Committee: Environmental Commission (EC)

Topic: Addressing the overconsumption of energy caused by digital transformation

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Position: Deputy President

Personal Introduction

Dear delegates,

I am Effrosyni Christidou, and I am a student at the German School of Athens. I have been a part of the MUN community for 2 years, and I consider the conference organised by the Campion School to hold a special place in my heart. I hope that, serving as your deputy chair in the Environmental Commission, I will be able to provide you with equally wonderful experiences as those I've had as a delegate. This will be my 15th conference and my fifth time chairing. This study guide should only constitute the basis of your research. I advise that you also look up the issue more thoroughly on your own and try to explore more solutions.

Please do not hesitate to contact me at effrosynichristidou@gmail.com

I am looking forward to meeting you all!

Yours,

Effrosyni Christidou

Topic Introduction

As we welcome a more technological era, a digital transformation and the integration of technology in our society have become inevitable. It has transformed the way industries operate, governments work, and individuals communicate and interact. The digital transformation (DT), driven by technologies such as AI, Internet of Things (IoT), blockchain, and big data analytics, has played a major role in improving efficiency, productivity, and innovation in businesses. It is a force that shapes not only industry practices but also the lives of individuals and the broader society by redefining social interactions, employment patterns, education, and even healthcare.

Digital technologies are directly responsible for around 2% of energy-related greenhouse gas emissions today.[1] Specifically, the digital sector produces between 2% and 4% of global greenhouse gas (GHG) emissions, a large part of which is from chipmaking.[2] Data centres and data transmission networks are responsible for 1% of energy-related GHG emissions.[3] According to the International Energy Agency's (IEA) Electricity 2024 report, data centres worldwide consumed a massive 460 terawatt-hours (TWh) in 2022. By 2026, this could exceed 1,000 TWh, more than double the 2022 total, and an amount roughly equivalent to the electricity consumption of Japan. Global data centre electricity usage in 2021 was 220–320 TWh, which equates to approximately 0.9% –1.3% of global final electricity demand.

Digitalisation's negative consequences encompass energy consumption, greenhouse gas emissions, electronic waste (e-waste), and resource depletion. Global e-waste reached 62 million metric tons in 2022[4], and data centres alone accounted for nearly 1% of the world's electricity demand in 2019.[5] These processes often involve rare earth elements, which are typically extracted through environmentally degrading methods.

According to the IPCC, improvements in energy efficiency from digital technologies can help reduce energy demand in all end-use sectors. Rapid improvements in energy efficiency have helped limit energy demand growth from data centres and data transmission networks, which each account for about 1 - 1.5% of global electricity use.[6] Green data centres have emerged as a sustainable

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[1] IEA. "Digitalisation - Energy System." *IEA*, 2023, www.iea.org/energy-system/decarbonisation-enablers/digitalisation.

[2] Bieser, Jan C.T., et al. "A Review of Assessments of the Greenhouse Gas Footprint and Abatement Potential of Information and Communication Technology." *Environmental Impact Assessment Review*, vol. 99, Mar. 2023, p. 107033, https://doi.org/10.1016/j.eiar.2022.107033.

[3] International Energy Agency. "Data Centres and Data Transmission Networks." *IEA*, 11 July 2023, www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

[4] United Nations. Global E-waste Monitor 2024. United Nations Institute for Training and Research (UNITAR) and International Telecommunication Union (ITU), 20 Mar. 2024.https://unitar.org/about/news-stories/press/global-e-waste-monitor-2024-electronic-waste-rising-five-times-faster-documented-e-waste-recycling?utm_source=chatgpt.com

[5] International Energy Agency. "Data Centres & Networks." IEA Energy System – Buildings – Data Centres and Data-Transmission Networks, 2023.https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

[6] Intergovernmental Panel on Climate Change. Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by Priyadarshi R. Shukla et al., Cambridge University Press, 2022, https://www.ipcc.ch/report/ar6/wg3/.

alternative to traditional data centres, focusing on reducing energy consumption and environmental impact through innovative technologies and practices.

While digital tools can support climate goals by improving energy efficiency in areas like smart grids and industrial systems, their growth must be carefully managed to prevent a net increase in emissions. The rising energy demand that these developments spur has the potential to negate much of the progress the industry has made on reducing emissions. Aligning digital transformation efforts with global sustainability targets requires integrating low-carbon strategies and responsible digital growth models.

Definition of key concepts

Digital Transformation

Digital transformation (DT) is "the process of adoption and implementation of digital technology by an organisation in order to create new or modify existing products, services and operations by the means of translating business processes into a digital format."[7]

Overconsumption of energy

Overconsumption of energy is "the excessive consumption or use of goods and services (energy, land, water or materials) that cause harm or detrimental effects to humans and/or the environment, namely by exceeding the carrying capacity and life-supporting systems of the planet and its ecosystems."[8]

[7] "Digital Transformation," Wikipedia, last modified July 2025, https://en.wikipedia.org/wiki/Digital_transformation.

[8] "Overconsumption," Ornamo, accessed August 21, 2025, https://www.ornamo.fi/en/services/sustainability/glossary-of-terminology/.

Sustainable Digitalisation

Sustainable digitalisation is "the integration of digital technologies in ways that reduce environmental impact, such as lowering energy use and electronic waste. It supports climate goals by using renewable energy, efficient infrastructure, and circular economy practices."[9]

Data centre

A data centre is "a building, a dedicated space within a building, or a group of buildings[1] used to house computer systems and associated components, such as telecommunications and storage systems."[10]

Hyperscale

In computing, hyperscale is "the ability of an architecture to scale appropriately as increased demand is added to the system."[11]

Artificial intelligence (AI)

Artificial intelligence (AI) is "the capability of computational systems to perform tasks typically associated with human intelligence, such as learning, reasoning, problem-solving, perception, and decision-making. It is a field of research in computer science that develops and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximise their chances of achieving defined goals."[12]

Machine learning (ML)

Machine learning (ML) is "a field of study in artificial intelligence concerned with the development and study of statistical algorithms that can learn from data and generalise to unseen data, and thus

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[9] Organisation for Economic Co-operation and Development. A Green Digital Transformation: Enabling a Sustainable Future. OECD, 2022, https://www.oecd.org/digital/green-digital-transformation.pdf.
[10] "Data center," Wikipedia, last modified August 2025, https://en.wikipedia.org/wiki/Data_center.
[11] "Hyperscale computing," Wikipedia, last modified August 2025, https://en.wikipedia.org/wiki/Hyperscale_computing.
[12] "Artificial intelligence," Wikipedia, last modified August 2025, https://en.wikipedia.org/wiki/Artificial_intelligence.

perform tasks without explicit instructions. Within a subdiscipline in machine learning, advances in the field of deep learning have allowed neural networks, a class of statistical algorithms, to surpass many previous machine learning approaches in performance."[13]

Carbon footprint

A carbon footprint (or greenhouse gas footprint) is "a calculated value or index that makes it possible to compare the total amount of greenhouse gases that an activity, product, company or country adds to the atmosphere."[14]

Background Information

Overview of Energy Consumption Trends

In 2022, data centres globally consumed an estimated 460 terawatt-hours (TWh), and their total electricity consumption could reach more than 1,000 TWh in 2026.[15] The IEA has estimated that global electricity demand from data centres could double between 2022 and 2026, fueled in part by AI adoption.[16] In 2022, data centres consumed an estimated 460 TWh of electricity. The rapid growth of artificial intelligence-related services over the last 12 months has meant that providers have invested in power-hungry graphics processing units (GPUs). Estimated global data centre electricity consumption in 2022 was 240–340 TWh, or around 1–1.3 per cent of global final electricity demand.[17] This excludes energy used for cryptocurrency mining, which was estimated to be around

[13] "Machine Learning," ISO, accessed August 21, 2025, https://www.iso.org/artificial-intelligence/machine-learning.
[14] "Carbon Footprint," Encyclopædia Britannica, last modified August 2025, https://www.britannica.com/science/carbon-footprint.
[15] ---. "Executive Summary – Electricity 2024 – Analysis." *IEA*, 2024, www.iea.org/reports/electricity-2024/executive-summary.
[16] International Energy Agency, Electricity 2024: Executive Summary, IEA, 2024, https://www.iea.org/reports/electricity-2024/executive-summary.
[17] International Energy Agency, Data Centres and Data Transmission Networks, IEA, 2023, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

110 TWh in 2022.[18] AI will be the most significant driver of this increase, with electricity demand from AI-optimised data centres projected to more than quadruple by 2030.[19]

Since 2010, data centre energy use (excluding crypto) has grown only moderately despite the strong growth in demand for data centre services, thanks in part to efficiency improvements in IT hardware and cooling and a shift away from small, inefficient enterprise data centres towards more efficient cloud and hyperscale data centres.

Sources of High Energy Use in Digital Tech

Information and Communication Technology (ICT) encompasses data centres, communication networks (wired and mobile) and user-devices (such as smartphones and laptops). The ICT sector represented around 4% of global electricity consumption in 2020.[20] User devices represent a majority of GHG emissions (around 57%), then networks and data centres, about 20% each.[21] The ICT sector used about 4% of the global electricity in the use stage and represented about 1.4 % of the global GHG emissions in 2020. User devices accounted for over half of all GHG emissions, with equal parts relating to the use stage and other lifecycle stages. For networks and data centres, the use stage GHG emissions are dominating.[22]

Electricity usage from Communication Technology (CT) is estimated to contribute up to 23% of the globally released greenhouse gas emissions in 2030.[23] Data centres and data transmission networks each accounted for 1–1.5 % of global electricity use in 2022. Data centre electricity use (excluding

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18 International Energy Agency, Data Centres and Data Transmission Networks, IEA, 2023, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

19 International Energy Agency, "AI Is Set to Drive Surging Electricity Demand from Data Centres," IEA, 2024, https://www.iea.org/news/ai-is-set-to-drive-surging-electricity-demand-from-data-centres-while-offering-the-potential-to-transform-how-the-energy-sector-works.

20 "Sustainability and ICT – Mobility Report." *Ericsson.com*, 2024, www.ericsson.com/en/reports-and-papers/mobility-report/dataforecasts/ict-sustainability.

21 Malmodin, Jens, et al. "ICT Sector Electricity Consumption and Greenhouse Gas Emissions – 2020 Outcome." *Telecommunications Policy*, vol. 48, no. 3, Jan. 2024, p. 102701, https://doi.org/10.1016/j.telpol.2023.102701.

22 Malmodin, J., et al. "ICT Sector Electricity Consumption and Greenhouse Gas Emissions." Energy Policy, vol. 48, 2024, pp. 102701. Elsevier, https://doi.org/10.1016/j.telpol.2023.102701.

23 Andrae, A. S. G., and T. Edler. "On Global Electricity Usage of Communication Technology: Trends to 2030." Journal of Communication and Computer, vol. 6, no. 1, 2015, pp. 117–157. https://ideas.repec.org/a/eee/telpol/v48y2024i3s0308596123002124.html.

crypto) was 240–340 TWh in 2022, and data transmission network energy use was 260–360 TWh, or 1–1.5 % of global electricity consumption each. Mobile networks accounted for around two-thirds of total network energy consumption.[24]

At one point, personal computers and monitors accounted for 39 % of ICT energy use, followed by data centres and servers at 23 % of energy use. Computers, data centres and networks consume 10 % of the world's electricity; 30 % of this electricity goes to power terminal equipment (computers, mobiles and other devices), 30 % goes to data centres, and 40 % goes to the network[25].

Data centres use a significant proportion of energy for cooling the ICT equipment. In 2016, Google applied DeepMind's artificial intelligence to reduce energy used for data centre cooling by up to 40%, setting a new standard for smart energy optimisation.[26] More recently, in 2023, Meta and Microsoft began piloting immersion cooling systems at scale to further reduce data centre cooling loads. The period between 2018 and 2020 saw a major surge in cloud computing and remote work, which significantly accelerated the expansion of global data centre infrastructure.[27]

Environmental Impact

The environmental challenges of digital transformation must be overcome for several critical reasons. First, as digital technologies become increasingly integrated into daily life, the environmental footprint of the digital economy is expected to rise significantly. For instance, the number of Internet of Things (IoT) devices worldwide is forecast to almost double from 15.9 billion in 2023 to more than 32.1 billion IoT devices in 2030. The Internet of Things (IoT) refers to a network of physical devices, vehicles, appliances, and other objects embedded with sensors, software, and connectivity, which allows them to collect and exchange data over the internet. The IoT is a network made up of devices

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[24] International Energy Agency. "Data Centres and Data Transmission Networks." International Energy Agency, 2023, https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

[25] Parliamentary Office of Science and Technology. "Energy Consumption of ICT." POSTnote No. 677, September 2022, https://researchbriefings.files.parliament.uk/documents/POST-PN-0677/POST-PN-0677.pdf.

[26] DeepMind. "DeepMind AI Reduces Google Data Centre Cooling Bill by 40%." DeepMind, 2016, https://deepmind.google/discover/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-by-40/.

[27] Microsoft. "Microsoft Quantifies Environmental Impacts of Datacenter Cooling from Cradle to Grave in New Nature Study." Microsoft News Center, 2023, https://news.microsoft.com/source/features/sustainability/microsoft-quantifies-environmental-impacts-of-datacenter-cooling-from-cradle-to-grave-in-new-nature-study/.

connected to the internet, and can connect, enabling interaction and automation among everyday objects.[28]

This rapid proliferation not only leads to heightened energy demand, exacerbating issues related to carbon emissions and fossil fuel reliance, but will also result in a substantial increase in electronic waste production. In 2022, Nvidia released the H100, a data centre GPU designed to offer massive efficiency gains for large-scale AI and high-performance computing workloads — a significant technological response to the growing power demands of modern AI models.[29] Second, the environmental impact of digital technologies is not confined to local areas; rather, it has far-reaching global implications. The expansion of digital infrastructure presents a complex web of environmental challenges that span from the extraction of raw materials to the disposal of obsolete equipment, affecting ecosystems and contributing to climate change. They require vast amounts of electricity to power servers, cooling systems, and other essential equipment. This energy consumption translates directly into carbon emissions, particularly when the electricity is generated from fossil fuels. As data centres grow in size and number, their energy footprint will continue to rise unless significant improvements are made in energy efficiency and the adoption of renewable energy sources.

Data centre load growth has tripled over the past decade and is projected to double or triple by 2028. The report estimates that data centres consumed about 4.4% of total U.S. electricity in 2023 and are expected to consume approximately 6.7% to 12% of total U.S. electricity by 2028. These forecasts indicate that data centres will consume as much as 580 TWh annually in 2028, translating to about 123 GW and representing up to 12% of total U.S. electricity consumption.[30]

In a negative future, the relentless demand for data centre hardware, coupled with a linear economic model, will accelerate resource depletion and exacerbate the e-waste crisis. The manufacturing of servers, networking equipment, and storage devices requires significant quantities of critical raw materials, including rare earth elements, copper, and precious metals. Environmentally damaging

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[28] "Number of Connected IoT Devices Growing 13% to 18.8 Billion Globally." IoT Analytics, 2023, https://iot-analytics.com/number-connected-iot-devices/.
[29] "H100 Tensor Core GPU." NVIDIA, 2022, https://www.nvidia.com/en-us/data-center/h100/.
[30] "DOE Releases New Report Evaluating Increase in Electricity Demand from Data Centers." U.S. Department of Energy, 2024, https://www.energy.gov/articles/doe-releases-new-report-evaluating-increase-electricity-demand-data-centers.

mining practices are intensified to meet demand, further degrading ecosystems and contributing to biodiversity loss.[31]

Greenhouse gases are gases that trap heat in the atmosphere. The primary source of energy generating greenhouse gases is still largely derived from fossil fuels, contributing significantly to greenhouse gas emissions.[32] This reliance on non-renewable energy sources not only exacerbates climate change but also strains local power grids. Greenhouse gas emissions must be cut in half by 2030 to stay on track with the Net Zero Emissions by 2050 Scenario.[33]

Electronic waste contains hazardous materials, such as lead, mercury, and cadmium, which can leach into the environment if not properly managed. The rapid pace of technological advancement leads to a constant stream of obsolete devices, contributing to a growing e-waste problem. The extraction and processing of raw materials for digital devices can lead to habitat destruction and pollution.[34]

Efficiency Gains vs. Rebound Effects

Why is it that advances in energy efficiency do not result in a reduction of energy demand? Most critics focus on so-called "rebound effects". Improvements in energy efficiency often encourage greater use of the services which energy helps to provide. For example, the advance of solid state lighting (LED), which is six times more energy efficient than old-fashioned incandescent lighting, has not led to a decrease in energy demand for lighting. Instead, it resulted in six times more light. In some cases, rebound effects may be sufficiently large to lead to an overall increase in energy use. For example, the improved efficiency of microchips has increased the use of computers, whose total energy use now exceeds the total energy use of earlier generations of computers, which had less energy-efficient microchips. Finally, money saved through improvements in energy efficiency can also be spent on other energy-intensive goods and services, which is a possibility usually referred to as

[31] "Critical Raw Materials and Resource Use in ICT." European Commission, 2022, https://ec.europa.eu/critical-raw-materials.

[32] International Energy Agency. "Greenhouse Gas Emissions and Electricity Use." IEA, 2023, https://www.iea.org/reports/global-energy-and-emissions.

[33] International Energy Agency. "Greenhouse Gas Emissions and Electricity Use." IEA, 2023, https://www.iea.org/reports/global-energy-and-emissions.

[34] "Electronic Waste Management Factsheet." United Nations Environment Programme, 2023, https://www.unep.org/resources/report/global-e-waste.

the indirect rebound effect. In 2021, researchers and environmental groups began warning that AI's rapid energy use was beginning to cancel out the efficiency gains from better hardware and data centre cooling, pushing the issue into mainstream energy and climate debates.[35]

Societal Relevance

Digital technologies are transforming societies by enabling new ways of working, learning, and communicating, but this transformation comes with significant energy implications. While digitalisation can drive efficiency improvements and support climate goals, the rapid growth in digital devices and services also leads to increased energy demand, raising concerns about sustainability and equity. Societal challenges include ensuring affordable access to energy-efficient digital tools, addressing the environmental impacts of electronic waste, and managing the energy footprint of data centres and networks. Understanding and balancing these factors is crucial to harnessing the benefits of digitalisation without exacerbating environmental and social inequalities. Between March and June 2025, major tech companies like Microsoft and Amazon began transitioning to AI-optimised data centres powered by renewable energy sources such as wind and solar, in an effort to align growth in AI computing with climate and energy goals.

[35] "The growing energy footprint of artificial intelligence." ScienceDirect, 2023. https://www.sciencedirect.com/science/article/pii/S2542435123003653

Cooling systems

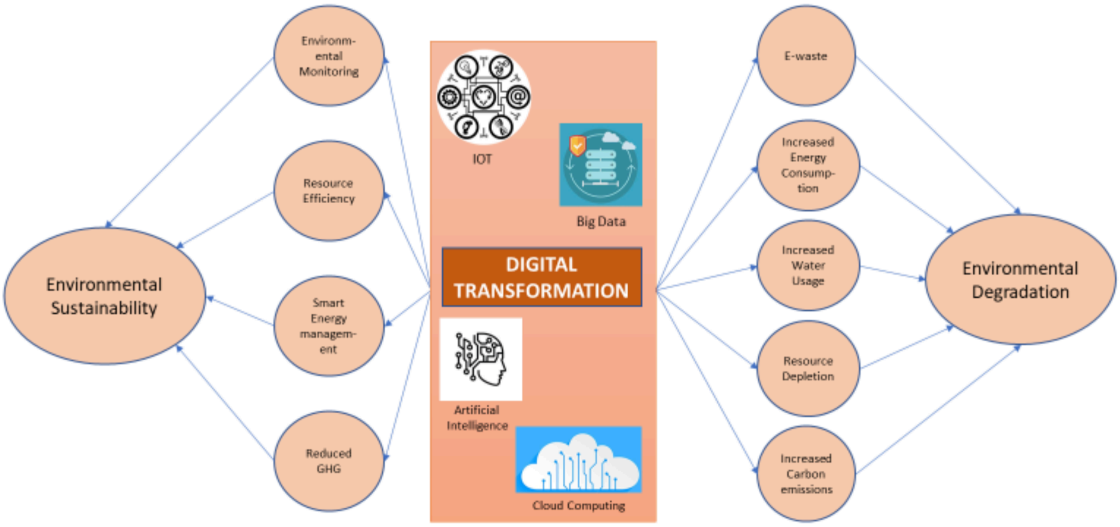

Figure 1: Graph depicting Data centre cooling systems regulate the temperature and humidity levels within data centres to maintain optimal conditions for equipment performance and longevity. These systems typically include air conditioning units, chillers, and precision cooling technologies such as raised floor cooling or overhead cooling systems.[36]

Date	**Description of the event**
15 August 1981	IBM launches the first PC, accelerating demand for enterprise computing and data storage
4 September 1998	Founding of Google
14 March 2006	Amazon Web Services (AWS) launches its first services (EC2 and S3)
20 July 2016	Google's DeepMind AI cuts data centre cooling by 40%
5 October 2020	Cloud boom and remote work surge, the rapid and significant increase or growth in the use of

[36] Mariah. "The Environmental Impact of Digital Storage: What You Should Know." *The Bigger*, 22 July 2025, www.thebigger.com/the-environmental-impact-of-digital-storage-what-you-should-know/.

	cloud computing services and remote work practices
21 March 2022	Nvidia releases H100 GPU with massive AI efficiency gains
February 2023	Meta &Microsoft pilot immersion cooling at scale
20 December 2024	US DOE warns data centre power use may triple by 2028
June 2025	Major players shift to AI-optimised, renewable-powered data centres like OpenAI and Google

Major countries, organisations and alliances

United States of America (USA)

The United States hosts more than 30% of the world's data centres, making it a global hub for digital infrastructure.[37] Google reduced data centre cooling energy by 40% using DeepMind AI.[38] Amazon has committed to achieving 100% renewable energy usage for its data centres by 2025. The US Department of Energy warns that data centre power use could nearly triple by 2028. Microsoft pioneers renewable-powered data centres and immersion cooling technologies to reduce energy use.

China

Since 2021, China has deployed more than 2.1 million 5G base stations to increase network capacity and provide ubiquitous digital connectivity.[39] However, this expansion has led to a misalignment between cellular traffic and energy consumption, reducing carbon efficiency—the amount of

[37] "Global Data Center Trends 2025." *@Cbre*, 2025, www.cbre.com/insights/reports/global-data-center-trends-2025.
[38] Evans, Richard, and Jim Gao. "DeepMind AI Reduces Google Data Centre Cooling Bill by 40%." *Google DeepMind*, Google, 20 July 2016, deepmind.google/discover/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-by-40/.
[39] Li, Tong, et al. "Carbon emissions and sustainability of launching 5G mobile networks in China." arXiv, 14 June 2023, https://arxiv.org/abs/2306.08337.

network traffic delivered per unit of carbon emission. This decline in carbon efficiency has resulted in a 'carbon efficiency trap,' estimated to cause an additional 23.82 megatons of carbon emissions in China. To mitigate this issue, they have proposed 'DeepEnergy,' an energy-saving method leveraging collaborative deep reinforcement learning and graph neural networks. DeepEnergy models complex collaboration among cells, enabling effective coordination of tens of thousands of cells, which could help over 71% of Chinese provinces avoid carbon efficiency traps. Additionally, integrating DeepEnergy with renewable energy sources like solar power could achieve over 50% of the mobile network's net-zero goal.[40]

France

In 2020, the digital sector accounted for 2.5% of France's annual carbon footprint and 10% of its yearly electricity consumption.[41] Without any action, projections point to an increase in greenhouse gas emissions of more than 45% by 2030.[42] Facing this rapid digitalisation, France stands at the forefront of integrating ecological responsibility into the digital realm, pioneering a comprehensive approach to address the environmental impacts of digital technologies.[43]

India

India's data centre market is expected to grow at a compound annual growth rate of over 12% through 2025, significantly increasing energy demand.[44] The government has introduced policies like

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[40] Li, Tong, et al. "Carbon Emissions and Sustainability of Launching 5G Mobile Networks in China." arXiv, 14 June 2023, https://arxiv.org/abs/2306.08337.

[41] Agence de la transition écologique (ADEME) and Autorité de régulation des communications électroniques et des postes (ARCEP). "The Digital Environmental Footprint in France." ADEME, 2022, https://en.arcep.fr/fileadmin/user_upload/04-22-english-version.pdf.

[42] ADEME and ARCEP. "Assessment of the Digital Environmental Footprint in France – Forward-Looking Analysis for 2030 and 2050." ADEME, 2023, https://www.arcep.fr/fileadmin/user_upload/grands_dossiers/environnement/ADEME-Arcep_Study_on_the_digital_environnemental_footprint_in_France_-_Part_3.pdf.

[43] Ministère de la Transition écologique. "Green IT." Ministère de la Transition écologique, 2020, https://www.ecologie.gouv.fr/politiques-publiques/green-it.

[44] "India Data Center Market Size, Share, Growth & Report 2033 - IMARC." IMARC Group, https://www.imarcgroup.com/india-data-center-market.

the India Energy Conservation Building Code to promote energy-efficient infrastructure.[45] Tata Consultancy Services is committed to sourcing 100% renewable energy for its data centres.[46] The company Infosys has achieved carbon neutrality and powers its operations with renewable energy.[47] The India Green Data Centre Council works to establish green standards and encourage the adoption of energy-efficient technologies to reduce the sector's carbon footprint.[48] Industry reports warn that without intervention, India's data centre energy consumption could strain the national grid, highlighting the urgency of sustainable practices.[49]

The European Union (EU)

The European Union aims to improve data centre energy efficiency through its Green Deal and digital strategy. It requires member states to report energy use and promotes common standards for sustainability. European companies invest in renewable energy and advanced cooling to reduce carbon footprints. Without coordinated efforts, rising data centre energy demand could hinder climate goals. The EU also supports AI research to optimise energy use in the digital economy.

World Bank

The World Bank and the International Telecommunication Union (ITU), a specialised United Nations agency for information and communication technologies, have partnered to improve the measurement of greenhouse gas emissions and energy consumption in the ICT sector. The joint report, Measuring the Emissions & Energy Footprint of the ICT Sector, compiles data from over 30 countries, covering telecommunications networks, data centres, and consumer devices. This collaboration provides governments with standardised tools and methodologies to assess the

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45 "Energy Conservation Building Code (ECBC)." Bureau of Energy Efficiency, https://datacenters.lbl.gov/sites/default/files/ECBC_22June2017_printed_Nov2019%20Final1%20%284%29.pdf.

46 "How Green Data Centers Are Powering Sustainability Goals." Tata Consultancy Services, https://www.tcs.com/content/tcs/global/en/what-we-do/services/sustainability-services/white-paper/green-data-centers-sustainable-future.

47 "Carbon Neutrality | Environmental - Infosys." Infosys, https://www.infosys.com/about/esg/environmental/energy.html.

48 "IGBC Data Centers: Leading Energy Conservation in Technology." Indian Green Building Council, https://igbc.in/igbcdatacenters/.

49 "Blue Seas and Green Electrons: Powering India's AI Data Centres." Institute for Energy Economics and Financial Analysis (IEEFA), https://ieefa.org/resources/blue-seas-and-green-electrons-powering-indias-ai-data-centres.

environmental impact of ICT and helps inform policy-making aimed at reducing carbon footprints. The ITU plays a central role in setting global ICT standards and facilitating international cooperation on sustainable digital development and climate action.[50]

The Green Grid

The Green Grid (TGG), a global consortium dedicated to advancing energy efficiency and sustainable practices in data centres, has developed several metrics and tools to optimise resource usage. These include Power Usage Effectiveness (PUE), Water Usage Effectiveness (WUE), and Carbon Usage Effectiveness (CUE), which help data centre operators assess and improve their energy and resource efficiency. TGG also collaborates with organisations like the U.S. Environmental Protection Agency (EPA) to enhance programs such as ENERGY STAR® for data centres, promoting best practices and standards in the industry.[51]

2Degrees

2degrees is a global online platform that facilitates collaboration among businesses to drive sustainable practices and reduce environmental impact across supply chains. The platform enables companies to engage with suppliers, share best practices, and implement initiatives focused on energy efficiency, waste reduction, and resource optimization. By providing tools and resources for transparent reporting and performance tracking, 2degrees empowers organizations to set and achieve science-based sustainability targets, fostering a community committed to responsible business practices."[52]

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[50] Ayers,Seth,Ballan,Sara,Gray,Vanessa,McDonald,Rosie. "Measuring the Emissions and Energy Footprint of the ICT Sector : Implications for Climate Action (." *World Bank*, 21 Mar. 2024, documents.worldbank.org/en/publication/documents-reports/documentdetail/099121223165540890/p17859712a98880541a4b71d57876048abb.

[51] "The Green Grid." *Www.thegreengrid.org*, www.thegreengrid.org/.

[52] "Our Mission and History - Manufacture 2030." *2degreesnetwork.com*, 2016, www.2degreesnetwork.com/. Accessed 28 Aug. 2025.

Previous attempts to solve the issue

European Green Digital Coalition (EGDC)

The European Green Digital Coalition (EGDC), launched in March 2021, is a collaborative initiative involving 37 ICT companies and supported by the European Commission and the European Parliament. The coalition aims to harness the potential of digital solutions to reduce greenhouse gas emissions across various sectors. In its pilot phase, the EGDC developed science-based methodologies to assess the net environmental impact of ICT solutions, considering both their positive contributions and direct footprints. These methodologies, validated by an Independent Advisory Board, are designed for adoption by a wide range of industrial and societal actors to improve environmental footprints through digital solutions.[53]

Energy Savings and Energy Resilience Law (2021)

Feedback and results from the application of the REEN law have been relatively disappointing. The law's fairly general measures are not accompanied by any sanctions if they are not respected. The observatory on the environmental impact of the digital sector, launched at the same time as the REEN law, bears witness to the fact that 2022 is clearly not the year in which emissions from the digital sector will have started to fall. We can nevertheless welcome the fact that the REEN law includes a territorial dimension for large metropolises, with the obligation to have a roadmap around responsible digital technologies by 2025 (these metropolises should have started working on this as early as 2023).[54]

Liquid Cooling & Water Heat Reuse (Google, Microsoft)

Liquid cooling is increasingly recognised as a viable solution to the rising energy demands of modern data centres. By directly cooling servers with liquids rather than air, energy consumption for cooling can be reduced by nearly half. Moreover, the heat captured through these systems can be repurposed for heating buildings or other processes, creating a circular energy flow. However,

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[53] European Green Digital Coalition, Science-Based Methodologies for Assessing ICT Environmental Impact (European Green Digital Coalition, 2021), https://egdc.eu.

[54] "Agritech's Environmental Footprint - Aspexit." *Aspexit*, Feb. 2024, www.aspexit.com/agritechs-environmental-footprint/. Accessed 28 Aug. 2025.

despite these advantages, adoption remains limited due to high installation costs and the need for specialised knowledge to maintain these systems. As infrastructure upgrades are capital-intensive, many data centre operators hesitate to make the transition, slowing the widespread implementation of these eco-friendly technologies.[55]

EU Digitalising the Energy System Action Plan (2022)

The EU's Digitalising the Energy System Action Plan, launched in 2022, establishes science-based methods to accurately measure digital sustainability across the energy sector[56]. This initiative aims to harmonise reporting and promote transparency among EU-based companies. However, the plan's impact is somewhat constrained by its geographical scope, as it primarily targets organisations within the European Union, limiting global reach. Additionally, the adoption of these sustainability standards has been slower than anticipated, partly due to the complexity of integrating new measurement frameworks into existing systems."[57]

Possible solutions

AI-driven energy management

AI-driven energy management uses artificial intelligence algorithms to optimise energy consumption in data centres and digital networks. By continuously monitoring usage patterns and adjusting cooling, computing loads, and power distribution in real time, AI can significantly reduce wasted energy. This approach not only improves operational efficiency but also helps lower carbon emissions. While promising, implementing AI energy management requires advanced infrastructure and significant upfront investment, which can be a barrier for smaller operators.

[55] "Data Centers, AI, and Liquid Cooling." *Datacenterdynamics.com*, 26 July 2025, www.datacenterdynamics.com/en/opinions/data-centers-ai-and-liquid-cooling/. Accessed 28 Aug. 2025.

[56] European Commission. "Digitalising the Energy System – EU Action Plan." EUR-Lex, 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A52022DC0552.

[57] European Green Digital Coalition, Science-Based Methodologies for Assessing ICT Environmental Impact (European Green Digital Coalition, 2021), https://egdc.eu.

Global AI chip efficiency

Global AI chip efficiency refers to the advancements in the design and manufacturing of specialised processors that power artificial intelligence applications. These chips are optimised to perform AI tasks at a higher speed and lower energy consumption compared to traditional processors. Improving AI chip efficiency is critical as the demand for AI-driven services grows, helping to reduce the overall energy footprint of digital technologies worldwide. However, despite progress, challenges remain in balancing performance with power use and in making these chips affordable and widely accessible.

Advanced Cooling Technologies

Advanced cooling technologies such as liquid immersion, direct‑to‑chip cooling, and rear‑door heat exchangers are transforming thermal management in data centres by slashing energy use for cooling by up to 50% or more[58] compared to traditional air cooling. They allow denser hardware configurations, reduce physical footprint, cut operational costs, and improve performance in the long term. Free‑air cooling and cold aisle containment systems leverage ambient conditions by using outside air when possible and separating cold supply from hot exhaust to enhance airflow efficiency. These methods significantly lower cooling energy use and operational costs. However, adoption of liquid immersion and direct‑to‑chip techniques remains limited due to high capital expenditure, technical complexity, retrofitting challenges, and maintenance hurdles, while the effectiveness of free‑air and cold aisle systems is strongly dependent on local climate conditions.

Energy-Efficient Ethernet

Energy‑Efficient Ethernet (EEE) is defined to reduce power consumption by allowing physical layer devices to enter a low‑power idle mode during periods of low data activity. This approach reduces energy usage in switches and PHYs when there is no traffic. EEE can cut idle power consumption by up to half or more while retaining full compatibility with existing equipment. Frame coalescing techniques help maximise energy savings by delaying exit from low‑power idle mode until sufficient

[58] The Green Grid, Energy Efficiency Metrics and Best Practices for Data Centers (The Green Grid), https://www.thegreengrid.org.

traffic accumulates. Combined with green networking practices—such as optimised routing, hardware consolidation, smart switches, and automation—EEE contributes to lowering the environmental impact of digital infrastructure. However, actual energy savings rely heavily on consistent implementation across both hardware and software layers.

Green software development to reduce execution waste

Green software, also known as sustainable software, is designed, developed and implemented to limit energy consumption and reduce environmental impact. Its core objective is to minimise energy consumption while maintaining performance and functionality. This focus includes selecting energy-efficient algorithms and programming languages, reducing computational complexity, minimising resource usage, and avoiding redundant or bloated code. Monitoring and profiling tools help identify energy hotspots and streamline execution. Such practices result in software that runs faster, uses less memory and processing power, and consumes less energy—especially vital in cloud computing and mobile environments. Despite growing awareness and the availability of frameworks like Software Carbon Intensity, widespread adoption remains slow due to a lack of standardised metrics, insufficient incentives, and limited knowledge of green coding principles.

Edge and modular computing

Edge computing brings computation and data storage closer to the data source, reducing latency and saving energy by cutting long-distance data transmission. It enables real-time, context-aware processing across distributed systems. Modular data centres support the edge by offering scalable, energy-efficient deployments tailored to local demand. However, managing many distributed edge nodes poses challenges in standardisation, maintenance, and security.

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