



Sustainable by Design: Foundations for a Just and Green Digital Infrastructure

A Position Paper Contributing to CODES Shift 2 on Sustainable Digital Infrastructure

By the Coalition for Digital Environmental Sustainability (CODES)

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INTRODUCTION

Digitalization is proving ever more clearly to be a double-edged sword. On one side, digital technologies are widely regarded as a cornerstone of sustainable development: they streamline processes, open up access to knowledge, and speed up the innovations needed to protect the climate and conserve resources. Concrete applications for the environment already span a wide range, from smart energy and grid management to environmental monitoring and climate modeling.



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On the other side, building the digital infrastructure that makes all of this possible carries a mounting environmental cost of its own. The information and communication technology (ICT) sector is already responsible for a sizeable portion of global greenhouse gas emissions and its energy and water demands are climbing steeply as data centers, networks and connected devices multiply. Its appetite for raw materials is immense, and at the end of the product life cycle, electronic waste is piling up faster than recycling systems can cope.

Layered on top of these environmental pressures are structural and social imbalances, ranging from a widening digital divide and the concentration of market power in the hands of a few corporations to the exposure of infrastructure to the impacts of climate change.

The Coalition for Digital Environmental Sustainability (CODES), established under a United Nations mandate, outlines how this tension might be eased through its three “shifts”—Align, Mitigate, and Accelerate: aligning digitalization with sustainability goals, curbing its harmful side effects, and deliberately steering digital innovation toward sustainable development (CODES 2022).

Digital infrastructure is expanding rapidly across the globe. The decisive question, however, is not *whether* it will grow, but *how*.

DIGITAL INFRASTRUCTURE AS THE FOUNDATION FOR SUSTAINABLE TRANSFORMATION AND GLOBAL COMPETITIVENESS

A high-performing digital infrastructure is the indispensable precondition for delivering the core objectives the CODES coalition sets out (CODES n.d.). Yet that same foundation is also the source of the environmental burden described above. The energy, water and material demands of digitalization do not arise in the abstract; they are generated by the physical build-out of data centers, networks and devices. The way this infrastructure is designed, sited, powered and retired therefore determines whether it becomes a lever for sustainability or an accelerant of environmental harm. The “how” is, at its core, an environmental question.

It is not, however, only an environmental one. How infrastructure is built also determines who gets to use it at all, and on this measure the global picture is starkly uneven. Data from the International Telecommunication Union (ITU) document a still-severe global connectivity gap. While connectivity is treated

as a pillar of daily life in developed regions, billions of people worldwide remain offline, the majority of them living in the Global South (ITU 2025a). For these regions, building basic infrastructure and fostering digital capabilities is existential if they are not to be permanently cut off from the global economy.

The growth pressure exerted by artificial intelligence (AI), cloud computing and the Internet of Things sharpens this global inequality further and, in doing so, magnifies the very environmental pressures set out at the outset. While AI-induced productivity gains could raise the level of global GDP by nearly 4 percent within a decade, advanced economies stand to benefit disproportionately (Cerutti et al. 2025); the United States alone controls an estimated 74 percent of global high-end AI supercomputing capacity (Haag 2025). Economic regions without access to state-of-the-art computing power, cloud infrastructure and specialized semiconductors risk being left behind (Cerutti et al. 2025). This dynamic could also trigger a “reshoring” of economic activity toward technologically advanced regions, further widening the income gap between the Global North and the Global South. The competitive logic this creates is powerful: firms



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and states race to expand compute capacity to remain viable—but that same race is what drives the surging electricity use, water consumption and resource extraction that make digitalization an environmental concern in the first place. The competitiveness imperative and the environmental imperative are thus two sides of a single build-out.

This is the question at the heart of this CODES position paper. Its core argument is that digital infrastructure can only become a lever for a “Sustainable Planet in the Digital Age” if the way it is built is itself sustainable: environmentally, structurally and socially. The section that follows therefore begins by examining the principal environmental, structural, and social challenges posed by the expansion of digital infrastructure, before turning to concrete solutions.

KEY ECOLOGICAL CHALLENGES

The ICT sector faces a set of closely interlinked ecological challenges that span its entire value chain – from energy use and emissions through raw material extraction and water consumption to electronic waste. These ecological costs are often intensely local in character, concentrated at the specific sites where water is drawn, power is consumed and e-waste is ultimately discarded, while the resulting infrastructure is used globally and without reference to place. A user issuing a query or streaming a video rarely perceives the local water stress or grid pressure their use has helped to create, and this disconnect between where the cost falls and where the benefit is enjoyed weakens the feedback loops that might otherwise translate local impact into demand-side accountability.

ENERGY & EMISSIONS

ICT contributes substantially to the global ecological footprint and is responsible for an estimated 1.5% to 4% of worldwide greenhouse gas emissions (ITU / World Bank 2024). Around 6% to 12% of global electricity consumption is attributable to the production and use of digital devices, networks and infrastructures (UNCTAD 2024). Data centers are a particular

focus, as their electricity consumption rose to around 485 TWh in 2025 – equivalent to the demand of the whole of France – and could roughly double to around 950 TWh by 2030 (IEA 2026). A key driver of this development is artificial intelligence, whose required computing power is doubling every 100 days, driving energy demand to grow by 26% to 36% annually (ITU n.d.).

MATERIAL BASE & RAW MATERIAL EXTRACTION

Beyond its energy demand, the sector’s footprint extends deep into the supply chain, as the build-up of digital infrastructures is associated with enormous resource intensity: while manufacturing a two-kilogram computer requires around 800 kilograms of raw materials, a smartphone requires around 70 kilograms (UNCTAD 2024). Technological complexity is increasing steadily, so that modern smartphones today contain up to 63 different chemical elements (UNCTAD 2024). Particularly critical is the rising demand for minerals such as lithium, cobalt and graphite, which is expected to increase sharply over the coming decades (UNCTAD 2024). As extraction and processing are often concentrated in a few countries such as the DR Congo or China, geopolitical dependencies arise alongside massive ecological costs caused by environmental degradation and water pollution in the mining regions (UNCTAD 2024). China alone supplies 99 % of the world’s gallium (used in power electronics), controls 95 % of the market for high-purity silicon battery manufacturing capacity (IEA 2026).

WATER CONSUMPTION

This pressure on natural resources is mirrored in the sector’s water footprint: the water consumption of digital infrastructures, in particular data centers, has developed into a critical environmental risk, as these facilities require enormous amounts of water for their cooling systems (ITU / World Bank 2023).

The largest share of the sector’s water footprint occurs beyond the physical boundaries of data centers. The IEA estimates global data-center water use at



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around 560 million cubic meters per year, with around two-thirds of this volume stemming not from on-site cooling, but from the electricity generation required to operate the servers. Under the IEA base-case scenario this demand driven largely by AI could more than double to about 1.2 billion cubic meters by 2030. Much of the true water burden is therefore shifted upstream to power-producing regions that may lie far from where the computation takes place (IEA 2025). Google's sites alone consumed over 21 million cubic meters of water in 2022, and consumption is rising sharply (UNCTAD 2024). Between 2021 and 2022, Google recorded a 20% increase in its water use, while Microsoft's rose by as much as 34% over the same period (GI 2025).

In the US, data centers could require between 2.6 and 5.5 million cubic meters per day of new water supply capacity by 2030 – comparable to New York City's average daily water supply (Han et al. 2026). Competition for water is particularly problematic in water-scarce regions: according to an analysis by Bloomberg News, around two-thirds of the new data centers built or under development since 2022 are located in places that already suffer high water stress (Nicoletti et al. 2025). Beyond cooling, the digital infrastructure's water footprint extends upstream into chip manufacturing itself: semiconductor fabrication relies on vast quantities of ultrapure water and the sector's global consumption already reached an estimated 751 million cubic meters in 2021. This demand is set to intensify further, as the advanced 3- and 5-nanometer process nodes underpinning AI hardware require substantially more water per chip than previous generations (GI 2025).

E-WASTE

At the end of the life cycle, these challenges culminate in a growing waste problem: in 2022, the world generated a record 62 million tonnes of electronic waste, with e-waste generation growing almost five times faster than documented formal collection and recycling (Baldé et al. 2024). Only about 22.3% of global electronic waste was documented as collected and processed in an environmentally sound

manner. Of the metals contained in this e-waste, worth an estimated US\$91 billion, only US\$28 billion were recovered (Baldé et al. 2024). Within digital infrastructures, the short hardware refresh cycles in data centers in particular aggravate the problem, as servers are often replaced after only a few years (ITU / World Bank 2023). Developing countries bear the main burden of these ecological costs through illegal exports of electronic waste and inadequate formal recycling systems, leading to severe environmental and health damage from pollutants such as mercury (UNCTAD 2024).

STRUCTURAL AND SOCIAL CHALLENGES

Beyond these ecological pressures, the expansion of the ICT sector raises an equally pressing set of structural and social challenges. The very infrastructures that drive its environmental footprint also determine who benefits from digitalization, who controls it, how resilient it is in the face of a changing climate, and how transparently its impacts can be measured at all.

UNEQUAL INFRASTRUCTURE: THE DIGITAL DIVIDE DEEPENS GLOBAL INEQUALITIES

The uneven build-up of digital infrastructures entrenches global inequalities by deepening existing socioeconomic divides. Foreign investment, moreover, is heavily concentrated in a few markets: in the Global South, 80% of projects flowed into just ten economies, while core infrastructures in the least developed countries remain chronically underfunded (UNCTAD 2025). In the age of artificial intelligence, this divide threatens to create a “two-speed world” in which a privileged minority benefits from innovation while marginalized groups, particularly in rural areas of less developed countries, increasingly fall behind (ITU 2025a).

MARKET CONCENTRATION AND SOVEREIGNTY: DEPENDENCE ON A FEW CORPORATIONS



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Closely tied to the question of who gains access is the question of who controls the underlying infrastructure, which today is marked by a massive market concentration that endangers the digital sovereignty of many nations and regions (ITU 2025a). This becomes particularly evident in cloud computing, where at the end of 2023 just three US corporations – Amazon Web Services, Microsoft Azure and Google Cloud – controlled almost three quarters of the global market (CODES 2024a). The concentration is even more extreme in specialized AI infrastructure: only 16% of countries host any AI-specialized cloud capacity at all, and 90% of that capacity is concentrated in the United States and China (Aczel et al. 2026). This dominance is increasingly extending to the physical level: hyperscale technology companies now play a leading role in financing new submarine cable systems, extending their control over international data flows (ITU 2025a). This concentration of market power in the hands of a few players creates critical dependencies that restrict competition and increasingly displace local providers (EDPS 2015, UNCTAD 2025). As cloud solutions and networks must now be regarded as critical infrastructure, their concentration in the hands of a few global conglomerates leaves societies and economies vulnerable to political tensions and security risks (EDPS 2015).

CLIMATE RESILIENCE: INFRASTRUCTURE AS A VICTIM OF CLIMATE CHANGE

Beyond these questions of access and control, the infrastructure itself is becoming increasingly fragile, as digital infrastructures are turning into victims of climate change: extreme weather events such as flooding, heatwaves, storms and rising sea levels massively threaten the physical basis of global connectivity (ITU / World Bank 2023). While heatwaves push cooling systems to their limits and can lead to critical outages – as the 2022 heatwave demonstrated at Google and Oracle data centers in Europe – flooding can destroy hardware and shorten the planned service life of infrastructure facilities (ITU / World Bank 2023). Low- and middle-income countries, which are often located in geographically

vulnerable coastal areas, are particularly at risk (ITU / World Bank 2023).

THE TRANSPARENCY AND DATA GAP: A LACK OF RELIABLE MEASUREMENT OF THE ICT SECTOR'S ECOLOGICAL FOOTPRINT

Underlying all of these challenges is a more fundamental problem of visibility: one of the greatest obstacles to sustainable digitalization is the lack of a reliable data basis on the ecological footprint of the ICT sector, as most countries have so far carried out no systematic measurement of greenhouse gas emissions and energy consumption at the national level (ITU / World Bank 2024). France is regarded as a global pioneer here: its regulatory authority, Arcep, was the first regulator in the world to collect and publish detailed environmental data on the ICT sector on the basis of a legal mandate (ITU / World Bank 2024). While large listed companies do publish ESG reports, these often lack both a country-level breakdown of the data and a consistent allocation of emissions to direct emissions, indirect emissions from purchased energy, and other indirect emissions along the value chain in the sense of the Greenhouse Gas Protocol (ITU / World Bank 2024, ITU 2025b). Amazon (AWS) illustrates this gap: despite reporting the largest location-based scope-2 emissions of all major providers, the company does not disclose its electricity consumption, making it impossible to derive the carbon or water intensity of its operations (de Vries-Gao 2026). The gap is particularly glaring with regard to water consumption and the recording of e-waste volumes, as fewer than one third of data center operators, for instance, systematically measure their water requirements (ITU / World Bank 2023).

LEVERS FOR SUSTAINABLE DIGITAL INFRASTRUCTURE

The challenges set out above are interlinked, and so are the responses to them. The levers below follow a single thread: from the physical and material core of the infrastructure outward to the people it must serve, and finally to the governance that holds the



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whole system accountable. Part A addresses the ecological footprint of the build-out (energy, materials, water and e-waste); Part B addresses who gets access and who controls the infrastructure; and Part C addresses the cross-cutting conditions of governance, resilience and transparency, on which every other lever depends. Throughout, the aim is to relieve all environmental pressures at once, rather than easing one, such as energy, at the expense of another, such as water or raw materials.

A. REDUCING THE ECOLOGICAL FOOTPRINT OF THE BUILD-OUT

The footprint of digital infrastructure can be tackled along a progression that moves from inside the facility outward to the surrounding energy system.

Efficiency Gains Are the Foundation, Not the Finish Line

The foundation lies in reducing waste inside the facility. Virtualization can maximize server utilization and lower idle-state consumption, while energy-efficient IT components cut electricity demand. Because replacing hardware also carries an embodied cost in raw materials and e-waste, efficiency gains should be weighed against the footprint of new equipment rather than pursued through ever-shorter refresh cycles (ITU / World Bank 2023). Furthermore, efficiency gains are no guarantee of a lower absolute ecological footprint: through rebound effects, total energy consumption can keep rising despite technical progress, because the volume of AI queries grows faster than efficiency gains can offset it (Aczel et al. 2026, Behrendt et al. 2026).

Circular-by-Design as the Standard Approach

The sector's material footprint is the product of a linear model of extraction, manufacture, use and disposal; shifting it onto a circular footing is the central lever for easing both raw-material extraction and the mounting e-waste burden (UNCTAD 2024). The most effective intervention sits at the design stage:

“circularity by design” means engineering devices for durability, repairability and modularity, assessed against standards such as ITU-T L.1023, and reinforced by extended producer responsibility rules that hold manufacturers accountable across the life cycle and fund collection systems (ITU / World Bank 2023, Baldé et al. 2024). Extending product lifetimes is the most direct countermeasure to planned obsolescence. In data centers, refresh cycles of often just one to five years could be extended to up to ten years through secondary use, and a guaranteed right to long-term software updates would help keep functional hardware in use (ITU / World Bank 2023). Second-life strategies, such as refurbishing servers and reusing drives and memory modules, can be encouraged through tax incentives, and the recovery of critical minerals such as lithium and cobalt can be scaled to ease primary extraction (ITU / World Bank 2023, UNCTAD 2024). Because many countries in the Global South lack adequate recycling capacity, targeted technical and financial transfer is needed to build formal systems that replace hazardous informal practices (UNCTAD 2024). Finally, cross-border waste flows must be governed far more tightly: consistent enforcement of the Basel Convention, sanctions for illegal exports, and end-to-end documentation duties prevent low-income countries from bearing the environmental burden of the Global North (ITU / World Bank 2023).

Closed-Loop Cooling and Heat Reuse Cut the Water Footprint

Because cooling often accounts for a large share of total consumption, the method chosen matters for water as much as for energy. Water-light approaches such as closed-loop direct-liquid or immersion cooling should be preferred over water-intensive evaporative cooling, and waste heat can become a resource where data centers act as “prosumers,” feeding thermal energy into urban district-heating networks (ITU / World Bank 2023). Water itself must be managed as deliberately as energy: closed-loop cooling, rainwater and greywater reuse, and the siting of new capacity away from water-stressed regions reduce competition for scarce supplies, while a



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dedicated metric, Water Usage Effectiveness (WUE), makes consumption measurable and comparable in the first place (ITU / World Bank 2023). A concrete example of tapping an alternative water source is Google's data center in Hamina, Finland, which has cooled its servers with seawater since opening: cold seawater is pumped through pipes left over from the site's former life as a paper mill into the facility's heat exchangers, kept separate from the freshwater circulating within them, and — once it has absorbed the heat — mixed with cooler seawater before being returned to the sea (GI 2025).

Beyond Green Claims: Ensuring Additional Renewable Energy Supply

Shifting to renewables is crucial to decarbonizing the sector. It must be ensured that the transition to renewable energy actually leads to the addition of new renewable energy capacity, rather than merely redistributing existing green capacity. Data centers can also facilitate the integration of variable renewable energy sources by providing a significant source of demand-side flexibility (RMI 2024).

B. INFRASTRUCTURE FOR ALL: ACCESS, EQUITY AND SOVEREIGNTY

If the build-out is to narrow rather than widen global inequality, access must be treated as a question of justice, and dependence on a few dominant providers must be reduced.

Closing the Rural Digital Divide Through Integrated Infrastructure and Financing

Closing the urban-rural gap means moving beyond purely market-driven models. A technology mix of fiber, mobile and satellite (notably low and medium Earth orbit) extends reach, while targeted financing instruments such as direct public investment, public funding, public-private partnerships, and green financing initiatives channel capital into areas where private investment alone is not initially profitable (ITU 2025a). Local internet exchange points (IXPs) further

reduce dependence on costly international bandwidth and improve network quality (ITU / World Bank 2023).

Lower Prices Start with Lower Barriers to Entry

As the cost of devices and services is the main barrier for low-income users, competition-friendly regulation that eases market entry and the mandatory sharing of passive infrastructure (masts, ducts) lowers both prices and deployment costs. Reducing import duties on entry-level smartphones and basic services, and strengthening secondary markets for refurbished hardware, helps bring access and connection to the 2.2 billion people still offline (ITU 2025c).

Reducing Dependence Through Local Capacity Building

Dependence on a few US and Chinese corporations is evident in cloud computing and increasingly in privately owned submarine cables (CODES 2024a, ITU 2025a). To reduce it, investment agreements should actively promote technology transfer on mutually agreed terms, licensing should prioritize regional providers, and open-source software and Digital Public Infrastructure (DPI) should be encouraged so that countries can build more durable and independent services (CODES 2024b, ITU / World Bank 2023). Targeted training of local engineers is essential to operate and maintain modern data and cloud infrastructure on the ground (ITU / World Bank 2023). Reducing reliance on primary raw materials from politically concentrated markets, such as China for rare earths, likewise strengthens supply-chain resilience and sovereignty (UNCTAD 2024).

C. GOVERNANCE FOR A RESILIENT AND ACCOUNTABLE INFRASTRUCTURE

Four cross-cutting conditions determine whether the infrastructure can be financed, governed and sustained responsibly over time: the right instruments must exist to steer capital and procurement, the



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rules must be fair across countries, its impact must be measurable, and it must withstand a changing climate. What cannot be financed cannot be built, what cannot be measured cannot be steered, and infrastructure that fails in a heatwave delivers no benefit.

Financial Incentives as the Key to Mainstreaming Green ICT

Governments can use green public procurement to mandate minimum efficiency standards for IT services (ITU / World Bank 2023); Germany's Blue Angel ecolabel for data centers, verified by an independent auditor mandated by the Federal Environment Agency (UBA), shows how such standards can be operationalized (ITU / World Bank 2023, UBA n.d.). On the capital side, green bonds and sustainability-linked loans channel investment into efficient and circular technologies, while tax relief for certified energy-management systems and subsidies for energy and water audits give operators further reason to optimize (RMI 2024, ITU / World Bank 2023). To avoid widening the digital divide, these instruments must remain accessible to smaller operators and providers in lower-income regions, not only to the largest incumbents. Strategic siting concepts can route computing power toward regions rich in renewable energy, provided relocation does not deepen the geographic concentration of digital capacity (RMI 2024).

Ensuring Access Through Fair International Rules

Equitable access ultimately rests on fairer global governance (CODES 2024c): affected communities in the Global South must be included in decision-making so that they share in the benefits rather than only bearing the ecological costs of extraction and e-waste (UNCTAD 2024). Embedding sustainability and transparency criteria directly into international internet standards helps create a digital architecture that is both efficient and fair (CODES 2024a, ITU n.d.).

What Isn't Measured Can't Be Governed

The single greatest obstacle is the lack of comparable data, as most countries still carry out no systematic measurement of the sector's emissions, energy and water use (UBA n.d., ITU / World Bank 2024). Governments should encourage companies to report annually across Scopes 1, 2 and 3 as well as on water and energy consumption, applying the Greenhouse Gas Protocol together with sector-specific methodologies such as ITU-T L.1450 (ITU-T 2025) and the life-cycle standard ITU-T L.1410 (ITU-T 2024) for consistency (ITU / World Bank 2023, ITU / World Bank 2024). Reporting must cover the entire value chain, since embedded emissions can account for up to 63 % of the footprint (ITU / World Bank 2024). Data center providers, manufacturers and states should make such data accessible through public registers like Brazil's PBGHG or the United Kingdom's company register (ITU / World Bank 2024). For data centers specifically, metrics beyond mere electricity use should be made mandatory. The widely used Power Usage Effectiveness (PUE) is a weak proxy, so WUE, the Renewable Energy Factor (REF), Carbon Usage Effectiveness (CUE) and the life-cycle-based KPI4DCE improve steerability across all resource dimensions (UBA n.d.). Realizing this requires telecommunications, energy and environmental regulators to build integrated datasets together, and national statistical offices to receive the support needed to capture digital environmental data systematically (ITU / World Bank 2024).

Protecting ICT as a Critical Infrastructure

The physical basis of digitalization, above all submarine cables, is increasingly exposed to both climate change and human activity. In 2024 the ITU and the ICPC established the International Advisory Body on Submarine Cable Resilience to improve coordination on repairs; this should be reinforced by multilateral frameworks that accelerate permitting for cable repairs and harmonize protection laws in coastal waters (ITU 2025a). For the growing number of connectivity satellites, stronger international coordination on debris management and the responsible use of orbits is equally needed (ITU 2025a).



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Resilience by Design

Resilience must become a core element of national digital strategies rather than an afterthought (ITU / World Bank 2023). Site-specific climate-risk profiles, incorporating factors such as flooding, heat and sea-level rise, should identify vulnerabilities early and guide the siting of new facilities toward lower-risk areas, drawing on long-term projections rather than historical conditions alone (ITU / World Bank 2023). Resilient design (elevating critical hardware,

earthquake-resistant construction, effective drainage) protects the physical base, while software-based redundancy and geographically distributed data centers maintain continuity when individual sites fail. Embedding explicit targets for decoupling digital growth from resource consumption into national plans ensures that the “twin transition” of digital and green is designed coherently (ITU / World Bank 2023, RMI 2024).

CONCLUSION: BUILD ONCE, BUILD RIGHT, BUILD GREEN

The analysis presented here leads to a single conclusion: the expansion of digital infrastructure is not a technical inevitability to be managed, but a choice to be made. The question is not whether digital infrastructure will grow, but how, and that question is, in the final analysis, neither a purely technical nor a purely environmental one. It is a political and ethical decision. Every data center that is sited, every network that is laid, and every device that is manufactured and retired encodes a set of choices: about whose emissions and water stress are tolerated and whose are spared; about who is connected and who is left offline; and about whether control over the digital foundations of modern life is concentrated in a few corporations or distributed more justly. Infrastructure is never neutral. To decide how it is built is to decide what kind of digital world it will sustain, and whose.

This is why sustainable digital infrastructure cannot be treated as one priority among many. It is the precondition for all three shifts that CODES set out in its Action Plan for a Sustainable Planet in the Digital Age. Sustainable-by-design infrastructure sits at the heart of CODES Shift 2 and is the explicit focus of CODES Impact Initiative 5 on Sustainable Digital Infrastructure. This position paper contributes to that endeavor, yet its argument reaches across all three shifts: get the foundation wrong, and every other ambition is built on sand.

The infrastructure decisions taken in this decade, driven by the compute demands of artificial intelligence, cloud computing and the Internet of Things, will lock in patterns of energy use, water consumption, market power and exclusion for decades to come, and retrofitting a misbuilt digital order is far costlier than constructing it correctly the first time.

The imperative is therefore simple to state and demanding to deliver: build once, build it right, build it green. Build once, by extending hardware lifetimes, embracing circularity and resisting the false economy of ever-shorter refresh cycles. Build it right, by treating connectivity as a question of justice and sovereignty rather than of markets alone. Build it green, by powering the build-out with genuinely additional renewable energy, managing water as deliberately as electricity, and siting capacity where it does least harm.

None of this can be achieved by any single state, regulator or company acting alone; it demands coordinated international action on common standards, shared metrics, technology transfer and multilateral governance of precisely the kind that CODES was created to convene.

Ultimately, the task is not merely to make data centers more efficient. Efficiency is necessary but not sufficient, and pursued in isolation it can become an alibi for leaving a system’s underlying logic unquestioned. Moreover, efficiency gains alone tend to generate rebound effects.

The deeper challenge is to transform the structures within which data centers operate: the concentrations of market power that decide who controls the digital economy, the standards that define what counts as sustainable, and the consumption patterns that treat finite resources as limitless. That is a transformation of political economy, not



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of engineering alone. This paper establishes the political framework on which it can be built: the shared diagnosis, the common vocabulary and the concrete levers. A sustainable planet in the digital age will not be the by-product of better technology; it will be the result of better choices.

Disclaimer: In preparing this paper, AI-assisted analysis (Gemini Notebook) was used to review the referenced sources in order to identify key challenges and potential levers. AI tools were also used to support the translation and language refinement of the document into English (DeepL Translator and Claude Opus 4.8, final Proofreading with Claude Opus 5.5). All outputs were reviewed and validated by the authors prior to publication.

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