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Transition Templates: AI and digital pathways to net zero+

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AI can be seen as the ultimate and most extreme manifestation of extractive technological accelerationism. The prodigious energy demands of running AI infrastructure threaten to eclipse the decarbonisation agenda, as the construction of new data centres multiplies energy use. The AI & Digital sector is one of five sectors under review in the Transition Templates: Pathways to Net Zero+ research project. Transition Template (TT) maps decarbonisation pathways in a four-step process. In this report, we describe how we use this preliminary TT process, as described in greater detail in a second RSD13 TT report,[1] to map energy pathways for the AI & Digital sector. AI & digital futures will be determined by the material and energy requirements of digital technologies to a degree that remains underexplored. Using tools including the Transition Templates Four Future Framework (TT-FFF), the research focuses attention on the ecological context and consequences of AI & Digital in ways that explore the aspirations and promises of AI while considering boundaries of resource and energy requirements. We focus on any possible decarbonisation of the sector, while keeping in mind how this sector's energy demands impact the renewable energy requirements of other sectors. The TT Four Future Framework pushes the AI & Digital Net Zero+ enquiry into space for our (hoped-for) capacity for planetary regeneration.

KEYWORDS: AI, digital, futures, climate change, decarbonisation, net zero, mapping, templates, transitions, pathways, transition design, systemic design, futures

RSD TOPIC(S): Mapping & Modelling, Methods & Methodology, Sociotechnical Systems

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[1] *https://rsdsymposium.org/pathways-to-net-zero-transition-templates/*

Report Introduction

The dominant narrative of technology is one unimaginably vast body of water moving in one pre-ordained direction, inexorably leading to a utopian ocean. This metaphor is made explicit by Amazon, one of the world's largest tech platforms and a mass retailer that operates at a planetary scale. In contrast, relational thought encourages ways of thinking of not one technology future but of interconnected futures – of tributaries, streams, stormflows, eddies, and lakes threaded through infinitely varied ecosystems, and all heading towards diverse destinations.

Digital technologies and rapidly growing AI infrastructures present specific and densely interwoven challenges in the area of climate change and wider ecological crises. Current developments in this sector are dramatically accelerating greenhouse gas emissions. When considering AI and digital ecologies, it is difficult to disentangle the socio-political dimension and its far-reaching ecological impact. These interconnected ecologies, in which human-made digital information structures are inextricably embedded in bio-organic and resource cycles, form a complex multi-dimensional landscape. This research is informed by this mode of ecological design thinking.

This report introduces the initial work-in-progress for the AI & Digital sector of the Transition Templates: Pathways to Net Zero+ research project (2023-2026). The AI & Digital TT Ecosystem Frameworks (figures 1 and 2) encourage systemic framing and approaches to analysis and the generation of transition pathways for decarbonisation. Two versions of the initial framework focus on four domains of activity in decarbonising AI & Digital ecosystems: 1) governance and policy; 2) infrastructure and hardware; 3) users and user practices; and 4) applications and software in Figure 1. Framework A, these domains manifest across users, impacted communities, and industry and advocates, in Figure 2. Framework B, the domains intersect with service-product, socio-spatial, and socio-technical relationships. Framework B references Fabrizio Ceschin and Idil Gaziulusoy's 'The DfS innovation framework' (2020, 144) to explore different dimensions of energy transitions in the sector.

These AI & Digital Ecosystem Frameworks are used in a four-step process for understanding, envisioning, strategising, and implementing pathways to decarbonisation. These steps are explained in a second RSD13 paper (Boehnert, 2024). The work is inspired by Peter Jones and Kristel van Ael's recent Design Journeys through Complex Systems: Practice Tools for Systemic Design (2022). These steps are adapted for each sector, so the templates here are unique to the AI & Digital domain.

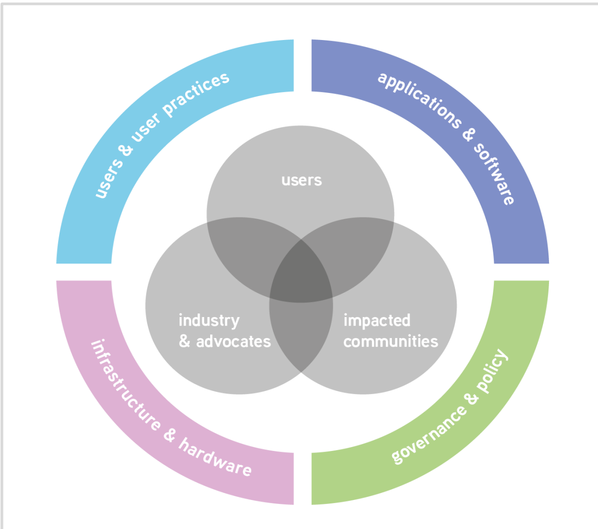

Figure 1. AI & Digital TT Ecosystems Framework A

Figure 2. AI & Digital TT Ecosystems Framework B

Step 1: Understanding and Framing the Data

Step One is the foundation for the next stages. In the initial scoping exercise for the AI & Digital rotation, the TT Network of Actors the AI & Digital sector can be used to map actors in national, community, and international contexts. Across these contexts is a list of major platforms, consultancies, AI development companies, Internet service providers (ISPs), hardware providers, regulatory authorities, research groups, and NGOs focused on the digital sector.

The next part of Step One involves collecting and assessing relevant data according to the TT Innovation Landscape Matrix (TT-ILM). This tool is based on the earlier Innovation Landscape Matrix featuring three levels of analysis: the systemic level, the service level, and the product *level to encourage an ecosystem perspective, as "a design ecology and makes visible the systemic interactions that connect across multiple scales" (Dewberry, Boehnert & Sinclair 2024). These levels are then mapped across three factors of impact: Materials, Society/People, and Structures. We have identified 18 questions that point to critical data points to collect for further assessment in AI & Digital, including:*

- *Systems level for materials: What resources and infrastructures does the system rely on (e.g. renewable/non-renewable energy, shipping, etc.) that generate GHGs?*
- *Systems level for structures: What are the key trends at a system level that influence the effectiveness of innovation functions or outcomes? (e.g. increased interconnectedness through smart technology).*
- *Service level for materials: What needs are met through the service?*
- *Product level for materials: What resources does the product contain or use during its lifespan?*
- *Product level for society/people: What basic human needs does the product meet?*

A TT Synthesis Map may be created to combine the previous processes to visualise key data points, information, and analysis on one image. This early-stage research seeks to understand context as a foundation for later steps, ideally with help from actors identified in the TT Network of Actors. This iterative process may adopt approaches typically applied in agile development, which is widely used in the AI & Digital sector.

Step 2: Envisioning Futures

In the Envisioning Futures step, information and analysis from Step One are further investigated with futuring methods and through the frame of ecological design thinking with the Transition Templates Four Futures Framework (TT-FFF, see figures 4, & 5). This experimental tool is described in more detail in the other RSD13 paper (Boehnert, 2024). The first future, "extract", is business as usual with its normative resource, carbon, and energy-intensive dynamics, i.e. defuturing unsustainability. The second future, "sustain", maps measures to minimise or mitigate harms from the unsustainable extract dynamic. The third future, "restore", explores practices that seek to repair current and historical damages. Finally, the most transformative sector is "regenerate." The regenerate future vision takes a fully ecological and systems-oriented approach to consider how this sector's activity could actively contribute to a wider project of wholesale planetary regeneration. These four futures build on the *model of progress towards regenerative design developed initially by ecological design theorists Pamela Mang and Bill Reed (2012) and Daniel Wahl (2016) and widely embraced recently in design and architecture as an appropriately ambitious model considering the scale of various elements of the polycrises.*

Whereas the immense energy and ecological impact of other sectors of the Transition Template research process is already widely acknowledged and significant work to develop decarbonising and regenerative practices (in-home energy, for example), in the AI & Digital sectors, there are only a few fragmented research initiatives that could be situated in the "sustain" category. Progress towards sustainability in digital infrastructure is limited (Pan et al, 2022). Very few lines of enquiry match restore or regenerate scenarios. The sector is unavoidably resource and carbon-intensive in its fundamental infrastructures (Gupa et al, 2022). There is simply no way to make digital network materials on an industrial scale without ecologically destructive activities.

We identify two pathways to significant carbon reduction and regeneration. First, a radical scaling back of computer infrastructure manufacture and comprehensive measures to extend the life of current hardware. Second, a deployment of only massively regenerative projects that can justify the ecological impact of their infrastructures. In the futures envisioning step, it is clear that reaching significant progress in the "sustain" future scenario will necessitate huge culture and sectoral shifts, for example:

- *Slowing down in data centre growth (Infrastructure & Hardware)*
- *Enforced frameworks for open standards, interoperability and right to repair (Ozturkcan, 2023) (Governance & Policy)*
- *Scale back of engagement-optimised UX with increased focus on healthy-use frameworks (UINW 2023) (Applications & Software)*

The "restore" scenario envisions a fundamental transformation in our relationship to digital network technologies, for example:

- *Widespread take-up of de-digitised modes of living (Users & User Practices)*
- *Decarbonisation of current infrastructures with data/compute minimal approaches (Infrastructures & Hardware)*
- *Robust regulatory, fiscal measures to:*
    - *restrict data centre growth*

- *enforce extended life for devices and infrastructures*
- *phases out closed platform architectures*
- *curtail programmatic advertising*

The "regenerate" scenario takes us into territory that is scarcely imaginable in our prevailing discourse and culture. Measures include a comprehensive reversal of polarity from technology optimised for speed and engagement to technology optimised for minimum ecological impact. In this scenario, we emphasise a shift towards intermittent connection, contingent on available energy. A truly regenerative digital network infrastructure is an immense challenge. We envision some possibilities:

- *Biocomputation sensor networks to optimise bio-organic resilience and regeneration*
- *Comprehensive decarbonisation of digital manufacturing and supply chains through the use of recycled materials, emissions mitigation, upscaling of renewable energy sources, and water conservation*
- *Built out of low-intensity intermittency-optimised:*
    - *connected urban rewilding*
    - *mycelial carbon stores*
    - *agro-ecological food networks*

This preliminary summary illustrates how the Transition Template Four Futures Framework (TT-FFF) can shift a focus towards more ambitious future visions and facilitate the possible development of more serious decarbonisation pathways. We completed the TT-FFF as a spreadsheet, then in Miro, and then in a spreadsheet (figure 5). This example demonstrates the value of the TT-FFF in illustrating and communicating more ambitious transition proposals for net zero+ and beyond.

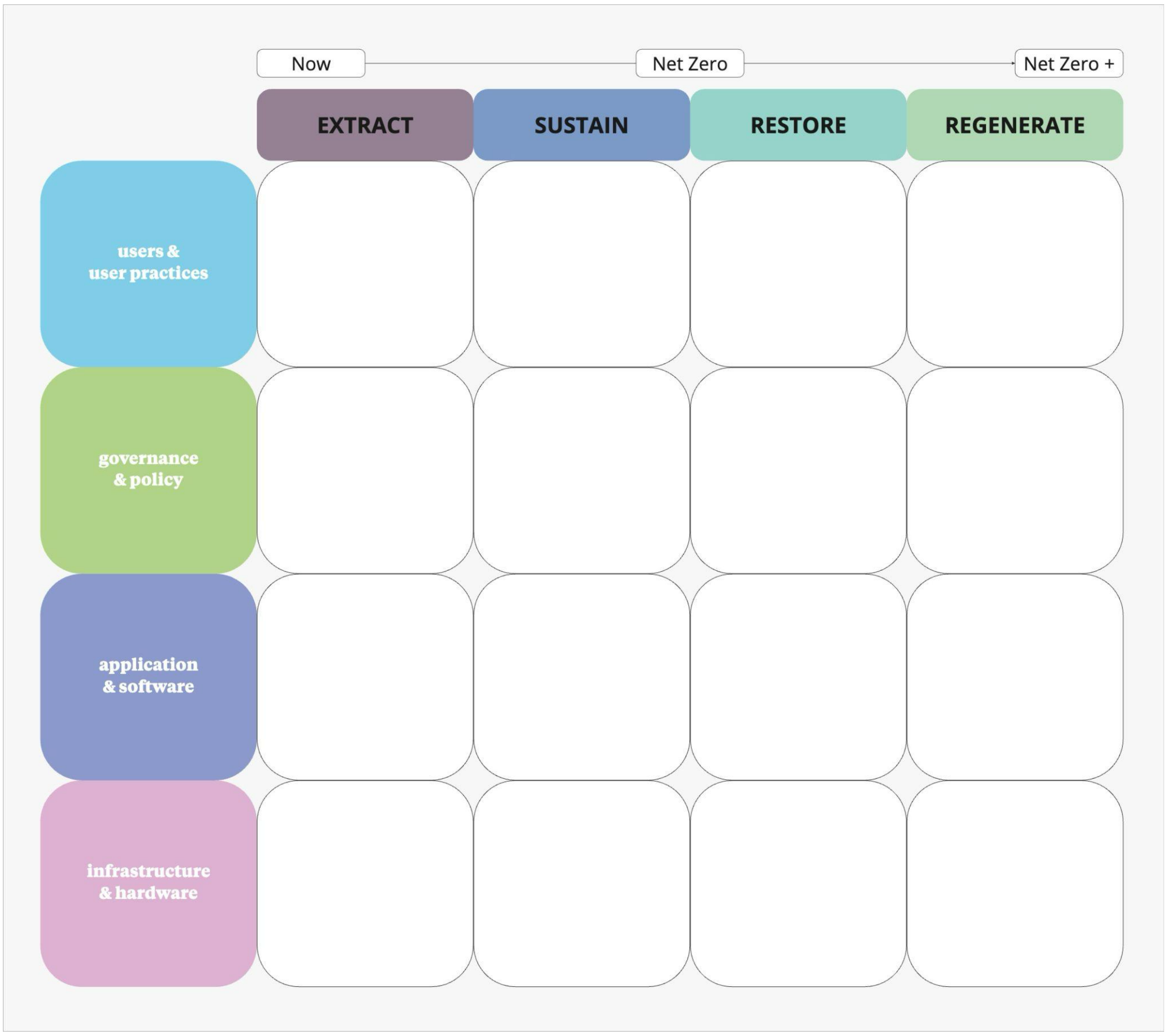

Figure 4. Transition Templates Four Futures Framework (TT-FFF)

	EXTRACT	SUSTAIN	RESTORE	REGENERATE
GOVERNANCE & POLICY	Focus on fostering "innovation" of LLMs and other AI apps Lack of focus on platform user habits No regulation on right to repair Platform interoperability not required	Resource impact frameworks for assessing AI Shift in focus towards responsible AI Enforced frameworks for open standards, interoperability and right to repair Enforced requirements for energy and resource impact transparency for users Support for development of community repair and recycling networks Enforced support of devices to end of life Regulations and fiscal incentives to restrict data centre growth tax enforcement of extractive platform business models	Robust regulatory, fiscal measures to: - restrict data centre growth - enforce extended life for devices and infrastructures - Phases out closed platform architectures- curtail programmatic advertising - require digital services to have human support and community-supported moderation - restrict VC based growth investment models- very tight controls on AI applications - shift towards to task specific, distributed and low-intensity models - publicise tech energy infrastructures Widespread and concerted support to: - build community focused platform architectures - repair and recycle networks - digital free spaces and services - promote re.used and low.intensity compute alternatives	Reverse Polarity of governance frameworks to: - digital last - ultra low intensity infrastructure - bandwidth, computation rationing in alignment with other sectors- - only open architectures - advancing minimal compute approaches - decommissioning all programmatic advertising stringent data storage restrictions- • - comprehensive investment in resilience architecture massive investment in bio-computation, low intensity compute- and networks for bio-regeneration
INFRA-STRUCTURE & HARDWARE	Rapid scaling up and building out data centres Aggressive integration of AI and compute intensive services Increasing shift towards cloud based services Continual updates and rapid obsolescence of older devices Locked down devices that cannot be repaired or life.extended by users	Slow down in data centre growth- shift towards efficiency Data centres shift towards energy conservation- filtered air. and extending life Application services allow for client based data storage depending on energy profile App services rolled out to support data efficiency and energy minimisation Devices designed for self-repair Older devices supported for entire hardware lifespan	Decommissioning of older inefficient data centres Sustainability overhaul of current data centres with community energy and heat integrations Shift Towards energy contingent digital services and processes- i.e. digital processes only take place when renewable energy is abundant Partial decarbonisation of supply chains with shift to renewable energy, emissions mitigation Research and development of low impact substrates and materials Decarbonisation of current infrastructures with data/compute minimal approaches Shift towards low-impact battery material technologies Public ownership of tech renewable energy infrastructure Strategic development of low intensity hardware and devices- such e.ink instead of OLED development of low speed infrastructures Building digital infrastructure resilience with open architectures, high contingency operations,. heat and flood resistance	Rapid scale back of infrastructures- with integrated advanced recycling loops Advancement of ultra-low energy/resource impact compute infrastructures- based on re-used tech Build out of low intensity intermittency-optimised: - carbon sequestration networks - connected urben rewilding and mycelial carbon stores - agro-ecological food networks Advance granular energy optimisation platforms with low-intensity intermittent networks Create bio computation sensor networks to optimise bio-organic resilience and regeneration Research and development of organic substrates and materials for computation Comprehensive decarbonisation of digital manufacturing and supply chains through - use of recycled materials, emissions mitigation, upscaling of renewable energy sources, water conservation Rationing of hardware production to align with climate/biodiversity regeneration goals
APPLICATIONS & SOFTWARE	Major shift towards AI based services and integration of AI Focus on generalised LLM and frontier-based models Apps driven by increased AI-driven Programmatic advertising models Spend on public campaigns and political influence campaigns to head off regulation Continual updates and obsolescence of older devices	Scale back of engagement-optimised UX increased focus on healthy-use frameworks Scaled back AI-integration- and AI free options Shift towards distributed, targeted AI models Reduced dependency on programmatic advertising Rolling out of open standards and interoperability Open repair toolkits and resources available to all Software supporting devices to end of life Integrated waste recycling into supply chains Integrating energy and resources use transparency into all user experience	Phasing out of programmatic advertising platform architectures Shift towards low-intensity utility focused apps- optimised for older devices Shift away from "usability centred" design Human and analog first design focus Phasing out of proprietary platform architectures Maximising support for older devices Tech financing models shift away from growth to wealth to building community resilience building low-intensity networks for biodiversity, urban-foresting and rewilding data centres Low.intensity- resilience building with connected communities Shift towards digital "intermittency" AI digital platforms supported with regulated human support and moderation- in community strengthening processes and cultures	From digital first to human/energy/life first From more and faster to less and slower From always on to sometimes on- depending on energy provision From user centred design to planet first design- multiple holistic design UX pathways for interaction Widespread shift to organic/analog/energy focused interaction Phase out of "smart" devices to low-impact- minimal interference devices Depowering and decommissioning of platform architecture and economies All digital networks integrated into wider community/organic networks Open architecture AI for specific "wicked" ecological problems on low-intensity infrastructures Networked resilience applications for strengthening communities Low-compute infrastructures for facilitation dynamic deep adaptation
USERS & USER PRACTICES	Platform addiction Ongoing platformisation Rapid AI uptake- integrating into all applications Maximal automation Latest software, hardware Hardware constantly updated- last year model disposed of e.waste	Culture shift towards platform harm reduction- digital free spaces re-use, repair networks develop demand for non-ai-- more distributed services older devices kept for longer e-waste recycled	Widespread take-up of de-digital modes of living Digital devices generally restricted in public spaces, schools Commercial and public services require non-digital alternative access points Awareness of energy and resource cost of Digital platforms is ubiquitous Older devices become more desirable than newer ones Low impact devices are especially sought after Shift away from global digital platforms Increase in community-based interaction and building offline communities	Reverse polarity of digital platforms: - from latest devices to longest serving - maximum speed to minimum impact - instant- to intermittent - maximum engagement to minimum interaction digitise everything to humanise everything - frictionless to friction Widespread scale back of digital infrastructures Connected community based networks for urban rewilding, intelligent responsive agro-ecology Low.-intensity- community centred energy dynamic management networks

Transition Templates: Pathways to Net Zero+: The Four Future Framework (TT-FFF). Ai & Digital. August 2024. Boehnert & Alexander. Funded by the ARHC.

Figure 5. TT Four Futures Framework (TT-FFF) Ai & Digital.

Step 3: Opportunities and Strategies

The third step seeks opportunities and strategies for decarbonisation. Here, the templates must address sector-specific challenges. Firstly, there is the pan-global and to some degree, trans-physical nature of these services, platforms, and networks. These networks may be presented as non-physical by their gatekeepers - in the "cloud", and so on - but they do, of course, have a vast materiality with corresponding ecological impact. Nevertheless, they remain distinctly unaccountable, unreachable, and to some degree unknowable to community-based initiatives - even while having significant control over distinctly national and regional markets.

Decarbonisation applies to current infrastructures along with new projects as the sector has every intention of massively expanding its geographic - and consequently - ecological footprint. Therefore, the work must consider processes for planning and commissioning new infrastructures, as well as new products. Above all, we will need to consider the wider regulatory and governance climate, as it is hard to imagine that the sector will unilaterally scale back in its well-established business priorities of growth, engagement and compute without significant external pressure. The work in this step is still in its initial phases.[2]

Step 4: Adoption and Implementation

This fourth step is also still only in the scoping phase. We use the TT Adoption & Implementation Template to map short-term to mid-term and mid-term to long-term adoption of proposed interventions. Within these timeframes, we look for the key drivers for change that can affect tangible reductions in emissions and impact with almost immediate results, such as shifts in right-to-repair laws, and incentives for keeping older devices, as well as tax incentives for ecologically efficient data centres.

Mid to long-term decarbonisation of the sector will require far-reaching change to underlying business models, design, and supply chains. Carbon emissions may be reduced by 10 or 20 per cent through moderate changes to practice - reducing impact by 80 per cent, for example, will require systemic changes such as integration of circular supply chains and sourcing carbon-efficient input components, such as semiconductors. Transition on this scale

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[2] *Note from 2025 - Step 3 has been significantly revised in 2025. This text documents the evolution of our thinking and theoretical positioning.*

will require fundamental shifts in culture, which would be difficult for even a major digital platform company to achieve in isolation. For these reasons, the Adoption & Implementation phase will consider approaches to put in place in the near term. Shifts in practices will provide the affordances for more transformational shifts further down the transition pathway.

Conclusion

The overarching narrative of technology flowing in one pre-ordained direction has been recycled and adapted for AI to an extent that, in technology discourse, the terms "AI" and "technology" have enmeshed. It is hard to find a technology company - or, for that matter, a technology NGO or research group - that does not see its future and AI as inexorably interwoven. Meanwhile, the prodigious energy demands of running AI infrastructures have finally gained attention (De Vries, 2023). In the US, plans to decommission coal-fired power stations are being shelved as AI data centres put the US electricity grid under extreme pressure (Saul et al, 2024). The Transition Template method is being tested and refined in the AI & Digital sector. This work already offers insights into approaches and challenges of decarbonisation. Currently, AI and digital infrastructures are accelerating in the opposite direction. The futures we imagine for AI, digital platforms, infrastructures, and cultures encompass various currents.

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