SUSTAINABLE RESOURCE MANAGEMENT FOR DATA CENTRE COOLING

Asia-Pacific & Japan | April 2025

Prepared in collaboration with:

Microsoft

NALCO Water
An Ecolab Company

CONTENTS

EXECUTIVE SUMMARY

As the demand for cloud services grows across the Asia-Pacific & Japan (APJ) region, data centres face increasing pressure to reduce resource consumption and environmental impact.

Cooling systems, essential for data centre operations, traditionally rely on power, water, and/or refrigerants. Considering varying geographic locations and climate conditions, data centre cooling solutions must make trade-offs around energy, water and refrigerant use factors.

Advanced cooling methods combined with cloud computing efficiency have substantially reduced the energy, water, and use of high Global Warming Potential (GWP) refrigerants required to deliver cloud services. However, the additional heat load generated by increased computational loads associated with the expansion of cloud services will likely strain cooling strategies adopted in current data centre designs.

This whitepaper provides an overview of the key factors for data centre cooling, how this is being influenced by the expansion of cloud services, the evolution of regulation of environmental performance in APJ, and how these different factors may influence data centre development in the coming years. It also points to the opportunities for the data centre sector to collaborate with regulators across the region in shaping regulation that drives innovation and provides a pathway for the sustainable development of the sector.

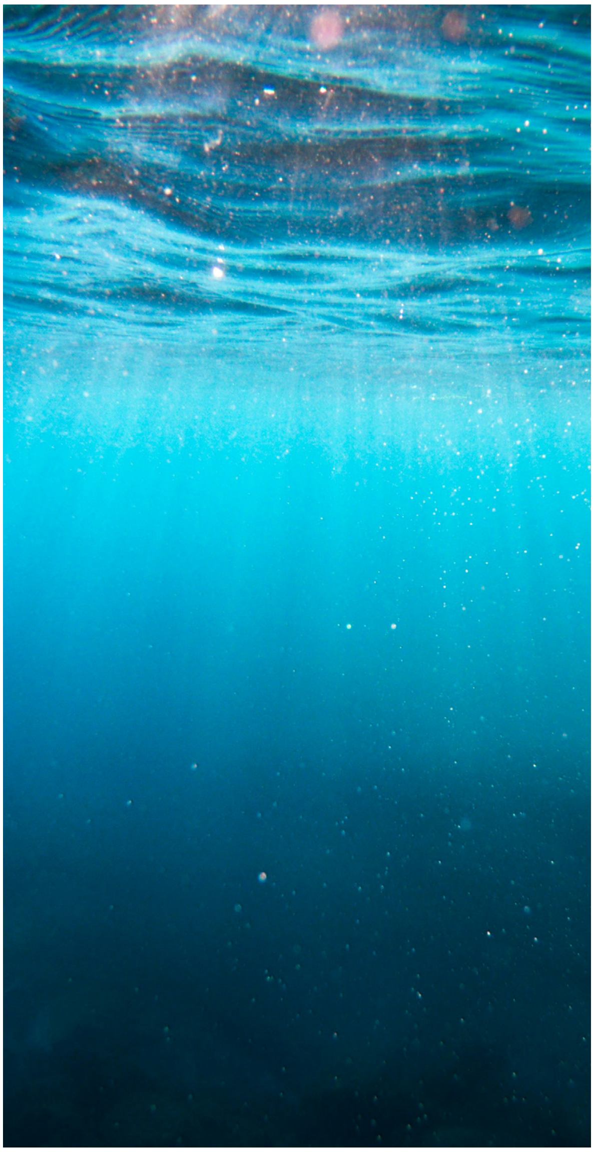
OVERVIEW OF RESOURCE MANAGEMENT CHALLENGES FOR DATA CENTRE COOLING IN APJ

The drive for efficiency

Growing demand for cloud services has spurred the rapid growth of data centres in recent years. Data centres are a crucial element of APJ's digital infrastructure, enabling every digital interaction in society, from everyday internet use to critical services like emergency response, transport, and banking. Data centres consist of servers that process, store, and distribute vast amounts of data, generating significant heat in the process. This large output of heat makes cooling an essential element of data centre design. In most instances, the cooling process is resource intensive. As demand for data centres grows, there is increased urgency to make cooling systems more energy and water efficient.

Data centre cooling systems use a combination of three resources: energy, water, and refrigerants. With the growing need to disclose and reduce the usage of these resources, it is essential that the data centre industry accelerates the adoption of efficient cooling techniques, especially in energy constrained or water-stressed environments. While refrigerants remain a key aspect of cooling systems in data centres, its disadvantages include having a high Global Warming Potential (GWP) and being less energy-efficient.

As such, the challenge of reducing resources used in data centre cooling is complex. Alternatives to energy-intensive, refrigerant-based cooling systems using water may require structural changes to data centre design. Further, the cooling strategy typically requires trade-offs between the use of water and energy.



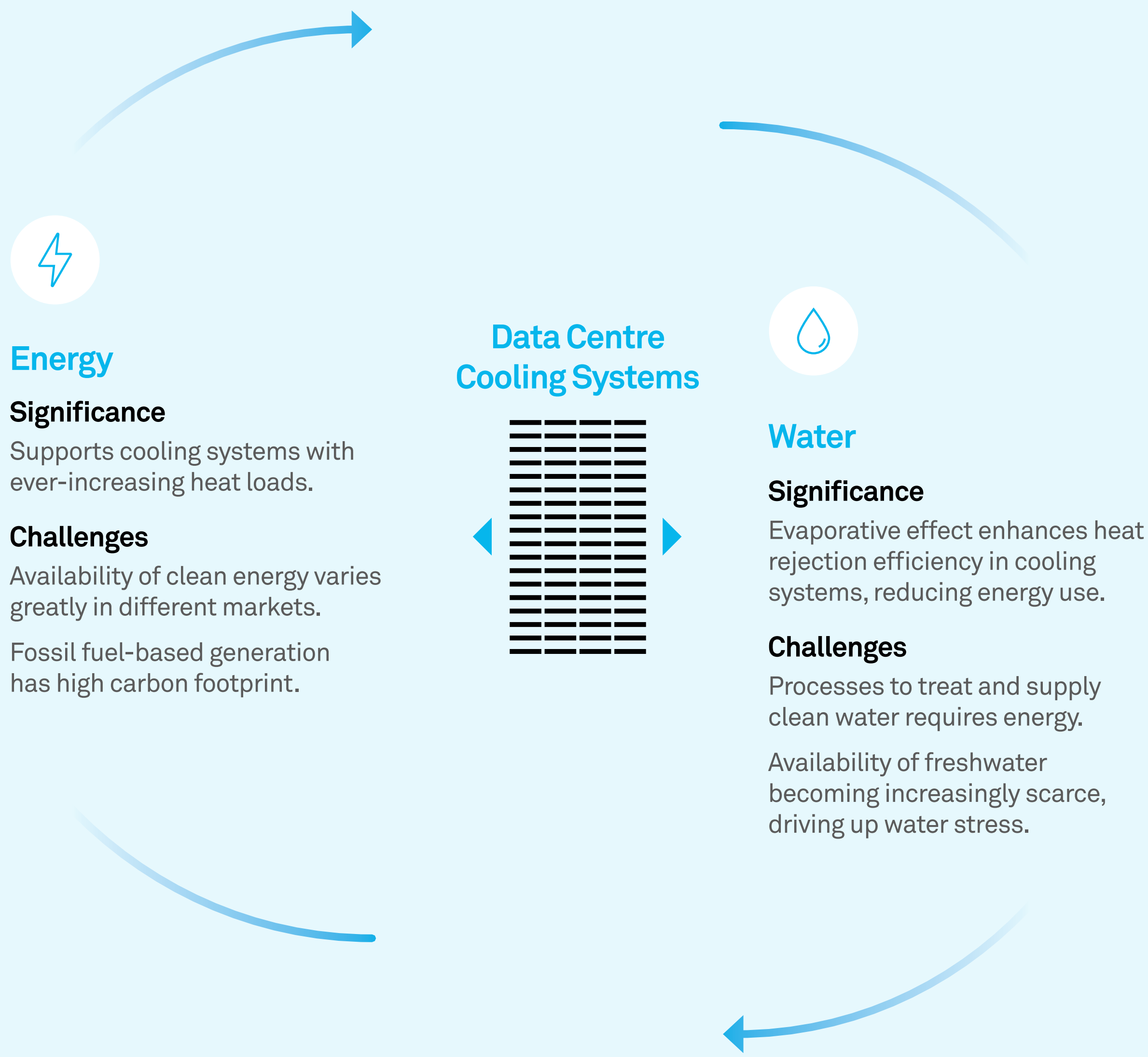
With the expansion of cloud services, the energy resourcing for cooling is expected to increase as higher cooling loads will be required compared to general compute data centres. While the levels of energy efficiency associated with current data centre cooling strategies may be optimal today, they will need to be further optimised to attain new levels.

The optimisation process will result in trade-offs between energy and water, often assessed with the aid of metrics such as the Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE). PUE is a ratio that describes how much of the total energy consumed by a data centre goes specifically to computing equipment, in contrast to cooling and other uses.

WUE measures water usage effectiveness in terms of litres of water used per energy unit (kWh) of the data centre IT equipment.

WUE and PUE vary significantly depending on the type of cooling technology deployed. As an example, data centres in Australia may utilise adiabatic cooling systems, which use water to support cooling loads when temperatures peak, but little to no water when temperatures are lower. This optimised approach delivers low WUE values while reducing energy use compared to fully ‘dry’ air-cooled only systems.

Graphic 1: Summary of the energy-water nexus for data centres showing each resource’s significance, interdependency, and challenges faced in managing the trade-offs.



MEASURING RESOURCE USE
FOR DATA CENTRE COOLING

PUE and WUE are used to track the effectiveness of optimisation measures designed to reduce energy and water use. The use of these metrics promotes transparency, accountability, and compliance with global standards such as the Global Reporting Initiative (GRI), the International Sustainability Standards Board (ISSB), as well as national sustainable finance reporting initiatives and taxonomies. The standardisation of these metrics also supports an internationally consistent roll-out of regulatory targets that are intended to guide the industry towards reducing the intensity of resource use.

Power Usage Effectiveness (PUE)

The PUE metric is intended to determine a data centre's energy efficiency by identifying the ratio of its total energy consumption against the energy consumption of its information technology equipment.[1] The PUE is calculated by dividing the facility's total energy consumption (in kWh) against the energy required to operate the data centre's IT equipment:

$$\text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$$

A low PUE number indicates that a data centre is operating efficiently. A low PUE is also indicative that power use in a data centre is mainly associated with its IT equipment, with minimal power used to operate supporting equipment such as cooling systems. Introduced by The Green Grid in 2007 as a 'self-help' energy efficiency monitoring metric, PUE is specified under the ISO standard/IEC 30134-2:2016.

Water Usage Effectiveness (WUE)

The WUE is calculated by dividing the total annual water used (withdrawal) by a data centre (measured in litres) by the total amount of energy (measured in kWh) needed to operate data centre IT equipment.

$$\text{WUE} = \frac{\text{Annual Water Usage}}{\text{IT Equipment Energy}}$$

A low WUE value indicates efficient water usage. Developed for the data centre industry as part of The Green Grid's White Paper #35[2], the WUE metric is recognised under ISO standard/IEC 30134-9:2022.

[1] PUE: A Comprehensive Examination of the Metric | The Green Grid
[2] WP#35 - Water Usage Effectiveness (WUE): A Green Grid Data Center Sustainability Metric | The Green Grid

INCREASING IMPETUS TO ASSESS DATA CENTRE COOLING RESOURCE MANAGEMENT HOLISTICALLY

In June 2023, the Infocomm Media Development Authority (IMDA) of Singapore launched one of the world's first standards for optimising energy efficiency in data centres in tropical climate countries.[3] These voluntary standards will enable the operations of data centres at higher temperature settings to optimise energy efficiency.

In December 2023, the Monetary Authority of Singapore (MAS) launched the Singapore-Asia Taxonomy for Sustainable Finance at COP 28.[4] Considered the world's first multi-sector transition taxonomy, it defines green and transition activities for eight key sectors including information and communications technology.

While there are similarities to the EU Taxonomy (i.e. requiring a GWP<675 for refrigerants)[5], much of the Technical Screening Criteria (TSC) for taxonomy alignment is dependent on attaining the Singapore Green Mark Scheme (GMS) Platinum or Gold certification and its associated PUE values for the "Green" (Full Alignment) and "Amber" (Transition) criteria respectively.

The Singapore GMS is a certification scheme that assesses and validates a building's (or data centre's) holistic sustainability performance, across areas of water, energy, and indoor environmental quality amongst others. It must be noted that the Taxonomy's transition criterion is only applicable to data centre retrofits and a WUE threshold comes into play for both these criteria should the activity occur outside Singapore. These schemes are likely to become commonplace across various markets in the region as other jurisdictions start to regulate data centre design and performance.

Unlike the EU Taxonomy, the Singapore-Asia Taxonomy is voluntary. To encourage adoption, the public sector could use it as a framework for government tenders in Singapore, where five per cent of the evaluation criteria of tenders is being awarded to sustainability credentials from FY24.

But these developments, which will determine the sustainability of data centres, will trigger a need for policymakers to assess the interdependencies between water, energy, and refrigerant, prioritising them based on their holistic sustainability performance.

On a similar trajectory, Malaysia[6] has announced PUE and WUE thresholds for eligibility towards government incentive schemes, while Australia has mandated that public sector data centre procurement services must attain a 5-star National Australian Built Environment Rating System (NABERS) rating or an equivalent PUE<1.34 with effect from July 2024.[7] NABERS also includes provisions for assessing and accounting for emissions from refrigerants. These two rating schemes are heavily reliant on data centre energy use as a single factor of measure for sustainability performance. They would need to evolve from their current form to align with the more holistic approach adopted in the EU.

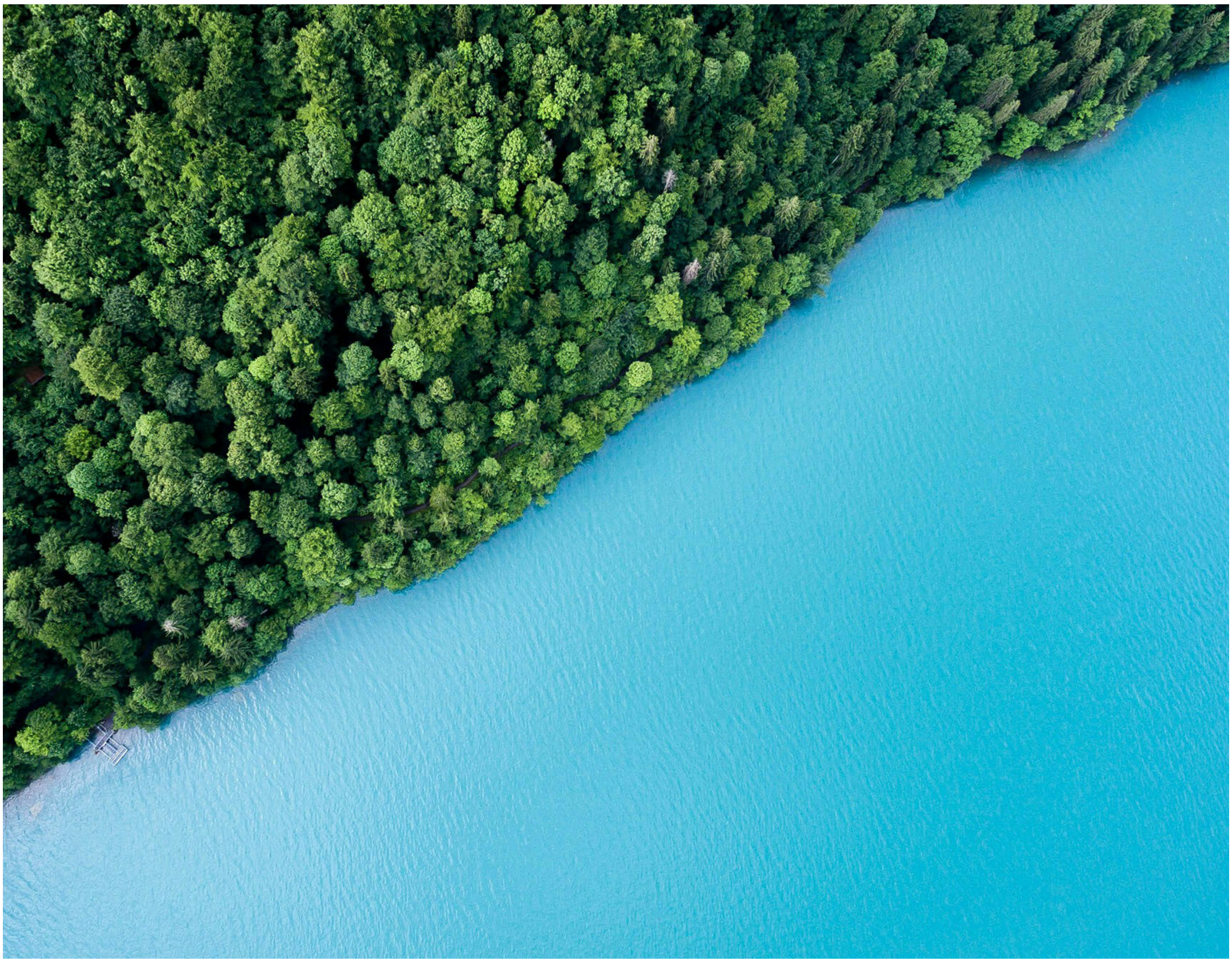
Additionally, the publication of Green Data Center Government Procurement Demand Standards by the government of the People's Republic of China in 2023 prescribes PUE and WUE limits of 1.3 and 2.5L/kWh respectively from 2025.[8]

Noting the need to balance resource needs, the Government of Japan is introducing a minimum PUE requirement for data centre developments while offering incentives for developing data centres outside of Tokyo and Osaka to balance the distribution of clean energy supply and enhance resilience.[9]

3 Sustainability Standard Introduction for Data Centres | IMDA
4 MAS Launches World's First Multi-Sector Transition Taxonomy
5 taxonomy-regulation-delegated-act-2021-2800-annex-1_en.pdf
6 Miti finalising sustainable development guidelines for data centres | The Star
7 Data Centre Sustainability: The Time is Now | NABERS
8 Notice of the Ministry of Finance, the Ministry of Ecology and Environment, and the Ministry of Industry and Information Technology on Printing and Distributing the "Government Procurement Demand Standards for Green Data Centers (Trial)"
9 Japan wants more rural data centers, and light-based networks may help - Nikkei Asia

Table 1: Summary of regulatory drivers towards increasing data centre cooling efficiency introduced in different markets in the APJ region.

Market	Regulatory drivers
Australia	Extension of the NABERS Energy rating to data centres as a form of sustainability rating system for efficiency assessment by Australian Sustainable Finance Institute (ASFI).
Singapore	Introduction of data centre-specific criteria for the GMS certification, defined in part by PUE limits, aimed at increasing adoption of data centre optimisation standards promoting higher energy efficiency. GMS also forms a component of the Singapore-Asia Taxonomy for Sustainable Finance.
Malaysia	Introduction of PUE and WUE limits as a pre-qualification standard for the development of data centres.
People's Republic of China	Introduction of a set of standards prescribing PUE and WUE limits for data centres.
Japan	Introduction of a minimum PUE requirement for data centre developments and incentives for development of data centres in rural areas to balance distribution of clean energy and increasing resilience.



Water governance challenges and opportunities in APJ

An effective implementation of local policies for water management and stewardship remains pivotal in APJ. Most countries in the region have adopted policies with goals and responsibilities for water institutions.

However, there are still opportunities to make these policies more targeted:

79%

of APJ countries have no policy instruments to allocate or monitor groundwater extractions.[10]

67%

of APJ countries have not established priority water allocation in the event of scarcity or emergency.[10]

67%

of APJ countries do not have formal requirements for monitoring of water policy implementation.[10]

There has yet to be a globally adopted water sustainability target to guide corporate and government responsibility and action on water use that would encourage sustainable sourcing of water which emphasises reducing, recycling, and replenishing water as an approach to address water stress. This presents the largest opportunity where the data centre industry can catalyse this process by working with governments in the APJ region. Echoing the self-regulatory initiative introduced by the Europe-centric Climate Neutral Data Center Pact (CDNCP)[11] which outlined WUE targets, a similar approach between regulators and the industry could be introduced for adoption in the APJ region.

[10] OECD Publishes Policy Paper on Water Governance in Asia-Pacific | IUCN
[11] Climate Neutral Data Centre Pact presents new water metrics to European Commission – Climate Neutral Data Centre Pact

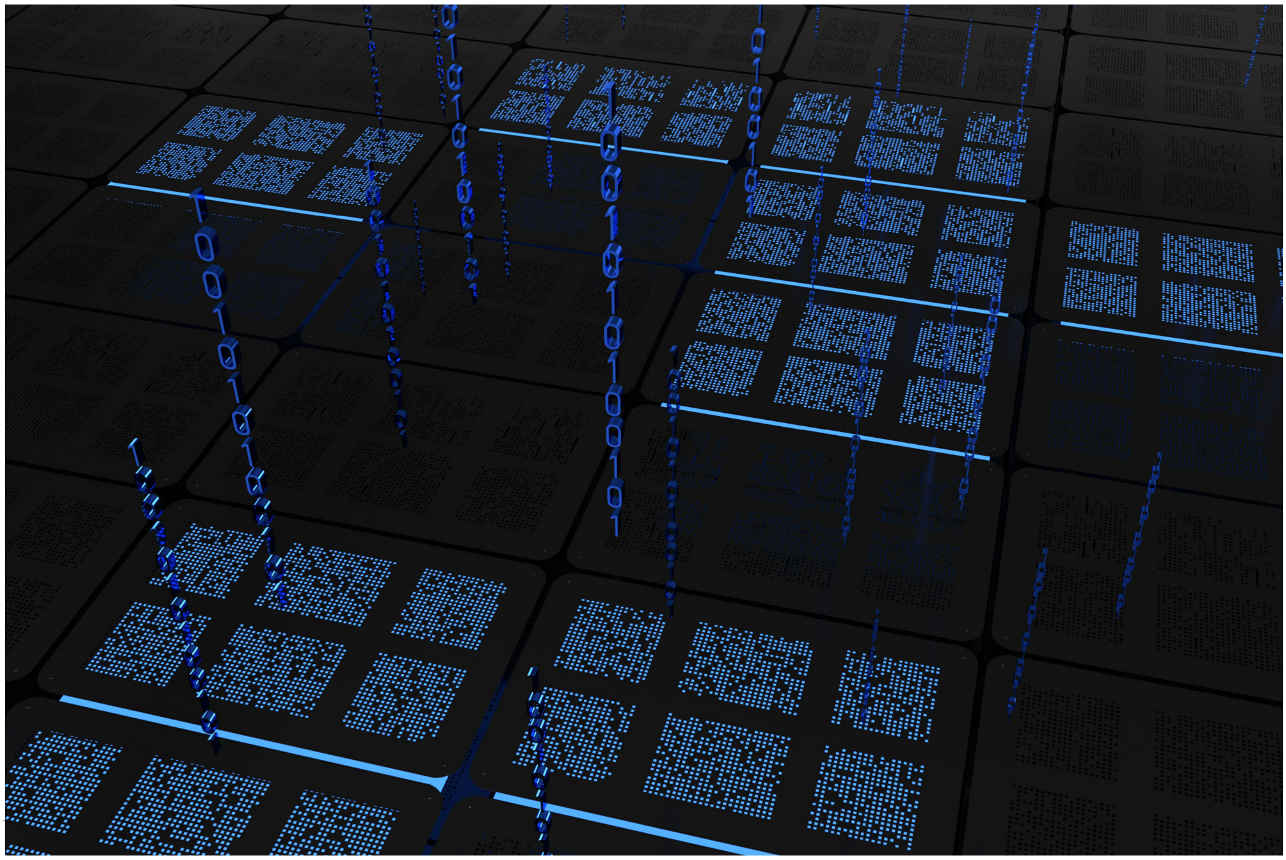
REGULATION DRIVING DEPLOYMENT OF MORE RESOURCE EFFICIENT DATA CENTRE COOLING SOLUTIONS IN APJ

The expected growth forecast for data centres in the APJ region is expected to be 13.3 per cent annually by 2028.[12] As the industry pivots toward supporting denser AI-based deployments, a sustainable approach supported by a suitable regulatory framework is essential.

Innovation across APJ markets has already led to progressively more efficient data centres. Regulatory developments are further accelerating the sector's drive for rapid advancements. These new generation data centres are capable of achieving PUE numbers that are much lower than previous designs, aided by advancements in chip design that enable operations to be sustained at higher temperatures.

Building understanding between the industry and regulators is essential. Equipped with better understanding of the advancements in the industry, regulators can set attainable and targeted limits that drive the industry towards better efficiencies. The industry must continue to innovate and embrace the longer-term benefits that such changes will bring to all stakeholders.

One example of this success is the implementation of PUE and WUE limits in Australia, China, Malaysia, and Singapore. These limits have driven the increased adoption of innovative cooling technologies, such as direct-to-chip cooling. This balances the need to support ever-increasing processing capabilities brought about by AI while being energy and water efficient.



[12] Asia Pacific Data Centres

CHARTING THE PATH FORWARD TO ENABLE RESOURCE EFFICIENT DATA CENTRE COOLING IN APJ

It is critical the APJ regulatory frameworks consider the holistic assessment of data centre sustainability performance metrics, by considering the interdependencies of water, energy, and refrigerant use. This approach ensures optimal data centre cooling strategies, that take full account of climatic impacts as well as energy and water availability.

Research and development of scalable innovative cooling technologies will enhance data centre sustainability performance by reducing energy and water use and improve their efficiencies. Adopting international standards and best practices will enable transparent reporting and disclosure of data centre resource use.

As the industry progresses, it is also essential to promote Life Cycle Assessments (LCA), which integrate environmental impacts across the full lifecycle of data centres and cost-benefit analysis for data centre cooling system implementation and retrofits. This includes a full spectrum of costs and benefits, spanning environmental, social, natural resource management, and financial impacts.

The growth in demand for cloud computing has necessitated the need for more stringent requirements around cooling system efficiencies. Regardless of how evolving regulation and reporting requirements change the definitions of what constitutes an efficient data centre, the factors presented in this whitepaper will remain the key enablers in consistently developing data centres that meet or exceed ever-evolving industry efficiency standards around power and water use.

FIVE KEY TAKEAWAYS TOWARD MORE SUSTAINABLE DATA CENTRES

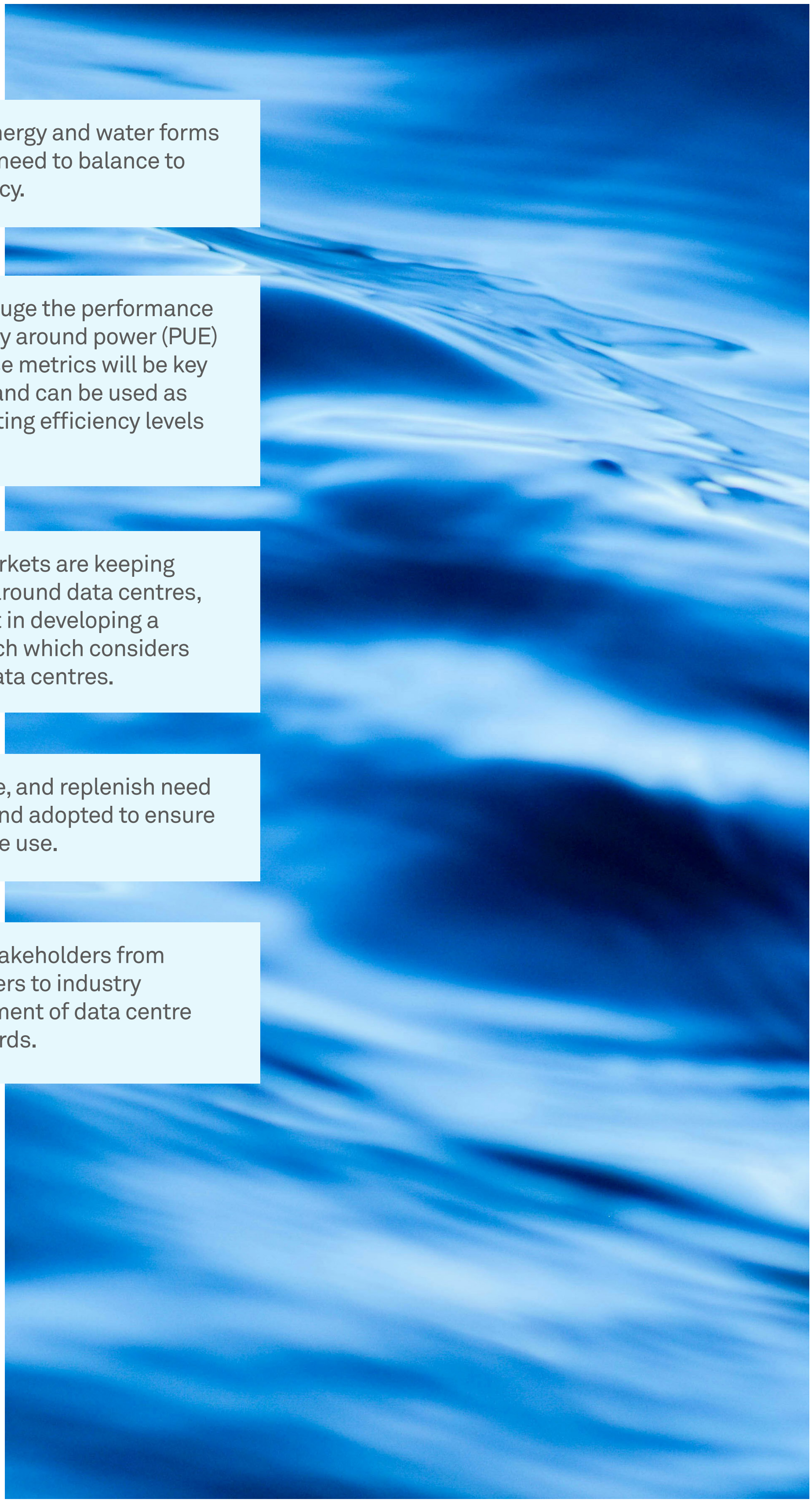
01 The interdependency of energy and water forms a nexus that data centres need to balance to optimise resource efficiency.

02 Metrics are available to gauge the performance of a data centre’s efficiency around power (PUE) and water (WUE) use. These metrics will be key for sustainable financing and can be used as a first step to identify existing efficiency levels and for benchmarking.

03 Regulators in different markets are keeping abreast with innovations around data centres, and this proves significant in developing a holistic regulatory approach which considers energy and water use in data centres.

04 Strategies to reduce, reuse, and replenish need to be widely encouraged and adopted to ensure sustainable water resource use.

05 Collaboration across all stakeholders from regulators to utility suppliers to industry players will drive improvement of data centre industry efficiency standards.



About AirTrunk

AirTrunk is a leading hyperscale data centre specialist delivering essential infrastructure to scale Asia-Pacific & Japan's digital future, accelerated by cloud and artificial intelligence. The company's growing data centre platform meets the needs of the world's most transformational companies, delivering customers a scalable data centre solution at a significantly lower build and operating cost than the market. AirTrunk creates shared value with communities by embedding sustainability through industry-leading energy and water efficiency, renewable energy solutions and its social impact program.

For more information on AirTrunk, visit airtrunk.com

Microsoft Cloud Involvement

This whitepaper was prepared in collaboration with the Microsoft Cloud ESG Planning team and AirTrunk. It is intended to highlight the sustainability tradeoffs of data centre designs in the Asia-Pacific region. It is not an extension of or additional to Microsoft's corporate environmental sustainability policies or goals. More information on Microsoft's policies on sustainability may be found in the 2024 Environmental Sustainability Report by Microsoft's Vice Chair and President, Brad Smith, and Chief Sustainability Officer, Melanie Nakagawa.

About Nalco Water, an Ecolab Company

Nalco Water empowers operations around the world to protect water, a vital resource. We partner with companies across a wide range of industries, working side by side to develop solutions for their specific water needs and business goals. For more information: https://en-sg.ecolab.com/nalco-water