QUILTER CHEVIOT

RESPONSIBLE INVESTMENT

Greening algorithms:

Artificial Intelligence and emissions

Across Quilter we have identified three thematic engagement priorities. This is part of our climate change theme.

Climate Change is the defining issue of our time and we are at a pivotal moment. From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly.

SDG Alignment

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

15 LIFE ON LAND

> *"AI's impact on carbon emissions is a complex issue, with AI both contributing to and potentially mitigating climate change."*
>
> AI overview, Google

Introduction

The world is set to exceed the target global temperature increase of 1.5°C above pre-industrial levels outlined in the 2015 Paris Climate Agreement. In this context, the acceleration of artificial intelligence (AI) use and ensuing data centre growth has raised further concerns over climate action. Over 100 countries (plus the European Union) have committed to achieving net zero emissions. Understanding the implications of AI proliferation is essential.

From a shareholder perspective, some companies pivotal to AI expansion, particularly cloud hyperscalers[1] like Amazon, Alphabet, and Microsoft, have set ambitious decarbonisation plans. For example, Microsoft aims to be carbon negative by 2030, and Alphabet targets net zero emissions across all operations and value-chain by 2030. These goals are challenged by the energy demands of AI transformation.

While not all data centre activity is AI related, running complex AI workloads like large language models (LLMs) used in generative AI applications is energy-intensive, impacting both server equipment power and cooling requirements. AI solutions' increased complexity raises the power needs for manufacturing the smaller, intricate semiconductors used in servers and produced by companies like TSMC. Emissions from data centres are already estimated at around 3% of the global total, comparable to those from the aviation industry. The energy requirements to train and use AI models are not equal, some specific models like Intel's TinyBERT, which retrieves answers from text, consumes a

1 i.e. a large cloud service provider

relatively small amount of power — about 0.06 watt-hours per 1,000 queries (equivalent to running an LED bulb for 20 seconds). At the opposite end of the scale, large language models such as OpenAI's GPT-4 or DeepSeek, need thousands of times more energy for a similar query. The result has been compared to turning on stadium floodlights to look for your keys. As generative AI solutions develop it is likely that more specific task-based models develop for customised needs.

Understanding AI's net impact on emissions is complex. While data centre expansion increases emissions, AI solutions can enable wider economic efficiencies and innovations that reduce emissions. For instance, AI services aid in designing next-generation solar panels, optimising power grid distribution, and reducing the carbon intensity of cement production. By understanding the interplay between technological advancements, regulatory landscapes, and energy demand dynamics, investors can navigate the evolving landscape and capitalise on emerging opportunities.

Our engagement

From a materiality perspective we identified the companies within our centrally monitored universe with the most significant exposure to AI. Companies like Microsoft and Amazon are at the forefront of developments, driving innovation while grappling with the challenges of sustainability. Activities at companies like AMSL, ASMI, TSMC, Infineon and Equinix are also shaping the wider AI ecosystem and its emissions profile, where advances in hardware technology are crucial for addressing AI's energy demands. Companies like these are also exploring AI-optimised cooling, and smarter data centre design and operations to limit AI's energy consumption. This is a nuanced landscape and despite highlighting the above tensions, AI's role in the climate transition is increasingly recognised as a critical driver of growth and innovation. Companies must balance the benefits of providing and using AI solutions with current transition commitments. We engaged the below companies to better understand this topic as well as explore the opportunities and the management of the risks related to the emissions implications of AI service growth. We managed to hold some form of dialogue with all the above companies, apart from Microsoft who did not respond to our request to engage.

What is AI?

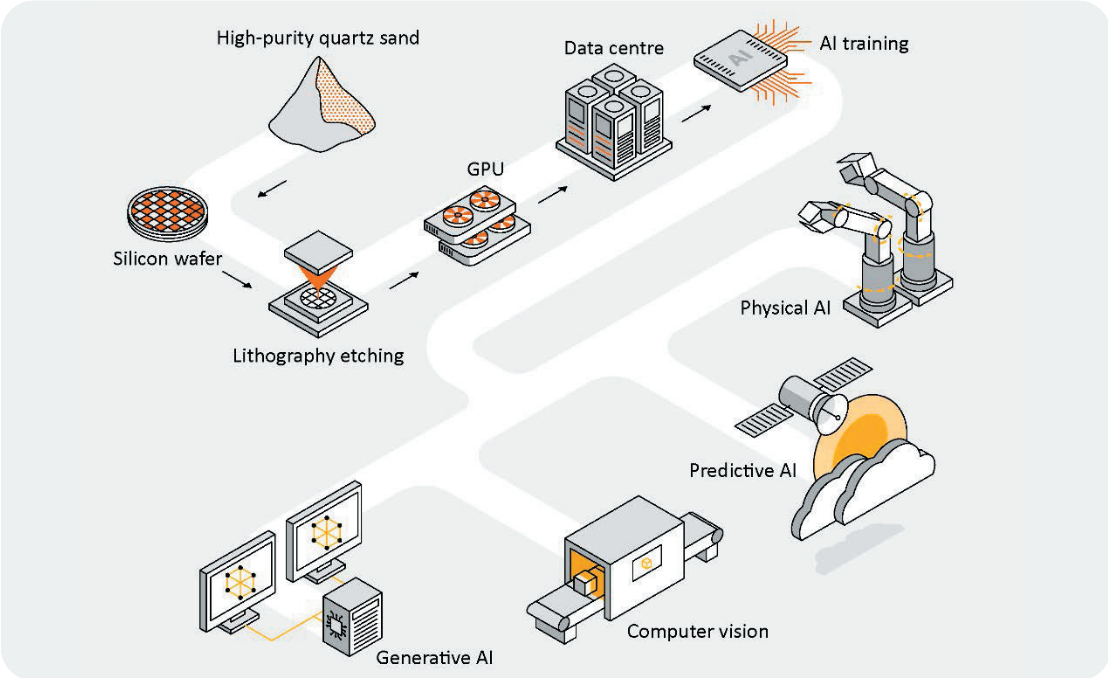
There is no universal definition of artificial intelligence, but it can be broadly defined as the scientific field dedicated to creating machines capable of performing tasks that usually require human intelligence. AI has evolved from traditional computational methods relying on programmed instructions to systems that learn from data to identify patterns, make predictions, and execute actions. These AI systems continually improve through training.

This thematic engagement focuses on the emissions implications of Generative AI expansion, but it is important to note that different AI processes perform a myriad of different tasks and today's AI systems can be classified under the below frequently used terms:

- **Generative AI**: Refers to applications that focus on generating new content, such as text, images, audio, and video using language models (and models using non-text forms).
- **Predictive AI**: Predictive AI employs models to forecast future outcomes. It finds applications in various fields such as scientific modelling, weather forecasting, predictive maintenance of energy infrastructure, and finance.
- **Computer vision**: Enables machines to interpret visual data like images and videos, mimicking human vision. Using deep learning and machine learning, it performs tasks such as object detection, facial recognition, image classification, and interpretation. It is used in self-driving cars, medical imaging, security, and augmented reality.
- **Physical AI**: Systems that interact with the real world, like autonomous cars, robots, and drones. Unlike traditional industrial robots which are programmed to perform single tasks in tightly controlled environments, modern AI systems can learn from their environment and adapt to dynamic and unpredictable situations[2].

2 Energy and AI: IEA Special report,' International Energy Agency, April 2025

IEA AI infrastructure and types of applications (AI is supported by complex supply chains)[3]



Key findings

Grand ambitions

Encouragingly all companies engaged had ambitious climate plans. Throughout the value chain, from semi-conductor equipment manufacturers like ASML to large cloud service providers like Amazon - all had net zero emissions goals, with most targeting a date before 2050 covering all relevant emissions. For example, Amazon's Climate Pledge commits the company to reaching net-zero carbon emissions by 2040 and Equinix, a provider of data centre infrastructure, aims to achieve carbon 'neutrality' by 2030 (a plan validated by the Science Based Target Initiative).

For many companies who are upstream in the AI value chain (particularly semiconductor/ equipment manufacturers) Scope 3 indirect emissions[4] are a material part of the overall picture. We observed some market leading programs from the companies like ASML, ASMI, Siemens and TSMC in attempting to reduce emissions within their supply chains. ASMI echoes others requiring participation in the external Carbon Disclosure Project (CDP) questionnaire program from suppliers, with 88% of critical & strategic suppliers now reporting this data. The company is also partnering with major players in the semiconductor hyperscale space (including Googe and HP) through the Catalyze program. The initiative aims to advance the adoption of renewable electricity throughout the global semiconductor value chain by allowing suppliers and smaller companies to join advance power purchase agreements (usually beyond their resourcing) to stimulate renewable energy demand and decarbonise supply chains. For many AI upstream companies, over 90% of total emissions fall under Scope 3, the accelerated adoption of renewable electricity throughout the value chain emerges as a crucial step forward.

These efforts to take responsibility for indirect emissions and influence the wider supply chain is potentially transformative for overall AI decarbonisation. We have already witnessed the historic power of deliberate procurement policy, when large cloud service companies like Microsoft spearheaded corporate power purchase agreement (PPAs) shortly after the turn of the millennium. These early, but expensive, contracts were vital for renewable energy technologies to reach scale and precipitated a steep cost decline for wind and solar power.

Cloud service providers and data centre infrastructure companies have seen material improvements in terms of data centre efficiency, a key component of the emissions efficiency in providing cloud and AI solutions. In 2024 AWS data centres (Amazon's cloud services business) reported a global 'power use effectiveness' (PUE) measure of 1.15. PUE is a metric that measures how efficiently a data centre uses energy. A PUE score of 1.0 is considered perfect, indicating that all energy used by the facility goes directly to computing. The best performing AWS site was in Europe with a PUE of 1.04[5].

3 Image from 'Energy and AI: IEA Special report,' International Energy Agency, April 2025
4 Scope 3 emissions are all indirect emissions, not included in Scope 2 (emissions from power use), that occur in the value chain. These could be upstream or downstream and those emissions from supplier, customers and other third parties. These are separate from Scope 1 emissions which relate to those emissions from direct operations.
5 Amazon 2023 Sustainability Report

Companies that matter are struggling to meet targets

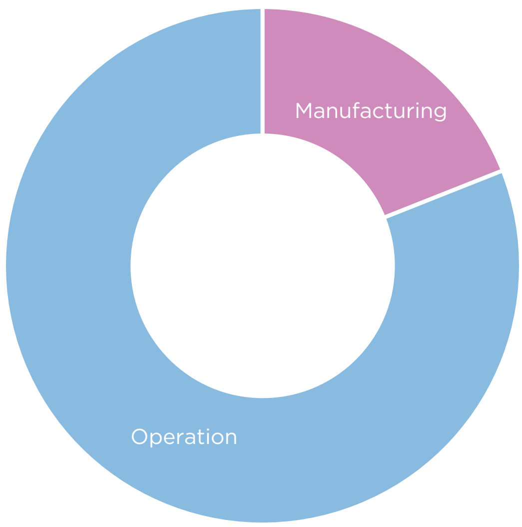
Absolute decarbonisation performance is, however, mixed and highlights the difficulties many the largest providers of AI solutions are facing in expanding business activities but reducing overall emissions. For Amazon, in 2023 (the most recent comprehensive data available), year on year carbon intensity (grams of CO2 per $ sales) was down 13% but since the baseline of 2019 both Scope 1 operational emissions and Scope 3 indirect emissions increased on an absolute basis (by 250% and 30% respectively).

A similar problem is being faced by Microsoft, which experienced a 29% increase in total emissions since 2020[6]. Much of the rise was driven by the construction of new data centres partly prompted by the provision of generative AI solutions. The embedded emissions arise from the carbon in construction materials such as cement, glass, and steel, as well as in hardware components like semiconductors and servers. This build out of data centres (and therefore emissions spike) could be temporary but once the sites are operational, we could see a more permanent increase in direct power related emissions (Scope 2).

For large cloud service providers, data centre infrastructure companies and AI related manufacturers it is worth noting that Scope 2 emissions (related to power consumption) have declined in most cases over the past five years. Many including Equinix and Amazon have already met targets related to low carbon energy consumption. A significant part of climate transition planning has been to match all the electricity consumed by global operations with 100% renewable energy. This has mostly been achieved via renewable energy certificates (RECs) and power purchase agreements (PPAs). RECs are issued by power generators every time they add one megawatt hour of renewable energy to the grid. PPAs are a contractual obligation to buy a certain amount of electricity from a specified renewable energy generator (or specific project). PPAs are typically longer-term (over 10 years) and the guaranteed revenue stream can be critical in underwriting the funding required to expand renewable energy capacity. The evidence supporting 'additionality' of RECs has come into question. Often the prices of certificates are too low and uncertain to influence significant renewable energy investment[7]. This has led criticism that those relying heavily on RECs as a structural part of climate transition plans are overstating emissions reductions, as most RECs may not lead to additional renewable energy or emissions reductions. While PPAs have played a historic role in catalysing renewable power scaling, a reliance of RECs may be artificially reducing emissions tallies.

While upstream companies like ASML, ASMI, Siemens and Infineon are on course to meet ambitious decarbonisation plans, most lifecycle emissions related to AI services are embedded in construction and power demands of the data centres operated by large cloud service companies. For the companies that matter, emissions are travelling in the wrong direction.

Data centre server electricity demand



Manufacturing amounts to less than 20% of total life-cycle electricity demand of data centre servers. The complex semiconductors used for AI solutions require even more energy to power servers. 'Operation' presumes a server lifetime of five years[8].

6 Microsoft 2024 Sustainability Report
7 'Most companies buying RECs aren't actually reducing emissions,' The Conversation, June 2022
8 IEA analysis based on Garcia Bardon, et al. (2021), Boavizta (2021), and Dell (2019)

Hunt for clean energy

A significant portion of the Scope 2 power emissions reductions required by value chain actors like Infineon, ASML and ASMI can be achieved through smaller localised decarbonisation plans. Levers for achieving reductions include decreased use of natural gas consumption through energy efficiency measures (e.g. reusing waste heat from factories for office conditioning), electrifying main industrial locations and increasing solar capacity on premises. For companies providing AI cloud services, data centre infrastructure or even pure-play semiconductor manufacturing (like TSMC) the energy requirements dwarf localised solutions. In 2023 TSMC energy consumption accounted for almost 10% of electricity consumption in Taiwan[9]. For Equinix, a brand-new data centre may require up to 0.5GW of highly reliable power, so rooftop solar or wind turbines will not be adequate.

The power needs for AI hyperscalers are immense and increasingly concentrated among a few key players. By 2029, cloud service providers like AWS, Google, and Microsoft are projected to handle nearly 60% of global data centre capacity, up from around 20% in 2017[10]. Despite ongoing improvements in energy efficiency, the rapid expansion of data centres and power-intensive AI activities is challenging their net zero commitments.

In response, companies like Amazon are taking bold steps to stay on track. In 2024, Amazon invested over $1 billion in three nuclear energy agreements to support new Small Modular Reactors (SMRs). These advanced nuclear reactors have a smaller footprint and quicker build times, making them suited for providing carbon-free energy sooner. Amazon also partnered with Talen Energy to co-locate a data centre next to an existing nuclear facility in Pennsylvania, directly powering it with low-carbon energy and extending the reactor's life.

Microsoft is also investing in the previously obsolete Three Mile Island nuclear power plant, recognizing the importance of utilising existing facilities, especially as electricity grids face increasing strain. In the US, connecting new power generation assets to the grid can take nearly a decade, highlighting the need for innovative solutions.

Question around the additionality of RECs aside, in 2025, Amazon was the largest corporate purchaser of renewable energy for the fifth year in a row. By Q4 2024, the company had supported over 600 wind and solar projects globally, including 40 utility-scale projects. Notably, Amazon targets renewable projects on carbon-intensive grids, significantly impacting emissions reduction. For instance, Amazon's nine utility-scale solar and wind farms in India, a country heavily reliant on fossil fuels, aim to avoid 55 times more carbon emissions annually compared to similar projects in Sweden, which has a highly decarbonised grid. In July 2024, Amazon announced it had achieved 100% renewable energy for its global operations, seven years ahead of its 2030 goal. The tech sector accounted for 92% of new clean energy purchases in the US in 2024[11].

Despite the impressive clean energy investments touted by many technology giants, the reality on the ground is more complex. The actual electricity powering today's sprawling data centres largely comes from national grids still dominated by gas and, to a lesser extent, coal. The unique energy appetite of generative AI—surging unpredictably during training and remaining consistently high during operation—doesn't align well with the variable rhythms of solar and wind. Instead, these demanding systems crave reliable, round-the-clock energy, typically supplied by fossil fuels. As a result, the rapid expansion of data centre infrastructure has sparked not just a race to secure renewable power credits, but also a notable resurgence in gas-fired energy projects designed to keep pace with AI's power needs[12].

9 'Energy and AI: IEA Special report,' International Energy Agency, April 2025
10 'Hyperscale operators and colocation continue to drive huge changes in data center capacity trends', Synergy Research Group
11 'We still don't know how much energy AI consumes,' Financial Times, May 2025
12 'Inside the AI race: can data centres every truly be green?', Financial Times, August 2025

Upstream innovation: supportive ecosystem actors

Within the AI value chain, European companies are showing strong dedication to product innovation aimed at reducing emissions, which also cuts energy costs.

ASML, a semiconductor equipment manufacturer is focused on developing energy-efficient hardware enhancements, such as improvements to the extreme ultraviolet (EUV) lithography systems. EUV lithography enables the printing of the most advanced and small chips. Cheaper, more energy efficient, deep ultraviolet (DUV) lithography systems are the backbone of the semiconductor industry and the majority of ASML sales, but EUV technology will enable the move to smaller 3 nanometre[13] and even 1.6 nanometre semiconductors. EUV technology is often compared to a precision scalpel, capable of carving out the finest features, while DUV can be compared to a skilled artist's brush which is versatile and reliable, but with limitations in creating the smallest details[14]. Despite EUV's higher energy demands, ASML has managed to reduce power consumption of EUV machines by 54% since 2018.

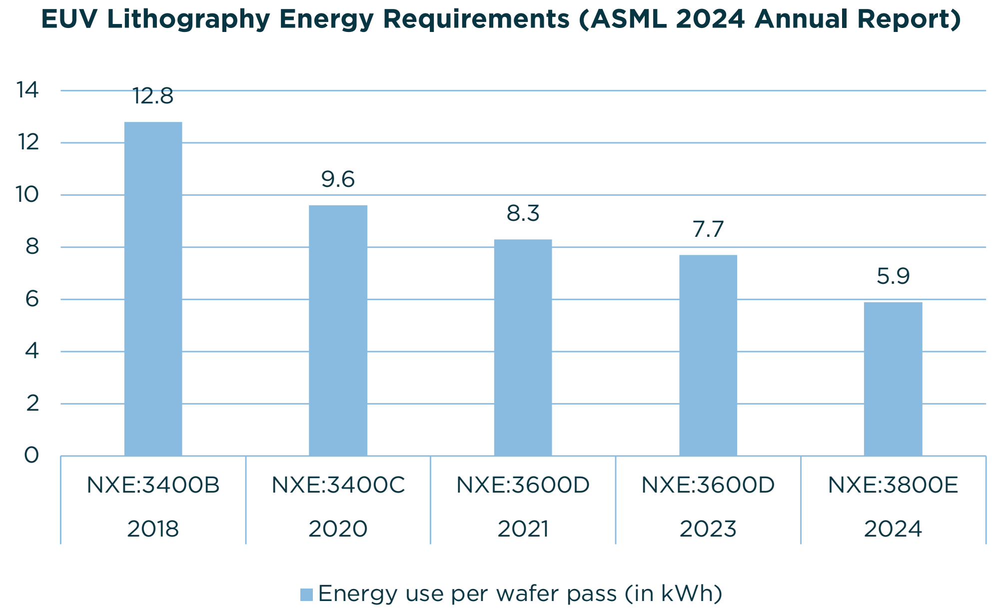


Chart showing the 54% reduction in energy required to run successive models of ASML's EUV lithography machines (essential equipment for manufacturing the most advanced semiconductors used in AI applications).

ASMI designs and manufactures semiconductor wafer processing equipment. The company is a leader in deposition technology and advanced logic foundry. In other words, the processes of adding layers of material onto a semiconductor wafer and making advanced circuits that are crucial to the functioning of AI chips and other advanced computing devices. ASMI is focused on growth areas, such as high-bandwidth memory and AI demand. In summary the company is enabling more energy efficient chips to be produced more energy efficiently. Advanced deposition tools will also be critical enablers of smaller more efficient semiconductors that will play a key role in AI expansion.

Infineon produces power supply units (PSU) for data centres and AI edge hardware, projecting significant revenue growth in these areas. The PSUs improve energy efficiency in data centres, while AI edge solutions localise processing, reducing energy intensity and latency — vital for applications like self-driving vehicles that cannot afford to be hampered by potential delays from cloud-based AI decision making.

Though many of the companies within the AI 'ecosystem' have a limited direct impact on the large energy requirements needed to train and utilise AI models, the focus on energy-efficient product innovation will help reduce overall power consumption. As highlighted above, companies like ASML and ASMI are dedicated to reducing Scope 3 emissions in supply chains and product usage, amplifying decarbonisation in their operations through collaboration.

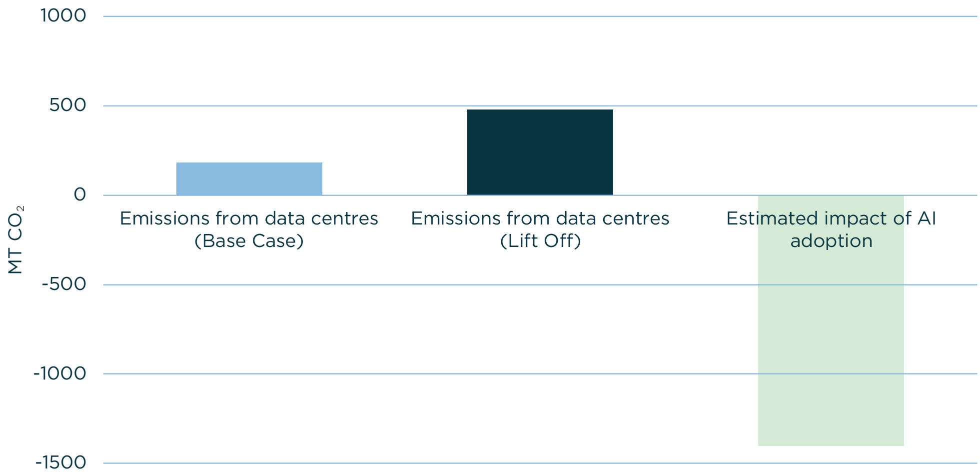
13 A nanometre (nm) is a unit of length in the metric system, equal to one billionth of a metre (0.000000001 metre)
14 www.girolino.com/euv-vs-duv-the-future-of-chip-manufacturing/

Potential emissions savings from AI

Is the expansion of AI negative for hyperscalers' transition plans but positive for the world?

AI applications in the energy sector are being used for a variety of optimisations, many of which will lead to emissions reductions. Examples of use cases include improved methane detection to identify leaks, design assistance for next generation solar panels, optimising fuel mix inputs for cement manufacturers and optimising building energy consumption (i.e. heating, ventilation and air conditioning controls). Google maps, an AI dependent technology, is another good example of a service that has had a significant real world impact in optimising vehicle journeys and reducing associated traffic related emissions. The IEA predicts that widespread adoption of AI technology by 2035 could lead to global emissions reductions that would be three times larger than total data centre emissions (even after accounting for a significant increase in such facilities)[15].

Projections of emissions growth from data centres relative to the emissions savings of AI adoption by 2035



The first two columns of the chart above show the IEA's projected increase in data centre emissions under both a steady expansion (Base Case) and rapid expansion (Lift Off) scenarios. Conversely the third column shows that in the IEA's widespread adoption case, AI impacts could materially improve global emissions trajectories in end-use sectors by 2035. This chart does not include potential 'rebound' effects which could negate some emissions savings. The effects include higher energy consumption as AI related services shift demand away areas like public transport towards higher levels of autonomous car travel.[16]

Under a widespread adoption scenario, large companies should benefit from lower costs by embedding AI into the automation of IT services, call centres and sales functions[17]. On engaging Amazon, we learned that the company commissioned a study by Accenture demonstrating that an effective way to reduce carbon emissions is by moving IT workloads from on-premises infrastructure to AWS data centres. We approach this study with an appropriate level of critical assessment, but the point holds true more broadly for businesses shifting IT and AI workloads. Given the advanced level of energy and cooling optimisation at larger datacentres, the study[18] estimates AWS's infrastructure is up to 4.1 times more efficient than on-premises set-ups, and when workloads are optimised on AWS, the associated carbon footprint can be reduced by up to 99%. On-premises refers to organisations running hardware and software within their own physical space, and 85% of global IT spend by organisations remains on-premises. As AI workloads become more complex and data-intensive, they will require new levels of performance from systems that complete millions of calculations every second, along with memory, storage, and networking infrastructure. This requires energy and has a corresponding carbon footprint.

Most of the companies targeted as part our engagement focused on the scaling of AI, particularly generative AI (using large language models) and data centre expansion. However, the use of AI in industrial applications, as pioneered by

15 'Energy and AI: IEA Special report,' International Energy Agency, April 2025
16 'Energy and AI: IEA Special report,' International Energy Agency, April 2025
17 'What to buy if AI is transformative,' Financial Times, May 2025
18 "Moving onto The AWS Cloud Reduces Carbon Emissions," Accenture

several leading industrial sector companies, is changing the way manufacturing facilities operate, more often using smaller tailored private models. This is in the field of generative AI but also predicative industrial AI applications, demonstrating that while the energy requirements (and implicate emissions) are accumulating in some parts of the economy, in others AI solutions are being used to rapidly improve process efficiency and energy management.

AI solutions are central to Siemens' strategy, with over 2,000 AI engineers and numerous patents. Siemens uses AI to improve predictive maintenance and energy management, such as simulating train performance in extreme environments and developing AI-assisted cooling systems for data centres. The Siemens Industrial Copilot, developed with Microsoft, enables natural language communication with machines, enhancing human-machine interaction. In its Chengdu factory, Siemens has combined predictive maintenance with energy-saving measures, increasing energy efficiency by 25% and achieving site-level net-zero operations for Scope 1 and 2 emissions seven years ahead of target. A digital twin[19] of the facility, created using Siemens NX software, continues to optimise operations. The success of these AI-driven improvements has led Siemens to offer commercial digital twin software solutions.

Summary

We have been impressed by the ambitions and achievements of many companies engaged throughout the AI value chain. In most cases demonstrating the quality and commitment of underlying investee companies. Upstream value chain actors have a strong focus on energy efficient product innovation, inspired by client demand opportunities and internal corporate climate transition plans.

Further downstream, it is increasingly clear that the ambitions of the cloud hyperscalers' climate targets are facing heightened headwinds as demand for cloud-based services grow. This has been exacerbated by the scaling of demand for AI solutions and its implicit increased energy requirements. Accelerated action will be needed to meet the company goals, including more support for low carbon energy procurement that materially reduces emissions, rather than a heavy reliance of renewable energy certificates (RECs). Efforts will need take place at a company level but also require a supportive local and national policy environment where data centres are located. It will be crucial to monitor if emissions remain elevated or retreat as demand stabilises, data centre operations are further optimised, and more meaningful low carbon sources of energy are secured.

It is important to note, that some of the energy investments proposed by large clouds service providers are also speculative. Despite the fanfare given to small modular nuclear reactors (SMRs), none are yet operational. Alphabet recently signed a PPA with a nuclear fusion provider, a technology which is yet unproven. While we welcome the foresight, present challenges demand a focus on today's technology solutions if climate targets are to be achieved.

While company emissions trajectories are under strain and will be monitored by investors, the potentially transformative opportunity should not be ignored. We are seeing companies already using and commercialising AI related products to great effect. Many in both technology and industrial sector applications are being used to optimise energy use and drive down emissions. The aggregate effect could outweigh the impact of a well-managed scaling of data centre expansion. None of this is certain, and all is to play for – but there is a pathway to an elusive 'cake and eat it' scenario.

19 A digital twin is a virtual model that mirrors a physical object, process, or system, using real-time data and simulation to provide insights and predictions.

Next steps

Looking ahead, we are committed to keeping a close watch on how investee companies rise to the challenge of their climate transition plans. Our stewardship process will remain proactive, ensuring that our climate risk management expectations are clearly communicated.

As artificial intelligence continues its rapid ascent, our focus will broaden beyond efficiency and emissions to embrace the complex ethical landscape that surrounds AI. With these technologies becoming ever more embedded in commercial and industrial processes, questions of ethics, transparency, and accountability have never been more pressing. We plan to actively engage with companies to better understand—and shape—how they navigate the twin challenges and opportunities brought by AI.

In the coming year, we will launch a new thematic engagement initiative, delving into the critical issues of AI bias, fairness, privacy, and transparency. Companies should pursue innovation that not only drives progress but also earns the trust of stakeholders and the broader public. With thoughtful collaboration and vigilant oversight, we believe this era of AI can become a catalyst for both business success and positive societal impact.

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