

Extended Essay

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How has the expansion of Artificial Intelligence affected our energy sources and consumption, and how will humanity handle this ethically and sustainably?

Intro

In the past 25 years, the technology we use has come a very long way. We have gone from iPods and DVD players, which we once thought were the future, to now Artificial Intelligence(AI) a short 25 years later. What makes AI so exciting is its ability to solve complex problems with the information we give it. AI can process this information much faster than humans can do on their own. For example, we use AI software such as ChatGPT to answer questions and come up with unique responses within whatever parameters we give it. But this is only a small way AI can benefit us. AI is capable of enhancing our healthcare, education, and finance industries more rapidly than ever before. This being said, AI is undeniably important for us to continue researching and developing. If we successfully develop AI, it will change the pace of human advancement forever.

But at what costs do the revolutionary capabilities of AI come with? AI uses tons of our non-renewable energy sources and natural resources in both the production of its hardware and its lightning-fast processing. "According to Furthur Market Research, storage capacity surpassed one zettabyte (ZB) in 2016, 4.8 ZB in 2022, and is expected to reach 50 ZB by 2035. Clearly, AI energy consumption is destined to become a real challenge" (Robb). This quote puts into perspective how rapidly AI is advancing and having a larger impact on our lives. We as humans need to keep up with these rapidly growing rates because if we don't, it will continue destroying and depleting our non-renewable natural resources and energy supplies that we are so reliant on. Running out of these scarce resources would lead to serious problems in many capacities. Understanding these aspects of AI's resources and energy consumption is necessary to grasp the magnitude of the problems and solutions we have at hand.

So, with an invention that can change the world forever in both a very positive and very negative way, we as humans play the most crucial role in deciding the nature of AI's impact. Will it accelerate the advancement of mankind forever, or will it deplete Earth's resources and cause turmoil amongst our generation and the generations to come? This is a problem that we need to tackle in an efficient, sustainable, and ethical way.

Many have speculated, studied, and researched new solutions to make AI more sustainable and ethical. Some of these solutions include active archives, developing energy-efficient hardware, using renewable energy and resources, and optimization, such as model pruning, knowledge distilling, and quantization. With a variety of options to make AI more sustainable and ethical, it is now a crucial decision we must make to the best of our ability. Making this decision must be done by carefully analyzing our solutions and choosing the most suitable options. How has the mass construction of AI data centers in the United States affected the world's energy sources and environment, and how will government and AI corporations manage this issue ethically and sustainably?

Expansion of Artificial Intelligence

In 1956, John McCarthy, a professor at Dartmouth College, organized a summer workshop to clarify and develop ideas about thinking machines. He chose the name "artificial intelligence" for the project. This workshop/conference at Dartmouth is widely considered the birth of artificial intelligence as a field of research. Their goal was "to make machines use language, form abstraction and concepts, solve kinds of problems now reserved for humans and improve themselves" (Lawrence Livermore National Laboratory). In the following years, the field grew quickly with many more "researchers investigating techniques for performing tasks considered to require expert levels of knowledge, such as playing games like checkers and chess.

By the mid-1960s, artificial intelligence research in the United States was being heavily funded by the Department of Defense, and AI laboratories had been established around the world” (Lawrence Livermore National Laboratory). This is how AI went from not existing to a part of the United States Department of Defense budget within a decade. This was very rapid expansion.

But this is only because of the potential AI showed, which was the type of advancement people and governments were so hungry for. This is why AI is still developing decades later in 2025. As AI continues expanding, so do the computational requirements of AI models.

Traditional processors have started struggling to keep up with this expansion. “They require excessive amounts of energy and are inefficient. That's where neuromorphic AI chips come in. Designed to revolutionize how AI operates, these chips mimic the human brain's pattern recognition, allowing AI to process information faster, smarter, and in a more energy-efficient way” (Brooks). The expansion of AI has come so far that to keep up with its demands, we’ve designed a system that works the same way our brain does. This is only one of many impressive examples to show how advanced AI has become in such a short amount of time.

In 2023, investments in AI were as follows in these countries: United States: US\$50.6 billion, China: US\$11.2 billion, EU: US\$6.1 billion, India: US\$2.84 billion, United Kingdom: US\$2.6 billion, Israel: US\$1.59 billion, Others: US\$7.5 billion. AI has gone from humble beginnings at a workshop in Dartmouth College to now being heavily invested in by many major countries. This is because they know it will become a Global tool revolutionizing many industries such as education and healthcare. Advancing industries like these all over the globe would change the lives of many people who may be struggling to get the education or medical help they need. This makes AI a very desirable tool and one worth investing billions of dollars into.

Because 63% of organizations globally plan on adopting AI within the next 3 years, “AI market size is expected to grow by at least 120% year-over-year (National University).” Clearly, not only is AI expanding faster than ever before, but it is now being used by more organizations than ever before. This growth of businesses and organizations implementing AI systems in their businesses is another huge step in AI’s expansion. Expansion through businesses and organizations is also projected to help AI contribute \$15.7 trillion to the global economy by 2030. This means huge changes for businesses, governments, and investors. Most importantly, this means big changes for the vast majority of normal citizens, who interact with these businesses, use their healthcare systems, and are educated by them daily. This will cause life to change positively for everyone in society, not just the wealthy.

While the expansion of AI and its use in these industries is a good thing, it is also important to take account of how much AI’s energy and resource demands are increasing. “Electronic waste, for example, contains dangerous chemicals that contaminate the environment when discarded. The World Economic Forum (WEF) already projects that by 2050, generated e-waste will have surpassed 120 million metric tonnes” (Adebayo). To visualize that, imagine nearly 12,000 Eiffel Towers of waste. “The forecast for AI energy consumption by 2030 is 20 percent of global electricity supply, if current growth trends continue” (Adebayo). This puts into perspective how much waste AI produces as well as how much energy and resources are needed to power AI’s computational powers. As AI continues to grow, so will its energy and resource demands.

AI’s processes also use tons of our non-renewable resources and energy, but so does training and developing new versions of AI. Two examples in particular of AI advancement using lots of energy are BERT and the GPT models. “A study by researchers at the University of

Massachusetts showed that training a single large AI model like BERT could generate a carbon footprint of 626,000 pounds of CO₂” (Adebayo). This is equivalent to five times the lifetime emissions of one car. The current version of ChatGPT, powered by GPT-4, for example, “has about 1.8 trillion parameters that help determine how it responds to inputs. For context, that's six times larger than the 175 billion parameters of GPT-3, and 1,200 times bigger than GPT-2. It took the same amount of power to train GPT-3 as 120 average American homes consume in a year. Imagine how much power it took to train GPT-4” (Adebayo). This shows how expanding and developing AI also uses lots of resources and releases tons of emissions and waste, not just using it.

Advantages

The reason society has been so hungry for AI’s development is because of how beneficial it is and how much potential it has. AI already has major effects on most of the world as 77% of devices being used have some form of AI. This shows that we benefit from AI every day when using most devices. “There are perhaps 700 people in the world who can contribute to the leading edge of AI research, perhaps 70,000 who can understand their work and participate actively in commercialising it, and 7 billion people who will be impacted by it” (Franke). These devices impact all of us, making life easier and more convenient by getting tasks done faster. In general, most people desire an easier and more comfortable life, hence the cause of AI’s rapid growth.

The Korea Advanced Institute of Science and Technology (KAIST) created the first neuromorphic AI chip designed for large language models (LLMs) in 2024. This neuromorphic chip maintains very impressive capabilities while only using 1/625th the power of NVIDIA’s graphic processing units(GPU). By bridging the gap between brain-inspired computing and

real-world applications, these chips could unlock unprecedented advancements, including the following: “AI-powered prosthetics and brain-computer interfaces that mimic human cognition more effectively, advanced robotics with real-time learning and independent decision-making (Brooks).” Making these advancements in AI would provide revolutionary advancements in many industries, such as health and education. If not the convenience or making things easier, these types of advancement in such vital industries are what we really need from AI.

Because of these advantages that AI provides, and the potential that it has, many major countries are investing lots of money into its development. Funding for AI by governments in 2023 totalled to US\$82.43 billion. This impressive number proves that AI development is important to society and that it is going to have an even larger impact in the future than it does currently. As we continue investing more money into AI, it will continue developing to become faster, more efficient, and more powerful. AI has unlimited possibilities of good it can do for us, it’s just a matter of how we handle it.

Disadvantages

Otherwise, AI will become a destructive problem for us, destroying our supplies of non-renewable resources and energy. As previously stated, “There are perhaps 700 people in the world who can contribute to the leading edge of AI research, perhaps 70,000 who can understand their work and participate actively in commercialising it, and 7 billion people who will be impacted by it” (Franke). While this does mean everyone can be affected positively by AI, having limited human resources to develop and understand how AI works is a disadvantage because it shows how unaware we are of AI’s capabilities and how unprepared we are for its developments, both negative and positive. The only people who understand what’s going on are the scientists and engineers who study AI and the governments they work for. Most of what these

people care about are positive impacts, and they will continue ignoring negative impacts as long as we let them. “Regulatory standards in the US have not advanced enough to accommodate artificial intelligence (AI) developments (Franke).” We need to reevaluate how AI impacts us globally and find solutions to the negative impacts that AI brings along with all of its good attributes and potential.

“Most large-scale AI deployments are housed in data centres, including those operated by cloud service providers. These data centres can take a heavy toll on the planet. The electronics they house rely on a staggering amount of grist: making a 2 kg computer requires 800 kg of raw materials. As well, the microchips that power AI need rare earth elements, which are often mined in environmentally destructive ways” (UNEP). Using so many raw materials is damaging to our non-renewable resource supply. This becomes especially harmful when we mine the resources in destructive ways. “Driven in part by the explosion of AI, the number of data centers has surged to 8 million from 500,000 in 2012, and experts expect the technology’s demands on the planet to keep growing” (UNEP). With 8 million data centers around the world, many of which house countless computers, multiplying the amount of data center computers by 800kg of raw materials per computer equals a staggering amount of raw materials being used on computer hardware. On top of using tons of raw materials, these data centers are also responsible for massive amounts of electric waste. “The global data center power usage, according to the International Energy Agency (IEA), was estimated in 2022 as 240-340 terawatt hours (TWh). In addition, the forecast for AI energy consumption by 2030 is 20 percent of global electricity supply, if current growth trends continue” (Adebayo). Electronic waste contains mercury, lead, and other hazardous materials. These hazardous materials pose a threat not only to humans but also to wildlife and ecosystems.

As if this wasn't enough, data centres use water during construction and, once operational, to cool electrical components. Globally, AI-related infrastructure may soon consume six times more water than Denmark, a country of 6 million, according to one estimate. This is a serious problem considering that roughly 26% of the human population doesn't have access to clean or safely managed drinking water to begin with. Society needs to take a step back and figure out how to sustainably manage AI before we use so much precious water on it, totally disregarding the needs of 26% of our human population. This statistic specifically is one important to focus on because it is a global issue that causes death, disease, and dehydration in many places throughout the world when not solved.

Loudoun County

In the United States, AI data centers have been popping up in clusters. Next to DC in Northern Virginia, Loudoun County has turned into a “data center ally” (Tinsman). In Loudoun County alone, more than 200 data centers have been built, and another 117 are in the planning stages. While this is great economic growth in many ways, such as providing 12,000 jobs for the county and the 3,500 different companies that use these data centers, these data centers still come with the previous destructive side effects. With so many data centers in one county, there is bound to be very negative impacts on the environment. “Data centers are the only growing source of energy demand in Virginia, and they are expected to double the load on the state's electricity grid—which is primarily powered by natural gas—by 2040” (Kimmel). This is terrible because although these data centers are great for economic growth, they cause so much damage to the air and surrounding ecosystems in Northern Virginia. It is not worth sacrificing the environment for environmental growth, and for this to be okay, finding sustainable and ethical solutions is necessary.

Finding Solutions to These Issues

Luckily, businesses and governments are noticing these destructive qualities of AI, especially in regions like Loudoun County, where there are so many AI data centers. For that reason, “AI companies could soon be required by regulation to reveal the carbon 'footprint' of their models, as is the case in other industries” (Adebayo). Governments recognizing the need for regulating AI is the most important first step for solving the problems we’re having. This allows for legal action to be taken with businesses that don’t respect environmental, sustainability, and ethical standards. Because of this, many companies are trying to find solutions through renewable energy. This would mean that we would no longer be wasting massive amounts of finite resources. For instance, some of Google's data centers now run solely on renewable energy. This makes the carbon footprint caused by training and deploying AI much less. Other companies are joining in, exploring options like “drawing power from solar and wind farms, and otherwise considering methods to drastically cut emissions arising from power supply of AI—which serves both the environment and the bottom line” (Adebayo). With the government now taking steps to solve this issue, major companies that use AI are too, which is very important because not only does it help the issues at hand, but also pushes solutions on the smaller businesses that use AI. Ultimately, leading to a cleaner usage of AI.

With governments now more involved with solving environmental issues relating to AI than ever before, we’re able to research possible solutions to these issues with more funding and more efficiently than in previous years. One potential solution, which could solve the large sustainability issue that comes with storing data, is active archiving. Active archiving gives companies with intelligent data management layers the ability to move data where it belongs based on activity, cost, and performance. The data that AI applications need is shifted to where it

can be rapidly analyzed. Otherwise, “it sits in a lower storage tier such as hard disks, optical disks, or tape” (Robb). This data layer makes sure that there are never long delays when trying to find data. “Automated tiering takes care of data movement. This contains costs and provides eco-friendly long-term storage or performance storage as needed” (Robb). With these features active archives could be a great way for companies to manage their data in a cost-efficient and sustainable way in the future.

Next, optimization is a great way to help manage AI’s need for large amounts of energy. Optimization does this through model pruning, knowledge distilling, and quantization. “Model pruning is the method of selectively removing redundant neurons from neural networks while at the same time reducing model size” (Adebayo). Simply, this means that with little or no loss in performance, model pruning gets rid of any unnecessary or extra networks that AI uses. This technique and knowledge distillation are both supported by the AI development community. Knowledge distillation is when a small AI model is trained to replicate the behavior of a large model. Removing these extra networks and size of AI models saves tons of energy that would otherwise be wasted. While this isn’t totally supported by developers because of the reduction in numerical precision that is caused in AI calculations, “quantization leads to as much as 50 percent computational cost savings. With these techniques, AI systems scale down computational costs to more manageable levels and reduce energy consumption” (Adebayo). This allows for tremendous cuts in cost and energy consumption with AI, which is crucial for solving many issues.

However, one solution that stands out the most is neuromorphic AI chips. They revolutionize how AI operates because of their design, which mimics the human brain's pattern recognition. This allows these chips to process information “faster, smarter, and in a more

energy-efficient way” (Brooks). This is a monumental advancement because not only does it advance AI capabilities, but it also does it in a more energy-efficient way. “Unlike conventional processors that rely on sequential execution, neuromorphic processors operate in parallel.” This simply means they process multiple tasks simultaneously rather than one at a time. This allows the parallel processing chips to operate with significantly less power. Meaning that neuromorphic AI chips are able to save power and work at much faster speeds. The Korea Advanced Institute of Science and Technology (KAIST) created the first neuromorphic AI chip designed for large language models (LLMs) in 2024. This design was significantly smaller than NVIDIA's graphic processing units (GPUs), “it uses just 1/625th of the power while maintaining impressive AI capabilities” (Brooks). Using 1/625th of the power while working at faster speeds, makes neuromorphic AI chips one of the most effective solutions by far. Implementing these solutions would significantly reduce AI’s carbon footprint by improving sustainability and energy usage. If neuromorphic AI chips could be implemented properly, they could completely solve the current issues society faces with no problem.

Conclusion

Undoubtedly, Artificial Intelligence is one of the most exciting new technologies for all people. AI’s potential to change the world with its power to process information and solve complex problems at rates never seen before has all industries and governments hungry for its help, but what’s most important for now is making sure that its negative environmental impacts are solved ethically and sustainably. This is especially important for places like data center alley, in Northern Virginia, where AI data centers run the economy.

Continuing to develop sustainable technology should be the priority for all communities and AI developers, not just those in counties like Loudoun. Along with making sure that millions

of businesses and corporations around the world are required to use AI in environmentally friendly, sustainable, and ethical ways. With neuromorphic AI chips, and introducing renewable energy sources to AI, we are in a great position to prevent AI's negative impacts in the future, as long as we prioritize what is right for the environment and communities, who are so heavily impacted by AI.

Work cited:

Robb, Drew. "AI Strategies Under Siege: Inefficient Archiving Solutions Skyrocket AI Energy Consumption." EWeek, Dec. 2024, p. N.PAG. EBSCOhost, research.ebsco.com/linkprocessor/plink?id=e2fec12e-ffbe-340a-97b2-28db7959c8b7.

Adebayo, Kolawole Samuel. "Understanding AI Energy Consumption: Trends and Strategies for 2024." EWeek, Oct. 2024, p. N.PAG. EBSCOhost, research.ebsco.com/linkprocessor/plink?id=5d5b6605-5304-3ac3-a3ee-b7a33e00a62b.

Brooks, Brittany. "AI Chips Inspired By The Human Brain Are On The Rise." EWeek, Jan. 2025, p. N.PAG. EBSCOhost, research.ebsco.com/linkprocessor/plink?id=43241ef5-856c-332b-b3f5-ba6a93d587df.

Franke, Ulrike. HARNESSING ARTIFICIAL INTELLIGENCE. European Council on Foreign Relations, 2019. JSTOR, <http://www.jstor.org/stable/resrep21491>. Accessed 7 Mar. 2025.

National University. "131 AI Statistics and Trends (2024)." National University, National University, 1 Mar. 2024, www.nu.edu/blog/ai-statistics-trends/.

"Artificial Intelligence (AI) Software Market Size: 2023 to 2030." Abiresearch.com, 2023, www.abiresearch.com/news-resources/chart-data/report-artificial-intelligence-market-size-global.

UNEP. "AI Has an Environmental Problem. Here's What the World Can Do about That." UNEP, 21 Sept. 2024, www.unep.org/news-and-stories/story/ai-has-environmental-problem-heres-what-world-can-do-about

Science and Technology.” St.llnl.gov,

st.llnl.gov/news/look-back/birth-artificial-intelligence-ai-research.

“AI, Energy, and Climate: What’s at Stake? Hint: A Lot.” *Federation of American Scientists*, 12

May 2025, fas.org/publication/ai-energy-climate-whats-at-stake/. Accessed 25 May 2025.

Tinsman, Brian. “Data Centers - Loudoun County Economic Development, VA.” *Loudoun*

County Economic Development, VA, 2016,

biz.loudoun.gov/key-business-sectors/data-centers/.

Kimmel, Julie. “Data Centers Destroying Climate Progress in Virginia.” *Moms Clean Air Force*,

29 Apr. 2025, www.momscleanairforce.org/data-centers-in-virginia/. Accessed 25 May

2025.