Digital Infrastructure Modernization for an AI Future: Opportunities and Challenges Ahead

GeSI
GLOBAL ENABLING SUSTAINABILITY INITIATIVE

CEO FOREWARD

The Global Enabling Sustainability Initiative (GeSI) is a member-centric business association dedicated to leading the movement that defines, demonstrates, and acts on the enabling role of digital solutions in sustainability. We have over two decades of experience driving the sustainability agenda through cross-sector engagement, strategic partnerships, research, and sector expansion.

GeSI's members represent nearly $4T of market capitalization and play leadership roles on every continent.

We are proud to introduce this new report on Digital Infrastructure Modernization for an AI Future, which explores the rise of artificial intelligence and the progress in digital infrastructure required to drive parallel advancements in energy efficiency, carbon reduction, and data processing.

We are grateful to GeSI members and partners who have contributed to this work, and for their commitment to the sustainability journey ahead. We would like to give special thanks to our partners at US Telecom and GeSI members such as AT&T, Cisco, Colt, Deutsche Telekom, Kyndryl, and Verizon for providing use cases and expert input.

We hope you find this report useful, apply the insights and take action in your organization.

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The USTelecom – The Broadband Association (USTelecom) is the United States's leading trade association representing service providers and suppliers for the telecom industry. USTelecom members provide a full array of services, including broadband, voice, data, and video over wireline and wireless networks. Its diverse member base ranges from large publicly traded communications corporations to local and regional companies and cooperatives, serving consumers and businesses around the world.

Colt Technology Services (Colt) is a global digital infrastructure company which creates extraordinary connections to help businesses succeed. Colt's customers benefit from expansive digital infrastructure connecting 32,000 buildings across 230 cities, more than 50 Metropolitan Area Networks and 250+ Points of Presence across Europe, Asia, the Middle East, Africa and North America's largest business hubs.

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SUMMARY

The rapid pace of artificial intelligence (AI) advancement raises critical questions about whether our progress in digital infrastructure and ICT modernization can keep up; however, it also offers a unique opportunity to drive parallel advancements in energy efficiency, carbon reduction, and data processing. As Sam Altman stated in Davos in 2024: "We still don't appreciate the energy needs of this technology. There's no way to get there without a breakthrough." [1]

Without a clear understanding of AI's net impact—balancing both the environmental costs and the potential benefits—media narratives and political discourse risk becoming polarized, which may inhibit the information and communication technology (ICT) industry's growth and innovation.

This paper posits that broad participation in the AI economy, maintaining and expanding international competitive positions, and achieving sustainability and net zero objectives requires adopting a balanced, net impact perspective of AI-driven digital and energy infrastructure. We suggest that policy frameworks and industry strategies should move beyond simplistic, one-sided arguments for or against AI, focusing instead on comprehensive, nuanced assessments and wholistic, system-level perspective on digital infrastructure. We explore the system perspective through three use cases the transition from copper to modern technologies such as fiber optic networking, advances in more advanced network hardware and dynamic connections, and the role of data centers and toward cloud computing.

This paper provides a roadmap for industry stakeholders, investors and regulators to engage with AI in a way that considers both the positive and negative implications of AI on the environment, thereby fostering sustainable growth and responsible innovation in the ICT sector.

(01.) "OpenAI CEO Altman Says at Davos Future AI Depends on Energy Breakthrough," Reuters, January 16, 2024, https://www.reuters.com/article/openai-davos-energy-breakthrough-idUSKBN1ZZ000. Accessed September 12, 2024.

1 Introduction

AI isn't just a concept of the future—it's already reshaping our daily lives.

In 2024 alone, according to the AI Index 2024 Annual Report, over 1,800 new AI businesses emerged, reflecting a notable increase from previous years. [2] Investments in AI, particularly in generative technologies, have surged to $25.2 billion. According to a 2023 McKinsey report, The State of AI in 2023: Generative AI's breakout year, more than half of organizations (55%) are now using AI, a sharp rise from just 20% in 2017. [3] This rapid adoption underscores AI's transformative potential, driving innovation, improving efficiency, and solving complex problems across various industries.

As we advance into this AI-driven future, we are encountering both significant challenges and exciting opportunities. AI's relationship to energy consumption exemplifies these challenges and opportunities. While AI's high energy demands are notable, in the long run AI technology ultimately could enable reductions in energy consumption and other sustainability advances. Improving digital infrastructure, the networks upon which AI depends , can drive positive change by mitigating network energy consumption. Transitioning from analog copper networks to modern digital networks relying on fiber and spectrum will likely hasten network energy efficiency and functionality for AI.

(02.) "The AI Index 2024 Annual Report," AI Index Steering Committee, Institute for Human-Centered AI, Stanford University, Stanford, CA, April 2024, https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf. Accessed September 12, 2024.

(03.) McKinsey & Company, The State of AI in 2023: Generative AI's Breakout Year (August 1, 2023), https://www.mckinsey.com/insights/the-state-of-ai-2023. Accessed September 12, 2024.

2 The Energy Needs of AI Are Surging, But It Can Be a Tool for Sustainability

The impact of AI on sustainability is complex and may change over time.

The impact of AI on sustainability is complex and may change over time. On one hand, AI presents significant sustainability challenges because it is expected to consume much more energy than currently available using traditional energy platforms. For example, the energy demands of data centers, which are crucial for AI operations, are expected to surge dramatically. By 2030, these centers are predicted to account for 3% to 4% of the world's total electricity use, up from just 1% to 2% in 2023. Research from SemiAnalysis estimates that AI could drive data centers to use 4.5% of global energy generation by 2030. [4] The International Energy Agency warns that by 2026, data centers might consume as much electricity as the entire country of Japan. [5]

A significant part of this energy surge is due to the intense computational needs of AI. For instance, an AI-powered search query can require ten to a thousand times more energy than a standard search. While some AI models are more efficient, the broader push to integrate AI tools often overlooks their substantial energy consumption. To illustrate, a single ChatGPT query requires 2.9 watt hours (Wh) of electricity, compared with 0.3 Wh for a Google search, according to the International Energy Agency. [6]

The growing energy demand from AI has broader societal implications. Increased energy consumption could exacerbate energy inequality, particularly affecting countries and communities that already face energy scarcity or high costs. Developing regions, where energy infrastructure is less robust and access to power is uneven, could be further disadvantaged if AI-driven demands lead to higher energy prices or shortages. On the other hand, and despite these challenges, the intersection of AI and energy also presents unique opportunities. AI technologies themselves hold the potential to optimize energy consumption across various sectors by improving demand forecasting, enhancing grid management, and driving more efficient energy use. AI could play a crucial role in integrating renewable energy sources into the grid, balancing supply and demand more effectively, and reducing reliance on fossil fuels. Additionally, the push for more sustainable AI solutions is driving innovations in energy-efficient computing, with advances in hardware and algorithms aimed at reducing the carbon footprint of AI technologies. As businesses invest in AI, there is a growing awareness of the need to balance innovation

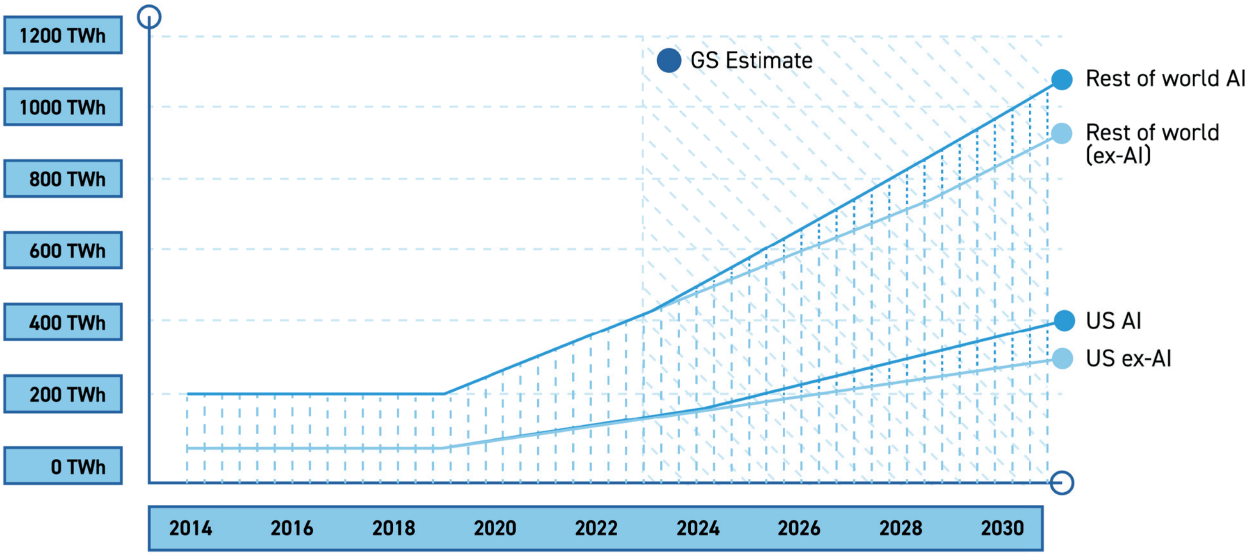
(04.) Dylan Patel, Daniel Nishball, and Jeremie Eliahou Ontiveros, "AI Datacenter Energy Dilemma - Race for AI Datacenter Space: Gigawatt Dreams and Matroyshka Brains Limited by Datacenters Not Chips," SemiAnalysis, March 13, 2024, https://www.semi-analysis.com/articles/ai-datacenter-energy-dilemma. Accessed September 12, 2024.

(05.) International Energy Agency, Electricity 2024: Analysis and Forecast to 2026 (2024), https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf. Accessed September 12, 2024.

(06.) "IEA Study Sees AI, Cryptocurrency Doubling Data Center Energy Consumption by 2026," Data Center Frontier, March 9, 2024, https://www.datacenterfrontier.com/iea-study-sees-ai-cryptocurrency-doubling-data-center-energy-consumption-by-2026. Accessed September 12, 2024.

with sustainability goals. For instance, despite strong commitments to reduce carbon footprints, both Microsoft [7] and Google [8] reported significant increases in their emissions in 2024—30% and 13%, respectively—but are simultaneously investing in AI solutions to manage and reduce these emissions more effectively. By optimizing supply chains, predicting and managing environmental risks, and advancing smart grid technologies, AI can contribute significantly to climate action. [9] A 2023 report by Google and Boston Consulting Group indicated AI has the potential to help mitigate 5% to 10% of global greenhouse gas (GHG) emissions by 2030 and significantly bolster climate-related adaptation and resilience initiatives.

DATA CENTER POWER DEMAND



Source: Masanet et al. (2020), Cisco, IEA, Goldman Sachs Research

(07.) Microsoft Corporation, How Can We Advance Sustainability? 2024 Environmental Sustainability Report (2024), https://www.microsoft.com/sustainability-report-2024. Accessed September 12, 2024.

(08.) Ben Gomes and Kate Brandt, "Our 2024 Environmental Report," Google Blog, July 2, 2024, https://blog.google/outreach-initiatives/sustainability/2024-environmental-report/. Accessed September 12, 2024.

(09.) European Commission, "Commission Adopts EU-Wide Scheme for Rating Sustainability of Data Centres," March 15, 2024, https://energy.ec.europa.eu/news/commission-adopts-eu-wide-scheme-rating-sustainability-data-centres-2024-03-15_en. Accessed October 13, 2024.

3 Digital Infrastructure is the Backbone of AI

"Infrastructure is destiny when it comes to AI," writes Sam Altman, CEO of OpenAI. [10]

This statement underscores the critical role that infrastructure—both physical and digital—plays in shaping the future of AI. While much attention is given to energy infrastructure, the often-overlooked digital infrastructure that powers AI also presents both challenges and opportunities. For example, as discussed below, the modernization of infrastructure from analog copper to digital technologies like fiber and wireless will significantly reduce the energy needs of an AI-driven future.

To fully capitalize on these benefits, we, the Global Enabling Sustainability Initiative (GeSI), propose adopting a system-wide perspective on digital infrastructure modernization. This involves looking beyond individual components to consider the broader ecosystem of foundational systems and technologies that support data collection, storage, management, processing, and distribution. This holistic view helps in evaluating both the positive impacts and potential drawbacks of modernization efforts. Our proposed methodology,

(10.) Sam Altman, "Who will control the future of AI?" The Washington Post, July 25, 2024, https://www.washingtonpost.com/opinions/2024/07/25/sam-altman-ai-democracy-authoritarianism-future/. Accessed September 12, 2024.

informed by decades of expertise in managing ICT infrastructure and explained in detail in a later section, provides a comprehensive framework for assessing the net impacts of various modernization strategies. [11]

The rapid pace of AI advancement raises critical questions about whether our progress in digital infrastructure and ICT modernization can keep up. However, it also offers a unique opportunity to drive parallel advancements in energy efficiency, carbon reduction, and data processing. As Sam Altman stated in Davos in 2024: "We still don't appreciate the energy needs of this technology. There's no way to get there without a breakthrough." [12]

Failing to balance digital infrastructure upgrades with broader energy transition efforts could have severe consequences—not just for the climate but also for economic development and everyday life. In 2023, the ICT sector consumed between 5% and 9% of global electricity. [13] By 2030, this could rise to as much as 20%, highlighting the urgent need for a coordinated approach to modernization. However, these challenges also present opportunities for economic growth and innovation. The move towards more sustainable digital infrastructure could lead to new technologies and business opportunities, contributing to a greener and stronger AI economy.

(11.) Global e-Sustainability Initiative (GeSI), Evaluating the Carbon-Reducing Impacts of ICT: An Assessment Methodology(2024), https://www.gesi.org/research/evaluating-the-carbon-reducing-impacts-of-ict-an-assessment-methodology. Accessed September 12, 2024.

(12.) "OpenAI CEO Altman Says at Davos Future AI Depends on Energy Breakthrough," Reuters, January 16, 2024, https://www.reuters.com/article/openai-davos-energy-breakthrough-idUSKBN1ZZ000. Accessed September 12, 2024.

(13.) Erol Gelenbe, "Electricity Consumption by ICT: Facts, Trends, and Measurements," Ubiquity 2023, no. August (2023): 1-15, https://dl.acm.org/doi/10.1145/3621662. Accessed September 12, 2024.

4 Solutions for Enabling a Sustainable AI Future

As we navigate the complexities of an AI-driven world, modernizing digital infrastructure can pave the way for more sustainable and efficient technologies. In this section, we dive into the following three key areas where innovation and thoughtful infrastructure upgrades and operational improvements are enabling significant advancements in energy efficiency and data management:

The Next-Generation Network Story – From Copper to Digital Technologies:

The transition from copper to next generation networks such as networks based on fiber optics represents a monumental leap in both energy efficiency and data transmission capabilities. Fiber and spectrum-based network technologies offer a significant improvement over analog copper lines, both in terms of improving data volume and speed and reducing net environmental impact. The shift to fiber and spectrum-based communications networks is reducing the energy required for data transmission, significantly cutting down on carbon emissions.

Moreover, the recycling of legacy copper infrastructure where possible presents a unique opportunity to support the energy transition. By recycling old copper wiring, businesses can create a sustainable business model that aligns with broader environmental goals. Perspectives from industry leaders like AT&T, Bell Canada, and Colt Technology Services, as expanded upon later in this paper, demonstrate how this transition is being managed effectively, showcasing the potential for significant gains in both efficiency and sustainability.

The Dynamic Connections Story:

Over the past decade, advancements in network hardware, infrastructure, and operations have driven significant gains in efficiency and sustainability. This evolution started with the shift from legacy copper-based systems to more advanced optical networks and was further advanced with the development of software defined networking (SDN) and network function virtualization (NFV).

Beyond these gains in efficiency, modern network equipment has also become more energy proportional, meaning that its energy consumption scales with data traffic levels. When idle, these devices consume significantly less power, and their energy use rises in proportion to increases in data traffic.

Compare this to legacy copper-based infrastructure, which is line powered, meaning the lines and equipment supporting them must be powered and "on" 24 hours/day, 7 days/week. Because of the nature of this legacy technology, all lines and equipment in an area must be continually powered to allow for the usage by a dwindling number of customers. Only 1.3% of households rely solely on landlines. As more and more communications service is offered via other technologies including fiber we can assume that not all of these households are using copper voice services, yet legacy copper networks are required to remain "live" and operational despite the small percentage of households that rely on them. [14]

This enhancement in energy proportionality means that efforts to manage capacity and traffic levels now have a greater impact on reducing energy consumption and emissions than in the past. Cloud providers are leveraging similar models to enhance the efficiency of data centers and IT platforms, using economies of scale and advanced capacity management—driven by data analytics—to optimize performance.

The Data Center Story:

Data centers are at the heart of AI's infrastructure needs and are evolving to better support the dynamic management of computing workloads. [15] However, traditional metrics for assessing data center efficiency are becoming increasingly outdated. These metrics often fail to account for the integrated nature of modern data centers, where IT equipment and cooling systems are no longer separate entities but part of a unified infrastructure.

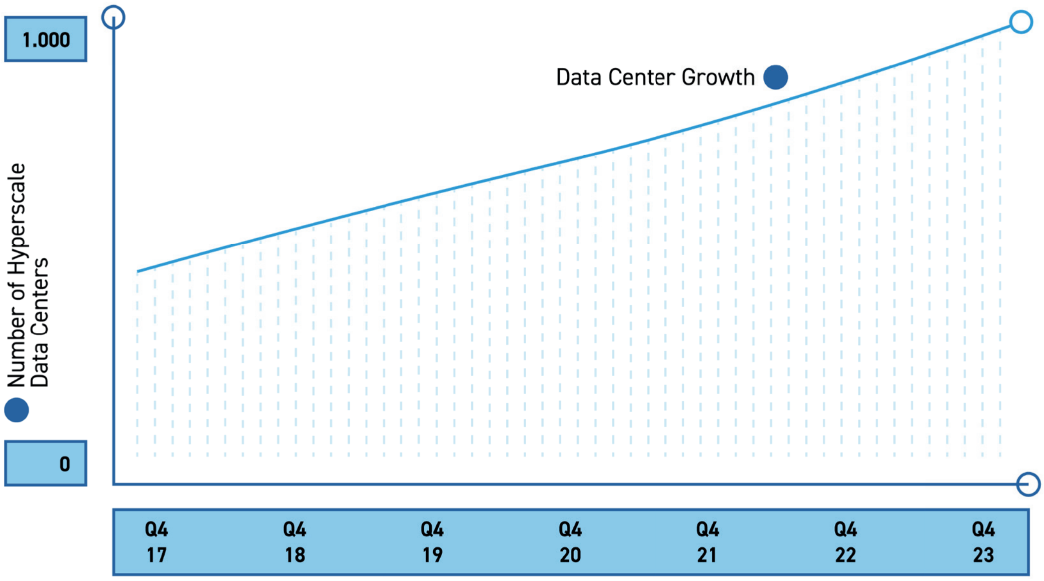
(14.) Blumberg, S.J. and J.V. Luke. 2023. "Wireless Substitution: Early Release of Estimates from the National Health Interview Survey, July – December 2023." National Center for Health Statistics. https://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless202406.pdf

(15.) UK Designates Data Centers as Critical National Infrastructure, Enhancing Support and Economic Growth," Industrial Cyber, September 12, 2024, https://industrialcyber.co/critical-infrastructure/uk-designates-data-centers-as-critical-national-infrastructure-enhancing-support-and-economic-growth/.

As data centers adapt to these new realities, operators can no longer shift the responsibility of managing IT computing infrastructure entirely to their customers. Regulatory pressures, particularly from the European Union, are pushing for more comprehensive efficiency metrics that better reflect the true environmental impact of data centers. [16]

For businesses, this means that choosing the best approaches, architectures, and venues for application workloads requires a careful analysis of both resources and energy consumption. By undertaking such an analysis, organizations can optimize their operations, reduce energy use, and contribute to a more sustainable future all while supporting IT agility.

HYPERSCALE DATA CENTERS



The growth in the number of hyper scale data centres worldwide
Source: Synergy Research Group

(16.) European Commission, "Commission Adopts EU-Wide Scheme for Rating Sustainability of Data Centres," March 15, 2024, https://energy.ec.europa.eu/news/commission-adopts-eu-wide-scheme-rating-sustainability-data-centres-2024-03-15_en. Accessed October 13, 2024.

5 The Next-Generation Network Solution: From Copper to Modern Technologies

The shift from legacy copper to modern fiber optic cables and other advances in digital technologies has transformed and continues to transform the communications industry. This change is not just about improving network performance but also about supporting the growing demands of AI and achieving critical energy savings across the system of digital infrastructure.

As the industry moves away from copper, which has been the backbone of voice telecommunications for over a century, it is embracing more modern broadband network technology for its superior energy efficiency and environmental benefits. These efficiencies are crucial in offsetting the significant energy consumption of AI technologies, ensuring that as AI grows, it does so sustainably.

A great deal of legacy communications infrastructure has its roots in copper wire, dating back to the 19th century. The landmark moment came in 1892 when Alexander Graham Bell made the first long-distance phone call from New York to Chicago. This breakthrough laid the foundation for over a century of voice communication technologies that relied heavily on copper.

Over the past few decades, the communications industry has undergone major transformations, with fiber optics replacing analog copper as the preferred technology of our communications networks and the preferred technology solution to meet consumer demand for always on, always connected. These shifts have enabled the networks to work faster, more efficiently and with smaller and smaller environmental footprints. Regulators should prioritize supporting this shift from copper to more energy efficient digital networks that will provide a critical offset for the increasing energy demands of AI.

ENHANCING RECYCLING WITH AI

Recycling legacy copper, when possible, reduces reliance on environmentally harmful mining practices, lowers carbon footprints, and supports the development of a circular economy where valuable materials are continuously reused. AI technologies can improve the efficiency of recycling processes by accurately sorting and separating copper from other materials, enhancing the yield and quality of recycled copper. This makes the recycling process more cost-effective and accessible, encouraging broader adoption of copper recycling.

INDUSTRY FINDINGS ON COPPER VERSUS FIBER

Telefónica, a global leader in telecommunications, announced in 2023 the closure of all its copper central offices, citing that transitioning to fiber reduces the environmental impact of its fixed network in Spain by up to 94%. [17] The business, which began phasing out copper in 2014, is striving for a 100% fiber network due to fiber's superior performance and sustainability.

Verizon, in its 2023 ESG report, noted that its "focus on network modernization and decommissioning (i.e., powering down) of legacy equipment that no longer serves business or customer needs continues to result in significant energy savings." In particular, Verizon observed that it has also been able to decommission certain energy intensive switches and utilize newer intelligent edge network platforms as it migrated services to fiber technologies, explaining that its " fiber-delivered broadband services are at least 100 times more efficient on a kilowatt hour (kWh) per gigabyte basis than copper-delivered broadband services." [18]

Similarly, altafiber, a regional US internet provider, is transitioning from copper to fiber, noting that powering its copper-based networks account for over 48% of the company's annual carbon emissions, compared to just 6% for its fiber networks over nearly the same geographic area. [19] Altafiber analysis shows that it takes an average of 172 kilowatt-hours (kWh) per year to serve a subscriber via its legacy copper network, while service the same subscriber with its fiber-optic network requires only 6 kWh per year—a staggering 97% reduction in power consumption and emissions. [20] The significant power and emissions savings from transitioning customers to its fiberoptic service is crucial to altafiber's goal of reducing emissions by 40% by 2030.

Nokia, in a 2021 report, "Fiber for a sustainable broadband future," called fiber significantly more climate friendly than other fixed broadband technologies and stated that "most operators are in the process of upgrading older copper and cable networks to deep fiber or full fiber-to-the-home networks." The shift to fiber technology ensured that the explosion in demand for data has not led to a massive increase in emissions; emissions have decreased in recent years. Overall, since 2007, the home broadband power consumption has been reduced by 38% while speeds have increased by a factor of 64. [21]

Taken together, these company efforts to replace copper networks with fiber save energy and cost while delivering enhanced services for customers.

(17.) "Telefónica Closes All Its Copper Central Offices," Telefónica, April 19, 2023, https://www.telefonica.com/en/communication-room/press-room/telefonica-closes-all-its-copper-central-offices/.Verizon ESG Report 2023 at p. 45, accessed October 18, 2024.(https://www.verizon.com/about/sites/default/files/Verizon-2023-ESG-Report.pdf).

(18.) Verizon ESG Report 2023 at p. 45, accessed October 18, 2024.(https://www.verizon.com/about/sites/default/files/Verizon-2023-ESG-Report.pdf).

(19.) Nadja Turek, "Leaving a Greener Legacy," altafiber Blog, Oct 27 2022, https://blog.altafiber.com/greener-legacy, Accessed October 27 2022

(20.) Nadja Turek, "Are You Considering the Carbon Footprint of Your Internet Service?" altafiber Blog, Oct 14, 2024. Accessed October 14, 2024.

(21.) Geert Heyninck, "Fiber for a Sustainable Broadband Future," Nokia Blog, March 17, 2021, https://www.nokia.com/blog/fiber-for-a-sustainable-broadband-future/#. Accessed September 12, 2024.

GOVERNMENT AND THIRD-PARTY SUPPORT FOR FIBER

In 2020, the European Commission declared fiber to be the most energy efficient broadband technology following a 2017 study launched by Europacable. [22]

The FTTH Council Europe also supports the environmental benefits of full fiber networks, highlighting their lower energy requirements and associated greenhouse gas emissions. In 2020, FTTH Council Europe released a study prepared by WIK Consult that describes benefits of fiber for consumers, the economy, society and the environment, stating that, "In areas where FTTH has been widely deployed, considerable benefits could be gained by facilitating copper switch-off including reduced CO2 emissions." [23]

The Boston Consulting Group also views fiber as the future of broadband, urging businesses to develop phaseout strategies for copper. [24] According to the firm, fiber networks are less vulnerable to disruptions caused by severe weather or extreme temperatures, making them more reliable and sustainable in the long term.

THE HIGH ECONOMIC VALUE OF COPPER WIRE

The economic value of copper remains substantial in the telecommunications industry. The global copper wire and cable market was valued at approximately USD 158.9 billion in 2021 and is expected to grow to around USD 249.1 billion by 2030, with a compound annual growth rate (CAGR) of roughly 5.77% between 2022 and 2030, according to Zion Market Research. [25]

In the U.S., about 60% of all copper and copper alloys are used due to their electrical conductivity, and about 80% of that is in wire and cable. Each year, a growing portion of US demand for copper is driven by the demand for copper wires, as reported by the Copper Development Association. [26]

RECYCLING LEGACY COPPER INFRASTRUCTURE: CLIMATE AND MARKET VALUE

Providers are encouraging users to switch to digital or mobile option As we transition to fiber, a key question arises: What happens to all that copper? As high-grade copper becomes scarce, mining lower-grade deposits becomes more costly and damaging. Recycling, on the other hand, requires up to 85% less energy than mining and smelting virgin copper, reducing greenhouse gas emissions and environmental harm. Copper is highly recyclable without losing quality, offering a sustainable solution to meet growing demand while reducing electronic waste and preserving natural resources.

(22.) European Commission, "Fibre Is the Most Energy Efficient Broadband Technology," November 24, 2020, https://digital-strategy.ec.europa.eu/en/library/fibre-most-energy-efficient-broadband-technology. September 12, 2024.
(23.) Ilsa Godlovitch and Peter Kroon, Copper Switch-Off: European Experience and Practical Considerations (WIK Consult for FTTH Council Europe, November 30, 2020), https://www.wik.org/fileadmin/Studien/2020/Copper_switch-off_whitepaper.pdf. Accessed September 12, 2024.
(24.) https://www.bcg.com/publications/2021/copper-networks-fiber-optic-network-shift
(25.) "Copper Prices - Historical Chart and Data," MacroTrends. https://www.macrotrends.net/1476/copper-prices-historical-chart-data.
(26.) https://www.macrotrends.net/1476/copper-prices-historical-chart-data. Accessed September 12, 2024.

Recycling copper, when feasible, especially from telecom networks, has many benefits, including a very robust and valuable after market. Recycled copper typically retains about 90% to 95% of the value of new copper, making it a viable alternative to virgin copper, according to the Copper Development Association. [27] However, recycled copper cables often have a reduced value due to the impurities that might remain after the recycling process.

Even when recycled, copper retains value because it retains its operational qualities. For example, bare stripped copper wire is currently valued at $3.60 per pound, with recycled copper prices ranging from $1.60 to $3.60 per pound, compared to the current price of virgin copper at $4.17 per pound, as of September 11, 2024.

CASE EXAMPLE: AT&T

AT&T has made significant strides in recycling copper as it modernizes its telecommunications infrastructure. Between 2021 and 2023, the company undertook a major initiative to recycle 14,524 metric tons of copper from its legacy networks, which in turn led to the avoidance of approximately 71,800 metric tons of carbon dioxide (CO_2e) emissions. The volume of copper recycled was equivalent to about 1.015 million metric tons of mined copper ore, highlighting the substantial environmental benefits of recycling legacy copper from telecom infrastructure. Another point of comparison is 14,524 metric tons represents just over 1M pickup trucks.

This initiative underscores the significant environmental value of recycling copper extracted from communications networks. As the industry continues to evolve, the role of copper recycling will remain critical, both in managing existing infrastructure and in supporting future sustainability efforts in other industries.

(27.) Copper Development Association, Inc. 2024 'Recycling of Copper.'https://www.copper.org/environment/lifecycle/ukrecyc.html

6 The Dynamic Connections Solution

Dynamic connection technologies can promote environmental benefits and facilitate the enabling role of AI solutions.

The evolution of network technologies extends beyond the cables themselves to include the sophisticated systems that manage data flow. Modern platforms are moving away from fixed infrastructure and static systems and embracing technologies like software defined networking (SDN) and network function virtualization (NFV).

SDN allows for dynamic scaling and rapid provisioning, transforming network operations and enabling seamless integration between different service providers. It uses a software-driven approach to network architecture and management, aiming to create an open, programmable network that consolidates multiple services. Central to SDN is the controller, which facilitates communication between application programming interfaces (APIs) and hardware. Its programmability allows network administrators to customize functions, such as traffic routing and security policies, through software interacting with the controller.

SDN and NFV are not just about improving efficiency—they're revolutionizing the way networks operate, turning them into foundational platforms for cloud transformation. By enabling more dynamic and flexible network management, these technologies are helping to create a more robust and scalable digital infrastructure.

THE VALUE CHAIN IMPACT

The integration of network evolution with cloud platform development is further enabling a new era of "intent-based" use of ICT platforms. This concept, which applies SDN and NFV to current sustainability and operational challenges, allows networks not just to provide adequate capacity from point A to point B, but to optimize the flow of traffic based on geographic (greener routes) and temporal (greener times) considerations as data moves through the network.

Coupled with advances in energy monitoring and management, these new capabilities enable real-time optimization of IT infrastructure and operations, actively reducing carbon emissions by adjusting workloads accordingly. For example, tools developed by Flexidao with businesses like Google and Microsoft illustrate how such systems can dynamically manage energy use for AI workloads, balancing the need for speed and capacity with the goal of minimizing environmental impact.

ECONOMIC BENEFITS

The economic benefits of on-demand IT resource provisioning and use are now well established thanks to the explosion of "cloud" based services. Until recently, agility in network provisioning and use was constrained by legacy infrastructure and systems; however, with the advent of virtualized networks, the "on-demand" model is emerging in the network world.
One of the key challenges to agile networking has been the layered nature of how networks have been built over time. This means that dynamic provisioning of network services benefits from dynamic interoperability between providers, which is just starting to emerge. One example is the partnership between Colt and Belgian telecom Proximus to build a proof of concept on network API integration. [28]

ENVIRONMENTAL BENEFITS

As part of the migration of network infrastructure and services to next generation platforms, massive energy savings are helping to reduce the emissions of large-scale network providers over time. Unlike their cloud and data center counterparts who are seeing emissions rise significantly over the past two years as a result of AI deployments, network providers have continued to provide increased capacity that is decoupled from emissions.

The exponential gains in network hardware efficiency will certainly level off over time, however the promise of dynamic provisioning and workload shifting will enable network providers to reduce not only their own emissions but the emissions of cloud providers and other hard to decarbonize sectors such as energy, agriculture, transport, and construction.

CASE EXAMPLE: COLT TECHNOLOGY SERVICES AND CISCO SYSTEMS

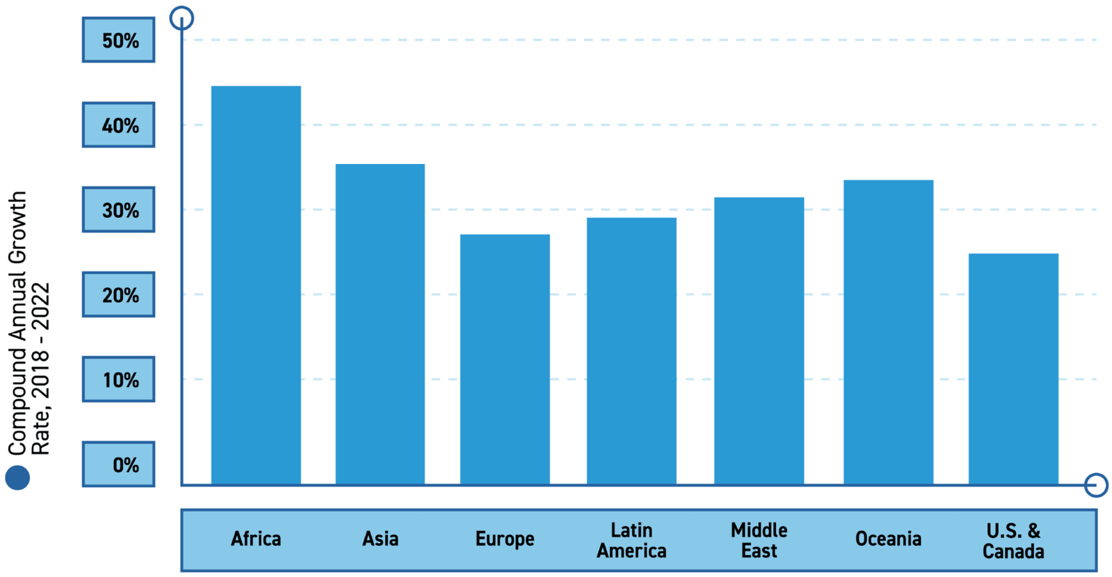
A prime example of this transformation can be seen in recent upgrades to the network of Colt Technology Services. As Vivek Gaur, Vice President of Engineering at Colt, has stated: "The next stage in sustainable networks is ensuring we're optimizing for the best outcome for Colt and its customers. We are leading the way in intent-based networking alongside our partners, which gives customers the option to optimize based on key criteria, such as the best time to move data, the lowest latency route, or shifting intensive workloads such as AI model training to cloud regions with lower emissions."

(28.) "Colt and Proximus Trial New Proof of Concept to Test API Collaboration and End-to-End Network as a Service Automation," Colt Technology Services, July 9, 2024, https://www.colt.net/resources/colt-and-proximus-trial-new-proof-of-concept-to-test-api-collaboration-and-end-to-end-network-as-a-service-automation/. September 12, 2024.

Through these upgrades, Colt has demonstrated substantial improvements in both capacity and energy consumption. For instance, the equipment required to support a 100Gb connection has been reduced from 21 units of rack space to just 1 unit, and from 171 watts of energy consumption to a mere 5.5 watts. In another case, 13 units of rack space were reduced to just 2, while energy use dropped from 26 watts to 7 watts. As a result, since 2021, Colt has achieved a 35-fold increase in network capacity, a 95% reduction in the physical space required for equipment in data centers, and a 69% decrease in costs.

Ultimately, whether the objective is to maximize speed and capacity for a specific AI process or to minimize environmental impact, modern networks provide the flexibility to support both goals, guiding users towards the most efficient and sustainable approach. These advancements have been made possible by innovations in SDN and NFV, new equipment from vendors, and the strategic efforts of product, architecture, and operations teams dedicated to leveraging these technologies to their fullest potential.

INTERNATIONAL INTERNET BANDWIDTH GROWTH BY REGION



Data as of mid-year.
Source: © 2022 TeleGeography

7 The Data Center and Cloud Solution

The cloud also can enhance environmental outcomes and promote the benefits of AI.

One significant way businesses are optimizing IT utilization is through the widespread adoption of cloud-based deployments. Contrary to a single, unified approach, the term "cloud" encompasses a variety of methods for deploying and managing IT infrastructure. Models such as Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS) all represent strategies where IT capacity is provisioned on a shared platform, allowing for flexible scaling up or down as needed, rather than relying on dedicated facilities.

Often described as enhancing IT flexibility, cloud computing dramatically reduces the upfront infrastructure investment required to launch a new software business, essentially bringing it down to near zero—a fact evidenced by the surge in AI startups. This model also offers the potential for virtually unlimited scalability to accommodate rapid growth, making it highly attractive to investors by minimizing risk and maximizing potential returns.

INDUSTRY DEVELOPMENTS

However, the rapid increase in cloud adoption has also led to a corresponding rise in emissions for hyperscale cloud providers. This growth has prompted these businesses to innovate swiftly in enhancing energy efficiency. As the energy demands of data centers escalate, businesses that service the data center market are pioneering new methods of on-site energy generation and storage, as well as adopting advanced techniques like liquid cooling to manage energy use more effectively.

Regulatory landscapes are evolving alongside these technological advancements, particularly within the European Union. The new Energy Efficiency Directive (EED) [29] requires data center operators to explore innovative approaches and integrate with other infrastructures, such as district heating systems. Over time, we can expect to see much closer integration and collaboration between data center operators and energy providers, as their shared interests and capabilities continue to develop. This trend towards integration is detailed in white papers like the one published by the Sustainable Digital Infrastructure Alliance (SDIA) on data center and energy system integration. [30]

(29.) European Commission, Energy Efficiency Directive. 2023. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en#:~:text=The%20revised%20directive%20introduces%20an,reporting%20obligation%20on%20data%20centres.&text=The%20Commission%20has%20taken%20a,frequently%20asked%20questions%20and%20guidance

(30.) Sustainable Digital Infrastructure Alliance (SDIA), Utility of the Future Report, accessed September 12, 2024, https://sdialliance.org/resources/utility-of-the-future-report/. Accessed September 12, 2024.

VALUE CHAIN IMPACTS

By optimizing IT use through cloud-based models and enhancing energy efficiency, businesses are not only supporting their own growth but also contributing to a more sustainable and efficient digital future. The impact of cloud and data centers is something businesses are becoming increasingly aware of, and news organizations are covering with ever greater frequency.

However, the headline grabbing and polarized nature of news means that the impact of cloud and data centers is rarely, if ever, presented in a balanced way that highlights the tradeoffs. As a result, we are supporting the new European Green Digital Coalition (EGDC) Net Impact Methodology as a more valuable way of understanding the impact of ICT. [31]

ECONOMIC BENEFITS

The shift towards cloud as the default deployment model of IT infrastructure reflects the well understood economies of scale for cloud providers and the advantages of on demand service provisioning and auto scaling. However, many of these benefits also require changes in operations, processes, tooling, and skill sets, which inevitably lag the technology advancements.

To ensure organizations are making the most of cloud, whole new areas of practice such as FinOps are emerging. FinOps is essentially the disciplined optimization of cloud-based IT infrastructure and services based on comprehensive and detailed analysis of cloud provider billing systems. It has emerged in response to what is commonly known as cloud sprawl or shadow IT, where software developers take advantage of simple and easy to use deployment tools While these cloud optimizations are undertaken, it is equally important to deprovision and remove cloud instances no longer in use to lower energy consumption and cost.

ENVIRONMENTAL BENEFITS

As one might expect, the efficiency gains of FinOps often have the side effect of reducing environmental impact, which, along with increasing interest in green software development, has led to the emergence of GreenOps. GreenOps takes the same approach as FinOps in leveraging cloud provider billing systems for insight, but optimizes with a view towards reducing carbon emissions, which usually also reduces cost.

(31.) Green Digital Coalition, Net Carbon Impact Assessment: Methodology for ICT Solutions (April 2024), https://www.greendigitalcoalition.eu/assets/uploads/2024/04/EGDC-Net-Carbon-Impact-Assessment-Methodology-for-ICT-Solutions.pdf. Accessed September 12, 2024.

The emergence of these new cloud disciplines is the natural evolution of what is commonly known as DevOps, where software developers have essentially taken over many of the tasks formerly handled by separate IT operations staff. The nature of cloud systems lends itself to this combination of functions and creates both new advantages and new challenges for IT teams.

As the various practices outlined here converge into "intent based optimization," network and cloud providers will increasingly find themselves collaborating on new approaches and integrating their services to the benefit of customers and the environment.

8 The Importance of Net Impact Solutions

For years, ICT businesses have recognized and promoted the positive impact of ICT technologies, not only on their own sustainability goals but also on the goals of their customers. Digital solutions can have a net positive enabling role, especially in achieving broader sustainability objectives.

In 2015, AT&T set an ambitious "10x Goal," committing to reduce their customers' carbon footprints by an amount equivalent to ten times AT&T's own annual carbon footprint within ten years. As AT&T's carbon footprint decreased from 2015 to 2020 through ongoing carbon mitigation efforts, the target was adjusted accordingly. To maintain the original ambition and impact, AT&T introduced the Gigaton Commitment in 2021, aiming to reduce emissions by one billion metric tons, equivalent to the weight of 10,000 fully loaded aircraft carriers.

While commitments like these often face skepticism, AT&T addressed this by partnering with Business for Social Responsibility (BSR) and the Carbon Trust to develop a rigorous net impact methodology. Initially released in 2015 and updated in 2020, this methodology has helped AT&T stay ahead of its Gigaton Commitment targets.

GeSI has been a leader in exploring the enabling potential and net impact of ICT technologies on sustainability. GeSI's SMART reports and sector guidance form the basis for industry commitments and the European Green Digital Coalition (EGDC) methodology, where GeSI served as Secretariat for the methodology development. As ICT becomes increasingly crucial in advancing AI-driven sustainability, understanding these impacts will be vital for policymakers, investors, and business leaders in making informed decisions.

Effective decision-making often involves navigating conflicting information and opinions, and net impact methodologies are essential tools for this process. Whether engaging with regulators, investors, or customers, it is critical to frame the benefits of new technologies within the context of their potential downsides. This balanced approach helps to ensure that positive impacts are communicated transparently and effectively.

Emerging concepts like contextual or authentic sustainability complement traditional ESG performance measures. Among these new approaches are the UN Sustainable Development Performance Indicators and the EGDC Net Impact Methodology led by GeSI.) The EGDC, formed in March 2021, developed this methodology to ensure that digitalization supports green transitions, particularly in sectors such as energy, transport, agriculture, and construction.

The EGDC's Net Impact framework provides a standardized, science-based approach for assessing the net carbon impact of ICT solutions. It enables business leaders and policymakers to evaluate and invest in greener digital technologies that are more energy and material efficient. This methodology quantitatively assesses greenhouse gas emissions, measured in CO2e, and considers both positive and negative effects, providing a holistic view of an ICT solution's environmental impact. As the EGDC methodology is tested and applied to various scenarios, from transportation and agriculture to manufacturing and smart cities, the methodology could become the blueprint for industry leaders.

Robust assessment methodologies like those developed by EGDC are crucial for maximizing the intended impact of digital solutions on sustainability. By adopting these frameworks, the ICT sector can better measure and communicate the true impact of its innovations on the environment, society, and economy.

9 Conclusion

The modernization of digital infrastructure is central to meeting the demands of AI and ensuring sustainable technological advancement. As AI continues to transform industries, the resulting increase in energy consumption highlights the urgent need for efficient and environmentally responsible infrastructure solutions.

Modern technologies, including fiber optics, with lower energy consumption and reduced greenhouse gas emissions compared to traditional copper networks, represent a significant step forward in this regard. The shift away from copper not only enhances network reliability and efficiency but also contributes to substantial environmental benefits. As AI-driven demand grows, phasing out copper networks in favor of fiber optics and other modern digital technologies will be critical for managing energy consumption responsibly. Initiatives such as AT&T's copper recycling program further exemplify how repurposing existing materials can reduce environmental impact while delivering economic advantages.

Furthermore, advancements in network management technologies, such as SDN and NFV, are enabling more dynamic and energy-efficient operations. These innovations allow for real-time optimization of network resources, helping to reduce emissions and align with sustainability goals.

Overall, embracing these technological advancements while prioritizing sustainability will be crucial for meeting the growing demands of AI and digital infrastructure. By integrating more efficient technologies and practices, the industry can support AI's potential while minimizing its environmental footprint, thereby fostering a more sustainable and resilient digital future.

10 Bibliography

AI Index Steering Committee. The AI Index 2024 Annual Report. Institute for Human-Centered AI, Stanford University, April 2024. https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf.

Altman, Sam. "We Must Get This Right: AI and the Global Fight Between Democracy and Authoritarianism." The Washington Post, July 25, 2024. https://www.washingtonpost.com/opinions/2024/07/25/sam-altman-ai-democracy-authoritarianism-future/.

"Colt and Proximus Trial New Proof of Concept to Test API Collaboration and End-to-End Network as a Service Automation." Colt Technology Services. July 9, 2024. https://www.colt.net/resources/colt-and-proximus-trial-new-proof-of-concept-to-test-api-collaboration-and-end-to-end-network-as-a-service-automation/.

"Environmental Sustainability." AltaFiber. Accessed September 12, 2024. https://www.altafiber.com/about-us/environmental-sustainability.

European Commission. "Fibre Is the Most Energy Efficient Broadband Technology." November 24, 2020. https://digital-strategy.ec.europa.eu/en/library/fibre-most-energy-efficient-broadband-technology.

European Commission. "Commission Adopts EU-Wide Scheme for Rating Sustainability of Data Centres." March 15, 2024. https://energy.ec.europa.eu/news/commission-adopts-eu-wide-scheme-rating-sustainability-data-centres-2024-03-15_en.

European Commission. "Commission Adopts EU-Wide Scheme for Rating Sustainability of Data Centres." March 15, 2024. https://energy.ec.europa.eu/news/commission-adopts-eu-wide-scheme-rating-sustainability-data-centres-2024-03-15_en.

Gelenbe, Erol. "Electricity Consumption by ICT: Facts, Trends, and Measurements." Ubiquity 2023, no. August (2023): 1-15. https://dl.acm.org/doi/10.1145/3621662.

Global e-Sustainability Initiative (GeSI). Evaluating the Carbon-Reducing Impacts of ICT: An Assessment Methodology. 2024. https://www.gesi.org/research/evaluating-the-carbon-reducing-impacts-of-ict-an-assessment-methodology.

Godlovitch, Ilsa, and Peter Kroon. Copper Switch-Off: European Experience and Practical Considerations. WIK Consult for FTTH Council Europe, November 30, 2020. https://www.wik.org/fileadmin/Studien/2020/Copper_switch-off_whitepaper.pdf.

Gomes, Ben, and Kate Brandt. "Our 2024 Environmental Report." Google Blog. July 2, 2024. https://blog.google/outreach-initiatives/sustainability/2024-environmental-report/.

Green Digital Coalition. Net Carbon Impact Assessment: Methodology for ICT Solutions. April 2024. https://www.greendigitalcoalition.eu/assets/uploads/2024/04/EGDC-Net-Carbon-Impact-Assessment-Methodology-for-ICT-Solutions.pdf.

Guinness, Harry. "How Does Choosing Fiber Internet Benefit the Environment?" Frontier. September 30, 2022. https://www.frontier.com/blog/how-does-choosing-fiber-internet-benefit-environment.

Heyninck, Geert. "Fiber for a Sustainable Broadband Future." Nokia Blog. March 17, 2021. https://www.nokia.com/blog/fiber-for-a-sustainable-broadband-future/#.

"IEA Study Sees AI, Cryptocurrency Doubling Data Center Energy Consumption by 2026." Data Center Frontier. March 9, 2024. https://www.datacenterfrontier.com/iea-study-sees-ai-cryptocurrency-doubling-data-center-energy-consumption-by-2026.

International Energy Agency. Electricity 2024: Analysis and Forecast to 2026. 2024. https://iea.blob.core.windows.net/assets/18f3ed24-4b26-4c83-a3d2-8a1be51c8cc8/Electricity2024-Analysisandforecastto2026.pdf.

"Copper Prices - Historical Chart and Data." MacroTrends. Accessed September 12, 2024. https://www.macrotrends.net/1476/copper-prices-historical-chart-data.

Microsoft Corporation. How Can We Advance Sustainability? 2024 Environmental Sustainability Report. 2024. https://www.microsoft.com/sustainability-report-2024.

McKinsey & Company. The State of AI in 2023: Generative AI's Breakout Year. August 1, 2023. https://www.mckinsey.com/insights/the-state-of-ai-2023.

"OpenAI CEO Altman Says at Davos Future AI Depends on Energy Breakthrough." Reuters. January 16, 2024. https://www.reuters.com/article/openai-davos-energy-breakthrough-idUSKBN1ZZ000.

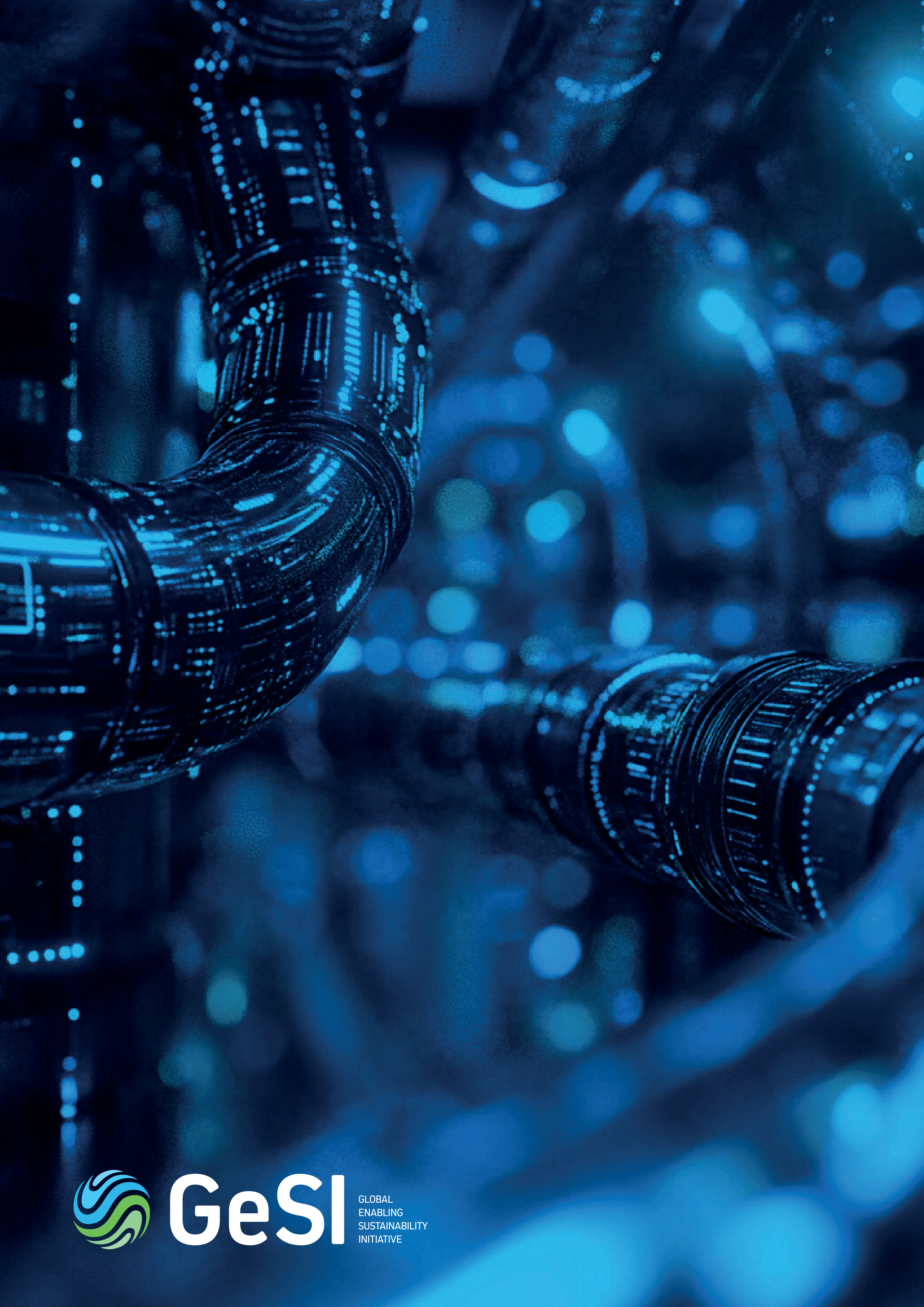
Patel, Dylan, Daniel Nishball, and Jeremie Eliahou Ontiveros. "AI Datacenter Energy Dilemma - Race for AI Datacenter Space: Gigawatt Dreams and Matroyshka Brains Limited by Datacenters Not Chips." SemiAnalysis. March 13, 2024. https://www.semi-analysis.com/articles/ai-datacenter-energy-dilemma.

Samantha Murphy Kelly, "Still love your landline? Phone service providers are getting closer to phasing it out," CNN, February 5, 2024, https://www.cnn.com/2024/02/05/tech/landline-phone-service-phasing-out/index.html. Accessed September 20, 2024.

Sustainable Digital Infrastructure Alliance (SDIA). Utility of the Future Report. Accessed September 12, 2024. https://sdialliance.org/resources/utility-of-the-future-report/.

"Telefónica Closes All Its Copper Central Offices." Telefónica. April 19, 2023. https://www.telefonica.com/en/communication-room/press-room/telefonica-closes-all-its-copper-central-offices/.

"UK Designates Data Centers as Critical National Infrastructure, Enhancing Support and Economic Growth." Industrial Cyber. September 12, 2024. https://industrialcyber.co/critical-infrastructure/uk-designates-data-centers-as-critical-national-infrastructure-enhancing-support-and-economic-growth/.



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