CONTRIBUTIONS TO A FRAMEWORK APPROACH FOR SUSTAINABLE DIGITAL INFRASTRUCTURES

Current Developments and Leverage Points for More Sustainable Data Centers and Hardware

CODES

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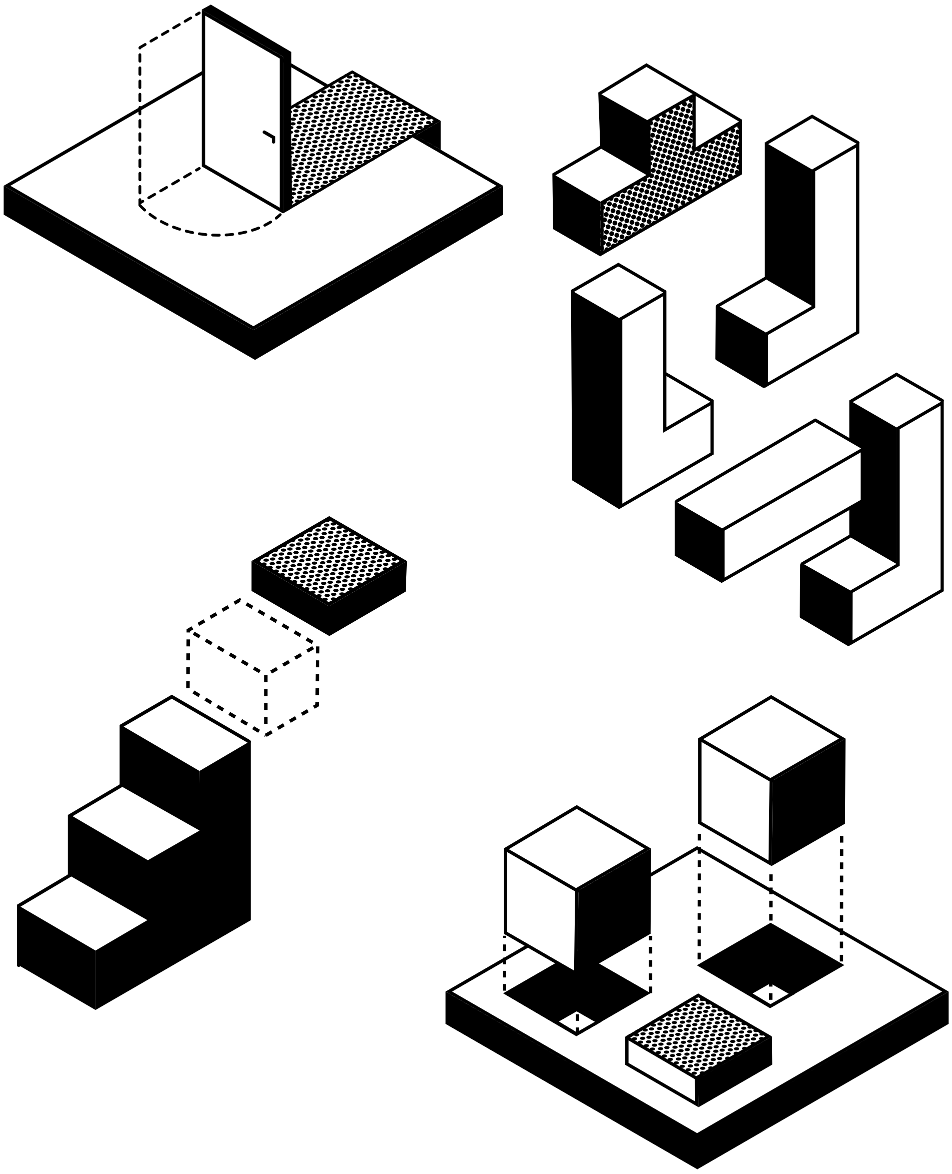

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1. INTRODUCTION - STEPS TOWARD A FRAMEWORK APPROACH

The digital economy continues to expand and in effect resource constraints regarding extractive minerals, energy use and other climate relevant effects of digital technologies are becoming more visible. Therefore, the environmental and social impact of digital infrastructure, data, data centres, network infrastructure, hardware and software have come into sharper focus. Data centres, crucial for the storage and processing of information, can have significant environmental footprints if not designed and managed thoughtfully. Additionally, the rapid evolution of networks and the proliferation of data generation in the context of AI raises questions about resource management, transparency, and community involvement. To navigate this complex landscape, it is essential to develop sustainability frameworks to balance regional differences with global standards. This requires collaboration between industry leaders, policymakers, civil society, and research institutions to ensure that digital transformation aligns with environmental goals and social equity.

The creation of such a framework is a milestone envisioned as part of the CODES Impact Initiative 5. Sustainable Procurement and Green Digital Infrastructure Pledge. The aim of Impact Initiative 5 is to create an international science-based framework to enable standardization and harmonization of sustainable procurement principles and green digital infrastructure criteria across governments, corporations and other stakeholders involved in planning, designing, financing and development of digital infrastructure worldwide. This paper captures the results of two workshops hosted in 2024 as part of a project created by the German Environment Agency (UBA) on behalf of the Coalition for Digital Environmental Sustainability (CODES), conducted by the Berlin-based organisations Konnektiv, SUPERRR Lab and Green Web Foundation. The workshops invited the CODES community and other leading experts working on sustainable digital infrastructures to discuss current technological and policy developments as well as potential leverage points for a framework approach. The workshops focussed on data centers and hardware as two specific building blocks for digital infrastructure, in accordance with the definitions and existing work conducted by UBA and CODES. The authors of this paper synthesised and further developed outcomes of the workshops in order to provide the following contributions for a framework approach for sustainable data centers and hardware, including recommendations for specific policy arenas to engage in.

2. DATA CENTRES, DATA AND NETWORKS

In the face of an increasingly datafied economy and big data, data has become a critical resource that can have enormous potential to achieve the SDGs. Data alone is not inherently valuable and should be dealt with as a raw material, it requires computational power to become a source of insight and information. As data volumes increase exponentially, so does the demand for the infrastructure needed to store, process, and transfer it through data centres and network systems. Data centers and networks are the backbones of digital infrastructure. Therefore, a holistic view of digital infrastructure as a 'means of production of digital resources' is needed, considering data centres as factories or logistics hubs, networks as roads and data as the packages that need processing and moving.

2.1. Current technology and policy developments impacting data centres, data and networks

The following are some of the policy relevant developments regarding sustainable data centres and networks identified and discussed throughout the two expert workshops hosted by CODES in 2024:

- Monopolistic ownership structures
- Environmental effects of data centres
- Data sustainability

A. Monopolistic Ownership Structures

By the end of 2023, Amazon Web Services, Microsoft Azure and Google Cloud owned and controlled almost ¾ of the global cloud computing market. These Big Tech companies are increasingly building and managing their own exclusive, fully integrated data centres, moving away from previous models that relied on shared facilities serving a broader range of clients. This shift represents a trend toward greater control and self-sufficiency in digital resource production by these major cloud providers. It is predicted that with the current rising demand for data centres and the doubling of the total number of hyperscale data centres worldwide that in the next five years, the biggest conglomerates will probably control at least 50% of **self-owned** and **self-built** data centres. Addressing monopolies in digital infrastructure is essential for building sustainable systems, as the concentration of power among a few tech giants can lead to inefficiencies, increased resource consumption, and limited competition. These monopolies often operate with little regulation and have vertically integrated structures that allow them to dominate not only digital services but also related sectors like energy and land use. By controlling these resources, they can drive unsustainable practices without accountability. Ensuring diverse, competitive, and accountable digital infrastructure is key to fostering innovation, reducing environmental impact, and aligning with sustainability goals. Furthermore, high concentration of market power allows leading providers to establish significant barriers to market entry through economies of scale, network effects and lock-in mechanisms. The European Union's Digital Markets Act, for instance, is a significant step toward addressing gatekeeping by major digital platforms. However, it falls short in fully tackling anti-competitive practices within the cloud computing sector, particularly by not thoroughly regulating certain types of software practices, such as bundling or limits to interoperability, that reinforce these dynamics.

As local communities and ecosystems are directly impacted by the environmental and socio-economic implications of unsustainable data centre and network practices, digital infrastructure must be treated as **critical infrastructure** and it would push policymakers to prioritise its sustainability in ways that benefit the broader public. By treating it as critical infrastructure, governments can use their leverage to introduce policies and funding programs that prevent monopolies, encourage competition, and incentivize green practices and influence procurement decisions, such as community-owned energy and interoperability, among others as mentioned above. Furthermore, impacted communities must be involved in the decision-making processes. Moreover, for governments, having their own data centers also provides a safer and more resilient alternative by ensuring greater control over sensitive data, reducing dependencies on private corporations, largely headquartered in other countries, and enhancing national security. Despite there being efforts by several governments, a global framework, which regulates digital infrastructure as critical infrastructure and synergises efforts, is still missing.

B. Environmental effects of data centres and networks and ways to optimise use of energy and other resources

Much of today's cloud infrastructure is based on architecture that is over 15 years old, characterised by **energy-intensive** and **always-on resources**. For example, water cooling is often employed to improve the energy efficiency of data centres. However, this practice can have significant local environmental impacts, as observed in places like Texas, where the use of water cooling is part of the broader strategy to reduce power costs. Additionally, they are responsible for 1% of Greenhouse Gas (GHG) emissions globally as well as **increasing e-waste**. Furthermore, the operation of telecommunication networks is increasingly putting a strain on the environment, also through GHG emissions from electricity production, energy and resource consumption and disposal during manufacturing, land use and energy and resource expenditure during installation. In addition, data centres and networks each account for 1 - 1,5% of global electricity use. Therefore, efforts to minimise their environmental impact and optimise their resource use are crucial. Such efforts include

- **Powering data centres with renewable energy sources** to reduce the reliance on fossil fuels and minimise carbon emissions.
- **The procurement and deployment of energy efficient and** green data centres and network system components, adopting advanced energy-efficient servers, network and cooling hardware.
- **Optimising data flow and minimising redundancies** in network paths is another measure aimed at reducing energy use and improving efficiency. This includes practices like edge computing, which processes data closer to users, minimising data transfer requirements.
- **Key performance indicators (KPIs)** that balance energy efficiency with reduced GHG emissions in network infrastructure.
- **Heat recapture** as an important measure for capturing and repurposing waste heat from data centres to provide heating for nearby buildings or industrial processes helps offset environmental impact and supports a circular energy system.
- **Recycling of network infrastructure**, not just deploying new devices. Managing e-waste proactively, alongside recognizing the

complexities of siting data centres and networks in regions with minimal regulation, often in global majority countries.

Thoughtful designs and practices do, however, exist; for example data centres in Switzerland and Finland which demonstrate effective use of underground spaces and renewable energy sources. Nonetheless, real-world examples of sustainable data centres remain underrepresented. In addition, the conversation around networks is currently moving beyond merely expanding infrastructure to include considerations of recycling network components and reducing the environmental footprint of digital services. It is important to note that improving data centre efficiency and access can lead to **rebound effects**, where gains in efficiency result in increased consumption. Addressing this requires a holistic shift from focusing solely on efficiency to achieving genuine environmental relief. It is clear that there is a need in more holistic policymaking and while some policies do exist, such as the EU Ecodesign Regulations for Servers and Data Storage Products, which includes schemes for the improvement of energy efficiency at component level, as well as national efforts, such as Singapore's temporary ban on new data centre building or Chile pulling Google data centre's permit, there is still a need for regulatory efforts on a global level.

C. Towards Sustainable Data Management & More Effective Environmental Policy

With the rapid expansion of digital infrastructure, traditional data management practices often overlook the environmental impact of the rising demand for digital data. Therefore, there is a need to shift towards sustainable data management practices. Sustainable data management is the practice of collecting, storing, processing, and sharing data in a way that minimises environmental impact, promotes efficient use of resources, and ensures ethical, equitable access to information. One essential aspect is **transparency** in environmental reporting for data centres, which should include open access to environmental data and indicators related to energy use, emissions, and resource consumption. This transparency can empower stakeholders and communities to hold data centres accountable and support policies that promote environmental protection. There is, therefore, a need for regulated environmental reporting standards for data centres. Germany has taken initial steps in this direction with the Energy Efficiency Act (EnEfG), which sets minimum efficiency standards and establishes an ambitious framework for energy use. Another critical dimension is **data sufficiency and quality**, which focuses on collecting only the necessary amount of high-quality data to achieve specific goals. This approach minimises environmental impact and avoids excessive data generation, aligning with the principle of "data sobriety." Publicly accessible, machine-readable data can enhance efficiency, but data collection should be restrained and purposeful. While it is embedded in related practices, such as data minimisation, e.g. for privacy in the GDPR, initiatives promoting data sufficiency for sustainability, such as the Global Reporting Initiative, need to be embedded in regulatory frameworks.
Sustainable data management is an essential part of effective environmental policy and open access to **environmental data will support more effective environmental policy**. Improved policies around the storage and accessibility of environmental data will be key to achieving this balance, addressing interoperability challenges, and supporting sustainable and fair data management practices. Finally, **community involvement in data generation and governance**, such as through models used in countries like Senegal, ensures that the data accurately represents the climate impact of digital infrastructure on local communities which can enhance **context specific policy making**. Additionally, inclusive data focuses on the participation and consent of local communities and thereby prevents data exploitation and advocates for fair data ownership.

2.2. Strategic Leverage Points

As mentioned above, sustainable data centres require a **holistic policy framework** which goes beyond merely calling for energy efficient infrastructure. The following can be strategic leverage points toward such a framework approach:

- Shifting the view to digital infrastructure as critical infrastructure data center ownership
- Approaching environmental impacts of data centers with site-specific tax incentives
- Creating a benchmark for data centre environmental impact whilst improving efficiency and optimised use of resources

Shifting the view to digital infrastructure as critical infrastructure & data center co-ownership:
A holistic approach to sustainable digital infrastructure must address the monopolisation of the building blocks of digital infrastructure and the high concentration of market power. Although several

countries have recognized data centers as critical infrastructure, integrating them into national security and economic frameworks, public or community co-ownership of digital infrastructure is less common. Ideas can be drawn from other digital infrastructures, such as telecommunication regarding the possibilities of community or public co-ownership. For instance, in the United States, hundreds of communities have invested in publicly owned wired telecommunications networks, many served by rural electric cooperatives. A framework approach could therefore include concepts around recognizing digital infrastructure as critical infrastructure and developing models of community and public co-ownership.

Approaching Environmental Impacts of Data Centers with Site-Specific Tax Incentives

Taxation and regulation of data centres are becoming essential as their growth impacts both local environments and economies. Many data centres are located in regions with **tax incentives and low regulatory standards**, such as in the US where environmental regulations are low, which can lead to resource-intensive practices and environmental costs that are not directly accounted for in operational budgets. Amortised costs for data centres generally cover expenses directly related to hosting, such as electricity, land, and cooling systems, but they rarely address broader environmental impacts, such as water scarcity or emissions from constant power usage. Incentives like tax breaks can make it financially viable to build data centres in resource-scarce areas like deserts, despite the high environmental cost of cooling and maintenance. However, these incentives should be carefully considered, as data centres differ significantly from traditional real estate investments, where long-term sustainability might not be a factor. A balanced approach to data centre taxation could include **environmental levies, carbon taxes, or location-specific impact fees,** ensuring that data centres contribute more holistically to the communities in which they operate. By **aligning tax policies with sustainable practices** and creating incentives for eco-friendly infrastructure, governments can help drive responsible growth in the data centre sector, balancing economic benefit with environmental stewardship. Such incentives exist in several countries, such as the Reduced Electricity Tax in Finland and Norway which is offered to data centres that meet certain energy efficiency criteria.

Creating a benchmark for data centre environmental impact whilst improving efficiency and optimised use of resources

Regulatory frameworks for data centres with a set of global standards or goals for varying site-specific differences are needed. Today, requirements for sustainable data centres vary greatly depending on geographical context. For instance, cooling solutions in arid regions like Saudi Arabia, the UAE, Spain, Chile and water-stressed areas of the US are fundamentally different from those in cooler climates like Norway. These differences mean that design efficiency goals cannot be one-size-fits-all; instead, they must be adaptable to local environmental and economic realities. Currently, regulations for data centres often lack the specificity needed to address these variations, making it difficult to apply a uniform standard globally. This highlights the need for a **bottom-up approach** to framework development, where local and regional conditions inform the criteria rather than relying solely on global mandates. Such an approach can ensure that data centres are not only sustainable but also align with the specific needs and challenges of the regions in which they are built.

- Such a framework for sustainable data centres would draw the vision for alternative approaches to digital centres in terms of sustainability and focus on regional demands. It must require uniform **settlement criteria** to set the standard for new data centre building. Settlement criteria are general guidelines used to identify suitable locations for data centres before specific projects are proposed. They assess the broader suitability of an area, ensuring that data centre projects are placed in locations that support sustainable and efficient operations from the start. These include criteria such as proximity to renewable energy sources, access to sustainable cooling options and minimised ecosystem disruption among others. Examples for settlement criteria already exist in countries such as the Netherlands.
- At the same time, this framework would identify standards for regional sustainable digital infrastructure which in turn define **local impact assessments**. Local impact assessments are specific, in-depth studies of a single proposed data centre project's effects on the surrounding environment and community. These assessments evaluate factors such as water usage, energy consumption, emissions, and

waste management, which can vary significantly based on local conditions. They are conducted later in the planning process, once a location is chosen, and provide detailed recommendations for reducing negative impacts. Additionally, local impact assessments provide insights into the socioeconomic implications of data c entres. Local impact assessments verify the adherence to the settlement criteria.

2.3. Key Policy Arenas for 2025

CODES can engage in different policy arenas in 2025 in order to advance the idea of a framework for sustainable data centres and networks. As digital transformation continues to accelerate, several key policy arenas in 2025 will shape the future of sustainable digital infrastructure, especially in more tech-heavy and globally diverse contexts and can become powerful partners for CODES:

- One of the major milestones is the *WSIS+20 Review Process*, which will provide a critical platform for integrating sustainability goals into global digital policies. This process emphasises the importance of ensuring representation from a wide range of expertise and stakeholders, fostering inclusive discussions about the future of digital governance.
- Another example is the *African Actors of Data Center Association (ADCA)* is actively seeking partners to promote green and sustainable data centres in Africa. As a group of industry leaders, ADCA's role is particularly relevant in driving the conversation around sustainable practices on the continent. Their planned events in 2025 offer valuable opportunities for collaboration and collective action towards sustainable data centre practices.
- Another significant platform is the *Internet Governance Forum (IGF)*, where discussions around the environmental impacts of digital infrastructure can be expanded. The involvement of the UN Tech Envoy will ensure that these discussions remain visible and aligned with broader UN sustainability goals. Additionally, multilateral development banks play a crucial role in setting investment criteria for infrastructure projects, making it essential to integrate environmental considerations into their funding decisions.
- Key events such as *COPs 29 and 30* will further highlight the intersection of climate action and digital transformation. Ministerial Declarations like the one on Green Digital from COP29 will likely shape global commitments to reducing the environmental impact of digital technologies. The *Declaration on Responsible AI for the SDGs*, spearheaded by BMZ and UNDP, will also be critical in aligning AI development with sustainability goals, emphasising the importance of responsible AI practices.
- Efforts to mainstream sustainability checks in public procurement, finance, and development cooperation will be vital in 2025. Organisations such as the *Open Compute Project (OCP)* and the regional Internet registry for Europe, the Middle East and parts of Central Asia, *RIPE NCC*, can help drive technical standards that align with environmental goals. Meanwhile, discussions on software foundations and *Capping AI* discourse will address the need for balancing technological advancements with their ecological footprint.

Collectively, these arenas represent key opportunities to advance the integration of sustainability into the digital sector, ensuring that as we build and expand digital infrastructure, we do so in a way that supports global environmental and social goals. By engaging in these spaces, stakeholders can help shape a digital future that is both inclusive and sustainable.

3. SUSTAINABLE DIGITAL HARDWARE

Hardware is a very broad topic area comprising hardware needed to run networks, data centres as well as consumer products. Today, the production of digital hardware is concentrated in a small number of countries and production facilities, primarily in regions with the infrastructure and capital to support large-scale manufacturing. Corporations based in these countries control much of the supply chain, from assembly lines to high-tech production processes. However, the environmental and social costs of this system are distributed far more widely. Communities around the world, particularly in the Global South, bear the brunt of these impacts, whether through extractive mining practices that degrade local ecosystems, or through the accumulation of e-waste shipped to regions lacking proper disposal or recycling infrastructure, shouldering the hidden costs of a system largely driven by a few major global players. A framework for sustainable digital hardware needs to address these disparities and power imbalances.

3.1. Current Technology and Policy Developments Impacting Hardware Sustainability

There are a number of current developments, both technological and policy developments impacting hardware sustainability. Understanding these current dynamics is an important prerequisite for the development of a framework for sustainable digital hardware. The most relevant dynamics identified in the two expert workshops hosted and discussed below are:

A. The Right to Repair
B. The digital product passport
C. Labour rights regarding e-Waste and extractive industries
D. Distributed manufacturing and circular economy
E. Software development and AI

A. The Right to Repair (R2R) as a Key Instrument for Sustainable Digital Hardware

The Right to Repair movement addresses the environmental and social issues arising from restrictive repair policies that favour frequent device replacement over reuse. By making repair knowledge, spare parts, and tools accessible, Right to Repair policies enable consumers to extend the life of their devices, reducing the need for frequent replacements. This approach helps combat the fast turnover of digital devices, which contributes significantly to e-waste. Right to Repair aligns with circular economy principles by facilitating repair, refurbishment, and reuse, keeping products in use longer. Initiatives such as open ledgers, like those pioneered by Leandro Navarro, track the lifecycle of second-hand electronics, making it easier for consumers and businesses to trace a device's history and determine its repair potential. This transparency fosters trust and fairness in the second-hand market, creating more sustainable, equitable electronics reuse systems. While progress is evident, international agreements on the Right to Repair face challenges. Manufacturers argue that protecting intellectual property and preventing counterfeiting are concerns, and some fear that unauthorised repairs could compromise safety or quality. However, advocates counter that well-designed right to repair legislation can provide necessary safeguards without infringing on intellectual property rights or product quality.

B. Hopes and Limitations for Digital Product Passports (DDP)

The Digital Product Passport (DPP) is a policy initiative from the European Union aimed at promoting transparency and sustainability in the lifecycle of digital products, both hardware and software. It provides detailed information about a product's origin, components, recyclability, and environmental footprint, facilitating a more circular economy for digital products. Further, the International Telecommunication Union (ITU) has developed frameworks and standards related to a global digital product passport (DPP), specifically for Information and Communication Technology (ICT) products, as part of its circular economy and sustainability initiatives. Key ITU recommendations, such as Recommendation ITU-T L.1070, outline the requirements and opportunities for a DPP aimed at fostering circularity and transparency within the ICT sector. This includes providing essential product information, like component durability, repairability, and recyclability, which can support responsible consumption and efficient lifecycle management for digital devices. The passports aim to streamline recycling and repurposing by providing information on how a product can be dismantled or recycled. Further, by making environmental impacts visible, the DPP incentivizes companies to adopt eco-friendly design principles, such as modularity for easier repairs, upgradability, and the use of sustainable materials. However, there are concerns including complexities in standardising data across various ICT devices and concerns about data privacy, especially when sharing detailed product information globally. Moreover, industry players may use DPP requirements as an opportunity to restrict repair and maintenance information to authorised service providers only. This could limit independent repair businesses and consumers from accessing necessary information or tools for repairs, which is particularly concerning in the Global South, where access to official service providers and resources is limited.

C. Labour Rights as Critical Policy Area for Sustainable Hardware Production

Labour rights are a critical but often overlooked aspect of sustainable hardware production and e-waste recycling, particularly in the Global South where informal recycling is widespread. E-waste recycling often takes place in informal or unregulated environments, where labour protections are minimal or non-existent. Workers, including children, are exposed to hazardous materials without adequate safety measures, fair wages, or job security. Recognizing and formalising these labour roles is essential for enforcing fair wages, proper categorization, and protective equipment. To address the lack of focus on labour rights, a shift is needed toward regulations that incentivize socially responsible recycling and reuse practices. Extended Producer Responsibility (EPR) is one such mechanism. By requiring producers to take responsibility for the entire lifecycle of their products, EPR can encourage safer, regulated recycling practices that integrate labour protections. Proper implementation of EPR can create formal job opportunities in recycling and refurbishment, helping to transition the workforce from informal to protected labour environments. To integrate labour rights into sustainable hardware production effectively, global and national policies must emphasise social justice and labour standards. This would involve updating EPR frameworks to include labour considerations, enforcing traceability systems that track working conditions, and supporting formalisation initiatives in recycling sectors. Such measures could shift the industry towards not only environmental sustainability but also social equity.

D. Localised and Distributed Manufacturing for Sustainable Hardware Production

Distributed manufacturing has gained attention as a sustainable approach to digital hardware production, offering potential environmental and social benefits through localised and decentralised production. This approach aligns with circular economy goals by enabling the on-demand, location-specific manufacturing of components, which reduces transportation emissions, encourages resource efficiency, and supports local economies. Part of the EU's Circular Economy Action Plan, the "Ecodesign for Sustainable Products Regulation" (SPR) promotes product durability, repairability, and recyclability, which aligns with the goals of distributed manufacturing. By mandating eco-design and repair-friendly practices, the regulation could drive demand for localised manufacturing of repair parts and recyclable components in the EU. New trade agreements and shifts in export controls, especially in the tech sector, influence where and how distributed manufacturing can expand. For instance, in the U.S., the CHIPS Act focuses on bolstering domestic semiconductor manufacturing, but it could have broader implications for distributed manufacturing in hardware.

E. Software Obsolescence and AI as Critical Factors for Hardware Sustainability

Software development significantly impacts the sustainability of digital hardware, especially as applications become more memory-intensive and computationally demanding. Key influences include rising energy consumption, increased demand for specialised hardware, and the acceleration of hardware obsolescence. Modern software applications, especially those using AI, are increasingly resource-hungry. Machine learning models and other AI-powered functions require substantial processing power, pushing existing hardware limits and increasing energy consumption. This trend is applications demanding more memory and computing power and shortening the useful life of hardware. AI is a particular concern because it drives demand for high-performance processors, GPUs, and specialised chips, all of which have high energy requirements. Policies are beginning to address software efficiency, with some governments exploring energy labelling for digital services and applications. These standards could incentivize developers to prioritise leaner, more efficient software, reducing the hardware demands and energy consuming applications. Although not yet mainstream, such policies would align software development with energy efficiency and environmental goals. The EU's SPR, for example, is encouraging sustainable practices in tech procurement, including requirements for recyclability and repairability, which could influence how AI-ready hardware is sourced and used. Moreover, sustainability-focused AI regulations could encourage optimised, resource-conscious AI models, mitigating the rapid obsolescence and environmental impact associated with intensive software applications.

3.2. Strategic Leverage Points

There are different strategic leverage points that can be harnessed when further developing a framework for sustainable digital hardware. These leverage points can include learning from previous policy interventions, understanding the most impactful topic areas for policy intervention as well as harnessing the power of collaboration by connecting relevant stakeholders:

Building Sustainable Hardware through Open-Source and Interoperability

Open-source technologies and interoperability are crucial for sustainable digital hardware as they support reuse, repair, and collaboration across hardware and software ecosystems. Open standards and compatibility can extend product lifespans, reduce e-waste, and empower consumers to make sustainable choices without being locked into proprietary ecosystems. Open standards and interoperability allow different components and devices to work together across brands and generations, making it easier to replace or upgrade specific parts rather than entire devices. For example, if hardware components adhere to common standards, users can replace a single component rather than discarding the whole device. Modular systems like Fairphone are based on this principle, demonstrating how open-source and interoperable design benefits both the consumer and the environment. The EU's regulation requiring a standard USB-C charger for electronic devices is a landmark in promoting interoperability. The policy eliminates the need for multiple chargers for different devices, reducing e-waste significantly. This directive also provides a model for other regions, showing how enforcing common standards across devices can reduce environmental impacts and simplify the consumer experience. It is vital to learn from policy success stories such as this one in order to understand where future leverage points for more sustainable hardware, based on interoperability and modularity can lie.

Leveraging Public Procurement for Sustainable Digital Hardware

By prioritising sustainability in procurement policies, governments can drive market demand for durable, repairable, and responsibly manufactured electronics, influencing manufacturers to adopt more sustainable practices across their product lines. Relevant public procurement strategies can include Here are several strategies for using public procurement to support sustainable digital hardware:

- **Mandating Sustainable Criteria in Procurement Contracts:** Governments can incorporate sustainability criteria into procurement requirements, mandating that devices meet standards for repairability, modularity, and durability. For instance, procurement guidelines could require adherence to specific certifications, such as TCO Certified, EPEAT, or Blue Angel, which assess products on environmental impact, material sourcing, and repairability.
- **Supporting Transparency and Material Reclamation:** Public procurement policies can demand transparency regarding sourcing and production practices. Companies like Fairphone, which disclose material sources and maintain commitments to fair labour practices, offer a model for transparency in digital hardware. This can also include mandating digital product passports to ensure traceability and facilitate end-of-life recycling or repurposing, contributing to a circular economy.
- **Promoting Long-Term Product Longevity and Total Cost of Ownership:** Governments can consider not only the initial purchase price of hardware but also the total cost of ownership, including maintenance, repair, and end-of-life disposal. By factoring in these long-term costs, procurement policies can favour products that are designed for longevity and easy maintenance.
- **Advocating for Open Standards and Interoperability:** To prevent technological lock-in and support a repair-friendly ecosystem, procurement policies can require that products use open standards and interoperable components.

Understanding and Connecting Certification Schemes for Sustainable Hardware

Blue Angel is Germany's national certification for environmentally friendly products and has expanded to digital hardware, including computers, monitors, and smartphones. The certification assesses criteria such as material health, energy efficiency, recyclability, and product durability. Blue Angel is known for its rigorous standards and focus on protecting both human health and the environment, making it a trusted certification for eco-conscious consumers in Germany and Europe. Around the world, different certification schemes exist, including:

- RMAP, managed by the Responsible Minerals Initiative (RMI), certifies that electronics producers source conflict-free minerals responsibly,
- EcoLogo, part of UL (Underwriters Laboratories) Environment, is one of North America's oldest environmental certification programs and includes digital hardware within its scope and
- The Global Electronics Council, EPEAT, a global certification for electronic products that meet high environmental and social standards.

An important step toward a global and encompassing approach to more sustainable digital hardware can be to foster dialog and exchange between certification bodies and understand what it would take to have a globally recognized certification for sustainable digital hardware.

Breaking Down Silos: Toward a Lifecycle Approach for Sustainable Digital Hardware
Current discussions around sustainable hardware are siloed. This means that for instance advocates for sustainability in extractive industries are not necessarily coordinated and working together with the right to repair movement or stakeholders working on topics like e-waste. A more holistic perspective is needed - one that encompasses the entire lifecycle of products, from mining raw materials to managing e-waste at the end of life. A holistic design philosophy that connects different phases of the product lifecycle can help avoid “carbon tunnel vision” and ensure that the entire environmental impact of digital solutions is considered. To this end, stakeholder engagement is critical. By bringing together groups focused on minerals, e-waste, and software, we can foster collaboration and share best practices across regions.

Focusing the Framework by Prioritising High-Influence Areas
Overall, it is important to recognize that the market-bound nature of hardware development often limits the reach of policies, especially when considering open-source innovation and community-driven approaches to product development. Therefore, it is important to consider where a framework for sustainable digital infrastructure could have the biggest effect, given current market dynamics. Instead of targeting all kinds of hardware at once, progressive policy stakeholders may want to focus on areas they can more easily influence, like network technology and publicly procured hardware, rather than focussing on consumer devices. A framework could initially target critical infrastructure components, such as routers, servers, and data centre hardware, which are heavily utilised in both public and private sectors. These areas have substantial environmental impact and, unlike consumer devices, are less subject to frequent replacement cycles, making them ideal for policies emphasising durability, repairability, and energy efficiency. Policy initiatives targeting network technology could emphasise modularity and repairability, ensuring that essential infrastructure can be maintained long-term without frequent replacements.

3.3. Key Policy Arenas for 2025

CODES can engage in different policy arenas in 2025 in order to advance the idea of a framework for sustainable digital infrastructure and hardware.

- The UN has a unique mandate to address these challenges by fostering communication across the value chain, from extraction to waste management. For example, initiatives like the *International Forum on Mining and Minerals* could address the need for a moratorium on unsustainable mining practices.
- Reports like the *UNCTAD Digital Economy Report 2024* underscore the importance of transparency in manufacturing. Member states can push for regulations that ensure products are only approved if they meet transparency standards. Additionally, global monitoring efforts and databases on e-waste can support this drive for accountability, helping countries better manage the lifecycle impacts of digital technologies.
- Furthermore, the *WSIS+20 Review Process* offers a unique opportunity to integrate sustainability into digital policies, while the UNFCCC COP meetings could provide a platform to improve the measurability of hardware’s environmental footprint. The *IGF Dynamic Coalition* on the Environment and the UN’s ongoing review of the Internet Governance Forum highlight the need to bridge discussions between resource management, digital policy, and environmental impact.
- Regarding the right to repair movement, multi-stakeholder alliances like the *PREVENT Waste Alliance* can help connect local repair communities to global policy dialogues, ensuring that solutions reflect the needs of diverse stakeholders.

4. RECOMMENDATIONS FOR CODES STRATEGIES AND ACTIVITIES

The CODES community can be an important driver of a framework for sustainable digital infrastructures. The following recommendations are possible activities for the CODES in this context:

4.1. Recommendations for Datacenters and Networks

The path toward sustainable data centres and networks requires a collaborative, multifaceted approach that balances regional, often **site-specific differences** with a growing set of global standards and goals. Actively building resonance between the normative guidance of (global) goals and the specificity of individual localities is a key leverage for building digital infrastructures that are just for the planet and its people. CODES and other stakeholders can play a critical role in this transition, fostering dialogue, research, and policy development to ensure that the digital transformation is both environmentally sustainable and socially equitable:

- The CODES community can advocate for the development of a set of criteria for assessing data centre environmental impacts. This includes providing the scientific basis for policy decisions, such as those related to the material footprint of data centres. Research projects could explore the entire value chain of data centres, from design to operations. CODES can serve as the connecting point between academia and policymakers.
- The CODES community can start working on a blueprint for a settlement criteria framework for the building of new data centres. The CODES community can connect government community stakeholders as well as the tech community in host countries to facilitate a bottom-up approach to such framework development
- By engaging in high-level regional discussions, CODES can advocate for the development of a prototype for assessing different regulatory approaches, capturing the complexities of diverse geographical and economic contexts.
- CODES could build a community of practice around sustainable data centres that would allow stakeholders to share knowledge and best practices.

4.2. Recommendations for Hardware

CODES can play a pivotal role in addressing current technology and policy developments and facilitating conversations and knowledge sharing between stakeholders in different areas like sustainable mining and end-of-life solutions in order to create a more holistic approach for sustainable digital hardware. Further, the CODES community can champion specific topic areas thus ensuring they are considered in relevant policy debates around sustainable hardware:

- CODES can advocate for interoperable hardware standards that simplify component replacement and recycling across manufacturers, similar to the EU charger standard. Emphasising modularity and compatibility will reduce e-waste and create opportunities for localised repair and recycling networks.
- The CODES community includes government stakeholders that can act as champions when it comes to procurement for sustainable digital hardware.
- The CODES community can help connect certification bodies and create a fora for global exchange on how to connect in order for certifications to be globally recognized and part of a more holistic approach to sustainable digital hardware.
- The CODES community can play an important role in de-siloing discussions and bringing together stakeholders who are not yet connected but working on different ends of the spectrum for sustainable hardware in order to build alliances and elevate the topic on relevant policy agendas.
- Leading a very broad discussion on sustainable hardware that may not be very impactful because of limited ways consumerism can be influenced by CODES and other policy actors. It may therefore be more effective for policy actors working toward a just and sustainable transition to focus on network and data centre related hardware. CODES can help focus the discussion and work on a framework for sustainable digital hardware concentrating on areas where the CODES community and other stakeholders can be most impactful.

5. CONCLUSION - CONSIDERATIONS AND STEPS TOWARD A FRAMEWORK

Digital infrastructure forms a complex system that requires strategic governance. However, a systems perspective is often missing - data, data centres, and networks do not exist in isolation but should be aligned with clear goals around the services they enable. Moreover, the role of international organisations should **shift from promoting specific tech-**

nologies to prioritising public interest, especially in the context of digital infrastructures. Communities must be at the heart of defining digital needs, emphasising socio-technical perspectives over purely technical solutions.

Sustainable management of digital infrastructure is complex due to the absence of clear, interpretable data that accounts for both immediate and long-term impacts. For instance, reducing cooling in data centres can save energy and decrease CO_2 emissions in the short term, making it appear more sustainable. However, less cooling can shorten the lifespan of hardware due to overheating, leading to more frequent replacements. This introduces additional emissions and environmental costs from the production, transportation, and disposal of hardware, potentially offsetting any initial energy savings. Defining sustainability in this context requires **considering the balance between operational efficiency and hardware longevity**, taking into account the cumulative impact of component production, energy use, and e-waste.

To address these complexities, it's crucial to **adopt a holistic approach to data collection** that encompasses the entire lifecycle of digital infrastructure components. Sustainability decisions that seem beneficial on a facility level may prove unsustainable when viewed from an industry-wide perspective, particularly when factoring in supply chains and e-waste. Developing standardised metrics and universally applicable guidelines can aid in interpreting data accurately across various scales, allowing stakeholders to better assess trade-offs and design infrastructure that balances immediate operational efficiency with long-term environmental stewardship.

Creating a sustainable digital future requires a comprehensive approach that addresses not only technological innovation but also social, economic, and environmental justice. By focusing on transparency, circularity, and international collaboration, we can ensure that the benefits of digital technologies are equitably shared while reducing their environmental impact. The path forward includes **building bridges between local efforts and global standards**, ensuring that digital progress supports a sustainable future for all. By addressing gaps in current policies and fostering global cooperation, a more sustainable and equitable digital future that balances the demands of technological innovation with the imperative to protect our planet can be achieved.

When designing a **framework for sustainable digital infrastructure** it is important to reflect whom this is for and what actors will be able to work with such a framework. A framework for sustainable digital infrastructure provided by CODES could fulfil different functions. It could provide policymakers at local, regional, and national levels with guidelines and standards for assessing the environmental impact of digital infrastructure projects, a framework to address the power dynamics of such projects, including data centres and networks. It would support the integration of environmental impact assessments (EIAs) into permitting processes and help policymakers establish benchmarks for compliance. Additionally, the framework could assist multilateral bodies, such as the UN, in aligning sustainability goals across nations, helping to set minimum sustainability standards on a global scale. Further, civil society organisations, environmental advocacy groups, and local communities could use the framework to understand and monitor the sustainability impacts of digital infrastructure projects in their regions. The key role for CODES is to create alliances and fora for different stakeholders to engage. By bringing decision-makers, financial investors, and UN bodies like ITU, UNDP, and UNEP together, CODES can promote a more holistic approach to digital sustainability, learning from EU frameworks while including partners from the Global South.