Google

March 2025

The AI Opportunity for Europe's Climate Goals - a Policy Roadmap

Executive Summary

Artificial intelligence (AI) tools can help create a competitive, prosperous, and sustainable future for Europe. Studies estimate that AI could help mitigate 5–10% of global greenhouse gas (GHG) emissions by 2030[1] - equivalent to the total annual emissions of the European Union - while generative AI alone could add €1.2 trillion to Europe's economy in ten years and boost annual productivity by up to 1.4%[2]. Accelerated AI adoption under the EU's 2024-2029 mandate can play a key role in fast-tracking progress toward its 2050 climate-neutrality goal while increasing competitiveness, resilience and security – key priorities in its new Strategic Agenda.

Google operates 7 data centres and 12 cloud regions across Europe, and has signed agreements to purchase more than 3.7 gigawatts of clean energy generation capacity[3]. We are also pursuing a bold goal to reach net-zero emissions across our operations and value chain by 2030, supported by a goal to run on 24/7 carbon-free energy (CFE) every hour of every day on every grid where we operate.

Building on Google's EU AI Opportunity Agenda (2024) and the joint BCG-Google report on Accelerating Climate Action with AI (2023), this white paper lays out potential actions that European leaders could pursue to harness AI to meet the EU's climate and competitiveness goals. These actions fall within three key pillars:

1 Enable AI for Climate

Policymakers can lay the critical foundations to enable uptake of AI to meet EU climate goals, including enabling high-quality data, investing in technology infrastructure, and cultivating talent.

2 Deploy AI for Climate

Policymakers can use AI to define and deliver on public sector climate and societal priorities, and encourage the uptake of AI solutions by the private sector to do the same.

3 Guide AI for Climate

Policymakers can guide sustainable deployment of AI by evolving electricity markets and driving infrastructure decarbonisation and AI transparency.

Enabling AI

To achieve adoption of AI solutions that can accelerate climate action across industry and the public sector, EU policymakers must first establish a fundamental enabling framework that fosters the general uptake of AI solutions focused on:

1. Making technology infrastructure accessible and affordable: Technology to analyse and interpret the physical world is essential to creating the digital inputs that power AI solutions, while compute and connective infrastructure like data centres and network cables are the physical backbone upon which digital solutions are built. To foster digitalisation of climate-related data, the EU can improve access to funding for data collection devices such as smart meters and drones for use in emissions-intensive sectors. To broaden availability of digital infrastructure for AI-for-climate solutions, the EU can adopt targeted measures like voucher schemes providing financial support to help SMEs access high-speed broadband services, and fibre industry standards to increase the uptake of high-speed connectivity in EU Member States. It can also improve electricity grid infrastructure and planning to create a favourable environment for data centre development.

2. Increasing availability of high-quality datasets in climate-relevant sectors: AI solutions rely on data inputs in order to be effective. Datasets that are incomplete, unavailable, fragmented, or lack interoperability can inhibit the development of AI solutions requiring these sources of information. The EU can address this by adopting measures that encourage the interoperability of devices within climate-relevant sectors like transportation, electricity, industry, and agriculture, while taking privacy and cybersecurity into account. Further, the EU can leverage the European Data Governance Board to promote the publication of climate-related datasets, such as from the energy labels of national housing stock or on parking demand gathered by municipal authorities, to enable AI providers to build climate action solutions using this public data.

3. Cultivating awareness and building expertise: Abundant data and infrastructure will be inconsequential without human talent capable of building, deploying, interpreting, and adapting AI solutions to further the EU's sustainability goals. The EU can foster AI skills development in the public sector by developing specialised training programs for public officials (similar to AI4GOV), for example training on AI solutions to enable climate-resilient public infrastructure planning. For the private sector, upskilling and reskilling programs that integrate AI and sustainability, such as a European Academy for Skills for the Clean Economy, could offer training programmes that blend AI skilling with learning focused on key climate-relevant sectors like energy, agriculture, transportation, and others.

Deploying AI

Policymakers can also focus on encouraging deployment of solutions that support the EU's climate goals. They can support integration of AI into the planning and operation of public services for both mitigation and adaptation, and ease barriers to deployment in the private sector, particularly in four sectors that have the greatest potential for AI-powered emissions reduction: energy, industry, transportation, and agriculture.

1. Defining and delivering on public sector climate priorities: The EU and its Member States can harness the power of AI to measure environmental changes and track progress towards environmental goals. In addition, the forthcoming EU Climate Adaptation Plan is an opportunity to establish an EU strategy for empowering civil protection authorities to harness digital technology for flood risk management and other forms of crisis response.

2. Encouraging private sector adoption of AI solutions: The EU can accelerate private sector deployment of AI solutions to achieve decarbonisation while enhancing competitiveness in four key sectors:

   A. In the *energy sector*, entities overseeing European electric grid operations can adapt guidelines for managing grid congestion to include use of AI solutions. The Commission can utilise the upcoming Strategic Roadmap for Digitalisation and AI in the energy sector to encourage use of AI to integrate distributed energy resources and battery storage, improve demand forecasting, and enable demand response measures. The Commission can develop recommendations to fully leverage AI to meet the provisions of the Energy Performance of Buildings Directive.

   B. To accelerate *industrial decarbonisation*, the European Commission and Member States can consider prioritising, in the context of the Clean Industrial Deal, R&D initiatives focused on AI applications for industrial process decarbonisation, and establish regulatory sandboxes to encourage experimentation and innovation in AI technologies for industrial applications.

   C. In the *transport sector*, the European Commission could establish a new Roadmap on AI for Transport that could outline strategies and timelines to integrate AI into the sector, including initiatives to promote R&D, incentivise investment in AI-driven technologies, and support workforce upskilling. In the aviation sector, the European Commission, in partnership with the International Civil Aviation Organisation (ICAO), could develop common guidelines for comprehensive contrail monitoring at a global level.

   D. The *agriculture sector* can benefit from dedicated funding streams supporting R&D that can develop and deploy AI-enabled solutions for crop monitoring, pest control, harvesting robotics, food distribution, inventory management and shelf-life monitoring, weather forecasting, and waste reduction, amongst other opportunities.

Guiding AI

Policymakers can help guide the sustainable and responsible deployment of AI-powered solutions and infrastructure to boost AI's beneficial impacts while mitigating any potential risks, by focusing on two key areas:

1. Enabling data centre decarbonisation and AI transparency: To encourage and support decarbonisation, the upcoming EU sustainability rating scheme for data centres could incentivise best-practices in sustainability, including adoption of hourly, local carbon-free energy matching. The EU could also develop frameworks for electricity demand response that accommodate the operational constraints of data centres, and simplify permitting processes to encourage data centres to recover and utilise waste heat where technically or economically feasible. The development of methodologies and standards is also important in order to accurately measure the energy impact of AI models.

2. Evolving electricity market mechanisms to enable growth of carbon-free energy: The Clean Industrial Deal and Electrification Action Plan can provide the momentum to further decarbonise Europe's energy systems, supporting the deployment of carbon-free electricity across Member States. Electricity market mechanisms under the Electricity Market Design can be updated to incentivise the development of more firm and flexible carbon-free resources, such as advanced geothermal, long-duration energy storage, and next-generation nuclear. It is also crucial to stimulate investments in the next generation of clean energy technologies by streamlining permitting processes and incentivising procurement. Lastly, the electricity market design should enable market instruments such as 24/7 carbon-free Power Purchase Agreements and granular Guarantees of Origin, which enable the matching of produced carbon-free electricity to demand on an hourly basis.

At Google, we look forward to partnering with the EU to take full advantage of the opportunity AI offers, delivering the twin green and digital transitions that the EU has committed to.

02 Introduction

The European Commission has identified competitiveness and prosperity as key strategic priorities for the next five years. AI can be a powerful tool for meeting these objectives and advancing EU climate objectives.

The EU is taking extensive action to decarbonise. It has committed to climate neutrality by 2050, with an interim target of reducing net greenhouse gas (GHG) emissions by at least 55% compared to 1990 levels by 2030, and 90% by 2040. While GHG emissions have been steadily declining since the 1990s, the EU intends to pick up the pace to meet its 2030 target and increase its focus on sectors where the required emission reductions are significant (e.g. buildings and transport)[4].

The EU also recognises decarbonisation as an opportunity for growth, as articulated in both Ursula von der Leyen's political guidelines for 2024-2029 and Mario Draghi's 2024 report on the future of European competitiveness. The Clean Industrial Deal presents a further opportunity to build on the EU Green Deal and decarbonise industry, while driving prosperity and competitiveness.

AI-powered solutions can help the EU deliver climate mitigation and adaptation that is commensurate with the scale and speed required to meet its climate goals. Indeed, studies estimate that AI can help mitigate 5–10% of GHG emissions by 2030 - the equivalent of the total annual emissions of the European Union.

AI excels at computational tasks crucial for unlocking climate action:

- Information: AI tools can analyse vast datasets, providing valuable insights that help inform decisions. For example, AI can help identify investment opportunities in clean energy and energy efficiency, as well as the accurate tracking of progress towards climate goals.

- Prediction: AI tools can significantly improve climate forecasting models, enabling better preparation for extreme weather events and derisking investments that will improve climate resilience.

- Optimisation: AI tools can optimise to find incremental gains across complex systems like energy grids, logistics networks and industrial processes, leading to substantial cost savings and reductions in GHG emissions.

Innovative AI solutions are already playing a key role in many governmental mitigation, adaptation and resilience strategies, from enhancing energy efficiency, to accelerating the rollout of renewables, decarbonising industries and facilitating responses to climate-related disasters. However, only part of AI's potential is yet deployed.

What are the levers the EU can pull to ensure that AI solutions are deployed at the speed and scale required to meet EU climate goals? To unlock the full potential of AI for climate action and prosperity, policymakers should create a balanced and supportive policy framework that fosters and encourages responsible AI innovation while mitigating its potential risks.

Enable, Deploy, Guide

Building on Google's EU AI Opportunity Agenda (2024) and the joint BCG-Google report on Accelerating Climate Action with AI (2023), this white paper lays out potential actions that European leaders could pursue to harness AI for climate. These actions fall within three key pillars:

- Enable – policymakers can lay the critical foundations to enable uptake of AI to meet EU climate goals, including enabling high-quality data, investing in technology infrastructure, and cultivating talent.

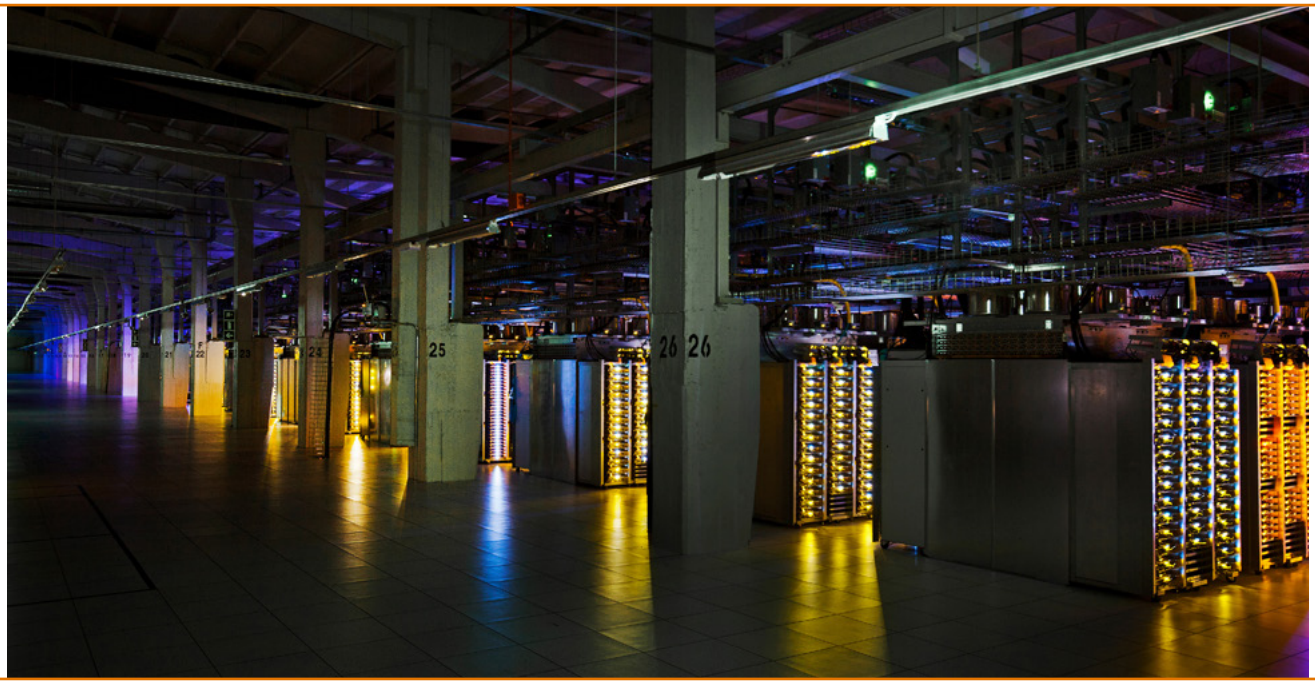
- Deploy – policymakers can use AI to define and deliver on public sector climate and societal priorities, and encourage the uptake of AI solutions by the private sector to do the same.

- Guide – policymakers can guide sustainable deployment of AI by evolving electricity markets and driving data centre decarbonisation and AI transparency

Methodology

Google developed this paper, with support from FTI consulting, by benchmarking the EU's progress to date on its Digital Decade targets and European Green Deal initiatives. We then conducted targeted interviews and roundtable discussions with industry and policy experts to inform each recommendation. Thank you to everyone who supported this process[5].

03 Enabling AI for Climate in the EU



Europe is well placed to seize the opportunities of the data economy and maximise the potential of AI solutions to deliver on its rapid decarbonisation goals while delivering much needed productivity and growth.

This section outlines and analyses the three critical inputs that AI needs to develop, scale and be at its most effective in pursuit of these goals:

1. Technology access and affordability
2. High-quality data collection
3. Capacity development

3.1 Making Technology Infrastructure Accessible and Affordable

The EU Council has articulated the ambition that the EU should become "a prime location for the development of AI"[6].

Like any emerging technology, AI needs the right physical and organisational systems and foundations in place to fulfil its potential. Europe must therefore develop this infrastructure, working closely with industry to make it both accessible and affordable. A solid technology infrastructure for AI requires three components:

1. Data collection devices, including satellites, smart devices and drones
2. Connectivity infrastructure, including fibre cables and 5G networks
3. Computing infrastructure, such as data centres and the cloud.

1. Data Collection Devices

The EU has made significant investments into the continent's technological infrastructure to facilitate the twin green and digital transitions. Several of these investments aim specifically to improve the collection of geospatial data through satellites and other data collection devices. For example, the European Space Agency's Climate Change Initiative (CCI) offers consistent, decades-long satellite data records of climate variables to more than 500 researchers and climate modellers across Europe. The CCI is complemented by the Copernicus satellites, which collect global environmental data and Earth observations from ground-based, airborne and seaborne measurement systems, and make the findings freely accessible to users.

EU satellite geospatial data has enabled several AI-powered climate solutions. Google uses data from the Sentinel 2 satellites for its wildfire detection and tracking tools. Project Contrails, again from Google, uses METEOSAT data to optimise airplane flight paths to reduce contrails[7].

The EU is also investing in the rollout of smart meters through policy initiatives such as the EU Electricity Directive and the 'Clean Energy for all Europeans' package.

However, despite admirable progress, uptake of digitalisation devices has been inconsistent. For example, smart meter deployment has reached 100% coverage in Spain, Sweden and Finland, while others lag behind. Similarly, the sluggish adoption of smart devices in farming for example, such as soil moisture sensors that automate irrigation, has led to a lack of high-resolution agricultural data.

Policy Recommendation

Improve access to funding for data collection devices in emissions-intensive sectors and to enable adaptation responses

The Clean Industrial Deal presents a pivotal moment to accelerate the widespread adoption of data collection devices across energy, mobility, industry and agriculture. The EU could leverage the deal to communicate the potential efficiency gains and environmental benefits derived from deploying smart devices, alongside providing targeted guidance for their use.

The EU could also provide clear information about funding opportunities. Many entities that would benefit from the implementation of data collection devices, including Member States and companies, are missing out on existing funding opportunities because they are unaware of eligibility criteria. Instruments like the European Regional Development Fund and Cohesion Fund often serve multiple purposes, which means stakeholders are not always aware of the specific interventions they can be activated for. By streamlining information and providing clear guidance about the available funding instruments for devices like smart meters and agricultural sensors and space-related research, the EU can improve access and accelerate deployment.

Google Earth Engine: a Planetary Scale Platform for Earth Science Data and Analysis

Google Earth Engine (GEE) is an AI-powered initiative that leverages high-quality datasets, such as those provided by the Copernicus satellites, for climate action. GEE can analyse complex datasets to monitor deforestation, assess renewable energy potential, and track other environmental factors. It combines a vast catalogue of satellite imagery and geospatial datasets with planetary-scale analysis capabilities, managing ready-to-use scientific datasets that are frequently updated. Scientists, researchers, and commercial organisations use GEE to advance scientific research and deliver on their sustainability commitments.

2. Connectivity Infrastructure

The EU is well on its way to cutting-edge digital network infrastructure – a key to 'exploiting the untapped potential of data'[8] for climate-relevant sectors and beyond. Deployment of both gigabit fixed connectivity[9] (over 78% of EU households) and 5G (over 89% of EU households) is progressing well, according to the European Commission's latest 'Broadband Coverage in Europe' report.

Many individual Member States have also set out national plans to improve their connectivity infrastructure.

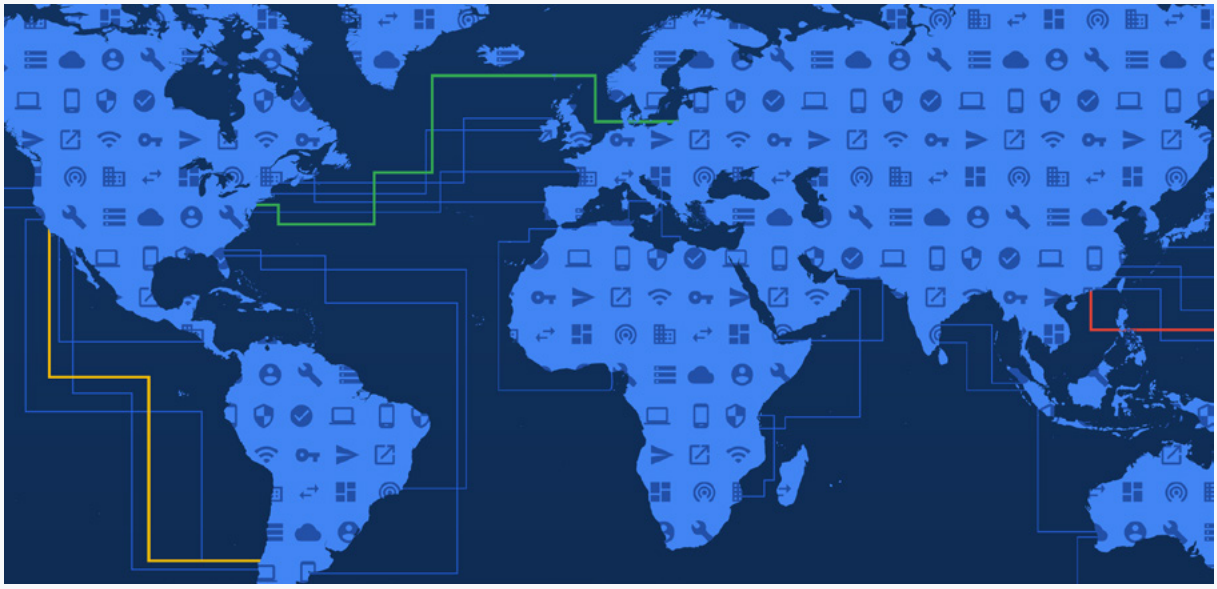
- Germany wants to triple fibre-optic connections by 2026
- France has adopted plans to expand 5G coverage
- Spain is planning to improve network coverage, access to essential services and territorial cohesion

However, disparities remain. Regions with challenging terrains often experience insufficient and/or expensive connectivity, with some communities lacking even basic services. Significant private and public funds are already earmarked to help support these underserved regions, and emerging technologies, such as wireless optical and satellite, are also becoming much faster and more affordable.

Consumers and businesses are also lagging in their adoption of the fast connectivity available to them. This is a fundamental problem for Europe, delaying the necessary digital transformation that will unlock climate action and the resulting long-term economic growth and global competitiveness impact.

Nuvem Subsea Cable Will Improve Connectivity Around the World

Expected to enter service in 2026, the Nuvem subsea cable will connect Portugal, Bermuda and the US, making transatlantic data transfer much faster and more reliable. The cable will provide the bandwidth and low latency that is required for data-heavy technologies like AI to function smoothly.



Policy Recommendation

Adopt targeted measures like voucher schemes and fibre industry standards to increase the uptake of high-speed connectivity in EU Member States

Policymakers can implement an array of complementary policy measures to help, some of which are already in use. These include, for example, voucher schemes providing financial support to help SMEs access high-speed broadband services, or industry standards on terminology for fibre.

Diversity of infrastructure will also boost the EU's overall connectivity. Technologies like satellite and optical wireless can work alongside fibre and 5G to improve connectivity across regions, while submarine cables can upgrade international connectivity. Incentivising private investments in EU Member States can also help to stimulate infrastructure roll-out in lagging regions and expedite new 5G (and eventually 6G) use cases, based on advanced connectivity solutions.

3. Computing Infrastructure

Cloud computing services have become even more indispensable to the digitalisation of government operations and citizen services. The cloud, alongside being critical to the development of AI-led climate solutions, is an enabler of economic growth, modernisation and climate action in the EU and its Member States. Data centres, which host cloud services, enable businesses and the public sector to significantly improve the energy efficiency of their information technology.

One fundamental challenge is a lack of infrastructural investment. Looking across the Atlantic, the investment gap in information and communications technology (ICT) and cloud-related services between the EU and the US totals some 1.28 trillion EUR.

Despite the critical role of data centres in enabling AI and other advanced technology solutions, the framework conditions needed to enable the timely and responsible development and connection of the required data centre capacity are not in place in all EU markets. For example, challenges with how electricity network operators manage grid connection queues are delaying data centre connections in some Member States, while rules for how capacity on the grid is reserved are often not suited to the unique development model of data centres. Alongside this, there is significant EU-wide variance in the rules governing the development, connection and operation of data centres, resulting in a highly fragmented regulatory environment.

In addition to this fractured landscape, insufficient access to reliable power grids and clean energy sources hampers the ability of data centres to connect in a timely fashion and minimise operational emissions.

Policy Recommendation

Improve and harmonise framework conditions to incentivise the development of compute infrastructure, including policies related to infrastructure planning and energy supply

Data centres are the backbone of the digital age. Member States should identify opportunities to improve the framework conditions to enable investment in and development of data centres within their territory. These improvements should ensure:

- Sufficient investment in electricity grids, plus a regulatory framework for system operators that incentivises them to maximise the potential of the existing network.
- That capacity reservation and connection rules for industrial electricity consumers are suited to the growth model of data centres.[10]
- And that regulated electricity charges are cost-reflective and balanced, protecting the competitiveness of electro-intensive industries.

Policy Recommendation

Improve integration of data centres into energy planning processes

Data centres are increasingly recognised in high-level energy planning documents, both for climate and energy systems (e.g. some National Energy and Climate Plans) and energy infrastructure (e.g. ENTSO-E Ten Year Development Plan). However, better integration of data centres into energy planning processes, as well as in national planning frameworks, could reduce the timelines and costs of developing this vital infrastructure. Better planning helps ensure that supporting infrastructure, like electricity networks, are developed with the most up to date outlooks for data centre capacity needs.

The full implementation of data transparency provisions under the Electricity Market Directive and the Grid Action Plan, and in particular the publication of grid hosting capacity maps by grid operators would enable both electricity producers and consumers to make informed decisions on installation locations, potentially expediting clean technology deployment and reducing the burden on system operators (both Transmission System Operators and Distribution System Operators). Furthermore, this transparency could optimise grid usage by facilitating connections where capacity exists and highlighting areas where solutions are needed.

3.2 Increasing Availability of High-Quality Datasets in Climate-Relevant Sectors

As articulated by Ursula von der Leyen in her political guidelines for 2024-2029, access to data drives competitiveness, accounting for almost 4% of EU GDP, and is key to decarbonisation, productivity and societal innovations.

Access to high-quality datasets is essential to maximise the effectiveness and reliability of AI-based interventions. In general, high-quality datasets are comprehensive, representative, redundancy-free and easily accessible while taking cybersecurity and privacy considerations into account. Consistent and reliable access to high-quality datasets makes training new AI models much more efficient. In its European Data Strategy, the European Commission refers to data as the "lifeblood of economic development", showcasing how it can drive sustainable development and achieve the objectives of the European Green Deal.

Since the adoption of the European Data Strategy, the EU has introduced several cross-sectoral initiatives in pursuit of a secure single market for data, capable of boosting growth and creating value, while minimising carbon emissions. The Digital Product Passport (DPP), for example, aims to enhance transparency across product value chains about products' materials and environmental impacts.

In addition, the EU has targeted specific sectors to leverage data to effectively monitor sustainability progress. The EU's Farm Sustainability Data Network Regulation (FSDN) and the Soil Monitoring and Resilience Directive (SMRD) seek to collect comprehensive data on farming practices,

Climate TRACE Emissions Data Helps to Reduce our Global Footprint

Climate TRACE[11] uses AI to monitor power plant emissions from space. Launched in 2019, this non-profit coalition of more than 100 universities, scientists and AI experts analyses data from 300+ satellites and over 11,000 sensors. The result? A free, open and accessible inventory of global GHG emissions.

environmental impacts and social factors to encourage sustainable soil management and green farming.

Encouraging data collection, sharing and accessibility are all key to reaching the availability, coverage and granularity of data that will turn it into the 'lifeblood of economic development'.

1. Data Fragmentation

Despite the EU's strong data sharing framework, the multitude of data collection and data governance provisions across EU and national initiatives leads to fragmented datasets, disconnected data pools and incompatible platforms. While this is a challenge for innovation at large, it is particularly problematic for specialised climate data, where a lack of standardisation further challenges the capacity to leverage AI's full potential.

Fragmented datasets further limit the ability to develop AI solutions. For example, power production data is usually siloed with individual operators hindering the development of models that could more accurately predict wind and solar power output by leveraging AI-generated weather forecasts. Similarly, datasets required to develop battery optimisation solutions are currently available across various publications. Fragmented datasets also hinder the ability to share data between Member States or with third-countries.

The EU has already taken significant steps to improve data fragmentation in key sectors, most notably through the introduction of Common European Data Spaces, such as the ones for mobility, energy and environment, which aim to address fragmentation across sectors. In addition, the ITS (Intelligent Transport Systems) Directive, sets out a system of National Access Points (or NAPs) to enable better cooperation for the reuse of data across Europe. The Action Plan for the Deployment of Data Spaces in Spain also foresees the development of a sustainable mobility data space.

Policy Recommendation

Develop interoperability standards across data collection devices in climate-relevant sectors and/or short-term incentives to stimulate data sharing and use

To make the most of its existing investments in technological infrastructure, the EU should promote global interoperability standards across devices in the single market. The EU can draw inspiration for these horizontal standards from existing sectoral solutions, such as the rules on interoperability and access to smart metering data. This includes a reference model for Member States, which marks a valuable step towards a more unified and consumer-centric energy market.

The EU may also consider developing these solutions in partnership with industry through GovTech initiatives in the Interoperable Europe Act and similar legislation. Such public-private partnerships will not only enable the Interoperable Europe Community to benefit from the insights of all its members but will help to increase the capacity of public data collection infrastructure, reduce access limitations and ensure affordable access to technology infrastructure.

Policy Recommendation

Adopt and implement common data sharing guidelines and standards for cross-sectoral and international data collection, storage and access

To counter the fragmentation of datasets across the EU and internationally, the EU should implement the recommendations of the JRC report[12] and introduce common guidelines to standardise data collection, storage and access. This will ensure the interoperability of different technologies and coherence between Member States. Adopting common guidelines for the Green Deal Data Space (GDDS) should also ensure its compatibility with the Energy, Mobility and Agriculture Data Spaces (which are also currently under development). However, full technical harmonisation may ensure optimal synergy between the sectoral Data Spaces and other data-related EU initiatives.

Such AI-ready datasets would help stimulate innovation in data science and contribute towards developing sectoral AI solutions in service of sustainability. The upcoming European Data Union Strategy is a key opportunity to advance this objective.

2. Data Accessibility

The European Commission has already taken significant steps to increase data accessibility through the creation of Common European Data Spaces. These aim to facilitate the pooling and sharing of relevant data using common standards and protocols, while simultaneously setting fair, transparent, proportionate and non-discriminatory conditions for data access.

Despite positive steps to encourage better data access, particularly in business-to-business (B2B) and business-to-consumer (B2C) relationships, national security, confidentiality considerations and language barriers may discourage public entities from sharing high-quality datasets with third parties, especially in cross-border situations. For instance, while Copernicus offers valuable data, technical constraints or data sensitivity occasionally result in access limitations. Furthermore, public or private entities might not know the value their data holds because data collection and sharing within a specific sector and the economic rationale to do so might not always be aligned. This can lead to the underutilisation of data with knock-on effects for the broader data economy.

To boost accessibility and fully leverage the potential of AI solutions for climate, the EU can seek to enhance collaboration between AI technology providers and environmental data stakeholders, within the Union and internationally. In particular, the EU should facilitate access to data generated by public entities.

Policy Recommendation

Increase the transparency of datasets generated through national projects

To increase (re)use of publicly collected data by the private sector and other government entities, Member States could publicise or increase the data transparency of national projects, such as from the energy labels of national housing stock or on parking demand gathered by municipal authorities. Leveraging European Data Innovation Board - a multi-stakeholder expert group established under the Data Governance Act - could facilitate and expedite this process, helping Member States proactively identify and share publicly held datasets capable of generating economic, scientific and social value.

A subgroup could be created under the European Data Innovation Board which is open to stakeholders from industry, academia and civil society. The subgroup could also recommend initiatives, including pilot projects and use-case demonstrations, to ensure AI climate applications are tailored to the specific needs of different datasets. It could also seek inspiration from other sectors to support data reusability initiatives (e.g. the EU's flagship '1+ Million Genomes' strategy for clinical data in the healthcare space).

UN Data Commons for the Sustainable Development Goals

The Data Commons[13] is a platform that uses AI to synthesise publicly available information across different datasets and makes data that would otherwise be difficult to understand and interpret accessible to a wide audience. It democratises climate data and raises climate awareness.

Building on the Data Commons, the UN and Google have built the UN Data Commons for the Sustainable Development Goals (SDGs). The tool tracks progress towards the 17 SDGs using various metrics that allows policymakers, NGOs, academics and other interested parties to quickly and easily access, visualise and understand relevant data. The data and insights can in turn be used to develop data-driven strategies that accelerate progress towards the SDGs.

3.3 Cultivating Awareness and Building Expertise

Without human talent capable of building, deploying, interpreting and adapting AI solutions to further the EU's sustainability goals, it will not matter how much data is generated or how much infrastructure is installed across the EU. The right people with the right skills will turn algorithms into action, while anchoring AI in a human-centric approach.

Cultivating this talent begins by spreading awareness of AI's possibilities and risks amongst all stakeholders - public and private sector, civil society and education, media and the general public.

Beyond mere awareness raising, AI technical expertise is also crucial. The European Commission expects approximately 3.5 million new jobs in renewable energy sectors by 2030. At the same time, demand for ICT specialists is expected to double. Cultivating talent with both climate-related experience and AI training will not only help to fill these emerging talent pools, but also ensure climate experts can identify the potential of AI within their field of work, and vice versa. Convergence between these groups will help to break down silos and unlock rewarding synergies.

1. Expanding Capacity Building Initiatives for Public Officials

The public sector has a crucial role to play in stimulating the uptake of AI solutions for sustainability. For this to happen, public officials need to be equipped with the skills to understand how AI works and ways it can address environmental sustainability challenges. Programmes like AI4GOV, which aims to train the next generation of functional public sector specialists in AI, are essential. More initiatives to support public officials to use technology to solve their sustainability challenges would be welcome.

Capacity building initiatives on sustainability and AI must be delivered jointly, training public officials to understand the full spectrum of solutions.

Policy Recommendation

Develop specialised training programmes for public officials in AI for climate action

Hands-on workshops and projects in which officials can experiment with AI tools specifically tailored for climate action can foster a deeper understanding of AI's potential in real-world scenarios and accelerate progress through knowledge-sharing. For example, environmental data and insights powered by AI, such as Google's Environmental Insights Explorer, can help city and regional governments better understand mobility patterns and identify the highest-impact transportation interventions to support their carbon reduction targets.

The European Commission could explore developing and launching such programmes through existing initiatives, such as AI4GOV and other training opportunities. This will enable public officials to collaborate with experts to develop AI-powered solutions for specific climate challenges facing their communities.

2. Expanding Capacity Building Initiatives for Workers

To improve EU competitiveness, Commission President Ursula von der Leyen introduced the first ever Executive Vice President (EVP) for People, Skills and Preparedness. This new role embeds skills into the Commission's institutional structure and is well aligned with Mario Draghi's recommendations. The new Union of Skills will launch several key actions such as a STEM Education Strategic Plan, an Action Plan on Basic Skills, and new large-scale partnerships under the existing Pact for Skills.

Google's AI Opportunity report estimates that 61% of jobs will be augmented by generative AI in the next five years, while 7% will require a more significant change or adaptation to AI. Of the potential GDP gains from AI, €500 billion depends on reskilling and upskilling. We therefore support efforts to develop an AI-ready workforce and accelerate digital skill transformation. Despite the significant focus the EU has placed on developing both green and digital skills throughout the recent mandate, broad awareness and expertise in the use of AI to facilitate climate action is still severely limited.

This is innately connected to the general skills shortages and uneven spread of digital skills across the EU.

The solar sector is a good example: SolarPower Europe finds that while new digital energy technologies require more digital skills from workers, there are clear barriers towards upskilling, including a lack of training materials and certifications, lack of harmonisation, and burdensome administrative procedures.

Besides skill shortages and regional disparities, the EU lacks talent combining digital and climate expertise, crucial for the twin digital and green transitions. Without professionals skilled in both areas, the EU will likely struggle to fully harness the potential of technological solutions like smart grids, predictive maintenance and carbon monitoring tools.

Lastly, the level of awareness and understanding of AI needs to be tailored to the individual and their position within the business, as well as the business itself. For example, executives with a role in management, sustainability, legal compliance or engineering will require a different understanding of AI as it relates to their area of competence. Similarly, a technician employed by a family business, a supply chain manager of a multinational company and a process engineer at a steel mill all require different skills and expertise to benefit from the full potential of AI to make their business more sustainable. To meet these demands, capacity building initiatives need to be relevant, accessible and responsive to the needs across different professions and industries.

Policy Recommendation

Upskill and reskill workers by developing specialised public-private partnership programmes and leverage existing skilling programmes

Closer public-private cooperation is needed to develop a comprehensive offering of training programmes that integrate AI and sustainability. Through this collaborative training, workers can benefit from the accessibility of public education programmes while policymakers benefit from industry expertise in AI and green technologies. While good examples exist, such as the EU-funded Artificial Intelligence Skills Alliance (ARISA) and the AI-Enabled ICT Workforce Consortium, specialised partnerships focused on digital skills for sustainability are needed.

A European Academy for Skills for the Clean Economy could help address this gap. Bringing together the European Commission, leading organisations from the sustainability and digital fields, industry and academia, this Academy could offer training programmes in high-demand skills in key sectors, such as energy, agriculture, biodiversity, transportation and waste management. This would address skills shortages and increase the employability of those enrolled, with an emphasis on adult education and lifelong learning.

To ensure that qualifications obtained through the Academy and partner institutions are recognised across the EU, the Academy could offer micro-credentials[14] for each completed programme, based on the European Credit Transfer and Accumulation System (ECTS). The Academy could be realised via its inclusion in a Quality Jobs Roadmap (or other strategies) to improve the uptake of skills in the Union. It could also be piloted through existing initiatives such as the European Net-Zero Academies' framework governance mechanism under the Net-Zero Industry Act (NZIA).

To make existing skilling programmes more accessible, the number and capacity of Erasmus Mundus graduate programmes that focus on green AI could be expanded. Increasing available programs will foster cross-border collaboration and address capacity limitations. Of the few that currently exist, the Sustainable Information Technologies for Societies Joint Masters, for example, admits only 100 students per year. Moreover, the Commission could create a dedicated Erasmus+ scheme focused on green AI skills, open to a broader group of students enrolled in higher education and VET learners. By connecting the opportunity to study abroad with acquiring green AI skills and expertise, students across all disciplines and levels of education can be encouraged to gain valuable digital skills that improve their position in the labour market.

04 Deploying AI for Climate in the EU

4.1 Defining and Delivering on Public Sector Climate Priorities

4.2 Encouraging Private Sector Adoption of AI Solutions

The EU has established ambitious goals for key sectors: increasing the share of renewable energy in overall consumption to 42.5% by 2030, mandating energy savings of 11.7% by 2030, incorporating circularity and resource efficiency throughout products' value chain, and achieving a 90% reduction in transport emissions.[15]

Additionally, the EU is committed to better monitor, protect and restore its natural ecosystems. This includes urgent efforts to predict and mitigate natural disasters like floods and wildfires, and protect 30% of EU land by 2030.

To support these goals, the EU has adopted tech-driven initiatives to improve its policymaking at the intersection of AI and climate. Destination Earth (DestinE), powered by EU supercomputers and AI, aggregates vast amounts of environmental data to develop new climate adaptation and mitigation strategies. Digital technologies are already being deployed to support sustainability legislation. For example, there is a proposal to use the Forest Monitoring Regulation to map forest vulnerabilities, track climate threats and inform disaster preparedness planning. Similarly, the Methane Regulation supports using AI to improve the analysis of satellite data and identify high-methane-emitting sources.

Policymakers can further accelerate the adoption of AI by supporting public sector initiatives and by easing barriers to deployment in the private sector. It's important that any such initiatives tailor strategies to meet regional needs. The European Green Digital Coalition has helped with this, firstly by adopting the first science-based methodology to measure the net environmental impact of digital solutions, and secondly by developing sector-specific Deployment Guidelines.

4.1 Defining and Delivering on Public Sector Climate Priorities

AI-powered interventions can enhance the efficiency and quality of public services in the EU. Judicious applications of AI could save the public sector an estimated EUR 250 billion, while making administration, education, healthcare and other services deliver better results to the millions who depend on them[16].

Policymakers can apply AI-informed algorithms to model the short and longer-term impact of different policy scenarios to find the most effective and efficient combinations of policies to maximise social, economic and environmental returns.

When it comes to targeted climate action, AI's strength lies in its ability to be customised to specific challenges, such as drought and wildfire forecasting in Spain, or power grid optimisation in Germany[17]. While the EU and its Member States have already begun to leverage this potential, there are opportunities to go further in two areas: (1) tracking implementation of policy measures and improving policy design by deploying AI to measure progress, and (2) climate adaptation planning and crisis response.

In taking the lead on deploying AI to tackle climate change, the public sector can demonstrate its potential, build public trust, and inspire private entities to step up.

1. Tracking Implementation of Policy Measures and Improve Policy Design by Deploying AI to Measure Progress

EU Member States increasingly leverage AI to enhance public sector strategic planning and legislative enforcement. In several countries, public officials have applied machine learning algorithms to satellite imagery to reduce investigation time and manage the cost of detecting illegal waste sites. Similarly, equipping polluting industries with AI-powered sensing equipment provides real-time emissions data, which in turn allows public officials to more effectively enforce emission limits. In France, the agency for biodiversity is developing an AI tool to identify and prioritise at-risk zones and follow up on non-conformity checks. This facilitates improved policy making and helps monitor the environment.

Policy Recommendation

Use AI to track progress towards environmental goals

The EU and its Member States should harness the power of AI to track progress towards environmental goals, such as those outlined in the 8th Environment Action Programme (EAP) or Nationally Determined Contributions (NDCs). This could be integrated into initiatives, such as the announced Apply AI Strategy. More broadly, global initiatives like the UN Data Commons for Sustainable Development Goals, can be leveraged AI to collect economic and social data to measure the Union's climate progress against broader competitiveness metrics.

Tapestry Helps Grid Operators Forecast Scenarios to Meet Public Sector Goals

Tapestry empowers grid operators to deliver clean, reliable, and affordable electricity by providing advanced forecasting and simulation tools. As a division of X, Alphabet's moonshot factory, Tapestry uses AI to create a virtualised view of the electricity system, predicting scenarios from milliseconds to decades into the future.

Helping Cities and Regions Measure, Analyse and Reduce Emissions

Google's Environmental Insights Explorer (EIE) is a freely available data and insights tool that uses AI modelling capabilities to help cities and regions measure their emission sources, run analyses, and identify reduction strategies.

EIE was developed in close collaboration with cities and partners such as C40 Cities and the Global Covenant of Mayors. EIE data is currently available for close to 9,000 regions across Europe, measuring building and transport emissions, tree canopy and rooftop solar potential.

In Aarhus, Denmark, the local government has leveraged EIE to create a more complete picture of traffic data, giving the city the context to measure and monitor the success of their carbon reduction interventions. Similarly, Athens has used EIE insights to update their vehicle emissions calculations and inventories, and help reach their GHG emission reduction targets.

2. Climate Adaptation Planning and Crisis Response

AI has become a valuable tool for authorities to respond to climate-related natural events. AI-powered early warning systems are revolutionising disaster preparedness by analysing real-time data from diverse sources, including satellites and weather stations. These AI systems provide more accurate and timely forecasts of extreme weather events, enabling better-targeted interventions that minimise the impact on communities and infrastructure.

A valuable example of this is the Copernicus Emergency Management Service (Copernicus EMS). This system equips Civil Protection Authorities and Humanitarian Aid Agencies with timely and accurate high-quality geospatial information derived from satellite imagery and other sources, supporting emergency management for floods, forest fires, extreme heat and droughts.

Policy Recommendation

Leverage AI in climate adaptation planning, and in crisis response to climate-related hazards

The EU Climate Adaptation Plan is an opportunity to establish a strategy for empowering civil protection authorities to harness digital technology for flood risk management and other forms of crisis response. This can build on the EU's Mission on Adaptation to help authorities better understand climate risks, develop preparedness strategies, and test and deploy innovative solutions for resilience.

Using AI to Map the Boundaries of Large Wildfires and Provide Accurate Wildfire Information to Affected Communities and Fire Authorities

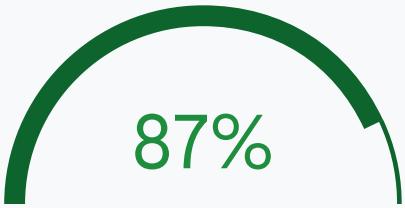
Google Research uses AI to detect wildfires, identifying their boundaries and making this information available through Google Search and Maps, including during driving direction related searches — complementing existing on-the-ground efforts to help people access information during a crisis. A boundary tracking system sends push notifications with the wildfire information to nearby users and communities. These tools have been deployed in Europe, including in Portugal and Greece, helping people stay safe and get timely alerts about fires happening close to them. In August 2024, during the wildfires in Athens, Google sent push notifications to 210 thousand people and 2 million people saw the alert that displayed nearby road closures, supporting cautious decisions at times of crisis.

4.2 Encouraging Private Sector Adoption of AI Solutions

Four sectors have the greatest potential for AI powered emissions reduction:

- **Energy:** As highlighted in Mario Draghi's report, the energy sector is responsible for about 40% of the EU's GHG emissions. AI can boost efficiency and accelerate innovation, optimising electricity grid management and facilitating the integration of renewable energy sources.
- **Industry:** Industrial processes account for just over 9% of the EU's total GHG emissions. AI can optimise manufacturing processes, reducing the environmental footprint of products and the businesses that make them.
- **Transport:** AI can optimise transport systems. This is crucial given that over 70% of EU citizens live in urban areas, where congestion and inefficient systems account for 23% of GHG emissions.
- **Agriculture:** Agriculture accounts for more than 10% of EU's GHG emissions. Scaling AI applications, for tasks such as precision farming and crop monitoring, can also help reach the EU's Farm to Fork Strategy, including reducing chemical pesticide use and nutrient losses by 2030.

In a survey of over 1000 global leaders from the public and private sector, 87% said they recognised AI's potential in addressing climate change.



However, the EU's private sector has yet to meet the EU's Digital Decade targets for AI adoption.

To bridge this gap, businesses need clear, actionable guidance, best practices and incentives. Leaders need to see how AI can optimise processes, conserve resources, improve efficiency and anticipate climate-related physical risks. Other tactics can also help encourage private sector investment and innovation in AI, such as developing incentives such as certification frameworks and networks of excellence, and showcasing how data can be monetised.

Ensuring consistent implementation and alignment between EU and national policy initiatives is equally important to prevent fragmentation.

1. Energy

Power Sector

AI can play a significant role in helping achieve Europe's goals on energy decarbonisation, resource efficiency and electrification. Europe has made significant progress in the digitalisation of its energy systems, but there is still more to be done to leverage the potential of digital technologies. AI can help utility companies improve their forecasting, optimise renewable asset maintenance, integrate distributed energy resources and battery storage, manage network congestion, and enable demand response programs.

Important foundations are being put in place, including: the European Commission's Action Plan on Digitalising Energy Systems (DoEAP); the rollout of the development of a common European energy data space; and the upcoming roadmap for digitalisation and AI in the energy sector. These will help accelerate the adoption of AI-powered solutions in the power sector.

Policy Recommendation

Accelerate the implementation of the Digitalisation of Energy Action Plan in the context of the upcoming Strategic Roadmap for Digitalisation and AI in the energy sector and establish new guidelines for congestion management

The upcoming strategic roadmap for digitalisation and AI in the energy sector is an opportunity to build on the European Commission's Action Plan on Digitalising Energy Systems (DoEAP) and position AI at the heart of the transition. By taking advantage of the new energy data space, the roadmap can facilitate the integration of flexible energy resources and distributed generation to create a smarter, more resilient energy system.

The recently launched Smart Energy Expert Group can bring together stakeholders to drive change – in particular to optimise grid operations. We recommend that the European Network of Transmission System Operators (ENTSO-E) and European Distribution Systems Operators (EDSO) develop or review existing guidelines to integrate using AI for congestion management. This process should highlight relevant use cases to improve network operator performance scores within the Digital Twin of the European Electricity Grid Initiative.

Buildings

AI deployment in large buildings can reduce energy use by 20-40% without compromising comfort, saving 1% of direct emissions. Increasing the adoption of AI and smart thermostats could save 5-6% of direct building emissions by 2050, while also contributing to grid stability and demand response programs.

Moreover, when combined with aerial imagery and environmental data, AI can rapidly and accurately assess rooftop solar potential, making it easier for property owners and accelerating solar panel deployment. The revised Energy Performance of Buildings Directive (EPBD) and European Solar Rooftops Initiative introduce ambitious measures to achieve a climate-neutral building stock by 2050, fostering the large-scale deployment of solar energy on rooftops in buildings. Strategic integration of AI can play a significant role in achieving this objective.

Predicting Power Output Ahead of Generation

Google DeepMind has proven AI can help predict wind power availability 36 hours in advance. The machine learning system takes in weather forecasts and historical wind turbine data and outputs wind power predictions. Then, based on these predictions, the model recommends time-based commitments to the grids a full day in advance.

As referenced in the skills section earlier in this paper, the EU solar workforce needs to improve its digital skills - particularly in AI - to take full advantage of this growth. The Digital Europe Programme (DEP) has already invested in upskilling and reskilling initiatives to improve the digital skills of the EU's workforce. However, solar requires sector-specific investments to ensure that the workforce understands the value of AI in driving solar growth, knows how to use AI in their work, and has access to training and networks. We therefore recommend sector-specific elements in up/reskill programmes, whether through public-private partnership opportunities or existing skilling programmes, such as those mentioned in section 2.3.

Policy Recommendation

Develop recommendations to guide local public authorities, energy and urban planning agencies, and construction companies to fully leverage AI to meet the provisions of the Energy Performance of Buildings Directive (EPBD)

Clear and actionable recommendations can help to guide public authorities, energy and urban planning agencies, construction companies and residents to fully leverage the provisions of the EPBD. This includes encouraging local governments through, for example, initiatives like the EU Mission for Climate-Neutral and Smart Cities. This approach would help officials to develop and deploy AI-driven tools to assess the solar energy potential of buildings on a large scale.

Additional steps to enable the use of AI for buildings include offering incentives to integrate AI into building automation systems, developing standardised protocols for AI-powered systems, and establishing AI-driven building energy management platforms.

To increase the number of residents installing solar panels, it should be made easier for them to understand the value of solar for their household. Ideally, this would involve giving residents access to user-friendly tools that can calculate the potential savings they will make by installing solar. Such a tool should work across a wide range of use cases and contain up-to-date information on national support schemes.

Solar API: Driving Faster, Smarter Solar Energy Solutions

Solar API (Application Programming Interface) leverages Google's extensive mapping and computing capabilities to deliver detailed rooftop data, including solar potential, high-resolution imagery, and financial insights. By providing this valuable information to customers and partners, it streamlines and enhances the efficiency and transparency of solar energy system installations. Solar API covers 472 million buildings across 40 countries, including much of Europe.

Reducing Methane Emissions

The EU's new Methane Regulation introduced a public global methane monitoring tool that uses satellite data and input from certified providers to track high-emitting energy sources. They publish annual performance profiles for countries and producers.

AI can improve methane leak monitoring and support public authorities, upstream producers and infrastructure operators in their compliance efforts. It can use satellite data and cloud computing to quantify and trace methane emissions to their source.

Policy Recommendation

Develop international guidelines on the use of AI for monitoring methane emissions

The EU's Methane Regulation could also help to shape international norms and standardise algorithms and technologies used for methane detection (e.g. leak detection and repair programme, monitoring of super-emitters). This standardisation, through for example the EU's involvement in the International Methane Emissions Observatory or the International Energy Agency, could ensure the accuracy, reliability, and interoperability of methane detection systems, facilitating their widespread deployment and effective monitoring of methane emissions.

2. Industry

AI's unique capacity to analyse vast datasets from sensors and production lines to identify patterns, optimise processes, and facilitate sorting can lead to significant cost savings and improved resource use. AI-powered predictive maintenance can also anticipate equipment failures before they occur, allowing for proactive maintenance and reducing downtime. This not only saves costs but minimises unplanned emissions caused by malfunctions.

Policy Recommendation

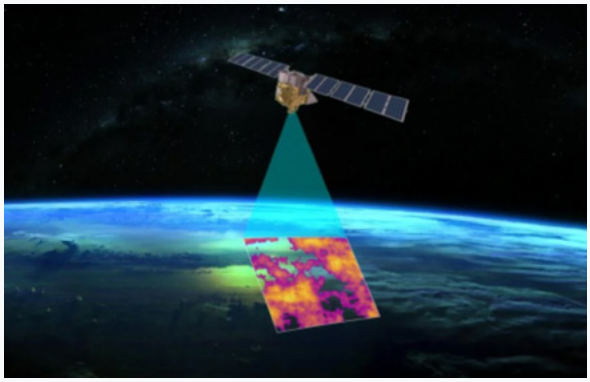
Encourage use of AI in R&D initiatives in the Clean Industrial Deal, and establish net-zero regulatory sandboxes

To accelerate industrial decarbonisation, the European Commission and Member States should consider prioritising, in the context of the Clean Industrial Deal, R&D initiatives focused on innovative AI applications for industrial processes. By building on existing efforts like the Testing and Experimentation Facilities for AI under the Digital Europe Programme, the EU may drive the development and deployment of AI-powered solutions. Integrating these initiatives into the Net Zero Industry Act's "transformative industrial technologies for decarbonisation" framework, through the forthcoming delegated act,[18] may provide a clear pathway to scale up AI-driven industrial solutions.

MethaneSAT Helps Reduce Global Methane Emissions

The Environmental Defence Fund (EDF)'s new satellite, MethaneSAT, monitors methane emissions from around the world. Using advanced algorithms powered by Google Cloud, and in collaboration with scientists at Harvard University, the satellite calculates methane emissions in specific places.

Image Credit: MethaneSAT LLC



In addition, establishing net-zero regulatory sandboxes, as suggested by the NZIA, in close collaboration with industry, research institutes, social partners, and civil society, may encourage experimentation and innovation in AI technologies for industrial applications, allowing companies to test and refine solutions.

3. Transport

Many European cities grapple with congestion, pollution and inefficiencies. AI-driven solutions, like those piloted by initiatives such as AI4Cities, offer a way to optimise traffic flow, reduce emissions, and create more sustainable urban environments. These real-life demonstrations can serve as blueprints for local, regional and national authorities.

Policy Recommendation

Develop a dedicated Roadmap to support AI-driven solutions for Transport, in collaboration with cities and the private sector, outlining concrete actions to accelerate AI deployment and increase competitiveness

Creating a Roadmap on AI for Transport, in tandem with the AI Roadmap for Energy, could support the deployment of AI solutions within the transportation sector. Such a Roadmap should outline strategies and timelines to integrate AI into the sector, including initiatives to promote R&D, incentivise investment in AI-driven technologies, and support workforce upskilling.

Concretely, the Roadmap could help to improve AI uptake in the transport sector by encouraging the consistent publication of real-time public transit schedules across the EU. By providing reliable information on public transport options, cities can incentivise people to choose greener modes of transportation, such as cycling or walking. Expanding participation in this platform beyond Transport Ministries, national transport authorities and public transport operators to include technology providers could allow the Connected, Cooperative, & Automated Mobility Partnership (CCAM) to test and scale AI applications in areas such as predictive maintenance, traffic optimisation, and intelligent transport systems.

Curbing Carbon Emissions with Google Maps AI

Fuel Efficient Routing (FER) on Google Maps leverages AI to plan driving routes that continue to provide a fast route to your destination, while also minimising fuel or battery consumption and curbing carbon emissions. FER is estimated to have reduced about 2.9 million metric tons of GHG emissions (the equivalent of taking 650,000 fuel-based cars off the road in a year) between 2021 and 2023[19]. Google Maps also provides, on average, more than 3 billion km of public transit results per day. In 2023, Google added over 30,000 km of bike lanes, providing people with information on a wider range of transit and urban mobility options to empower them to make more sustainable choices.

Using AI to Reduce Traffic and Travel Emissions Across 16 Cities

Google's Project Green Light uses AI to help city traffic engineers optimise traffic lights at intersections to improve traffic flow and reduce emissions caused by stop and go traffic. With this information, cities can make cost-effective updates to existing infrastructure to reduce the number of stops cars make at red lights. Early numbers from Project Green Light indicate the potential to reduce stops by up to 30% and reduce emissions at intersections by up to 10%[20].

Reduce Aviation Emissions

AI can help to mitigate aviation's contrails emissions by combining vast data including satellite imagery, weather and flight path data - to develop forecast maps to test if pilots can choose routes that avoid creating contrails. Pilots were able to reduce contrails by 54% with just 2% additional fuel, which is estimated to be as low as 0.3% additional fuel usage across an airline's flights. This makes contrail avoidance a cost-effective measure to reduce aviation's net warming. Google is now partnering with EUROCONTROL to provide aircraft flying through European airspace with information about how to avoid creating contrails.

Policy Recommendation

Develop internationally-aligned guidelines on the use of AI for contrails tracking

To address the international nature of contrail impacts, and to support effective implementation of EU Emissions Trading System (ETS) for aviation, the European Commission, in partnership with the International Civil Aviation Organisation (ICAO), could develop common guidelines for comprehensive contrail monitoring at a global level. This approach would help align efforts across all involved bodies, preventing the duplication of monitoring systems and promoting consistency in emissions tracking. Additionally, the EU should foster greater collaboration among Member States to facilitate airspace-based trials on contrail avoidance, potentially through the revised Single European Sky Regulation.

4. Agriculture & Forestry

The EU has made significant strides to promote AI adoption, incentivising environmentally friendly practices, such as precision farming, through eco-schemes, and by providing €200 million under Horizon 2020 and Horizon Europe for R&I supporting AI applications tailored to agriculture, such as crop monitoring, pest control, and harvesting robotics.

While these initiatives represent a significant step forward, there is still a lack of widespread agricultural digitalisation across Member States, with sustainability initiatives often confined to precision farming applications[21]. AI solutions can also help to optimise food distribution, inventory management and shelf-life monitoring, significantly reducing waste. AI can also significantly improve weather forecasting, helping farmers make more informed decisions about planting, irrigation, and harvesting based on more accurate and granular predictions of temperature, rainfall, and other critical weather parameters.

AI can also support the EU's ambitious biodiversity goals by monitoring carbon sequestration, land use changes, and forest degradation, in the context of the EU Deforestation Regulation and the Forest Monitoring Regulation.

Policy Recommendation

Introduce financial incentives to support deployment of innovative digital technologies as part of sustainability programmes in the agricultural sector

To accelerate the integration of AI into agriculture, dedicated funding streams could be established, for instance through a Just Transition Fund, as recommended by the Strategic Dialogue on the Future of EU Agriculture, to support AI R&D tailored to agricultural needs, while tailored support and training programs can address the digital divide, especially for smaller farms.

Policy Recommendation

Strengthen existing collaboration frameworks for the exchange of knowledge and best digital practices in the agricultural sector

Existing frameworks like the Strategic Dialogue on the Future of EU Agriculture, the Agricultural European Innovation Partnership (EIP-AGRI) and the EU CAP Network can be leveraged to connect stakeholders like farmers, researchers, policymakers, and advisors and facilitate knowledge sharing and the development of practical, region-specific AI solutions in agriculture.

Mainstreaming at national level the Agricultural Knowledge and Innovation Systems (AKIS) can also facilitate collaboration and knowledge exchange among stakeholders, as these systems link public authorities with farmers and technology providers.

By leveraging national Farm Advisory Services (FAS), as highlighted in a recent European Policy Centre report, farmers can be empowered to adopt digital tools and meet CAP requirements, overcoming barriers to digital access and accelerating agricultural sustainability. These frameworks may also help to showcase successful AI implementation cases from across the EU, which may inspire and guide other Member States, reducing regional disparities.

05 Guiding the Deployment of AI

5.1 Addressing Potential Environmental Impacts of AI Operators

Policymakers can help guide the sustainable and responsible deployment of infrastructure and AI-powered solutions to boost AI's beneficial impacts while mitigating any potential risks.

5.1 Addressing Potential Environmental Impacts of AI Operators

Electricity demand is rising across the economy due to the convergence of factors such as onshoring, electrification of transport, heat and industry, and adoption of AI. As the digital economy grows, the economic and societal returns are accompanied by growth in energy use. According to the International Energy Agency (IEA), global electricity use will need to grow more than 2.5x by 2050 to meet the demands of economic growth, electrification, and universal energy access. The public and private sector can work together to meet this demand responsibly.

While AI offers new solutions for climate action, it has its own environmental impact. According to the IEA World Energy Outlook 2024, data centre electricity consumption in 2022 was estimated to be in the range of 240 to 340 TWh, around 1% to 1.3% of total electricity consumption. The same report notes that, growth of electricity demand for data centres is projected to be rapid, but the level looks set to remain relatively small in the context of overall global demand growth. Technology companies are already leaders in deploying clean energy. Tested optimisation practices, when used together, can reduce the energy required to train an AI model by up to 100x, and reduce associated emissions by up to 1,000x[22].

Initiatives worldwide, including many being driven out of Europe, are focused on improving data centre sustainability through comprehensive reporting, energy efficiency, and accelerated deployment of carbon-free energy sources. With these initiatives, and by building on the strong track record of the digital sector on energy efficiency and clean energy procurement[23], the environmental footprint of AI infrastructure can be mitigated, ensuring a more sustainable and responsible approach to technological advancement.

1. Enabling Data Centre Decarbonisation and AI Transparency

A range of legislative and non-legislative measures are already in place that will support the digital sector to be transparent about its environmental impact, and drive improvements in data centre sustainability, including the Code of Conduct for Data Centres (EU DC CoC) which has been signed by more than 500 data centres, and the Climate Neutral Data Centre Pact, which data centre operators developed and launched in cooperation with the European Commission, to help reach climate neutrality for European data centres by 2030. Under the Energy Efficiency Directive (EED), the EU has also adopted targeted legislation that requires transparent reporting on the energy performance and sustainability of data centres, while mandating the development of an EU-wide sustainability rating scheme for data centres. Most recently, the AI Act introduced transparency requirements on the environmental impact of AI models.

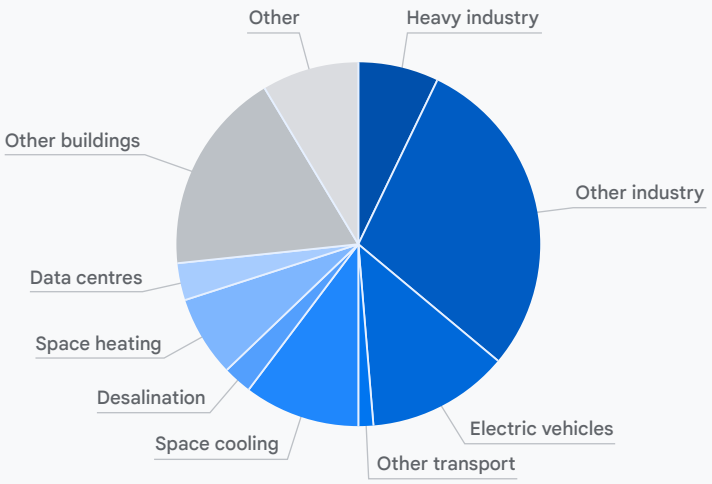
Good progress has already been made on data centre energy efficiency; data centre operators are the leading buyers of renewable energy both in Europe[24] and worldwide[25]. However, more can be done to enable full operational decarbonisation, 100% use of carbon-free energy, and the further implementation of waste heat recovery projects.

Policy Recommendation

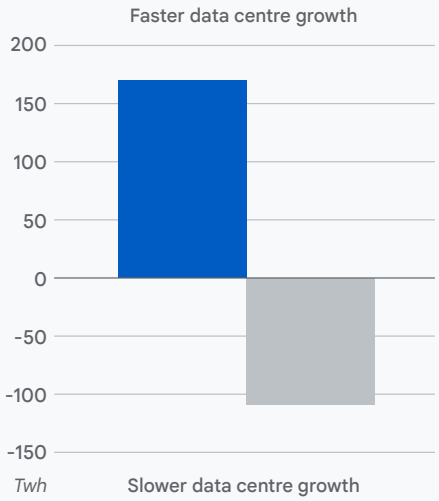
Ensure that the EU-wide sustainability rating scheme for data centres encourages best-practices in sustainability, including adoption of hourly, local carbon-free energy matching

The EU-wide sustainability rating scheme for data centres can be a key driver of progress. It can be designed to recognise and reward best practice to incentivise operators to innovate, fully decarbonise their electricity supply and encourage efficient use of data centre infrastructure. It should champion KPIs that are within the control of the data centre operator (e.g. Power Usage Effectiveness, Water Usage Effectiveness, Renewable Energy Factor) and are in line with the EED reporting scheme. Other KPIs that are not fully in the control of the operator (e.g. Energy Reuse Factor) should not carry the same weight. Instead, the scheme should include additional 'bonus indicators' on top of the core KPIs, particularly an indicator that recognises hourly carbon-free energy matching.

Electricity Demand Growth, 2023–30
6,760 TWh



Electricity Demand Sensitivities for Data Centres, 2030



IEA (2024) World Energy Outlook 2024.

It is also important to ensure the EU Taxonomy technical screening criteria for sustainable data centres are harmonised with the EED sustainability framework.

Policy Recommendation

Develop new frameworks for demand response that accommodate the operational constraints of data centres

Demand response (DR) participation can be expanded to include a broader range of industries, including data centres, by developing a voluntary framework that accounts for the diverse operational constraints of different sectors, such as activation notice periods, volume, duration. To enable large-scale adoption, this approach requires updating and harmonising DR aggregation models across Europe. Key actions include removing the requirement for customers to operate exclusively through Balancing Responsible Parties (BRPs) and revising ancillary service frameworks to facilitate and incentivise DR participation. This harmonisation would unlock significant flexibility potential while ensuring alignment with EU energy market objectives.

Policy Recommendation

Simplify permitting processes for data centre heat recovery

We suggest implementing policies and measures that enable data centres to recover and utilise waste heat. In particular, the process of obtaining permits for connecting data centres and other industrial sites to district heating networks should be simplified to reduce administrative barriers and accelerate project implementation.

Policy Recommendation

Develop methodologies and standards to measure the energy impact of AI models

Today there are significant challenges with assessing the energy consumption of individual AI models. Many AI foundational models have multiple generations of iterative training and fine-tuning, and experimentation in development which provides an unclear boundary on which to measure energy use. For some models, historical energy usage data may not be available. Another challenge is allocating the energy usage of a foundational LLM across various use cases in which derivative AI models are being deployed.

The development of methodologies and standards is important in order to accurately measure the energy impact of AI models. The development of these methodologies requires proper engagement and consultation with industry, and consistency and alignment with international efforts, for example measurement methodologies under consideration by bodies like the International Energy Agency (IEA) or International Standards Organisation (ISO), or that may be developed by other jurisdictions outside of the EU.

Google Aims to Run on 24/7 Carbon-Free Energy by 2030

Google's 24/7 Carbon-Free Energy (CFE) programme aims to support every Google product and service with carbon-free energy sources, every hour of every day, on every electricity grid where the company operates, by 2030. In 2023, Google's average hourly carbon-free energy score[26] across all regions was 64%. Ten of our grid regions achieved at least 90% CFE, with six of them being in Europe[27].

2. Evolving Electricity Market Mechanisms to Enable Growth of Carbon-Free Energy

The new Renewable Energy Directive (RED III) introduces an ambitious target of 42.5% renewable energy share by 2030. RED III is expected to boost renewable electricity for data centres, helping to reduce their environmental impact. While RED III provides momentum for increasing renewable energy capacity, its expansion is still hampered by slow and complex permitting processes for renewable projects and insufficient grid infrastructure. This bottleneck delays both renewable installations and grid expansion. Moreover, although the long-standing policy focus on renewable energy targets has boosted renewables like wind and solar power, it may have neglected the need to advance other firm and flexible carbon-free energy technologies – such as advanced geothermal, long-duration energy storage, and next-generation nuclear – all needed to fully decarbonise electricity grids in Europe.

Corporate purchasers of clean energy, including data centre companies, have contributed to the rollout of renewable power through long-term power purchase agreements (PPAs). Indeed, the data centre sector is the biggest contributor to new renewable generation capacity via Corporate Power Purchase Agreements (CPPAs), both in Europe and globally. Yet the current system of monthly or annual Guarantees of Origin fails to accurately represent the actual energy mix used by data centres.

The Clean Industrial Deal and Electrification Action Plan can provide the momentum to further decarbonise Europe's energy systems, supporting the deployment of carbon-free electricity across Member States to meet the growing demand from industry and retail consumers.

Policy Recommendation

Update electricity market mechanisms under the Electricity Market Design to incentivise the development of more firm and flexible carbon-free resources by implementing increasingly stringent emission performance caps, and scoring criteria that favour zero emission technologies in capacity market mechanisms and ancillary services.

All carbon-free energy technologies can contribute to the EU's decarbonisation objectives, and allowing for multiple technology pathways will reduce risks. The EU Emissions Trading Scheme (ETS) is focused on bringing down emissions from European power and industry plants through a technology-neutral CO2 price.

Europe's need for firm and flexible resources will also grow as the penetration of variable renewables increases. The market mechanisms that secure these resources (namely Capacity Remuneration Mechanisms (CRMs) and ancillary services) must evolve to allow technologies like storage to participate, and should favour carbon-free technologies to reduce Europe's dependency on gas imports. The EU should fully implement the gradually decreasing stringent emission performance caps foreseen by electricity market design rules in these market mechanisms. In addition, a scoring criteria that weights towards zero emission technologies should be introduced within CRMs and ancillary services markets. Barriers limiting participation of storage, renewables, demand response and other technologies may also be removed by ensuring that designated capacity factors when measuring contribution to resource adequacy do not tilt procurement in favour of fossil-fuelled capacities when system needs could be equally met by carbon-free technologies.

Without these reforms it may be difficult to scale investment in the technologies needed to fully decarbonise, contributing to higher gas dependency and costs for consumers.

Policy Recommendation

Stimulate investments in the next generation of clean energy technologies by streamlining permitting processes and incentivising procurement

To continue to play a leading role in innovation, the EU can also continue to prioritise R&D and industrial deployment of advanced clean energy technologies to achieve the decarbonisation of the energy system. These technologies will be needed to complement the rapid growth of wind and solar power and ensure additional EU key priorities in terms of flexibility and reliability.

We recommend Member States and the European Commission to further streamline permitting processes, for transmission and distribution infrastructure under the EU Action plan for Grids and for strategic clean energy projects under the Renewable Energy Directive, emergency regulations and the implementation of the Net Zero Industry Act. Digitalisation of permitting processes can significantly support this goal. In line with the Draghi report, the Commission should also consider extending acceleration measures that currently apply to renewable energy projects and net-zero strategic projects to heat networks, hydrogen, CCUS, and offshore infrastructure.

To enhance support for public-private cleantech procurement of these technologies, we recommend the Commission to also simplify procedures under the Innovation Fund, European Investment Bank, and the Important Projects of Common European Interest (IPCEIs), as recommended in the Draghi report. These should scale demonstration test beds, provide low-interest or grants financing, and expand public investments in first-of-a-kind scale pilots, with roadmaps for industrial deployments.

Policy Recommendation

Encourage the rapid implementation of granular Guarantees of Origin (GOs), enabling the matching of produced carbon-free electricity to demand on an hourly basis

The electricity market design should allow large electricity consumers to procure clean energy that matches their consumption patterns on an hourly basis, by enabling market instruments such as 24/7 fossil-free Power Purchase Agreements (PPAs) and granular Guarantees of Origin, which enable the matching of produced carbon-free electricity to demand on an hourly basis. Analysis has shown that by steering more consumers towards a 24/7 CFE framework, Europe can support both the deployment of mature renewable technologies and the commercialisation of the next generation of technologies needed to completely decarbonise the grid. This can deliver deeper emission reductions by reducing fossil fuel investment and improving the integration of renewables into the energy system.

RED III enabled for the first time the issuance of GOs at the hourly or sub-hourly level.[28] However, Member-State implementation of systems to provide granular GOs has lagged. European issuing bodies could adopt ENTSO-E's recommendations to evolve the current GO system towards a target model in which GOs are time-stamped and their trade across borders is eventually limited to the levels of available capacity between bidding zones. Working towards this target model can provide additional incentives to develop CFE resources, flexibility and even network infrastructure in locations where they are most needed. Furthermore, by contracting for carbon-free energy on an hourly basis, consumers can reduce their exposure to volatile electricity prices even further than with single-technology PPAs, enhancing the competitiveness of energy sourcing options in Europe.

06 Conclusion

Enabling and deploying AI-powered decarbonisation in the EU has significant potential to drive competitiveness and prosperity.

While progress has been made, the pace of emissions reduction needs to accelerate significantly if the EU desires to meet its ambitious climate targets. By enabling better forecasting, informing policy decisions, and optimising complex systems, AI can revolutionise the EU's approach to climate change mitigation and adaptation.

The EU's Digital Decade targets, the European Green Deal and the Clean Industrial Deal provide a basis to leverage AI to meet the EU competitiveness and climate objectives. By aligning these initiatives, a powerful synergy can be built between digital transformation and environmental sustainability. Accelerated AI adoption under the 2024-2029 EU mandate can play a key role in meeting the EU's climate-neutrality goal — and in so doing, also address other priorities such as competitiveness, resilience and security, as set out in the EU's new Strategic Agenda. Through the development of new standards, targeted support measures, improved incentives and new collaboration frameworks, the EU can seize the advantages of this revolutionary technology to meet societal goals.

Google remains committed to collaborating with stakeholders across Europe to harness the power of AI for responsible innovation. Working together, we can unlock AI's full potential to help the EU address its climate goals and create a more sustainable and secure future. The time for action is now, and AI will be a primary tool to combat this challenge.

07 Appendix

Full Summary of our Policy Recommendations:

Enable	Making technology infrastructure accessible and affordable	Improve access to funding for data collection devices in emissions-intensive sectors and to enable adaptation responses
		Adopt targeted measures like voucher schemes and fibre industry standards to increase the uptake of high-speed connectivity in EU Member States
		Improve and harmonise framework conditions to incentivise the development of compute infrastructure, including policies related to infrastructure planning and energy supply
		Improve integration of data centres into energy planning processes
	Increasing availability of high-quality datasets in climate-relevant sectors	Develop interoperability standards across data collection devices in climate-relevant sectors and/or short-term incentives to stimulate data sharing and use
		Adopt and implement common data sharing guidelines and standards for cross-sectoral and international data collection, storage and access
		Increase the transparency of datasets generated through national projects
	Cultivating awareness and building expertise	Develop specialised training programmes for public officials in AI for climate action
		Upskill and reskill workers by developing specialised public-private partnership programmes and leverage existing skilling programmes

Deploy	Defining and delivering on public sector climate priorities		Use AI to track progress towards environmental goals
			Leverage AI in climate adaptation planning and in crisis response to climate-related hazards
	Encouraging private sector adoption of AI solutions	Energy	Accelerate the implementation of the Digitalisation of Energy Action Plan in the context of the upcoming Strategic Roadmap for Digitalisation and AI in the energy sector and establish new guidelines for congestion management
			Develop recommendations to guide local public authorities, energy and urban planning agencies, and construction companies to fully leverage AI to meet the provisions of the Energy Performance of Buildings Directive
			Develop international guidelines on the use of AI for monitoring methane emissions
		Industry	Encourage use of AI in R&D initiatives in the Clean Industrial Deal and establish net-zero regulatory sandboxes
		Transport	Develop a dedicated Roadmap to support AI-driven solutions for Transport, in collaboration with cities and the private sector, outlining concrete actions to accelerate AI deployment and increase competitiveness
			Develop internationally-aligned guidelines on the use of AI for contrails tracking
		Agriculture & Forestry	Introduce financial incentives to support deployment of innovative digital technologies as part of sustainability programmes in the agricultural sector
			Strengthen existing collaboration frameworks for the exchange of knowledge and best digital practices in agricultural sector

Guide	Addressing potential environmental impacts of AI operators	Enabling data centre decarbonisation and AI transparency	Ensure that the EU-wide sustainability rating scheme for data centres encourages best-practices in sustainability, including adoption of hourly, local carbon-free energy matching
			Develop new frameworks for demand response that accommodate the operational constraints of data centres
			Simplify permitting processes for data centre heat recovery
			Develop methodologies and standards to measure the energy impact of AI models
		Evolving electricity market mechanisms to enable growth of carbon-free energy	Update electricity market mechanisms under the Electricity Market Design to incentivise the development of more firm and flexible carbon-free resources by implementing increasingly stringent emission performance caps, and scoring criteria that favour zero emission technologies in capacity market mechanisms and ancillary services
			Stimulate investments in the next generation of clean energy technologies by streamlining permitting processes and incentivising procurement
			Encourage the rapid implementation of granular Guarantees of Origin, enabling the matching of produced carbon-free electricity to demand on an hourly basis

Reference Point: Summary of Acronyms

AI	Artificial Intelligence
B2B	Business-to-business
B2C	Business-to-consumer
CAP	Common Agricultural Policy
CCI	Climate Change Initiative
CFE	Carbon-Free Energy
EED	Energy Efficiency Directive
EDSO	European Distribution Systems Operators
EIE	Environmental Insights Explorer
ENTSO-E	European Network of Transmission System Operators
EPBD	Energy Performance of Buildings Directive
ETS	Emissions Trading System
FSDN	Farm Sustainability Data Network Regulation
GDDS	Green Deal Data Space
GHG	Greenhouse gas
ICT	Information and communications technology
IEA	International Energy Agency
ITS	Intelligent Transport Systems
NZIA	Net-Zero Industry Act
RED	Renewable Energy Directive
SME	Small and medium-sized enterprises
SMRD	Soil Monitoring and Resilience Directive
VET	Vocational education and training

Notes

1 Boston Consulting Group, Accelerating Climate Action with AI, (2023)
2 Implement Consulting, The economic opportunity of AI in the EU, (2024)
3 As of the end of 2023. Actual generation capacity may vary from the signed amounts based on changes during construction or project terminations.
4 According to the 2024 State of the Energy Union report and the EU Climate Action Progress Report 2024,
5 We would like to extend our appreciation and gratitude to all the individuals and organisations that participated in one-to-one interviews, roundtable discussions, fireside chats or broader discussion forums.
6 https://www.consilium.europa.eu/media/65398/2930-06-23-euco-conclusions-en.pdf
7 Contrails, short for condensation trails, are the line-shaped clouds that may be spotted behind airplanes. They form when water vapour in the air condenses around tiny particles of soot and other pollutants emitted by airplane engines. Contrails can trap heat in the atmosphere by reflecting heat back to Earth, which can contribute to global warming.
8 Political Guidelines 2024-2029_EN
9 Fixed infrastructure involves wired connections that remain stationary. It forms the backbone of high-speed, reliable connectivity.
10 The growth of data centre campuses is typically phased and there is some inherent uncertainty in the timeline by which they grow into their maximum power reservation. By ensuring that capacity reservation and connection rules accommodate this staged growth, data centre operators can plan major long-term investments in this essential infrastructure.
11 Climate TRACE was established using financial support from Google.org
12 Joint Research Centre (2024), Unlocking Green Deal Data: Innovative Approaches for Data Governance and Sharing in Europe
13 The Data Commons platform is hosted by Google
14 Micro-credentials certify the learning outcomes of short-term learning experiences, for example a short course or training. They offer a flexible, targeted way to help people develop the knowledge, skills and competences they need for their personal and professional development (Source: EC)
15 Intelligent infrastructure or intelligence transport systems are defined in the ITS Directive as systems in which ICT are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.
16 Source: Google paper on "The economic opportunity of AI in the EU-27: Beyond the hype- capturing the long-term economic potential of generative AI in the EU", publication date Oct 01 2024.
17 Congestion management refers to the management of certain areas of the grid system where electricity flows have a negative effect on the available transmission capacity of the grid.
18 According to the NZIA, by 30 March 2025, the Commission shall adopt a delegated act to amend the Annex on the basis of the list of net-zero technologies set out in Article 4 to identify the sub-categories within net-zero technologies (e.g. "transformative industrial technologies for decarbonisation") and the list of specific components used for those technologies.
19 Google (2024) Environmental Report, p.81, footnote 6
20 Reductions in stops estimates are based on early data points from Google's analysis of traffic patterns before and after recommended adjustments to traffic signals that were implemented during tests conducted in 2022 and 2023. Emissions reductions estimates are modeled using a Department of Energy emissions model. A single fuel-based vehicle type is used as an approximation for all traffic, and it is not yet adjusted for local fleet mix. These data points are averaged from coordinated intersections, and are subject to variation based on existing scenarios. We expect these estimates to evolve over time and look forward to sharing continued results as we perform additional analysis
21 EC (2023) Approved 28 CAP Strategic Plans (2023-2027) Summary Overview for 27 Member States
22 Google (2024) Environmental Report
23 IEA (2024) Tracking Clean Energy Progress - Data Centres and Data Transmission Networks
24 RE-Source (2024) PPA Deal Tracker
25 IEA (2024) Tracking Clean Energy Progress - Data Centres and Data Transmission Networks
26 Carbon-free energy (CFE) technologies include the types of electricity generation that do not directly emit carbon dioxide, including solar, wind, geothermal, hydropower, and nuclear. In addition, when deployed with the appropriate guardrails, low-carbon technologies including sustainable biomass and carbon capture and storage (CCS) can contribute to a CFE portfolio. Energy storage systems (ESS) can contribute as well. See Google (2021) 24/7 Carbon-Free Energy: Metrics & Methodologies for more information on how we calculate our carbon-free energy score.
27 Google (2024) Environmental Report, p.77
28 "In the context of a more flexible energy system and growing consumer demand there is a call for a more innovative, digital, technologically advanced and reliable tool to support and document the increasing production of renewable energy. To facilitate digital innovation in that field, Member States should, where appropriate, enable issuing guarantees of origin in fractions and with a closer to real time timestamp." RED III Preamble.

The AI Opportunity for Europe's Climate Goals - a Policy Roadmap

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