

ASSESSING THE ENERGY IMPLICATIONS OF ARTIFICIAL INTELLIGENCE AND EXAMINING THE CASE FOR NUCLEAR POWER

ZOYA AKHTER

INTRODUCTION

The Artificial Intelligence (AI) revolution is most often analysed through advances in algorithms, training techniques, data availability, and computational capability. Increasingly, however, the trajectory of AI development is being shaped by a more fundamental constraint: access to energy. The large-scale deployment of AI systems is reshaping electricity consumption in ways that put a strain on existing energy infrastructures, bringing questions of power generation, reliability, and sustainability to the forefront of technology and energy policy debates. It is in this context that a convergence between AI and nuclear energy is emerging, driven by the fundamental requirements of sustaining AI at scale. This is captured succinctly by Sam Altman, Chief Executive Officer (CEO) of OpenAI who noted that “abundant intelligence is largely built on abundant energy.”¹

Ms **Zoya Akhter** is an independent researcher specialising in civil nuclear energy, climate policy, and emerging technologies. She has previously worked with the Centre for Aerospace Power and Strategic Studies, New Delhi, and later with a climate-tech startup, and is the author of *Nuclear Energy in Asia Post Fukushima*.

1. “Why Amazon, Microsoft, Google and Meta are Investing in Nuclear Power”, CNBC(Youtube), 2025, https://docs.google.com/document/d/1jkyfspkKymPdxmqhbMUbWPJFdhVQsm-5Ps_Eg9l97Ew/edit?tab=t.0. Accessed on December 3, 2025.

Major technology companies have also begun to pursue nuclear power as a source of firm, low-carbon electricity for their data centre operations. Google, for instance, has entered into an agreement with Kairos Power to develop, and get electricity from, advanced Small Modular Reactors (SMRs), while Meta has signed long-term contracts with Constellation to secure nuclear power

The convergence is increasingly reflected in the actions and statements of leading figures within the AI ecosystem, many of whom have referred to nuclear power as essential to sustaining long-term AI development. Sam Altman has backed advanced fission and fusion ventures through investments in companies such as Oklo and Helion Energy², while Bill Gates, co-founder of Microsoft and current chair of the Gates Foundation, has championed next-generation

reactor technologies through TerraPower.³ Major technology companies have also begun to pursue nuclear power as a source of firm, low-carbon electricity for their data centre operations. Google, for instance, has entered into an agreement with Kairos Power⁴ to develop, and get electricity from, advanced Small Modular Reactors (SMRs), while Meta has signed long-term contracts with Constellation to secure nuclear power from the Clinton nuclear plant for its AI and data centre facilities.⁵ Taken together, these developments show that the growth of AI is shaped not just by advances in computation, but also by access to power that is reliable, scalable, and clean.

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2. "Sam Altman: Nuclear Energy for a Billion Years", *Market and Markets*, July 13, 2023, <https://www.marketsandmarkets.com/industry-news/Sam-Altman-Nuclear-Energy-Billion-Years>, Accessed on November 6, 2025.
 3. Obed Manuel and Steve Inskeep, "Bill Gates is Going Nuclear: How his Latest Project Could Power US Homes and AI", NPR, June 14, 2024, <https://www.npr.org/2024/06/14/nx-s1-5002007/bill-gates-nuclear-power-artificial-intelligence>. Accessed on November 14, 2025.
 4. "Google and Kairos Power Partner to Deploy 500 MW of Clean Electricity Generation", Kairos Power, October 14, 2024, https://kairospower.com/external_updates/google-and-kairos-power-partner-to-deploy-500-mw-of-clean-electricity-generation/. Accessed on November 14, 2025.
 5. Pippa Stevens, "Meta Signs Nuclear Power Deal with Constellation Energy", CNBC, June 3, 2025, <https://www.cnbc.com/2025/06/03/meta-signs-nuclear-power-deal-with-constellation-energy-.html>.

This renewed attention to nuclear energy is taking place against a backdrop of rapidly rising electricity demand from data centres. For example, in 2024, data centres accounted for approximately 1.5 percent of global electricity consumption, or about 415 terawatt-hours (TWh).⁶ This is comparable to the annual electricity use of countries such as Spain or Sweden. It is estimated that this demand will more than double by 2030, reaching nearly 945 TWh.⁷ Meeting this surge in demand will be challenging for the existing energy infrastructure. While renewable sources such as solar and wind are central to decarbonisation efforts, they are intermittent sources of power, meaning that they are dependent on fluctuating natural or weather conditions, and cannot generate electricity continuously, in the absence of complementary systems, and require substantial investment in energy storage, grid flexibility, or back-up capacity to ensure reliable, round the clock electricity supply.

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In practice, this gap unfortunately, has often been filled by fossil fuels. The International Energy Agency (IEA) estimates that fossil fuels collectively supply nearly 60 percent of global data centre electricity demands, raising concerns that AI, which is often framed as a driver of efficiency and sustainability, may become carbon-intensive as it scales. This concern is particularly relevant for tech companies that are racing to build new data centres, many of which have committed to net-zero emissions and other strong, sustainable goals. Meeting these commitments

6. "Energy Demand from AI", International Energy Agency (IEA), 2025, <https://www.iea.org/reports/energy-and-ai>. Accessed on November 12, 2025.

7. Ibid.

while sustaining AI-driven growth requires energy sources capable of delivering clean, firm power at scale.

Coincident with the AI demand fuelling support for civil nuclear power, broader geopolitical developments, particularly the ongoing US-Israel-Iran-War and the blocking of the Strait of Hormuz, have prompted countries to reassess their energy security architecture. Together, these developments have highlighted the vulnerabilities of fossil fuel dependence and are reinforcing the strategic value of nuclear energy. Having experienced cycles of prominence and decline over the past few decades, nuclear power is once again gaining traction amid converging pressures of energy security and decarbonisation.

Against this backdrop, this paper examines how AI's rising energy demands are shaping renewed interest in nuclear power. It explores the factors driving the nuclear appeal and assesses what this emerging relationship implies for the future of civil nuclear energy and the long-term sustainability of AI-driven technological growth.

HOW ENERGY INTENSIVE ARE DATA CENTRES?

According to the International Energy Agency, there is no AI without electricity.⁸ This is not a metaphorical statement, but rather a literal one as AI systems—from data centres to machine learning—require constant power to function. Older AI models such as classic machine learning or predictive AI, primarily analysed and recognised patterns in existing data without generating new content. In contrast, generative AI models, like ChatGPT or Google Gemini, create new outputs in the form of text, images, or videos. Producing this content requires much larger computations across massive neural networks, which require significant amounts of electricity.

8. Costas Mylonas, "Artificial Intelligence Requires Energy—But Under What Conditions?", ENA Institute for Alternate Policies, March 30, 2026, [https://enainstitute.org/en/publication/artificial-intelligence-requires-energy-but-under-what-conditions/#:~:text=The%20International%20Energy%20Agency%20\(IEA,roughly%20945%20TWh%20%5B3%5D](https://enainstitute.org/en/publication/artificial-intelligence-requires-energy-but-under-what-conditions/#:~:text=The%20International%20Energy%20Agency%20(IEA,roughly%20945%20TWh%20%5B3%5D). Accessed on March 31, 2026.

Further, AI models do not consume electricity just for computation purposes but also for cooling, storing, and moving huge amounts of data within data centres. These facilities contain thousands of servers and Graphic Processing Units (GPUs), along with complex cooling, networking, storage and back-up systems. All this adds up to the power needs. Unlike older digital infrastructure, AI data centres run dense, energy-intensive workloads that can't easily be paused or moved to off-peak hours. As a result, their electricity demand is not only large but also continuous, necessitating a steady baseload requirement.

The energy footprints of AI become particularly apparent when we examine seemingly small, individual tasks. According to a new study by researchers at Hugging Face and Carnegie Mellon University, using a generative AI model to generate a single image requires roughly the same amount of electricity as fully charging a smart phone!⁹ Even if this appears modest in isolation, at scale, the cumulative effect is massive as hyperscale data centres run millions of such inference and training operations continuously, round the clock. The power requirements of a single hyperscale data centre are, thus, significant enough to influence local grid planning and generation capacity decisions as it is estimated that they consume as much electricity as tens or even hundreds of thousands of households.¹⁰

These tasks and facility-level patterns aggregate into substantial system-level demand. While it is difficult to measure exactly how much of data centre energy use comes from AI—since these facilities support many different digital services—there is growing agreement that AI is now the main driver behind this rising demand. Globally, it is estimated that data centres already consume more than 400 TWh of electricity annually—a figure comparable to the total demand of a G7 country, with projections indicating that total

9. Melissa Heikkilä, "Making an Image with Generative AI Uses as Much Energy as Charging Your Phone", *MIT Technology Review*, December 1, 2023, <https://www.technologyreview.com/2023/12/01/1084189/making-an-image-with-generative-ai-uses-as-much-energy-as-charging-your-phone/>. Accessed on November 2, 2025.

10. Dawn Stover, "AI Goes Nuclear", *The Bulletin.org*, December 19, 2024, <https://thebulletin.org/2024/12/ai-goes-nuclear/>. Accessed on October 6, 2025.

consumption could more than double to around 1,000 TWh per year by 2030 as AI adoption accelerates.¹¹ Similarly, analysts at Goldman Sachs believe that power consumption at data centres is going to skyrocket, increasing by over 160 per cent by 2030.¹²

Some analysts, however, argue that energy projections for data centres are speculative and exaggerated. They cite factors such as worst-case growth assumptions and “duplicate requests,” where developers submit multiple grid connection applications for the same project, as sources of inflation in projected energy demand. While these problems do persist and some projections for AI are potentially inflated, the scale of real-world investment into expanding AI data centres and ensuring its power supply demonstrates that the underlying electricity demand is genuine and growing.

According to the Rocky Mountain Institute (RMI), at present over 2.2 terawatts of generation capacity is stalled in interconnection queues.¹³ The sheer scale of the backlog, remains a massive indicator of intent. Even a conservative 50 per cent discount for duplicate applications leaves a demand profile that is historically unprecedented. The demand then doesn’t appear to be just theoretical or a projection pushed by the energy industry as some critics point out. When companies like Alphabet and Microsoft are spending billions of dollars a year on planned data centre infrastructure, the demand appears to be grounded in real demand, not just inflated projections.

Nvidia CEO Jensen Huang too recently emphasised this constraint on AI growth in a podcast, stating that energy, not chips, is now the main limiting factor. He noted that the power grid is struggling to keep up with rising demand from AI data centres and suggested that large tech companies may

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11. “The Atom and the Algorithm: Nuclear Energy and AI are Converging to Shape the Future”, International Atomic Energy Agency (IAEA), December 3, 2025, <https://www.iaea.org/newscenter/statements/the-atom-and-the-algorithm-nuclear-energy-and-ai-are-converging-to-shape-the-future>. Accessed on December 10, 2025.
 12. “Is Nuclear Energy the Answer to AI Data Centers’ Power Consumption?”, Goldman Sachs, January 23, 2025, <https://www.goldmansachs.com/insights/articles/is-nuclear-energy-the-answer-to-ai-data-centers-power-consumption>. Accessed on March 18, 2026.
 13. Alisia Peterson, Katie Seigner, et. al, “The Interconnection Queue Continues to be a Barrier to American Economic Competitiveness”, rmi.org, March 17, 2026, <https://rmi.org/interconnection-reform-ai-data-centers-generator-queues/>. Accessed on March 23, 2026.

eventually operate small nuclear reactors on-site to provide steady, reliable power to their facilities.¹⁴ Further, from a policy perspective, the risk of underestimating demand and consequently underbuilding firm capacity may outweigh the risks of overestimation, especially in such critical sectors.

Analysts also often present efficiency improvements in computing, through better chips, better algorithms, and optimised data centre design, to reduce energy use per task as an important solution to AI's rising electricity demand. While these improvements are essential, they alone are unlikely to keep up with the rapid scale and pace of AI-driven growth. Historically, efficiency gains have often led to more use overall as lower costs make technologies easier and cheaper to deploy, a phenomenon known as the rebound or Jevons effect. According to an analysis by Epoch AI, while efficiency is improving as algorithms get optimised each year, the total demand, however, is also rising rapidly, and so are training costs and power requirements associated with it.¹⁵ In the AI context, efficiency improvements are often used to build larger models and run them more widely, so total energy use continues to rise. Therefore, efficiency alone cannot solve AI's energy problem; it must be complemented by parallel efforts to expand access to firm, low-carbon, and scalable electricity.

Tracing the Trends in AI Energy Demand

The reality of AI's growing energy demand carries important implications for energy systems. Beyond the sheer volume of electricity that it requires, it is also reflective of a qualitative shift in its character: towards continuous and reliability-sensitive power consumption. This qualitative shift is being driven by the rapid evolution of AI capabilities. New models are being introduced at a remarkable pace, often within months of one another, with each one bringing a new range of capabilities. AI systems have progressed

14. John Dyer, "Why Nvidia's Jensen Huang Thinks AI's Future Depends on Nuclear Power", sightlineu308, December 8, 2025, <https://sightlineu308.com/2025/12/why-nvidias-jensen-huang-thinks-ais-future-depends-on-nuclear-power>. Accessed on March 27, 2026.

15. "Trend in Artificial Intelligence", Epoch.ai, <https://epoch.ai/trends>. Accessed on March 26, 2028.

Modern AI workloads, particularly large multi-modal models and agentic systems, impose continuous, high baseline demand.

Training runs can last days or weeks without interruption. This makes their energy needs mostly inflexible.

from relatively simple text-based chatbots to multi-modal models that can process and generate text, images, audio, and increasingly, high-fidelity video too. These advances happen with high level of computation for each task. Generating these outputs, especially videos or large-scale simulations requires immense processing power.

Thus, the energy required per task, which is referred to as the “inference cost,” is rising sharply, with each interaction requiring sustained as well and intensive computational effort.

AI is also moving toward agentic systems. This refers to highly advanced artificial intelligence that carries out multi-step tasks over an extended period of time, autonomously, and with minimal human supervision. These tasks cannot be delayed or paused unlike earlier digital services and require continuous operation to function effectively, creating a steady and persistent energy load. As AI systems get embedded into global commerce, industry, and critical infrastructure, even seemingly brief power outages stop being just minor inconveniences as they can disrupt entire automated processes. Traditional electrical grids, by contrast, were designed around predictable demand peaks—daytime industrial use or evening residential consumption—and relied on dispatchable generation to meet these loads. Modern AI workloads, particularly large multi-modal models and agentic systems, impose continuous, high baseline demand. Training runs can last days or weeks without interruption. This makes their energy needs mostly inflexible and places stress on grids which are not optimised for sustained, round the clock operation.

Another notable trend is how the geographic footprint of AI infrastructure is also expanding rapidly. As AI infrastructure expands, in both scale and scope, it is beginning to reshape the structural and geographic patterns of electricity consumption worldwide. Trillions of dollars in investment are

expected to flow into the construction of new AI and cloud computing hubs, not only across established markets in the United States, Europe, and China, but also across emerging digital corridors in Asia, Latin America and Africa.¹⁶ For instance, the Asia-Pacific region is expected to emerge as the world's largest data centre market outside of

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North America by 2030. Southeast Asia especially is witnessing rapid growth in hyperscale data centres, making it one of the fastest growing regions for such investments.¹⁷ Each of these new facilities will require access to large, reliable, and preferably low-carbon sources of electricity.

Recognising this rising demand, several Southeast Asian countries are exploring civil nuclear power programmes. Even nations without existing nuclear infrastructure are considering the option.¹⁸ Brunei, for instance, despite its vast petroleum reserves, is evaluating the nuclear option¹⁹, while Malaysia, which aspires to become a regional computing hub, recognises the need for constant and reliable power supply²⁰ to attract investment from global tech giants. This trend is mirrored globally, from Vietnam and Russia recently signing nuclear deals²¹ to Switzerland reconsidering its 2017 decision

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16. "The Atom and the Algorithm: Nuclear Energy and AI are Converging to Shape the Future", IAEA, December 3, 2025, <https://www.iaea.org/newscenter/statements/the-atom-and-the-algorithm-nuclear-energy-and-ai-are-converging-to-shape-the-future>. Accessed on December 10, 2025.
 17. Adam Pitman, "AI is Redrawing Southeast Asia's Data Centre Map", ERPToday, March 5, 2025, <https://erp.today/ai-redrawing-southeast-asia-data-center-map/>. Accessed on March 28, 2026.
 18. Anton L Delgado, "Southeast Asia Revisits Nuclear Power Plans for AI Data Centers as Iran War Disrupts Energy Supplies", apnews.com, March 26, 2026. <https://apnews.com/article/southeast-nuclear-energy-power-artificial-intelligence-c08108c2c5da7fd263098ff43748eac5>. Accessed on March 30, 2026.
 19. "Southeast Asia Turns to Nuclear as Iran War Disrupts Energy Supplies", NPR.org, March 26, 2026, <https://www.npr.org/2026/03/26/g-s1-115291/southeast-asia-turns-to-nuclear-as-iran-war-disrupts-energy-supplies>. Accessed on March 30, 2026.
 20. Delgado, n. 18.
 21. "Vietnam and Russia Advance Nuclear Power Deal as Energy Security Concerns Grow in Southeast Asia", *Arab News*, March 25, 2026, <https://www.arabnews.com/node/2637465/world>. Accessed on March 30, 2026.

to phase out nuclear energy²², reflecting a growing recognition that stable, low-carbon baseload power is essential for supporting the next generation of AI infrastructure.

THE CLIMATE IMPERATIVE

The current AI boom and the consequential expansion of AI infrastructure is colliding with the climate crisis that has reached a state of emergency. With global warming poised to breach the critical 1.5-degree Celsius threshold²³, the world is approaching irreversible tipping points. Atmospheric carbon dioxide (CO₂) concentrations saw their largest-ever recorded jump in 2024,²⁴ driven by stubbornly high emissions and the dangerous weakening of natural carbon sinks. The effects of the worsening crisis are grim: Greenland is now losing an estimated 30 million tons of ice every hour,²⁵ while climate-fuelled hazards are wreaking havoc on a global scale. In India, for example, extreme weather events were recorded on 99 per cent of the days in the first nine months of 2025.²⁶ Climate change acts as a “threat multiplier,”²⁷ exacerbating existing vulnerabilities across health, food security, and social stability. The International Chamber of Commerce (ICC) reports that extreme weather has cost the global economy over \$2 trillion²⁸ in the past decade alone, affecting the livelihoods of one-fifth of the

22. “Switzerland Edges Toward Lifting Ban on New Nuclear Plants”, [swissinfo.ch](https://www.swissinfo.ch/eng/climate-adaptation/switzerland-edges-toward-lifting-ban-on-new-nuclear-plants/91086012), March 12, 2026, <https://www.swissinfo.ch/eng/climate-adaptation/switzerland-edges-toward-lifting-ban-on-new-nuclear-plants/91086012>. Accessed on March 28, 2026.

23. Fred Pierce, “Overshoot: The World is Hitting Point of No Return on Climate”, [e360.edu](https://e360.yale.edu/features/1.5-degrees-tipping-points), January 28, 2026, <https://e360.yale.edu/features/1.5-degrees-tipping-points>. Accessed on March 28, 2026.

24. Ibid.

25. Damian Carrington, “Greenland Losing 30m Tonnes of Ice an Hour, Study Reveals”, *The Guardian*, January 17, 2024, <https://www.theguardian.com/environment/2024/jan/17/greenland-losing-30m-tonnes-of-ice-an-hour-study-reveals>. Accessed on March 28, 2026.

26. “Experts Failing to Account for Ripple Effects from Extreme Weather, Paper Warns”, *Yale Environment 360*, March 27, 2026, <https://e360.yale.edu/digest/casading-impacts-extreme-weather>. Accessed on March 30 2026.

27. “Climate Change Recognized as ‘Threat Multiplier’: UN Security Council Debates Its Impact on Peace”, [news.un.org](https://news.un.org/en/story/2019/01/1031322), January 25, 2019, <https://news.un.org/en/story/2019/01/1031322>. Accessed on March 30, 2026.

28. “The Economic Cost of Extreme Weather Events: Could Cost Economy \$2 Trillion over the Last Decade”, [iccwbo.org](https://iccwbo.org/news-publications/policies-), November 11, 2024, <https://iccwbo.org/news-publications/policies->

world's population. The geopolitical stakes are equally high, as seen when climate-induced droughts in one region trigger social unrest in another²⁹, a cascading effect that turns environmental instability into global insecurity.

For the technology sector, the timing of the AI boom creates a fundamental conflict. As companies and countries intensify their net-zero commitments, meeting the massive energy demands of AI through fossil fuels is counter-productive, as it directly undermines the sustainability targets that these same corporations have attempted to champion. While renewable energy sources like wind and solar are essential components of the transition, they face inherent limitations in the context of AI. The fundamental intermittency of weather-dependent sources, along with significant storage, land-use, and reliability challenges, means that they often cannot provide round the clock reliability that hyperscale data centres require.

This crisis has fundamentally shifted the focal point of energy policy discussions from “how do we get more power” to “how do we get the right kind of power.” Meeting the scale of AI demand requires a tool that is both low-carbon and firm, capable of providing steady, baseload electricity regardless of weather conditions. As the following section details, nuclear energy emerges as the most promising solution to this structural and environmental deadlock.

DRIVERS BEHIND THE RENEWED INTEREST IN NUCLEAR ENERGY

As AI continues to scale, it places a distinct set of demands on electricity systems, characterised by continuous operation, high power density, and the need for long-term supply predictability, among other factors. Nuclear power is uniquely positioned to meet these operational and strategic requirements. The Director General of the International Atomic Energy Agency Rafael Mariano Grossi, recently stated in this context “We can now say with clarity: the AI revolution, through its scale and speed, was always

reports/new-report-extreme-weather-events-cost-economy-2-trillion-over-the-last-decade/ .
Accessed on March 28, 2026.

29. n. 26. Accessed on March 29, 2026.

going to choose nuclear energy as a partner. The only question was ‘when?’. Today, we know that the answer is ‘now.’”³⁰

The following section outlines the key attributes of nuclear power that are shaping its growing consideration within the AI-energy nexus.

Firm, Non-Intermittent Generation

While much of the energy discourse emphasises on clean power, in the context of AI expansion, clean and constant are the important features that move the needle. Large AI systems need a constant and reliable supply of electricity because they run round the clock to train models and deliver real-time services. Power interruptions or fluctuations can disrupt operations, lead to data loss, and cause high economic costs, making uninterrupted electricity a critical operational requirement. Within this context, a central feature that has renewed interest in nuclear power is its ability to provide firm power, meaning that it is a consistent source of power. It is non-intermittent in nature, not relying on weather conditions, unlike wind or solar power generation, and, thus, operates independently and can generate electricity continuously over extended periods.

Notably, the provision of firm power does not imply that nuclear energy is incompatible with renewable-heavy electricity systems. On the contrary, Nuclear Power Plants (NPPs) have demonstrated operational flexibility in certain grids, particularly where nuclear generation plays a dominant role. In France³¹, for example, nuclear reactors adjust output to help balance fluctuations in renewable power generation and changes in demand. This combination of firm generation and operational flexibility allows nuclear power to increase production when renewable output is low and reduce it when renewables are abundant, thereby supporting grid stability.

30. n. 16.

31. Thor Lindskog, “Intermittency and the Appeal of Nuclear Energy”, Nordsip, January 4, 2022, <https://nordsip.com/2022/01/04/intermittency-and-the-appeal-of-nuclear-energy/>. Accessed on December 3, 2025.

High-Capacity Factors

Another defining characteristic feature of nuclear power that makes it increasingly relevant to meet AI-driven electricity demand is its high capacity factor. The capacity factor refers to a metric used in energy analysis that measures the extent to which a power plant operates at or near its maximum potential output over a given period. A capacity factor of 100 per cent, for instance, indicates that a plant is producing electricity at full power continuously, while lower capacity factors reflect periods of reduced output.

According to the US Department of Energy, “Nuclear has the highest capacity factor of any other energy source, producing reliable and secure power more than 92 per cent of the time in 2024. That’s nearly twice as much as a coal (42.36%) or natural gas plant (59.9%) that are used more flexibly to meet changing grid demands and almost 3 times more often than wind (34.3%) and solar (23.4%) plants.”³²

While some AI workloads can be scheduled or shifted to off-peak periods, the overall demand of hyperscale data centres remains largely continuous and high-density. Nuclear power, thus, is a highly reliable source of electricity, which is particularly valuable for AI infrastructure.

Clean Source of Power

Nuclear power is one of the cleanest sources of electricity with near-zero operational emissions.³³ When assessed across its full lifecycle, including uranium mining, fuel processing, plant construction, operation, and decommissioning, its Greenhouse Gas (GHG) emissions remain among the lowest of all electricity sources.³⁴ According to the Nuclear Energy Institute (NEI), US nuclear power generation prevented over 471 million

32. “What is Generation Capacity?”, US Department of Energy, March 30, 2025, <https://www.energy.gov/ne/articles/what-generation-capacity>. Accessed on November 12, 2025.

33. “3 Reasons Why Nuclear is Clean and Sustainable”, US Department of Energy, March 31, 2020, <https://www.energy.gov/ne/articles/3-reasons-why-nuclear-clean-and-sustainable>. Accessed on November 2, 2025.

34. Olivia Lai, “Nuclear Energy Carbon Emissions Lowest Among Electricity Sources, UN Reports”, Earth.org, November 24, 2021, <https://earth.org/nuclear-energy-carbon-emissions-lowest-among-electricity-sources-un-reports/>. Accessed on October 15, 2025.

Spent fuel is managed under stringent safety and regulatory regimes, with storage systems undergoing continuous monitoring and designed for long-term containment.

metric tonnes of carbon dioxide emissions in 2020 by displacing fossil-fuel-based electricity.³⁵ The avoided emissions are roughly equal to removing about 100 million passenger vehicles from the road for a year and exceeded the emissions reductions achieved by all other clean energy sources combined in the United

States during that period.³⁶ This characteristic has become increasingly salient as AI-driven electricity demand intersects with corporate decarbonisation commitments and national climate targets.

However, at the same time, nuclear power's environmental profile is more complex than that of other clean sources of power. Public and political debates around nuclear energy continue to be mired by concerns of long-term radioactive waste management and the low-probability but high-impact risk of severe accidents. However, the total volume of used nuclear fuel is relatively small, since the energy density of nuclear fuel is very high. For instance, it is estimated that the total volume of spent nuclear fuel generated in the US over several decades would occupy less than a single football field if stacked to a depth of about ten yards.³⁷ Moreover, spent fuel is managed under stringent safety and regulatory regimes, with storage systems undergoing continuous monitoring and designed for long-term containment.

In fact, some countries like France³⁸ do not even treat used nuclear fuel as waste right away. The spent nuclear fuel is reprocessed to recover usable materials, allowing additional energy to be generated from fuel that would otherwise be treated as waste. Emerging reactor technologies are also being developed with the capacity to utilise recycled or spent fuel, offering the potential to extract further energy, while also being able to

35. n. 33.

36. Ibid.

37. "5 Fast Facts about Spent Nuclear Fuel", US Department of Energy, October 3, 2022, <https://www.energy.gov/ne/articles/5-fast-facts-about-spent-nuclear-fuel>. Accessed on October 22, 2025.

38. Ibid.

reduce the volume and longevity of high-level radioactive waste. For instance, fast neutron reactors operate differently than conventional thermal reactors, which, when combined with closed fuel-cycle systems, are able to reuse the spent fuel multiple times!³⁹ This, in principle, would not only extract much more energy from the same amount of uranium but also leave behind less radioactive waste, and for a shorter period of time.

Another feature that strengthens the case for nuclear power is its exceptionally high energy density and corresponding small land footprint. This means that nuclear power plants produce a large amount of electricity from a relatively small area of land.

High Energy Density and Small Land Footprint

Another feature that strengthens the case for nuclear power is its exceptionally high energy density and corresponding small land footprint. This means that nuclear power plants produce a large amount of electricity from a relatively small area of land. By extension they also cause less disruption to ecosystems. For example, a conventional 1,000-megawatt (MW) nuclear power plant in the United States typically occupies just over one square mile of land. In comparison, wind farms would require 360 times more land area to generate an equivalent amount of electricity, and solar Photo Voltaic (PV) plants would require 75 times more land area. If compared with other renewable sources of power, this means that over three million solar panels or over 430 wind turbines (excluding capacity factor) would be required to produce the same amount of power as a typical nuclear reactor.⁴⁰

This spatial efficiency is increasingly important in places hosting data centres, where land availability, transmission constraints, and local opposition often pose challenges with regard to the pace and scale of new energy infrastructure development.

39. Lucy Ashton, "When Nuclear Waste is an Asset, not a Burden", *IAEA Bulletin*, September 2023, vol. 64-3, <https://www.iaea.org/bulletin/when-nuclear-waste-is-an-asset-not-a-burden>. Accessed on October 18, 2025.

40. n. 33.

This matters even more as AI infrastructure grows. Large data centres need huge amounts of electricity in specific locations, usually close to strong power grids, fast internet connections, and supportive regulations. As nuclear power can supply ample low-carbon electricity from just a few compact sites, it aligns well with the practical realities of building and powering AI and cloud computing infrastructure.

SMALL MODULAR REACTORS: EXPANDING THE NUCLEAR VALUE PROPOSITION

While conventional nuclear power plants, as discussed, already possess many of the characteristics required to support energy-intensive AI infrastructure, growing policy and industry attention has increasingly focussed on Small Modular Reactors (SMRs) as a complementary pathway for meeting future electricity demands. SMRs, as the name indicates, are small nuclear reactors that typically generate up to 300 megawatts (MW) of electricity per unit, significantly less than conventional reactors, which often exceed 1,000 MW. The defining feature of SMRs lies in their modular design: they are manufactured as standardised components in factory settings and then transported to sites for assembly, rather than being constructed entirely on-site. As hyperscale data centres expand, their electricity requirements too increase gradually. In this regard, the modular design aligns well as it can be added sequentially, allowing generation to scale alongside AI workloads. Staged deployment may help in reducing the risks of over or under-building capacity and could appeal to technology firms planning long-term investments under uncertain demand conditions.

SMRs are also designed to overcome several challenges of large conventional plants. Factory-based manufacturing and standardised designs for instance aim to reduce construction complexity, shorten timelines, and improve cost predictability, though these benefits have not yet been demonstrated at a commercial scale. Many SMR designs emphasise enhanced safety, using passive systems and improved resilience to external hazards.

If SMRs are successfully deployed as intended, they could be better positioned than conventional nuclear power plants to support large-scale AI systems, as they offer greater flexibility, scalability, and cost predictability.

CHALLENGES AND CONSTRAINTS

Notwithstanding their technical advantages, NPPs and SMRs face a fair share of regulatory, economic, supply-chain, and societal challenges. First, deployment timelines have been a major setback. Nuclear projects generally are very time intensive as they involve complicated and lengthy processes of planning, licensing, and construction before they can become operable. In many countries this can take about a decade or more (while countries like China take much less time due to streamlined processes).⁴¹ But many AI companies need power much sooner, generally estimated to be within the next three to five years.

Second, regulatory and licensing frameworks further delay the deployment prospects. Although rigorous oversight is essential for ensuring nuclear safety, approval processes for new reactor designs, particularly First-Of-A-Kind (FOAK) and advanced technologies such as SMRs, remain complex and time-consuming. The existing regulatory systems that govern nuclear power were largely designed for traditional, large scale-reactors. This creates uncertainty when it comes to SMRs, as regulators have to determine several new aspects, such as how to license a reactor built in a factory, or how to assess safety systems that don't fall under old safety and regulatory assumptions among other factors. In addition, at a global level, these challenges are compounded by the absence of a fully harmonised global framework. Differences in national safety standards, licensing processes, and liability regimes mean that a reactor that is approved in one country may not be approved in another country. Not only will developers need to redo licensing for each market, but it would also drive up the timelines and costs, making it harder for projects to get financed and slower to deploy.

41. Claire Brown, "How Long Will it Take to Build a Nuclear Power 'Renaissance' in the US?", *The New York Times*, October 23, 2025, <https://www.nytimes.com/2025/10/23/climate/us-nuclear-industry-growth.html>. Accessed on December 18, 2026.

Economic challenges also remain significant. While it is anticipated that as the industry transitions from First-Of-A-Kind (FOAK) to Nth-Of-A-Kind (NOAK), the costs of SMRs will come down, many analyses, however, suggest that they may still not be able to match the costs of existing power technologies in the coming years at least.⁴² In this regard, in 2023, the NuScale Carbon Free Power Project in Idaho was cancelled⁴³ due to escalating costs and an inability to secure sufficient off-takers, underscoring the difficulty of achieving economies of scale for SMRs.

Improvements in project delivery, standardisation, and supply-chain maturity are other important factors that will help in determining whether SMRs can realise their promised advantages in a cost predictable manner and within construction timelines.

Finally, public perception, even after all these years, continues to be a prominent factor that influences the prospects of nuclear power. Concerns of safety, radioactive waste management and proliferation continue to influence policy decision-making. Despite having one of the lowest death rates⁴⁴ (per unit of energy produced) among all energy sources, the fear around nuclear power continues to exist. This translates into public resistance, siting challenges, and regulatory delays, which slow deployment. This, however, has gradually been changing as the general public is slowly learning about the benefits and safety aspects of nuclear power. In the US, the Natural Resources Defence Council (NRDC), one of the most distinguished environmental groups, that has historically held anti-nuclear sentiments, has recently extended its support in restarting a nuclear power plant in Iowa for

42. Ján Mykhalchuk Hradický, "Faster, Cheaper, Smarter? The Promise and Pitfalls of Small Modular Reactors", Globesec.org, June 2, 2025, <https://www.globesec.org/what-we-do/commentaries/faster-cheaper-smarter-promise-and-pitfalls-small-modular-reactors>. Accessed on November 13, 2025.

43. "Idaho SMR Project Terminated", *World Nuclear News*, November 9, 2023, <https://www.world-nuclear-news.org/articles/idaho-smr-project-terminated>. Accessed on November 18, 2025.

44. James Conca, "How Deadly Is Your Kilowatt? We Rank The Killer Energy Sources", *Forbes*, June 10, 2012, <https://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/>. Accessed on November 17, 2025.

one of Google's data centres.⁴⁵ A Gallup poll conducted last year too revealed that public support for nuclear energy as a source of electricity in the US reached 61 per cent, just one percentage point below its 2010 peak, which was the highest level recorded in over three decades of tracking.⁴⁶ However, this alone is insufficient. Building public support requires moving beyond technical advocacy toward sustained trust-building. This, in turn, must be grounded in transparency to enhance credibility and meaningfully address public concerns.

The challenges currently plaguing the nuclear industry, however, are not unsolvable. They are transitional factors and are associated with regulatory learning curves, high costs in the initial days, immature supply chains, etc. Regulatory frameworks are evolving to incorporate SMRs, supply chains are being rebuilt, and industry leaders are learning from FOAK projects and accordingly developing their deployment approaches. The current state of SMRs is thus reflective of both the promise of scaling nuclear power as well as the complexities involved in the process.

CONCLUSION

The AI boom is happening at a time that is distinctly different from earlier waves of digitalisation. Today, this growth comes at a time when electricity demands are rising at unprecedented rates. The climate crisis, which for the longest time was considered a problem for the future is wreaking havoc around the world and the geopolitical uncertainties are high. Whether AI proves to be beneficial or dangerous in broader social terms remains an open and contested debate. What is far less uncertain, however, is the speed of its expansion. AI is developing at an unprecedented speed, and appears to be largely inevitable. The central question, therefore, is not whether it

45. Amy Harder, "Exclusive: AI Power Demand Cracks Resistance to Nuclear Power", Axios.com, <https://www.axios.com/2026/03/16/environmental-ai-power-nuclear-demand>, March 16, 2026. Accessed on March 28, 2026.

46. Megan Brennan, "Nuclear Energy Support Near Record High in US", Gallup, April 9, 2025, <https://news.gallup.com/poll/659180/nuclear-energy-support-near-record-high.aspx>. Accessed on March 30, 2026.

will scale, but how it will scale, and what consequences it will have for the energy system and the planet.

Policy support from governments and financial commitments from private players in the current climate indicate that the future of nuclear energy appears to be on an upward trajectory. Advances made in reactor design and manufacturing also signal a positive shift within energy strategies. According to the World Nuclear Association (WNA), global nuclear capacity is projected to skyrocket, more than three times, to about 1,446 gigawatts (GW) by 2050, provided existing reactors continue operations and countries meet their targets.⁴⁷ While its potential is significant, realising it will, however, require addressing the economic, regulatory, and technical hurdles through continued policy support and innovation.

While nuclear power is an essential and promising energy source in the path towards decarbonisation and a more sustainable future, it is however not a panacea to the existing energy crisis. No single technology can meet all the challenges of rising electricity demand, reducing carbon emissions, and ensuring energy security. A resilient energy future will require a diversified mix in which nuclear and renewables operate as complementary elements rather than substitutes.

Importantly, sustainability is not a concern for the future—it is an urgent and dangerous factor shaping technology development right now. If AI is to grow in a way that is economically feasible, environmentally responsible, and resilient in a complex geopolitical landscape, it is important that the energy systems that support it must also evolve accordingly. Nuclear power's ability to move from renewed promise to actual deployment will be a key factor in determining whether AI's expansion worsens the existing energy and climate challenges or becomes compatible with a more sustainable global future.

47. Delgado, n. 18.