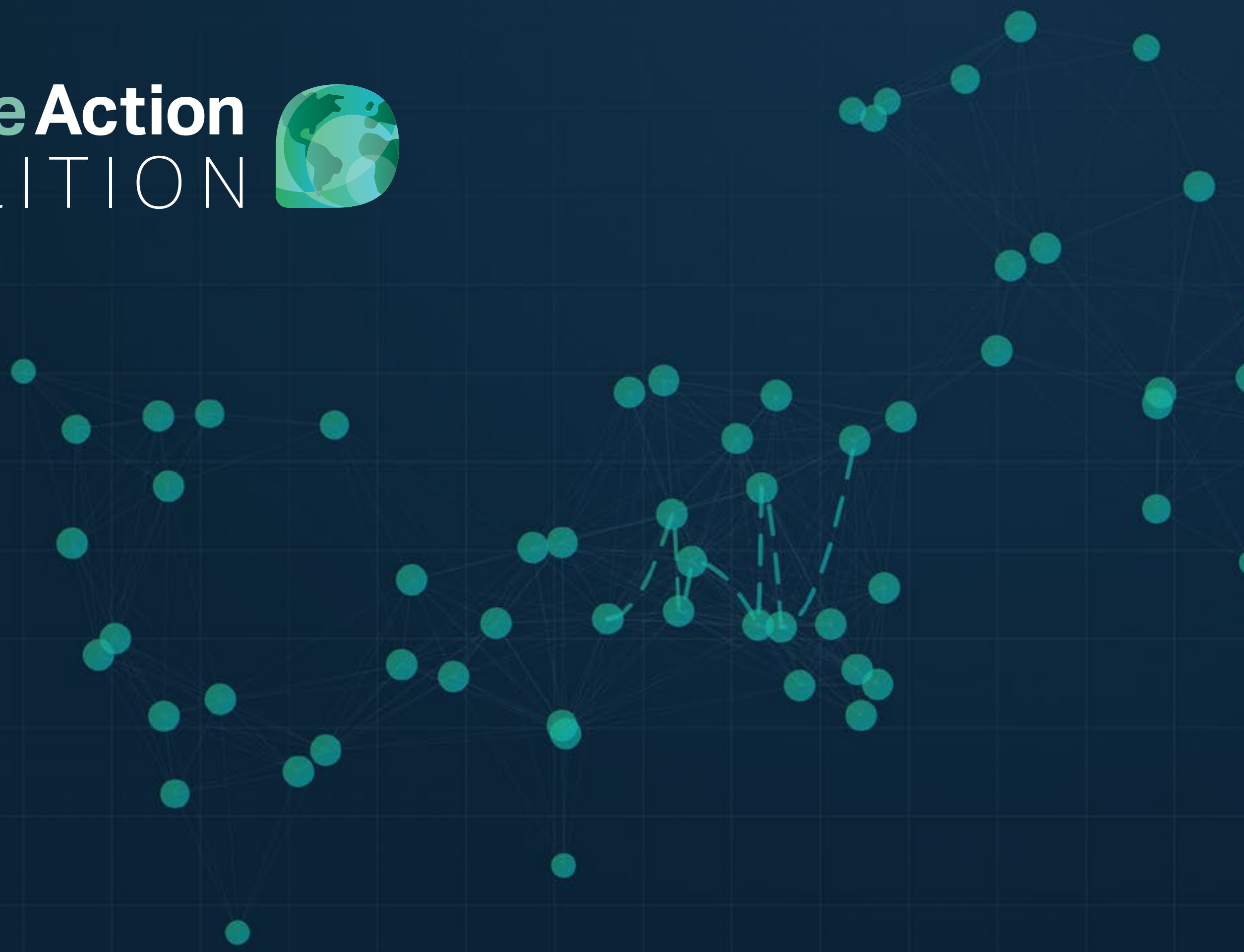
Climate Action COALITION

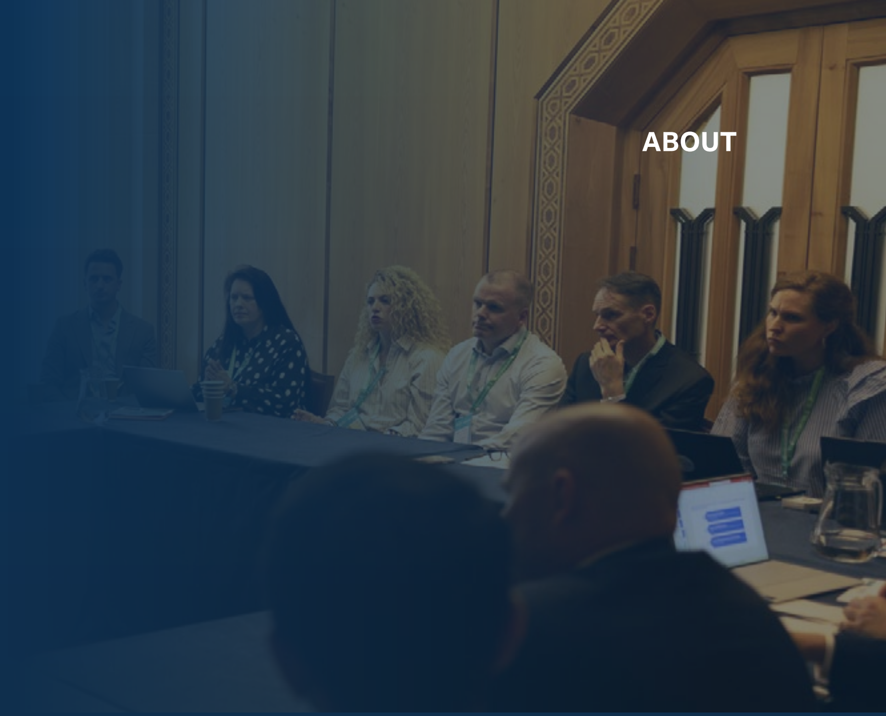


Net Benefit AI: Scaling Solutions, Opening Opportunities

Defining the responsible role for AI in the energy transition

Co-chaired by

Ambassador Patricia Espinosa &
Rt. Hon. Chris Skidmore OBE



About

About the Climate Action Coalition

The Climate Action Coalition was established in 2024 and launched at London Climate Action Week in July 2024 by Secretary John Kerry. Its purpose is to convene and highlight the opportunities across both the private and public sector for collaboration to scale up real world solutions to deliver climate action. It hosts roundtables at the Innovation Zone at COP and at London Climate Action Week, in addition to hosting the Post-COP Summit in London.

About the Net Benefit AI: Scaling Solutions, Opening Opportunities

The Net Benefit AI: Scaling Solutions, Opening Opportunities is co-chaired by Ambassador Patricia Espinosa, the former UNFCCC Executive Secretary between 2016-2022 and COP30 Envoy for Latin and South America, and Director of One Point Five, and Chris Skidmore, the former UK Energy Minister and Chair of the UK Independent Net Zero Review in 2023. The Taskforce held regular evidence sessions between April and June 2026, focusing on defining the responsible role of artificial intelligence within the energy transition

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Contents

Introduction

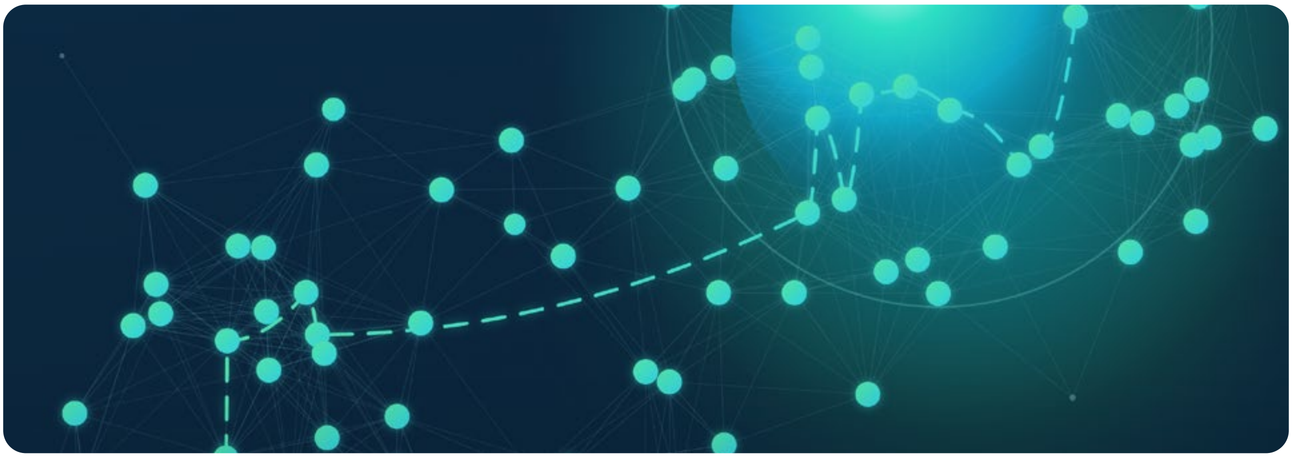
Rt Hon Chris Skidmore OBE and Ambassador Patricia Espinosa

The AI Revolution is transforming our world. Already, the application of its computing power is changing the way we work and do business, presenting new opportunities to rethink the very processes and patterns of our existence. The adoption of AI and its rapid scaling seem at this moment to be exponential. It is an industrial revolution to the nth degree.

That this transformation is happening is undeniable. There is no turning back on the road ahead. Yet we will face future forks in the road, that present choices which will define not only our present generation, but the welfare of future generations ahead. Will we ensure that AI transforms our world for the better, or will we allow our world to be transformed by AI for the worse? Of course, the challenges faced and decisions we make apply to many aspects of AI, its ethical application and responsible use. For this Climate Action Coalition report, we will focus our attention on the leadership required to ensure that AI is a positive force for good in our world, present and future. AI can be used to reduce emissions in a world that needs urgently to bend the emissions curve downwards if we are to meet temperature goals set by the Paris Agreement for the end of the century. AI must be part of the solution, not part of the problem.

Already, there are concerns regarding the impact that the rapid development, deployment and sheer scale of data centres is having, both in terms of global electricity use, and the corresponding emissions. It is important however to set this rise in the wider context of other rapidly scaling technologies that are also having a significant impact on electricity use and emissions; for instance the rise in air conditioning as global temperatures rise. For the first time, however, the deployment of data centres and AI has meant that, along with the need for rapid electrification as we set out in our first report, Pathways To Progress, we need grid and electricity systems that are fit for the future. This requires the effective deployment of storage alongside low and no carbon clean energy generation technologies to meet growing demand. In addition AI is providing the operational tools to unlock existing grid capacity by freeing stranded and wasted power.

There is a clear and urgent need to ensure that the growth and connection of AI infrastructure is achieved in the most sustainable way. Outdated and inefficient means of powering data centres using fossil fuels bring long standing challenges of volatile prices, as international events have recently shown, and unresolved issues of energy security and uncertain supply. We need the data centres of tomorrow to be powered by clean power. Data centre Power Purchase Agreements at scale have been shown to encourage investment in renewables. Another emerging option is on-site power generation using microgrids which providethe opportunity for facilities to generate their own electricity . Such projects can change the relationship with the surrounding transmission system including using contractual frameworks to bring new clean power to the grid. There is already exciting work underway on the need to establish international frameworks, partnerships and agreements on the best design models and standards to deliver clean energy data centres and ensure that across the world, in every country, the most efficient and productive means of generating AI with sustainable forms of power is adopted. We have been delighted to work with the UNFCCC, the European Commission, the Green Digital Alliance and the International Telecommunications Union



along with a number of green data centre and AI coalitions to highlight not only the work that is ongoing to deliver this mission, but to set out what will be needed for the future if this mission is truly to succeed. The need for a renewed focus on international partnerships and agreements, so that we have in place frameworks that ensure AI progress can sit alongside the Paris Agreement, is both urgent and a necessity for forthcoming climate conferences to solve. This has been the focus of one of our evidence roundtables on international partnerships and agreements. We highlight what has been delivered so far on this issue, as well as what will need to be established, in the first section of the report.

Yet as the World Economic Forum (WEF) has shown, the real challenge we should be asking and setting ourselves is how AI and its technologies can have a net positive impact upon society and the world, so that the application of AI and its benefits outweigh any additional emissions that AI infrastructure and data centres may generate in the future. This is the core challenge of this report, which we also believe is an opportunity; an opportunity to demonstrate what solutions are already being developed, or are in place, that highlight how AI is already delivering emissions reductions across different industries. Indeed, there are so many sectors where this is the case, that for this report we have limited our focus to the energy system itself- solutions that are reducing emissions across nature and climate will potentially be the focus for a separate report.

The solutions presented in this report are not merely early stage and innovative solutions that need significant additional capital or trialling to be scaled up: rather, they are ready to be adopted in real time, before 2030. This is key: we cannot wait for AI to prove its value; its value is in delivering the solutions needed for today, as well as tomorrow. The solutions that we present cover key sectors that have been the focus of our roundtable evidence sessions, including Industry and Manufacturing, Buildings and Transport, AI Infrastructure and data centres. These solutions are also not technocratic in nature, but rather demonstrate how a problem is being solved, and the potential for the future is being unlocked. AI can be the key to opening a door of unimagined possibilities, yet already we know what is possible, we have the AI solutions at hand to deploy now. We just need a focus to ensure that the positive application of AI solutions is welcomed and recognised, or risk being drowned out by a negative and unconstructive narrative that AI is instead destabilising our progress on climate. Rather, we would say that our progress on climate now depends on our effective and correct use of AI for the better.

AI is here to stay: the choice must be to choose how it can be shaped and directed towards a pathway of possibilities and positivity, that makes our planet a better, not worse, place to live.

The focus of this report is therefore how we can shape a narrative, and frame that future pathway, that will ensure that communities and countries across the world will make the same choice, towards a recognition that AI must play a crucial role not merely in the climate conversation, but as an emerging crucial weapon in the fight against climate change, as well as a key tool in the adoption at pace of the energy transition. AI is the future: let us ensure that this future is one which works for people and planet, for the benefit of all.

PART ONE:

The Challenge And Response

Section 1: The Challenge

AI's Expanding Energy Footprint and the Dual Challenge Ahead

Artificial Intelligence is the defining technology of the 21st century. It is reshaping productivity, accelerating scientific discovery, and transforming the global economy.

The context for AI expansion is that the AI companies, data centre investors, developers and operators are in a race to bring infrastructure capacity to market. All governments are also in a race as they seek to meet AI economic growth objectives - through a combination of efforts to attract large data centre developments within their borders and the building of local commercial AI ecosystems to drive productivity and overall GDP growth over the next decade.

But long-term, the growth of the AI economy and environmental sustainability are inseparable.

Spanning public policy, commercial objectives, people and planet putting AI in all its forms to work for a green future is complex, challenging and vital.

As AI systems scale, so too does the energy required to power them. This tension sits at the heart of today's climate and energy debate: can AI reduce more emissions than it generates? The answers depend on how quickly the world can steer AI development toward low carbon infrastructure, efficient model design, and applications that accelerate decarbonisation across every sector.

The challenge is not simply the volume of electricity required, but the type of electricity, the timing of demand, and the location of AI infrastructure. AI's energy footprint is rising at the same moment that countries are attempting to decarbonise and stabilise their grids, as they seek to electrify whole industries, transport and heating, while expanding renewable generation and decarbonisation efforts. The risk is that AI becomes an additional source of strain on already congested networks, competing with households, industry and transport for clean power. Yet the opportunity is equally significant: AI can act as a force multiplier for the energy transition, improving forecasting, reducing waste, accelerating planning, and enabling system wide optimisation.

This duality—AI as both a source of new demand and a tool for accelerating decarbonisation—defines the central question of this report. The world is entering a period in which digital and energy systems are becoming deeply intertwined. AI workloads increasingly resemble a new category of baseload electricity demand, while the energy transition increasingly depends on digital intelligence to manage complexity, variability and scale. Understanding this relationship is essential for designing policies that harness AI's benefits while mitigating its risks.

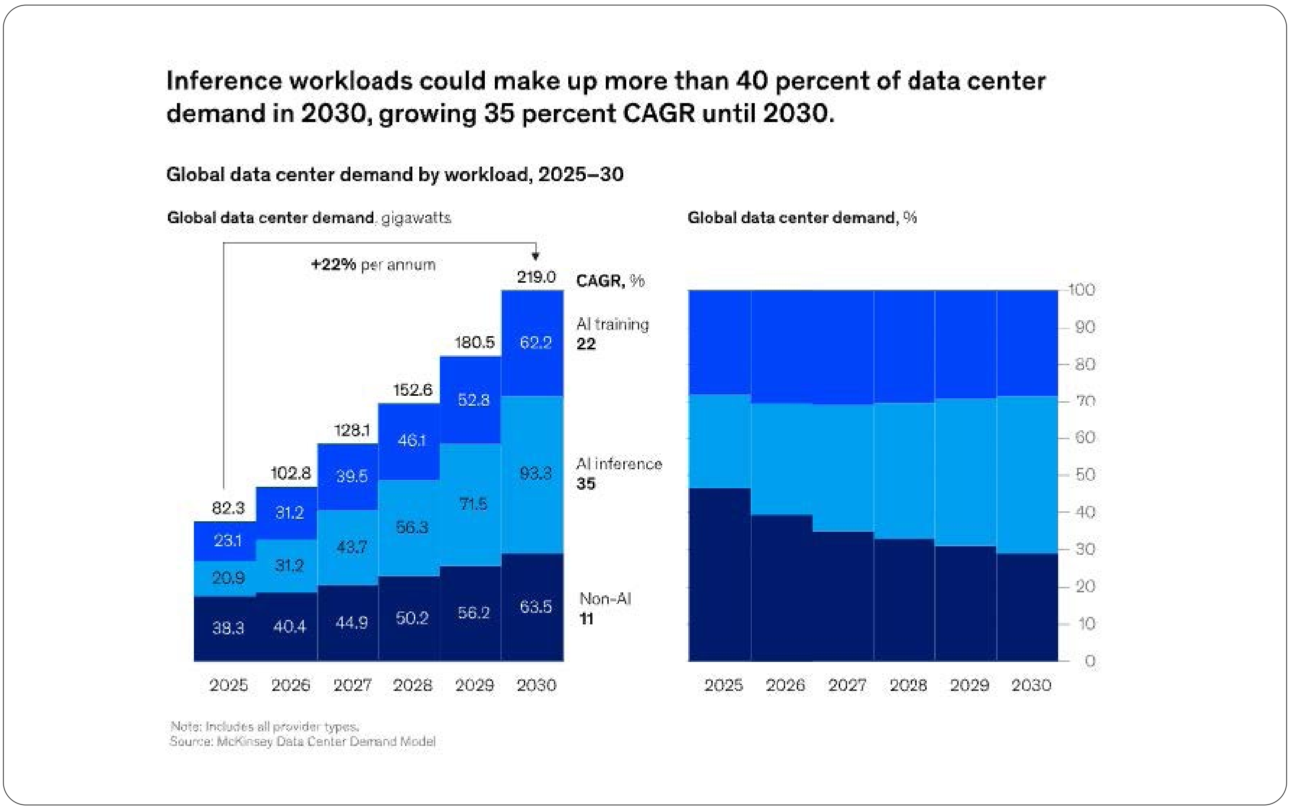
The scale of the challenge is globally significant. Frontier-scale AI training models require tens of thousands of processors, consuming tens of gigawatt hours of electricity per training cycle[1]. Meanwhile, inference—the process of running models to generate outputs—has become a continuous, global, always-on workload. A single inference request uses only a small amount of energy, but billions of daily interactions create a persistent baseload that increasingly resembles a new category of national electricity demand[2].

This section sets out the challenge of AI's rapidly rising energy demand. It provides an overview overview of what has happened so far, what is underway, and where the evidence points next. It

FIGURE 1

Figure1. Growth in inference data centres to 2030

Source: https://www.mckinsey.com/featured-insights/week-in-charts/the-future-of-ai-workloads



also establishes the context for the sector specific pathways explored in **Part 2** and the case studies presented in **Part 3**.

From Traditional Machine Learning to High-Density AI

For most of the past decade, the energy footprint of artificial intelligence was modest. Traditional machine-learning tools—such as regression models, random forests, or decision-tree systems used in finance, logistics or public sector analytics—run efficiently on standard enterprise servers. Their energy use is negligible in the context of national electricity systems.

The shift came with the rise of deep learning, generative AI, and multimodal models capable of processing text, images, audio and video. These systems rely on large neural architectures trained on vast datasets, requiring specialised hardware such as GPUs and TPUs.

The result is a step change in energy intensity. Even as data centre operators improve efficiency, the overall energy required for training is expected to rise due to the rapid growth in model size and capability.

The most immediate and concentrated energy impact comes from the training phase of large Generative AI models. Training typically occurs in hyperscale data centres using Pre-Training Models (PTMs) such as the Generative Pre-trained Transformer (GPT) family.

Such models require specialised hardware, high-density compute clusters, and advanced cooling systems, resulting in significantly higher energy consumption.

Each new generation of these models requires:

- larger datasets
- more computational steps
- longer training cycles
- denser, more power-intensive server infrastructure

Even as data centre operators improve efficiency, the overall energy required for training is expected to rise due to the rapid growth in model size and capability.

The industry has moved from models with billions of parameters to models with trillions, with no sign of slowing[4] - although there are moves towards so-called Small Language Models. This growth is driven by competitive pressure, user expectations, and the expanding range of tasks AI systems are expected to perform. Larger models tend to be more capable, but they also require more compute, more memory, and more energy.

However, as AI becomes embedded in everyday services—from search engines and productivity tools to industrial automation and public sector systems— long-term drivers of AI's energy footprint expand beyond training to include inference.

Inference happens billions of times per day becoming a continuous, global energy and processing workload. This shift from training-dominated to inference-dominated energy use is one of the most important structural changes in the digital economy.

Inference workloads also have different characteristics from training workloads.

As AI systems move from experimental deployment to mass adoption the balance of energy use shifts to an operational stage where models generate outputs, answer queries, or automate tasks.

Inference executed continuously and at global scale:

- A single inference request uses only a small amount of energy.
- However, billions of daily interactions across digital services, industrial automation, and emerging agentic workflows create a persistent, compounding baseload on energy and data centre infrastructure.
- This baseload increasingly resembles a new category of always-on electricity demand, with implications for grid planning, renewable integration, and local network capacity.

For policymakers, the key message is that AI is not a monolithic energy consumer. Its climate impact depends on:

- the type of AI model
- the stage of its lifecycle (training vs. inference)
- the design and location of the data centres that host it
- the carbon intensity and resilience of the surrounding electricity system

Understanding these distinctions is essential for designing effective regulatory frameworks, planning grid upgrades, and ensuring that AI deployment aligns with national climate action goals.

The implications are profound. AI is no longer a niche workload that can be managed within existing data centre infrastructure. It is becoming a major component of national electricity demand, with significant implications for grid planning, renewable integration, and local network capacity.

Where AI Lives: The Rise of AI Factories and Inference Hubs

The data centre digital infrastructure industry is undergoing a structural shift to building and operating AI factories. Alongside hyperscale AI campuses—often located in remote areas with access to cheap land and renewable energy—a new class of inference-focused data centres is emerging in and around cities that will require high density power infrastructure often where grid capacity is limited. In some locations inference risks becoming the dominant driver of AI-related emissions over the next decade. These AI Edge facilities will support a mix of real-time, low-latency applications such as autonomous vehicles, robotics, augmented reality, and industrial automation[5].

This shift has major implications for energy systems. Hyperscale AI campuses can be located near renewable-rich regions, such as the Nordics or the US Pacific Northwest, where hydropower and wind provide abundant low-carbon electricity. Inference hubs, by contrast, must be located near users. AI inference systems are expected to represent 50% to 65% of this energy consumption — equivalent to 10% to 20% of the total global consumption [6].

The resource intensity of AI factories is coming under increased scrutiny. The physical footprint of AI infrastructure raises questions around the embodied carbon intensity of AI factory building shells, about water use, and land use. Despite AI factories moving away from traditional cooling methods where evaporative cooling required significant use of high volumes of water, to direct to chip closed loop liquid cooling, data centre developments have led to tensions in regions facing drought or water scarcity. While there is no escaping the construction of high-density data centres involves carbon-intensive materials such as steel and concrete cloud hyperscalers and AI factory developers are engaging with industry bodies on cradle to grave carbon measurement of embodied carbon of materials and equipment through collaboration with bodies such as the Green Building Council, LEED, Bre and others to reduce lifecycle emissions.

These challenges are compounded by the speed at which AI infrastructure is being deployed. Developers are racing to build capacity, often outpacing the ability of regulators, utilities and communities to assess impacts and plan accordingly. This creates a risk of misalignment between digital infrastructure and energy system needs.

It is the combination of the increasing power densities demanded by these next generation processors combined with the forecasted scale out demand for AI workloads requiring GWs of electricity that is reshaping the relationship between data centre developers and energy sector power generation, transmission and distribution players. And the national market regulators.

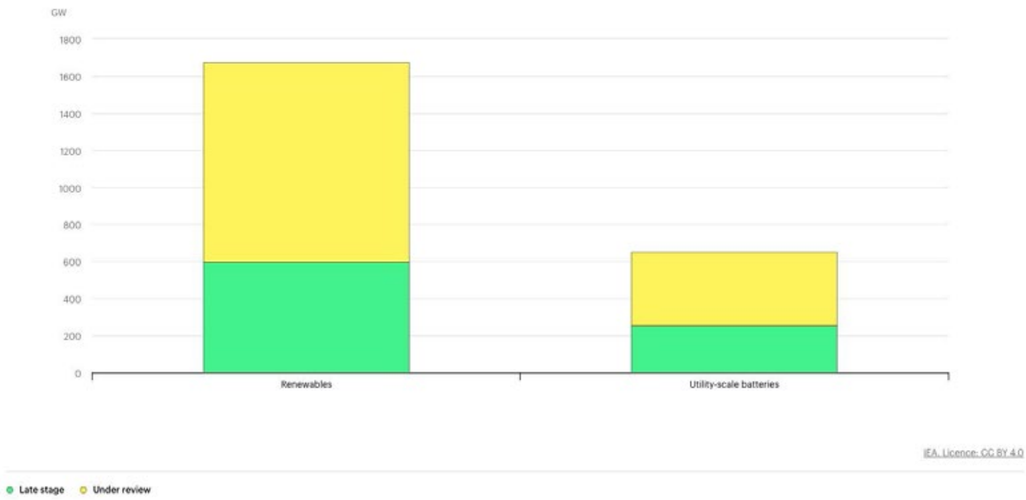
The need for energy at scale is the major factor pushing the AI data centre industry into new policy and regulatory domains.

Yet there are also opportunities. AI factories can support grid stability by providing flexible demand,

FIGURE 2
Overview of key AI and hyperscale global facilities operating and currently in development[10]
(Note: Capacity figures reflect maximum planned or IT-load capacities for these specific campus developments, some of which are being built in phases over the coming years).
Source: Gemini AI

Region	Project / Campus	Location	Operator	Power Demand
North America	Meta Hyperion AI Campus	Northern Louisiana, USA	Meta	5,000 MW
North America	Stargate Supercluster	Texas, USA	OpenAI / Oracle	Up to 5,000 MW
North America	Susquehanna AWS Campus	Pennsylvania, USA	AWS	1,200 MW
North America	NextEra / ExxonMobil AI Campus	Southeastern USA	NextEra / ExxonMobil	1,200 MW
North America	AWS Mississippi Facility	Mississippi, USA	AWS	Scaling to 1,000 MW
North America	xAI Memphis Facility	Tennessee, USA	xAI	1,000 MW
Middle East	Abu Dhabi AI Campus	Abu Dhabi, UAE	G42 / Microsoft	Up to 5,000 MW
Asia	China Mobile Intelligent Computing Center	Inner Mongolia, China	China Mobile	1,200 MW
Europe	SoftBank Campus	France	SoftBank Group	5,000 MW
Europe	Start Campus Sines	Sines, Portugal	Start Campus	1,200 MW
Europe	Blackstone Northumberland	Northumberland, UK	Blackstone	1,000 MW+
Europe	Project Lighthouse / Vantage EU Expansion	Cardiff, Wales, UK	Vantage Data Centers	Up to 902 MW
Europe	Microsoft Aragon Campus	Aragon, Spain	Microsoft	500+ MW
Europe	VIRTUS Saunderton & Berlin	UK & Germany	VIRTUS Data Centres	Up to 375 MW combined
Europe	xAI Colossus (EU/UK Expansion)	EU/UK repurposed sites	xAI	300 MW+ per cluster
Europe	Nebius AI Factory	Lappeenranta, Finland	Nebius	350 MW

FIGURE 3
Renewable energy and utility-scale battery capacity in advanced stages waiting in connection queues globally, by project stage, 2025
https://www.iea.org/reports/electricity-2026/grid



participating in demand response programmes, and integrating both off-site and on-site renewable generation and storage. They can also provide waste heat for district heating networks, greenhouses and industrial processes. With the right policies and incentives, AI infrastructure can become a key asset for the energy transition.

The Global AI Infrastructure Build-Out

The scale of investment in AI infrastructure is unprecedented. To date, more than $1 trillion has been committed globally to the development and construction of AI data centres by hyperscale cloud providers and generative AI companies[7]. McKinsey estimates that global spending on data centres could reach $7 trillion by 2030, driven by the race to scale AI capabilities[8].

This build-out is reshaping the geography of the digital economy. Countries are competing to attract AI investment, offering incentives, streamlined permitting, and access to renewable energy. At the same time, developers are seeking locations with abundant clean power, favourable climate conditions, and supportive regulatory environments.

The result is a new energy-digital nexus in which data centre developers, utilities, regulators and governments must coordinate far more closely than in the past.

AI, Grids and the Energy System Bottleneck

The rapid expansion of AI infrastructure is occurring at the same moment that electricity systems worldwide are undergoing profound structural change. Grids originally designed for a fossil-fuel era—built around large, centralised power stations and predictable demand patterns—are now being asked to accommodate intermittent renewables, electrified transport, electrified heating, and increasingly, high-density digital loads from data centres. The result is a growing mismatch between the pace of digitalisation and the pace of grid modernisation. Over 2 500 GW[11] of renewable, large-load and storage projects are currently stalled in grid queues worldwide, according to the IEA.

Power access has become the number one bottleneck for AI factories. Grid-connection queues stretch beyond a decade in some regions. Transmission expansion takes 5–15 years—far slower than the pace of AI deployment – typically 24-36 months from design to ready for service (RFS).

This creates a structural mismatch: soaring AI-driven demand on one side, and delayed integration of low-carbon supply on the other. Developers are increasingly exploring alternative power options, including:

- On-site solar and wind
- Private-wire arrangements
- Microgrid powered AI factories
- Grid-scale batteries
- Advanced geothermal
- Fuel-cell systems
- Small modular reactors (post-2030)

The International Energy Agency (IEA) estimates that global data centre electricity consumption could reach close to 1,000 TWh annually before 2030, driven largely by AI workloads[12]. This is equivalent to the electricity consumption of Japan. In parallel, as noted, renewable and storage projects are stuck in grid-connection queues worldwide, waiting for transmission upgrades that can take a decade or more[13]. This creates a structural bottleneck: AI demand is rising exponentially, while grid capacity is expanding linearly.

In some markets, the impact is already visible. Ireland previously introduced strict limits on new data centre connections in Dublin due to grid congestion[14]. The Netherlands has paused approvals for hyperscale facilities in several provinces. In the United States, utilities expect to invest $1.1 trillion over the next five years in new generation and grid capacity, driven in large part by AI and data centre load growth[14].

The UK faces similar pressures. National Energy System Operator (NESO) predicts that electricity demand from EVs, heat pumps and data centres will rise by around 30 TWh by 2030, equivalent to 10% of today's total demand[15]. With nearly 100 new data centres planned by the end of the decade, the UK is entering its fastest-ever period of digital construction. Schneider Electric forecasts that data centres alone could add up to 71 TWh of additional demand over the next 25 years[16].

With coordinated planning, AI can avoid the risk of becoming a new source of grid strain. With the right

FIGURE 4
Electricity consumption by data centres, 2020-2035
https://www.iea.org/data-and-statistics/charts/electricity-consumption-by-data-centres-2020-2035

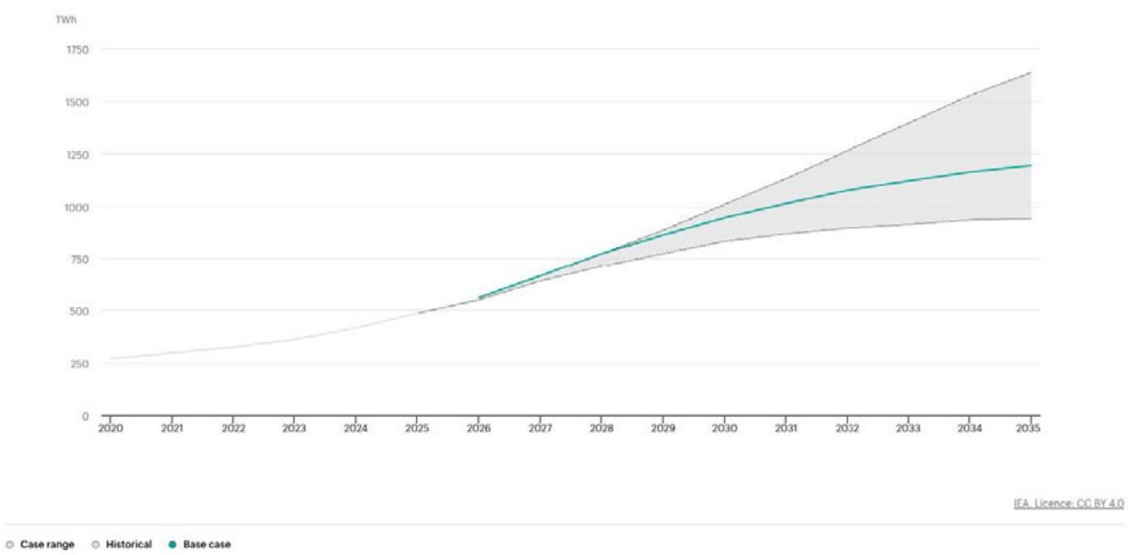
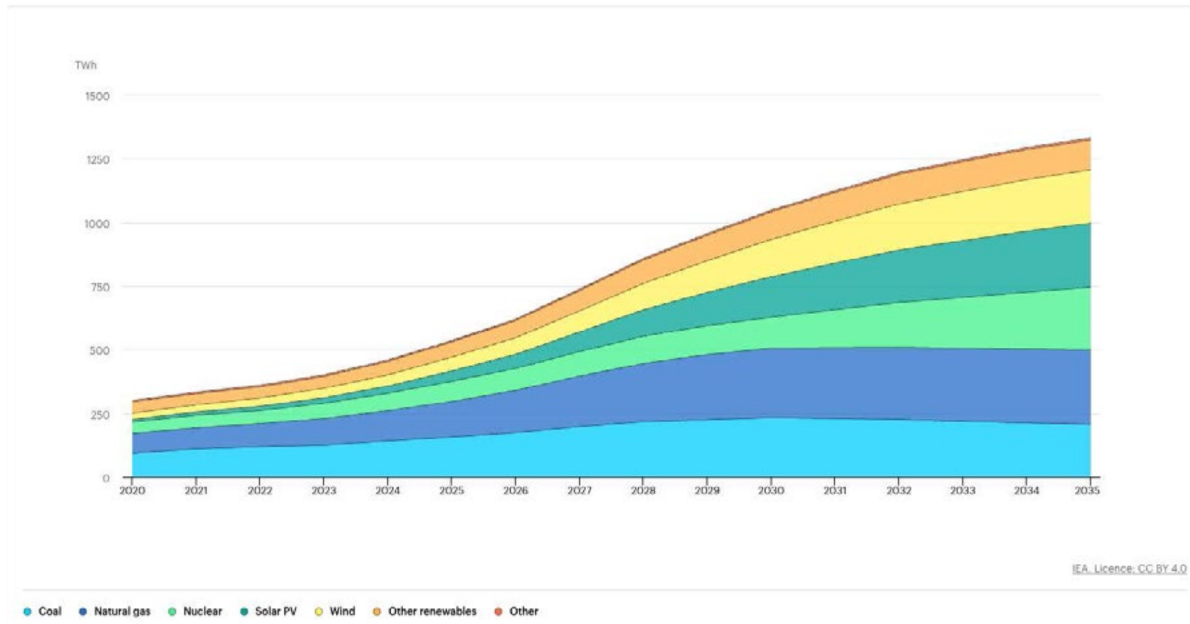


FIGURE 5

Sources of global electricity generation for data centres

IEA (2025), Sources of global electricity generation for data centres, Base Case, 2020-2035, IEA, Paris https://www.iea.org/data-and-statistics/charts/sources-of-global-electricity-generation-for-data-centres-base-case-2020-2035, Licence: CC BY 4.0



governance AI infrastructure can become a catalyst for grid modernisation, accelerating investment in renewables, storage, and flexible demand.

AI's Energy Mix and Emissions Trajectory

The climate impact of AI depends not only on how much electricity it consumes, but on the carbon intensity of the electricity system that supplies it. According to the IEA, coal supplies around 30% of the electricity consumed by data centres globally, with the highest shares in China[17]. Natural gas accounts for around 26%, while renewables supply 27% and nuclear 15%.

Even with rapid renewable growth, fossil fuels are expected to meet more than 40% of additional data centre electricity demand this decade[18]. This raises legitimate concerns that AI's energy footprint could undermine progress toward net zero.

The IEA estimates that carbon dioxide emissions from electricity generation for data centres will peak at around 320 $MtCO_2$ by 2030, declining only slightly to 300 $MtCO_2$ by 2035 as nuclear and renewables expand[19]. These figures do not include Scope 3 emissions from hardware manufacturing, construction, or water use, which remain poorly reported.

Yet the emissions trajectory is not predetermined. AI's climate impact varies dramatically depending on:

- Where data centres are located
- When they consume electricity
- How they are cooled
- What hardware they use
- How efficiently models are trained and run
- How quickly grids decarbonise

Public Attitudes, Behaviour and the Social Licence for AI Infrastructure

As demand for digital infrastructure continues to grow, communities are asking important questions about how data centers affect their daily lives. And residents want to understand the impacts not only on local water resources, but also on energy cost and reliability. on noise levels, on land use, and on overall quality of life in their communities. These concerns are all legitimate and deserve transparent engagement.

Public attitudes toward AI and digital infrastructure are becoming a decisive factor in the pace and shape of deployment. While AI is often perceived as an abstract, intangible technology—experienced through apps, search engines or productivity tools—the physical infrastructure that enables it is highly visible to the communities that host it. Data centres, substations, transmission lines and cooling systems occupy land, consume water, and draw significant amounts of electricity. As a result, the social licence to operate for AI infrastructure is emerging as a critical determinant of where and how quickly new capacity can be built.

Polling across Europe and North America shows a complex picture. The public broadly supports technological innovation and recognises the economic benefits of digital investment, yet concerns about energy use, water consumption, land availability and local environmental impacts are rising[20]. In the UK, Climate Action Coalition polling shows that voters across the political spectrum strongly support cheaper, more reliable clean power, but have limited awareness of the role AI infrastructure plays in shaping energy demand[21]. This disconnect creates fertile ground for misinformation, with exaggerated claims about AI's energy use circulating alongside narratives that understate the challenge. The level of public pushback against new data centers especially in the US is accelerating. According to analyst group STL Partners, as of 2025, public opposition had impacted approximately $77 billion of projects. Northern Virginia was the epicentre of much of the build out, and consequently the most pushback, with approximately $48.7 billion of delayed capacity. However, projects across at least nine states - covering every region of the US - have been hit by opposition and protests.[22]

The invisibility of digital consumption contributes to this tension. People interact with AI-enabled services on handheld devices without any awareness of the data centre clusters powering those interactions. This creates a psychological gap between digital behaviour and physical impact. At the same time, communities hosting data centres experience the infrastructure directly: construction traffic, noise, land use, and perceived competition for clean-energy capacity.

Social licence depends on demonstrating clear, local benefits. These may include:

- Grid support, through flexible demand, frequency response and load shifting
- Heat reuse, supplying district heating networks, greenhouses or industrial processes
- Local job creation, particularly in construction, operations and maintenance
- Ongoing education, digital and AI economy ecosystem building
- Investment in renewable generation, including private-wire arrangements
- Community benefit schemes, such as energy-efficiency upgrades or local training programmes

Without these tangible benefits, AI risks becoming a new flashpoint in the politics of the energy transition—particularly in regions already facing grid constraints or water scarcity.

Sovereign AI and the Geopolitics of Compute

A major trend reshaping the digital landscape is the rise of Sovereign AI—the idea that nations should develop, train and operate AI systems within their own borders. This shift is driven by concerns about data privacy, national security, economic competitiveness and technological dependence. Deloitte's 2026 data suggests that more than 77% of enterprises now consider the physical location of AI development and data centre hosting when choosing technology vendors[23].

Sovereign AI has profound implications for energy systems. As noted above, in the past, global cloud providers could build data centres in locations with natural advantages—such as Iceland or the Nordics, where cool climates reduce cooling needs and abundant hydropower provides clean, low-cost electricity. Sovereign AI requirements disrupt this model by pushing high-density computing facilities into countries with limited grid capacity, higher-carbon electricity, or severe water constraints.

This creates a new geopolitical dynamic in which:

- Compute = strategic asset
- Energy = national security
- Data = sovereign resource

Countries are now competing not only for AI talent and investment, but for the clean energy capacity required to power AI infrastructure. The geopolitics of computing is becoming inseparable from the geopolitics of energy.

For governments, this raises questions around:

- How much AI capacity should be hosted domestically?
- How should AI demand be integrated into national energy planning?
- What standards should apply to siting and emissions?
- How can AI growth be aligned with net zero commitments?
- These questions sit at the heart of the challenge—and opportunity—outlined in this report.

Section 2: Climate Policy

AI Impact, Data Integrity and Reporting Gaps

A foundational barrier to managing the climate impact of AI is the lack of consistent, granular, and verifiable data on energy use and emissions. Often data centres report their carbon emissions at highly aggregated corporate or regional levels, making it difficult to isolate the energy cost of specific AI operations. A carbon report might state the annual electricity consumption of an entire data centre complex, but it rarely distinguishes between:

- Generative-model training
- Continuous inference
- Standard cloud workloads
- Storage
- Networking
- Cooling

Current carbon-accounting practices rely heavily on annual or monthly regional averages, even though grid carbon intensity fluctuates hour by hour and node by node[19]. Scope 3 emissions—from hardware manufacturing, construction, and water use—are rarely disclosed with precision[20].

Governance frameworks are beginning to emerge. The EU AI Act introduces new transparency requirements for high-risk systems. ISO/IEC standards are being developed for sustainable computing. IEEE initiatives are exploring responsible AI design. The OECD is working on cross-border governance principles. The challenges that remain include:

- Real-time carbon accounting
- Detailed lifecycle emissions reporting
- Energy aware model design
- Siting and permitting standards
- Water-use disclosure
- Hardware efficiency benchmarks

However, there is much work underway involving policymaker and operator collaboration.

The Global Dialogue on AI Governance, is a platform for governments and multi-stakeholder groups that are deliberating on the most pressing challenges posed by AI.

There are numerous initiatives on AI governance currently being developed across multilateral bodies.

These include:

- The Independent International Scientific Panel on AI[24], which works to bridge cutting-edge research with global policymaking by providing rigorous, independent scientific analysis of AI risks.
- The AI Governance for Humanity Lab[25]. An international initiative created to support the global governance of artificial intelligence.

- The European Commission Global Gateway Program[26] is an umbrella term for the EU strategy created to boost smart, clean and secure connections in the digital, energy and transport sectors, and to strengthen health, education and research systems across the world. The EU's original aim was to mobilise up to €300 billion in investments worldwide between 2021 and 2027. In October 2025 the Commission announced that this target had been met, and set a new objective of mobilising €400 billion in investments by 2027.

These have their origin in the Global Digital Compact[27] adopted at the 2024 Summit of the Future, which set out a shared vision for an open, safe and inclusive digital future.

Progress on Cutting AI's Carbon Footprint

As AI adoption accelerates, so too does the urgency to manage AI's growing energy and carbon footprint. The challenge is not simply to contain AI's demand, but to redesign the systems around it so that intelligence and sustainability advance together. Around the world, governments, technology providers and energy operators are beginning to act—deploying cleaner power for data centres, improving the efficiency of AI models, redesigning digital infrastructure, and building the policy frameworks needed to ensure transparency and accountability. These emerging pathways show that AI's environmental impact is not fixed; it can be shaped through deliberate choices in energy sourcing, model design, infrastructure planning and governance. Taken together, they form the foundation for a future in which AI becomes not a burden on the energy transition, but a catalyst for cleaner, smarter and more resilient systems.

Cleaner energy supply for data centres[28]

As AI demand accelerates, large data centres are becoming major new sources of electricity consumption and therefore major opportunities for decarbonisation. Operators are increasingly turning to renewable power purchase agreements (PPAs), collocated solar and wind, and grid-scale storage to secure low-carbon electricity. Some are also exploring advanced geothermal and fuel-cell systems to reduce pressure on local grids.

The expansion from a smaller number of very large AI training facilities to many smaller, inference sites may also provide more opportunity to better match dispersed AI infrastructure with equally dispersed clean and low carbon energy

FIGURE 6
Use of digital twin technology to drive efficient data centre design, operations and grid connectivity
https://blogs.nvidia.com/blog/omniverse-blueprint-ai-factories-expands/

generation. For example, a solar farm, and battery storage infrastructure, would have little impact on the overhead of a 500MW AI training facility but could provide a significant proportion of the energy needs of a 5MW edge inference site. Looking ahead, the IEA expects[29] small modular reactors (SMRs) to become viable after 2030, offering stable, low emissions baseload power suitable for AI campuses. For policymakers, this shift means data centres are evolving into long-term clean energy partners, capable of anchoring new renewable and clean-power projects that benefit the wider grid.

Efficiency improvements in AI models

AI's energy footprint is driven not only by data centres but also by the design of the models themselves. Techniques such as model pruning, quantisation, and knowledge distillation can dramatically reduce the energy required for each query. Hardware advances — including specialised chips and accelerators designed specifically for AI inference — further cut electricity use. MIT Technology Review notes that these efficiency gains are essential as AI usage scales to billions of queries per day. For governments, these technology advances highlight the need for efficiency standards, procurement guidelines, and R&D incentives that reward models delivering the same capability with lower energy and carbon intensity.

Data centre design innovation

AI-ready data centres, also known as AI Factories, are being redesigned to manage far higher heat loads than traditional facilities. Liquid cooling systems — from direct-to-chip to full immersion — are becoming standard because they use less energy and enable heat reuse for district heating, greenhouses, and industrial processes.

AI, via digital twin technology, from organisations such as AVEVA and NVIDIA, can also be used to optimize how data centres are designed and constructed, how they are connected to the grid, and finally how they are operated including efficient management of the mechanical (cooling), electrical (power) and IT equipment inside the facility. The use of digital twins – effectively digital models - provides the potential for between 10% and 25% energy reduction by enabling visibility into how energy is going to be consumed across hundreds of different types of infrastructure assets.

Location strategy is also shifting. Operators are increasingly siting facilities in cooler climates, near renewable-rich regions, or adjacent to hydropower and geothermal resources. For policymakers, these trends open opportunities to align data centre growth with regional clean-energy strategies, industrial heat reuse programmes, and grid-planning objectives.

As well as driving efficiencies in where data centres are physically located, AI factories can geographically shift workloads - including those of manufacturing and other energy intensive activities - to areas of low grid demand or locations of abundant or excess green energy. This adds to the value of renewable energy because the variable generation can be matched with variable demand more effectively. AI applied to power use by energy intensive industries can also improve the system by load shifting to the use of battery power at times of grid stress. This leads to higher utilization of existing energy resources where and when most needed, Organisations such as NVIDIA, Emerald AI and the UK National Grid have also shown how AI data centres can dynamically adjust power consumption[30] in response to real-time signals, without disrupting critical workloads.

The Role of Policies, International Standards and Governance Frameworks

Governments and standards bodies are now building the regulatory foundations needed to manage AI's energy and climate impacts. New frameworks require operators to report real-time energy use, carbon intensity, and cooling performance, while AI developers must disclose training emissions and inference efficiency.

International bodies such as the OECD and ISO are increasingly focused on AI energy reporting, sustainable computing, responsible innovation, and equitable access to AI infrastructure. A global governance architecture is emerging — but gaps remain.

The Climate Action Coalition Taskforce convened a dedicated roundtable to examine the emerging ecosystem of international standards, governance frameworks and industry initiatives relevant to sustainable AI and data centre operations.

A consistent theme emerging from discussions was the need for greater transparency, standardisation and accountability regarding the environmental impacts of AI systems and the infrastructure that supports them.

Participants highlighted the importance of:

- Standardised methodologies for measuring AI-related energy consumption, emissions and water use.
- Transparent environmental reporting by technology companies and data centre operators.
- Internationally recognised sustainability benchmarks and certification schemes.
- Alignment between digital transformation strategies and climate objectives. Policies that incentivise investment in energy-efficient and low-carbon digital infrastructure.

As AI becomes more powerful and more pervasive, the need for responsible governance becomes more urgent. The IEEE's Global Artificial Intelligence Systems (AIS) Flourishing and Well-Being Initiative builds on IEEE 7010, focusing on aligning AI with ecological sustainability, developing metrics for well-being and environmental impact, supporting policymakers and corporations, and embedding flourishing and sustainability into AI design. This complements emerging standards on transparency, safety, and energy-aware AI development.

Several emerging frameworks—including the European Green Digital Coalition methodology[31] for measuring digital carbon footprints, the ITU-T L.1801 framework on the environmental sustainability of AI systems, Green Software Foundation: Software Carbon Intensity for AI, IEEE P7100 - Environmental Impacts of Artificial Intelligence, AFNOR (French standards body) - General framework for frugal AI, and new standards being developed by IEEE and other international bodies—are helping establish common approaches for measuring and managing the environmental impacts of AI infrastructure. (See below)

The discussion covered existing EU frameworks relevant to AI data centres which include the European AI Act and the European Chips Act.

In parallel, the Joint Research Centre has developed concrete guidelines and best practices underscoring the need to establish green data centres. Best practices and regulatory instruments, such as the Energy Efficiency Directive and the Taxonomy Regulation, are increasingly expected to embed stringent standards for data centre efficiency.

Debates on AI infrastructure have highlighted the intersection between green and digital transformation, drawing attention to how national AI strategies incorporate environmental and climate considerations. In this context, the Paris Agreement is understood to position technological innovation as both a driver and an enabler of climate action.

A persistent challenge lies in the institutional and professional separation between digital policy and climate or environmental policy. Many organisations and expert communities focus predominantly on one of these domains, rather than working across both.

For resource circularity and the greening of economies, efforts are therefore seen as needing to align closely with the European Green Deal. At the same time, the rapid expansion of AI is viewed as reinforcing the urgency of addressing the digital divide, so that the benefits of digital and green innovation are more evenly distributed.

Another central issue, particularly evident in Europe, concerns the acceleration of the pathway from research to market, enabling innovations to be commercialised and scaled across sectors. In this regard, support for the Team Europe data governance programme in Africa illustrates how AI can be deployed through concrete use cases and demonstration projects focused on climate applications, developed jointly by the European Commission and partner countries.

Scientific and digital programmes, including those promoting the development and use of local digital twins, are also seen as important enablers. The combination of AI, supercomputing and local digital twins is described as a means of empowering policymakers in areas such as internet infrastructure, energy and digital services. In parallel with the implementation of the Energy Efficiency Directive, the European Commission is preparing new communications on the role of AI within the energy system.

International collaboration forms another key dimension. Cooperation with the ITU on the Green Digital Action Hub, supported by a large number of countries, aims to bring together initiatives and actors working on digital and green innovation. The

Digital for Development (D4D) Hub, which brings together 16 EU member states and the European Commission, provides a mechanism to align programmes and present a coherent European approach to digital for development.

Within this wider landscape, the European Green Digital Coalition has developed methodologies for assessing the carbon footprint of digital technologies across sectors and has already generated a substantial portfolio of concrete use cases where these impacts are being measured. There is a growing expectation that policy frameworks should be deployed to incentivise transparent environmental reporting and the development of sustainable AI infrastructure. Particular emphasis is placed on large technology companies disclosing their emissions and their energy and water use associated with AI systems and data centres.

Finally, participants underlined the need for standardised approaches and methodologies to measure the environmental footprint of AI. Standards are presented as a foundation for responsible AI, offering technical tools that support ethics and governance, data quality, integrity, security, safety, interoperability and interfaces. Testing and certification are identified as essential end-stage components of the standardisation and deployment process, ensuring that AI systems and data centre infrastructures meet agreed environmental and technical requirements.

The Evolving Institutional Ecosystem - Emerging AI-Climate Coalitions

The intersection between sustainability and digitalisation, including AI in all its forms, is transformational but creates complexity as its impacts are being felt across different dimensions of society.

This makes AI governance extremely complex, both technically and in terms of its economic and social impacts covering aspects from cybersecurity to job security, from misinformation to lack of transparency or accountability.

The international governance landscape has rapidly mobilized to address the digital-environmental paradox. Rather than competing with existing frameworks, the work of the Climate Action Committee (CAC) AI Taskforce is intentionally designed to dovetail with a growing consensus of international standards. All share the aspiration to ensure that openness, safety, and inclusiveness become essential components of global AI governance.

A network of statutory and non-profit bodies is emerging to bridge the gap between computer science and climate science, fostering open-source carbon tracking tools, localized green-compute registries, and standardized disclosures for corporate digital footprints. Other initiatives on AI governance are currently being developed across multilateral bodies, including UNESCO, the OECD, ITU, the UNFCCC, and many others.

The UN Global Dialogue on AI Governance is designed to shape the rules on AI. It is a platform for governments and multi-stakeholder groups, including tech companies that are deliberating on the most pressing challenges posed by AI.

The World Economic Forum (WEF) Net-Positive AI Energy Framework: Formulated in late 2025 in collaboration with global industry experts, this framework provides a blueprint for an "impact-first" approach to AI deployment. It establishes a shared language for decision-makers, shifting the goalpost from mere carbon mitigation to achieving net-positive AI energy, a condition where the documented energy and emissions savings enabled by an AI tool across the physical economy explicitly exceed the full lifecycle energy consumption of the AI system itself. The framework hinges on three core levers: design for efficiency, deploy for impact, and shape demand wisely.

The IEEE AI Standard (2025/2026): Developed by the Institute of Electrical and Electronics Engineers, this standard institutes rigorous benchmarks for measuring, reporting, and validating the lifecycle environmental impacts of AI. It mandates verifiable metrics for data center power utilization effectiveness (PUE) tied directly to algorithmic workloads, pushing software developers to treat energy efficiency as a core performance metric alongside processing speed and accuracy.

ITU-T L.1801 (02/2026): Environmental sustainability of artificial intelligence and emerging ICT systems.

This ITU Recommendation provides a holistic framework for evaluating the environmental impact of AI systems, covering direct and indirect impacts, assessment, and mitigation strategies. The scope includes: Overview of the impacts of AI systems on the environment; Framework for evaluating the environmental impact of AI.

FIGURE 7
Existing Frameworks and What They Seek to Achieve

Framework / Initiative	Project /v Campus
European AI Act	Establishes a risk-based regulatory framework for AI, ensuring AI systems are safe, vtransparent, accountable, and respectful of fundamental rights while supporting innovation.
European Chips Act	Strengthens semiconductor manufacturing capacity, supply-chain resilience, technological sovereignty, and digital competitiveness within Europe.
Energy Efficiency Directive	Promotes energy efficiency across sectors, including requirements and standards relevant to data centres and digital infrastructure.
EU Taxonomy Regulation	Provides a classification system for environmentally sustainable economic activities, helping direct investment toward sustainable projects and infrastructure.
European Green Deal	Seeks to make Europe climate-neutral while promoting sustainable economic growth, resource circularity, and environmental protection.
Paris Agreement	Establishes a global framework for climate action and recognizes the role of innovation and technology in achieving climate goals.
Global Gateway	Mobilizes investment for sustainable infrastructure, including green data centres, digital connectivity, clean energy, and innovation ecosystems.
European Green Digital Coalition	Develops methodologies and practical use cases to measure and reduce the carbon footprint of digital technologies across sectors.
Green Digital Action Hub	Coordinates international initiatives and stakeholders working at the intersection of digital transformation and sustainability.
D4D Hub (Digital for Development Hub)	Aligns digital development programmes among EU member states and partners to promote inclusive and sustainable digital transformation globally.
Team Europe Data Governance Programme in Africa	Supports AI and data governance projects in Africa, including demonstration projects applying AI to climate and development challenges.
WEF Net-Positive AI Energy Framework	Promotes an impact-first approach to AI deployment, ensuring AI-enabled energy and emissions savings exceed the full lifecycle impacts of AI systems.
IEEE AI Environmental Impact Standard	Establishes benchmarks for measuring, reporting, and validating the lifecycle environmental impacts of AI systems and associated infrastructure.
ITU-T L.1801	Provides a comprehensive framework for assessing, measuring, and mitigating the environmental impacts of AI systems and emerging digital technologies.
UN Global Dialogue on AI Governance	Facilitates international dialogue on AI governance among governments, industry, academia, and civil society to shape global AI rules and norms.
Independent International Scientific Panel on AI Emerging AI-Climate Coalitions	Supplies independent scientific assessments of AI opportunities and risks to support evidence-based policymaking.
LEED	Bridges climate and digital communities through carbon tracking tools, green-compute registries, open standards, and disclosure frameworks. **LEED Gold:** PUE targets, 100% renewable energy matching, strict lifecycle waste diversion. Hot/cold aisle containment, early-stage PPA integration. **LEED Platinum:** Net-zero operational carbon, zero-potable water for cooling, active grid-balancing systems. Direct-to-chip liquid cooling, on-site solar, BESS infrastructure.
Global Real Estate Sustainability Benchmark[32]	GRESB is an industry-led organization that provides sustainability assessments, benchmarks, and data for real estate, infrastructure, and other real assets. It helps investors and asset managers evaluate ESG performance, climate risks, resilience, and long-term value creation. "To provide financial markets with actionable sustainability insights, data, and benchmarks."
United for Efficiency (U4E)	The United Nations Environment Programme (UNEP)-led **United for Efficiency (U4E)** initiative is supporting governments in developing sustainable procurement and efficiency standards for digital infrastructure, including data centres and computer servers.

Together, these initiatives represent the foundations of a more coherent international framework for sustainable AI deployment. They provide policymakers, investors, operators and technology developers with the tools needed to ensure that future AI growth is aligned with climate objectives, resource efficiency and long-term economic resilience.

Section 3: Addressing The Gaps

Towards Sustainable AI Infrastructure: Reducing Data Centre Carbon Impacts and Improving Energy Efficiency

The Growing Imperative for Sustainable Data Centres

The rapid expansion of artificial intelligence is driving an unprecedented increase in demand for data centre capacity. The pace of planned data centre construction now exceeds earlier projections, reflecting the accelerating deployment of AI systems across the global economy. While AI presents significant opportunities for economic growth, innovation and climate action, it also raises critical questions regarding the sustainability of the infrastructure that underpins it.

Global data centres consumed an estimated 448 terawatt-hours (TWh) of electricity in 2025. If data centres were considered a sovereign nation, they would rank as the world's eleventh-largest electricity consumer, surpassing countries such as Saudi Arabia and trailing only larger industrial economies. The UN has warned that data centres 'could consume 945 terawatt-hours of electricity annually by 2030 – nearly triple the combined annual electricity use of Pakistan, Bangladesh, and Nigeria, countries collectively home to more than 650 million people'.

The sustainability challenge extends beyond electricity consumption alone. Data centre expansion has implications for water resources, land use, grid infrastructure and broader social equity considerations.

Ensuring a just and inclusive energy transition requires balancing the growing energy demands of digital infrastructure with the affordability and accessibility of electricity for households, businesses and public services. Though disputed, the issue of rapid growth in data centre demand can contribute to upward pressure on electricity prices in some regions is a topic of debate, highlighting the need for integrated planning between digital infrastructure, energy systems and communities.

Unmanaged growth in data centre capacity risks increasing pressure on electricity networks, water systems and local environmental resources. It can also contribute to higher greenhouse gas emissions where electricity generation remains dependent on fossil fuels.

Conversely, sustainable data centre development can strengthen energy security, support economic competitiveness, attract investment and contribute to national decarbonisation objectives. Sustainability should therefore be viewed not as a constraint on digital growth but as a critical enabler of resilient, future-proof AI infrastructure

Emerging Best Practice: Green Data Centres in Operation

A growing number of data centre operators are demonstrating that large-scale digital infrastructure can be developed while significantly reducing environmental impacts.

Leading facilities increasingly utilise high proportions of renewable electricity, advanced energy management systems, highly efficient cooling technologies and circular approaches to resource use.

Common characteristics of best-in-class green data centres include:

- Procurement of renewable electricity through direct power purchase agreements or on-site generation.
- Low Power Usage Effectiveness (PUE) ratings achieved through advanced design and operational optimisation.
- Deployment of water-efficient or water-neutral cooling technologies.
- Waste heat recovery systems that provide heat to neighbouring buildings and district energy networks.
- Continuous monitoring and disclosure of energy, water and carbon performance.
- Integration of sustainability objectives into facility design, procurement and operations.

These examples demonstrate that environmental performance and operational efficiency can be mutually reinforcing, reducing costs while improving resilience and supporting climate objectives.

The adoption of a wider international framework for more sustainable data centres should also fit in with existing corporate commitments that have been publicly made by many companies.

- AWS has committed to reaching net-zero carbon emissions by 2040[33] as part of Amazon's broader Climate Pledge, and reports that it already matches 100% of the electricity consumed by many AWS data centre regions with renewable energy purchases. Its strategy for AI and cloud infrastructure focuses on scaling renewable power procurement, improving data centre energy efficiency (including advanced cooling technologies), and offering customers tools to measure and reduce the carbon footprint of workloads hosted on AWS. Amazon Sustainability

- Google has set a goal to operate its data centres and campuses on 24/7 carbon-free energy by 2030[34], moving beyond annual renewable matching to hourly, location-specific decarbonisation. This objective applies directly to the company's AI infrastructure, which is being optimised through custom hardware (such as TPUs) and data centre design to improve energy efficiency per unit of compute. Google positions this 24/7 carbon-free energy target as central to delivering low-carbon AI services at scale. Google Data Centers

- Microsoft has previously pledged to be carbon negative by 2030[35], including across its cloud and AI data centre operations, and to remove all historical emissions since its founding by 2050. For its rapidly expanding AI infrastructure, Microsoft is combining aggressive renewable energy and power purchase agreements with investments in grid decarbonisation and carbon removal, while also setting internal carbon fees to drive efficiency and low-carbon design in data centres. Microsoft Sustainability

- Meta has committed to achieving net-zero emissions across its value chain by 2030[36], building on its existing goal of net-zero emissions for its own operations, including data centres. Its AI and data infrastructure strategy centres on powering facilities with 100% renewable energy, improving energy and water efficiency in hyperscale data centres, and disclosing progress through sustainability reporting, with the stated aim of supporting low-carbon digital and AI services as demand grows.

Key Advisory Consideration

The evidence suggests that future AI competitiveness will increasingly depend not only on computational capability but also on the efficiency and sustainability of the infrastructure supporting it. Governments, regulators and industry stakeholders should therefore prioritise policies and investment frameworks that:

1. Accelerate deployment of renewable-powered data centres.

2. Establish mandatory environmental reporting and disclosure standards.

3. Promote energy and water efficiency as core performance metrics.

4. Support waste heat recovery and circular resource use.

5. Encourage international standardisation and interoperability.

6. Ensure data centre development contributes positively to local communities and energy systems.

By embedding these principles into future planning and governance frameworks, countries can support continued AI innovation while minimising environmental impacts and strengthening the resilience of their energy systems.

Cross-Cutting Objectives Emerging Across All Frameworks

The policy discussion on AI data centres moving to net zero reveals a growing convergence around six common goals:

1. Sustainable AI Infrastructure – energy-efficient data centres, green computing, and renewable-powered digital infrastructure.

2. Transparent Environmental Reporting – standardized disclosure of AI-related emissions, energy use, water consumption, and carbon footprints.

3. Measurement Standards – common methodologies for assessing AI environmental impacts and lifecycle emissions.

4. Innovation and Commercialisation – accelerating green and digital innovations from research laboratories into scalable market solutions.

5. Bridging Digital and Climate Policy – integrating environmental objectives into national AI and digital strategies.

6. Inclusive Development – reducing the digital divide while ensuring AI supports sustainable development and climate resilience globally.

3.6 A New Governance Architecture for AI and Energy

The rapid growth of AI has exposed gaps in existing governance frameworks. Traditional digital-policy tools—focused on data protection, cybersecurity and competition—are not designed to manage the energy and climate impacts of high-density compute. At the same time, energy-policy frameworks rarely account for the unique characteristics of AI demand.

A new governance architecture is emerging, built around three pillars:

Transparency and measurement

Governments and standards bodies are developing requirements for real-time reporting of energy use, carbon intensity, cooling performance and water consumption. These include:

- EU AI Act transparency provisions
- ISO/IEC standards for sustainable computing
- IEEE initiatives on responsible AI design
- OECD guidelines on AI governance

Siting and permitting standards

Countries are beginning to integrate AI infrastructure into national energy planning. Emerging standards include:

- Renewable-energy procurement requirements
- Grid-impact assessments
- Water-use disclosure
- Heat-reuse integration
- Local-benefit schemes

These standards aim to ensure that AI infrastructure supports, rather than strains, local energy systems.

Efficiency and model design incentives

- Governments are exploring ways to encourage:
- Efficient training techniques
- Hardware designed for low carbon inference
- Demand shifting to periods of high renewable output

These incentives are essential for aligning AI development with climate goals.

Summary

Part 1 has outlined the scale and complexity of AI's energy and climate challenge: rising demand, constrained grids, governance gaps and public concerns. Yet it has also highlighted the significant opportunity for AI itself to accelerate decarbonisation of digital infrastructure as it scales, and across the wider economy.

Part 2 turns to the other side of the equation—how AI is already making a difference, and the sector pathways through which it can deliver emissions reductions at scale. It examines the practical applications of AI in energy systems, industry, transport, agriculture, buildings and climate modelling, setting the stage for the detailed case studies presented in Part 3.

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PART TWO:

Making a difference: Sector Pathways for AI Impact

Section 1. The Opportunity: AI's Net-Positive Potential for Climate Action

Despite the challenges outlined in **Part 1**, there is strong evidence that AI can be a net-positive contributor to climate action. Lord Nicholas Stern's 2025 study Green and Intelligent found that AI could reduce global emissions by up to 5.4 billion tonnes by 2035 if deployed responsibly[24]. This would more than offset the projected increase in emissions from AI infrastructure itself. To achieve this however, requires a step change in both the way we measure and report data on AI emissions savings, but also the successful deployment of AI solutions for the future, scaling up these opportunities rapidly so that AI can deliver wider societal emissions reductions.

AI's potential climate benefits fall into three broad categories:

System-level optimisation

AI can improve the efficiency of energy systems, industrial processes, transport networks and buildings. These gains reduce emissions not by building new infrastructure, but by making existing systems work better. Examples include:

- Renewable-generation forecasting
- Battery-storage optimisation
- Industrial process control
- Traffic-flow optimisation
- Smart-building energy management

Acceleration of clean-energy deployment

AI can speed up planning, permitting, design and construction of renewable-energy projects. Tools that analyse aerial imagery, zoning rules, environmental constraints and grid-connection options can reduce development timelines by months or even years.

Enhanced climate modelling and adaptation

AI can improve the accuracy and granularity of climate projections, enabling better risk assessment, infrastructure planning and early-warning systems. These capabilities are essential for protecting vulnerable communities and planning resilient infrastructure.

The challenge is ensuring that these benefits are realised at scale, and that AI's own energy footprint does not undermine its contribution to climate goals. This requires coordinated action across governance, infrastructure, model design and public engagement.

AI's climate impact is not theoretical—it is already reshaping how sectors including energy, industry, transport, agriculture and digital infrastructure operate today. Across the case studies in this report **(See Part 3)**, AI consistently demonstrates the same pattern of value: sharper forecasting, smarter optimisation, faster decision-making and more efficient use of existing assets. These capabilities matter because the most effective emissions reductions come not from building entirely new systems, but from improving the performance of the ones we already depend on.

This section highlights the sectors where AI is already cutting emissions at scale and shows how targeted, responsible deployment can unlock system level efficiencies across the economy. It also includes a deeper dive into how AI data centres as a sector can be made more efficient and sustainable and lower the energy and carbon footprint of AI at source.

How AI Helps Cut Sector Specific Emissions

Despite the scale of the challenge, AI in its various forms provides a powerful toolkit for accelerating climate action and the energy transition. There are several high-impact domains where AI is already reducing emissions or enabling system-level efficiencies with strong potential for scale. (Examples of these solutions are explored in more depth in Part 3.)

Smarter Power Grids and Clean Electricity

The global shift toward renewable energy is creating new challenges for how modern power grids operate. Unlike traditional fossil fuel plants, which can produce electricity on demand, wind and solar output rises and falls with the weather. Because these resources don't always align with when people need power, grids can become congested, power quality can suffer, and clean energy is sometimes wasted—a problem known as curtailment, where renewable generation is turned off simply because the grid cannot absorb it at that moment.

AI can help address this balancing challenge. By analysing real-time weather data and broader regional patterns, machine learning systems can predict how much wind and solar power will be available hours or even days ahead. With more accurate forecasts, utilities can plan their operations more effectively, adjusting other energy sources, preparing storage systems, and managing grid flows to ensure that clean energy is used rather than discarded. For example, the Government of Chile has established a national goal to achieve carbon neutrality by 2050. A solution developed by Google DeepMind's GraphCast, a machine learning weather prediction model, with Google's Tapestry's expertise in grid modelling,

has resulted in a wind speed forecasting model tailored for Chile that is up to 15% more accurate than the current industry standard **(See Part 3)**.

AI is increasingly being used to help balance the power grid as renewable energy grows. In practice, these applications sit at the centre of the transmission system, helping operators match variable wind and solar supply with the constantly changing patterns of consumer demand. STATISTIC OR EXAMPLE NEEDED

The European Commission has outlined its intent around the issue via its Strategic Roadmap for Digitalisation and AI in the Energy Sector[1]. The roadmap identifies several key areas for support and development from sustainable data centre expansion to digitalisation and AI for the energy system. Specifically on AI, the EC states that AI-based operation and maintenance optimisation could save up to €94 billion ($110 billion) annually by 2035 and is committed to developing sovereign, secure AI models for the energy sector. The EC has also committed to supporting the development of AI foundation models for grid management and planning as a digital backbone for the energy system. Teresa Ribera, EC Executive Vice-President for Clean, Just and Competitive Transition stated: "Digitalisation of energy system is Europe's chance to get more from the same infrastructure we have and reduce bills for consumers."

Another strong example comes from the UK's domestic energy system[2]. AI-enabled platforms now manage the charging of hundreds of thousands of electric vehicles in ways that support grid stability. By monitoring real-time grid conditions—such as frequency levels and the carbon intensity of electricity—AI can automatically shift EV charging to the cleanest and least congested times of day. Instead of charging during peak demand, these systems coordinate a collective shift so that EV batteries draw power when renewable generation is high or overall demand is low. This reduces strain on the grid and makes better use of clean energy that might otherwise go unused. For example, Centre for Net Zero (CNZ), supported Octopus Energy and the King Climate Action Initiative at the Abdul Latif Jameel Poverty Action Lab (J-PAL), created a randomised controlled trial with over 13,000 consumers in the UK to evaluate one of the world's largest AI-managed EV charging tariffs. The project showed that managed charging provided significant load-shifting. The tariff led to a 42% reduction in peak household electricity use, with the entirety of EV demand shifted to off-peak hours[3] **(See Section 3)**.

AI is also transforming how large-scale battery storage facilities operate. Utility scale Battery Energy Storage Systems (BESS) must constantly decide when to charge and when to release power back to the grid. These decisions depend on market prices, weather conditions, and the health of the batteries themselves. Advanced AI models analyse all this information in real time to optimise each charging and discharging cycle. By preventing overcharging, adjusting operations as batteries age, and managing

FIGURE 1

AI-managed EV charging tariffs reduce grid strain and manage pricing

https://www.centrefornetzero.org/papers/ai-in-charge-large-scale-experimental-evidence-on-electric-vehicle-charging-demand

heat levels, AI helps extend the lifespan of these expensive assets while improving their overall performance. For example, AI-powered BESS can extend battery life by up to 40%, significantly reducing replacement costs[4].

Speeding Up Clean Energy Projects

Expanding the physical infrastructure needed for the clean energy transition means overcoming a range of logistical, regulatory, and engineering challenges. Installing technologies such as home heat pumps, commercial solar panels, or community scale battery systems has traditionally been slowed by labour-intensive site surveys and long permitting processes.

AI is now helping to speed up these steps. For households, heat pump installations are becoming faster and more affordable thanks to AI tools that automate much of the early assessment work. By analysing aerial photos, regional mapping data, and 3D building models, AI can quickly determine a home's heating needs, assess roof strength, identify the best placement for solar panels, and plan equipment layouts—reducing the need for multiple onsite visits by engineers. For example, as discussed in one of the roundtables supporting this report, UK start-up Planarific[5] explained how it has used drone imagery, GIS data, and AI-generated 3D models of over 2,000 social homes to estimate heat demand, roof suitability for solar, and retrofit options at scale. This cut the number of required on-site engineer visits per property from three or four down to roughly one or two.

At the utility level, AI is improving how large wind and solar projects are planned and connected to the grid. Choosing the right location for these projects requires balancing many factors: access to transmission lines, land conditions, environmental protections, and community considerations. AI can evaluate all these datasets at once, helping planners identify sites that minimise environmental impact while making the best use of public and private investment. Xcel Energy[6], for example, reports that AI-enhanced forecasting and planning tools built on industrial technology company AVEVA's platform have already delivered "millions of dollars" in operational value by improving how wind generation is integrated into the grid.

AI is also being used to streamline the administrative side of clean energy development. Generative AI tools can review environmental rules, zoning histories, and engineering requirements to help developers prepare accurate, compliant permit applications. This reduces paperwork bottlenecks and shortens the early planning and approval stages from years to months. The result is lower financial risk and faster deployment of clean energy projects onto the grid. For example, AI-assisted environmental impact assessment (EIA) tools used in UK infrastructure planning have shown up to an 80% reduction in manual review time[7].

Cutting Industrial Emissions

As previously stated, heavy industries such as steel, cement, and chemicals account for a large proportion of global greenhouse gas emissions. These sectors are especially difficult to decarbonise because their core processes rely on extremely high temperatures and carbon intensive chemical reactions.

While long-term solutions, such as green hydrogen and full electrification, require major investment and new infrastructure, AI can deliver meaningful emissions reductions right now. World Economic Forum figures[8] estimate that AI-driven optimisation could cut global industrial emissions by between 10 and 20% in some instances.

In facilities such as steel furnaces and cement kilns, AI systems are already improving efficiency and lowering fuel use. These industrial processes have traditionally been run within fixed operating parameters that struggle to adapt to changes in raw materials, moisture levels, or internal temperature conditions. AI changes this by analysing thousands of real-time data points to create a live digital model of what is happening inside the furnace or kiln. Using this model, AI can make continuous, precise adjustments—finetuning fuel and oxygen levels, regulating material feed rates, and managing airflow. These optimisations reduce unnecessary heating cycles, prevent fuel waste, improve production yields, and significantly lower the carbon intensity of each ton of material produced[9].

For example, Covestro is a leading German manufacturer of high-quality polymer materials, has a goal of becoming net zero by 2035. By using AI for process simulation and predictive analytics from industrial software specialist AVEVA, Covestro achieved a 30% reduction in energy consumption and a 39% decrease in $CO2$ emissions per ton of product, with a trajectory toward a 50% reduction by 2030[10]. **(See Part 3)**

AI is also speeding up the development of new clean-energy materials. Creating next generation electric vehicle batteries or advanced filters for carbon capture systems has traditionally required years—often decades—of slow, trial-and-error testing in physical laboratories. AI changes this by allowing much of that work to happen virtually including via digital twins. Instead of building and testing every material by hand, AI can rapidly model and assess millions of potential compounds in software. This dramatically shortens the discovery process from decades to just weeks, helping scientists identify promising, highly efficient materials far faster than before. For example, Microsoft's AI platform screened 32 million[11] potential battery materials in 80 hours[12].

AI's predictive abilities also improve the reliability of existing clean energy infrastructure. Equipment such as wind turbines, tidal energy systems, and solar-power inverters operate in harsh environments and can suffer unexpected failures. When that happens, repairs can take months, often forcing utilities to fall back on fossil fuel backup plants.

To prevent this, AI systems continuously monitor data from sensors embedded in these assets—tracking vibration, sound, heat, and other indicators. By spotting tiny irregularities long before they become serious, AI can forecast mechanical problems weeks in advance. This allows operators to carry out maintenance at convenient times, such as when wind or sunlight is low, avoiding major breakdowns and keeping clean energy production as high and stable as possible. For example, GE reports that AI-based predictive maintenance[13] can detect turbine component failures up to 6–8 weeks before they occur, reducing unplanned downtime by up to 20%.

Reducing Agricultural Emissions

Agriculture, forestry, and land use practices are major contributors to global climate change, largely because they release powerful short-lived pollutants such as methane and nitrous oxide. These emissions are difficult to manage because they come from many dispersed sources, making them hard to track and control.

AI is beginning to change this. By combining advanced models with high-resolution satellite imagery and on-the-ground sensors, land managers can now monitor agricultural emissions with far greater accuracy. Methane from livestock or from flooded rice fields, for example, can be detected almost in real time. Machine learning systems analyse satellite and aircraft data to identify and measure methane plumes from farms, pipelines, or waste sites. With this information, farmers and regulators can take immediate action, such as adjusting livestock feed or changing irrigation cycles in rice paddies, to reduce emissions.

There is also even potentially a role AI can play in how food tastes – specifically low carbon intensity alternatives to meat and dairy. AI can be used in the development of 'alternative proteins'[14] which may have reduced environmental footprints.

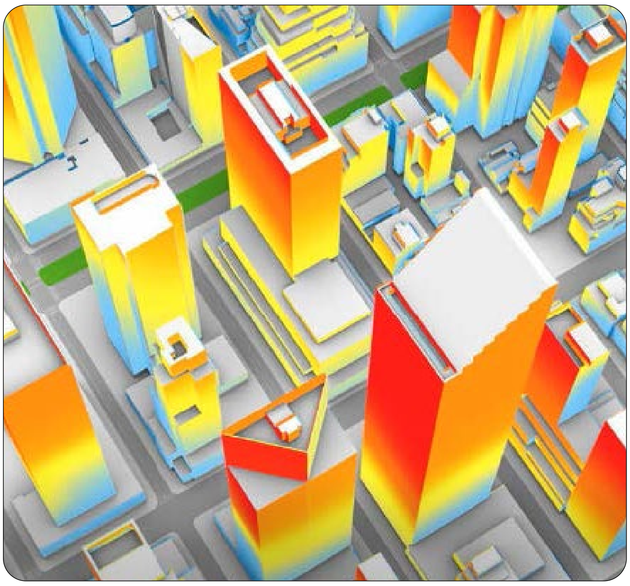
AI is also reshaping how soils and fertilizers are managed. Overuse of synthetic nitrogen fertilizers is a major source of nitrous oxide emissions and water pollution. AI tools help prevent this by analysing detailed information about soil moisture, past crop yields, local weather forecasts, and even drone imagery of plant health. Using these insights, AI can determine exactly how much fertilizer and water each part of a field needs. Automated machinery can then apply these inputs with precision, reducing waste, protecting soil health, and preventing excess nitrogen from escaping into the atmosphere. For example, AI precision spraying systems can reduce herbicide use by 87% – representing a cost saving to farmers of more than 60%[15].

Planning Net-Zero Infrastructure

Planning the physical layout of a fully decarbonized society requires decisions that will shape communities for decades. Choices made today about electricity networks, urban development, and flood protection infrastructure will influence both emissions and climate resilience well into the next century. These decisions are difficult because they must be made under significant uncertainty—from long-term weather patterns to economic and population shifts.

AI is becoming a powerful tool for this kind of long-range infrastructure planning. In the energy sector, grid operators are using AI to design the large-scale upgrades needed to support widespread electrification of heating and transport. Building a grid capable of serving millions of heat pumps and electric vehicles requires analysing countless variables: population growth, EV adoption rates, local renewable energy potential, and the physical limits of existing circuits. AI can process all of this information at once and recommend the most cost-effective placement of new substations, transmission lines, and storage facilities. This helps prevent overloads while reducing land use and keeping investment costs manageable.

FIGURE 2
Use of AI for daylight and solar simulations inside standard design tools
https://www.fosterandpartners.com/news/foster-plus-partners-launches-cyclops-plugin-to-enhance-sustainable-design



AI also strengthens climate risk planning through far more precise modelling. Traditional global climate models are often too coarse to show how climate impacts—such as extreme heat or flooding—will play out at the level of individual neighbourhoods. Advanced AI systems can take these broad models and "downscale" them, integrating local data on terrain, building density, heat-island effects, and water flows. The result is highly detailed projections of how climate change will affect specific streets, districts, and coastal areas.

With this level of insight, municipal governments can plan net-zero infrastructure more effectively, placing green spaces, reflective materials, drainage systems, and flood-protection assets exactly where they will have the greatest impact. This supports both emissions reduction and the protection of vulnerable communities.

AI is already reshaping how buildings are designed, retrofitted, and operated, with direct implications for emissions and energy use. Engineering consultancy WSP uses its evolutionary design tool Daisy[16] to explore thousands of building variants and optimise massing, façade area, daylight, and both operational and embodied carbon, as demonstrated on complex projects such as hospitals.

Foster + Partners has developed Cyclops[17], a real-time analysis engine that runs daylight and solar simulations (and is being extended to CFD and carbon metrics) inside standard design tools, enabling architects to see performance impacts instantly as they draw; they have also deployed AI-enhanced digital twins, such as for the KSA Pavilion at Expo Osaka, to support thermal optimisation and predictive maintenance in operation. The UK Green Building Council has mapped a growing ecosystem of AI innovators, from low-carbon concrete optimisation (e.g. Material Evolution[18]) to generative layout and structural tools (e.g Preoptima[19], StructurePal[20]) and smart building operating systems (e.g. BrainBox AI) that deliver autonomous control and energy optimisation in existing assets.

Greener Homes and Smart Energy Use

While industrial and utility scale improvements are essential, a large share of national energy use still comes from everyday decisions made inside private homes. Residential buildings consume significant amounts of energy for heating, hot water, and cooling. Yet motivating millions of households to retrofit their homes or change daily energy habits remains one of the biggest barriers to achieving national net-zero goals.

AI helps bridge this gap by acting as an intelligent, behind-the-scenes system embedded in home devices and local planning tools. At the household level, AI-enabled smart-home systems remove the need for residents to constantly adjust thermostats or manage appliances. Instead, machine-learning tools analyse how a home is used—when people are present, how quickly rooms lose heat, and the real-time cost and carbon intensity of electricity. The system then automatically manages heating and cooling, warming the home when clean energy is plentiful and reducing demand during peak periods, all without affecting comfort.

At the community level, AI unlocks major efficiencies in home retrofit planning. By analysing property records, historical energy performance data, and smart meter patterns, AI can quickly identify neighbourhoods with the highest energy waste. It can then recommend targeted upgrades—such as insulation, new windows, or heat pump installations—and calculate the expected cost savings and emissions reductions for homeowners. This approach removes administrative bottlenecks and marketing costs, turning scattered individual upgrades into coordinated, high impact community decarbonisation programmes.

At the neighbourhood scale, startups like Planarific and Kestrix combine drones, photogrammetry, and computer vision to generate "lightweight BIM" and thermal maps for thousands of homes at once, as in Barking & Dagenham's social housing estate, enabling portfolio-level retrofit planning and far more targeted investment. Together these applications show how AI can increase design quality, compress analysis cycles from weeks to minutes, and unlock mass retrofit—key levers for decarbonising the built environment.

AI-Driven Transport and Traffic Management

AI is already delivering tangible emissions reductions in the transport sector and will be critical to the broader energy transition. In road traffic management, adaptive signal control systems such as Yunex as Fusion (deployed in Tees Valley and by Transport for London) and Google's Project Green

FIGURE 3
Use of AI computer vision for thermal imaging in housing and other buildings
https://news.eonenergy.com/news/google-maps-of-heat-loss-e-on-and-coventry-city-council-launch-drone-scans-with-tech-startup-kestrix-to-drive-warmer-homes-at-scale

FIGURE 4

Improved traffic management with adaptive signal control systems.

https://uk.yunextraffic.com/newsroom/tees-valley-combined-authority-selects-fusion/

Light use AI and live traffic data to optimise signal timings, cutting stops by up to around 30% and reducing fuel use and congestion at key junctions. Research at Loughborough University's TRAICE[21] centre is extending this with smart-camera–based control and AI-enabled digital twins that let city teams query congestion causes and explore interventions in near real time, delivering order-of-magnitude productivity gains in transport operations.

Public transport authorities like Transport for Greater Manchester are applying AI to optimise bus routes[22], timetables and service quality, while autonomous and demand-responsive bus pilots (e.g. in Edinburgh) show that more reliable, flexible services can shift trips away from private cars. In freight and logistics, companies such as UPS use AI routing and load optimisation to eliminate millions of unnecessary vehicle miles each year[23], cutting fuel use and CO_2, and aviation operators are beginning to use AI to reroute flights around atmospheric conditions that create warming contrails, addressing non-CO_2 climate impacts. Taken together, these applications illustrate how AI can make existing transport infrastructure significantly more efficient and low carbon, while supporting a shift to cleaner modes rather than relying solely on vehicle electrification.

Coordinating the End-to-End Energy System

The real strength of artificial intelligence is not just its ability to improve individual sectors, but its capacity to coordinate across the entire economy. Research from institutions such as University College London and the Alan Turing Institute highlights[24] that reaching net zero requires treating energy, transport, manufacturing, and the built environment as parts of one interconnected system. These sectors constantly exchange resources, data, and power, and decisions in one area often have immediate consequences in another.

AI provides the intelligence layer that links these systems together. For example, as already noted, a vehicle-to-grid (V2G) network depends on AI to manage the relationship between electric vehicles and the power system. The AI determines when an EV should charge, when it should pause, and when it should send electricity back to the grid, such as during a sudden drop in wind generation. This coordination helps stabilise the grid while supporting clean energy use.

AI also strengthens circular economy practices by connecting manufacturing with waste management systems. It can track how materials move through the economy, predict when industrial scrap will become available, and route byproducts, such as waste heat from data centres or leftover slag from steel production to new uses. These might include heating nearby homes or producing low carbon cement.

By managing these complex, cross sector flows in real time, AI delivers efficiencies that traditional, siloed management approaches simply cannot achieve. This systemwide optimisation is essential for building a resilient, low carbon economy.

A Plan for Net-Positive AI Energy

The examples of AI's impact on reducing emissions across sectors are just some of the examples across a wide range of sectors where AI is already realising greater efficiency gain and productivity savings that are translating also into emissions reductions.

The IEA have stated that the adoption of existing AI applications in end-use sectors could lead to 1 400 Mt of CO2 emissions reductions in 2035 in the Widespread Adoption Case, though they note that 'this does not include any breakthrough discoveries that may emerge thanks to AI in the next decade. These potential emissions reductions, if realised, would be three times larger than the total data centre emissions in the Lift-off Case, and four times larger than those in the Base Case'[25].

The challenge will be for AI as a sector to demonstrate its overall benefit to society, rather than face the threat of being viewed in the public and popular imagination as a danger to humanity. As has been demonstrated in part one, the energy use of data centres is a concern, but not an insurmountable one. The technology and use of AI itself in helping to design more efficient and environmental data centres, at the same time as a better future use of AI, can ensure that the data centre expansion and its resulting energy use is manageable, if approached in a strategic fashion.

In addition to greater and better international co-ordination and collaboration on data centre deployment and use to optimise for environmental purposes, there should also be a global framework for the measurement and management of AI related emissions.

Better Data, Better Narratives

One of the key challenges for AI is that its exponential growth has resulted in a focus on its demand, rather than the accurate assessment of the opportunities to reduce emissions that it can unlock. There have been several studies on the opportunity of AI to achieve this, yet these are forecasts and do not represent an accurate reflection of baseline data.

In contrast, the focus has been on the growing emissions impact of AI, though estimates are wide ranging, and inaccurate, with no clearly defined framework to measure this.

Unless we are able to measure AI's positive impact for good, we will be unable to understand what has already been delivered and achieved, and what can be achieved for the future.

International Measurement and Data

Already there have been calls among key AI companies for a global institution that will help to regulate and protect against the speed of AI innovation, to safeguard against any negative consequences. Alongside global regulation, there is a moment in time to set effective scope related emissions frameworks, that can aid the benchmarking of progress that AI is able to deliver on emissions reductions. AI is already transforming how we can more effectively measure and track carbon related emissions in real time, rather than at more lengthy time assessments.

AI and the Global Stocktake 2028 and future NDC process

In addition to this is the role that AI can play across the wider NDC process of countries and their future climate and emissions plans. In addition to setting out the plans for renewable generation, energy efficiency reduction and wider decarbonisation, future NDCs should now be fully engaged with the AI opportunity to deliver the necessary outcomes for the future.

The second global stocktake will commence at CMA 8 (Nov 2026) and conclude at CMA10 (Nov 2028). Covering the period of 2024 – 2028, the outcome of GST 2 will inform Parties in updating and enhancing, in a nationally determined manner, their actions and support in accordance with relevant provisions of the Paris Agreement, as well as in enhancing international cooperation for climate action.

This can be an important moment to recognise that since the previous Global Stocktake and NDCs 3.0, the advance of AI had taken place at such an exponential rate, that its impact must be included in the process, but also the measurement of the emissions reduction and decarbonisation delivery that AI can realise should be not only on the agenda for the second global stocktake, but a key outcome for the stocktake should be to forge an international agreement and global goal on AI, similar to the trebling of renewables pledge that was created at COP28, a goal that would focus on delivering a net benefit return to society.

A Global Pledge for Net Benefit AI: Opportunities for Collaboration and Adoptio

There can be no doubt that national level targets and ambitions have helped to drive forward decarbonisation and emissions reductions, whether on phasing out fossil fuels, powering past coal, or trebling renewable power generation. In our previous Climate Action Coalition Global Clean Power taskforce report, we called for a global goal on electricity as a proportion of overall energy demand use: recently, the COP31 presidency has proposed that there should be a global goal of 35% of electricity powering overall final energy use by 2035.

We now need a similar goal to deliver net benefit AI that can not only ensure the responsible environmental use of AI, through the deployment of sustainable data centre frameworks and regulations, as set out in part one, but also a wider goal that demonstrates how AI can be a force for good- if deployed into priority sectors that deliver the greatest environmental impact.

Net Positive AI Energy Framework

The World Economic Forum's Net-Positive AI Energy Framework provides a blueprint for aligning AI's growth with energy, climate, and economic goals. It rests on three action drivers: design for efficiency, deploy for impact, and shape demand wisely. These action drivers are supported by three strategic enablers: consumer education and workforce upskilling, ecosystem collaboration, and transparent measurement and accountability.

Designing for efficiency means embedding sustainability into AI systems from the start. It means developing energy-efficient chips and accelerators, optimising models through sparsity, pruning, and quantisation, building green data centres powered by clean energy, recovering waste heat, and tracking life-cycle impacts. It means recognising that training is brief but power-intensive, while inference — the process of running AI models — can exceed training energy over time. It means building systems that achieve their purpose with minimal energy and material use.

Deploying for impact means prioritising AI applications that deliver measurable emissions reductions. It means integrating AI into national and corporate decarbonisation strategies, aligning AI deployment with clean energy availability, and focusing on use cases that deliver real-world benefits. It means recognising that AI is not a goal in itself, but a tool for achieving broader objectives — from grid optimisation and industrial efficiency to building management and transport planning.

Shaping demand wisely means managing AI demand to reduce unnecessary energy use. It means using appropriately sized models, reducing redundant inference, and aligning AI workloads with renewable availability. It means recognising that not every task requires a frontier model — that smaller, more efficient models can often deliver the same results at a fraction of the energy cost.

These action drivers are supported by strategic enablers. Consumer education and workforce upskilling are essential for responsible AI use. Ecosystem collaboration is essential for aligning incentives, sharing best practice, and building trust. Transparent measurement and accountability are essential for tracking progress, identifying gaps, and ensuring that AI delivers net-positive outcomes. This framework aligns closely with the Climate Action Coalition's mission: to accelerate real-world solutions that deliver efficiency, security, and growth.

Summary: A Moment of Choice

We are at a crossroads. AI is not inherently a climate solution, nor is it inherently a climate risk. It is a force multiplier whose impact depends entirely on how it is designed, deployed, and governed. The challenge is clear: AI's energy demand is currently rising faster than our ability to decarbonise it. The opportunity is equally clear: AI can accelerate decarbonisation across every sector of the global economy.

The task ahead is to ensure that AI becomes a net-positive contributor to climate action — delivering more emissions reductions than it consumes in energy. This requires leadership, collaboration, and a shared commitment to responsible innovation. It requires aligning AI with clean power deployment, embedding sustainability into AI design, prioritising high-impact use cases, and managing demand wisely. It requires building the infrastructure, governance, and workforce needed to support a net-positive AI future.

This is a call for coordinated action, responsible innovation, and a new narrative that positions AI not as a threat to the energy transition, but as one of its most powerful enablers. The challenge is significant. But the opportunity is greater still.

Footnotes

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PART THREE:

Energy Transition: Cross Sector Applied AI Case Studies

Introduction

Across every part of the energy system, AI is shifting from a promising concept to a practical tool delivering measurable emissions reductions, operational efficiencies and infrastructure optimisation today. The case studies in this chapter show how AI is already enhancing grid flexibility, improving forecasting accuracy, optimising transport flows, enabling real-time demand response in data centres, and strengthening decision making for both industrial operations and large-scale investment planning.

Whether applied to dynamic line rating, hydrogen supply chain modelling, predictive industrial maintenance or portfolio wide decarbonisation analysis, AI is helping organisations move from incremental improvements to system level transformation. Together, these case studies demonstrate a broader trend: AI is enabling energy, transport, industry and digital infrastructure to evolve from a paradigm of "building more" to one of "building smarter," accelerating progress toward Net Zero while improving resilience, affordability and long-term economic value.

Section 1: Grid and infrastructure

Modernizing the power grid is essential for a carbon-neutral future. As renewable energy integration grows, AI provides the real-time awareness and automation necessary to manage complex, dynamic loads, ensuring the grid remains reliable and efficient without the need for constant, costly greenfield infrastructure development.

Key themes:

- AI is boosting the capacity and reliability of existing grids — from dynamic line ratings to EV load shifting, better wind forecasts, and distribution-level digitisation, intelligence is unlocking performance without major new build-outs.
- Real-time visibility and forecasting are becoming essential — continuous sensing, digital twins, and high-accuracy weather and load predictions are replacing manual, reactive grid operations.
- Flexibility is emerging as a core grid resource — AI enables smarter use of variable renewables, shifts demand at scale, and helps operators manage congestion and losses across both transmission and distribution.

FIGURE 1
A cross section of one of CTC Global's new smart conducting lines, the core piece of the GridVista System[2]

TABLE 1
Summary of key AI case studies

Type	Project	Organisations	Use of AI	Key outputs/value
Grid and infrastructure	AI-powered smart transmission	CTC Global	Real-time sensor health & dynamic line rating	Optimized throughput & predictive maintenance
Grid and infrastructure	EV charging trial	Centre for Net Zero, King Climate Action Initiative	AI-managed tariff automation	42% peak load reduction; £343–£650 bill savings
Grid and infrastructure	Wind Forecasting	Chile Gov, Google Tapestry	GraphCast & physics-based ML models	15% more accurate wind forecasting
Grid and infrastructure	Grids of the Future	Global Energy Alliance	Network Modelling, Geo Modelling, Decision support	Grid management with real-time AI-driven intelligence
Buildings and transport	Green Light	Google (Maps)	Traffic flow modelling & signal optimization	Up to 30% fewer stops; 10% lower emissions
Buildings and Transport	Real-Time Net Zero Planning and Delivery Across Scotland's Railway	Scotrail and OptimiseAI	AI-Powered Digital Twin Programme	20–50% utility savings forecast across the estate
Data Centre	AI Grid	Emerald AI, NVIDIA, National Grid	Real-time demand response	Up to 40% demand cut; 2GW potential capacity
Data Centre	Demand Response	Google, various US utilities	ML workload shifting	Grid stability; lower infrastructure costs
Data Centre	Heat Reuse	QMUL, Schneider Electric, APT	Data centre modernization	Recovered waste heat for campus use
Data Centre	Carbon-free Energy Manager: A new model for advancing data center decarbonization	Google - Engie	AI driven clean energy matching	Reduce costs for renewable sellers and buyers
Investment	Cross-portfolio Net Zero and Adaptation Planning	VYZRD	Applied AI Analytics to i.d. investment opps	AI is being used as analytics and decision-intelligence layer
Manufacturing/ Industry	Achieve Sustainable Growth	AVEVA - Covestro	AI to support sustainable polymer innovation	Ai op intelligence to reduce carbon and energy use while improving productivity using standardised energy and production data

Case study 1: Creating an intelligent grid through AI-powered smart transmission[1]

Project/technology summary:

- CCTC Global's GridVista platform transforms transmission lines into data-rich assets, uniquely integrating embedded fiber sensing and advanced analytics within the conductor to improve reliability and reduce cost turning existing transmission lines into intelligent, self-aware infrastructure that can safely unlock additional grid capacity without costly new build-outs.

Territory:

- United States

Organisations involved:

- CTC Global

Main challenge addressed:

- When building new energy infrastructure is increasingly complex, making the most of the grid is increasingly important. By bringing AI directly to transmission lines, CTC is one promising example of how to get this done. This awareness allows for a grid that can truly sense its own health in real time and provide unprecedented awareness of conditions on the entire line.

How AI was used:

- With the right data inputs, AI offers the ability to remember prior events, reason and solve complex problems quickly, and generate automated responses. Collectively, AI can actively put all this data to use, optimizing and automating the entire system with constant synchronicity.

- When most utility assets can run for decades and transmission largely traverses the same old rights-of-way, greenfield development can be costly for customers. Instead, embedded technology and AI systems can deliver value from existing systems through limited upgrades and better use of data.

Main outcomes/impact:

- A new approach — moving beyond basic automation to an intelligent system that's autonomous and responsive. It's not just IoT but AIoT — an AI of things that is evolving from useful but static point sensors and models that had to be manually processed and automated to something with an AI layer that can put that data to use, making decisions faster and more accurately than before. Awareness allows for a grid that can truly sense its own health in real time and provide unprecedented insight of conditions on the entire line.It's not just detecting potential failures, which can lead to critical outages or, worse, wildfires and other dangers. There's also the fact that more precise temperature data along the length of the conductor can help optimize line throughput.

- Furthermore, making decisions can happen faster and with more certainty because we're not relying on systems that lack near real-time insights.

- As it is, transmission systems are run conservatively, for good reason, to prevent dangerous operations and ensure reliable, economic operations. With better data and smarter analytics, operators can more finely tune grid capacity and operations, providing more benefits for everyone.

Key lessons learned:

- By combining these operating insights grid operators and project developers can run sophisticated simulations of line conditions. This precision allows for better planning and operating decisions, enabling partners to meet load growth by finding and harnessing the existing grid's untapped potential.

- By combining these operating insights with Google Tapestry's AI-enabled tools, grid operators and project developers can run sophisticated simulations of line conditions. This precision allows for better planning and operating decisions, enabling partners to meet load growth by finding and harnessing the existing grid's untapped potential.

- Building smarter, not just bigger. When any system faces a capacity problem, the obvious answer is to add more. More generation, more lines, more infrastructure. For some challenges, that's the right call. For the bulk power system, building smarter and intelligently is at least as valuable as building more. Crucially these days, it's often faster, cheaper, and lower risk, too.

Quote:

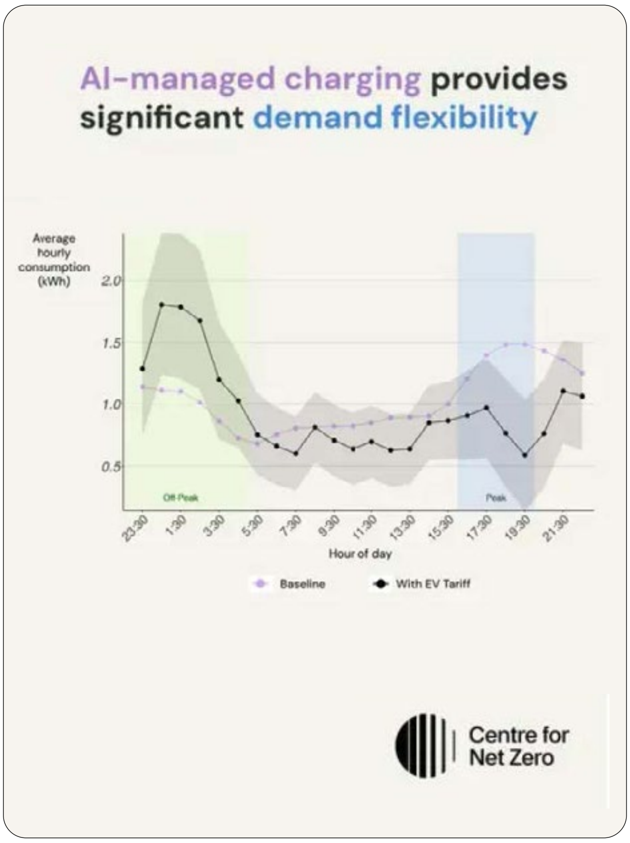
- CTC Global's CEO J.D. Sitton recently observed: "This awareness allows for a grid that can truly sense its own health in real time and provide unprecedented awareness of conditions on the entire line. Whether that's real time storm impacts, ice load, wind load, branches on the wire, temperatures on or under the line."

Case study 2: Large-Scale Experimental Evidence on Electric Vehicle Charging Demand[3]

Project/technology summary:

- Centre for Net Zero (CNZ), supported by the King Climate Action Initiative at the Abdul Latif Jameel Poverty Action Lab (J-PAL), created a randomised controlled trial with over 13,000 consumers to evaluate one of the world's largest AI-managed EV charging tariffs. Once adopted, the tariff dynamically controls EV charging to optimise across real-time wholesale electricity prices and ancillary markets - while respecting user preferences for battery state-of-charge and desired departure time.

FIGURE 2
AI managed charging and demand flexibility[4]



Territory:

- UK

Organisations involved:

- Centre for Net Zero, the King Climate Action Initiative at the Abdul Latif Jameel Poverty Action Lab (J-PAL)

Main challenge addressed:

- Electric vehicles (EVs) are successfully decarbonising road transport. Global sales have increased year-on-year over the past decade, comprising more than 20% of new cars in 2024, and are set to rise rapidly in the decades to come. However, this surge in adoption will place new demands on the electricity system which, left unmanaged, threatens to strain existing grid infrastructure and increase system costs ultimately borne by consumers.

How AI was used:

- Demand flexibility can shift EV charging away from peak periods and toward times when electricity is cheap and abundant, while delivering direct bill savings for households. Managed charging – third-party control, particularly using AI-driven automation – can ensure that demand closely aligns with real time grid conditions.

Main outcomes/impact:

- The trial provides novel empirical evidence that AI-managed EV charging can reshape electricity demand at scale, with considerable benefits for consumers and the grid.

Key lessons learned:

- Targeted consumer engagement can increase take-up of EV charging tariffs
- Managed charging provides significant load-shifting.
- Automation is accepted by users and highly responsive to system conditions.

Quantifiable savings:

- Among a 'harder-to-reach' sample, simply an email raised tariff adoption by 3.4 percentage points, while an extra offer of £50/month for three months nearly doubled that effect. Customers that switched to the tariff largely remained on it for the 12-month trial period.
- The tariff led to a 42% reduction in peak household electricity use, with the entirety of EV demand shifted to off-peak hours. This load-shifting did not change total household electricity consumption.
- High user adherence to the automated schedule, with manual overrides only accounting for 2.3% of total electricity consumption and more than half of households never using this feature. The AI-driven managed charging tariff was more responsive to wholesale electricity prices than a static time-of-use tariff that does not use managed charging.
- Our results suggest that AI-managed charging generates a consumer surplus, including a reduction in electricity bills by £343 per year - or £650 when compared to a standard flat tariff. For the electricity grid, strong empirical evidence exists that managed charging can provide EV demand flexibility at scale to lower system costs

Grid Case study 3: AI wind power forecasting[5]

Project/technology summary:

- The GraphCast x Tapestry project uses AI-enhanced weather modelling to deliver far more accurate wind-power forecasts—improving grid stability and enabling higher renewable integration in one of the world's fastest-decarbonising energy systems.

Territory:

- Chile

Organisations involved:

- Government of Chile, Google (DeepMind) and Tapestry

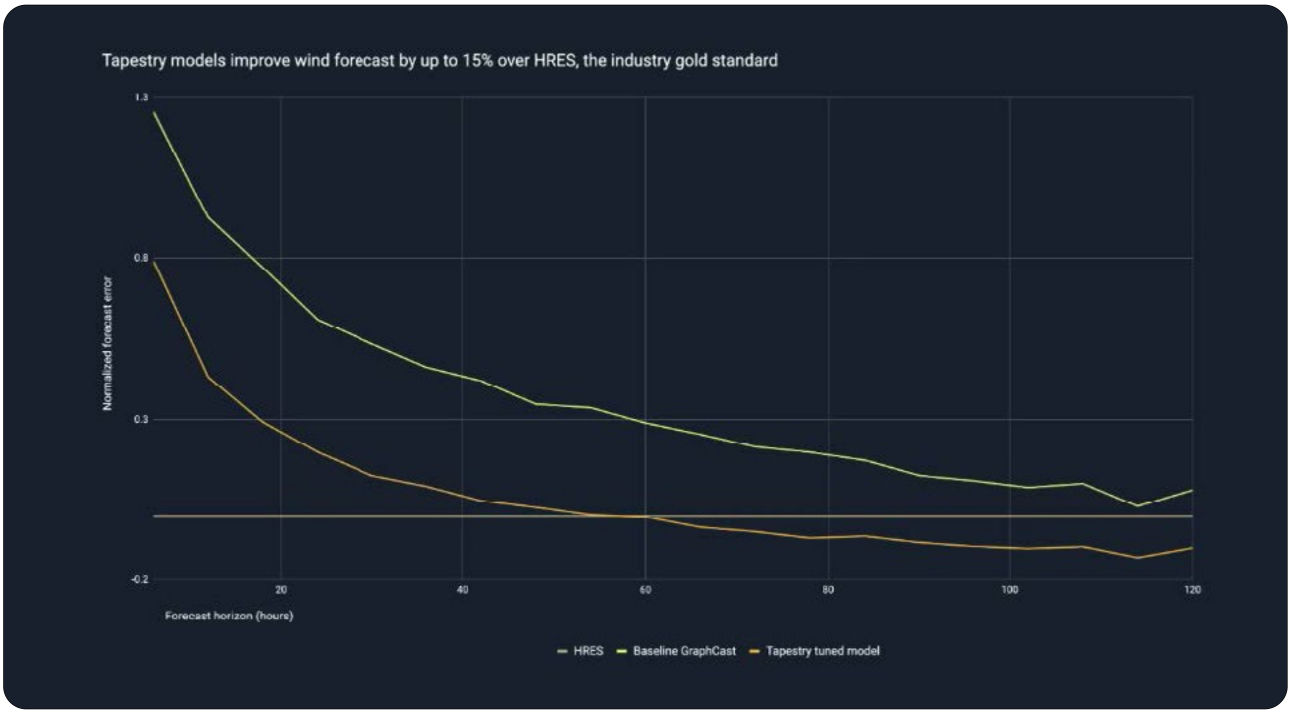
Main challenge addressed:

- The Government of Chile has established a national goal to achieve carbon neutrality by 2050. The country's energy sector is undergoing rapid transformation, driven by the increasing integration of renewable energy sources like wind and solar. Around 65% of the country's electricity is already generated by renewables, and this share is expected to rise to 93% in 2035. By 2030, Chile is expected to reach Phase 4 of variable renewable energy integration, indicating that variable renewable sources may meet almost all electricity demand at certain times.
- Accurately forecasting wind speed is crucial for grid operators to ensure reliability, stability and efficiency. This is because wind speed directly impacts the amount of power generated by wind turbines. However, traditional forecasting methods often struggle to capture the variability and uncertainty inherent in wind. Wind speed is influenced by complex weather patterns, atmospheric conditions and local terrain, making it challenging to predict with precision. Traditional forecasting methods, while useful for predicting demand for appliances like air conditioners, do not fully capture the dynamic nature of wind resources. This can lead to inaccuracies in forecasts, potentially hindering the efficient integration of wind power and increasing costs.

How AI was used:

- The GraphCast x Tapestry project uses AI and machine learning algorithms to analyse vast amounts of data from various sources, including weather patterns, historical wind speed data and sensor readings, to improve the accuracy and reliability of wind speed forecasts. By combining Google DeepMind's GraphCast, a machine learning weather prediction model, with Tapestry's expertise in grid modelling and

FIGURE 3
The graph shows the improvement Tapestry and GDM made to the untuned GraphCast model averaged over Chile wind farm locations, showing an up to 15% improvement over the High-Resolution Forecast (HRES) model produced by the European Centre for Medium-Range Weather Forecasts. (Normalized forecast error. RMSE skill score (normalized Root Mean Square Error difference) for 10 m wind magnitude)[6].



optimisation, this collaboration provides a more accurate and granular wind speed forecasting solution. Accuracy is enhanced by utilising a novel approach that integrates physics-based modelling and neural networks.

Main outcomes/impact:

- The forecasts enable grid operators to better manage the variability of wind power and maintain grid stability. The model also facilitates the integration of larger amounts of wind energy into the grid, supporting the transition to renewable energy sources while potentially minimising the need to curtail wind power generation, thereby maximising the utilisation of the clean energy resource.

Quantifiable savings

- The solution has resulted in a wind speed forecasting model tailored for Chile that is up to 15% more accurate than the current industry gold standard.

Case Study 4: Grids of the Future[7]

Project/technology summary:

- The Grids of the Future (GoTF) initiative demonstrates how AI-enabled grid digitisation can transform loss-making, undigitised distribution networks in the Global South into reliable, data-driven systems capable of integrating large volumes of distributed renewable energy.

Territory:

- Jaipur, Rajasthan

Organisations involved:

- Global Energy Alliance (GEA)

Main challenge addressed:

- More than 4.4 billion people in the Global South receive electricity through distribution grids that were never designed for the clean energy era.

These grids are largely undigitised, experiencing 16% Aggregate Technical and Commercial (AT&C) losses, with collection deficits as the primary driver, and operating with metering rates as low as 20%. As a result, they represent the hidden bottleneck of the global energy transition: not a lack of generation or storage, but a failure of grid intelligence.

- In Rajasthan, the stakes are especially acute. The state has a 30-GW Distributed Renewable Energy (DRE) target by 2030, yet integrating that capacity into an undigitized, loss-making grid is not feasible without first building real-time visibility and control.
- In Jaipur, unreliable electricity was costing farmers their harvests and forcing communities into dependence on expensive diesel generators. Grid management was manual and reactive, with no visibility into asset health, load conditions, or loss sources. Utility staff lacked the tools to anticipate failures, plan interventions, or quantify inefficiencies. The core challenge required simultaneously building digital infrastructure, institutional capacity, and a replicable model that other Global South utilities could adopt at scale.

How AI was used:

- GEA's DUET programme deploys AI across three progressive stages of grid digitisation, transforming utilities from reactive operators into data-driven, intelligent grid managers.
- Stage 1 — Geo Modelling: Field linemen use a mobile GIS application to capture asset data in real time. Assets are digitised on a software platform that geospatially and technically captures all relevant data about every grid asset, feeding a centralised digital twin of the entire distribution network.
- Stage 2 — Network Modelling: AI-driven Load Flow Analysis (LFA) ingests real-time power flow data from the Remote Monitoring System (RMS) of the main grid and from DREs, translating raw asset data into actionable grid intelligence. The platform runs AT&C loss analytics, network congestion identification, transformer loading analysis, and outage management — replacing guesswork with precise, location-aware operational intelligence.
- Stage 3 — AI-Enabled Decision Support: AI-driven asset health analytics enable predictive maintenance, reducing costly transformer failures before they occur. Peak demand forecasting, what-if scenario modelling, and smart meter data analytics allow distribution company officials to plan grid investments with far greater precision. Preventive interventions are guided by historical datasets.
- At the most advanced stage, utility staff interact with GPT-like natural language interfaces to query grid data conversationally, dramatically lowering the barrier to data-driven decision-making.
- Critically, the programme was designed specifically to understand the impact of existing DRE installations on the distribution grid and to optimise power demand management across the utility — directly supporting Rajasthan's renewable energy ambitions.
- Capacity building for utility officials is embedded throughout, ensuring AI tools are internalised and not simply installed. GEA also develops open-source tools, reference architectures, and grid data models designed for replication across hundreds of Global South utilities, building sovereign digital infrastructure and avoiding vendor lock-in.

Main outcomes/impact:

- The Jaipur pilot delivered measurable, quantified impact across reliability, efficiency, and financial performance. Approximately 2.5 million assets were successfully digitised — including 400,000 of 500,000 distribution transformers, 1.6 million of 2 million poles, and 1,400 of 1,650 substations — establishing India's most comprehensive utility digital twin to date.
- By replacing manual, reactive grid management with real-time AI-driven intelligence, DUET demonstrated that grid digitisation at scale is both technically feasible and economically compelling in emerging market contexts. Projected annual savings amount to approximately $53 million, comprising $12.4 million from reduced transformer failures through predictive maintenance, $14 million in power cost savings, and $27 million from the prevention of 355 GWh of AT&C losses.
- These outcomes directly catalysed India's first national grid digitisation roadmap, launched in

February 2026 through the GoTF Accelerator in partnership with AIDA and the Indian Energy Ministry. At the global level, the GoTF initiative targets reliable energy for 461 million people, avoidance of 1.5 gigatons of CO_2, 72 million jobs created or improved, and $65 billion in financing unlocked across 10 champion utilities representing 2.5 billion grid-connected customers.

Key lessons learned:

- Grid digitisation must be treated as a systems challenge, not a technology deployment. AI tools only deliver sustained value when paired with deep capacity building — utility staff must internalise the tools, not merely receive them.
- High-quality asset data capture in the field is foundational: no AI layer compensates for poor underlying data.
- Open-source architectures and replicable reference models are essential to avoid vendor lock-in and build sovereign digital infrastructure.
- A graduated exit model, where utilities progressively assume ownership, ensures long-term self-sufficiency. Global South utilities can leapfrog from loss-making, undigitized grids directly to AI-enabled sustainable operations — but only with the right sequencing

Quantifiable savings:

- $53M projected annual savings from the Jaipur pilot
- $12.4M annual savings from reduced distribution transformer failures (predictive maintenance)
- $14M annual power cost savings
- $27M annual savings from prevention of AT&C losses
- 355 GWh of AT&C losses prevented annually
- 16% AT&C loss rate addressed (collection deficits as primary driver)
- 2.5 million assets digitised: 400K/500K transformers, 1.6M/2M poles, 1,400/1,650 substations
- 30 GW DRE integration target supported (Rajasthan, by 2030)
- Expected impact by 2030
- 1.5 gigatons of CO_2 avoided
- 461 million people reached with reliable energy
- $65 billion in financing unlocked, representing 150x leverage
- 72 million jobs and livelihoods created or improved

Quote:

- "DUET has fundamentally changed how we manage our grid — from reactive firefighting to proactive, data-driven operations. The results in Jaipur demonstrate that AI-enabled grid digitisation can work at scale and serve as a blueprint for utilities across the Global South."

Section 2: Buildings and Transport

Urban environments face significant challenges regarding traffic congestion and related greenhouse gas emissions. AI-powered tools are now helping cities optimize existing traffic signal infrastructure, effectively reducing stop-and-go patterns and fuel consumption without requiring extensive physical construction

Key themes:

- AI turns existing infrastructure into smarter, lower-carbon systems
- — from traffic signals that cut stop-and-go emissions to buildings that self-optimise energy use.
- Real-time intelligence replaces slow, manual processes — cities and rail operators gain continuous, actionable insight instead of periodic reports or costly studies.
- Targeted, evidence-based optimisation delivers fast, scalable impact — small interventions (signal timing tweaks, building-level actions) generate large, system-wide carbon and cost savings.

Case study 1: Green Light optimizes traffic lights to reduce vehicle emissions in cities[8]

Project/technology summary:

- Green Light, operating across 20 cities worldwide, uses AI-driven traffic signal optimisation to cut unnecessary stops and reduce vehicle emissions by improving traffic flow at busy intersections

Territory:

- Global

Organisations involved:

- Google (Maps)

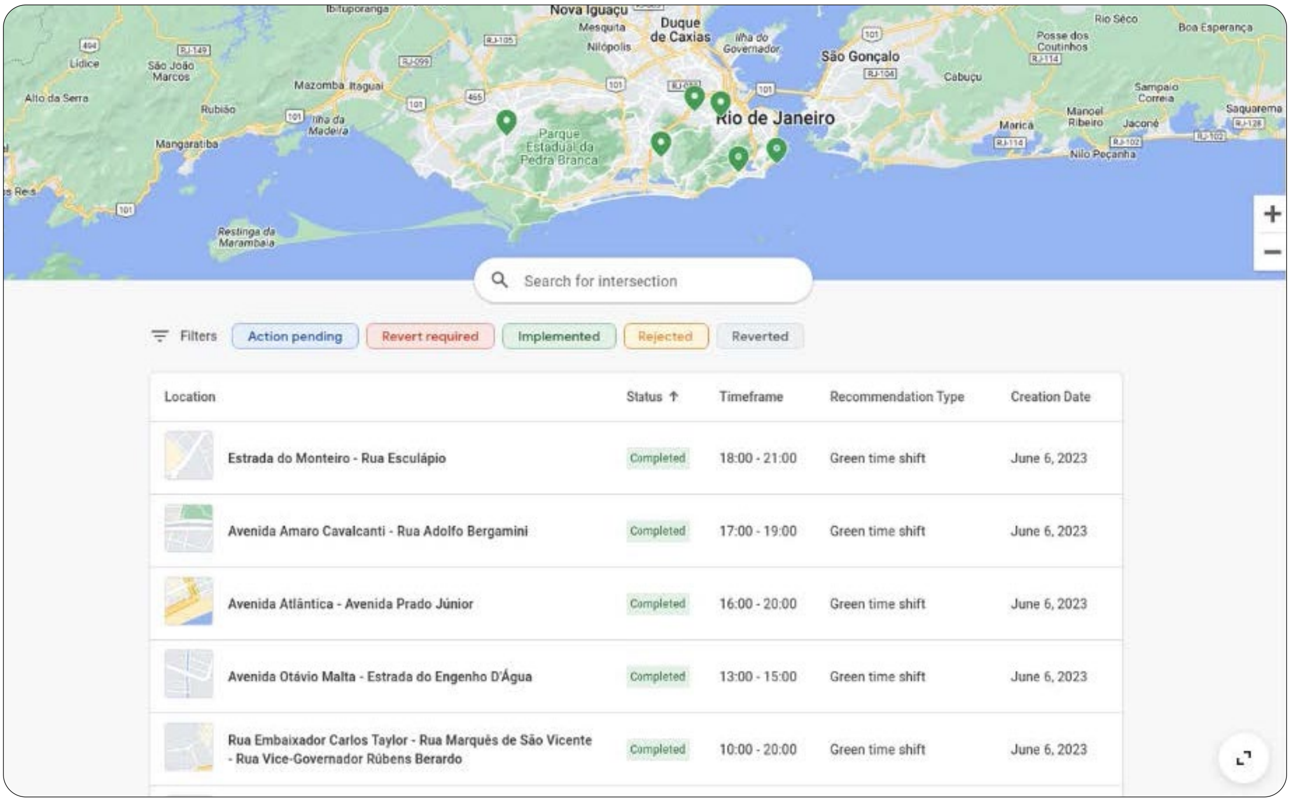
Main challenge addressed:

- Green Light uses AI and Google Maps driving trends, with one of the strongest understandings of global road networks, to model traffic patterns and build intelligent recommendations for city traffic engineers to optimize traffic flow. Early numbers indicate a potential for up to 30% reduction in stops and 10% reduction in greenhouse gas emissions. By optimizing each intersection, and coordinating between adjacent intersections, waves of green lights can be created and help cities further reduce stop-and-go traffic.

- Launched in 2023, Green Light is now live in 20 cities across four continents, from Haifa, Israel to Kolkata, India to Hamburg, Germany and recently Boston, USA – and in these intersections Google is able to save fuel and lower emissions for up to 47M car rides monthly.

- Road transportation is responsible for a significant amount of global and urban greenhouse gas emissions. It is especially problematic at city intersections where pollution can be 29 times higher than on open roads. At intersections, half of these emissions come from traffic accelerating after stopping. While some amount of stop-and-go traffic is unavoidable, part of it is preventable through the optimization of traffic light timing configurations. To improve traffic light timing, cities need to

FIGURE 4
The Green Light dashboard provides city-specific actionable recommendations?[9]



either install costly hardware or run manual vehicle counts; both solutions are expensive and don't provide all the necessary information.

How AI was used:

- Using AI, Google identifies possible adjustments to traffic light timing. Tthese adjustments are shared as actionable recommendations with the city. The city's traffic engineers review the recommendations, approve them, and they can easily implement them in as little as 5 minutes, using the city's existing policies and tools.

Main outcomes/impact:

- The Green Light dashboard provides city-specific actionable recommendations, showing supporting trends for each recommendation, with the option to accept or reject the suggestion. After a recommendation has been implemented, the dashboard shows an impact analysis report.

Quantifiable savings:

- Early numbers indicate a potential for up to 30% reduction in stops and 10% reduction in greenhouse gas emissions.

Quote:

- "Green Light has become an essential component of Kolkata Traffic Police. It serves several valuable purposes which contribute to safer, more efficient, and organized traffic flow and has helped us to reduce gridlock at busy intersections. Since November 2022, suggestions were implemented at 13 intersections. The outcome is excellent as per the feedback from commuters and traffic personnel," Vineet Kumar Goyal, Commissioner of Police, Kolkata, India

- "Green Light identified opportunities where previously there was no visibility and directed engineers to where there were potential benefits in changing signal timings. This provided valuable insights for our city with 2,400 traffic signals. Both the Green Light and Transport for Greater Manchester teams brought expertise and ideas to the table to improve journeys and reduce emissions," David Atkin, Analysis and Reporting Manager, Transport for Greater Manchester, England

Case study 2: Real-Time Net Zero Across Scotland's Railway: AI-Powered Digital Twins for Building Energy

Project/technology summary:

- ScotRail is using AI-powered semantic digital twins to generate real-time, estate-wide energy intelligence across stations and depots, enabling rapid, evidence-based decarbonisation and major cost savings without costly hardware upgrades.

Territory:

- UK

Organisations involved:

- OptimiseAI Limited (a Cardiff University spin-out) in partnership with ScotRail and Network Rail.

Main challenge addressed:

- ScotRail operates a diverse estate of around 360 stations and 9 depots, ranging from Victorian-era buildings to modern maintenance facilities spread across one of the UK's most geographically varied networks. Under public ownership, and with Scotland's net zero 2045 target written into law, every investment must be evidence-based and demonstrably achievable.

- Traditional energy management relied on periodic reporting, one-off consultant-led investigations and siloed data drawn from separate systems. The result was limited insight and limited confidence: teams could not easily identify where waste occurred, could not respond in real time, and could not build credible business cases without commissioning expensive bespoke studies.

- ScotRail was initially quoted six-figure sums for designs covering only heating systems across a handful of assets with no demonstrable return. This created a catch-22: securing investment approval required a robust business case, but building that case itself demanded major upfront spend, with answers two to three years away. The core challenge was therefore to generate trustworthy, estate wide energy intelligence quickly and affordably, without large upfront hardware investment, so that decarbonisation capital could be targeted where it delivers the greatest carbon and cost return.

FIGURE 5

The partnership was rapidly expanded to cover 25 stations and depots, with advanced optimisation at eight major sites including Aberdeen, Inverness and Queen Street[10].

How AI was used:

- OptimiseAI's Predict platform builds an AI powered semantic digital twin of each building directly from data the operator already holds. With a simple connection to existing smart-meter feeds of electricity and gas, and BMS/IoT data (where available) a calibrated model of each station or depot is generated within hours rather than months, with no large upfront sensor deployment. Unlike a conventional digital twin that merely mirrors a building's systems, a semantic twin integrates meaning and context: it doesn't just see the data, it understands it in relation to the building's operational goals, occupancy patterns and energy targets.

- The core innovation is how the system reaches a trustworthy answer, as It triangulates between three sources: (1) the building's actual metered consumption data; (2) an automated physics-based energy simulation model of the asset; and (3) OptimiseAI's own Fast Machine Learning (FastML) and LLM models. Where the three converge, confidence is high; where they diverge, the system flags anomalies and underperformance. This is what allows reliable insight even in the ~90% of older buildings that lack historical datasets or a Building Management System.

- These FastML models are proprietary, trained on the full body of data from OptimiseAI's previous deployments together with millions of publicly available building-performance records, and engineered for ultra-low-latency inference (analysis in milliseconds, deployable on low-cost edge hardware). Combined with ontology-based semantics (NLP), neural networks and genetic algorithms and a decade of patented Cardiff University research, this gives recommendations a statistical robustness that is difficult to replicate, contextualising each site against thousands of comparable buildings rather than its own history alone.

- Optimisation algorithms then generate fully costed static and dynamic optimisation action plans (LED, heat pumps, controls, fabric), each toggled to show cost, ROI and impact on energy, carbon and compliance targets. At priority sites, IoT sub-metering extends the twin to room and zone level, driving demand-responsive heating and lighting against real occupancy turning fragmented periodic reporting into continuous, real-time energy intelligence.

AI used:

- Machine Learning — proprietary Fast Machine Learning (FastML) models, trained on OptimiseAI's deployment data plus millions of public building-performance records, engineered for millisecond, edge-deployable inference
- Generative AI — LLM-based reasoning over the semantic digital twin, enabling natural-language interrogation and data-scarce inference
- Natural Language Processing — ontology-based semantics integrating heterogeneous building and operational data into a single contextual model
- Deep Learning — neural networks capturing nonlinear relationships across comparative building datasets, plus anomaly detection
- Optimization Algorithms — genetic algorithms generating costed, ROI-ranked decarbonisation action plans and multi-dimensional scenario planning

Main outcomes/impact:

- Within a single programme, ScotRail moved from siloed, periodic analysis to real-time, AI-driven management across its estate. By July 2025, Predict had generated live digital twins for 25 stations and depots, with eight major sites including Glasgow Queen Street, Aberdeen and Inverness, plus depots at Corkerhill, Shields, Yoker and Haymarket undergoing room- and zone-level optimisation. For the first time, all sites were benchmarked against the UK EPC standard, giving a consistent, comparable estate-wide view.
- The platform identifies potential utility savings of 20–50% against a £9 million annual utilities bill conservatively around £3 million per year. ScotRail reports that roughly £200k invested in innovation testing over three years can now be converted into large returns through precisely targeted investment, replacing speculative six-figure design studies.
- Equally significant are the organisational outcomes. The sustainability team shifted from a compliance-and-reporting function to a recognised innovation lab and internal problem-solver. Board-level energy questions are answered immediately and with precision; business cases are produced in hours, not months; and a network-wide Red-Amber-Green dashboard makes emissions data visible and actionable across the organisation making decarbonisation a shared responsibility rather than one department's concern.

Key lessons learned:

- All buildings can utilise a real time digital twin, by starting from data they already hold. Connecting existing smart-meter feeds let ScotRail reach a trustworthy proof of concept for a fraction of the cost of conventional static consultant surveys and reports, breaking the funding catch-22.
- Prove value on a small pilot, then scale on evidence rather than speculation. Translate everything into financial terms cost and ROI remove the emotion from decarbonisation decisions and win cross-departmental buy-in.
- Deploy across a deliberately diverse estate (historic and modern, urban and rural) to create a credible, replicable blueprint. Finally, treat compliance as a by-product of good real-time management, not a separate annual exercise.

Quantifiable savings

- 25 stations and depots covered by live, operational digital-twin models (expanded from an initial 15, then 25, by July 2025).
    - 8 major sites instrumented with IoT sub-metering for room/zone-level modelling and demand-responsive heating and lighting: Glasgow Queen Street, Aberdeen, Inverness, and depots at Corkerhill, Shields, Yoker and Haymarket.
    - All 25 sites benchmarked against the UK EPC standard for the first time, establishing a verified estate-wide performance baseline.
    - £9 million annual utilities cost across the estate quantified and modelled from live consumption feeds (electricity, gas).

    - ~£200k innovation investment deployed over three years to reach validated, data-based business cases — replacing the six-figure design studies previously required.
    - Business-case turnaround cut from months to hours, with predicted savings tracked live against actual metered performance.
- Forecast future savings:
    - 20–50% utility savings forecast across the estate, modelled from live consumption data against the £9m baseline, conservatively ~£3 million per year once identified measures are implemented.
    - Proportional carbon reduction tracked alongside cost savings, aligned to Scotland's legislated net zero 2045 target and ScotRail's decarbonisation pathway.
    - Pathway to 300+ further sites across the ~360-station, 9-depot estate, scaling the same approach on evidence rather than speculation.
    - Roadmap to expand into water and waste streams and integration with BIM models for whole-life operational efficiency assessment.
    - Benchmark from wider deployments: OptimiseAI's platform has delivered 20–47% energy and carbon reductions across complex estates including transport hubs and public-sector facilities, supporting the credibility of ScotRail's forecast range.
    - Compounding model accuracy: as more live data is gathered, forecast precision and identified savings are expected to increase.
    - Complementary to 100% UK renewable electricity already procured for stations and depots, forming a credible multi-layer decarbonisation strategy.

Quote:

- "The biggest shift is that we're no longer seen as the people who just tell you what you can't do or what regulations you need to follow. We're now viewed as problem-solvers who can help different departments achieve their objectives more efficiently. We can now test our decarbonisation strategies within the digital twin and demonstrate ROI, the tool gives us the ability to continuously track and optimise our savings on our path to net zero." — Poul Wend Hansen, Head of Sustainability, ScotRail
- "This kind of scalable approach represents the future we're heading toward: where efficient building estates will be the backbone of resilient cities." — Nick Tune, Founder & CEO, OptimiseAI

Section 3: Data Centres

While data centres are often viewed as rigid, high-demand loads, new AI technologies are transforming them into flexible grid assets. By dynamically adjusting power consumption in response to real-time grid signals, data centres can now help balance supply and demand, easing constraints rather than exacerbating them

Key Themes:

- AI data centres as flexible grid assets – Trials and deployments show high-performance AI workloads can be shifted or curtailed in real time, turning data centres from "always-on" constraints into controllable resources that help balance supply and demand and support variable renewables.
- Demand response and peak shaving at scale – By embedding AI powered demand response into long-term utility contracts and using intelligent workload management, data centres can provide gigawatt-scale flexibility, reduce peak loads, defer new generation and network investment, and lower system-wide costs.
- 24/7 carbon-free and clean energy matching – AI-optimised portfolio and hourly/locational matching models enable data centres to run on very high shares of carbon-free energy around the clock, cutting emissions while providing a scalable blueprint for other large loads.

Case study 1: AI Grid Technology Successfully Demonstrates the Ability of Data Centres to Adjust Power Needs

Project/technology summary:

- Emerald AI, EPRI, National Grid, Nebius and NVIDIA have shown that high-performance AI data centres can act as flexible grid assets rather than fixed, "always-on" loads, using Emerald Conductor to manage a 96-GPU NVIDIA cluster in London. In a UK-first trial, the system responded to over 200 real-time grid signals, cutting data centre power demand by up to 40% within seconds and sustaining load reductions for hours without disrupting critical AI workloads. At scale, this kind of AI-driven flexibility could free gigawatts of capacity on constrained grids, smooth peaks and support variable renewables.

Territory:

- UK

Organisations involved:

- Emerald AI, EPRI, National Grid, Nebius, and NVIDIA

Main challenge addressed:

- Today, most large data centres are treated as fixed, "always on" demand. As AI use grows and more facilities seek to connect, the idea that data centres are a fixed demand could increase network constraints and lengthen connection times. Demonstrating the ability of data centres to flex their power demand shows how they can ease constraints and unlock grid capacity, rather than be an extra source of inflexible demand.

How AI was used:

- The trial tested Emerald AI's software on a NVIDIA Blackwell Ultra cluster, a bank of 96 high performance GPUs at a Nebius data centre in London.

- Over five days in December 2025, more than 200 real-time simulated "grid events" were sent to the site to test Emerald's Conductor's ability to dynamically adjust the data centre's power consumption. Each time, Emerald AI's platform successfully adjusted power use to the requested level, cutting demand by up to 40% while critical workloads continued to run as normal.

Main outcomes/impact:

- As the UK prepares for over 6 GW of data centre deployments on the grid by 2030, this technology could enable AI data centres across the UK to add more than 2 GW of capacity back to the grid when needed.

Key lessons learned:

- The success of the trial demonstrates that AI data centres can move from being a source of electricity constraint to a controllable grid asset. By flexing demand in real time, they can help manage peaks, make better use of existing infrastructure, and support the connection of different sources of energy to the grid.

- The performance data will now be shared with industry, regulators and policymakers to influence future rules for "power flexible" data centre connections, including how such facilities could qualify for faster and larger connections where they agree to flex on request.

- The London trial serves as the operational blueprint for Aurora, a nearly 100MW power-flexible AI Factory, operated by NVIDIA in Virginia. By establishing measurement-based evidence for AI flexibility, the partners aim to set new global standards for interconnection.

Quantifiable savings:

- Peak smoothing: Successfully reacted to spikes in demand during half time of major football matches, proving AI can counterbalance sudden consumer electricity surges.

- Long-duration shifting: Followed load-reduction requests for up to 10 hours, helping the grid navigate periods of low wind or extreme heat.

- System management: Simulated a system stress event, shedding 30 percent of its load in roughly 30 seconds to help maintain grid resilience.

Quote:

- Steve Smith, President, National Grid Partners said: "As the UK's digital economy accelerates, there's concern that data centres could add pressure to an already constrained system. This trial proves the opposite can be true. High performance data centres don't have to place additional strain on the grid. With our partners, we've shown they can be connected and managed without major new network capacity, flexing their power up or down in real time to support the whole system. This approach will enable us to connect significant new demand more quickly and, help to lower network charges for customers over time."

- Dr Varun Sivaram, Founder and CEO of Emerald AI, said: "This trial demonstrates that AI infrastructure can be a dynamic force for the grid. With dozens of realistic AI workloads running simultaneously, we delivered fast emergency curtailment and sustained, precise peak reduction. The same approach we validated here can be applied to much larger AI factories, as the industry scales."

Case study 2: Google demand response[11]

Project/technology summary:

- Google is turning its AI infrastructure into a flexible grid resource by embedding 1 GW of demand response capacity into long-term contracts with U.S. utilities. By intelligently shifting or curtailing machine learning workloads across its data centres, Google can lower electricity demand during peak periods, helping stabilize the grid, avoid or defer new generation and transmission, and reduce system-wide costs.

Territory:

- United States

Organisations involved:

- Google, Indiana Michigan Power (I&M), Tennessee Valley Authority (TVA), Entergy Arkansas, Minnesota Power and DTE Energy

Main challenge addressed:

- Demand response enables Google data centres to be valuable assets for the power grid. Google's ability to shift or reduce its energy demand can help utility companies balance supply and demand and plan for future capacity needs. These agreements create a smart solution to make the electricity systems that serve its data centres more affordable and reliable.

How AI was used:

- Google's demand response capability allows us to limit or shift a portion of machine learning (ML) workloads running in our data centres. This reduces the overall data centre power demand, helping to stabilize the grid during certain hours or times of the year.

Main outcomes/impact:

- Data centre demand response plays an important role in translating energy growth into a smarter system that can create widespread cost-saving benefits.

- By allowing utilities to cover peak demand periods with existing grid resources, demand response can help optimize the build-out of new transmission and power plants. Research shows that even small amounts of flexibility in large electrical loads can save costs for entire power systems, easing rate pressure for all customers. This is because flexible demand reduces the need for new infrastructure designed only to meet short periods of peak use of the system — a primary driver of costs for electricity customers.

Key lessons learned:

- There are limits to how flexible a given data centre can be, and this capability will only be available at certain locations. Google is excited to keep learning about its potential and working to advance data centre design, grid planning processes, and market development to help realize it.

- This includes collaborating with states, regulators and Google's utility partners to modernize power system planning. While grid planners have historically assumed most new loads are inflexible, initiatives like EPRI DCFlex, in which Google is a founding member, are developing frameworks to fully value demand response as a capacity resource for the grid.

Michael Terrell, Google's Head of Advanced Energy "As AI adoption accelerates, we see a significant opportunity to expand our demand response toolkit, develop capabilities specifically for ML workloads, and leverage them to manage large new energy loads. By including load flexibility in our overall energy plan, we can manage AI-driven growth even where power generation and transmission are constrained"[12]

Case study 3: Queen Mary University of London Delivers Data Centre District Heating Project

Project/technology summary:

- Queen Mary University of London, together with Schneider Electric and APT, has transformed its research data centre into a resilient, heat-reusing energy hub. By modernising cooling and connecting the data centre to a campus-wide district heating network, waste heat is now captured to provide low-carbon heating and hot water for university buildings and student accommodation while directly cutting emissions, energy costs, and aligning with the university's sustainability goals.

Territory:

- UK

Organisations involved:

- Queen Mary University of London, Advanced Power Technology (APT), Schneider Electric.

Main challenge addressed:

- The companies have created a platform for heat recovery at the University's data centre, enabling waste heat from the facility to be connected to a campus-wide district heating network, providing heating and hot water for the buildings and student accommodation nearby

How AI was used:

- No direct use of AI but the technology has applications to improve the sustainability of AI data centres.

Main outcomes/impact:

- Prior to the modernisation project, Queen Mary's data centre was experiencing reliability, scalability, and availability issues, which required manual on-site interventions to fix. It was also becoming outdated, and its operations were, at times, impacted due to a build-up of heat in its server racks from its inefficient cooling systems.
- Future research computing may also have been hindered due to the data centre's hosting limitations. The refresh was, therefore, vital to improve and stabilise day-to-day operations, and its proximity to the campus' district heating network presented an opportunity for a new solution be designed and implemented to bring the data centre in line with the University's sustainability goals.

FIGURE 6
Queen Mary University of London's research data centre into a resilient, heat-reusing energy hub[13]

Key lessons learned:

- As a result of the work by Schneider Electric and APT, Queen Mary has developed a highly resilient research data centre that has increased its processing power and is more energy efficient.

- It has significantly increased the reliability and availability of its research data and both the systems' day-to-day operations and maintenance are more automated - requiring less manual intervention to keep the running at full capacity all year round. The university is also planning to move server equipment from across the campus into the new data centre, providing additional benefits including increased reliability, reduced costs and enhanced energy efficiency.

Quantifiable savings:

- More reliable data centre with enhanced HPC capabilities and future scalability. Recovered heat used for heating and hot water across the main campus.

- Data centre infrastructure that can meet current and future research computing needs, while supporting sustainability

Quote:

- Professor Jonathan Hays, Queen Mary University of London said, "The support we've had from APT and Schneider Electric has been unparalleled. Both companies came together to help us develop an exciting and innovative project which would enable us to provision for the future. The biggest impact is that we were able to deliver on what we promised while improving our sustainability. The new data centre is more reliable and efficient than ever, and through the heat recovery, we have significantly reduced our spending on heating and hot water, while gaining enhanced reputational benefits from taking a lead on sustainability within our data centre operations."

Case study 4: Carbon-free Energy Manager: A new model for advancing data centre decarbonization[14]

Project/technology summary:

- Google and ENGIE's Carbon-Free Energy (CFE) Manager in Germany shows how AI-driven, hourly clean energy matching can turn energy-intensive AI and data centre growth into a catalyst for grid decarbonization. The CFE Manager is projected to run Google's German data centres and offices on 85% carbon-free energy in 2026. This model cuts transaction costs, shifts risk to the party best placed to manage it, and aligns clean energy procurement with real-time demand, supporting Germany's wider decarbonisation and energy security goals while underpinning Google's €5.5 billion AI infrastructure investment.

Territory:

- Germany

Organisations involved:

- Google and ENGIE

Main challenge addressed:

- As hourly clean energy matching becomes a new standard for clean energy supply, new market models are needed to help companies use more clean energy around the clock. In Germany, Google and ENGIE have worked together on a CFE Manager Model to deliver around-the-clock clean power for Google's German operations. They recently extended their 24/7 CFE partnership to source hourly matched clean energy from new onshore wind and solar projects, complemented by battery energy storage systems (BESS) and pumped storage. ENGIE will also integrate energy volumes from Google's existing long-term PPAs with third-party providers. As a result of this flexible portfolio that balances supply and demand more precisely, Google's German data centres and offices are projected to run at 85% carbon-free energy in 2026. The agreement also supports Google's broader €5.5 billion investment in AI infrastructure and office locations in Germany between 2026 and 2030, bringing jobs, security and growth to the economy.

- The partnership is a key example of how buyers and utilities can work together to develop hourly matching solutions. Under this CFE Manager model, suppliers optimise clean power portfolios to meet corporate hourly matching targets, providing a scalable solution for buyers as their demand grows.

How AI was used:

- Locational and hourly matching ensures that the electricity consumption from an electricity consumer (in this case a data centre) is being met with clean electricity where and when it is being consumed. This reduces the consumers reliance on carbon-emitting electricity generation sources and also supports the integration of clean energy resources into the broader grid system. Numerous studies have explored how hourly matching can support electricity grid management and reduce electricity system costs, as well as accelerate clean energy, flexibility, and storage deployment.

- In the case of Google and ENGIE's agreement in Germany, their CFE Manager model supports the deployment of onshore wind, onshore solar PV and battery energy storage systems that enable Google's German operations to run at or near 85% carbon-free energy in 2026.

Key lessons learned:

- It can reduce transaction costs for both buyer and seller by aggregating multiple generation types within one scalable agreement.

- It helps reduce risk for clean energy buyers relative to traditional PPAs, bringing these risks to the party best equipped to manage them while providing the buyer with stable, predictable pricing.

- It is replicable and scalable, allowing the clean energy portfolio to grow dynamically alongside the buyer's electricity demand.

- It enables faster decarbonization of the buyer's electricity consumption and the broader electricity grid, since it deployed a portfolio of technologies needed to more fully match the buyer's around-the-clock electricity demand.

Quantifiable savings:

- The CFE Manager Agreement deploys a portfolio of clean energy technologies to enable Google to achieve 85% hourly carbon-free energy for its German operations.

Quote:

- "Building on the success of the partnership signed in 2021, Engie will further support Google's regional carbon free energy ambitions in Germany. By actively innovating on energy supply models Google aims to directly support German decarbonisation and energy security goals, and to create a clean, reliable, and affordable energy system for everyone." - Ainhoa Anda, Head of EMEA Energy Commercial Structuring, Google

Section 4: Investment

AI is rapidly reshaping how capital is allocated for the energy transition, enabling investors and asset owners to identify high-value decarbonisation opportunities far more quickly than traditional methods allow. By turning complex operational, sectoral and market data into actionable investment intelligence, AI helps organisations prioritise projects, assess feasibility and direct capital toward the highest impact interventions. More broadly, AI is emerging as a critical tool for accelerating Net Zero investment planning at portfolio and system scale.

Key Themes

- Portfolio-wide opportunity identification and analysis – to identify high-impact opportunities in energy efficiency, renewable energy, battery storage, demand optimisation and emissions reduction, dramatically accelerating the assessment process.

- Investment prioritisation and decision intelligence – AI evaluated opportunities against emissions impact, financial returns, capital requirements, implementation complexity and scalability, to direct capital towards the most impactful decarbonisation initiatives.

- Roadmap development and strategic planning – AI translated complex decarbonisation opportunities into actionable investment roadmaps.

Case study 1: Cross-portfolio Net Zero and Adaptation Planning[15]

Project/technology summary:

- AI Accelerating Portfolio-Wide Energy Transition Planning. Working with Vyzrd, a global investment fund with more than US$300 billion in assets used AI-driven decision intelligence to transform decarbonisation planning across a diverse portfolio of 30+ companies. By rapidly identifying, assessing and prioritising opportunities in energy efficiency, renewable generation, battery storage, demand management and low-carbon infrastructure, AI compressed a process that would traditionally take 12–18 months into just 3–5 weeks.

Territory:

Organisations involved:

- A global investment fund with $300 Bn+ operating and investment assets

Main challenge addressed:

- The Client's main challenge was to determine how AI could be applied in a practical and commercially meaningful way to accelerate its energy transition agenda across a large, diversified portfolio. While management had set an ambitious decarbonisation target, the portfolio included 30+ companies across sectors such as transportation, utilities, manufacturing and healthcare, each with different energy profiles, operational constraints and investment needs.

- The challenge was therefore not simply to identify AI use cases, but to understand where AI could unlock high-impact opportunities across energy efficiency, generation, demand optimisation and decarbonisation planning. Potential applications included improving asset efficiency, optimising power consumption, forecasting energy demand, supporting onsite renewables, assessing battery storage, and enabling coordinated portfolio-level initiatives such as inter-company power purchase agreements.

- A further challenge was translating these opportunities into robust investment decisions. Each opportunity needed to be assessed for operational feasibility, financial viability, emissions impact, implementation complexity and relevance across multiple sectors. Traditional approaches required to address the scope of analysis required 12 to 18 months of effort and significant investment at each operating company level, creating a major barrier to timely capital allocation.

- The platform helped address the challenge of converting a complex AI and energy transition landscape into a structured decision-intelligence framework, enabling the Client to prioritise opportunities, plan projects, set actionable roadmaps and allocate capital more efficiently.

How AI was used:

- AI is being used as analytics and decision-intelligence layer to accelerate and scale the identification, assessment and prioritisation of energy transition opportunities across the Client's portfolio. Given the number and diversity of portfolio companies, a traditional bottom-up assessment would have required extensive manual data gathering, operational interviews, engineering studies and financial modelling across each business. Vyzrd's AI-enabled approach helps compress this process by rapidly analysing company, sector, operational and market signals to identify where the highest-value decarbonisation and energy efficiency opportunities are likely to exist.

- The AI is applied to map relevant use cases across different operating contexts, including energy demand optimisation, asset efficiency, predictive maintenance, renewable generation potential, battery storage, load shifting, emissions reduction, process optimisation and coordinated procurement models such as cross-portfolio power purchase agreements. Instead of treating these as generic technology ideas, the AI helps contextualise each opportunity by sector, asset type, energy intensity, operational complexity and potential financial impact.

- AI is also used to support feasibility and prioritisation. It helps evaluate opportunities across multiple dimensions, including emissions impact, cost reduction potential, capital intensity, implementation complexity, scalability, technology readiness and strategic relevance. This enables management to compare opportunities across different sectors and operating companies using a consistent framework.

- Importantly, AI supports the translation of opportunity identification into action planning. By structuring insights into opportunity clusters, investment themes, prioritised initiatives and indicative implementation pathways, it enables the Client to move from a broad decarbonisation ambition to a more practical portfolio-level roadmap. This includes identifying quick wins, larger capital deployment opportunities, cross-company synergies and areas where further technical validation may be required.

- In this way, AI is not positioned merely as a technology solution, but as an enabler of faster, more consistent and more commercially grounded decision-making for energy transition, efficiency improvement and low-carbon growth.

Main outcomes/impact:

- The use of AI enabled the Client to move from a broad decarbonisation ambition to a more structured, portfolio-wide view of actionable energy transition opportunities. Instead of approaching each portfolio company through a lengthy standalone assessment, AI helped accelerate the identification of high-impact opportunities across efficiency improvement, energy optimisation, onsite renewables, battery storage, demand management and coordinated procurement models such as portfolio-level power purchase agreements.

- A key impact was the ability to compare and analyse opportunities across 30+ operating companies using a consistent decision framework. This helped management understand which initiatives were likely to deliver the strongest combination of emissions reduction, operational efficiency, financial value and implementation feasibility. It also enabled cross-sectoral prioritisation, highlighting where similar energy challenges or investment themes existed across otherwise different businesses.

- AI also helped address a critical capability constraint. Analysis of this scale would typically require large teams with specialist expertise across energy systems, engineering, finance, climate strategy and sector operations. Given constrained access to such talent, Vyzrd's AI-enabled technology platform helped bridge the talent gap by codifying expertise, automating parts of the analytical process and enabling faster, more consistent assessment at scale.

- Overall, AI's impact was to make decarbonisation planning more scalable, comparable and commercially grounded, providing a practical basis for capital allocation, project planning, target-setting and roadmap development.

Key lessons learned:

- AI delivers the greatest value when embedded within a structured decision-intelligence framework, rather than treated as a standalone technology initiative.

- Commercial viability and robust feasibility assessment are critical to attracting both internal and external investment for decarbonisation initiatives.

- Smart AI integration can help translate technical opportunities into investable propositions by assessing emissions impact, capital requirements, operating benefits, implementation complexity and financial returns.

- For diversified portfolios, AI should be combined with sector expertise, financial assessment and operational validation to support credible prioritisation.

- Simulation is powerful in advancing both understanding and risk management, helping decision-makers test transition capital deployment scenarios across energy efficiency, generation, storage and broader low-carbon investments.

- AI can also bridge talent gaps by scaling specialist analysis, while retaining expert validation for final investment decisions.

Quantifiable savings:

- Estimated effort savings: ~1,000 man years (actual)

- Estimated project cost savings: US 15 Mn+ in analysis, planning and feasibility assessment (actual)

- Time: 3-5 weeks (AI integrated approach) vs. 12-18 months - traditional approach (actual)

- Projected emissions reduction from selected projects: 30% tCO_2e reduction across portfolio (forecasted)

- Projected value creation from target projects: US$ 750Mn+ (forecasted)

Quote:

- "Our partnership with Vyzrd has demonstrated how AI can materially improve the speed, scale and quality of transition decision-making. Their technology has enabled us to convert a complex portfolio-wide challenge into an investible roadmap for investment, efficiency improvement and risk-managed capital deployment." Senior Executive (Investments)

Section 5: Industry and manufacturing

AI is beginning to play a pivotal role in decarbonising manufacturing by improving energy efficiency, strengthening process optimisation and enabling more informed technology and infrastructure decisions. Across the sector, AI is helping companies translate complex operational and engineering data into actionable insights that reduce emissions, enhance reliability and accelerate innovation. The case studies in this section illustrate this shift—from industrial AI improving polymer production efficiency at Covestro to generative AI making hydrogen supply-chain planning more accessible for businesses and regional stakeholders. Together, they show how AI can unlock practical, scalable pathways for low-carbon manufacturing and support the sector's transition toward cleaner, more resilient production systems.

Key Themes:

- Industrial AI systems integrate real-time data, machine learning and predictive analytics to optimise energy use
- AI-powered process simulation allows manufacturers to test new production methods and sustainability interventions in a virtual environment
- Actionable operational intelligence – AI transforms fragmented production, energy and asset data into decision-ready insights for engineers and operators.

Case study 1: AVEVA / Covestro: Using Industrial AI to Support Sustainable Polymer innovation[16]

Project/technology summary:

- Through its partnership with AVEVA, Covestro is demonstrating how AI can accelerate industrial decarbonisation while maintaining operational viability.
- By combining real-time operational data, predictive analytics, machine learning, and process simulation, the project identified inefficiencies, optimised energy use and tests lower-carbon production in a virtual environment before deployment.
- The approach has delivered a 30% reduction in energy consumption and a 39% reduction in CO_2 emissions per tonne of product.

Organisations involved:

- AVEVA / Covestro

Main challenge addressed:

- Chemical manufacturer Covestro's aim was to achieve sustainable growth while reducing its environmental footprint. The chemical industry faces the challenge of balancing long-term operational stability with the need to reduce energy consumption and CO2 emissions. Covestro sought to leverage digital transformation to optimize energy use, improve process efficiency, and support its goal of becoming net zero by 2035. The challenge was to implement a data-driven approach that could provide real-time insights, standardize energy and production data across plants, and enable scalable reductions in energy consumption and emissions while maintaining operational reliability, product quality, and economic competitiveness.

How AI was used:

- Covestro uses AVEVA PI System, Process Simulation and Predictive Analytics to create a connected operational intelligence environment. Production, energy and asset data are aggregated in real time, providing a trusted foundation for AI driven analysis and decision making.
- Machine learning models continuously monitor asset and process behaviour, detecting deviations that may indicate emerging equipment failures, process inefficiencies or abnormal energy consumption. These insights allow engineers to intervene before issues impact production, safety or sustainability performance. In their predictive maintenance program, no code AI models help identify emerging issues days to months before

potential failure, enabling proactive maintenance and reducing operational risk.

- At the same time, process simulation models enable engineers to evaluate new production concepts and sustainability initiatives in a virtual environment before implementation. This allows Covestro to assess technical feasibility, economic impact and environmental performance more rapidly and with lower risk. Engineers can test and optimize process changes, including innovations that support circular and lower carbon production, before deploying them in live operations.

- By combining operational data, machine learning, predictive analytics and simulation, Covestro can improve energy efficiency, optimize production processes and support more sustainable decision making across its operations. The ability to standardize and share trusted data internally and externally also fosters collaboration across the value chain, accelerating innovation and sustainability initiatives.

Main outcomes/impact:

- Covestro achieved a 30% reduction in energy consumption and a 39% decrease in CO2 emissions per ton of product, with a trajectory toward a 50% reduction by 2030. The digital transformation enabled more precise energy management, process optimization, and safer operations. AI driven anomaly detection, predictive maintenance and simulation enabled earlier identification of process inefficiencies, reduced unplanned disruptions and improved energy management. These capabilities helped Covestro accelerate operational improvements while supporting its long term decarbonization strategy. The approach demonstrated that deliberate, scalable digital initiatives could deliver measurable environmental and economic benefits without relying on fleeting technological trends

Key lessons learned:

- Focus on scalable, data-driven solutions and maintain a steady, deliberate approach to digital transformation. Enable the asset owner and process engineer to work with the AI products themselves through no-code, intuitive solutions enables a quick deployment and ROI. Prioritize human expertise alongside AI to ensure effective decision-making and innovation.

Quantifiable savings:

- 30% reduction in energy consumption per ton of product

- 39% of CO2 emission reduction per ton of product

- On trajectory to reach 50% emission and energy consumption reduction per ton of product by 2050.

Quote:

- “Our goal is to find more sustainable processes for more sustainable products. The challenge we’re facing is we have a lot of ideas and possibilities that can move us toward these goals. We need a tool to quickly and efficiently assess how real the impact of a new process will be, economically, technically, and in terms of environmental impact.” Franz Kirchhoff – Head of Process Modelling and Conceptual Design, Covestro.

Other notable case studies, solutions and suppliers

Not all the organisations that Climate Action engaged with via the roundtables developed as part of this report process had specific case studies but are worth noting for their technology, innovation and future potential.

- QGEMS Energy[17], based in the United Kingdom, has developed an AI-native digital energy operating system designed to coordinate distributed energy resources (DERs) in real time, providing a unifying layer across utilities, customers, markets and regulators. Its Grid Edge Management AI can orchestrate millions of control points, optimise DER dispatch, and settle energy transactions in seconds, while post-quantum security and immutable accounting make the system auditable and financeable. Early deployments show improvements in forecasting accuracy, energy efficiency and grid-edge responsiveness, positioning QGEMS as an emerging model for secure, AI-enabled coordination of distributed clean energy assets.

- University of Bath, GW-SHIFT. AI-Powered Decision Support for Hydrogen Deployment

- Developed by the University of Bath and GW-SHIFT, the AI-enhanced HyChain platform shows how generative AI can accelerate the shift to a hydrogen-powered, low-carbon economy by translating complex hydrogen supply chain models into clear, actionable insights. It enables SMEs, local authorities, and regional energy stakeholders to evaluate production, storage, transport, cost, and emissions scenarios without specialist expertise, lowering barriers to informed decision-making, improving access to planning tools, and helping users identify lower-carbon hydrogen pathways. In doing so, HyChain highlights AI's potential to democratise energy-system planning, de-risk investment decisions, and support faster deployment of clean energy infrastructure.

Summary

The transition to a sustainable energy future increasingly depends on our ability to optimise and decarbonise the systems we already rely on. The case studies in this chapter show that AI is no longer a distant promise but a practical instrument delivering measurable impact across grids, transport networks, data centres, industrial operations and investment portfolios. From Google and CTC Global's GridVista platform enabling real-time dynamic line rating, to Centre for Net Zero's AI-managed EV charging trial cutting peak loads by 42%, to Emerald AI and NVIDIA demonstrating 40% demand reduction in data centres, AI is already strengthening resilience and reducing the need for costly new infrastructure. In industry, Covestro's use of AI-driven operational intelligence has delivered double-digit reductions in energy use and emissions, while the HyChain hydrogen platform is expanding access to complex supply chain planning for SMEs and regional authorities.

Together, these examples illustrate a clear pattern:

- AI helps energy and industrial systems become smarter, more flexible and more efficient, enabling emissions reductions and cost savings long before new physical assets come online.

- By embedding AI-driven intelligence into grid operations, urban mobility, data-centre management and industrial production, we can accelerate climate progress while improving reliability and affordability.

- Building smarter, not simply bigger, is emerging as one of the most powerful and immediate pathways to a resilient, low carbon future.

Footnotes

[1] https://www.businesswire.com/news/home/20250617507388/en/Google-and-CTC-Global-Announce-Initiative-to-Expand-American-Electric-Grid-and-Transmission-Capacity-U.S.-Supply-Chain-with-Advanced-Conductors

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[3] https://www.centrefornetzero.org/papers/ai-in-charge-large-scale-experimental-evidence-on-electric-vehicle-charging-demand

[4] https://www.centrefornetzero.org/papers/ai-in-charge-large-scale-experimental-evidence-on-electric-vehicle-charging-demand

[5] https://www.iea.org/data-and-statistics/data-tools/energy-and-ai-observatory?tab=AI+for+energy&casestudy=AI-powered+wind+speed+forecasting

[6] https://x.company/case-study/tapestry-cen/

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[10] https://optimise-ai.com/en/case-studies/scotrail-train-station

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[13] https://download.schneider-electric.com/files?p_Doc_Ref=998-24218600&utm_source=web_notification&utm_medium=push_notification&utm_campaign=qmul&utm_content=press-release&utm_tactic=read-more&utm_id=qmul&campaign_objective=awareness&mcl_name=edc

14 https://www.engie-deutschland.de/en/press/engie-and-google-extend-their-partnership-247-carbon-free-energy-germany

[15] https://www.vyzrd.com/

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[17] https://qgemsprism.uk/

PART FOUR:

Conclusion: AI's opportunity is grounded in evidence

The evidence and insight presented across this report demonstrates that artificial intelligence is becoming a defining force in the global energy transition.

- **Part 1** set out the scale of the challenge: rising electricity demand from AI infrastructure and elsewhere, constrained grids, governance gaps, amid growing public concern as cases for policy change.

- **Part 2** showed that AI can have major net positive impacts on the greening of the energy system and accelerate decarbonisation across every sector of the economy.

- Yet it is in **Section 3**—through real-world case studies—that the full picture comes into focus. Here, applied AI at work is having practical impact, delivering measurable emissions reductions, operational efficiencies and system-level optimisation and pointing to even greater potential for net positive outcomes. We are grateful to the CAC partner companies and organisations for their contributions.

Across global energy systems, AI is already reshaping how infrastructure is planned, operated and maintained. Projects such as CTC Global, show how real-time sensor intelligence and dynamic line rating can unlock additional grid capacity without the need for costly new transmission lines. In Chile, the government's collaboration with Google DeepMind and Tapestry demonstrates how advanced forecasting models can improve wind generation accuracy by 15%, reducing waste of clean energy and strengthening system reliability. These examples and others illustrate a broader trend: AI is enabling grids to operate more efficiently and with greater resilience, supporting the rapid expansion of renewable energy.

AI is also transforming how consumers interact with the energy system. An EV charging trial led by the Centre for Net Zero and King Climate Action Initiative provides a clear demonstration of how AI can align consumer behaviour with system needs. For energy intensive sectors, the AI Grid project with Emerald AI, NVIDIA and National Grid shows how real-time demand response in data centres can cut load by up to 40%, which at scale has the potential to unlock as much as 2 GW of flexible capacity—equivalent to several large power stations.

For transport and city mobility, AI is delivering tangible emissions reductions in areas such as traffic control. ScotRail's AI-powered digital-twin programme is used for real-time net-zero planning and operational optimisation across Scotland's railway system.

Industry and manufacturing benefit from AI-enabled intelligence. AVEVA and Covestro's collaboration demonstrates how operations can reduce carbon and energy use while improving productivity.

All infrastructure project developments begin with investment, and AI is reshaping how organisations plan and prioritise capital deployment for energy transition projects through analysis of climate risk, infrastructure needs and decarbonisation pathways at scale.

Across these diverse examples, a consistent pattern emerges. AI is helping organisations move from incremental improvements to system level transformation. In energy, transport, industry and digital infrastructure the move from a paradigm of "building more" to one of "building smarter and extending existing asset operational life" is being informed by AI. This shift is essential for accelerating progress toward Net Zero while delivering long-term economic value.

The case studies highlight how AI's benefits are greatest when openness and transparency on challenges, limitations and potential for clean power and reduced emissions deliver public value.

The central message of this report is therefore one of opportunity grounded in evidence. AI is not a panacea, but the evidence is it can deliver meaningful climate impact today and in the future. The journey requires bold policy discussions that lead to the reframing of proposals, protocols and regulations to drive net carbon positive and efficiency actions. The challenge now is to scale these successes responsibly and ensure that AI's growth is aligned with national, regional and global climate goals.

It is the policy environment over the coming decade that will determine the balance between AI as a driver of climate progress or a source of additional strain. The studies in this report show that the tools, technologies and approaches needed for AI to support Net Zero already exist. The task ahead is to embed them across the economy, guided by clear governance, strong public engagement and collaboration on policies driven by a shared commitment to building cleaner, smarter and more resilient energy systems.

Appendix

Roundtable I: AI grids and clean power systems
Speakers:
- Lucy Yu, UK Government AI Champion for Clean Energy
- Chris Cheetham-West, Director for AI, Department for Energy Security & Net Zero

Roundtable II: Industry and Manufacturing
Speakers:
- Lord Nicholas Stern
- Dominic Waughrey, Executive Vice-President, World Business Council for Sustainable Development
- Sophie Miremadi, Vice-President, Government Affairs, AVEVA

Roundtable III: Buildings and Transport
Speakers:
- Daniel Scott, Chief Data Scientist, WSP
- Martha Tsigkari, Senior Partner and Head of Applied Research and Development, Foster+Partners
- Dr Haitao He, Director, Transport AI Innovation Centre

Roundtable IV: International Collaboration and Standards
Speakers:
- Bjorn-Soren Gigler, Senior Digital and Green Transformation Specialist (SNE), European Commission
- Robin Zuercher, Programme Lead, Green Digital Action, International Telecommunications Union

Roundtable V: Data Centres and AI Infrastructure
Speakers:
- Gallig Renaud, Fellow, Emerging Tech Incubation, AVEVA Chief Technologist Organisation
- Peter Templeton, US Green Buildings Council; Greening AI Data Centres Coalition
- Josh Parker, Head of Sustainability, NVIDIA
- James Fisher, Head of Strategic Partnerships, BRE Group

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