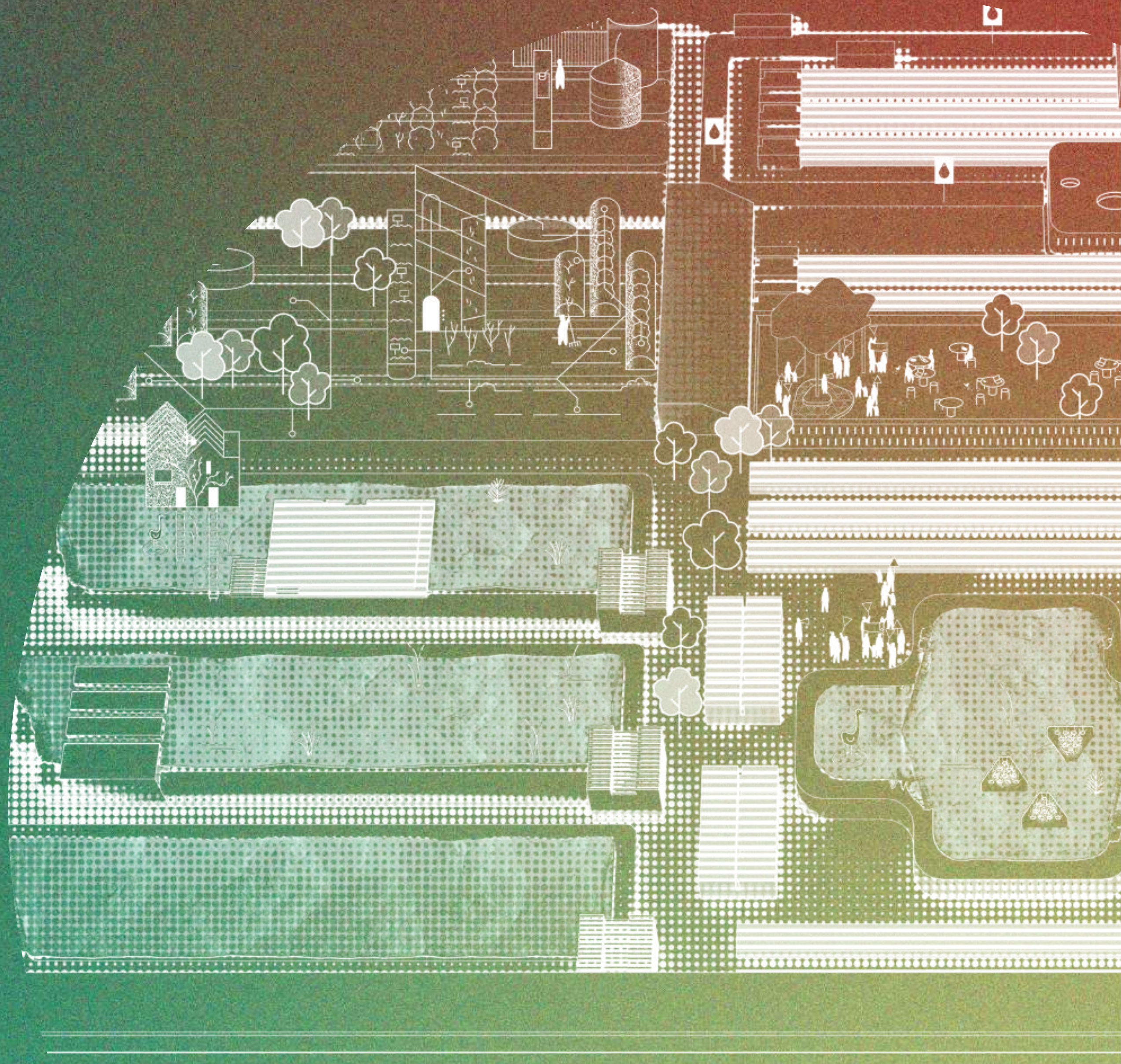
Issue 01

ARUP

Data Centre futures:
Water



Strategic design for water-conscious data centres

Foresight
September 2025

Data Centre Futures – looking beyond the asset

Twenty first century life – from the smallest everyday interactions to large-scale international and even extraterrestrial systems – is increasingly reliant on flows of data. All of us would notice if those flows were disrupted, yet relatively few of us are thinking deeply about the critical, digital infrastructure that translates data into something meaningful: the communications, services, operations that improve our lived experience.

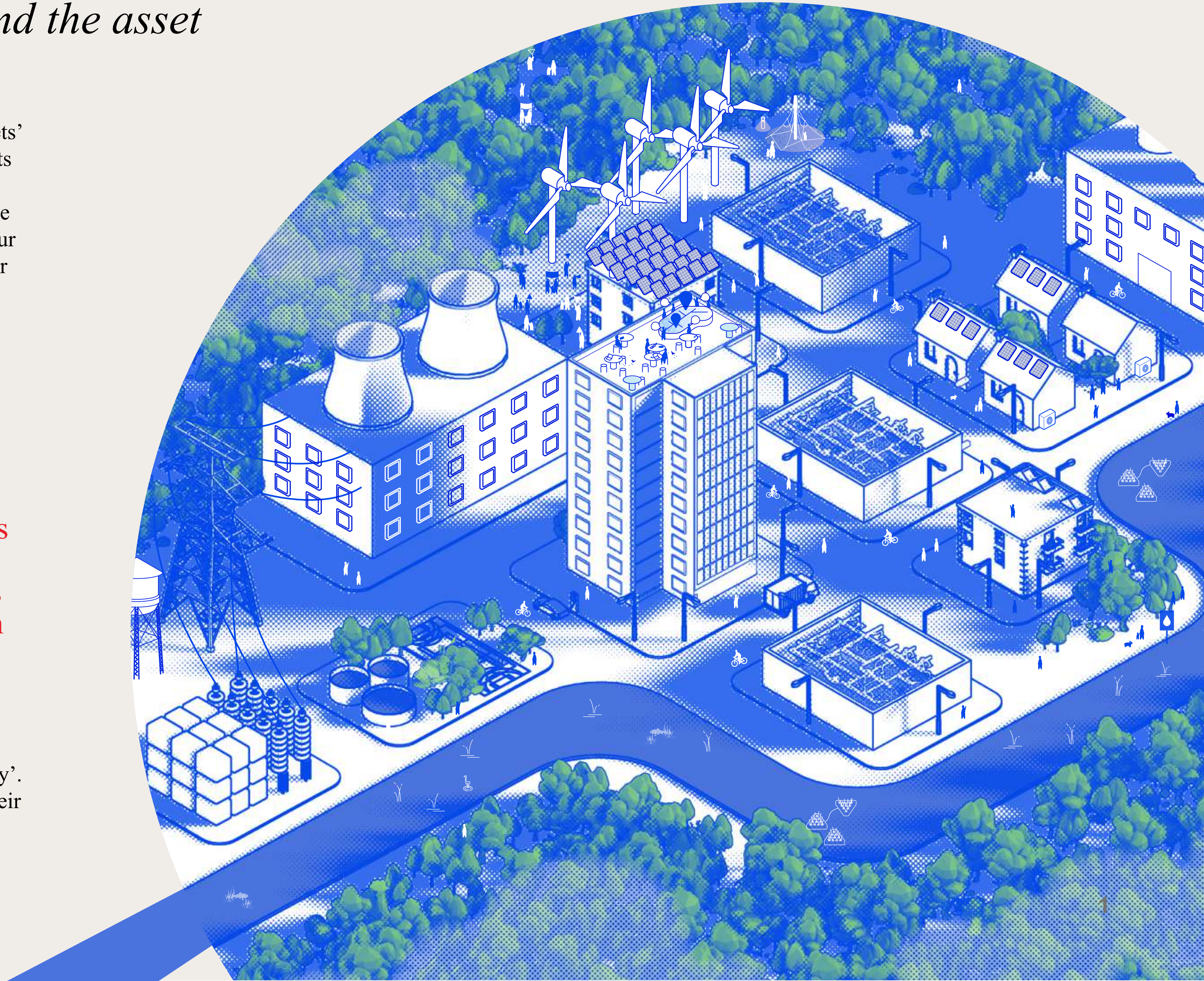
Thinking of them merely as 'assets' narrows our perspective and limits the potential for broader, positive impact through their design, while also risking negative effects on our experience and destabilising other essential flows in the short and longer term.

So, what defines a 'good' data centre? How can the facility be both a good neighbour' and a 'good ancestor'?

Within an 'urban metabolism', data centres are hubs through which flows of water, energy, materials, and people – as well as information – move. And as critical infrastructure, they can play a central role in shaping safe, resilient and regenerative places.

Data centres are the digital infrastructure hubs that store, process, and manage this data, yet their construction is struggling to keep pace with accelerating global demand.

Being a good *neighbour* requires rethinking of 'performance' metrics; a reframing of 'efficiency'. How can data centres improve their local place and local ecosystem?



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Data Centre Futures – looking beyond the asset

Being a good *ancestor* means recognising that the infrastructure we build today will become the legacy—or the relic—of tomorrow. Keeping the future in mind, designing for adaptability is key to creating positive impact. What happens when technological and socio-cultural evolutions make data centres, in their current form, redundant?

Within this and subsequent issues, we explore the Future of Data Centres, building upon our already broad range of insights on Arup.com.

We aim not to defend a single position, but elevate the conversation around data centres, encouraging more of us to ask better questions about dangerous assumptions and possible futures in this fast-evolving landscape.

Hit pause, look up and look around.

Urban metabolism – organism with flows (in and out)

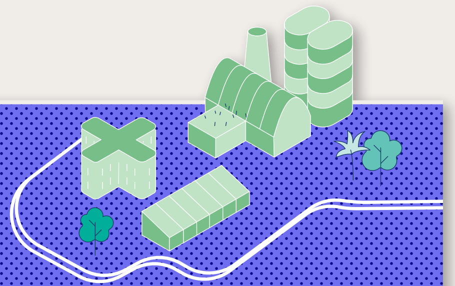
Data Centre Futures series

In collaboration with technical experts across Arup's global offices, the Foresight team presents the Data Centre Futures series.

Each issue explores a key theme, investigating emerging issues, trends shaping future context, critical reflections and informed speculation on longer-term possibilities. What is a data centre's long-term value and viability when compute technologies evolve faster than the structures built to contain them? Could data centres contribute more than they consume? How might they play a role in cultivating safe, resilient and regenerative places?

The first issue of this series focuses on Water.
What are the trade-offs involved in using water in data centres? When should water be used in a data centre? What might a water-scarce world mean for data centre design and delivery? How do data centres affect water-scarce areas? Might water offer new possibilities for the location and operation of digital infrastructure? What happens to 'water-rich' spaces at the end of a data centre's life?

01 Water



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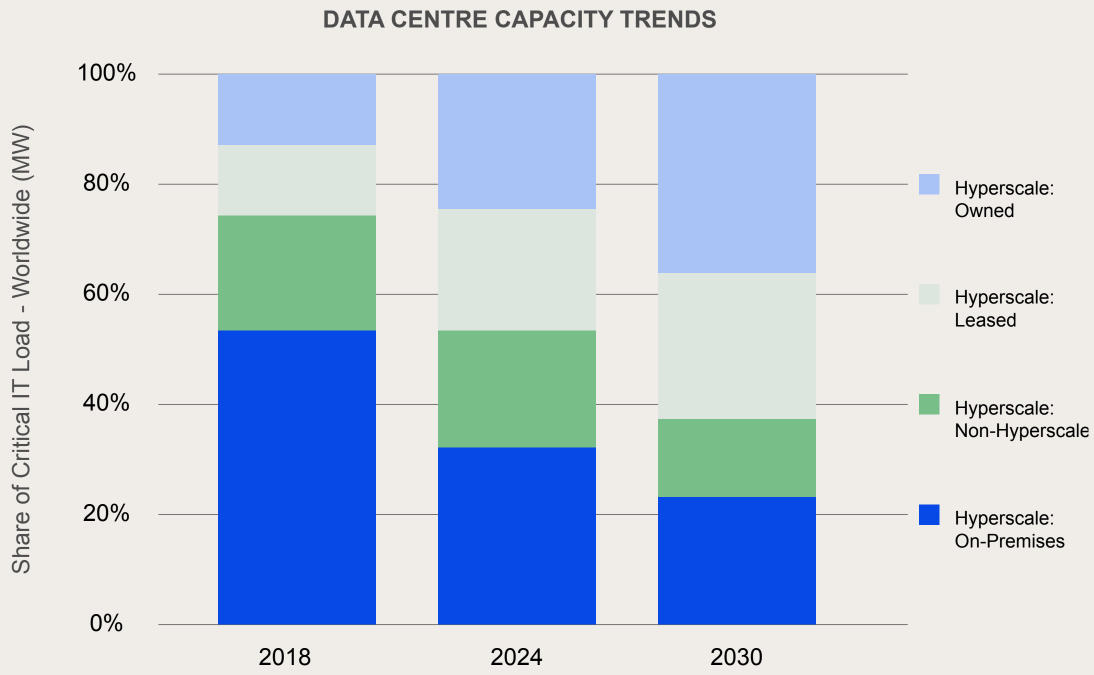
Current state of play – A system in flux

Despite underpinning every aspect of our modern digital lifestyles, data centres are set for a period of even faster growth, rapidly scaling to meet growing compute and data demand driven by AI and digitalisation.

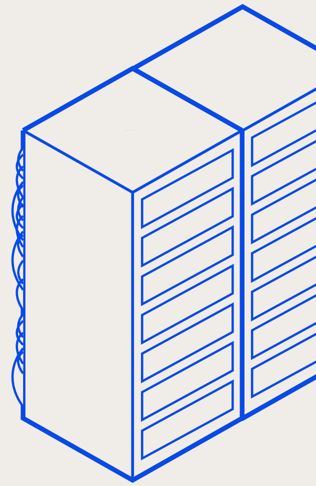
Some sources suggest that the volume of data created is set to triple by 2028, having already experienced a 60-fold increase from 2010 – 2023.[1] AI and compute power demands are set to grow.

AI requires a lot of compute power concentrated in a single place. Concentration of compute requires denser server racks which in-turn increases energy and cooling demand. With higher density computing, the effectiveness of air-cooling servers and racks diminishes, pushing developers to utilise other forms of cooling such as liquid cooling.[2]

Currently, most data centres use air cooling, with a 22% of data centres using liquid cooling.[3] Data centres use liquid and air cooling systems to remove heat from servers, racks, and other hardware. This process occurs both within the data halls and between the halls and external cooling units. Typically, these are closed-loop systems that transfer heat using either air or a specialised fluid.



Share of critical IT load handled by data centre type worldwide



* 70% of freshwater use feeds agriculture, 20% industry and 10 % is used by households

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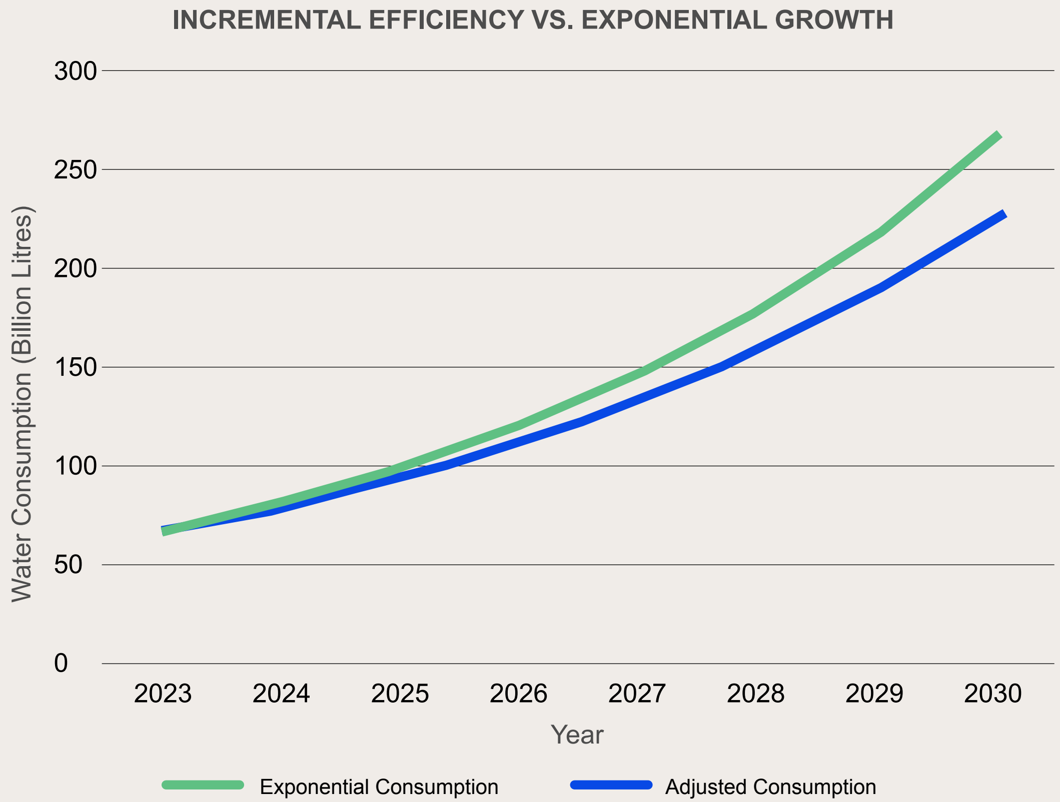
Current state of play – A system in flux

This commentary focusses on the potential water consumption that can occur with some external cooling plant and equipment. Utilising water can increase the efficiency of external cooling plants during certain climatic conditions. Adiabatic cooling is the term often used to describe the cooling increase associated with introducing water into the cycle. Trends point to water playing a growing role in data centres. The International Energy Agency (IEA) as part of its base case scenario estimates annual water consumption for data centres at 560 billion litres, rising to a projected 1,200 billion litres by 2030.[4] Data centres are also becoming bigger. Hyperscale data centres, where water is most likely to be consumed, accounted for just under a quarter of data centre capacity globally in 2018 but by 2024 that had almost doubled to 45% and is forecast to reach 62% by 2030.[5]

Whilst a global challenge, its impact is managed at a regional level, with some areas experiencing greater strain from ‘thirsty’ data centres than others, particularly in areas where hyperscale datacentres are concentrated. Data centres now rank among the top 10 water-consuming commercial industries in the US and the EU’s usage is set to surge 52% by 2030.[6 7] These are, however, just projections of trends and the current state of the market.

As demand grows, investors and operators struggle for new water sources, while authorities are faced with unpredictable capacity needs. Emerging markets such as Southeast Asia and Africa face even greater risks, as water scarcity and extreme weather can threaten operations in an increasingly volatile climate.

Given the high likelihood of ongoing digital demands and the subsequent increasing water stress, data centre operators are already prioritising water efficiency as a key part of sustainable operations. Innovative solutions are already being deployed to reduce or eliminate water use in critical cooling processes, paving the way for digital infrastructure growth that aligns with sustainable water use.



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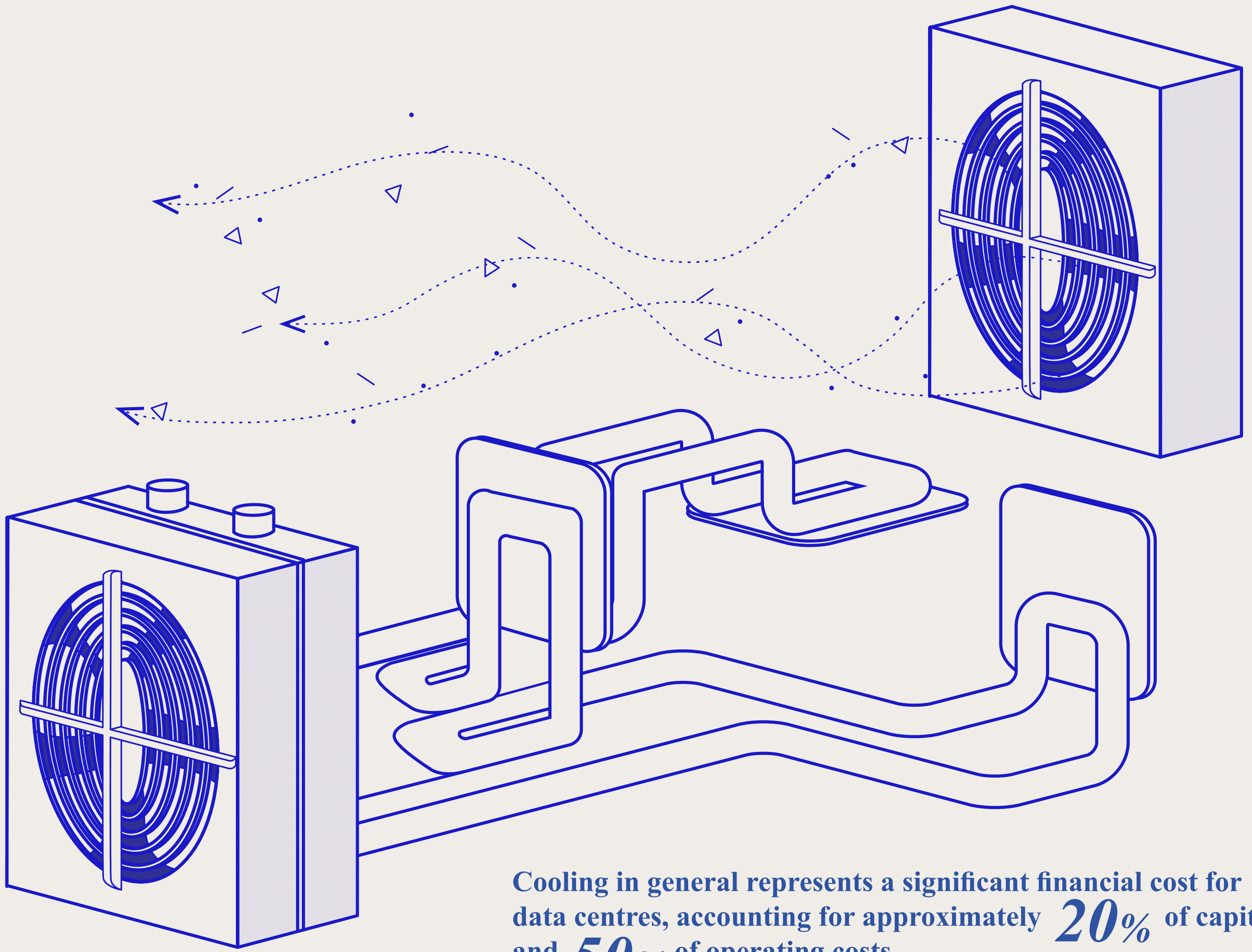
Why take a longer view?

Decisions made today are set to shape the future of the sector. Cycles in the built environment often take years, from site selection through design, permitting, construction, and delivery. As the data centre sector rapidly scales and evolves, it is crucial to anticipate 'what is next' to ensure value retention over time and minimise legacy issues in the future.

A long-term view is particularly important when it comes to water as its relationship with our digital infrastructure becomes increasingly complex. The focus on electrical energy efficiency in data centres has driven the growth of water as a medium to improve that efficiency.

Air-only cooling consumes more electrical energy and less water. Water-based or adiabatic systems consume less energy but more water.

While most data centres still rely on air cooling, liquid cooling is rapidly gaining ground as demand for efficiency and density grows, particularly in hotter climates and with increasing server rack density. Today, 22% of data centres are using liquid cooling.[8] The majority of these are seen in larger scale facilities, and those supporting AI which require more dense computing power. Cooling in general represents a significant financial cost for data centres, accounting for approximately 20% of capital and 50% of operating costs.[9]



Cooling in general represents a significant financial cost for data centres, accounting for approximately *20%* of capital and *50%* of operating costs.

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Why take a longer view?

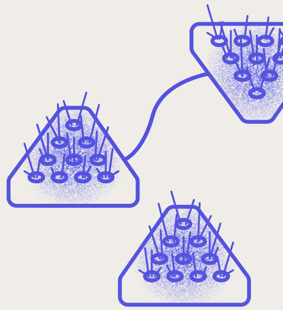
To help manage water demand many of it's heaviest users are assuming greater civic responsibility for local clean water supplies and working towards Water Usage Efficiency (WUE) targets through measures such as the Climate Neutral Data Centre Pact (CNDC) and corporate water positive commitments.[10] The CNDC sets an ambitious target for WUE by reducing today's average of 1.8 L/kWh to 0.4 L/kWh in water-stressed locations by 2040.[11]

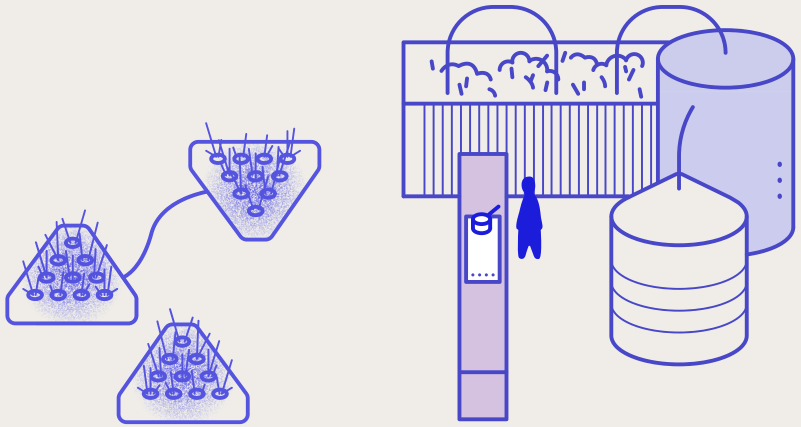
As the sector expands, it does so against the backdrop of climate change and unsustainable human activity disrupting global water cycles. Taking a long-term view scrutinises the decisions we make against water-related stressors – too little, too much, too dirty – which present practical and ethical challenges for assets that have been designed for stable environments. While it is impossible to predict the future, particularly in the context of climate change, it can at least be explored with a good understanding of where water resources will become more vulnerable.

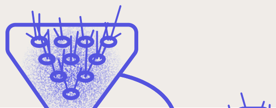
Understanding the future water context allows for decisions to be made across the data centre value chain preventing the risk of competing utilities (energy versus water) becoming reality. Some experts warn that digitalisation's water footprint could surpass its carbon footprint, an issue already being mitigated through renewables. But this outcome is not inevitable.[12]

Our future world is one that depends on data centres underpinning our daily lives, but also on sustainable management of our resources in a rapidly changing climate. These do not have to be mutually exclusive, we can reconcile the rapid growth of digital infrastructure with sustainable water use.

Achieving this will require taking a long-term view that moves us from a consumer and site-bound approach to a broader water system and water stewardship perspective.







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The evolving Water context for Data Centres – What's driving change?

Forces and factors shaping Water x Data Centre futures

strong trend

Too little water: Depletion of our natural water resources, from rivers to groundwater, longer periods with higher temperatures becoming more normal, intensifying drought and water scarcity1. Rise of 'Day Zero' monitoring

Too much water: More extreme weather events, flooding, sea level rise and coastal erosion

Establishing economy of water: Advancing hydropower and desalinisation technologies, as well as aquaculture

Public pressure: Mainstreaming of 'Net Water Positive' 2030 commitments by major owners/operators

Mapping systems: Emergence of district heating solutions and co-benefits of compute heat output – digital twinning and modelling of water bodies

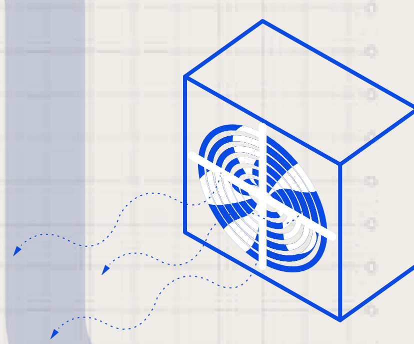
Weaponisation of water: e.g. transnational watershed disputes, targeting critical infrastructure

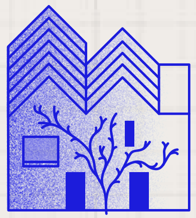
Rise of advocacy + legislation relating to the water bodies' 'rights' (ecological protection)

Emergence of 'cloud seeding' and weather modification experimentation by state and private actors

Next generation quantum compute requiring heightened cooling capabilities

weak signal

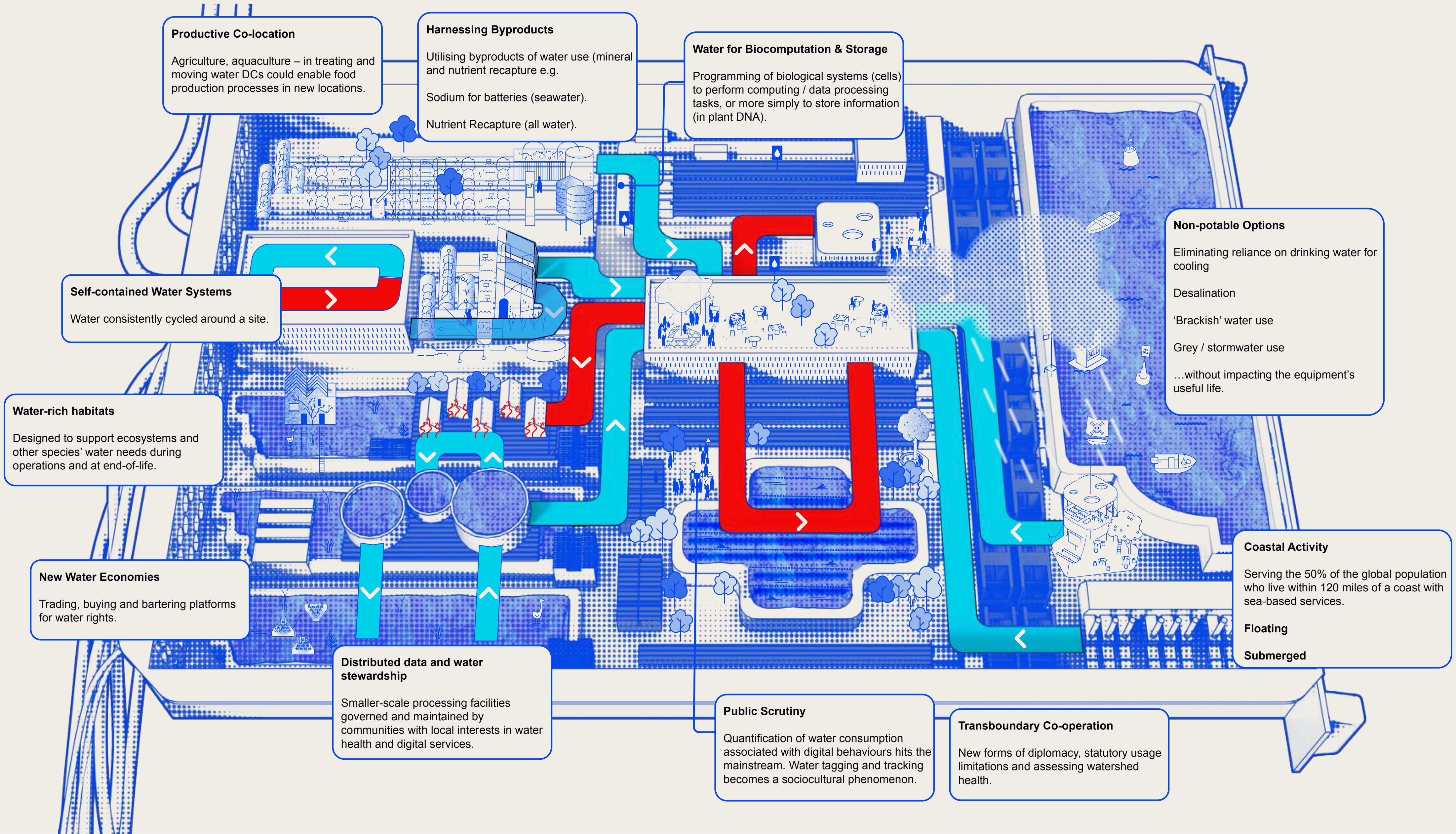




* Data Centres need high volumes for cooling in periods when there is less volume available e.g. summer season

2040: Speculative Futures

How might the relationship between water and data infrastructure evolve?



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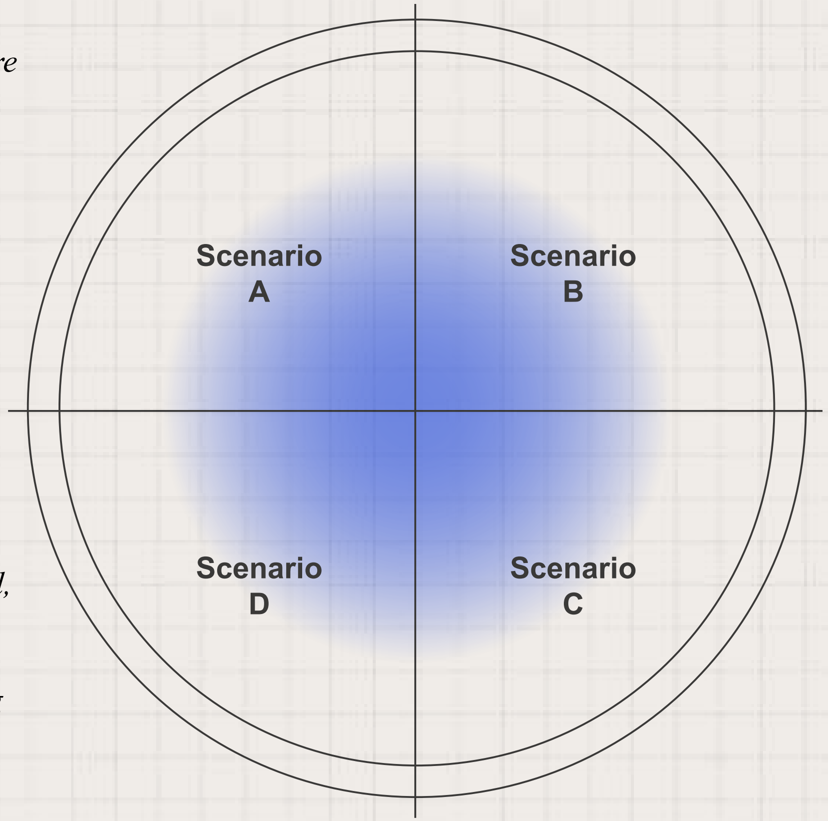
Next: possible futures for water and data centres

How might the relationship between water and data infrastructure evolve?

Scenario A:
Pervasive desalination, cloud seeding and smart catchment networks make freshwater plentiful, but treaty-level safeguards classify lakes, rivers and aquifers as public trusts. New data-centre projects must show negligible impact, stream live withdrawal data and accept temporary curbs during dry spells. Capital quietly favours clear reporting and fallback plans, while design teams negotiate with watershed councils to align expansion with ecological limits.

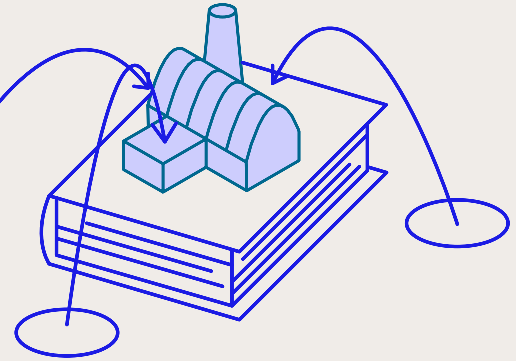


Scenario B:
Technical breakthroughs remove supply limits, but rights are bundled into long concessions held by governments or a handful of corporate utilities. Water systems are redesigned and rerouted according to data infrastructure needs, with a more centrally-planned and delivered integration with utilities. Pricing and access for other users become secondary. Investment rewards follow whoever secures priority allocations.

Scenario D:
Long drought cycles drain basins; the remaining water is licensed, traded and sometimes smuggled. High-volume consumers draw public ire, and usage caps ratchet up with little warning. Data-centre footprints shrink or migrate poleward; those still operating must pivot to dry or closed-loop cooling and buy high-priced permits. Capital marks down assets tied to volatile rights, while surprise policy shifts (export bans, windfall taxes, national-security curbs) keep boardrooms on edge.

Scenario C:
Persistent deficits push regions to adopt quota systems run by watershed councils with real-time meters and public dashboards. Allocation depends on meeting community benefit standards: smaller, modular data hubs that flex output, share surplus heat and contribute to local resilience earn priority slots. Equity stakes or water offsets are often required. Projects that cannot operate within tight seasonal ceilings face slow approvals or outright refusals, reinforcing a trend toward distributed, locally accountable infrastructure.

Arup Expert Piece: Thinking upstream and downstream



Catherine Buckley
Associate Director, Water Engineering
Arup, Dublin

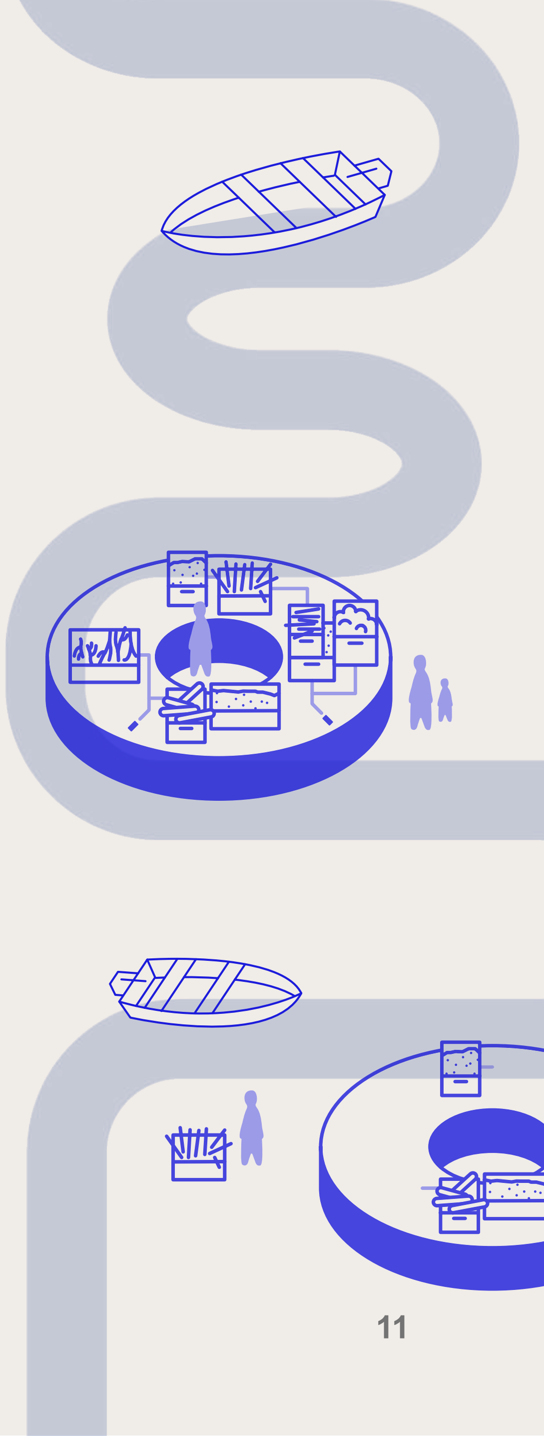
Stephen Griffin
Director, European Data Centre Business Leader
Arup, Dublin

A finite resource

Data centres are a newer and rapidly growing entrant into industrial water use, adding additional, and at times difficult-to-forecast, water demand on top of other vital, water-intensive sectors such as agriculture, textiles and sanitation. So how can data centres better manage their relationship with water to prolong the useful life of assets and meet ESG commitments?

When it comes to water, data centres face the same challenge as all industries and communities. Once our supplies are exhausted, we have no way to create more. Judicious water stewardship is in all of our best interests.

If we cannot make more water, what are the options? We can imagine how the proliferation of renewable energy could help us to prioritise WUE (the finite resource) over power, or PUE, a more renewable one. Air cooled heat exchange, or 'dry cooling', is being explored in places with existing restrictions on water use. While there are limitations to heat removal today, research shows promise in moving towards less water-intensive, lower maintenance dry cooling options.



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Arup Expert Piece: Thinking upstream and downstream

Choosing the right location and strengthening the local ecosystem

Choosing the right sites for data centres requires more than meeting today's criteria. It calls for the integration of a longer-term perspective on water availability and a deep understanding of the implications of a data centre on the broader local water resources and systems.

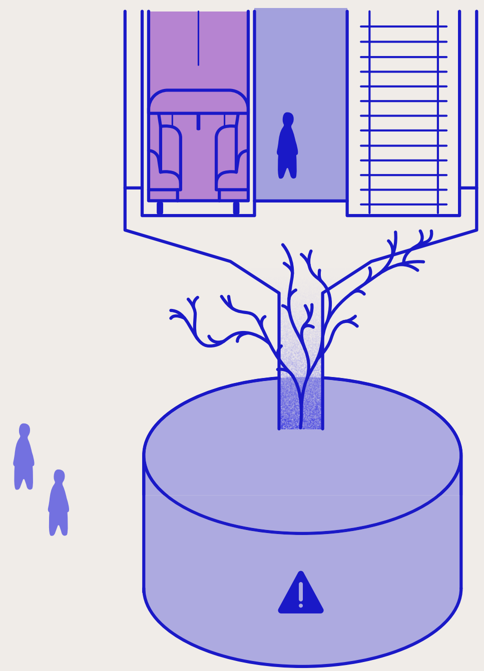
These decisions are strategic as they create an important and long-term "lock-in" effect. Trade-offs must be carefully assessed against evolving operational pressures.

While we can't create more water, data centre designers and operators can be major players in opening more cost efficient and continued supply. This can be helped through restoration of waterways and absorption capacities such as porous surfaces and spongey landscaping. In the same way as data centres have grown to be among the biggest investors in renewable energy and power grids, they could become leading agents of water restoration, recycling and the deployment of innovative reuse technologies within enhanced conveyance networks. What would a super-grid for water look like?

Measuring what matters for a more secure supply

Water systems have upstream and downstream impacts. To that end, in analogy to carbon emissions it helps to think in terms of 'Scope 1, 2 and 3 water usage' by keeping a catchment area perspective that involves both the sources of water supply and ecosystem impacts before the water reaches the data centre (i.e. upstream), and the consequences for water quality and availability after the water leaves the site (i.e. downstream). This may mean implementing more sophisticated ways to understand total water impact.

The Climate Neutral Data Centre Pact pushes for better WUE and other conservation metrics, which has been encouraging the use of non-potable sources such as grey or saline water and favouring sites in regions that are not water-stressed – but can we do more? It is important to consider the use of the water once it has gone through multiple cycles. For example, co-location with other local users can improve these metrics beyond the data centre asset alone. Farming and irrigation, industrial symbiosis - linking such consumers is an obvious but perhaps overlooked step that can support both new revenue streams and a more assured supply.



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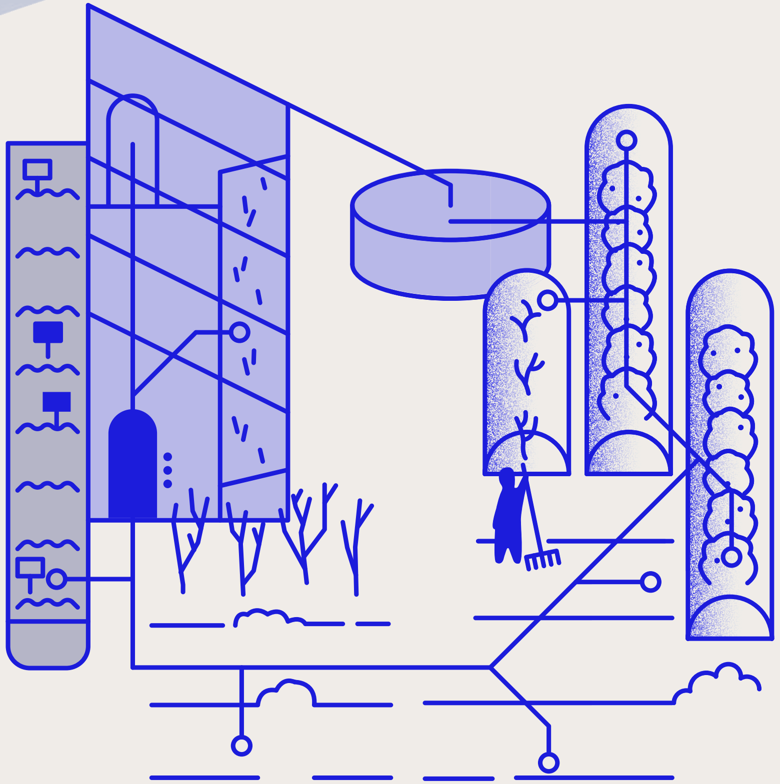
Arup Expert Piece: Thinking upstream and downstream

Moving away from freshwater use

Shifting from using freshwater is the other side of the coin. Resolving the technical operational challenges that inhibit the use of non-potable water could extend the useful life of assets in water-stressed areas.

Grey and brackish water is already being trialled for cooling in some data centres. Saline water – with desalination becoming more viable thanks to renewables – is another ripe source. Countries such as Australia and Singapore are actively embracing sewer mining at an industrial scale, which allows for a decentralised, local treatment of municipal wastewater for immediate non-potable reuse. Taking a wider geographical range of water sources into account also offers opportunity. District heating is required mostly during cold periods while irrigation is required during dry seasons. A certain agility is necessary to help switch between users and usages. Could compute be moved geographically to chase low-stress water regions in the same way as it does to chase renewable energy?



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Expert external perspective

Carl Ganter
Founder, Circle of Blue

The Faustian Bargain of AI and Data Centres: Will They Doom or Deliver Us from Water Crises?

The story of human civilisation is the story of water. From Mesopotamia to the Maya, the rise and fall of cultures have often hinged on their relationship to fresh water. Today, we face a modern iteration of this ancient story. At its heart is a fast-emerging paradox: the explosive growth of artificial intelligence and the data centres that power it, consuming staggering amounts of water, even as they tantalise us with the very tools, we need to manage water smarter than ever before.

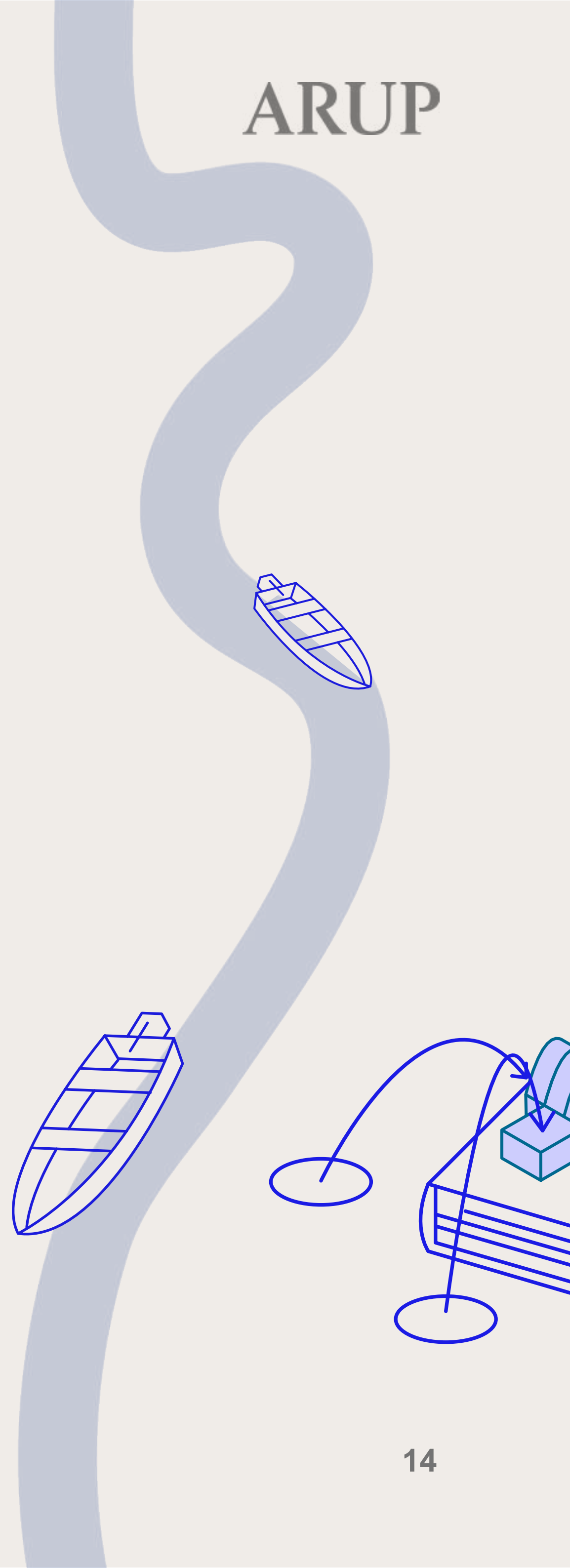
We are in a Faustian bargain with technology. The data centres that feed our thirst for generative AI, streaming video, and digital convenience are becoming among the fastest-growing users of water globally. In some regions, a single hyperscale data centre can consume as much water as a small city, syphoning off millions of gallons annually to cool servers that never sleep. In drought-stressed regions like the Western U.S., India, and northern Mexico, this demand competes with agriculture, ecosystems, and human access to safe water for the most basic needs of survival.

Unchecked, this trajectory could spell ecological collapse and even societal unrest, eerily reminiscent of the Maya civilization, which archaeologists now believe fell in part due to prolonged drought exacerbated by water overuse and poor planning. Are we also on a path where innovation becomes the architect of our undoing?

Paradoxically, this very tension is forcing a much-needed reckoning.

First, the surging demand for water from data centres has inadvertently cast a glaring spotlight on global water stress.

Communities, local municipalities and businesses are becoming increasingly aware of water constraints and are pushing back on developments and demanding reductions in consumption. Tech companies, faced with scrutiny from regulators, investors, and communities, are being compelled to disclose water usage, reassess locations, and seek more sustainable solutions. Conversations once relegated to the margins are now central in boardrooms, data strategy meetings and town halls.



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Expert external perspective

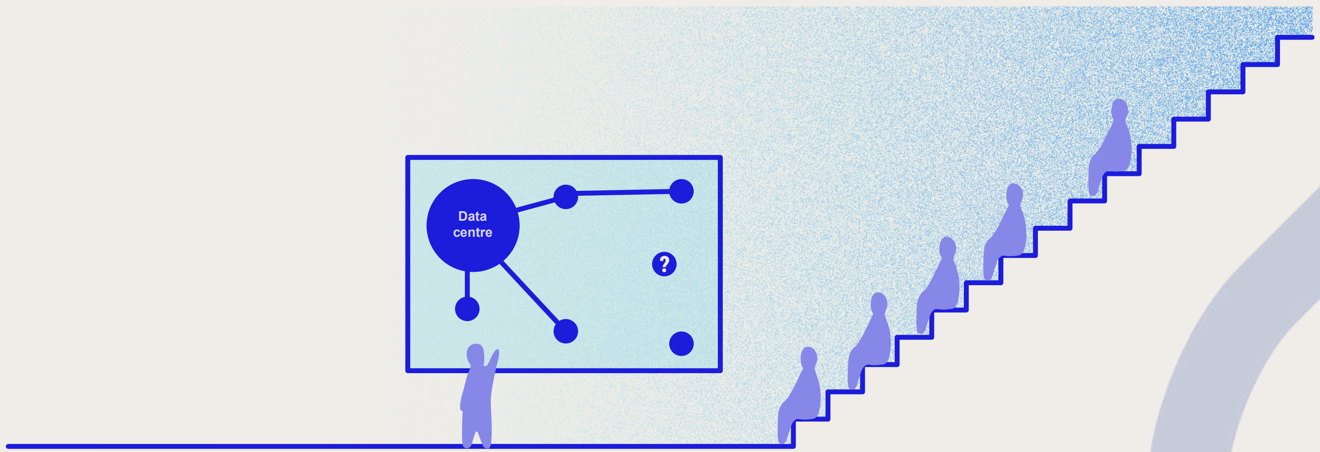
Second, and perhaps more profoundly, AI and the data centres that support it could become our greatest allies in solving water crises - if we act with vision, urgency and humility.

AI can process and analyse vast troves of environmental data, revealing patterns in rainfall, groundwater levels, agricultural consumption, social and environmental stability, and contamination and industrial waste that would otherwise be invisible. Coupled with satellite imagery and remote sensor networks, AI can help us "see" water systems in real time, anticipate shortages, prevent contamination, and improve efficiency across entire sectors. We can, quite literally, begin to count every drop as it touches food and energy production. Then we can truly design a new operating system for fresh water that aligns with speed and scale the data, narratives, policy and finance necessary to meet urgent needs. This is not science fiction, it is already happening. In the Netherlands, AI models help predict flood risks. In California, predictive algorithms optimise irrigation, saving water and energy. And in Singapore, a nation that prioritises water security, data-driven technologies are the backbone of its urban water strategy and a strategy of resilience for S.E. Asia.

But the window to match awareness and urgency with action and investment is closing. The decisions we make today will be felt for generations. At the same time, each day brings new reports of cities facing "Day Zero," when the taps could run dry, and of a rapidly drying planet as the aquifers that hydrate our cities, irrigate our crops… and cool our data centres… are increasingly depleted.

If AI is to help us survive the climate and water crisis, we must ensure that the data centres underpinning AI, do not deepen the very problem they could solve. That means aggressive investment in science-backed policy, water recycling, sustainable cooling technologies, regional planning, transparency, accountability and trusted communications. It means treating data centres not as invisible utilities that power our online curiosities, but as central players in our planetary future.

We can doom ourselves to repeat history, or we can write a new chapter where intelligence, artificial and human, helps us preserve what matters most. Water.



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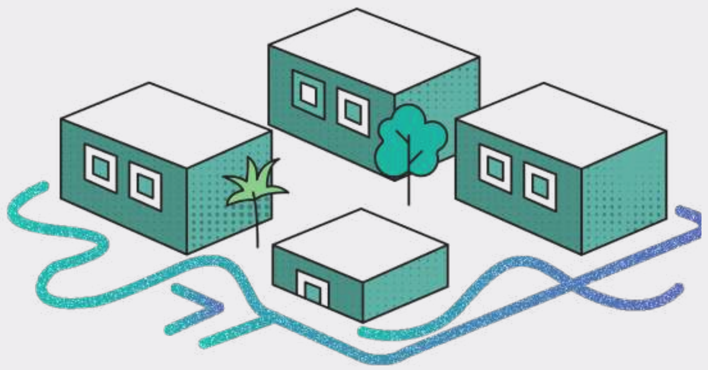
New: early signs of the future in the present

Case Studies

Meta Hyperscale Data Centre Campus (Spain)

An innovative partnership approach has proven to benefit all different stakeholders

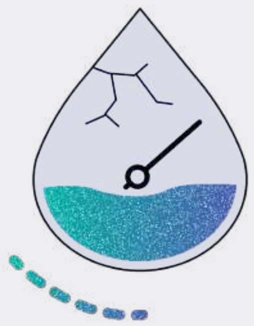


Meta faced environmental and community concerns over water use at its planned data centre in a water-scarce area of Spain. Dry cooling, higher server room temperatures and a sustainable water cycle design were deployed to reduce annual water consumption by nearly 80%.[13]

To ease community concerns, a participatory approach was taken with over 200 local residents and 30 associations to shape the development of a 60-hectare public park. This holistic approach that built public trust and reinforced Meta's 2030 water-positive goals helped secure regulatory approval for the project.[14]

Data centre developer – Water Stress Report (Germany)

A water strategy turns stress into resilience, future-proofing data centres in Germany

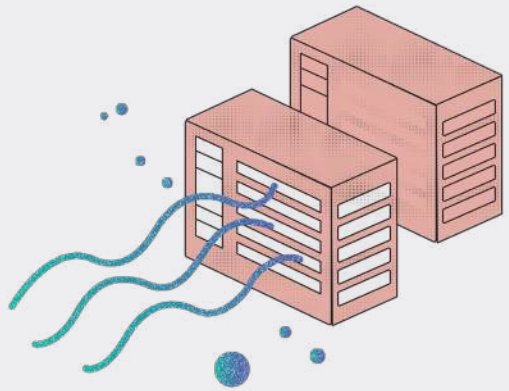


Arup supported a major data centre developer to understand how increasing water stress and regulatory pressure in Germany could affect its data centre operations and expansion plans.

A macro- and micro-level water stress assessment across three campuses, analysing infrastructure resilience, water supply risks, and regulatory exposure was conducted. This analysis identified outdated infrastructure, limited access to groundwater, and rising costs and restrictions on potable water use as key areas to focus on. Arup proposed a holistic water strategy, that mapped out regulatory risks and engagement pathways and featured an increased use of alternative water sources such as stormwater and reclaimed water. This enabled the developer to anticipate vulnerabilities, align with future regulations, and strengthen the resilience of its cooling and water systems

Digital Realty & Ecolab

Applying AI-driven water optimisation to advance sustainable data centres through collaboration



Digital Realty has partnered with Ecolab to deploy an AI-driven water conservation solution across 35 US data centres, aiming to cut water use by up to 15% and reduce the need to withdraw up to 126 million gallons of potable water annually.

The AI system identifies real-time operational inefficiencies in cooling systems and recommends improvements, enhancing sustainability and setting new standards for water conservation in the data centre industry.

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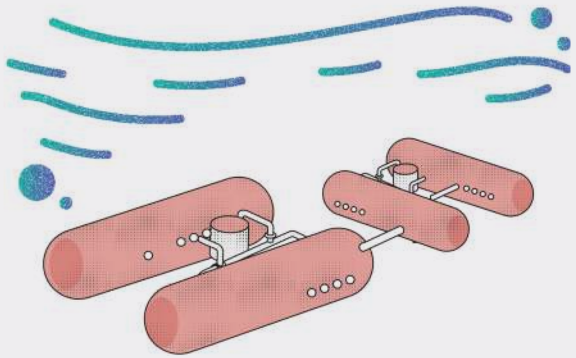
New: early signs of the future in the present

Case Studies

Highlander – China

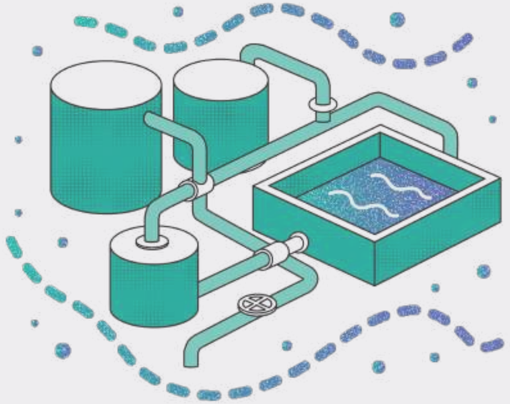
Leveraging deep-sea cooling to meet the exponential data demands of the 5G and 6G era



China is advancing its underwater data centre project in Lingshui, Hainan, by deploying 400 high-performance servers equivalent to 30,000 gaming PCs. These servers are cooled using seawater, which reduces energy costs and enhances security. The data centre supports AI-driven applications, handling massive computational tasks efficiently. China plans to deploy up to 40,000 underwater servers in the coming years. With the advent of the 5G and 6G era, data will increase exponentially, and undersea data centres could meet future demands for this growth, demonstrating the potential for sustainable, energy-efficient, and secure underwater data centres.

Equinix – Paris

Harnessing circular waste heat for sustainable operations

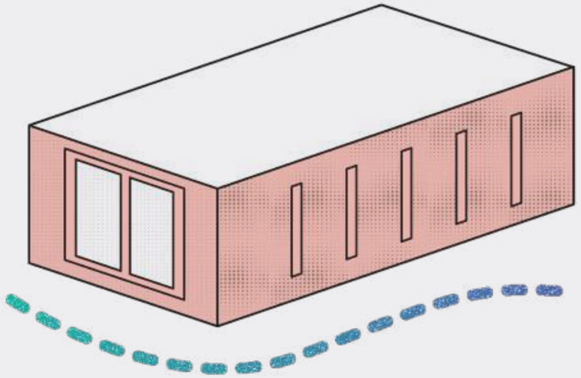


Paris is pioneering waste-heat recovery from data centres. Equinix's PA10 data centre in Saint-Denis supports the Olympic Aquatics Centre by using waste-heat recovery. Server exhaust at 28°C is elevated to 65°C via heat pumps and fed into the local district network, providing up to 6.6 MWth (≈10 GWh/yr) of heat.

This keeps the pools at competition temperature under a 15-year, no-charge agreement, reducing CO^2 emissions by around 1,800 tonnes annually. This initiative demonstrates how data centres can contribute to urban heating solutions, potentially transforming future digital estates into sustainable urban infrastructure.

Singapore Water Efficiency Strategy

Mapping sustainable water management strategies for data centres in Singapore



Singapore's Green Data Centre Roadmap aims to enhance sustainability in data centres by optimising water usage and improving cooling tower efficiency, which accounts for up to 97% of a data centre's water consumption. Key initiatives include reducing Water Usage Effectiveness (WUE) from 2.2 m^3/MWh to 2.0 m^3/MWh or lower over the next 10 years, equivalent to using 10% less water per energy unit.

This improvement will be achieved by enhancing cooling tower efficiency through recycling blowdown water and increasing Cycles of Concentration using electrolysis to clean cooling water for reduced freshwater use, mandatory water efficiency management practices, and government incentives.[17]

Recommendations

CONSIDERATIONS **NOW**

Responsible and efficient site selection:
As climate risks and water pressures grow, site selection becomes a strategic decision—critical not just for sustainability, but for long-term efficiency and operational adaptability.

Multi-disciplinary teams:
Data centres at the scale we see today are a relatively new phenomenon which call for new skill sets and collaborations. Disciplines from resilience, water and planning will increasingly play a role, from efficient water cycle policies and flood risk assessment to designing water intake systems.

Enhancing water infrastructure systems:
Leakage accounts for around one-third of treated water supply loss before it reaches users. Investing in leak-reduction programmes represents a very effective way to target the biggest sources of water loss.

Conscious co-location:
Growing partnerships between data centres and local authorities will be crucial to ensuring the capacity needs of compute, industry, community and ecology can be met. Normalising circular loops between data centre water use and adjacent utilities can deliver localised co-benefits while offering new revenue streams and meeting ESG goals.

Planning for end-of-life:
Data centres well-supplied with water have the potential to continue serving water-intensive needs when the hardware is removed. Designing with end-of-life in mind can ensure asset retains value for potential future occupants.

AND FOR THE **NEXT FIVE YEARS**

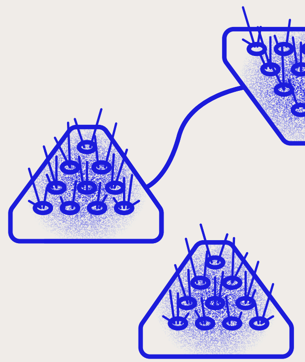
Respect nature's cooling services:
Operating with less water may be as simple as taking a different approach to risk. In some cases, and locations, passive cooling solutions can be highly effective and cost efficient.

Freshwater use reduction strategies:
Designing for less fresh water in cooling processes – for example, replacement with non-potable alternatives like recycled grey-water, brackish feed or renewable-powered desalination – can get ahead of cost and regulatory pressure likely to emerge in the face of water scarcity.

Mind the scope 3:
Understanding and measuring up and downstream water footprint – Ensuring that optimising for PUE does not impact negatively our WUE in specific locations.

System-level rebalancing:
Exploring the potential of extending today's "chase-the-power" logic to "chase-the-water" presents the opportunity to build an interconnected data-centre network shifting workloads depending on seasonality and water stress levels.

Enhance natural water systems:
Investing in the repair, restoration and health of waterways is an investment in a continued supply. Data centres can function as a positive intervention to deliver water systems that are cleaner, more available or more accessible to a wider range of stakeholders.



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