White Paper

Think...
Liquid cities

Inspire a better world
through influence
and design

ADP
Consulting : Engineering

We acknowledge the Traditional Custodians as the first engineers and designers of the lands on which we live, gather and work. We pay our respect to the Elders past and present.

Artwork: Created by Timothy Buckley, a proud Mununjali Man, this artwork titled 'Thrive' was commissioned by ADP, as a representation of our Reconciliation journey.

Think… Liquid cities and think big

As artificial intelligence drives demand for data centres, direct liquid cooling, once a fringe technology, is now moving into the mainstream. Could this immersive cooling innovation turn high energy consumer data centres into a circular energy source? Are we heading towards a future of liquid cities?

The International Energy Agency says data centres are responsible for around 1-1.5% of the world's energy-related greenhouse gas emissions – and this figure is only increasing.

The explosion of artificial intelligence applications is fuelling demand for bigger data centres and, without more sustainable design solutions, a far bigger carbon footprint.

Enter immersion cooling, or direct liquid cooling, which submerges computer servers and other components in tanks filled with non-conductive liquid coolant.

This innovative method replaces traditional cooling systems, like fans or air conditioning, by using liquid to dissipate heat directly.

Liquid in any given volume can hold approximately 3,500 times more energy than air – which is why so many industrial processes use water or liquid based systems.

It is already possible to use heat rejected by the cooling process to provide space heating or warm water to an adjacent process or building.

Picture a patchwork of data centres – some in building basements, others in stand-alone facilities – connected by a network of underground pipes that transport heated water across our cities.

Imagine swimming pools and surf parks, office end-of-trip facilities and manufacturing plants all sourcing low-cost, zero emissions heating and water.

With foresight and the right foundations, we can turn today's high energy consumer data centres into truly circular energy sources. We can also reduce the cost to operate these data centres by obtaining essentially free cooling.

What should Australia's property leaders do today to lay the foundations for the liquid cities of tomorrow?

Think… Supply and demand

It's no secret that digitalisation is driving demand for data centres. But by 2028, some analysts estimate…

All that supercomputing power needs server space and markets around the world are expanding their data centre inventories. Investment is expected to continue unabated. JLL's 2023 Investor Sentiment Barometer, for instance, found 50% of survey respondents plan to increase their assets under management in 2023.

6B
people

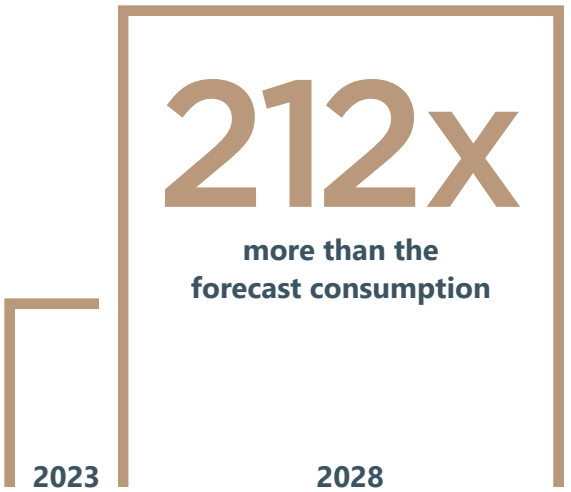
Around 90% of the global smartphone market – will be using generative AI

50x

Processing workloads will increase 50-fold

4,250
megawatts

of power will be consumed – that's…



Think… Supply and demand

Three key types of data centres – hyperscale, colocation and edge – all are on an upward trajectory.

	Current inventory		Under construction		Planned	
	Sqm	MW	Sqm	MW	Sqm	MW
Sydney	328,000	572	51,000	122	273,000	867
Melbourne	155,000	324	56,000	120	4,000*	18*
Hong Kong	7,392,000	577	3,874,000	293	1,759,000	49
Singapore	7,250,000	1,060	–	–	935,000	90

Hyperscale data centres are designed to handle enormous amounts of data and computational power. With a vast number of servers, storage systems and networking infrastructure, hyperscale data centres support cloud computing, big data analytics, AI and other resource-intensive applications. There are currently around 700 hyperscale data centres globally and the market is expected to hit $AU64 billion by the end of 2023. The world's four largest hyperscale platforms are Google, Microsoft, Amazon and Meta.

Colocation data centres are facilities where multiple companies can rent space to house their servers and IT infrastructure. These providers offer the physical infrastructure, including power, cooling and networking, while clients bring in their servers and equipment. Colocation is also a growing market, and is expected to near AU$86 billion by 2027, or a CAGR of 14.26%.

Edge data centres, also known as micro data centres, are smaller, decentralised facilities that provide computer and storage in locations closer to where data is generated and used. Because they are situated near their intended users, they allow for real-time data processing and analysis; response latency is reduced and bandwidth is optimised, which in turn facilitates the development of new applications. Michael Dell has predicted that edge data centres will one day be bigger than the cloud.

* It is understood this is higher than reported.

Note: Figures converted from square feet and rounded to the nearest thousand.

Source: JLL Data Centre Research, Q4 2022.

Think... Green

Data centres are among our most energy and water intensive infrastructure assets.

Data centres need power to operate – but around 40% of the average facility's power is spent on the crucial task of cooling. A large data centre can consume the equivalent energy to 50,000 homes.

Cooling the rows and racks of powerful computers also requires up to 19 million litres of water a day – a similar quantity of water to that consumed by a small city of 50,000 people.

Power usage effectiveness (PUE) and rack power density are two metrics used to measure the efficiency of data centres.

The Uptime Institute, a global organisation focused on data centre performance and efficiency, says the average PUE in 2022 was 1.55.

This means that for every unit of energy consumed by the IT equipment – such as servers, storage and networking – an additional 0.55 units of energy were consumed by the supporting cooling, lighting and power distribution infrastructure.

The higher the PUE value, the less energy-efficient the data centre – and data centre operators have spent the last decade looking for ways to lower their PUE.

Rack power density is a measure of the power demand and heat generation per unit of rack space. Around 40% of organisations that operate facilities with capacities above five megawatts say their densities are increasing rapidly, compared to 30% with smaller facilities.

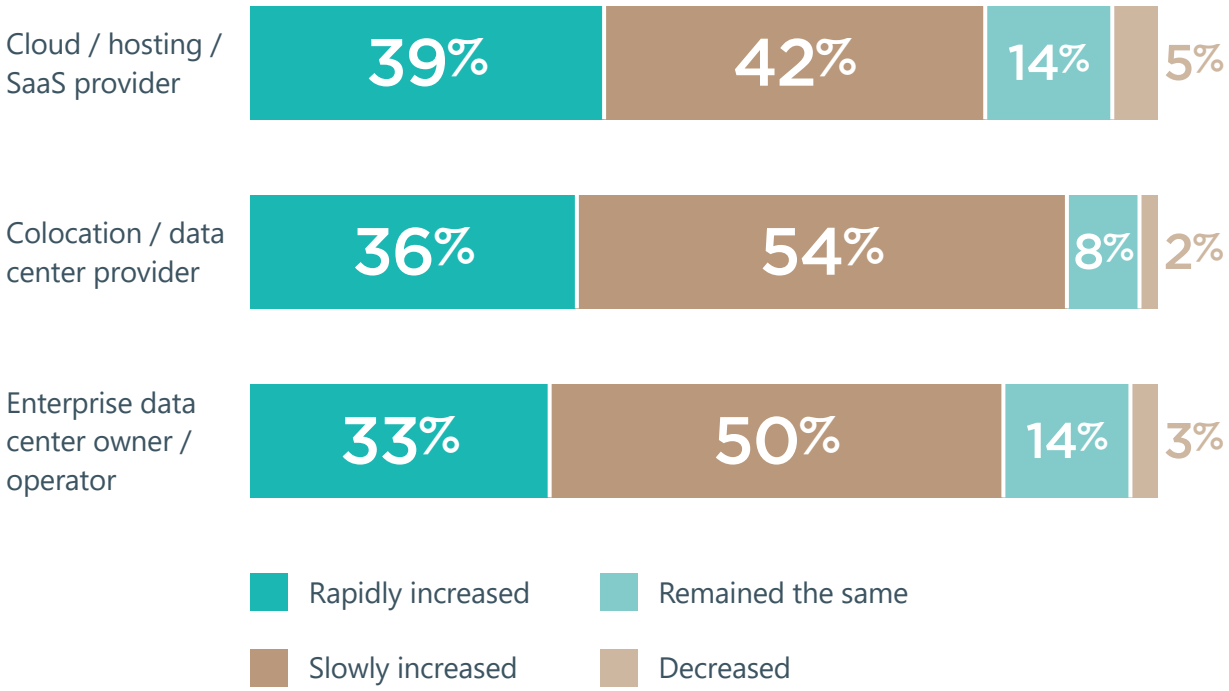
Most buildings consume energy in peaks and troughs, depending on their usage at that time of day. In contrast, data centres generally deliver a constant output. How can we harness this reliable source of energy?

Think... Green

The Uptime Institute expects power requirements to push a growing number of data centre operators – and their IT tenants – towards direct liquid cooling.

And this is why the global data centre liquid cooling market is expected to expand by a compound annual growth rate of almost 23% over the next few years.

Rack power density is on the rise



Source: Uptime Institute 2022

Think… Transformation

Liquid cooling uses the exceptional thermal capacity of liquid to absorb and transfer the heat created by the data centre.

There are multiple applications of liquid cooling including:

- **Single-phase immersion cooling** (where no air-based systems are required)
- **Two phase immersion cooling** (again, with no air-based systems)
- **Direct-to-chip liquid cooling** (a hybrid solution with air-based systems)
- **Rear-door heat exchangers** (another hybrid solution).

Rear door heat exchangers have been used for some time to provide additional supplementary capacity in air-based data halls.

In trials, direct-to-chip liquid cooling has been found to significantly increase the potential cooling capacity of an individual rack, but still requires air-based cooling to remove around 25% of the heat generated in the space.

Immersion cooling is a relatively new solution and the most energy-efficient form of liquid cooling on the market. Liquid cooling systems can raise the inlet temperature of the chilled, condenser water loop and, in turn, raise the return temperature of this loop to potentially more than 50°C. It's this warm water loop that could transform the way we heat Australian cities. Here's how…

Step 1: Locality heating

Rejected heat from a small data centre stored in an apartment or office basement is directed to heat the public swimming pools, spa and sauna, and as pre-heat for amenities like end-of-trip and commercial building heating hot water systems.

Step 2: District heating

With the help of a heat amplification system, such as heat pumps or solar collectors (which convert solar radiation into heat energy), and buffer tanks (which store energy), much hotter water can be supplied across a street-level network and across multi-building, mixed-use precincts.

Step 3: Urban heating

Taking this to the next level, we combine rejected liquid immersion warm water with geothermal heating to supply multiple districts with essentially zero emissions energy.

Think… Leadership

In October 2022, Facebook's parent company Meta announced a roadmap for a gradual shift to a water-cooled AI infrastructure. Announcing the move, Meta's vice president of Engineering, Alexis Bjorlin noted: "The power trend increases we are seeing, and the need for liquid cooling advances, are forcing us to think differently about all elements of our platform, rack and power, and data centre design."

Microsoft is also investigating liquid immersion as a cooling solution for high-performance computing applications such as AI, and has discovered that two-phase immersion cooling reduced power consumption of its servers by 5% to 15%.

Intel is working with the Open Compute Project and delivered an industry-first immersion warranty rider for Intel Xeon processors in 2022, which allows them to be immersed in liquid.

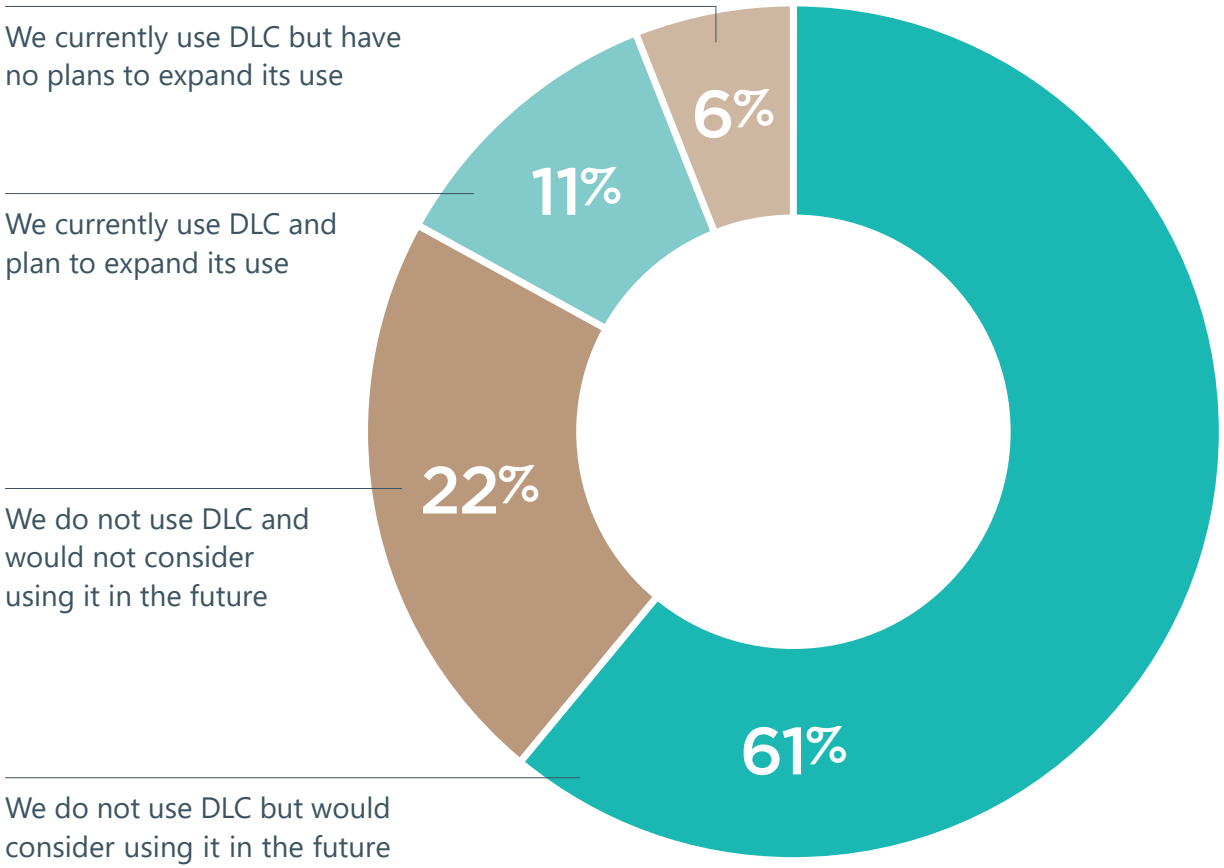
Then there's GRC and Submer, both world leading liquid cooling providers, which have developed highly efficient solutions with a roughly 40% lower total cost of ownership.

Submer's solution saves up to 95% on cooling costs, 55% on physical space and up to 40% on building costs. Most impressive, Submer's liquid cooling solution has a certified PUE of 1.02 – an impressive result when the industry's average PUE in 2022 was 1.55. It also provides the ability to maintain both Tier III and Tier IV certifications from the Uptime Institute, which had previously been a challenge for immersion cooling solutions.

The tech titans are exploring immersion cooling and looking to adapt and future proof their existing data centre facilities.

Think... Leadership

Percentage of data centre operators considering direct liquid cooling



Signposts on the revolutionary road

In late 2022, the international standards previously focused on air-based cooling (UL 2416 and IEC 62368-1) were updated to include specific references to immersion cooling. This represented a significant milestone, as data centre operators can immerse equipment in a non-conductive liquid and maintain their warranties. The pioneer of this innovation is Intel, and its new Xeon processor now has an immersion warranty rider for immersive cooling solutions.

Source: Uptime Institute, 2022

Think… Circular

Buildings generate around a quarter of Australia's emissions. Existing aged office buildings could be key to starting this revolution.

From 2023, a 5 Star Green Star rating – equivalent to Australian excellence – must meet the Green Building Council of Australia's Climate Positive criteria. Buildings must be 100% electric and fossil fuel free, powered by renewables and built with materials that are low in upfront carbon emissions. From 2026, all buildings seeking a 4 Star Green Star rating, representing 'best practice', must also meet these requirements.

Meanwhile, several Australian state governments are making the move away from gas. The Victorian Government released a gas substitution roadmap in 2022, while the ACT Government began to phase out fossil fuels at the beginning of 2023.

What does this mean for data centres and immersion cooling?

It means Australia's planners, designers and city-shapers are already thinking about new energy sources.

At the same time, embodied carbon – the carbon emissions consumed throughout a building lifecycle, from materials manufacture through to demolition and disposal – is in the property industry's line of sight.

The embodied carbon benefits are clear. Because immersion cooling is far more space efficient than air-based cooling, the size of the data centre – and the materials required to construct it – can be cut by around a third. The capacity of existing facilities can increase, rather than operators construct new facilities.

Edge data centre solutions open doors to adaptive reuse in a range of buildings, like existing commercial offices. These immersive cooling solutions can support the transition of existing buildings which use gas into 100% electric, highly sustainable colocation facilities close to businesses.

Think... Ahead

Sending reject heat through pipes is not novel. The ancient Roman Empire used hot water to heat baths and greenhouses, while France's first district heating system dates back to the fourteenth century.

But establishing a network of pipes to transport heated water from data centres to nearby buildings or facilities is a radical move – one that will require careful planning, coordination and consideration of technical and regulatory issues. This could convert data centres from being percieved as a consumer to a generator.

Australia's well governed and transparent market, highly skilled workforce and geographical size present significant growth opportunities. How do we use this opportunity to build liquid cities?

1. Start the evolution early: The biggest obstacle to liquid cities is the infrastructure requirements – most notably the pipes required to carry hot water from data centres to their surrounding precincts. Building owners may not be ready today, but that doesn't mean you can't provision the pipes and space for tomorrow.

2. Re-design regulation: Existing regulations do not accommodate a utility which provides district heating and cooling systems. This exists elsewhere in the world, so why not here? Safety, environmental and efficiency standards must evolve, as well as guidelines for heat transfer, thermal energy pricing and allocation. Australia will need a new regulatory body to assist with an energy transfer not of electricity or gas, but of hot and cold water.

3. Incentivise liquid cooling-ready developments: Councils can incentivise provisions for district heating and cooling systems by offering height bonuses or other planning benefits when developers accommodate connections and space now. Precinct-scale projects around Australia are already planning for a future climate with adaption and resilience strategies that stretch out to the end of the century. We can do the same with liquid cooling-ready developments.

4. Forge powerhouse partnerships: Collaborations between precinct owners, local authorities, data centre operators and energy utilities will take years to bear fruit, but strong foundations can be forged today. ADP is collaborating with a growing collection of like-minded organisations. Join us!

5. Build the buzz: Conversations with the community can also start today. By sharing the benefits of liquid cooling as a means to tackle several challenges in tandem, like climate action, energy security and affordable living, we can build excitement for liquid cities.

Think… Collaboration

Think is a thought leadership series developed by ADP to ask and answer some of the big questions confronting Australia's property and construction industry.

About ADP

ADP Consulting is one of Australia's largest, 100% Australian-owned, sustainability-led engineering consultancies.

We are on a quest to inspire a better world through influence and design. We work with industry-leading partners who care just as much as we do about innovation, design excellence and, importantly, our impact on the planet.

Always thinking, we push the boundaries in engineering and design to find the best solutions to the most complex projects.

Our experts

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