Briefing Note: Transitioning the UK Data Centre Sector to a Circular Economy Framework

Executive Summary

The transition from a linear "gold rush" to a circular data centre economy is a UK strategic imperative. It represents the only viable pathway to reconcile the exponential growth of AI and high-performance computing with the nation's Net Zero and resource security commitments. The future of the UK data centre is not as a siloed, power-hungry consumer of resources, but as a dynamic and integrated resource hub. In this new paradigm, data centres provide:

- **Compute**: Delivered with maximum efficiency and sufficiency.
- **Heat**: Acting as a primary thermal source for local communities.
- **Materials and components**: Serving as an "urban mine" for the critical materials, components, and devices that will feed the next generation of UK manufacturing.

Through the strategic levers of design, recovery, and collaboration, the UK can transform the data centre from a systemic bottleneck into a source of long-term competitive breakthrough. Every stakeholder, from operators and OEMs to policymakers and investors, has a critical role in activating this circular flywheel. Achieving this will secure the UK's long-term digital future, ensuring that the infrastructure of the AI age is as resilient and sustainable as the information it processes.

Framing the opportunity

The UK's digital infrastructure has moved from the background to the bedrock of modern society, earning its status as **Critical National Infrastructure (CNI)** alongside water, energy, and emergency services.[1] However, as we chase the AI "gold rush," our foundation remains surprisingly fragile. This sector is trapped in a wasteful **"take-make-dispose" model**, where aggressive hardware refresh cycles (as short as 12 months), reliance on the import of critical minerals, and poor asset visibility result in multi-billion-pound losses. This linear approach isn't just inefficient; but has the potential to overwhelm the energy grid among other resources, undermining the very resilience that the CNI designation aims to protect.

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[1] Rethinking the CNI designation is important, not all digital services are "critical." "Frivolous" services benefit from the same high-level infrastructure as vital ones, leading to massive resource waste.

To secure long-term competitiveness, the UK must pivot toward a broader **National Infrastructure Circular Transition**, with coherent, trusted, and comparable approaches across energy, water, carbon, and materials.

For data centres, this strategy proposes a shift from "disposable digital" to a sustainable ecosystem through targeted interventions: **DPPs enhanced traceability, Second-life IT VAT reductions**, **"Refurb by Default" mandates** and **Digital sufficiency programmes** for public tenders, establishing **National Component Reuse Hubs** and enforcing **Energy Reuse** standards for new and retrofitted builds. By industrialising component reuse into **Nationally Significant Infrastructure Projects (NSIP) Planning** and **unlocking secondary hardware lifecycles with firmware**, the UK can transform its data centres from resource-hungry liabilities into a resilient, high-performance backbone for the future economy.

Analysis of Systemic Bottlenecks and Infrastructure Strain

The current trajectory of the data centre industry is defined by an exponential surge in demand for compute capacity. The UK is the largest data centre hub in Europe FLAP-D[2] market, with London alone accounting for 80% of operational capacity. Massive institutional commitments, such as Amazon Web Services' £8bn investment and Microsoft's £30bn global deployment plans, indicate a market projected to grow by 20% over the next five years. However, this growth is increasingly constrained by systemic bottlenecks that threaten both operational uptime and national environmental targets.

AI-Driven Demand and the Sufficiency Dilemma

The rapid rise of Generative AI and Large Language Models has fundamentally altered the power, and material demands of global digital infrastructure. Global electricity consumption for data centres is projected to double by 2030, reaching 945 TWh; equal to the total annual usage of Japan. In the UK, this strain is even more acute, with compute demand forecast to increase 5.7 times by 2035, placing an unprecedented burden on the national grid and challenging the sustainability of current energy models.

Beyond energy and net-zero targets, the material lifecycle of data centre hardware presents a significant environmental crisis. Manufacturing these complex systems is highly resource-intensive, accounting for up to 65% of a server's total carbon footprint. As the industry pivots toward next-generation super-components, raw performance is being prioritised over efficiency, sufficiency, and circularity. This shift is creating a new wave of highly complex electronic waste that is significantly harder to recycle than previous generations, trapping the sector in a high-performance but fundamentally "linear" economy.

The analysis done by the DICE Network+ stakeholders' workshops and both primary and secondary research, reveals a chronic tendency toward over-provisioning to mitigate any perceived risk of downtime. Beyond rapid technological upgrades and Power Usage Effectiveness (PUE) efficiency mandates, hardware

[2] Frankfurt, London, Amsterdam, Paris, and Dublin

turnover is fuelled by infrastructure shifts (such as air to liquid cooling), security concerns, and cloud migrations. This is compounded by "comatose assets"; inefficient zombie servers kept running solely to avoid the perceived operational risk of decommissioning.

The Infrastructure Bottleneck: Power, Planning, and Land

The concentration of data centres in hubs such as West London and Slough has reached a point of infrastructure saturation. Grid overload in these areas has led to connection delays of up to ten years for critical non-digital projects, including housing and hospitals. Furthermore, approximately 20% of planned global data centre capacity additions by 2030 are considered at risk of significant delay due to electricity and planning constraints. (See Table 1 in Annex for a list of demand drivers and systemic constraints)

Circular Supply Chain Lack of Trust: Procurement and Financial Disincentives

A critical bottleneck identified is the lack of trust in Circular Business Models and, what experts call the "Sustainability Sandwich," where environmental objectives are squeezed by the competing pressures of price and rapid capacity delivery. This systematically devalues assets and reinforces a linear 'wasted' capital, where hardware is discarded every 3-5 years despite a functional 8–10-year lifespan.

Mapping the Digital Infrastructure Landscape: Findings

The DICE Network+ research and analysis of UK data centre documents reveal a landscape characterised by deep value leakage but high circular potential, at almost every stage of the lifecycle (see Figure 1).

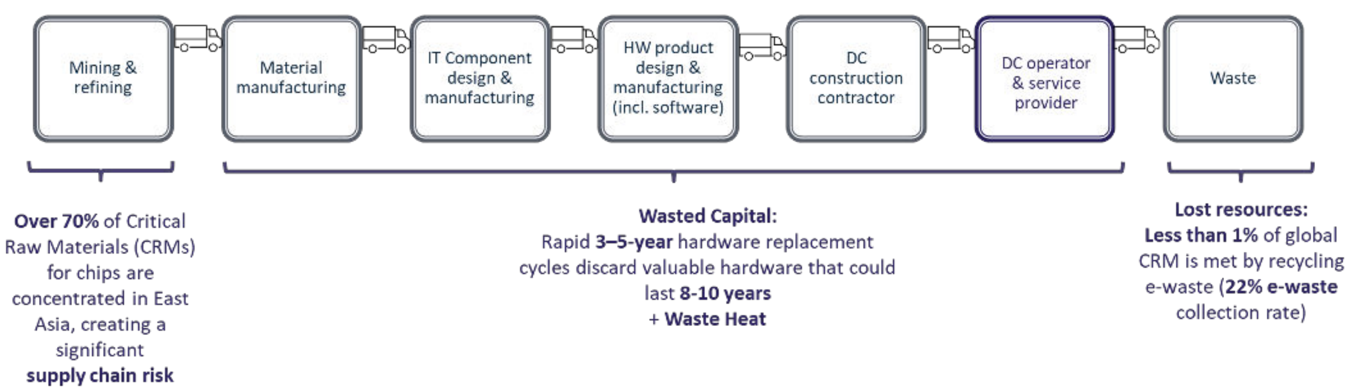

Figure1. Data Centre Supply Chain Value 'Leakage'

Financial and Material Value Leakage

The linear "take-make-dispose" model is not merely an environmental concern; it represents a profound financial haemorrhage. The aggressive replacement of servers results in "wasted capital," as high-performance hardware is discarded before its utility is exhausted. In 2022, the financial loss from unrecovered critical minerals in global e-waste reached USD 91 million. Furthermore, the sector fails to capture its largest waste stream: low-grade heat. Over 90% of electricity consumed by a data centre is dissipated as heat, yet the UK recovery rate for this energy remains a dismal 3-5%.

Supply Chain Risk and Geopolitical Exposure

The concentration of Critical Raw Materials (CRMs) for chip manufacturing in East Asia (where over 70% of the market is controlled) creates a significant geopolitical vulnerability for the UK's digital economy. The current model relies on the continuous extraction of virgin materials, making the UK's digital growth dependent on volatile international markets. Transitioning to a circular model that focuses on "urban mining" and component recovery is therefore essential to enable UK resilience.

The Problem of Asset Visibility and Trust

A fundamental barrier to circularity is the "Visibility Gap." Many operators lack unified visibility across their estates, meaning they do not know the age, utilisation, or exact health status of their assets. This prevents the effective planning of "cascaded" lifecycles, where hardware is moved from high-performance tiers to lower-tier workloads, which can also happen across industries (i.e., consumer devices). Furthermore, a lack of trust in "non-new" equipment prevents adoption; stakeholders don't trust the secondary market due to the absence of standardised testing and performance warranties, among other factors.

Circularity Opportunities for the Data Centre Industry

Lever 1 - Design for Value Retention

The greatest potential for systemic impact lies in embedding circular principles at the design and build phase. Proactive design shifts the focus from optimising solely for performance to a whole-lifecycle approach that prioritises repairability, upgradability, and material recovery.

- *Embracing Open Standards and Modularity*

The adoption of standardised layouts across Original Equipment Manufacturers (OEMs) is a critical enabler. Frameworks like those developed by the Open Compute Project (OCP)[3] eliminate vendor lock-in and enable interoperability, allowing flexible component (such as Network Interface Cards or storage bays) to be swapped and upgraded independently. This approach directly counters the "black box" design of legacy hardware, where a failure in one component often necessitates the disposal of the entire server. By designing systems where subsections can be replaced or repaired, the industry can significantly extend the lifespan of the most resource-intensive components. This is particularly vital as next-generation AI hardware becomes increasingly complex and integrated.

- *Design for Disassembly and Recovery*

To enable high-value recovery of CRMs, hardware must be designed for easy disassembly. Stakeholders proposed tool-less or low-tool disassembly and the dematerialisation of chassis structures. This allows for the high efficiency harvesting of chips and memory modules at the end of their first life. Currently, many

[3] https://www.opencompute.org/

printed circuit boards (PCBs) are shredded due to a lack of extraction infrastructure and diagnostic technology, leading to the total loss of valuable material content.

- *Liquid Cooling and Infrastructure Adaptability*

As compute densities increase, the industry is transitioning from air cooling to liquid cooling. This transition risks "stranding" legacy air-cooled racks that are still functionally useful. Circular design requires building infrastructure that can be retrofitted or repurposed for different cooling technologies over a 20–30-year lifespan, ensuring that the physical facility outlives multiple generations of IT hardware.

Lever 2 - Operate for Maximum Recovery

Designing for longevity is only effective if operations are transformed to capture asset value. This requires moving away from a mindset of "decommission and dispose" to one of "recover and redeploy".

- *The Secondary Market and Cascaded Lifecycles*

The global secondary server market represents a multi-billion-pound opportunity that remains largely untapped due to cultural and operational barriers. Hardware that is deemed "unfit" for high-performance AI workloads after three years often has many years of residual life for standard compute tasks, storage, or internal testing and development.

A graded performance approach would redefine the data centre as a tiered system rather than a binary new/old estate. Servers can be cascaded through proposed performance tiers:

- **Tier 1**: Leading-edge AI and high-frequency workloads (Primary life).
- **Tier 2**: Standard enterprise compute and web services (Secondary life).
- **Tier 3**: Long-tail storage, backup, and internal dev/test environments (Tertiary life).

- *Overcoming the Data Security Barrier*

Fear of imperfect data sanitisation is a primary driver of physical destruction policies, where functional drives and memory are shredded to protect against data leaks. Transitioning from physical destruction to auditable, certified software wiping is essential for preserving the functionality of data-bearing assets while maintaining security (e.g., see Blancco case example[4]). This allows high-value components to be safely restocked and reused, as demonstrated by the AWS re:Cycle hub, which supplies 13% of all spare parts needed for server repairs from retired inventory.

- *Hardware-as-a-Service (HaaS) Models*

Innovative business models, like HaaS, shift the focus from ownership to service loops. In HaaS, the provider retains hardware ownership throughout its entire lifecycle, fundamentally realigning their financial

[4] Blancco Hardware Decommissioning Services - https://blancco.com/

incentives toward durability, repairability, and high residual value. This model solves the "Sustainability Sandwich" problem by making the longevity of the asset a core part of the provider's profitability.

Lever 3 - Collaborate for Systemic Change

The data centre industry systemic challenges, of grid overload, supply chain risk, and e-waste, cannot be solved by individual companies in isolation. A consortia-led approach is required to create the market conditions for a circular ecosystem.

- *Industrial Symbiosis and Heat Reuse*

Reframing waste heat as a community resource is one of the most tangible opportunities for circularity. Data centres can be co-located with "heat off-takers" such as district heating networks, industrial greenhouses, or public swimming pools. For this to scale, systems thinking and infrastructure development collaboration is required to align the interests of Big Tech companies, data centre operators, local authorities, and utility providers. (See Microsoft's Community-First Infrastructure Initiative[5])

Germany's implementation of a minimum 10% Energy Reuse Factor (ERF) serves as a precedent for the UK. Startups like Heata[6] are turning waste heat into a resource by installing distributed server blocks in homes to provide residents with free hot water.

- *Strategic Integration with the Power Grid*

Data centres can act as stabilisers for the national grid through demand-side response and the second-life use of batteries. Large facilities often maintain massive Uninterruptible Power Supply (UPS) systems; circularity involves integrating these assets into "Virtual Power Plants" that can support grid resilience during periods of high demand. This approach helps mitigate the "tragedy of the commons" where shared infrastructure resources are depleted.

Actionable Policy Recommendations

To secure the UK's position as a global leader in digital infrastructure while meeting environmental imperatives, the following policy interventions are recommended:

1. Mandating Digital Product Passports (DPPs)

Introduce legislation to mandate DPPs for data centre hardware, starting with high-value components. DPPs create transparency by providing digital records of materials, carbon footprint, and repair instructions. This will:

- Enable "urban mining" by allowing refurbishers & recyclers to identify and recover CRMs efficiently.
- Build market trust by providing a verified history of hardware health and active hours.

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[5] Microsoft's plan to counter community resistance to AI data centres

[6] https://www.heata.co/

- Facilitate the transfer of ownership in secondary markets, reducing the "visibility gap".

2. VAT Exemptions for Refurbished Equipment and Repair Services

Current tax structures often penalise circular choices. The Treasury is advised to reduce or remove VAT on the sale of refurbished enterprise electronics and on repair services. This intervention would:

- Make refurbished hardware as accessible as new equipment, breaking the "Sustainability Sandwich".
- Stimulate a domestic repair economy capable of generating an estimated 31,000 jobs by 2035[7].
- Encourage businesses to choose reuse over replacement to save money and resources.

3. 'Refurb by Default' Public Procurement Policy

The UK government, as a major purchaser of digital services, should adopt a "refurb by default" policy for all non-critical public sector workloads. DEFRA has already begun piloting this approach.[4] Expanding this will:

- Create a "market pull" that de-risks investment in domestic second-life hubs that scan, categorise, and test devices for circular reuse or recycling.
- Reduce the public sector's digital carbon footprint and e-waste generation.
- Set a national standard for "performance-appropriate" procurement that private industry can follow.

4. Integration of Circularity into the NSIP and AIGZ Frameworks

Data centres opting into the Nationally Significant Infrastructure Projects (NSIP) regime or locating in AI Growth Zones (AIGZs) should be required to demonstrate integrated circularity and planning approval be conditional upon:

- A verified plan for waste heat utilisation with minimum ERF (i.e., 10%) for new and retrofitted buildings.
- Commitments to hardware second-life pathways or internal cascading.
- Use of competitive modular, open standards infrastructure to ensure facility longevity.

5. Mandatory Post-Warranty Firmware and Software Support

To prevent software-driven "planned obsolescence," the government should mandate that OEMs provide open-standard firmware post-first life or extended support after the initial 3–5-year lifecycle. This ensures that hardware remains functional for secondary users and prevents functional equipment from becoming obsolete due to a lack of software support.

[7] Green Alliance (2021) **Levelling up through circular economy jobs** https://green-alliance.org.uk/publication/levelling-up-through-circular-economy-jobs/

To achieve a circular digital economy (see Figure 2), stakeholders in the value chain must align on these key actions and benefits:

- **Operators:** Implement cascaded hardware lifecycles and heat reuse to reduce operational expenditures (Opex) and strengthen ESG compliance.
- **OEMs:** Design for modularity and provide post-warranty firmware to unlock secondary markets and ensure material security.
- **Investors:** Back HaaS business models to improve long-term asset resilience and mitigate investment risks.
- **Regulators**: Mandate DPPs and ERF targets to accelerate Net Zero progress and ensure grid stability.
- **Local Authorities**: Integrate data centres into local heat and power networks to provide affordable domestic heating and stimulate local job creation.

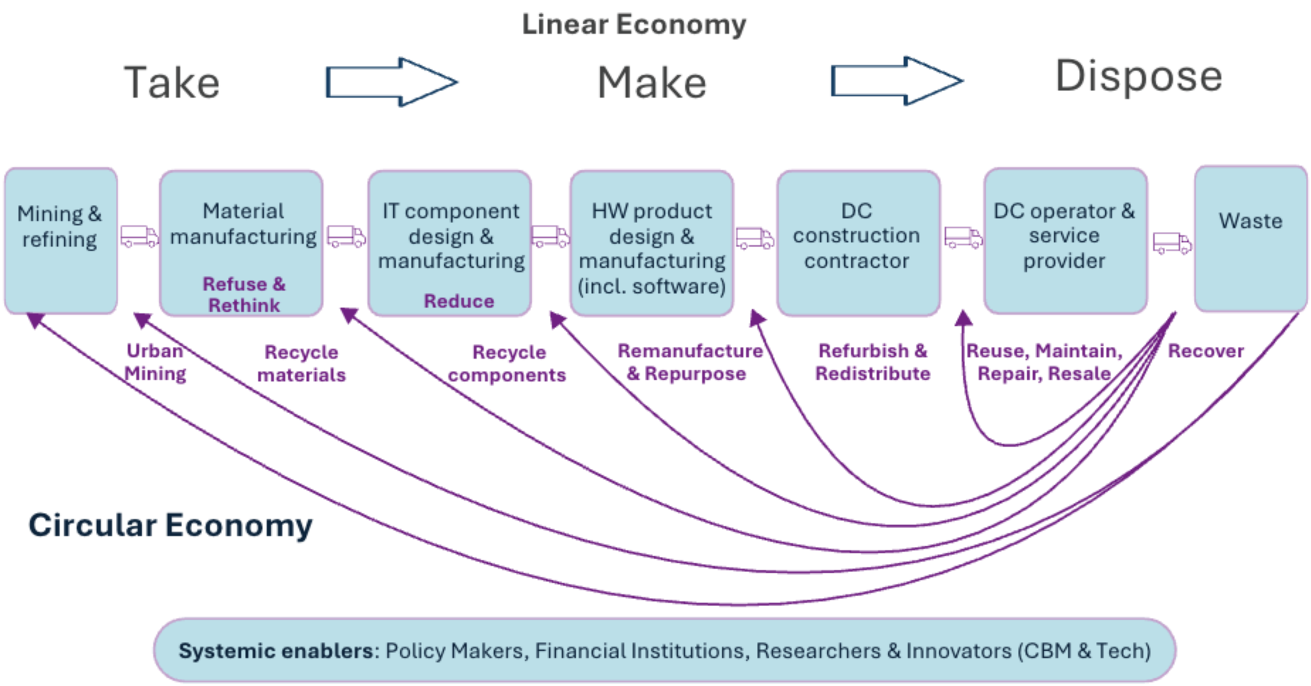

Figure 2. Data centre infrastructure circular economy system transition

Measuring Circularity: Metrics for the Digital Age

Traditional metrics like PUE are insufficient. While newer standards for water and carbon usage, such as those in the EU Code of Conduct, are improvements, they still fail to provide a complete picture.

- *Economic Value:* To measure economic value, governments should adopt **Digital GDP per kWh**. Current estimates of ~$150/kWh suggest that electricity is priced too low to incentivise meaningful efficiency gains.
- *Material Recovery:* To drive true circularity, we **must replace mass-based recovery targets with metrics focused on material criticality and value**. Current weight-based mandates prioritise heavy, low-value metals like steel, while ignoring the high-impact CRMs that are vital to supply chain security despite their minimal weight in hardware.
- *Digital Traceability:* Ensure a **high percentage of new hardware** is procured with DPPs to maintain full transparency.
- *Energy Efficiency:* Target **Energy Reuse Effectiveness** (ERE = PUE / (1 - ERF)), instead of only ERF, which accounts for both efficiency and recovered heat for local community use. Shift to a performance-based approach, prioritising how much work is actually being done relative to the energy consumed by servers (i.e., ITEE and ITEU from ISO 30134), making the distinction between "new" and "refurbished" components less relevant.
- *The Water-Energy Nexus:* **Water usage of the kWh of electricity generation**. Go beyond measuring water used for cooling, a holistic assessment must include the water saved at the power plant when the data centre reduces its electricity consumption, as electricity generation is water intensive.
- *Lifecycle Management:* Extend the **average functional life of hardware** to 8 years before it reaches final recycling stages.
- *Supply Chain Resilience:* Meet a **percentage of CRM needs locally** (i.e., >35%) through recovered streams to reduce reliance on virgin materials and geopolitical pressures

The DICE Network+

The DICE Network+ is a three-year UKRI EPSRC funded programme that seeks to leverage the power of the digital revolution to drive a circular economy across sectors and value chains. Led by the University of Exeter, our expert academic team comprises eleven investigators from nine UK universities. We are creating an inclusive, connected community harnessing interdisciplinary collaboration and research to guide industry partners, government bodies and policy makers towards a digitally enabled sustainable and circular economy.

Our work is focused on two key challenge areas:

- **EMBED:** Embedding sustainability and circularity within the design and development of digital and communication technologies.
- **ENABLE:** Realising the potential of the digital revolution to enable a circular economy across sectors.

By adopting a network of networks approach, harnessing interdisciplinary collaboration, research, and technological innovation, our network is a beacon for change, inspiring and guiding industries, policymakers, and communities towards a digitally enabled sustainable and circular economy.

We welcome engagement from policymakers, industry & academic partners DICE-Network@exeter.ac.uk

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For and behalf of the DICE Network+
With thanks to our contributors from the **DICE Network+ Data Centre Collaborative**
March 2026

Annex

Table 1 Data Centre Demand Drivers and Systemic Constraints.

Demand Driver	Quantitative Impact	Systemic Constraint
AI Workloads	5.7x national compute demand increase by 2035.	6–12-month hardware refresh cycles; rapid obsolescence.
Cloud Migration	£36.4bn pipeline in planned UK projects.	Grid connection wait times exceeding 10 years in London.
Data Sovereignty	6.9% of UK GDP is data-enabled.	Limited brownfield sites with necessary power densities.
High-Density GPUs	1.3 GW capacity in London; 170 MW under build.	Transition to liquid cooling strands legacy air-cooled racks.

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