

DIGITAL INFRASTRUCTURE FUTURES

PHASE 2 – DIRECTIONS PAPER

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Participating Organisations

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About this Paper

In June 2026, the Infrastructure Sustainability Council released the Phase 1 Emerging Insights Report. Shaped by input from ISC members, industry leaders, and practitioners, it set out to answer a critical question: what does the digital enablement of infrastructure mean for sustainability outcomes in Australia and Aotearoa New Zealand?

The Phase 1 report established a shared definition of digital infrastructure, organised the concept into a five-category matrix, and framed the relationship between digital and sustainability as a two-way lens. It was a working document by design, meant to test thinking and open a sector conversation that had not yet been had across Australia and Aotearoa New Zealand.

This Directions Paper takes the next step. Where Phase 1 mapped the landscape, this document explores the implications for infrastructure owners, practitioners, policymakers and industry, and identifies a range of opportunities that may warrant further consideration by ISC and its stakeholders.

It maintains a consistent two-way perspective: digital capability enables sustainability outcomes across the infrastructure lifecycle, while digital infrastructure is itself accountable for its sustainability impacts.

The paper is practical in intent. It is designed to help ISC members and other stakeholders understand emerging issues, identify opportunities and risks, and inform future conversations about how sustainability principles may be applied to digital infrastructure.

> *In short, this paper aims to: define digital infrastructure and its five categories; show how each category both supports and affects sustainability outcomes; give practitioners questions to ask across the asset lifecycle; and identify where ISC could help the sector act.*

While the paper identifies a number of potential opportunities for ISC, these proposed initiatives use existing ISC assets and should be viewed as areas for further investigation, engagement, and co-design with and partners rather than predetermined commitments or work programs.

The paper is structured as follows.

Part A: Condensed Contextual Framework

This part condenses the Phase 1 Insights Report to define digital infrastructure, the dual lens of enabler and footprint, and reintroduces the five categories of digital infrastructure as presented in the digital infrastructure sustainability matrix.

Part B: Category Deep Dives

Each of the five categories receives its own focus through a common template that covers scope and landscape to the sustainability case and the series` of questions using the Process, Organisation and Culture, Technology, and Information (POTI) framework. This gives practitioners high level guidance on how to engage in discussions and seek opportunities to enhance sustainability outcomes on projects.

Part C: Continuing the Conversation

This part brings the paper together through the dual lens of digital as an enabler of sustainability and digital as infrastructure. It sets out seven priorities for industry, government and infrastructure owners, and outlines how ISC will continue to convene discussion, build the evidence base and support sustainable digital infrastructure practice across Australia and Aotearoa New Zealand.

Part A

Context and Framework

Introduction

Infrastructure shapes how people live, work, move, and connect. The systems we rely on, from power grids and water networks to transport corridors and communications infrastructure, are being transformed by digital technologies that offer new ways to plan, build, operate, and sustain these assets.

The trajectory of digital infrastructure demand is uncertain, and the pace of technological change presents potential material risks of stranded assets and underutilised capacity. Meeting this challenge will require infrastructure systems that are adaptive, flexible, and modular by design, capable of scaling and reconfiguring as needs evolve.

Defining Digital Infrastructure and the Five Categories

There is no single, universally adopted definition of digital infrastructure. For the purposes of this paper, ISC defines digital infrastructure as the physical and virtual systems that enable data to be generated, transmitted, stored, processed, and applied to enhance infrastructure performance. The paper considers this through the lens of the full asset lifecycle, from planning and design through construction to operations and maintenance.

To apply this definition, ISC organises digital infrastructure into five categories. These categories are interdependent, often relying on one another to meet their respective performance requirements. Sensing infrastructure generates data that must be transmitted via connectivity networks, stored and processed in data infrastructure, analysed using computing and AI, and, increasingly, acted on by autonomous and robotic systems.



Connectivity infrastructure

Fixed broadband, mobile networks (4G/5G), LPWAN, subsea and terrestrial fibre cables.

Data Infrastructure

Data centres, cloud platforms (IaaS/PaaS/SaaS), edge compute nodes, data integration and interoperability layers.

Sensing and Device Infrastructure

Connected technology (IoT) sensor networks, smart and multifunction poles and other urban infrastructure elements, environmental sensing stations, and transport monitoring systems.

Computing and AI Infrastructure

Digital twin platforms, AI (generative, agentic and physical) and machine learning systems, high-performance computing clusters, and AI-specific hardware.

Autonomous and Robotic Infrastructure

Robotics, autonomous plant and vehicles, drones, and human-machine systems that translate digital intelligence into physical action across the construction, operation, and maintenance of infrastructure.

The full Digital Infrastructure Sustainability Matrix, which maps each category against capability, sustainability enablement, footprint, and current maturity, is set out in Appendix A. This matrix forms the basis of the category deep dives in Part B.

The Landscape: Global, Regional, and Australian and Aotearoa New Zealand Context

Several converging forces are reshaping the global digital infrastructure landscape, each with significant sustainability implications. Data centre demand is growing rapidly, driven by cloud migration and, more recently, AI workloads, with energy consumption by data centres projected to double globally by 2030[1].

AI is accelerating compute intensity and the workload on data centres, and understanding of the sustainability impacts of AI infrastructure, and how they are measured and reported, is evolving rapidly. Edge computing is distributing processing closer to the source, reducing latency and back haul energy while introducing new challenges around hardware management and distributed governance. Automation and robotics are emerging as a complementary force reshaping how infrastructure is delivered and operated, digital twin adoption continues to scale, and sovereign digital infrastructure is emerging as a policy priority.

Jurisdictions, including Singapore, the Netherlands, and the United Kingdom, are developing integrated frameworks that treat digital infrastructure sustainability as a regulated and reported dimension of infrastructure performance. Australia and Aotearoa New Zealand are at an earlier stage of that journey.

The regional context has distinct characteristics. Geographic scale, dispersed populations, and a significant remote and regional infrastructure challenge mean that connectivity gaps carry greater social and economic consequences than in more densely populated regions.

The policy environment continues to evolve, shaped by Australia's Digital Economy Strategy and National AI Plan (2025), the Security of Critical Infrastructure Act 2018, multiple responses to data centre growth, Australia's National Robotics Strategy (2024) and Aotearoa New Zealand's first national robotics roadmap, the SEQ Digital Plan, the Digital Strategy for Aotearoa, and the Infrastructure Australia and New Zealand Infrastructure Commission (Te Waihanga) pipelines[2]. A recurring gap across these frameworks is the absence of consistent sustainability assessment criteria across digital asset types.

First Nations Data Sovereignty

First Nations data sovereignty is a distinct and important dimension of the Australian and Aotearoa New Zealand context. Digital infrastructure affects how data about Country, communities and culture is collected, stored and used. The rights and frameworks that govern this differ between the two countries, and both need to be recognised.

In Australia, the AIATSIS Code of Ethics, the Maiam nayri Wingara Indigenous Data Sovereignty principles and the Australian Government's Framework for Governance of Indigenous Data set out principles for how Aboriginal and Torres Strait Islander data is collected, controlled and used. Priority Reform Four of the National Agreement on Closing the Gap adds a commitment to shared access to data[3]

In Aotearoa New Zealand, Māori data sovereignty rests on Te Tiriti o Waitangi. The Waitangi Tribunal has recognised Māori data as a taonga. Te Mana Raraunga, the Māori Data Sovereignty Network, has set out principles for its governance, and the Māori Data Governance Model offers practical guidance. Iwi and hapū hold authority over data about their people, whenua and resources. This means engaging with them directly as governance partners, not treating them as one stakeholder group among many.

For infrastructure owners in both countries, these principles bear on where data is hosted, who can access it, and who decides how it is used. They should inform the design and governance of digital infrastructure from the start. Seeking expertise on this agenda for your projects is encouraged.

The Two-Way Lens: Opportunity and Footprint

01

How digital accelerates sustainability outcomes

Digital infrastructure can accelerate sustainability outcomes across the infrastructure lifecycle. Based on member input and case study review, typical enabling capabilities may include:

- Data-driven planning that uses resources more efficiently, including materials, energy and waste, and improves asset utilisation through accurate demand forecasting and integrated decision-making.
- Digital twins that support efficient design and construction sequencing, reducing rework, project timelines, and lifecycle emissions.
- Internet of Things and connected technology that optimise energy use and extend asset life through condition monitoring and predictive maintenance.
- Artificial intelligence that optimises grid, transport, and water network performance in real time, improving efficiency and renewable integration.
- Connected infrastructure that underpins coordinated emergency response and climate adaptation across agencies and jurisdictions.

The sustainability opportunity is significant, but measured operational outcomes matter more than the technology deployed. For Honeywell Technologies, its recent paper sets out how integrating control systems, analytics, digital twins, and coordinated control rooms can help energy, water, transport and health assets anticipate risk, cut energy use and emissions, and recover faster from disruption[4]. The full paper is listed in the endnotes.

02

The sustainability footprint of digital infrastructure itself

Digital infrastructure also has a material footprint of its own, and that footprint potentially grows as, for example, AI workloads intensify. The main direct impacts are energy demand from data centres and the transmission infrastructure that supplies them; Scope 3 emissions[5] from manufacturing and shipping hardware; water used for cooling, especially in water-stressed regions; e-waste, where reuse and recycling pathways are still limited; and land use, siting and biodiversity impacts from large-scale rollout.

Second-order and systemic impacts include rebound effects, where efficiency gains drive higher overall consumption; faster growth in demand for energy, water and materials driven by AI; lifecycle pressures from rapidly obsolescing hardware and shortened refresh cycles; and locked-in dependencies on global supply chains for chips, rare earths, and critical minerals.

Social, Cultural, and Economic Sustainability

Sustainability extends beyond environmental outcomes. A credible discussion around digital infrastructure must also consider social equity, economic productivity, cultural values, and workforce transition. Digital connectivity enables social equity and access in regional and remote communities; productivity gains extend beyond cost savings to new service models and better decision quality; cultural considerations shape siting and how data drawn from Country is managed; and workforce transition and digital skills are central to realising the benefits of digitalisation.

The combined pace of AI and robotics is changing what infrastructure work looks like, who does it, and under what conditions. Some roles may be displaced, while others are being augmented. The role of humans is shifting in some circumstances from direct execution toward oversight, judgement, and exception handling, with implications for training, accreditation, and safe systems of work that have not yet caught up.

Ethical considerations are becoming material as autonomous systems take on more consequential decisions. These issues sit at the intersection of sustainability and social licence. Infrastructure that delivers strong environmental performance but erodes employment quality, transparency, or community trust is unlikely to meet a holistic definition of sustainability.

The Disclosure Driver

For many organisations, compliance obligations are often the most immediate driver. Mandatory climate disclosure is reshaping how asset owners, operators, and contractors account for their full emissions profile, and digital infrastructure sits within that frame. In Australia, the Treasury Laws Amendment (Financial Market Infrastructure and Other Measures) Act 2024 requires large entities, on a phased basis from 1 January 2025, to report against the Australian Sustainability Reporting Standards, aligned with IFRS S1 and S2[6]. Aotearoa New Zealand's mandatory disclosure regime is already in force[7]. Across both jurisdictions, Scope 3 requirements mean the emissions and resource footprint of procured digital services, such as cloud platforms, co-location facilities, and network infrastructure, may now need to be included in an organisation's own disclosures, where they are material to its value chain emissions.

Planning Under Uncertainty

Understanding digital infrastructure as a matrix rather than a single category matters because the sustainability implications vary across each category. A subsea cable has a fundamentally different footprint profile from an AI training data centre. Without a structured way to distinguish between technologies, those delivering, owning, and operating infrastructure risk applying generic sustainability thinking to challenges that demand specificity.

The matrix underpinning both papers also surfaces a challenge at the heart of digital infrastructure decision-making, namely the deep uncertainty about future demand, technology evolution, and the regulatory environment. While an important issue for ISC and it's members, deeper guidance on this topic is beyond the scope of this document, and has been identified as a future discussion item among ISC members.

The Digital Infrastructure Sustainability Matrix

The matrix is a proposed way to bring structure to the umbrella term digital infrastructure. It makes visible the differences in energy intensity, embodied carbon, hardware lifecycles, water consumption, and data governance obligations that sit behind the term, and in doing so provides a more transparent basis for decision-making. It provides a shared reference point for infrastructure owners, technology providers, contractors, and consultants who often approach digital infrastructure from different angles and with different vocabularies.

The full matrix, mapping all five categories against capability, sustainability enablement, footprint, and current Australian and Aotearoa New Zealand maturity, is provided in Appendix A.

In the following section of this paper, Part B examines each category of the matrix, using it as an evidence base for some key guiding actions for ISC members and other stakeholders.

It should be noted that some technologies span more than one category, so their placement in the matrix reflects their primary function rather than a fixed allocation. For example, digital twins sit under computing and AI because their core value lies in simulation and analysis, while cloud platforms, edge compute and data integration platforms sit under data infrastructure, even though each depends on and supports the connectivity, sensing and computing layers around it.



Part B

Category Deep Dives

Part B examines each of the five categories of the Digital Infrastructure Sustainability Matrix and offers guidance notes to enable ISC members to engage deeper with projects seeking to use digital as an enabler of sustainability, and/or supporting a digital infrastructure project to seek sustainability outcomes. Every category follows the same eight-part structure, so a reader can move across categories and compare like with like. Each category is examined both as an enabler of sustainability outcomes and as a category with its own material footprint.

The Eight Sections in Each Category Are:

Understand

1. Digital infrastructure scope - defines the specific technologies that make up the category and what each one does.
2. About this infrastructure - describes where the category sits in the wider system, how and where it is deployed, and who owns it.
3. The landscape: investment, legislation, and trends - sets out the investment activity and policy shaping the category across Australia and Aotearoa New Zealand.

Assess

4. Sustainability in practice - shows how the category enables sustainability outcomes across the infrastructure lifecycle.
5. Digital infrastructure issues to watch - identifies the category's own footprint and the risks that warrant attention.
6. The cost of inaction: gaps in the current landscape - explains what is lost when these issues go unaddressed and where the current gaps sit.

Act

7. The key questions - gives the questions a member organisation can ask to build a business case and govern well, arranged using the POTI framework.
8. Applying this across the asset lifecycle - works through five common questions across the asset lifecycle, each answered from the perspective most likely to raise it.

The observations, examples, and questions contained within the following category summaries are intended as practical considerations for discussion and decision-making. They do not constitute technical, legal, regulatory, procurement, cybersecurity, privacy, planning or financial advice. Organisations should apply these considerations in the context of their own governance frameworks, obligations, and operating environments.



Category 1

Connectivity Infrastructure

What Type of Infrastructure Does This Include

Fixed Broadband (NBN and Fibre)
high-bandwidth, low-latency, always-on wired connection; the backbone for fixed-site data exchange.

Mobile Networks (4G and 5G)
wireless connectivity for mobile assets, remote sensors, and field workers; 5G adds low latency and device density for real-time control.

LPWAN, Including LoRa
ultra-low-power, long-range, low-data-rate connectivity for distributed sensors across large geographic areas.

Subsea and Terrestrial Fibre Cables
very-high-capacity backbone for international and interstate data exchange; critical for cloud and AI workloads.

Key attributes

The transmission layer that moves data between assets, people, and systems. The other four categories rely on it to transmit data between assets, people and systems.

Located on fixed and movable objects, across urban and rural settings, supporting most critical infrastructure sectors and general municipal infrastructure.

Ranges from the passive and long-lived (cable corridors, conduit, fibre, towers), with service life typically measured in decades, to the active and shorter-lived (radio access equipment, exchange and headend hardware), refreshed on a much shorter cycle.

Its environmental impacts come mostly from the passive works, such as trenching, marine cable laying and land corridors. Its social and economic impacts come from coverage: where coverage is thin, communities miss out on services and opportunities, which deepens existing disadvantage.

The Landscape: Investment, Legislation, and Trends

The NBN now reaches almost all Australian premises through fixed-line, fixed wireless and satellite technologies[8], with 4G mature and 5G rollout underway across metropolitan areas.

In Aotearoa New Zealand, the Ultra-Fast Broadband programme was completed in 2022, giving around 87 per cent of New Zealanders access to fibre[9]. Rural connectivity programmes continue to extend mobile and wireless coverage.

Subsea and terrestrial cable investment is ongoing and carries a sovereign risk dimension identified in national security settings. New cable builds carry high embodied carbon and marine impacts that sit outside most current reporting.

The Security of Critical Infrastructure Act 2018 covers communications. A regional connectivity agenda continues to grow as a policy focus, driven by social equity and economic participation.

References: Security of Critical Infrastructure Act 2018; NBN Co coverage reporting; regional and remote connectivity programs.; Ministry of Business, Innovation and Employment (Ultra-Fast Broadband programme)

DUAL LENS: OPPORTUNITY AND FOOTPRINT

Sustainability Benefits of Digital Infrastructure

Remote and distributed workforce: reliable connectivity lets field teams operate assets and supervise plant from a distance, cutting vehicle trips and commuter emissions.

Smart metering and demand management: always-on networks carry the meter and control data that let energy and water utilities move demand away from peak periods and reduce peak loads, rather than build new peak capacity.

Monitoring at scale: the low cost and 5-to-10-year battery life of LPWAN make it viable to monitor remote catchments, farms, and assets where the cost of hard-wired monitoring could not be justified.

Distributed data infrastructure: high-capacity fibre lets compute and storage sit closer to where they are needed, helping to reduce the energy impact of centralising infrastructure.

Regional inclusion: reliable coverage supports health, education, employment and civic participation to regional, remote and First Nations communities, and lets local workers support communities without relocating.

Productivity in the regions: connected assets and remote operations lower the cost of serving dispersed populations and support new service models, from telehealth and small e-commerce businesses to precision agriculture and mining.

Digital Infrastructure Issues to Watch

01 **Active equipment energy consumption**
exchanges, headends, and tower electronics draw continuous power, and radio hardware refresh cycles generate a recurring e-waste stream.

02 **Copper legacy e-waste**
decommissioning copper network infrastructure as it is replaced by fiber creates a large one-off material stream that needs reuse and recycling pathways.

03 **Passive works carbon and marine impact**
embodied carbon in cable manufacture and installation, seabed disturbance during marine laying, and the labour and sourcing practices of cable and tower suppliers, are concentrated in the build phase.

04 **Ownership concentration**
a small number of mobile network operators and mobile network infrastructure providers control the network and supporting infrastructure, so they also hold much of the sustainability data and have significant influence over procurement and reporting.

05 **Siting and engagement**
tower sites and cable routes may affect communities and Country, so engagement and cultural heritage processes need to start early rather than be treated as late approval risks.

06 **The cost of the last mile**
remote coverage often depends on subsidy (eg. Mobile Black Spot Program) and shared infrastructure between mobile network operators. Where that falls short, coverage gaps can become significant gaps in economic participation and service delivery.

The Key Questions

Considerations that might help a member organisation build a business case for action and investment and to govern well are included in the table below.

P — PROCESS
Have we embedded embodied carbon, responsible sourcing and end-of-life criteria into passive infrastructure (the long-lived physical elements such as ducts, conduit, cables and towers, as distinct from active electronic equipment) procurement?

O — ORGANISATION AND CULTURE
Who inside our organisation holds the relationship with connectivity network stakeholders, and who is accountable for connectivity sustainability data?

T — TECHNOLOGY
Are we specifying open standards and oversized passive elements such as conduit and power feeds, so upgrades do not require civil rework?

I — INFORMATION
Have we set expectations for disclosure of energy and e-waste data to support our Scope 3 reporting?

Applying This Across the Asset Lifecycle

Below are five common questions you may face across the asset lifecycle, each from the perspective most likely to raise it.

Connectivity is the enabler layer. Across the lifecycle, the task is to surface a footprint that is sometimes considered low impact, while making the enabling case without overstating it.

Planning

State authority asset owner

"We are planning a regional connectivity program. How do we build sustainability into the business case when connectivity is assumed to be invisible?"

Present the case in two parts. As an enabler, quantify what the network unlocks, such as remote operations, smart metering, and environmental monitoring at scale. As part of footprint accountability, require network operators and delivery partners to disclose energy and e-waste data up front, making this information visible from the outset. Consider closing remote and regional gaps as a social equity outcome.

Design

Sustainability consultant

"I am advising on the design of new cable corridors and conduit. What sustainability specifications should I recommend?"

Specify oversized passive elements such as conduit and power feeds, and open standards, so future upgrades don't require civil rework. Separate the long-lived passive infrastructure from the shorter-lived active equipment so each renews on its own cycle. This modest uplift at the outset avoids stranded assets and waste over a 25-year-plus life.

Construction

Construction company sustainability manager

"We are installing subsea and terrestrial fibre. Where is the sustainability risk in the construction phase?"

Embodied carbon in cable installation and marine impacts during laying are the main construction footprint, alongside spoil, vegetation clearing and disturbance to Country along corridors. Capture and report the embodied carbon of the works, manage marine and ground disturbance to agreed controls, and seek modern slavery and responsible sourcing assurance from cable and equipment suppliers. Record data for Scope 3 reporting.

Operations and Maintenance

Asset owner and operator

"We operate assets that depend on digital networks. How do we account for connectivity we do not own?"

Clarify internally who holds the relationship with network owners and operators and who is accountable for connectivity sustainability data. Then make energy and e-waste disclosure a standing contract expectation, not a one-off request. Ownership is concentrated in a few operators, so a contract condition is the practical lever for Scope 3 reporting.

End of Life and Renewal

Asset owner and operator

"We are retiring copper as we move to fibre. What is the sustainability exposure at end of life?"

The copper-to-fibre transition creates a large e-waste stream that can be overlooked. Plan the retirement with reuse and recycling pathways rather than default disposal, and record the volumes. Align active equipment refresh with the passive asset's longer life so you replace no more than you need to.

The Cost of Inaction: Gaps in the Current Landscape

Wrongly assumed to be low impact
because connectivity can be overlooked as physical infrastructure, the embodied carbon of passive works and the e-waste of network transitions go unmeasured, so the footprint grows without appearing in any report or decision.

A widening regional divide
as services move online and assets become connectivity-dependent, coverage gaps in remote and regional areas can translate directly into social and economic exclusion.

Lock-in of passive assets
cable corridors and conduit laid now set outcomes for decades, so a decision made without sustainability criteria may lock in lower performance for the life of the asset.

Category 2

Data Infrastructure

What Type of Infrastructure Does This Include

Hyperscale Data Centres
very large scale, centralised compute and storage; host enterprise workloads, cloud services, and AI training at scale.

Edge Compute Nodes
distributed processing close to the source; reduce backhaul and enable real-time response for critical infrastructure.

Cloud Platforms
elastic, multi-tenant, API-driven compute and storage; scale capacity for asset management, BIM, and digital twins without new hardware.

Data Integration and Interoperability Platforms
standards-based (IFC, CityGML, GTFS) layers that connect disparate data sources across the asset lifecycle.

Key Attributes

The storage, processing, and integration layer. It stores and moves the data the rest of the system depends on, and increasingly hosts the AI workloads that sit on top of it.

Deployment ranges from very large, centralised facilities sited near power and water, often on urban fringes and in industrial precincts, to distributed edge nodes co-located with transport, energy, and water assets, to software-based integration layers with no fixed site of their own.

Hyperscale facilities have a concentrated, visible physical footprint and compete with communities and other sectors for grid capacity, water and land. Their location is therefore a social and economic consideration as well as a technical one.

Most of this infrastructure is owned and operated by the private sector, which shapes who holds the sustainability data and who makes the siting and energy decisions.

The Landscape: Investment, Legislation, and Trends

Data centre demand is growing rapidly, driven by cloud migration and, more recently, AI workloads, with major investment from international private sector operators.

Energy consumption by data centres is projected to double globally by 2030[10], putting pressure on electricity grids and water systems where facilities concentrate.

Federal and state governments have published guidance and commenced strategic reviews. The NSW strategy review and the SEQ Digital Plan Data Centre Strategy are active reference points.

The Treasury Laws Amendment (Financial Market Infrastructure and Other Measures) Act 2024, aligned with IFRS S1 and S2, brings the Scope 3 footprint of procured cloud and co-location into an organisation's own disclosure. Aotearoa New Zealand's mandatory disclosure regime is already in force.

References: Treasury Laws Amendment (Financial Market Infrastructure and Other Measures) Act 2024; Australian Sustainability Reporting Standards (IFRS S1 and S2); NSW data centre strategy review; SEQ Digital Plan.

DUAL LENS: OPPORTUNITY AND FOOTPRINT

Sustainability Benefits of Digital Infrastructure

Workload consolidation: moving compute from many on-premise server rooms into a Power Usage Effectiveness (PUE)-optimised facility lowers energy per unit of compute, where the facility is operated to a high efficiency standard.

Renewable procurement at scale: large operators can sign renewable power purchase agreements that individual asset owners cannot, shifting a significant share of their electricity demand to renewable sources.

Edge processing: handling data where it is generated cuts the energy of transmitting it back and forth and enables real-time optimisation of transport, energy, and water networks.

Data continuity: integration platforms reduce rework by keeping a single source of data across planning, design, construction, and operations, and unlock cross-sector optimisation across transport, energy, and water. Enterprise platforms that federate data across previously siloed systems, such as Honeywell Forge, are one example of this integration layer in practice. The Austroads Carbon Measurement and Reporting Tool case study below shows this integration in practice.

Community and resilience benefits: when planned with host communities early, facilities can reuse waste heat, use recycled rather than drinking water for cooling, help fund grid and water upgrades, and support local jobs and skills. These benefits are not automatic and need to be agreed as conditions of approval.

Onshore and sovereign hosting: keeping sensitive data in Australia and Aotearoa New Zealand supports Indigenous Data Sovereignty principles and community trust, while construction and operations create local technical and trade roles.

Shared scale: cloud and shared platforms give councils and smaller asset owners access to compute capacity that would be cost-prohibitive to build and operate independently, turning capital cost into operating cost.

Digital Infrastructure Issues to Watch

01 **Energy and water**
hyperscale facilities draw very high and continuous energy and water loads. Cooling water demand is acute in water-stressed regions and competes with other users. The Clean Energy Finance Corporation notes that cooling can account for around 40% of a data centre's total energy use, and that conventional evaporative cooling improves energy efficiency only by consuming substantially more water. This makes water-efficient cooling technologies essential as facilities scale[11].

02 **Embodied and siting impacts**
carbon embodied in construction, plus land use and heat island effects, are concentrated in the build and not typically attributed to the digital service. Imported plant and equipment also carries labour and sourcing risks that can sometimes be overlooked.

03 **Scope 3 opacity**
cloud and co-location emissions are often not disclosed at a usable level, and vendor lock-in limits an owner's ability to govern or improve them.

04 **Concentration and oversight**
siting, energy and water decisions are currently driven largely by commercial operators. This is changing. In March 2026 the Australian Government released national expectations for data centres and AI infrastructure developers[12], and in July 2026 it announced plans to legislate mandatory national standards covering the location, power, water and grid impacts of large data centres[13].

05 **Local benefit**
sometimes, large facilities can draw heavily on local land, grid and water but employ relatively few people once operating, so the benefit to host communities can be small relative to the load, and should be acknowledged and understood in any impact assessment process.

The Key Questions

Considerations that might help a member organisation build a business case for action and investment and to govern well are included in the table below.

P PROCESS
Does our procurement framework score energy Power Purchase Agreement (PPA) coverage, water intensity, embodied carbon in build, supplier sourcing practices, and decommissioning, weighted to our own risk, for example, water in a water-stressed region?

O ORGANISATION AND CULTURE
Who in our organisation is accountable for digital sustainability across technology, sustainability, procurement and finance, and do we have the in-house capability to undertake the necessary assessments?

T TECHNOLOGY
Is the facility designed for cooling replacement and rack-level density upgrades, so it holds value across multiple hardware generations?

I INFORMATION
Have we set Scope 3[14] disclosure expectations for cloud and co-location, with baseline questions on cooling efficiency, renewable commitment, and circular economy planning?

Applying This Across the Asset Lifecycle

Below are five common questions you may face across the asset lifecycle, each from the perspective most likely to raise it.

Sustainability governance of data infrastructure is still emerging. This lifecycle lens shows where criteria can be considered before commercial momentum restricts sustainability opportunity.

Planning

State authority asset owner

"A hyperscale data centre is proposed in our jurisdiction. What sustainability conditions should the planning team set?"

Set disclosure and performance conditions early: PUE, water source and intensity, renewable PPA coverage, embodied carbon in the build, and decommissioning obligations. In a water-stressed region, weight water heavily, and test for grid crowd-out against other sectors. Where regulatory oversight is still developing, planning conditions provide a mechanism to set expectations.

Design

Sustainability consultant

"I am advising on the design of a new data facility. What extends its sustainable life?"

Design for cooling replacement and rack-level density upgrades so the facility retains value across multiple AI hardware generations. Separate the long-lived building shell and grid connection from the shorter-lived compute, and size passive elements accordingly. This trades a modest upfront cost for substantially reduced stranded asset risk over the life of the infrastructure.

Construction

Construction company sustainability manager

"We are building a data centre. Where is the construction sustainability footprint?"

Embodied carbon in construction, land use, and heat island effects are the main construction impacts, alongside the water and energy the site will draw, plus construction waste, stormwater and biodiversity impacts. Measure and report the embodied carbon of the build, favour materials with verified environmental product data, seek responsible sourcing assurance for major plant, and design out heat island and land impacts where you can. Record construction emissions for the owner's Scope 3.

Operations and Maintenance

Asset owner and operator

"Most of our compute is cloud and co-location we do not run. How do we report and manage its footprint?"

Scope 3[15] means procured cloud and co-location now sit in your disclosure, but the emissions are sometimes opaque and vendor lock-in limits governance. Decide who internally owns digital sustainability across technology, procurement, and finance, then set disclosure and efficiency questions as contract conditions.

End of Life and Renewal

Asset owner and operator

"AI is driving fast hardware refresh. How do we manage the sustainability of decommissioning?"

Shortened refresh cycles and obsolescing hardware compound embodied carbon and drive e-waste. Build decommissioning and circular economy obligations into the original procurement so end-of-life is planned. Prefer refurbishment and reuse pathways, and record refresh cycles so the true lifecycle footprint is visible in operations.

The Cost of Inaction: Gaps in the Current Landscape

Decade-long lock-in
long-lived passive elements such as building shells, grid connections, and cable corridors commit a facility against workloads that may look very different. Criteria set at the design stage will influence performance well into the future.

Grid and water impact
unmanaged data centre growth can absorb the grid and water capacity other sectors need to decarbonise, turning a digital decision into a system-wide constraint.

The reporting gap
there is still no consistent, mandatory sustainability reporting for data centres, and few procurement criteria that treat digital assets on a like-for-like basis with conventional built assets.



CASE STUDY: AUSTROADS CARBON MEASUREMENT AND REPORTING TOOL (CMRT)[16]

Organisation: Austroads, supported by Jacobs
Location: Australia and New Zealand

What

CMRT Stage 2 is a single Australia–New Zealand cloud-based platform for quantifying, managing and reporting greenhouse gas emissions from road infrastructure construction and maintenance. It provides a centralised, secure, multi-user data and reporting environment for transport agencies, local governments, consultants and contractors. Delivered using an Agile approach, it brought together carbon specialists, software developers, data scientists, UX designers and transport infrastructure experts through iterative prototyping, user testing and staged releases, with data ownership and long-term hosting transferred to Austroads.

Why

Road infrastructure owners and delivery partners lacked a consistent, accessible approach to measuring and reporting greenhouse gas emissions across project lifecycles. Disparate tools and methodologies, including spreadsheet-based and agency-specific processes, created inefficiencies, reduced comparability between jurisdictions, increased reporting effort and limited the sector's ability to benchmark performance, identify emissions hotspots and realise carbon abatement opportunities at scale.

Outcome

The CMRT replaced fragmented jurisdiction-specific approaches with a single source of truth for emissions data, enabling consistent carbon accounting and benchmarking across projects, organisations and jurisdictions. It reduces the effort required to collect, validate and report carbon information. A bespoke web platform was found to be more cost-effective than continued use of Excel tools or third-party solutions, and as it is offered free to Austroads members, it reduces time, effort and licensing fees across the value chain. Over time, standardised data will provide insights into performance trends and emissions reduction outcomes.

CASE STUDY: HONEYWELL FORGE IMPROVES ENERGY EFFICIENCY AND ASSET PERFORMANCE AT PALACE TOWER PERTH[17]

Organisation: Honeywell, with JLL
Location: Perth, Western Australia

What

Palace Tower Perth, a premium commercial tower, deployed Honeywell Forge for Buildings, a cloud-based analytics platform that provides continuous insight into energy use, equipment condition and system performance. By analysing real-time and historical building data, the platform identifies operational issues not visible through conventional monitoring, and gives facilities teams and service partners a shared performance view that supports planning and monthly performance reviews.

Why

Premium commercial buildings are under increasing pressure to meet environmental performance targets while maintaining a high standard of occupant comfort. At Palace Tower, NABERS outcomes play a central role in operational decision-making. The building relied on a traditional Building Management System (BMS) that could not always surface hidden inefficiencies, such as overlapping schedules, control instability or undetected mechanical degradation. These issues can increase energy use, accelerate asset wear and reduce operational visibility over time.

Outcome

Within the first week, the platform identified redundant HVAC pre-cool and pre-warm cycles. It also found 19 Air Handling Units running fans at full speed due to slipping belts, manual overrides left in place after maintenance, more than 30 faulty or drifting sensors, and widespread control loop oscillation. Estimated avoided costs are $9,100, $14,440 and $6,900 annually across three findings, plus $2,000 to date from addressing overrides. Continuous monitoring of temperature, humidity and CO2 now helps align operations with NABERS Indoor Environment requirements, and maintenance has shifted from reactive to predictive, with better contractor coordination and less time spent diagnosing recurring issues.



Category 3

Sensing and Device Infrastructure

What Type of Infrastructure Does This Include

Internet of Things (IoT) Sensor Networks
low-power, distributed, sensors that report in real time or at set intervals when data is needed, generating low or high-volume condition and environmental data.

Smart and Multifunction Urban Infrastructure
street furniture such as poles that host smart lighting, sensors, cameras, communications, EV charging and, in some cases, edge compute in one networked asset.

Environmental Sensing Stations
fixed and mobile multi-parameter monitors for air, water, noise, biodiversity, and climate.

Transport Monitoring Systems
high-bandwidth, safety-critical systems for traffic management, incident detection, and demand-responsive operations.

Key Attributes

The layer that captures the state of assets and the environment: condition, performance, and environmental parameters, continuously and in real time. It is what turns a physical asset into a source of data.

Deployed across water and transport networks, the built environment, and natural environments: sensors on pipes and pumps, poles along streets, stations in catchments and along roads, and cameras across the transport network.

Ranges from cheap, numerous, low-power sensors deployed by the hundreds to networked street furniture and safety-critical transport systems that must not fail.

Because sensing touches communities, Country, and identifiable individuals, its deployment is a data governance and privacy question as much as a technical one.

The Landscape: Investment, Legislation, and Trends

IoT sensor networks are growing rapidly across water, transport, and the built environment.

Smart and multifunction poles are moving from pilot to mature, with the City of Melbourne and the City of Sydney as reference deployments.

Transport monitoring is mature, with Transurban, TfNSW, and VicRoads as reference points, and environmental sensing is established in water and environment agencies.

First Nations data sovereignty, the AIATSIS Code of Ethics, and privacy expectations for camera-based systems shape how sensing data can be collected, stored, and used.

References: AIATSIS Code of Ethics; Indigenous Data Sovereignty frameworks; applicable state privacy and surveillance legislation.

DUAL LENS: OPPORTUNITY AND FOOTPRINT

Sustainability Benefits of Digital Infrastructure

Predictive maintenance: continuous condition data enables operators to intervene before asset failure, cutting material waste, unplanned outages, and premature replacement. The Sydney Water sewer blockage case study below is an example.

Environmental evidence base: real-time monitoring gives the measured data that sustainability reporting and climate adaptation need, and provides early warning for hazards.

Asset consolidation: multifunction poles combine lighting, sensing, communications, and charging into one asset, removing duplicate street infrastructure and its embodied carbon, as well as de-cluttering the footpath to enhance access needs.

Demand-responsive operations: transport monitoring enables dynamic traffic management that reduces vehicle emissions and measures modal shift for enhanced insights and reporting.

Climate resilience: monitoring of asset conditions, water levels, atmospheric and ground movement gives owners data to act just in time, protecting assets and communities before and during extreme weather events.

Evidence for communities: air quality, heat, noise and transport data help councils target action where need is greatest, and sensing co-designed with Traditional Owners can support caring for Country programs.

Lower whole-of-life cost: condition monitoring can help in deferring capital replacement and cut the cost of unplanned outages.

Digital Infrastructure Issues to Watch

01 **E-waste and batteries at scale**
devices deployed at scale reach end of life together, and battery replacement across large fleets creates a recurring disposal task.

02 **Embodied carbon and refresh**
carbon in manufacture and installation, camera and sensor hardware refresh cycles, and limited visibility of where and how devices are made, can accumulate across large deployments.

03 **Data volume footprint**
high-bandwidth monitoring generates large data volumes that must be stored and processed, pushing part of the footprint into the data category.

04 **Governance and privacy risk**
sensing that touches communities, Country, and individuals carries data sovereignty and privacy obligations that, if unmet, become a social licence problem.

05 **Consent and surveillance**
cameras and sensors in public space, and on Country, need privacy, consent and First Nations data governance arrangements agreed before deployment, not after complaints arise.

06 **Unfunded running costs**
battery replacement, data storage, cyber security and maintenance are sometimes operational costs that can be missing from an early-stage business case,

The Key Questions

Considerations that might help a member organisation build a business case for action and investment and to govern well are included in the table below.

P — PROCESS
Have we developed data governance and privacy assessment within sensing procurement, and required end-of-life and battery disposal planning up front?

O — ORGANISATION AND CULTURE
Is accountability clear for data drawn from Country and communities, consistent with Indigenous Data Sovereignty principles?

T — TECHNOLOGY
Are we specifying open data standards and replaceable nodes so the network survives platform changes rather than being stranded?

I — INFORMATION
Have we defined what sensing data is retained, for how long, and how it feeds sustainability metrics without creating an unmanaged storage footprint?

Applying This Across the Asset Lifecycle

Below are five common questions you may face across the asset lifecycle, each from the perspective most likely to raise it.

Sensing deployment can outpace the development of the appropriate governance frameworks. The lifecycle lens is about defining data governance and end-of-life requirements early, before large scale deployment occurs.

Planning

State authority asset owner

"We are planning a large sensing network across public assets. What data governance and sustainability requirements should we define first?"

Define data governance requirements up front. Clarify accountability for data drawn from Country and communities, consistent with Indigenous Data Sovereignty principles, and set privacy expectations for camera-based systems. Sensing scales faster than its governance, so decisions now shape social licence. Require end-of-life and battery disposal planning as a condition, given the scale.

Design

Sustainability consultant

"I am advising on a sensor network design. How do I keep it from becoming stranded technology, that is, obsolete or unusable well before the end of its intended life?"

Specify open data standards and replaceable nodes so the network survives platform changes rather than becoming obsolete. Standards fragmentation is the main threat to the data's long-term sustainability value, so design for interoperability from the start. Favour low-power, long-lived sensors to reduce battery replacement and e-waste over the life.

Construction

Construction company sustainability manager

"We are deploying sensors and smart poles by the thousand. What is the construction phase risk?"

Embodied carbon in manufacture and installation, e-waste and batteries at the scale of deployment, and devices sourced from high-risk supply chains, are the main risks. Seek modern slavery and battery mineral sourcing assurance from suppliers, coordinate installation to reduce duplicate street infrastructure and disturbance to street trees and footpaths, and set up take-back. Record device counts and specifications so the owner can plan end-of-life from day one.

Operations and Maintenance

Asset owner and operator

"Our sensors generate huge data volumes. Does operating all this data carry a sustainability cost?"

Yes, storing and managing large volumes of data can carry a sustainability cost. Define what sensing data is to be retained, for how long, and how it feeds sustainability metrics, rather than storing everything by default. Retained data carries an energy and cost footprint in the underlying compute.

End of Life and Renewal

Asset owner and operator

"Our first generation of sensors is reaching end of life. How do we handle it sustainably?"

Devices deployed at scale can create a significant e-waste and battery disposal task if not planned. Set end-of-life and battery pathways at procurement, prioritise reuse and recycling, and record volumes recovered. Renew with replaceable-node designs and open standards so the next generation avoids the same stranding risk.

The Cost of Inaction: Gaps in the Current Landscape

Governance lag
sensing scales faster than the rules around it, so data sovereignty, privacy, and consent obligations trail deployment and are expensive to retrofit.

Standards fragmentation
without shared data standards, networks are stranded when platforms change, and cross-sector value never materialises.

Unplanned end of life
devices installed without an end-of-life plan become an e-waste liability that accumulates years later, for the future asset operator

CASE STUDY: IOT SEWER BLOCKAGE DETECTION DEVICES HELPING PREVENT WASTEWATER OVERFLOWS ACROSS GREATER SYDNEY[18]

Organisation: Sydney Water
Location: Greater Sydney wastewater network

What

Since 2019, more than 20,000 battery-powered IoT sensors have been installed across approximately 4,600 km of high-risk wastewater network. The sensors monitor wastewater levels in maintenance holes and send real-time alerts when rising levels indicate a developing blockage, combining sensing and device infrastructure, wireless connectivity, data platforms and analytics. Installation locations were prioritised using risk modelling, and an in-house IoT platform and operational processes support monitoring, alarm management and field response.

Why

Sydney Water's wastewater network serves more than 5.6 million people. Tree roots, grease, wet wipes and debris can cause sewer blockages that lead to wastewater overflows, impacting customers and the environment. Historically, many blockages were identified through inspections, customer reports or after an overflow had occurred.

Outcome

The program has detected and helped prevent around 1,800 potential overflows to date, averaging 300 to 400 detections per year. Each prevented overflow is estimated to avoid approximately $15,000 in remediation and recovery costs, along with negative stakeholder and customer experience. Avoided costs and reduced environmental impacts supported a payback period within four years, and the program has also improved condition-based maintenance.



CASE STUDY: BEYOND THE SAILS: THE TECHNOLOGIES POWERING THE SYDNEY OPERA HOUSE[19]

Read More

Organisation: Honeywell
Location: Sydney Opera House, Bennelong Point, Sydney

What

Honeywell building controllers continuously monitor the Opera House's seawater cooling system, providing real-time alarm notifications and ongoing plant optimisation. Smart sensors placed throughout the building measure indoor environment conditions such as temperature and humidity, alongside electricity and water consumption. Data from these sensors is aggregated in Honeywell Enterprise Buildings Integrator (EBI), giving the facilities team a single platform to inform building management decisions. The Opera House and Honeywell work together to troubleshoot issues, identify inefficiencies for early intervention, carry out regular maintenance and deliver equipment upgrades.

Why

The Sydney Opera House is a World Heritage-listed performing arts venue welcoming an audience of more than 1.3 million people each year. Operating a heritage building of this scale relies on complex systems working seamlessly behind the scenes to keep performers and visitors comfortable while managing energy and water use, safety and carbon emissions.

Outcome

Integrated controls and sensing have helped the Opera House reduce its water and energy use, contributing to a 6 Star Green Star rating from the Green Building Council of Australia, making it one of the first World Heritage-listed buildings to achieve this recognition. Real-time monitoring and alarms enable earlier intervention on faults and inefficiencies, improving operational efficiency and the reliability of building services.



Category 4

Computing and AI Infrastructure

What Type of Infrastructure Does This Include

Digital Twin Platforms
BIM-integrated virtual replicas fed by real-time data, used for simulation, planning, and operational optimisation across the full lifecycle.

AI and Machine Learning Systems
pattern recognition, prediction, and optimisation systems for grid balancing, predictive maintenance, demand forecasting, and route optimisation.

High-Performance Computing (HPC) Clusters
parallel processing systems for large-scale simulation, climate modelling, structural analysis, and AI model training.

AI-Specific Hardware (GPUs, TPUs, Neuromorphic Chips)
the specialised equipment that provides the compute power for AI across planning, construction, and operations.

Key Attributes

The analysis and intelligence layer. It turns data into simulation, prediction, and optimisation.

Ranges from largely software-based tools, such as digital twins and models that run on general-purpose computers, to physically intensive systems, such as HPC clusters and AI hardware, which use large amounts of power and water for cooling.

Sits mostly inside data infrastructure, so its footprint compounds the data centre footprint rather than sitting apart from it. On-device (edge) AI is starting to move some of it closer to the asset.

Model energy footprints are largely undisclosed, and the sector's ability to interrogate them is limited, so this is the least transparent category in the matrix.

The Landscape: Investment, Legislation, and Trends

Digital twin adoption is scaling across horizontal and vertical sectors, with Sydney Metro, Jacobs and Honeywell among the organisations applying them through the case studies provided in this section.

AI is accelerating compute intensity and the workload on data centres. Understanding of AI's sustainability impacts, and how they are reported, is evolving rapidly, and regulators and investors are focusing on it.

Australia's Digital Economy Strategy and National AI Plan (2025) set ambitions for AI adoption without yet embedding sustainability obligations.

AI-specific hardware carries supply chain concentration and geopolitical risk around rare earths and critical minerals, and short product cycles that drive e-waste.

References: Australia's Digital Economy Strategy; National AI Plan (2025); Australian Sustainability Reporting Standards (IFRS S1 and S2).

DUAL LENS: OPPORTUNITY AND FOOTPRINT

Sustainability Benefits of Digital Infrastructure

Digital twins can reduce rework and optimise resource use: real-time data and predictive modelling let teams test a design and its construction sequence before building it, reducing lifecycle emissions and shortening timelines.

Digital twins enable scenario testing: interoperable digital twins let planners test climate and resilience scenarios at the scale of the whole asset or network.

AI optimises networks in real time: applied to grids, transport, and water, it reduces curtailment, extends asset life through predictive maintenance, and improves renewable integration. The Jacobs-supported heavy-haul rail case study below shows how AI-supported modelling informs decarbonisation decisions.

Improving hardware efficiency: next-generation chips are reducing inference energy per operation and enabling on-device AI that avoids the cloud upload and download.

Enhancing public engagement: digital twins and AI decision support systems can help designers test more options, and give communities a visual way to understand and respond to proposals before they are built.

Better decisions earlier: simulation and optimisation can reduce rework, defer capital spend and extend asset life, with the largest gains in planning and design when changes to a scheme is often cheaper than latter stages of development.

Digital Infrastructure Issues to Watch

01 **Training and inference energy**
training large language models is highly energy intensive, and running them at scale carries an ongoing energy cost that does not stop after training.

02 **HPC footprint**
high-performance computing has substantial energy and cooling requirements, high embodied carbon, and short hardware refresh cycles.

03 **Greenwashing risk**
efficiency benefits are often claimed for AI and digital twins without measured outcomes, so a gain on paper can mask a net footprint increase.

04 **Supply chain and hardware exposure**
AI hardware depends on rare earths and critical minerals from concentrated supply chains, with environmental and human rights risks in extraction and manufacture, and short product cycles which can drive e-waste.

05 **Knowledge work and fairness**
routine design, scheduling and data processing roles could face displacement, and should be planned for with appropriate programs developed to ensure redeployment and transition opportunities are provided.

The Key Questions

Considerations that might help a member organisation build a business case for action and investment and to govern well are included in the table below.

P PROCESS
Do we require measured, verifiable sustainability outcomes from AI and digital twin projects at approval, rather than modelled or projected claims?

O ORGANISATION AND CULTURE
Do we have the capability to calculate the footprint of AI energy use and interrogate a model energy claim, and if not, how do we build it?

T TECHNOLOGY
Are our digital twins built on interoperable data schemas so new analytics layers can be added without rework?

I INFORMATION
Have we set expectations for disclosure of training and inference energy, with independent verification to guard against greenwashing?

Applying This Across the Asset Lifecycle

Below are five common questions you may face across the asset lifecycle, each from the perspective most likely to raise it.

This category potentially has both the greatest enabling potential and the largest footprint, and where measured outcomes matter most. Claims in this category will warrant close scrutiny given the evolving nature of the technology, and fluid policy environment.

Planning

State authority asset owner

"Projects increasingly claim AI will deliver sustainability benefits. What should we require at approval?"

Require measured, verifiable outcomes at approval, not modelled or projected claims, since methods for measuring and reporting AI's sustainability impacts are still developing. Ask for the training and inference energy behind the tool and whether the claimed saving is net of the model's own footprint. Screen out unverified efficiency claims as a greenwashing risk.

Design

Sustainability consultant

"I am advising on a digital twin for a major project. How do I frame its sustainability value and cost?"

Digital twins can reduce rework and optimise resource use, lowering lifecycle emissions, and enable climate scenario testing at planning scale. Build them on interoperable data schemas so you can add new analytics without rework, extending value. But digital twins can be compute-intensive, so pair the benefit with the energy cost and design for a measured outcome, not a modelled claim.

Construction

Construction company sustainability manager

"Our project team wants high-performance computing for modelling during delivery. What is the sustainability position we can take?"

High-performance computing carries high energy and cooling load, high embodied carbon, and short refresh cycles that drive e-waste, with hardware drawn from critical mineral supply chains carrying labour and environmental risk. Weigh up the modelling benefit against that footprint, and ask about cloud versus on-premise efficiency and supplier sourcing commitments rather than buying fast-refreshing hardware.

Operations and Maintenance

Asset owner and operator

"We run AI optimisation across our network. How do we report its footprint and prove the benefit?"

Set expectations for disclosure of training and inference energy from your providers and use independent verification where you can. With lacking standards, it is a challenge to consistently measure AI's footprint with respect to energy today, so treat it as a capability to build. Prove the benefit with measured before-and-after outcomes: curtailment avoided, asset life extended, or energy reduced, rather than assumed savings.

End of Life and Renewal

Asset owner and operator

"AI hardware evolves fast. How do we manage the sustainability of replacing it?"

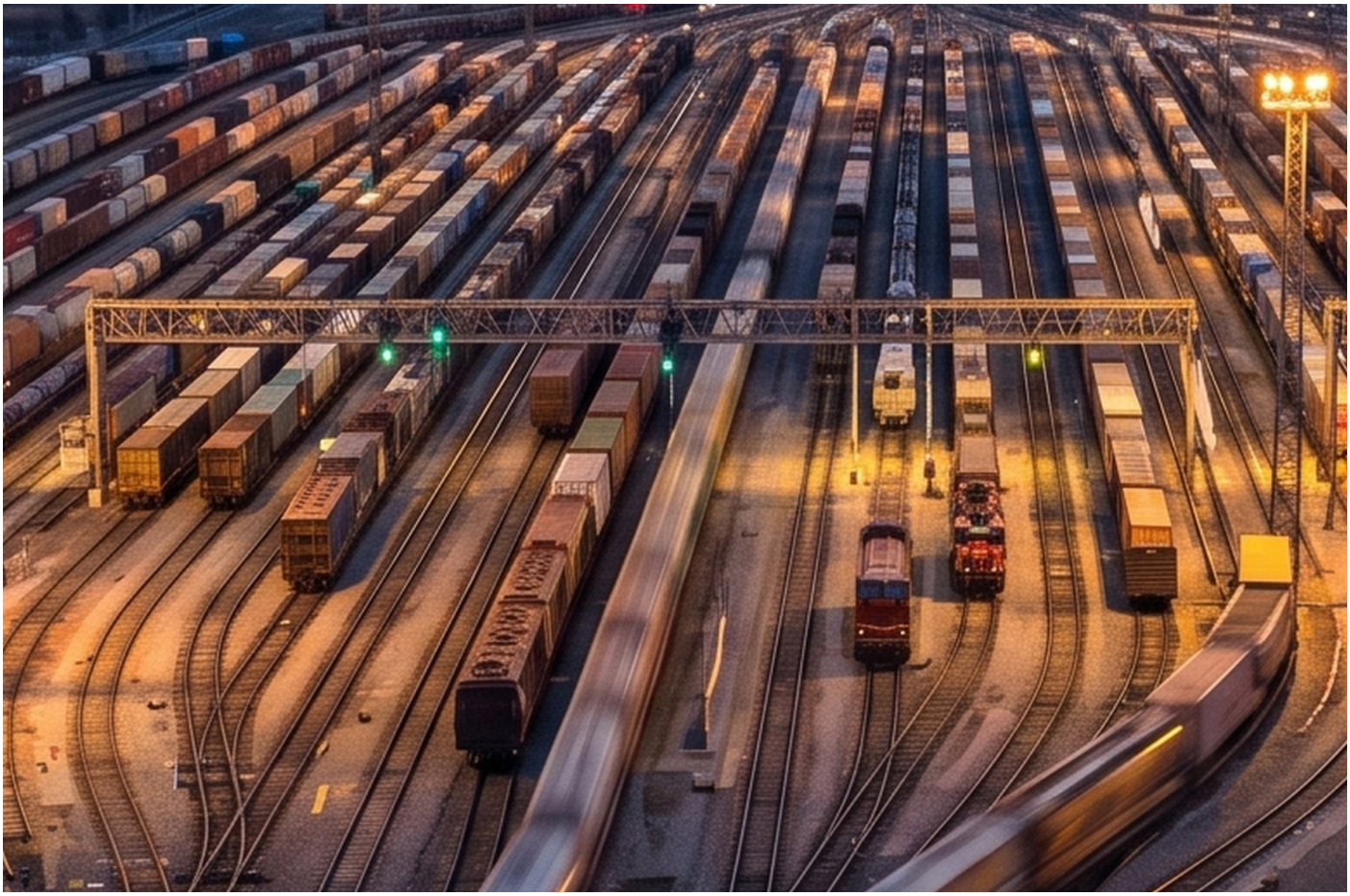
Short product cycles drive significant e-waste and lock in dependencies on chips, rare earths, and critical minerals. Plan refresh around genuine need rather than vendor cadence, build in reuse and recycling, and record the lifecycle footprint. Where compute is cloud-based, make refresh efficiency and circular economy commitments part of the provider disclosure.

The Cost of Inaction: Gaps in the Current Landscape

Unproven claims, and the real footprint
without a measured-outcomes requirement, AI is credited with sustainability benefits it cannot evidence while its own energy and hardware footprint expands.

No basis for comparison
there is no consistent way to report or compare the sustainability of AI systems, so buyers cannot tell an efficient tool from an energy-intensive one.

Rating coverage gap
rating tools do not yet cover AI and computing infrastructure on par with conventional built assets, so the highest-growth, least-transparent category sits outside our most common toolkit for sustainability.



CASE STUDY: AI-DRIVEN ENERGY OPTIMISATION FOR HEAVY-HAUL RAIL OPERATIONS[20]

Organisation: Confidential heavy-haul rail operator, supported by Jacobs
Location: Australia

What

Jacobs supported the development and use of a transparent modelling capability combining engineering simulation, optimisation and applied AI and analytics in a single decision-support environment. It models diesel-electric and battery-electric locomotive operation, energy consumption, battery performance, charging requirements, driver-performance effects and network-level operational scenarios. It was delivered in stages, from a red-flag review of existing assumptions and code to a coupled train dynamics and rail energy storage model, scenario analysis and progressive refinement using operational data.

Why

Heavy-haul rail operators seeking to decarbonise need to understand how battery-electric locomotives will affect energy demand, train performance, fleet utilisation, charging strategy and operational reliability. Traditional planning approaches are limited in assessing how train dynamics, battery state-of-charge, driver behaviour, charging infrastructure and network operations interact at system scale. This creates uncertainty in fleet replacement, minimum viable charging infrastructure, operational readiness and commissioning decisions.

Outcome

The client was able to rapidly assess thousands of scenario variations before committing to investment decisions, enabling informed selection of preferred options and providing critical inputs to the business case while reducing planning time and risk. The work reduced uncertainty around battery-electric locomotive adoption, minimum viable charging infrastructure, operating strategy and commissioning readiness. While commercial and operational metrics cannot be shared, the value lay in improved decision quality, traceability of assumptions and confidence in rail decarbonisation planning.



CASE STUDY: ISC CSF AI ASSISTANT ENABLES EFFICIENT DEVELOPMENT OF CSF CREDIT REPORTS[21]

Organisation: John Holland
Location: Multiple states

What

The ISC CSF AI Assistant is an AI application developed internally by John Holland's IT and Sustainability teams, with an external partner contributing Azure Prompt Flow and AI expertise. Deployed on John Holland's Azure infrastructure and integrated with project data repositories, it supports the development of CSF credit reports across multiple projects. It was introduced through a pilot program, with AI outputs compared against previously completed manual ISC reports and refined using feedback from sustainability subject matter experts (SMEs).

Why

ISC reporting requires significant resourcing and specialist expertise. Developing CSF credit reports demands comprehensive knowledge of sustainability initiatives across a project lifecycle that often spans several years, along with strong report-writing capability. This creates reliance on a limited pool of internal experts and can lead to dependence on external consultants.

Outcome

Teams report significant time savings and reduced cost and effort in preparing CSF credit reports, although formal resource gains have not yet been measured. SMEs estimate system outputs are approximately 70% complete before expert review and finalisation. The system has been used across four projects at different stages, from early development through to final submission.

Category 5

Autonomous and Robotic Infrastructure

What Type of Infrastructure Does This Include

Autonomous Plant and Haulage Vehicles
GNSS- and LiDAR-guided, geofenced, fleet-managed heavy vehicles that automate earthmoving, haulage, and repetitive site operations.

Connected and Autonomous Vehicles (CAVs)
sensor-rich, V2X-capable, software-defined vehicles that interact with road infrastructure to deliver passenger and freight services.

Aerial and Submerged Drones (UAVs, UUVs, ROVs)
battery-powered, remote or autonomous platforms that survey, monitor, and inspect hard-to-access assets.

Construction and Fabrication Robotics
task-specific, programmable robots for relevant tasks based on capability, such as bricklaying, welding, rebar tying, and additive manufacturing of structural elements.

Inspection and Maintenance Robotics
confined-space-capable robots that inspect and maintain pipes, tunnels, tanks, and other hazardous spaces.

Exoskeletons, Teleoperation, and Augmented Reality
human-in-the-loop systems that augment worker capability and enable remote operation.

About This Infrastructure

The infrastructure translates digital intelligence into physical execution across construction, operation, and maintenance. This is what separates it from sensing, which observes, and computing, which decides. When AI is used in the sensing-and-action loop, the term is 'physical AI'.

Deployed on construction sites, across road and rail networks, inside pipes and tunnels, power lines and marine assets, and on the bodies of workers. It operates in the environments people find most dangerous or hardest to reach.

Ranges from established autonomous haulage in mining through to emerging construction robotics and wearable systems still in pilot.

Because it changes what work is done, by whom, and under what conditions, its context is as much social, covering workforce, safety, and accountability, as it is environmental.

The Landscape: Investment, Legislation, and Trends

Australia has a National Robotics Strategy (2024) and Aotearoa New Zealand has published its first national robotics roadmap.

Autonomous haulage is established in mining, notably the Pilbara. CAV trials are underway in NSW, VIC, and QLD.

Drones are mature in surveying and utilities inspection. Inspection robotics is growing in water utilities, including Sydney Water, along with rail and energy networks.

References: Australia's National Robotics Strategy (2024); Aotearoa New Zealand national robotics roadmap (KiwiNet, NZRAS, Callaghan Innovation).

DUAL LENS: OPPORTUNITY AND FOOTPRINT

Sustainability Benefits of Digital Infrastructure

Precision reduces waste: highly accurate positioning and less idling reduce fuel use, rework and material waste on site.

Drones replace higher-emission survey methods: using drones instead of helicopters and crewed surveys substantially reduces inspection emissions and allows safe access to assets at height or in confined environments. The Sydney Water drone sampling case study below is an example.

Off-site robotic fabrication: construction robotics enables modular, factory-based fabrication that reduces material waste and transport impacts.

Safety and workforce: removing workers from high-risk tasks, and using tools such as exoskeletons to reduce strain injuries, improves worker safety and wellbeing. Through thoughtful design and deployment, automation can also create new skilled roles and learning pathways, but this depends on deliberate workforce planning.

Digital Infrastructure Issues to Watch

01 **Fuel source and hardware**
diesel-powered fleets still dominate autonomous plant, and sensor and compute hardware refresh generates e-waste. Efficiency gains do not remove the fuel or hardware footprint.

02 **Autonomous vehicle materials and induced demand**
battery raw materials raise supply chain environmental and human rights concerns, and easier autonomous travel may induce more travel that offsets the efficiency gains.

03 **Workforce transition**
routine inspection, monitoring, scheduling, and operator roles face possible displacement pressures, which is a sustainability issue through the employment quality and social licence lens.

04 **Accountability and oversight**
when an autonomous or physical AI-recommended action causes harm, questions of accountability, transparency, and the right level of human oversight and cybersecurity are likely, with few frameworks for transparency currently available.

The Key Questions

Considerations that might help a member organisation build a business case for action and investment and to govern well are included in the table below.

P — PROCESS
Have we brought workforce transition, safety, and accountability into procurement and approval, alongside capital cost and productivity?

O — ORGANISATION AND CULTURE
Are we planning for the shift from direct execution to oversight, judgement, and exception handling, and for the training and accreditation pathways it needs?

T — TECHNOLOGY
Are we considering the embodied carbon of robotic hardware and the fuel source of autonomous fleets, not just the operational efficiency gain?

I — INFORMATION
Have we defined accountability and transparency where autonomous decisions and physical AI affect communities and safety-critical operations?

Applying This Across the Asset Lifecycle

Below are five common questions you may face across the asset lifecycle, each from the perspective most likely to raise it.

This is the newest category, and the one with the largest social licence dimension. The lifecycle lens weighs clear environmental and safety wins against workforce transition, accountability, and the hardware footprint.

Planning

State authority asset owner

"We are planning to bring automation into our delivery and maintenance pipeline. What belongs in the sustainability case beyond productivity?"

Broaden the criteria beyond capital cost and productivity to include workforce transition, safety, and accountability. Infrastructure that improves environmental performance but erodes employment quality does not meet a credible definition of sustainable. As the newest category, practice is still forming, so planning decisions now shape the agenda and its social licence.

Design

Sustainability consultant

"I am advising on an automated or robotic solution. How do I assess its true sustainability?"

Consider the embodied carbon of the robotic hardware and the fuel source of any autonomous fleet, not just the operational efficiency benefits. Diesel fleets still dominate, and battery raw materials and induced demand can offset autonomous-vehicle gains. Design for the whole footprint, and quantify the clearest wins, such as drones replacing helicopter surveys.

Construction

Construction company sustainability manager

"We are introducing construction and inspection robotics on site. Where is the upside and the risks?"

Precision operation reduces fuel use, idling, rework, and material waste; drones substantially reduce inspection emissions, and workers are removed from high-risk tasks. The downside is sensor and compute hardware refresh generating e-waste, battery minerals with supply chain labour and environmental risk, drone and robot disturbance near sensitive habitat, and workforce transition.

Operations and Maintenance

Asset owner and operator

"We are moving to autonomous inspection and maintenance. What changes for us as operator?"

The human role shifts from direct execution to oversight, judgement, and exception handling, with implications for training, accreditation, and safe systems of work that have not caught up. Define accountability and transparency where autonomous action affects communities and safety-critical operations. Quantify the gains as well: emissions avoided compared with manned surveys and safety incidents removed.

End of Life and Renewal

Asset owner and operator

"Our autonomous plant and drones are reaching end of life. What are the sustainability considerations?"

Sensor and compute hardware refresh and battery raw materials create e-waste and supply chain exposure at end of life. Plan reuse, recycling, and responsible battery disposal, and record volumes. Renew with the fuel source and embodied carbon in mind, not just the productivity gain, so each generation reduces rather than repeats the footprint.

The Cost of Inaction: Gaps in the Current Landscape

Disruption not tracked
treating automation as a separate workforce or technology issue leaves its sustainability and social licence implications out of the sustainability assessment processes.

No way to weigh the trade-off
there is no shared method to weigh environmental and safety gains against employment quality, accountability, and community trust.

Change gets harder
practice is still evolving, so decisions made now, without a sustainability lens, may become established norms that are harder to change later.



CASE STUDY: DRONE-BASED WATER QUALITY SAMPLING IMPROVES SAFETY AND ACCESS AT REMOTE COASTAL AND WATERWAY MONITORING SITES[22]

Organisation: Sydney Water
Location: Greater Sydney and Shellharbour

What

Sydney Water established an in-house drone-based sampling capability using two types of remotely piloted aircraft, the DJI M350RTK with a 1-litre and the M400 with a 2-litre sample collection system, to collect laboratory samples from offshore and nearshore monitoring locations. Led by Laboratory Services and the Future and Mobile Labs initiative, the program has its own operating capability, governance, training and operational framework, and is integrated with existing environmental monitoring programs and laboratory workflows.

Why

Sydney Water undertakes extensive aquatic and environmental monitoring to understand the impact of water resource recovery facility discharges on waterways and coastal environments. Some sampling locations are difficult, hazardous or impossible to access using traditional methods, requiring vessels, cliff or rock platform access, or work near ocean swell. This exposes staff to marine and environmental hazards and can limit access to important monitoring locations.

Outcome

Drone sampling is now used within the Sydney Water Aquatic Monitoring (SWAM) Program, enabling sample collection at sites previously difficult or impossible to access. Critical monitoring sites along the Warragamba River near the Wallacia Wastewater Recovery Facility are now sampled wholly via drone. Additional benefits include reduced staff exposure to hazardous conditions, less reliance on vessels and associated resources, and faster sampling capability.

Roles, Interfaces and Outcome-Based Procurement

While throughout Part B, there has been mention of process and organisational capability and the need to build strong governance for digital infrastructure projects, it is worth highlighting further some key points.

As has been demonstrated in this section, no single stakeholder group delivers digital infrastructure. Government agencies and asset owners, consultants and designers, manufacturers and technology providers, systems integrators, delivery partners and operators each hold part of the picture across the lifecycle.

The sustainability performance of a project often depends less on any one contribution than on how well knowledge passes among them. Where those interfaces are unclear, policy intent can be lost in translation, specifications can lock in today's technology, and the people who manage the assets have little influence over how the next procurement is planned and designed. Clarifying roles, responsibilities and handover points is therefore critical.

Procurement is also a very practical place to strengthen these connections. Tender documentation still tends to focus on what a digital system should contain and how it should be configured. Giving measurable outcomes more weight lets each party contribute where it adds most value. Those outcomes include enhanced community wellbeing, energy and water savings, carbon reduction, operational efficiency, resilience, maintainability and interoperability.

Owners should be setting the outcomes they are seeking, with designers translating them into performance requirements. Technology providers advise on what current and emerging solutions can realistically deliver, and integrators ensure the categories in the matrix work together as a whole system.

This reinforces the adaptive planning and upgradeability principles set out earlier in this paper. Highly prescriptive specifications can limit an asset's ability to adopt new technology over a lifecycle that might outlast several generations of hardware. A balance of outcomes, core technical requirements and interoperability keeps that flexibility without weakening sustainability objectives.

Measured performance, rather than design assumptions alone, should shape future specifications and investment decisions on infrastructure projects. This also addresses the risk, flagged in the matrix, of sustainability claims for digital systems that are not backed by measured outcomes. It builds the evidence base that, for example, mandatory climate disclosure increasingly demands.

Taken together, these steps above create a line of sight from policy and sustainability objectives, desired outcomes, performance requirements, technology capability, systems integration, operations, measured outcomes and feedback. This gives ISC and its members a shared model for governing and procuring digital infrastructure projects, and supports ISC's advocacy case for embedding sustainability criteria in digital infrastructure procurement standards.



Part C

Continuing the Conversation

The five digital infrastructure categories explored in Part B, together with the procurement and lifecycle considerations examined throughout this paper, point to a clear conclusion: digital infrastructure is becoming inseparable from infrastructure itself.

This paper is not intended to prescribe a roadmap or define a future work program. Rather, it seeks to provide a foundation for industry discussion and identify the areas where greater attention, collaboration and leadership may be required as digital infrastructure becomes increasingly embedded within infrastructure planning, delivery and operations.

A Dual-Lens Approach

A consistent theme emerging from this work is that digital infrastructure should be viewed through two complementary lenses.

Digital as an Enabler of Sustainability
Digital technologies have the potential to improve sustainability outcomes across the infrastructure lifecycle. Connectivity, sensing, data platforms, digital twins, artificial intelligence and automation can improve resource efficiency, resilience, safety, decision-making and community outcomes.

Digital as Infrastructure
At the same time, digital infrastructure is increasingly an infrastructure asset class in its own right. Data centres, communications networks, sensing systems, computing platforms and autonomous technologies create environmental, social and economic impacts that must be understood, managed and assessed across their lifecycle.

Taken together, these lenses present both an opportunity and a responsibility. The challenge is no longer whether digital infrastructure will shape the future of infrastructure, but how to maximise its sustainability benefits while responsibly managing the sustainability footprint that comes with it.

Seven Priorities for Digital Infrastructure Sustainability

Drawing on the five categories explored in this paper, several priorities emerge for industry, government and infrastructure owners.

1. **Measure outcomes, not technology -** The success of digital infrastructure should be judged by the sustainability outcomes it delivers, not by the deployment of technology itself. Investments in digital capability should demonstrate measurable improvements in environmental, social and economic performance.
2. **Treat digital infrastructure as infrastructure -** Digital assets should be subject to the same lifecycle thinking applied to physical infrastructure. Planning, procurement, deployment, operation, upgrade, replacement and end-of-life impacts all require consideration.
3. **Embed sustainability into procurement and investment -** Procurement remains one of the most powerful levers for market transformation. Sustainability considerations should be integrated into digital infrastructure investment, procurement, contracting and decision-making processes.
4. **Strengthen governance, transparency and accountability -** As digital infrastructure becomes more pervasive, organisations require greater visibility of energy use, emissions, resource consumption, resilience, data governance and broader sustainability impacts.
5. **Build the evidence base -** The pace of technological development continues to outstrip the availability of evidence. Industry should invest in research, performance data, case studies and practical experience to better understand both the benefits and impacts of digital infrastructure.
6. **Plan for adaptation and resilience -** Digital technologies evolve rapidly, while infrastructure assets often remain in service for decades. Future-ready infrastructure will require flexibility, interoperability, adaptability and resilience to changing technologies, policy settings and community expectations.
7. **Shape policy and market settings -** Achieving sustainable digital infrastructure outcomes will require collaboration between governments, regulators, infrastructure owners, industry and researchers. Policy, procurement frameworks, reporting approaches and investment settings must evolve to recognise both the opportunities and impacts associated with digital infrastructure.

Looking Ahead

Realising the potential of digital infrastructure will require coordinated action across government, infrastructure owners, contractors, consultants, technology providers, researchers and industry bodies. No single organisation can address these challenges alone.

Building on the insights from both the Phase 1 and Phase 2 Digital Infrastructure papers, ISC will continue to convene industry discussions, share emerging insights, develop practical guidance and support the advancement of sustainable digital infrastructure practices across Australia and Aotearoa New Zealand.

The opportunity ahead is significant. Digital infrastructure has the potential to transform how infrastructure is planned, delivered and operated. Equally, it presents new sustainability challenges that demand attention, evidence and leadership.

Industry now has an opportunity to shape the future of digital infrastructure before practices, standards and expectations become entrenched. The decisions made today will influence not only how digital infrastructure is delivered, but the role it plays in creating a more sustainable future.

As this work progresses, ISC will continue to share updates, resources and opportunities for collaboration through the Digital Infrastructure Program at https://www.iscouncil.org/digital-infrastructure-futures/



Glossary of Terms

Acronyms and Abbreviations

4G / 5G: Fourth and fifth generation mobile network technologies. 5G offers lower latency and higher device density than 4G, supporting real-time control applications.

AI: Artificial intelligence. Computer systems that perform tasks such as pattern recognition, prediction, optimisation and content generation.

AIATSIS: Australian Institute of Aboriginal and Torres Strait Islander Studies. Publisher of the AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research.

ANZ: Australia and New Zealand (Aotearoa New Zealand).

API: Application programming interface. A defined way for software systems to exchange data and instructions.

AR: Augmented reality. Technology that overlays digital information on a user's view of the physical environment.

BIM: Building information modelling. A process for creating and managing structured digital information about a built asset across its lifecycle.

BMS: Building management system. A control system that monitors and manages building services such as heating, ventilation, air conditioning and lighting.

CAV: Connected and autonomous vehicle. A vehicle that uses sensors, software and communications to operate with partial or full automation and to interact with infrastructure and other vehicles.

CityGML: City Geography Markup Language. An open data standard for representing and exchanging 3D city and landscape models.

CMRT: Carbon Measurement and Reporting Tool. An Austroads cloud-based platform for quantifying and reporting greenhouse gas emissions from road infrastructure construction and maintenance.

CO2: Carbon dioxide.

CSF: Used in the paper in relation to ISC credit reports prepared under the IS Rating Scheme. Expansion to be confirmed by ISC.

Cth: Commonwealth (of Australia). Used to denote federal legislation.
EV: Electric vehicle.

GNSS: Global navigation satellite system. Satellite-based positioning systems, such as GPS, used for location and guidance.

GPU: Graphics processing unit. A processor designed for parallel computation, widely used to train and run AI models.

GTFS: General Transit Feed Specification. An open data standard for public transport schedules and associated geographic information.

HPC: High-performance computing. Clusters of processors working in parallel to perform large-scale simulation, modelling and AI model training.

HVAC: Heating, ventilation and air conditioning.

IaaS: Infrastructure as a Service. A cloud model in which computing, storage and networking resources are provided on demand.

IEA: International Energy Agency.

IFC: Industry Foundation Classes. An open, international data standard (ISO 16739) for exchanging BIM data.

IFRS S1 / S2: International Financial Reporting Standards sustainability disclosure standards. S1 covers general sustainability-related financial disclosures; S2 covers climate-related disclosures.

IoT: Internet of Things. Networks of physical devices fitted with sensors, software and connectivity that collect and exchange data.

IS Rating Scheme: Infrastructure Sustainability Rating Scheme. ISC's rating system for evaluating the economic, social and environmental performance of infrastructure across planning, design, construction and operations.

ISC: Infrastructure Sustainability Council. The peak industry body for advancing sustainable infrastructure across Australia and Aotearoa New Zealand.

IT: Information technology.

LED: Light-emitting diode. An energy-efficient lighting technology.

LiDAR: Light detection and ranging. A remote sensing method that uses laser pulses to measure distances and create detailed 3D representations.

LoRa: Long Range. A low-power wireless communication technology used in LPWAN networks.

LPWAN: Low-power wide-area network. Wireless networks designed for long-range, low-data-rate communication between battery-powered devices.

NABERS: National Australian Built Environment Rating System. A national rating system measuring the environmental performance of buildings, including energy, water, waste and indoor environment.

NBN: National Broadband Network. Australia's national wholesale broadband network, operated by NBN Co.

NSW: New South Wales.

NZRAS: New Zealand Robotics, Automation and Sensing network.

PaaS: Platform as a Service. A cloud model providing a managed platform on which users build and run applications.

POTI: Process, Organisation and Culture, Technology, and Information. The framework used in this paper to structure key questions for each category.

PPA: Power purchase agreement. A long-term contract to buy electricity, often from a specific renewable energy generator.

PUE: Power Usage Effectiveness. A data centre efficiency metric: total facility energy divided by the energy used by IT equipment. A value closer to 1.0 indicates higher efficiency.

QLD: Queensland.

ROV: Remotely operated vehicle. Typically an underwater vehicle controlled by an operator from a remote location.

SaaS: Software as a Service. A cloud model in which software applications are delivered over the internet on a subscription basis.

SEQ: South East Queensland.

SME: Subject matter expert.

SWAM: Sydney Water Aquatic Monitoring Program.

TfNSW: Transport for NSW.

TPU: Tensor processing unit. A processor designed specifically for machine learning workloads.

TWh: Terawatt hour. A unit of energy equal to one billion kilowatt hours.

UAV: Unmanned aerial vehicle. Commonly referred to as a drone.

UUV: Unmanned underwater vehicle.

UX: User experience.

V2X: Vehicle-to-everything. Communication between a vehicle and other vehicles, infrastructure, networks and road users.

VIC: Victoria.

Terms

Active equipment: The electronic and powered components of a network, such as radio equipment, exchange hardware and servers, which typically have shorter lifecycles than passive infrastructure.

Agentic AI: AI systems capable of planning and taking a sequence of actions to achieve a goal with limited human direction.

Asset lifecycle: The stages of an infrastructure asset from planning and design through construction, operations and maintenance, to end of life and renewal.

Australian Sustainability Reporting Standards: Australian standards for mandatory climate-related financial disclosure, aligned with IFRS S1 and S2, introduced on a phased basis from 1 January 2025.

Autonomous and robotic infrastructure: One of the five categories in this paper. Robotics, autonomous plant and vehicles, drones and human-machine systems that translate digital intelligence into physical action.

Backhaul: The part of a network that carries data from local or edge sites back to a core network or central facility.

Circular economy: An economic model that keeps materials and products in use for as long as possible through reuse, repair, refurbishment and recycling, minimising waste.

Cloud platform: Computing, storage and software services delivered over the internet from shared, remotely hosted infrastructure.

Co-location: A data centre service in which an organisation rents space, power and cooling for its own IT equipment in a facility operated by a third party.

Computing and AI infrastructure: One of the five categories in this paper. Digital twin platforms, AI and machine learning systems, high-performance computing clusters and AI-specific hardware.

Condition monitoring: Ongoing measurement of an asset's physical condition to detect deterioration or faults.

Connectivity infrastructure: One of the five categories in this paper. Fixed broadband, mobile networks, LPWAN, and subsea and terrestrial fibre cables that transmit data.

Country: A term used by Aboriginal and Torres Strait Islander peoples to describe the lands, waters, skies and relationships to which they are connected.

Critical minerals: Minerals essential to modern technologies, including digital hardware and batteries, with supply chains that may be concentrated or vulnerable to disruption.

Curtailment: The deliberate reduction of output from a generator, below what it could otherwise produce, often due to grid constraints.

Data centre: A facility housing computing, storage and networking equipment, with supporting power, cooling and security systems.

Data infrastructure: One of the five categories in this paper. Data centres, cloud platforms, edge compute nodes and data integration and interoperability platforms.

Data sovereignty: The principle that data is subject to the laws and governance of the nation, or the people, from which it originates.

Decommissioning: The planned retirement and removal of an asset or equipment from service.

Demand management: Measures that shift or reduce energy or water use, particularly at peak times, to avoid the need for additional capacity.

Digital infrastructure: As defined by ISC for this paper, the physical and virtual systems that enable data to be generated, transmitted, stored, processed and applied to enhance infrastructure performance.

Digital Infrastructure Sustainability Matrix: The framework used in this paper to map the five categories of digital infrastructure against capability, sustainability enablement, footprint and current maturity.

Digital twin: A virtual representation of a physical asset, system or network, updated with real-time or periodic data, used for simulation, planning and operational optimisation.

Drone: An uncrewed aerial, surface or underwater vehicle operated remotely or autonomously.

E-waste: Discarded electrical and electronic equipment, including devices, batteries and network hardware.

Edge computing: Processing data close to where it is generated, rather than in a centralised data centre, to reduce latency and data transfer.

Embodied carbon: Greenhouse gas emissions associated with the manufacture, transport, installation, maintenance and disposal of materials and equipment.

Exoskeleton: A wearable device that supports or augments a worker's physical movement, often to reduce strain and injury.

Fibre (optical fibre): Cable that transmits data as light, offering very high capacity over long distances.

Generative AI: AI systems that create new content, such as text, images or code, based on patterns learned from training data.

Geofencing: Use of a virtual geographic boundary to control where a vehicle or device can operate.

Greenwashing: Making misleading or unsubstantiated claims about the environmental benefits of a product, service or activity.

Hapū: In Aotearoa New Zealand, a Māori kinship group or subtribe.

Heat island effect: Higher local temperatures in built-up areas caused by heat-

absorbing surfaces, reduced vegetation and waste heat.

Human-in-the-loop: A system design in which a person monitors, guides or approves the actions of an automated system.

Hyperscale data centre: A very large data centre designed to support massive, scalable computing and storage workloads, typically operated by major cloud providers.

Indigenous data sovereignty: The right of Indigenous peoples to govern the collection, ownership and use of data about their communities, lands and resources.

Induced demand: An increase in use of a service or infrastructure resulting from improved access or reduced cost, which can offset efficiency gains.

Inference: The process of running a trained AI model to produce outputs, such as predictions or responses.

Interoperability: The ability of different systems, devices and data sources to exchange and use information.

Iwi: In Aotearoa New Zealand, a Māori tribal grouping.

Large language model: An AI model trained on large volumes of text to understand and generate language.

Last mile: The final segment of a network that connects end users or premises to the wider network.

Latency: The delay between sending and receiving data across a network.

Machine learning: A branch of AI in which systems learn patterns from data to make predictions or decisions without being explicitly programmed for each task.

Mandatory climate disclosure: Legal requirements for certain entities to report climate-related risks, opportunities and emissions.

Modal shift: A change in the share of trips made by different transport modes, such as from private car to public or active transport.

Multifunction pole: A street pole that combines functions such as lighting, sensors, cameras, communications and EV charging in one asset.

Neuromorphic chip: A processor designed to mimic aspects of the structure of the human brain, aimed at highly energy-efficient computation.

Open standards: Publicly available technical specifications that enable interoperability between products from different suppliers.

Passive infrastructure: The long-lived physical elements of a network, such as ducts, conduit, cables, towers and building shells, as distinct from active electronic equipment.

Physical AI: AI used within a sensing-and-action loop to direct physical systems such as robots, vehicles and machinery.

Predictive maintenance: Using condition data and analytics to anticipate failures and schedule maintenance before they occur.

Rare earths: A group of metallic elements used in electronics, magnets and batteries, with concentrated global supply chains.

Rebound effect: Where efficiency gains lower the cost of an activity and so increase overall consumption, offsetting part or all of the expected savings.

Scope 3 emissions: Indirect greenhouse gas emissions that occur in an organisation's value chain, including from purchased goods and services such as cloud and co-location.

Security of Critical Infrastructure Act 2018 (Cth): Australian legislation setting security obligations for owners and operators of critical infrastructure, including communications.

Sensing and device infrastructure: One of the five categories in this paper. IoT sensor networks, smart and multifunction urban infrastructure, environmental sensing stations and transport monitoring systems.

Smart metering: Meters that record and communicate energy or water use at frequent intervals, enabling demand management.

Social licence: Ongoing acceptance or approval of a project or organisation by its community and stakeholders.

Sovereign digital infrastructure: Digital infrastructure located, owned or controlled within a nation to support national security, data sovereignty and resilience.

Stranded asset: An asset that becomes obsolete, underused or uneconomic before the end of its expected life.

Subsea cable: A fibre optic cable laid on the seabed to carry data between countries or regions.

Taonga: In te reo Māori, a treasure or something of value, including intangible things.

Te Mana Raraunga: The Māori Data Sovereignty Network.

Te Tiriti o Waitangi: The Treaty of Waitangi, the founding agreement between Māori and the British Crown in Aotearoa New Zealand.

Te Waihanga: The New Zealand Infrastructure Commission.

Teleoperation: Remote control of a machine or vehicle by a human operator.

Training (AI): The process of developing an AI model by exposing it to large datasets, typically requiring significant computing power and energy.

Two-way lens: The perspective used in this paper: digital infrastructure as an enabler of sustainability outcomes, and as an asset class with its own sustainability footprint.

Water-stressed region: An area where demand for water approaches or exceeds available supply.

Whenua: In te reo Māori, land.

Workload consolidation: Moving computing workloads from multiple dispersed facilities into fewer, more efficient facilities.

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Appendix A

Digital Infrastructure Sustainability Matrix

This matrix maps the five categories of digital infrastructure against key attributes, capability, sustainability enablement, footprint, and current ANZ maturity. It is intended to inform Section 2.1 of the discussion paper and support the development of ISC's rating tool gap analysis.

Category key: 1 · Connectivity 2 · Data 3 · Sensing and devices 4 · Computing and AI 5 Autonomous and Robotics Enablement (+) Footprint (–)

	Infrastructure capability	Sustainability enablement	Technology	Key attributes	Sustainability footprint	Current maturity
Connectivity	Supports real-time asset monitoring, remote operations, and data-intensive workflows across infrastructure sites.	+ Enables remote workforce, reducing commuter emissions + Supports smart metering and demand management	**Fixed Broadband (NBN/Fibre)**	High bandwidth Low latency Always-on Wired	– Energy use in exchanges and headends – Copper legacy infrastructure e-waste	Established — NBN coverage >96%
	Connects mobile assets, remote sensors, and field workers; enables real-time data exchange at infrastructure sites.	+ 5G enables low-latency control of autonomous machinery + Supports connected vehicles and smart transport	**Mobile Networks (4G/5G)**	Wireless Low-latency (5G) Device density Edge-ready	– Tower energy consumption – Hardware refresh cycles and e-waste	4G mature; 5G metro rollout underway
	Connects distributed sensors across large geographic areas — suited to water, agriculture, and remote infrastructure.	+ Enables environmental monitoring at scale + Low-cost connectivity for remote and regional assets	**LPWAN / LoRa Networks**	Ultra-low power Long range Low data rate Low cost	– Minimal — battery life 5–10 years – End-of-life battery disposal	Growing — water and agriculture sectors
	Backbone of international and interstate data exchange; critical for cloud and AI workloads.	+ Enables distributed data infrastructure, reducing centralised energy loads	**Subsea and Terrestrial Fibre Cables**	Very high capacity Sovereign risk dimension Long-lived asset (25+ years)	– High embodied carbon in installation – Marine environment impacts during laying	Established; new cable investment ongoing
Data	Hosts enterprise workloads, cloud services, and AI training infrastructure at scale.	+ Consolidates workloads — more efficient than on-premise per unit compute + Renewable PPAs driving clean energy procurement	**Hyperscale Data Centres**	Massive compute & storage PUE-optimised Renewable energy targets Centralised	– Very high energy and water consumption – Embodied carbon in construction – Land use and heat island effects	Rapidly growing — AirTrunk, NextDC, Equinix
	Processes data close to source — reduces back haul, enables real-time response for critical infrastructure.	+ Reduces data centre energy by processing locally + Enables real-time optimisation of transport, energy, water	**Edge Compute Nodes**	Distributed Low-latency processing Small footprint Near source	– Harder to manage and optimise than centralised – Distributed hardware harder to power with renewables	Emerging — pilot deployments in transport
	Provides scalable compute, storage, and integration for asset management, BIM, and digital twin applications.	+ Enables rapid scaling without new hardware + Shared infrastructure more efficient than siloed on-premise	**Cloud Platforms (IaaS/ PaaS/SaaS)**	Elastic Multi-tenant API-driven Globally distributed	– Scope 3 emissions from cloud usage can be opaque – Vendor lock-in limits sustainability governance	Mature — widely adopted across sector
	Connects disparate data sources across the asset lifecycle — enabling coordinated planning and operations.	+ Reduces rework through data continuity across lifecycle stages + Unlocks cross-sector optimisation (transport + energy + water)	**Data Integration and Interoperability Platforms**	Standards-based (IFC, CityGML, GTFS) API-first Real-time and batch	– Primarily software — footprint in underlying compute	Developing — standards fragmentation remains a barrier
Sensing and devices	Monitors asset condition, environmental parameters, and operational performance continuously.	+ Predictive maintenance reduces material waste and unplanned outages + Real-time environmental monitoring informs climate adaptation	**IoT Sensor Networks**	Low-power Distributed Real-time High-volume data	– Battery waste from large-scale deployments – Hardware refresh and e-waste at scale	Growing rapidly — water, transport, built environment
	Street furniture that hosts lighting, sensors, cameras, comms, and EV charging.	+ Reduces duplicate street infrastructure + Supports active transport monitoring and air quality sensing + EV charging integration	**Smart / Multifunction Urban Infrastructure**	Multi-use Urban Networked Power-integrated	– Embodied carbon in manufacture and installation – Lighting energy use (offset by LED efficiency gains)	Pilot stage to Mature — City of Melbourne, City of Sydney
	Measures air quality, water quality, noise, biodiversity indicators, and climate parameters.	+ Provides evidence base for sustainability outcomes reporting + Supports early warning for climate and environmental hazards	**Environmental Sensing Stations**	Continuous monitoring Multi-parameter Fixed and mobile	– Minimal — low-power, long-lived assets	Established in water and environment agencies
	Enables active traffic management, incident detection, and demand-responsive infrastructure operations.	+ Dynamic traffic management reduces vehicle emissions + Enables modal shift measurement and active transport planning	**Transport Monitoring Systems**	High bandwidth Real-time Safety-critical Data-intensive	– High bandwidth generates large data volumes requiring storage – Camera hardware refresh cycles	Mature — Transurban, TfNSW, VicRoads

Digital Infrastructure Sustainability Matrix

Computing and AI	Creates virtual representations of physical assets enabling simulation, planning, and operational optimisation.	+ Reduces physical prototyping and rework — embodied carbon savings + Optimises operations for energy and resource efficiency + Enables climate scenario testing	**Digital Twin Capability**	BIM-integrated Real-time data feeds Simulation Full lifecycle	– Compute-intensive — ongoing energy cost – Requires high-quality data to avoid misleading outputs	Rapidly growing — Sydney Metro, Jacobs, Arup, WSP
	Optimises infrastructure operations in real time — grid balancing, predictive maintenance, demand forecasting, route optimisation.	+ AI-driven grid management reduces curtailment and emissions + Predictive maintenance extends asset life and reduces waste + Route and flow optimisation reduces energy use	**AI / Machine Learning Systems**	Pattern recognition Prediction & optimisation Requires training data	– Training compute is highly energy intensive – Model inference at scale has ongoing energy cost – Risk of greenwashing without measured outcomes	Rapidly growing — varies by application
	Supports large-scale simulation, climate modelling, structural analysis, and AI model training.	+ Enables climate and resilience modelling at infrastructure planning scale + Underpins digital twin simulation environments	**High-Performance Computing (HPC) Clusters**	Parallel processing High energy Specialised hardware On-premise or cloud	– Extremely high energy and cooling requirements – High embodied carbon and short hardware refresh cycles	Established in research, growing in infrastructure sector
	Provides the compute substrate for AI applications across infrastructure planning, construction, and operations.	+ Next-gen chips dramatically reduce inference energy per operation + Enables on-device AI at the edge without cloud dependency	**AI-Specific Hardware (GPUs, TPUs, Neuromorphic Chips)**	Accelerated inference Energy-per-operation improving Rapid evolution	– Manufacturing resource-intensive (rare earth minerals) – Short product cycles drive significant e-waste – Supply chain concentration — geopolitical risk	Embedded in cloud; emerging on-device (Physical AI)
Autonomous and Robotics	Automates earthmoving, haulage, and repetitive site operations; removes workers from high-risk operating environments.	+ Optimises fuel use through precision operation and reduced idling + Reduces rework via centimeter-level accuracy + Improves safety and reduces site incidents	**Autonomous Plant and Haulage Vehicles**	GNSS / LiDAR guided Geofenced operation Fleet-managed Heavy-duty	– Diesel-powered fleets still dominate – Sensor and compute hardware refresh cycles – Workforce transition risk in operator roles	Established in mining (Pilbara autonomous haulage); emerging in civil construction
	Self-driving vehicles that interact with road infrastructure and other vehicles to deliver passenger and freight services.	+ Smoother traffic flow reduces fuel use and emissions + Enables on-demand transit and shared mobility models + Removes human error as a road trauma factor	**Connected and Autonomous Vehicles (CAVs)**	Sensor-rich (LiDAR, radar, camera) V2X-capable Software-defined Safety-critical	– Battery raw materials and supply chain concerns – Sensor and compute energy load per vehicle – Induced demand may offset efficiency gains	Pilot stage — CAV trials in NSW, VIC, QLD; broad deployment 5–10+ years
	Surveys, monitors, and inspects assets across difficult-to-access environments, such as power lines, pipelines, bridges, marine infrastructure.	+ Replaces helicopter survey, cutting emissions by orders of magnitude + Faster inspection cycles reduce asset downtime + Removes workers from at-height and confined-water risks	**Aerial and Submerged Drones (UAVs / UUVs / ROVs)**	Battery-powered Remote or autonomous Payload-flexible Rapid deployment	– Battery e-waste from short product cycles – Airspace and privacy management overhead – Limited endurance restricts mission scale	Mature in surveying and utilities inspection; growing for asset monitoring and delivery
	Performs repetitive, precise, or hazardous construction tasks, such as bricklaying, welding, rebar tying, additive manufacturing of structural elements.	+ Reduces material waste through precision placement + Lowers embodied carbon through optimised material use + Enables off-site modular fabrication, cutting transport impacts	**Construction and Fabrication Robotics**	Task-specific Programmable On-site or factory-based AI vision integrated	– Embodied carbon in robotic hardware – Specialist skills and workforce transition – Maintenance and downtime can erode productivity gains	Emerging — early ANZ deployments in modular construction, tunnelling, and 3D-printed elements
	Operates inside pipes, tunnels, tanks, and other confined or hazardous spaces to inspect conditions and perform targeted maintenance.	+ Extends asset life through earlier defect detection + Reduces shutdown periods for inspection + Removes workers from confined-space and high-risk environments	**Inspection and Maintenance Robotics**	Confined-space capable Tethered or autonomous Sensor-integrated Specialist form factor	– Niche hardware with limited reuse across asset classes – Specialist operator training required – Connectivity-dependent in deep or submerged environments	Growing — water utilities (Sydney Water, Melbourne Water), rail tunnels, energy networks
	Augments human capability through wearable robotics, teleoperation, and AR-assisted operations on infrastructure sites.	+ Reduces musculoskeletal injury through load assistance + Enables remote operation of plant from safer locations + Improves first-time-right rates through guided workflows	**Exoskeletons, Teleoperation, and Augmented Reality Systems**	Wearable or wearable-integrated Human-in-the-loop Real-time feedback High collaboration / low autonomy	– Battery and electronics in wearables generate e-waste – Teleoperation dependent on robust connectivity — fragile in remote areas – Limited interoperability between vendor systems	Emerging — pilot deployments in construction, rail maintenance, and logistics



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