammad A. Islam; UT Arlington -Shaolei Ren; UC Riverside</p>
Synopsis	
Direct quotes we can use	
Energy and water usage	
sustainability	

	<p>‘Roadmap’ shows the environmental impact of AI data center boom Cornell Chronicle Cornell university: David Nutt, November 15, 2025</p>
Synopsis	<p>Mainly a summary on the research study paper: https://www.nature.com/articles/s41893-025-01681-y</p>
Extra info	<p>Many current data clusters are being constructed in water-scarce regions, such as Nevada and Arizona. And in some hubs, for example northern Virginia, rapid clustering can strain local infrastructure and water resources. Locating facilities in regions with lower water-stress and improving cooling efficiency could slash water demands by about 52%, and when combined with grid and operational best practices, total water reductions could reach 86%, the study found. The Midwest and “windbelt” states – particularly Texas, Montana, Nebraska and South Dakota – would deliver the best combined carbon-and-water profile.</p>

Direct quotes we can use	
Energy and water usage	<p>by 2030, the current rate of AI growth would annually put 24 to 44 million metric tons of carbon dioxide into the atmosphere, the emissions equivalent of adding 5 to 10 million cars to U.S. roadways. It would also drain 731 to 1,125 million cubic meters of water per year – equal to the annual household water usage of 6 to 10 million Americans. The cumulative effect would put the AI industry’s net-zero emissions targets out of reach.</p> <p>If decarbonization does not catch up with the computing demand, emissions could rise roughly 20%.</p> <p>However, decarbonizing the grid can only do so much. Even in the ambitious high-renewables scenario, by 2030 carbon dioxide would drop roughly 15% compared to the baseline, and approximately 11 million tons of residual emissions would remain, requiring roughly 28 gigawatts of wind or 43 gigawatts of solar capacity to reach net-zero.</p>

	<p>Artificial intelligence (AI) infrastructure, particularly the data centres required to power it, poses several contamination risks in Canada through its intense use of water, massive energy consumption, and contribution to electronic waste Vancouver Island Water Watch Coalition: November 4, 2025</p>
Synopsis	<p>Analyzes the water/air/soil contamination, strain of local resources, hazardous electronic waste AI infrastructures can cause.</p>
Direct quotes we can use	<p>. Experts in Canada warn that without sufficient oversight, the expansion of AI data centres could put significant strain on freshwater supplies and local ecosystems.</p>
Impacts	<ul style="list-style-type: none"> ● “Contaminated wastewater: <ul style="list-style-type: none"> ○ A significant portion of this water is used for evaporative cooling towers. At the end of the cooling cycle, the water is contaminated with chemical coolants, minerals, and heavy metals. This wastewater is then discarded, potentially contaminating local waterways. ● Strained local supplies: <ul style="list-style-type: none"> ○ As climate change puts a greater strain on water resources, the high volume of water consumed by data centres can create or worsen water stress in local communities. This is an especially significant concern in drought-prone regions, including some areas in Canada. ● Indirect contamination from power generation: <ul style="list-style-type: none"> ○ The electricity used to power data centres and their cooling systems often comes from thermal power plants (like coal or nuclear). These plants also require large amounts of water and are sources of thermal pollution and hazardous waste. ● Toxin leaching: <ul style="list-style-type: none"> ○ When e-waste ends up in landfills, toxic substances like lead, mercury, and flame retardants can leach into the soil and groundwater, eventually contaminating rivers and local drinking water. ● Ineffective recycling: <ul style="list-style-type: none"> ○ Current e-waste recycling methods often involve shredding and smelting. While this can recover some metals, it can also lead to the incineration of most plastics and chemicals, creating air pollution. ● Diesel generators: <ul style="list-style-type: none"> ○ Many data centres rely on backup diesel generators for emergency power. The testing and operation of these generators emit significant air pollutants.

	<ul style="list-style-type: none"> ● Increased fossil fuel reliance: <ul style="list-style-type: none"> ○ Growing AI demand is, in some cases, being used to justify extending the life of fossil fuel infrastructure. This results in local air pollution, such as fine particulate matter, which harms human health. ● Canada concerns: <ul style="list-style-type: none"> ○ Lack of oversight: <ul style="list-style-type: none"> ■ Experts warn that Canada lacks sufficient regulations to address the environmental impact of the growing AI industry. This lack of transparency allows data centres to operate with little public accountability for their water and energy use. ○ Water-stressed regions: <ul style="list-style-type: none"> ■ Concerns have been raised about proposed data centre projects in regions already experiencing water shortages. For instance, a planned data centre campus in northern Alberta, a drought-stricken area, is expected to require millions of litres of water daily. ○ Indigenous communities: <ul style="list-style-type: none"> ■ Indigenous groups, such as the Sturgeon Lake Cree Nation, have raised concerns that they were not properly consulted on the impact of these large-scale AI projects on their territories and water resources. ○ Policy gap: <ul style="list-style-type: none"> ■ Environmental organizations are calling for mandatory reporting on water and energy use, along with binding efficiency mandates for Canadian data centres.”
--	---

	Source: International Energy Agency. (April, 2025). Energy supply for AI. iea.org. https://www.iea.org/reports/energy-and-ai/energy-supply-for-ai
Synopsis	<p>Summary: How much and of which types of energy do data centres consume today? Projection that the current majority of fossil fuel consumption will be replaced with half of all consumption renewable by 2030 and the other half nuclear by 2035. CO2 consumption and use of fossil fuels is expected to increase and peak in 2030.</p> <p>Parties: Data centre operators, Investors, International community, and individual countries, International Energy Agency (IEA)</p> <p>Time range and location: 2025-2035, global</p>
Direct quotes we can use	
Data	<p>-”Global electricity generation to supply data centres is projected to grow from 460 TWh in 2024 to over 1 000 TWh in 2030 and 1 300 TWh in 2035 in the Base Case”</p> <p>-data centres predicted to rise from 1% of global electricity generation today to 3% in 2030, accounting for less than 1% of total global CO2 emissions.</p> <p>-US and China largest users of data centres by large, in both fossil fuels largest source of energy</p> <ul style="list-style-type: none"> - US: 40% natural gas, 24% renewable, 20% nuclear, 15% coal - China: 70% coal, 20% renewable, 10% nuclear, natural gas < 1% - Europe renewables and nuclear are set to supply most of the additional electricity required, with their combined share rising to 85% by 2030 -Japan and Korea together account for about 5% of global data centre electricity demand today

	<p>-remainder Southeast asia and India</p> <p>-CO2 emissions from electricity generation for data centres peak around or before 2030. However, in the Lift-Off Case, which sees significantly higher levels of fossil fuel-based electricity generation, they continue to increase until the early 2030s, peaking at nearly 1.5 times the maximum emissions level of the Base Case.</p> <p>-has some graphs on global energy generation and consumption by data centres as well as CO2 emissions and stuff</p>
	topics
Energy and water usage	<p>-Renewable energy sources expected to meet half of growing demand from data centres over next five years, then oil and gas, and Nuclear</p> <ul style="list-style-type: none"> -Coal 30%, largest currently -Renewables 27%, second currently ← based on energy consumption from local grids and onsite generation -Natural gas 26%, third currently -Nuclear 15%, fourth currently <p>-renewable fastest growing source due to rising global deployment, increasing investment in conversion (including from data centres into local renewable sources)</p>
sustainability	<p>-plan is for renewable to power half by 2030, and nuclear (Through SMRs (Small Modular Reactors)) to replace oil/gas/coal by 2035 for global energy consumption from data centres</p> <p>-data centres have drastically driven up energy consumption which has led to more renewable energy but also a lot more non-renewable energy consumption</p> <p>-Co2 emissions from data center energy consumption projected to rise to 320 Mt CO2 by 2030, and decline to 300 Mt CO by 2035</p>
Legal & governmental	-China and US introducing SMRs for Nuclear energy production

	Source: Liou, Joanne. (13 Dec, 2023). What are Small Modular Reactors (SMRs)??. iaea.org. https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs
Synopsis	<p>Summary: What SMRs are, their pros, and global integration of them.</p> <p>Parties: International Atomic Energy Agency (IAEA), Global community, Individual countries, Investors</p> <p>Time range and location: 2021 ish, Global</p>
Direct quotes we can use	
Data	<p>-Small modular reactors (SMRs) are advanced nuclear reactors that have a power capacity of up to 300 MW(e) per unit</p> <p>-SMRs produce 1/3 of what traditional nuclear reactors can generate</p> <p>-pros include: small size, easy modular production, easy transportation from factory to site, more possible sites due to small size, cheaper production, faster production, less customization needed so less time needed and specialization needed in production,</p> <p>-good for rural energy generation in places that struggle to get energy from faraway generations of power grid</p> <p>-micro ones are good as back up power generators in case of emergency</p>

	<ul style="list-style-type: none"> -runs on more passive systems and inherent safety characteristics to operate and ensure safety of reactor, allowing for automatic shutdowns in emergency without external interference (which decreases radioactivity) -generally need less fuel than traditional
	topics
sustainability	<ul style="list-style-type: none"> -many hope SMRs are an answer to increasing energy demands and more sustainability -energy generation can be adjusted to account for fluctuations in generation from renewable sources like solar and wind, to create more reliable hybrid systems -
Legal & governmental	<ul style="list-style-type: none"> -Thirty countries currently operate nuclear power plants. More than two dozen others are looking at nuclear energy to meet their power and climate needs. -Russia's Akademik Lomonosov, the world's first floating nuclear power plant that began commercial operation in May 2020, is producing energy from two 35 MW(e) SMRs -SMRs are under construction or in the licensing stage in Argentina, Canada, China, Russia, South Korea and the United States of America. -The IAEA has established the Platform on SMRs and their Applications, for countries to coordinate support related to all aspects of SMR development, deployment, oversight and their electric and non-electric applications, such as use in district heating and desalination systems. - IAEA Safety Report on the applicability of IAEA safety standards to SMR technologies

	<p>Source: Hanley, Steve. (2 Dec, 2025). Massive Data Centers May Make Groundwater Pollution Worse. cleantechnica.com.</p> <p>Credibility: organization has progressive left bias and wording, but is relatively reliable with providing factual information</p>
Synopsis	<p>Summary: Impacts of farming chemical pollution combined with new data centres in Morrow County, Oregon, USA. Concerns soil pollution, Water pollution and usage, <i>Health concerns within area inhabitants</i>, (ends up not really addressing AI much (more of an unbacked theory) and pollution mostly comes from bad farming practices and waste management)</p> <p>Parties: Morrow County inhabitants and Council, Amazon (company) & and its data centre, Morrow Port Government and waste management.</p> <p>Time range and location: 1992 to 2022. Morrow County, Oregon, Usa.</p>
Direct quotes we can use	<p>“Scientists believe consumption of even a small amount of nitrates can do significant harm to the human body. They can cause debilitating conditions in newborns and have been linked to increased risks of cancer.”</p> <p>(In Morrow County, Oregon, USA) “ -the federal limit for the presence of nitrates in drinking water — 10 parts per million.”</p> <p>“When Doherty collected the water samples, accompanied by an official with the county health office, they had taken an informal survey. Talking mostly to farmhands and factory workers who were reliant on well water, they asked if anyone in their household had one or more of the known medical conditions linked to nitrate exposure. According to Doherty,</p>

	<p>within the first 30 homes they visited, they heard of at least 25 miscarriages and a half dozen people living with one kidney.” Cooper writes.</p> <p>Greg Pettit, who worked for the Oregon DEQ for 38 years, told Cooper, “the more water you put on [the fields], the faster you’re going to drive the nitrogen through the soil and down into the aquifer.”</p> <p>Lisa Levandowski, a spokesperson for Amazon, told Cooper his story was “misleading and inaccurate. The truth is that this region has long-documented groundwater quality challenges that significantly predate AWS’ presence, and federal, state, and local agencies have spent years working to address nitrates from agricultural fertilizer, manure, septic systems, and wastewater from food processing plants.” -break- “Our data centers draw water from the same supply as other community members; nitrates are not an additive we use in any of our processes, and the volume of water our facilities use and return represents only a very small fraction of the overall water system — not enough to have any meaningful impact on water quality.</p>
Data	<ul style="list-style-type: none"> -In 1992, the Oregon DEQ measured an average nitrate concentration of 9.2 ppm across a cluster of wells in the Lower Umatilla basin. - In 2015, the average had risen 46 percent to 15.3 ppm. For some wells, DEQ found nitrate levels nearly as high as 73 ppm, more than 10 times the state limit of 7 ppm. -S&P Global estimates AI may contribute as much as \$17 trillion in new economic benefits
	topics
Energy and water usage (any kind of numbers)	<ul style="list-style-type: none"> -uses electricity that is typically sourced from thermal generating stations powered by coal, methane, or nuclear -Data centers use water for cooling systems -Water for cooling is generally sourced from surrounding area -many data centers recycle water (similar to car washes) -Water sources used by some data centres have been found to contain concentrate pollutants -(Amazon Data Centre) When the water is piped through the servers inside, the heat causes some of it to evaporate, which has the unintended effect of further concentrating the amount of nitrates contained in it. The water then gets sent to the Port of Morrow wastewater facility, where it gets mixed into the dirty lagoon wastewater. That so-called “process water” is then distributed to farms in the area. -data center operations do not add any nitrates to the water it uses to cool its servers -One of the factors in its decision to build in the area was access to a plentiful supply of water to cool its servers. -Amazon and the other large data center operators are not putting massive amounts of new carbon dioxide in the air to make electricity to power their operations, but at the same time they get their energy from other people that do
sustainability	<ul style="list-style-type: none"> - Waste water produced in Morrow county from farming gets sent to Morrow Port then to a one of the many lagoons in use to store tainted water - In lagoons solids get metabolized by Microbes which creates/releases Methane gas -The water left is highly dense in Nitrogen, which the Port then dumps back onto the farmlands where it reacts with soil to form Nitrates (which are a component of fertilizers)

Legal & governmental	<p>-In 2022 people in Morrow County started noticing an increase in serious health complications, including cancer (EXCERPT: “One had to have his voice box removed because of cancer. That is not unusual among heavy smokers, but this man had never smoked.”)</p> <p>-The predicted cause of the increasing Health concerns was High nitrates in Lower Umitilla aquifer, which majority of inhabitants pulled form to drink via wells</p> <p>-Jim Doherty, a rancher and member of the three-person board of commissioners for Morrow County, decided to test the prediction by sending water samples from 6 random residences in the county to a local Lab. The lab results showed that all 6 tested positive and were above the federal limit of 10 parts per million, and state limit of 7ppm</p> <p>-70 more residence’s well water was tested, 68 of which showed an average nitrate level 4 times the federal limit</p>
Leakage/environmental impact	<p>-in Eastern Oregon, USA the land has been polluted over time due to use of chemicals in farming (influenced by regions natural desert condition, unsuited for farming), which has recently worsened due to new data centres (ex; Amazon,)</p>

Source	<p>Peng Gao and Yu Tao. (5 July, 2025). Global data center expansion and human health: A call for empirical research. sciencedirect.com. https://www.sciencedirect.com/science/article/pii/S2772985025000262</p> <p>Credibility: reputable publisher and peer reviewed</p>
Synopsis	<p>Summary: Goes over water and electrical demand of Data centres; noise pollution, water pollution; impact on human health. Talks about possible solutions. Request more thorough investigative research to be done on the impacts of data centres.</p> <p>Parties: Data centres, Government,</p> <p>Time range and location: 2024 to 2030 ish, global</p>
Direct quotes we can use	
Data	<p>-Data Centres consumed 1.5% of global electricity in 2024 and are expected to represent nearly 10% of the electricity demand growth from 2024 to 2030</p> <p>-Data centers generate significant noise pollution primarily from <u>diesel</u> generators and Heating, Ventilation, and Air Conditioning (HVAC) systems, with internal noise levels reaching up to 96 A-weighted decibels (dBA)—well above the 85 dBA threshold considered harmful to hearing</p> <p>-A recent model indicates that the <u>U.S.</u> data centers in 2030 could contribute to nearly 1300 deaths annually, resulting in a <u>public health</u> burden of more than \$20 billion</p> <p>-In certain areas, data centers consume up to 57% of cooling water from potable sources</p> <p>-A typical hyperscale data center can use 3–7 million gallons of water per day for cooling purposes</p>
	topics
Energy and water usage	-data centres generally use drinking water for cooling systems, which puts strain on water

(any kind of numbers)	supplies
Legal & governmental	<p>exacerbates local water insecurity, increasing the risk of <u>waterborne diseases</u>, dehydration, and poor hygiene in affected communities. Key strategies include:</p> <ol style="list-style-type: none"> 1. Power data centers with renewable sources and replace diesel generators with battery storage or fuel cells to eliminate exhaust emissions (Go clean and renewable) 2. Use advanced cooling technologies to reduce water use and recycle waste heat, alleviating local <u>water scarcity</u> and enhancing energy efficiency (improve efficiency of cooling systems) 3. Mandate public reporting of data center pollution. Greater transparency and stricter standards would hold operators accountable and encourage cleaner practices (If you pollute you have to tell people) 4. Position new data centers away from populated or polluted areas and choose cleaner, low-density sites for energy-intensive workloads to reduce human exposure (let the animals deal with it/ go away from society where no pollution, don't create pollution any pollution = no problem) <p>-we need to start actually tracking pollution first hand and do something about it instead of just talking about what might be happening</p>
Leakage/environmental impact	<p>-persistent noise adversely affects data center staff, nearby communities, and local wildlife</p> <p>-Fossil-fueled power plants and <u>diesel</u> backup generators that power data centers emit <u>hazardous pollutants</u> such as <u>nitrogen oxides</u> and <u>fine particulate matter</u>, increasing rates of respiratory diseases, <u>cardiovascular conditions</u>, and elevating cancer risk in nearby communities.</p> <p>-Data centre water consumption exacerbates local water insecurity, increasing the risk of <u>waterborne diseases</u>, dehydration, and poor hygiene in affected communities.</p>

Source:	<p>Richardson, Kelly. (03 Dec, 2024). Understanding the impact of data center noise pollution. techtarget.com. https://www.techtarget.com/searchdatacenter/tip/Understanding-the-impact-of-data-center-noise-pollution</p> <p>Credibility:</p>
Synopsis	<p>Summary: Sources of noise pollution from data centres, impact of noise pollution, and possible solutions and noise pollution preventatives.</p> <p>Parties: Data centres, governments, people who live nearby data centres, data centre employees,</p> <p>Time range and location:</p>
Direct quotes we can use	<p>"Data center noise pollution from generators and cooling systems disrupts nearby communities and affects health." -Kelly Richardson</p> <p>"HVAC fans in data centers generate noise levels ranging from 55 to 85</p>

	<p>dBa. This noise contributes to the loud humming and buzzing sounds that people commonly associate with data centers.” -Gerry McGovern, an expert on the impact of digital technology on the environment and author of "Data centers are noisy as hell"</p>
<p>Data</p>	<ul style="list-style-type: none"> -Safe sound levels: 70 A-weighted decibels (dBA) or lower -Unsafe sound levels: 85 dBA and above is harmful to hearing -1 Small Diesel generator runs at about 85 dBA -1 large Diesel generator runs at about 100 dBA. -HVAC fans: generate 55 to 85 dBA -Noise inside data centers: can reach up to 96 dBA (according to C&C Technology Group) -Exposure to this level of sound can damage hearing within half an hour: Data center staff who experience prolonged exposure to high noise levels (at work) may suffer from hearing damage, decreased productivity and increased stress. -Natural gas generators: runs from under 50 to 100 dBA (sustainable substitute for diesel generators)
	<p>topics</p>
<p>Energy and water usage (any kind of numbers)</p>	<ul style="list-style-type: none"> -Diesel generators are the most common backup power option for data centers. -Small data centers under 5,000 square feet typically use two to five generators, while hyperscale data centers could need dozens. -for if cut off from main energy source -constant high power draw of electricity (from power grid) causes a low-frequency humming sound, similar to HVAC fans.
<p>sustainability</p>	<ul style="list-style-type: none"> -rise in AI and data storage demand, servers consume more energy by the day -Temperatures rise quicker when servers have large workloads, so HVAC systems (cooling systems) continuously work at an increased rate to cool the servers and aisles. -Natural gas generators produce less noise and carbon emissions compared to Diesel generators, which is the primarily generator as of now -Liquid cooling is a more sustainable way to cool data centers compared to HVAC fans. Water is more efficient at transferring heat, requires less energy consumption and reduces fan use, lowering noise levels. -optimizing airflow based cooling in data centres, so fans have less work. Also buying better quality fans.
<p>Legal & governmental</p>	<ul style="list-style-type: none"> -Facility administrators can minimize data center noise pollution by switching to natural gas generators for backup power, upgrading cooling systems, optimizing server rack layouts to enhance airflow and using thicker materials to insulate server rooms. -Local governments are starting to make laws that regulate the distance between data centers and residential areas. -In Fairfax County, Va., data centers must be at least 200 feet away from any residential district or property, experts must conduct noise studies before and after data center construction to ensure noise regulations are met, and all equipment must be behind a barrier that further reduces noise.

	<p>-In Granbury, Texas, bitcoin mining consumes more energy in data centers and increases noise pollution. The community's main concern lies with Marathon Digital Holdings' bitcoin mining data center. The company has since been involved in legal complications as the community raises health concerns over noise pollution. According to Fort Worth Report, Marathon Digital Holdings has replaced 20% of the facility's cooling system with liquid immersion cooling and deactivated nearly 100 air-cooled containers since the lawsuits.</p>
<p>Leakage/environmental impact</p>	<p>-Generators, cooling systems and energy drawn from the power grid produce data center noise pollution.</p> <p>-Noise levels during construction are also a concern due to the long amount of time needed for construction</p> <p>-constant humming or buzzing noise from data centers causes some people (people living in communities nearby data centres) to experience headaches, stress and sleep disturbance. Lack of sleep and stress can result in anxiety, cognitive impairment and cardiovascular risks. In more extreme cases, noise pollution can cause tinnitus and hearing loss.</p> <p>-noise pollution on land disrupts animal communication and forces them to seek new migration patterns.</p>

<p>Source:</p>	<p>Data Drain: The Land and Water Impacts of the AI Boom</p> <p>Credibility:</p>
<p>Synopsis</p>	<p>Summary:</p> <p>Parties:</p> <p>Time range and location:</p>
<p>Direct quotes we can use</p>	<p>“I don’t think places are acknowledging all the costs,” -Kim Reuben, a former senior fiscal systems advisor at the Lincoln Institute of Land Policy, said at a Land Policy and Digitalization conference convened by the Lincoln Institute, likening the extractive nature of data centers to coal mines.</p> <p>The facilities have also gotten “massive,” Bolthouse adds. “Each one of those buildings is using as much as a city’s worth of power, so that power infrastructure is having a huge impact on our communities. All the transmission lines that have to be built, the eminent domain used to get the land for those transmission lines, all of the energy infrastructure, gas plants, pipelines that deliver the gas, the air pollution associated with that, the climate impacts of all of that.”</p> <p>Across Northern Virginia, on-site diesel generators—thousands of them, each the size of a rail car—spew diesel fumes, creating air quality issues. “No other land use that I know of uses as many generators as a data center does,” Bolthouse says. And while such generators are officially classified as emergency backup power, data centers are permitted to run them for “demand response” for 50 hours at a time, she adds. “That’s a lot of air pollution locally. That’s particulate matter and NOx [nitrogen oxides], which impacts growing lungs of children, can add cases of asthma, and can exacerbate heart disease and other underlying diseases in the elderly.”</p> <p>“But what goes unacknowledged, from a natural systems perspective, is that all water is</p>

	<p>local,” says Peter Colohan, director of partnerships and program innovation at the Lincoln Institute, who helped create the Internet of Water. “It’s a small amount of water for a few queries, but it’s all being taken from one basin where that data center is located—that’s thousands and thousands of gallons of water being drawn from one place from people doing their AI queries from all over the world,” he says.</p> <p>“Wherever they choose to put a data center, it is like a giant soda straw sucking water out of that basin,” Colohan continues. “And when you take water from a place, you have to reduce demand or put water back in that same place, there’s no other solution. In some cases, at least, major data center developers have begun to recognize this problem and are actively engaging in water replenishment where it counts.”</p>
Data	<ul style="list-style-type: none"> -The number of US data centers more than doubled between 2018 and 2021 -evaporative room cooling is among the simplest and cheapest ways to keep the chips from getting overheated and damaged
	topics
Energy and water usage (any kind of numbers)	<ul style="list-style-type: none"> -mid-sized data centre consume as much water as a small town, while larger ones require up to 5 million gallons of water every day—as much as a city of 50,000 people. -A study by the Houston Advanced Research Center (HARC) and University of Houston found that data centers in Texas will use 49 billion gallons of water in 2025, and as much as 399 billion gallons in 2030 -A 2023 study by the University of California Riverside estimated that an AI chat session of 20 or so queries uses up to a bottle of freshwater. That amount can vary depending on the platform, with more sophisticated models demanding larger volumes of water, while other estimates suggest it could be closer to a few spoonfuls per query. -A conventional data center—think cloud storage for your work documents or streaming videos—draws as much electricity as 10,000 to 25,000 households, according to the International Energy Agency. -AI-focused “hyperscale” data center can use as much power as 100,000 homes - Artificial intelligence tools trained with large language models, such as Open AI’s ChatGPT, among others, use exponentially more computing power than traditional cloud services -Making a five-second AI-generated video uses about as much electricity as running a microwave nonstop for over an hour.
sustainability	<ul style="list-style-type: none"> -Early in the AI boom, in 2023, US data centers consumed 176 terawatt-hours of electricity, roughly as much as the entire nation of Ireland (whose electric grid is itself nearly maxed out, prompting data centers there to use polluting off-grid generators), and that’s expected to double or even triple as soon as 2028. -the facilities themselves are not powerful long-term job engines. Most of the jobs they create are rooted in their construction, not their ongoing operation, and thus are largely temporary. -Alternatives to water based cooling systems: <ul style="list-style-type: none"> -closed-loop water systems, which require more electricity (but have less water loss to evaporation) - immersion cooling, in which servers are submerged in a bath of liquid, such as a synthetic oil, that conducts heat but not electricity. Immersion cooling allows for a denser installation of servers as well, but is not yet widely used, largely due to cost.

	<p>-some data centres have started making water replenishment programs in the area they operate in to help counteract data centre consumption of water</p> <p>-Locating data centers in cooler, wetter regions can help reduce the amount of water they use and the impact of their freshwater withdrawals. And yet roughly two-thirds of the data centers built since 2022 have been located in water-stressed regions, according to a Bloomberg News analysis, including hot, dry climates like Arizona.</p>
Legal & governmental	<p>-many lawmakers are inviting data centres to build in their area in hopes of it stimulating economic benefits, they do this by giving take breaks among other things</p> <p>-Despite the state-level tax break, data centers make significant contributions to local coffers in Virginia. This is due to the large amount of land data centres use and have to pay property taxes on</p> <p>-many companies are less than forthcoming about how much water their data centers consume</p>
Leakage/environmental impact	<p>- Evaporative cooling also leaves behind high concentrations of salts and other contaminants (because the ratio becomes unbalanced, less water to same contaminants= higher containment percentage)</p>

To do for arabella;

- [The Environmental Cost of Data Centers ?](#)
- [Understanding the impact of data center noise pollution | TechTarget ?](#)
- [Data Centers and Water Consumption | Article | EESI](#)
- [Data centre water consumption | npj Clean Water](#)

Research collection evaluation

- Training AI models
- Data-center maintenance
- E-waste or hardware lifecycle impacts
- Are current AI practices environmentally sustainable?
- What factors most affect AI's environmental footprint? - energy consumption, water consumption from cooling systems + noise the cooling process produces, -land large ai data centres use
- Energy required to train AI models
- Energy per inference query
- ~~CO₂ emissions associated with AI/ Carbon emissions~~
- Mostly comes from back up generators run by data centres and increase on energy consumption on local power grids demanding more generation
- ~~Water used in cooling GPUs/ Water usage (for cooling data centers)~~
- Many data centres who run water based cooling systems reuse the water, however in the cooling process much of the water is lost from evaporation and more water needs to be sourced to replace it
- ~~Renewable vs fossil energy usage in data centers/ Energy generation alternatives for data centres~~
- Small modular reactors (SMRs)- nuclear reactor alternatives for energy generation
- Natural gas generators over Diesel ones
- Energy (MWh) for training models
- CO₂ emissions (tons)
- ~~Comparison of model sizes~~

Project trifold sections:

1. Background

a. Generative ai LLMs how they work (energy/water usage)

b. Data centers and how generative ai drive their energy consumption (electricity/water usage)

2. ENVIRONMENTAL IMPACTS (main focus)

a. Oceans animals

b. Land animals

3. -Noise pollution on land disrupts animal communication and forces them to seek new migration patterns.

a.

b. Supply strains

c. Effects on soil toxicity

- Toxin leaching:
- When e-waste ends up in landfills, toxic substances like lead, mercury, and flame retardants can leach into the soil and groundwater, eventually contaminating rivers and local drinking water.

d. Effects on water contaminant concentration

- e. A significant portion of this water is used for evaporative cooling towers. At the end of the cooling cycle, the water is contaminated with chemical coolants, minerals, and heavy metals. This wastewater is then discarded, potentially contaminating local waterways.
- i. Evaporation of water in water based cooling systems cause less water to be in the ecosystem, causing water:containment ratios to be off, increasing the concentration of contaminants in water and the environment

f. Effects on Ecosystems (Whole web)

- i. If migration patterns change, ecosystem patterns that many species rely on are impacted (including could possible make it harder for species that need to migrate to specific locations to breed or spawn to populate)
- ii. Loss of water
- iii. Higher concentrations of contaminants in water

g. Entry points for pollutants into environment from data centres

- i. Water from cooling being sent to local water treatment and back into main usage
- ii. HVAC fans and generators sound pollution
- iii. Destruction of ecosystems on the land where data centres are constructed

h. Effects on human health nearby

- i. -constant humming or buzzing noise from data centers causes some people (**people living in communities nearby data centres**) to experience headaches, stress and sleep disturbance. Lack of sleep and stress can result in anxiety, cognitive impairment and cardiovascular risks. In more extreme cases, noise pollution can cause tinnitus and hearing loss.
- i. **Effects of Noise pollution from data centres**
- i. -constant humming or buzzing noise from data centers causes some people (**people living in communities nearby data centres**) to experience headaches, stress and sleep disturbance. Lack of sleep and stress can result in anxiety, cognitive impairment and cardiovascular risks. In more extreme cases, noise pollution can cause tinnitus and hearing loss.
- ii. -Noise pollution on land disrupts animal communication and forces them to seek new migration patterns.
- iii. The noise pollution largely comes from a bunch of low quality HVAC fans being run at once. Introduction of hybrid cooling systems that use high quality fans and systems are the most effective at cooling, use less energy, and produce less noise pollution.
- iv. Large Diesel generators used by data centres as backup power generators are louder than alternative generators, like natural gas ones

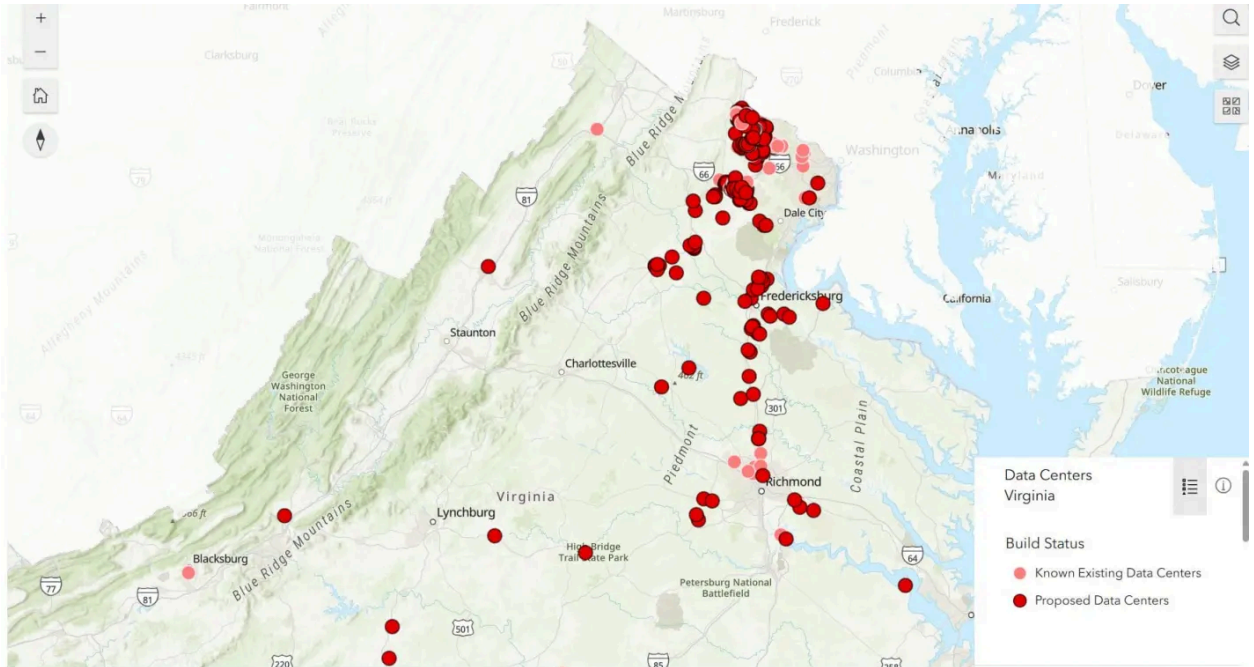
4. Conclusionary sections

a. Sustainability--are these current regulations enough?

- i. No not really quite yet, due to how new data centres are and the frenzy big tech companies are in to build them many regulation is struggling to keep up, especially with economic benefits data centres promise to the local government to bring if they aren't bothered and that if they are, they'll just go elsewhere

b. What we can do!!!

- i. **Where different renewable energies come in**
- ii. **Main solution; how can we use AI and more sustainable technologies to help climate change?**



“Existing and planned data centers in Northern Virginia. The state has been dubbed “the data center capital of the world.” Credit: Piedmont Environmental Council.”