Empowering Australia's Digital Future

Data Centres: Essential digital infrastructure underpinning everyday life

OCTOBER 2024

MANDALA

Note: All dollar figures are Australian dollars unless indicated otherwise.

mandalapartners.com

admin@mandalapartners.com

media@mandalapartners.com

Contents

Glossary

TERM	DEFINITION
Data centre	A specialised facility designed to host IT systems and associated components. These centres house servers, processors, networking equipment, and storage systems, along with supporting infrastructure like cooling systems and backup power generation. They enable various services including cloud computing, data analytics, content delivery, secure data storage and artificial intelligence.
Co-location data centre	A facility that provides shared space for multiple organisations to house their IT systems. Companies typically lease space in these centres to store and operate their hardware.
Data centre operator	Entities responsible for the management, maintenance, and operation of data centres.
Edge data centre	Smaller, often co-location, facilities usually with a capacity of 2 megawatts or less, strategically placed near end-users or businesses. Their proximity aims to reduce data transmission delays and enhance overall performance.
Hyperscale data centre	Large-scale data centres that have a design capacity of 50 megawatts or more, and typically support cloud services and extensive operations.
On-premise servers	IT systems and supporting infrastructure housed within an organisation's own facilities for their exclusive use. These are not shared with other businesses and are often located in dedicated rooms or areas within the organisation's commercial building.
Capacity	In a data centre context, capacity refers to the power handling capability for IT systems (IT load), typically measured in megawatts.
Maximum design capacity	The maximum theoretical IT load a data centre facility is engineered to support.
Deployable capacity	The power capacity for IT loads that is available for immediate use, but not reflective of actual power usage. This is the white space of the data centre that is fully provisioned with power and cooling systems, and is ready for the installation of IT systems.
Committed capacity	The power capacity that has been contracted or purchased by a customer for exclusive use, and may or may not have IT systems installed. This is only applicable for co-location data centres.
Active IT load	The real-time power load drawn by operational IT systems, representing actual electricity usage.
Central processing unit (CPU)	The CPU is the core computational component in a server, acting as the 'brain' of any computing device. It processes instructions from memory, executes required tasks, and returns results to memory. The CPU is essential for running the operating system and applications, handling all necessary computations.

TERM	DEFINITION
Graphics processing unit (GPU)	A GPU is a specialised electronic circuit designed for rapid mathematical calculations. It serves in tasks that involve applying similar mathematical operations to large datasets, such as graphics rendering, machine learning, and video editing, as well as the default choice for AI.
Compute power	In cloud computing, the term “compute” describes concepts and objects related to software computation. It is a generic term used to reference processing power, memory, networking, storage, and other resources required for the computational success of any program.
IT load	IT load refers to the power required by IT systems and networking equipment in a data centre. This includes the power for all computational, storage and processing tasks performed by the centre's computers.
Infrastructure load	This term describes the power required by non-IT systems that support efficient data centre operations. It includes power for cooling systems, lighting, and power distribution within the facility.
Megawatts (MW)	Megawatts are a global unit for measuring power requirements of various facilities. One megawatt is equivalent to 1,000 kilowatts or 1,000,000 watts.
Megawatt hours (MWh)	Megawatt hours measure the amount of electricity a facility requires over one hour. Annual electricity consumption is typically calculated by multiplying a device's megawatt rating by the number of hours in a year (8,760).
Gigawatt hours (GWh)	One gigawatt hour equates to 1,000 megawatt hours.
Terawatt hours (TWh)	One terawatt hour equates to 1,000 gigawatt hours or 1,000,000 megawatt hours.
Power usage efficiency (PUE)	PUE is a global standard for assessing data centre efficiency. It is calculated by dividing the total power used by a data centre (including IT and infrastructure loads) by the power consumed solely by the IT load. PUE values are always above 1, with lower values indicating higher efficiency.
Power purchase agreement (PPA)	PPAs are contracts where electricity buyers commit to purchasing power and/or large-scale generation certificates from renewable energy projects at a fixed price over an extended period.
Large generation certificate (LGC)	LGCs are tradable certificates issued to eligible large-scale renewable energy power stations. They represent the amount of renewable energy generated by these facilities, with one LGC equaling 1 megawatt hour (MWh) of renewable electricity generated or displaced.

Executive summary

Data centres enable our modern digital lives

Data centres are a crucial element of Australia's digital infrastructure, supporting everything from everyday internet use to critical services like emergency response, transport, and banking. These efficient, high-tech facilities enable cloud computing, powering digital activities and services Australians rely on daily.

The number of internet-connected devices and the number and scale of new digital services being used in Australian households is set to double between 2024 and 2030, driving rapid growth in data centre demand. To meet this surge in digital activity, including business adoption of cloud and AI services, data centre deployable capacity in Australia is projected to more than double from 1,350 megawatts (MW) in 2024 to 3,100 MW by 2030. Additional investment in Australia's data centre capacity is forecast to top $26 billion during this period to meet digital demand.

Data centre development will enable Australia's digital economy

Australia's growth ambitions, including for the creation of new tech jobs, depend on expanding data centre capacity. The data centre workforce itself needs to grow by 8,300 to reach 17,900 by 2030.

Four in ten data centre roles are currently experiencing shortages due to a lack of electronic equipment trade workers, electricians, computer network engineers, and information security professionals.

Australia's proximity to growing markets, political stability, land availability and cost-competitive renewable energy make it well-positioned for growth in data centre services that our digital economy will need.

Data centres make the digital economy more energy efficient and catalyse Australia's energy transition

Data centres play a crucial role in our digital economy by aggregating the electricity demand that supports and enables our digital lives. According to the Australian Energy Market Operator (AEMO), data centres consume 1 per cent of Australia's total electricity consumption, equivalent to 340 MW of grid load, or 3 terawatt hours (TWh).

Without data centres, businesses relying on their on-premise servers would consume an additional 2 TWh or more of electricity each year. This is equivalent to the electricity 280,000 Australian households consume each year. In addition, data centres are becoming increasingly efficient in their energy use. The average power usage effectiveness (PUE) of data centres globally has improved by 37 per cent since 2007, falling from 2.5 to 1.58. Data centres in Australia are even more efficient, with design PUEs as low as 1.15 and a median value of 1.30.

Major data centre operators have also committed to powering their facilities with 100 per cent renewable energy by 2030, largely through power purchase agreements. Growth in data centre capacity could provide additional renewable energy generation capacity equivalent to 2 per cent of electricity generated in Australia by 2030. This equates to approximately 5 per cent of the additional renewable energy generation capacity required to meet Australia's 2030 target of 82 per cent renewable electricity, that data centres could deliver through their climate ambitions.

Government and industry collaboration will unlock Australia's digital opportunity.

Government and industry must collaborate in three key areas to fully capture Australia's digital opportunity:

1. Streamline planning and approval processes for development permits and power allocation to help Australia capitalise on the data centre growth opportunity, and create greater certainty for operators.

2. Enable further investment and accelerate the construction of renewable energy projects, energy storage projects, and transmission infrastructure to support digital infrastructure demand and transition to net zero.

3. Prioritise workforce development and training to provide the skills for a robust data centre workforce, to strengthen Australia's digital infrastructure capabilities.

Australia can position itself as a leading digital economy and accelerate its clean energy transition by implementing the right policy settings and fostering industry partnerships in digital infrastructure.

EMPOWERING AUSTRALIA'S DIGITAL FUTURE

Data Centres: Essential digital infrastructure underpinning everyday life

Data centres - housing efficient, high-tech computers - are the engine room of Australia's digital infrastructure...

1,350 MW[1]
Deployable capacity in 2024
Projected to rise by more than double to **3,100 MW by 2030**

$26 Billion
Additional investment in data centres in Australia is forecast to top **$26 billion** to meet digital infrastructure demand

2X
Connected household devices
The number of devices in the household will **more than double by 2030**

Data centres will nearly double their workforce capabilities to support businesses and consumers...

2X
Workforce
Australia needs to almost **DOUBLE** its data centre workforce **by 2030**

4 in 10
Data centre roles are in shortage
creating opportunities for tech trade roles, ICT professionals and engineers

Data centres aggregate the electricity for the digital economy and catalyse renewable energy investments...

2 TWh
of energy saved
by hyperscale and co-location data centres - without them, on-premise services would use 67% more electricity, enough to power **280,000 homes**

100%
Renewables by 2030
Major data centres have committed to 100% renewables by 2030

NEARLY HALF
of global power purchase agreements in 2022 were signed by data centre operators, accelerating renewable projects

Getting the policy settings right will unlock Australia's digital opportunity...

- **Streamline approval processes**
- **Enable and accelerate renewables investment**
- **Workforce development**

1 According to AEMO's 2024 ESOO, data centre power consumption is equivalent to 340MW of grid load; AEMO (2024) *Electricity Statement of Opportunities*

1.

Data centres enable our modern digital lives

1.1 Data centres are the engine room of Australia's digital economy

Data centres are enabling every digital interaction in society. Data centres across the globe work together to process, store, and distribute vast amounts of data. They enable seamless access to online services and digital activities.

Australians are increasingly reliant on data centres to facilitate their digital lives. This has been driven in large part by the growth of cloud computing services and applications. We now spend more than six hours using the internet every day.[1] Every time we pick up a device to send a message, join a video call, use a shared drive or online collaboration tools, run an internet search, purchase goods or pay a bill online, we are relying on the advanced capabilities of data centres (see Exhibit 1).

Even when we're not actively online, data centres underpin essential services integral to our lives and our safety, such as emergency response systems, natural disaster warnings, transport, and banking.

Data centres provide the vital infrastructure to enable the internet and cloud-based applications. Importantly, they facilitate the delivery of critical government services, storing and processing the data required to run essential operations like Australia's passport, tax, and welfare systems.

The technological advancements enabling our digital economy have become a driving force for innovation, productivity, and economic growth. This will continue to unlock opportunities for Australia.

EXHIBIT 1:

Data centres touch everyone's daily life and are behind every swipe, tap, and click

Illustrative example of digital interactions that take place in a typical day

This is Claire. Claire lives with her two children in Sydney. She works for an accounting firm in the city. Claire relies on technology to make her day easier and more productive. Behind every swipe, tap, and click lies a vast digital ecosystem enabled by data centres making her digital interactions possible.

7am — **Claire is getting her family ready for the day**
- She checks if it will rain today using her BOM app
- She makes sure her train is on time on her Transport NSW app

9am — **At work**
- Claire joins a video call with her team over Microsoft Teams
- She processes invoices with cloud-based technology

12pm — **On her lunch break**
- Claire pays an overdue electricity bill on her phone
- Claire uses HotDoc to book a GP appointment for her son

4pm — **On her way to pick up the kids**
- Claire receives an email from her daughter's school to confirm her parent-teacher interview next week

7pm — **That evening**
- Claire lets her kids watch the latest episode of Bluey on Disney while she makes dinner

She needs data centres to...

- Calculate real-time weather and transport updates
- Deliver audio and video content to her laptop
- Securely connect to her bank
  Book appointments online
- Receive and reply to emails
- Find and stream content from around the world

Source: Mandala analysis.

1 DataReportal (2024) *Digital 2024: Australia.*

1.2 Data centres are efficient high-tech facilities housing state-of-the-art computers

The rise of digital technologies, specifically cloud computing, has modernised digital infrastructure, shifting computing power from individual devices and on-premise servers to centralised data centres. Data centres are efficient and secure high-tech facilities that host many servers housed in data halls. These computers scale in number with the size of the data centre.

Data centres host cutting-edge servers that enable our modern digital lives. These are supported by storage and networking infrastructure. The servers are capable of handling ever greater workloads due to increasingly powerful computer chips. They facilitate high-performance computing, which can run at speeds more than one million times faster than the fastest desktop or laptop.[2] Data is delivered to and from data centres through low-latency fibre connections, enabling speeds of more than 400 gigabits per second.

Critical support systems complement the equipment in data halls. These include efficient power distribution networks, advanced cooling systems to manage heat generation (such as liquid cooling), and reliable backup generators. Data centres leverage the latest generation technologies to optimise performance and energy use.

Data centres offer advanced physical, personnel, and cyber security protections to safeguard customers' systems and data. Physical security measures may include intruder-proof fences, double skinned walls, CCTV, biometrics, on site, 24/7 security, and secure deliveries to help protect the engine room of Australia's digital economy.

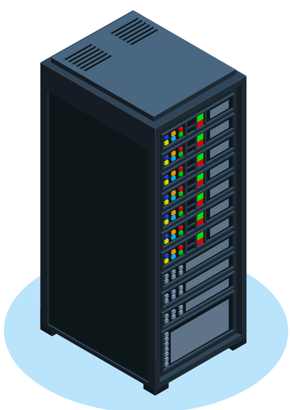
Data centres have become the vital link between the hardware and software layer of the digital value chain. They form a crucial component of our national digital infrastructure, coming together with utility services, such as power, water, and telecommunications, to generate value by enabling efficient and reliable delivery of digital services and applications.

EXHIBIT 2:

Data centres are facilities housing efficient high-tech computers that deliver the digital services we rely on everyday

- Data centres are specialised facilities that house a significant number of servers, depending on their size.
- They contain the IT systems, storage infrastructure and network infrastructure to process and store vast amounts of data.
- Servers are complemented with support systems, such as power distribution, cooling, and backup generators.

High-density racks



High-tech computers
Data centres host high-density servers with state of the art GPUs and CPUs that provide the compute power

Leading cyber security & protection
Data centres offer the latest capabilities in cyber security to ensure the security of people's information

High-speed, low-latency connectivity
High-speed servers and cables enable low-latency connections, bringing speeds of 400+ gigabits per second, maximising performance and enabling a seamless user experience

Efficient technologies
Data centres use new technologies like liquid cooling to improve their efficiency, and offset power usage through renewable energy, such as wind and solar

Source: AWS (2024) *What is a Data Center?*; Cisco (2024) *What Is a Data Center*; Construction Physics (2024) *How to build an AI data center*; Intel (2024) *Why Data Center GPUs Are Essential to Innovation*; Expert interviews; Mandala analysis.

2 IBM (2024) *What is high-performance computing (HPC)?*.

Organisations have transformed their approach to digital infrastructure over time. In the past, organisations maintained their own on-premise servers and computing infrastructure. Now, organisations outsource their computing and data storage needs to co-location data centres. These data centres work alongside hyperscale cloud providers to deliver reliable, scalable cloud services worldwide. These services underpin organisations' ability to efficiently run digital services and applications to support their operations and end consumers.

The impact of data centres extends right across the Australian economy. They are the core enabler of cloud services, which virtually all sectors of the economy are leveraging to enhance their operations, products, and services. This widespread adoption has led to a rapid shift towards a digital lifestyle for Australians and organisations all underpinned by data centres.

EXHIBIT 3:

Data centres are at the core of Australia's digital infrastructure

Work	Home	Government systems	Everyday services

Applications	Providers of digital services and applications and Software as a Service	
Hyperscale providers	Offer globally standardised IT and cloud services over the internet	
Data centre operators	Provide IT systems and equipment to process, store, and manage data	
Hardware providers	Provide processing and memory units known as chips needed for computing	
Utility services	Australia's digital economy relies on power, water, and connectivity	

Note: Non-exhaustive examples of businesses across each category.
Source: Expert interviews; Mandala analysis.

1.3 Data centre deployable capacity in Australia will more than double by 2030

Digital technologies and services are integral to modern life, enabling communication, work, healthcare, trade, entertainment, and more. Emerging technologies like AI will further enhance productivity and convenience. Australian households are rapidly increasing their adoption of internet-connected devices, with numbers expected to double between 2024 and 2030, continuing past trends. Likewise, business use of cloud services and applications is expected to continue to rise.

Data centres in Australia currently have a deployable capacity of 1,350 megawatts (MW), defined as the power capacity for IT loads that is available for immediate use, fully provisioned with power and cooling systems and ready for the installation of IT systems. The total power use of data centres include the IT load as well as the infrastructure load for support systems such as cooling.

As digital take-up continues, Australia's data centre deployable capacity is expected to more than double to 3,100 MW by 2030. This will attract up to $26 billion in additional investment,[3] and includes proposed projects by AirTrunk, AWS, CDC, Microsoft, and NEXTDC.

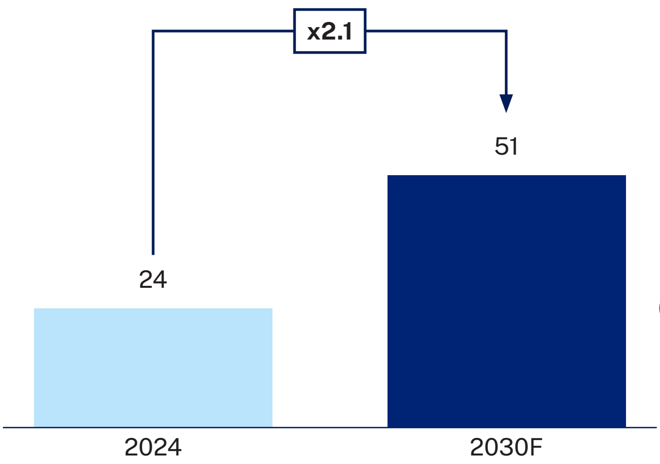
Hyperscale data centres will provide future growth in Australia's data centre capacity. These are larger facilities, with a size of at least 50 MW housing at least 5,000 individual servers, characterised by scalability and efficient infrastructure that support AI, automation, and big data computing.[4]

EXHIBIT 4:

Growing demand for digital services will double the deployable capacity of data centres in Australia to 3,100 megawatts by 2030

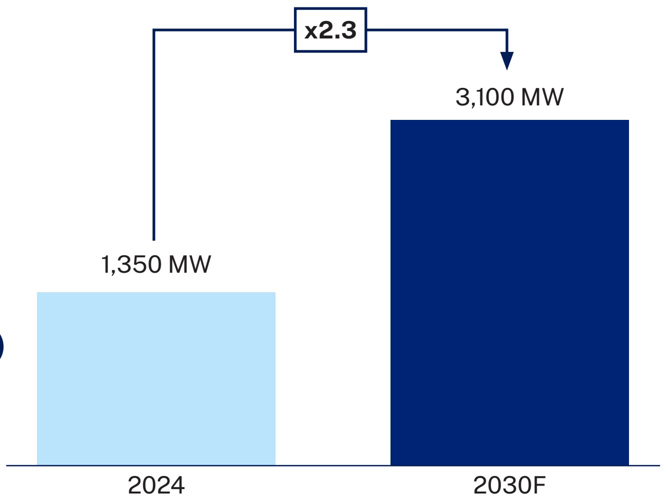
Internet-connected devices in Australian households

Average devices per household, 2024–2030F[5]



Data centre deployable capacity in Australia[6]

Megawatt (MW), 2024–2030F



Growing demand

x2.1
devices

Australians could have up to 2.1x more internet-connected devices in the home by 2030

Infrastructure investment

+AU$26
billion

Investment of $26 billion is required to construct the additional data centre capacity by 2030

Source: Morgan Stanley (2024) Australia – *Data Centre Handbook*; NBN (2024) *Australians feel the need, the need for speed*; Statista (2023) *Australia: average number of internet-connected devices per household*; Telsyte (2024) *Australia's smart home market set to crack $2.5B, driven by AI, energy savings and security*; Datacentremap; Data from select data centre operators; Expert interviews; Mandala analysis.

3 In comparison, non-mining capital investment in the December 2022 quarter for Australia was AU$29 billion; ABS (2024) *Private New Capital Expenditure and Expected Expenditure*.
4 IBM (2024) *What is a hyperscale data center?*.
5 Forecasts are based on the expected growth between 2021 and 2025.
6 Excludes on-premise servers, telecommunication, and government data centres.

2.

Data centre development will enable Australia's digital economy

2.1 Data centres underpin jobs right across the Australian tech sector

There are 9,600 full-time equivalent (FTE) jobs supporting data centre operations in Australia. The data centre workforce needs to grow by 8,300 to reach 17,900 by 2030 to continue powering Australia's digital economy.[7] The additional 8,300 jobs are for ongoing operational jobs, including tech trades (such as electricians and air conditioning technicians), engineers, and ICT professionals, required to support growing demand for data centre deployable capacity.

A strong data centre workforce will contribute to Australia meeting its goal of 1.2 million tech jobs by 2030. Expanding data centre capacity will support highly skilled tech roles like software engineers, cybersecurity experts, and cloud architects. Meanwhile, as data centres scale, they will provide the crucial infrastructure for Australia's cloud-based digital ecosystem to thrive and innovate, including the creation of new businesses and new and emerging high-tech workforce opportunities.

Data centres also support employment during the construction phase of these facilities. The construction phase requires approximately 15 jobs for every one data centre operational job. These jobs are typically in the construction sector and its supply chain. However, existing shortages of skilled workers, particularly in construction, may challenge the rapid expansion of Australia's digital infrastructure.[8]

Australia's digital infrastructure growth is facing significant challenges due to a data centre worker shortage. The shortage, with four in ten data centre roles, is particularly acute in two critical areas: tech trades and ICT professional roles.

Tech trades make up approximately one in 10 data centre jobs (11 per cent). This is even higher in pure play data centre operators such as AirTrunk, CDC and NEXTDC, making up approximately three in 10 jobs (30 per cent). These skilled jobs include electronic equipment trade workers, electricians, heating, ventilation and air conditioning technicians, and mechanical engineers. However, there is a shortage of these crucial workers who maintain and operate critical hardware.

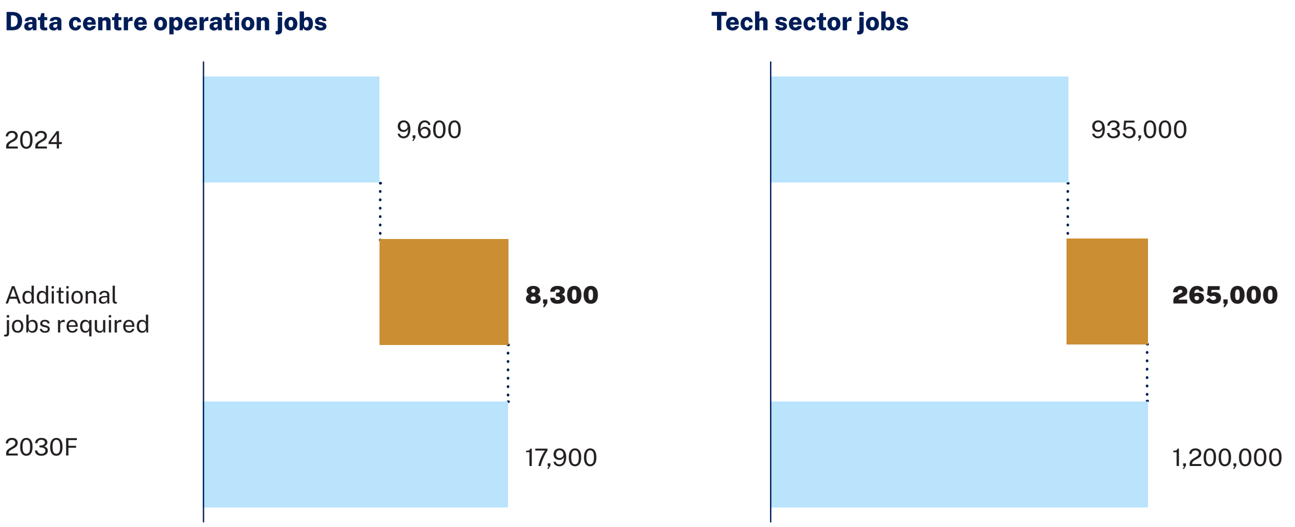
The situation is equally challenging for ICT professionals, who make up the largest segment (30 per cent) of the data centre workforce. There is a significant shortage of computer and network engineers, information security specialists, software engineers, and process engineers. These roles are vital for managing IT infrastructure, ensuring data security, and maintaining system performance.

The remaining roles are made up of executives and managers who oversee operations and strategic planning, business operations and other professionals who support overall functions and administration, and clerical, sales, and administrative workers who handle day-to-day operations. Together, these roles account for six in 10 data centre jobs (59 per cent).

EXHIBIT 5:

Growing Australia's data centre workforce will meet future demand and support jobs in the broader tech sector

Data centre and tech jobs in Australia, FTE jobs, 2024-2030F



Source: ABS (2021) *Census of Population and Housing*; IBIS (2024) *Cloud Storage Services in Australia*; Technology Council of Australia (2023) *Tech Jobs Update*; *Data centre provider data*; Mandala analysis.

7 Demand is measured by deployable capacity, reflecting the number of servers a data centre supports.
8 Australian Government (2024) *Skills Priority List*.

EXHIBIT 6:

Australia's digital infrastructure growth is hindered by skills shortages for tech trades and ICT professionals

Data centre workforce	Composition of workforce (*% of data centre workers, 2021*)		Most sought-after positions[10] vs national skill shortage (Shortage / No Shortage)
Operational roles (tech trades)[9]	11%	1 in 10 workers maintain and operate critical hardware	Electronic equipment trade worker (Shortage); Electrician (Shortage); Heating, ventilation and AC technician (Shortage); Mechanical engineer (Shortage)
Executives and managers	17%	2 in 10 workers oversee operations and strategic planning	Specialist managers (No Shortage); Chief executives and general managers (No Shortage); Managers (No Shortage)
Business ops. & other professionals	11%	1 in 10 support the overall functions and administration	Business and HR professionals (No Shortage); Office manager (No Shortage); Media manager (No Shortage); Legal (No Shortage)
Clerical, sales, admin. workers and other	21%	2 in 10 handle day-to-day operations	Admin. or office clerk (No Shortage); Storeperson (No Shortage); Service manager (No Shortage); Sales assistants and salespersons (No Shortage)
ICT professionals	30%	3 in 10 manage IT infrastructure and ensure data security and system performance	Computer and network engineer (Shortage); Information security (Shortage); Software engineer (Shortage); Process engineer (Shortage)

Overall data centre workforce shortage

4 in 10 data centre roles are currently in shortage

Note: This only includes jobs and roles required for the operation of data centres, and does not include any roles for the construction of data centres.
Source: ABS (2021) *Census of Population and Housing; Australian Government* (2024) *Skills Priority List*; Providers' job postings; Mandala analysis.

2.2 Data centres provide the capabilities to capture opportunities from digital transformation

Data centres drive economic growth through cutting-edge technologies like AI. As the latest innovation wave, generative AI could grow Australia's economy by $45 billion to $115 billion by 2030.[11] To fully capture these opportunities, Australia must leverage the large scale processing and storage capability that data centres provide.

Data centres provide the large storage capacity required to run, train, and deploy AI systems. This is particularly true for more complex and sophisticated AI systems, such as large language models. As these systems become even more advanced and complex, they will require larger storage, memory, and compute capabilities to operate efficiently and in real time, which needs data centres.

Data centres are increasingly housing specialised computer chips called graphics processing units (GPUs), which provide the immense computing power necessary for training and fine-tuning AI models. These chips are efficient at complex tasks, while other tasks can be handled by regular processors, such as central processing units (CPUs). GPUs are also supported by advanced cooling systems to manage the heat generated during the large workloads, to ensure the data centres operate efficiently.

Equally crucial is the network infrastructure within data centres, featuring high-speed connections that allow AI systems to process information and respond rapidly. This environment is essential for AI to perform well in real-world applications.

9 Tech trades include roles such as Design, Engineering and Science Professionals, Engineering & ICT Technicians, various Trades, as well as Machine Operators and Factory Process Workers.
10 Most sought-after positions are based on providers' job postings; non-exhaustive.
11 Microsoft and Technology Council of Australia (2023) *Australia's Generative AI Opportunity*.

2.3 Data centres need to be in proximity to urban areas to meet consumer demand

Data centres in Australia are strategically concentrated around cities. Sydney and Melbourne host 52 per cent of the country's data centres (see Exhibit 7). This proximity to large population centres is driven by customer demand, low latency, access to inputs, and network resilience.

Low latency is crucial to maximising a data centre's performance, with the exception of AI training. With 87 per cent of Australians living in urban areas,[12] data centres must be located nearby to ensure fast data transmission and a seamless user experience for most customers.

Capital cities provide easy access to essential inputs for data centres. They offer a pool of skilled workers, established power grids, and superior telecommunications infrastructure – vital for seamless data centre operations.

Lastly, proximity to major cities enhances network resilience. It allows for easier implementation of redundancy measures and simplifies disaster recovery planning, as multiple facilities can serve as backups.

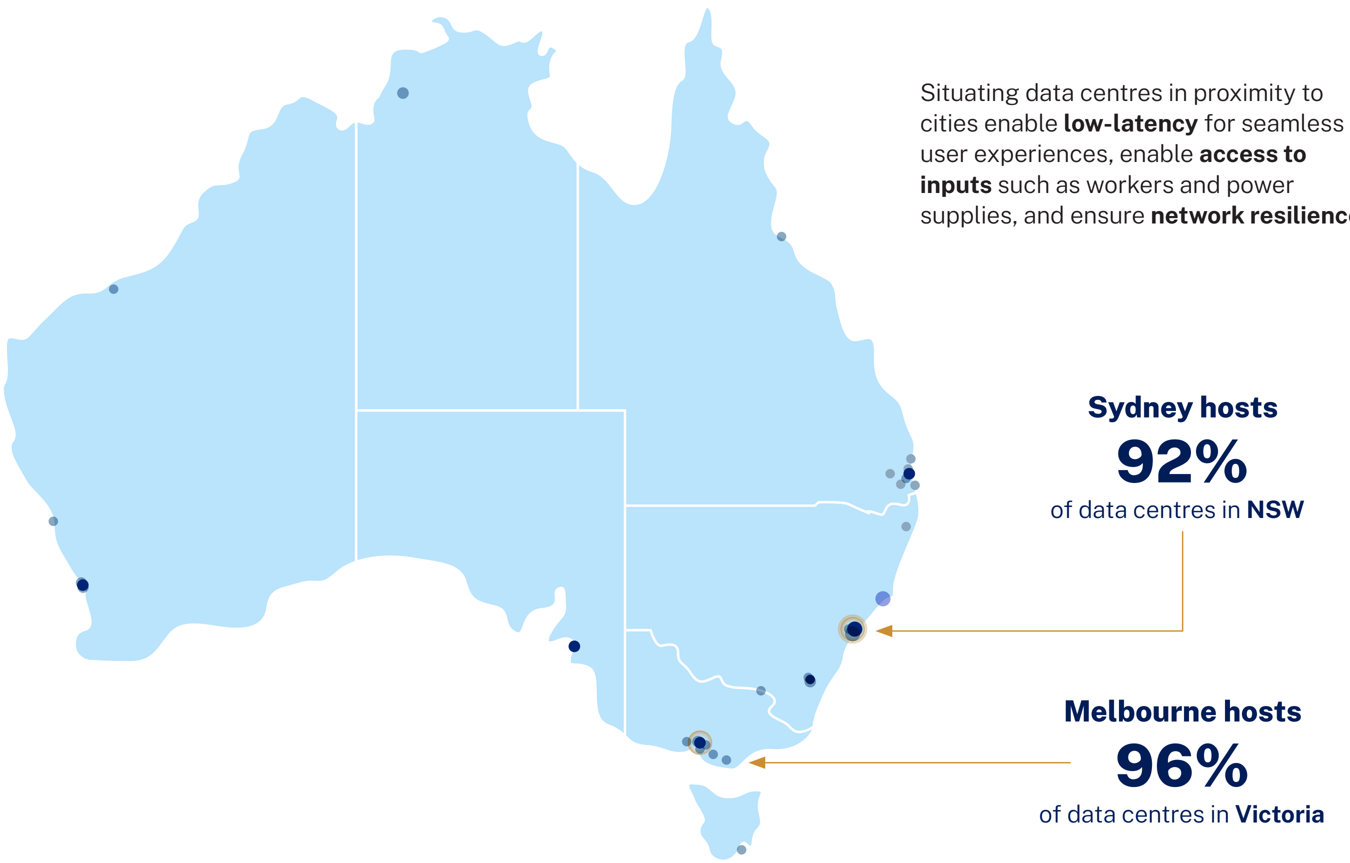
While the urban focus may present challenges in land availability and planning approvals, it remains crucial for meeting growing demand for data services. The strategic placement of data centres near cities is not just a necessity, but a key driver in the growth of our digital economy.

EXHIBIT 7:

Data centres in Australia are concentrated in proximity to cities to meet consumer demand

Deployable capacity by location, 2024

Hyperscale[13] ● Non-hyperscale ● 100 MW (size of bubble = deployable capacity)



Note: See appendix for more details on location of data centres in Australia.
Source: DataCenterMap; Data from select data centre operators; Expert interviews; Mandala analysis.

12 Based on population in 'Significant Urban Areas' as defined by the ABS; ABS (2024) *Regional population.*
13 Hyperscale data centre facilities are those with a design capacity of 50MW or more.

While proximity is important for everyday uses of data centres, other emerging uses such as AI training may not have similar requirements. Australia is well positioned but faces strong competition to become an Asia-Pacific hub for AI data centre operations. Australia offers several key advantages to growing our data centre sector.

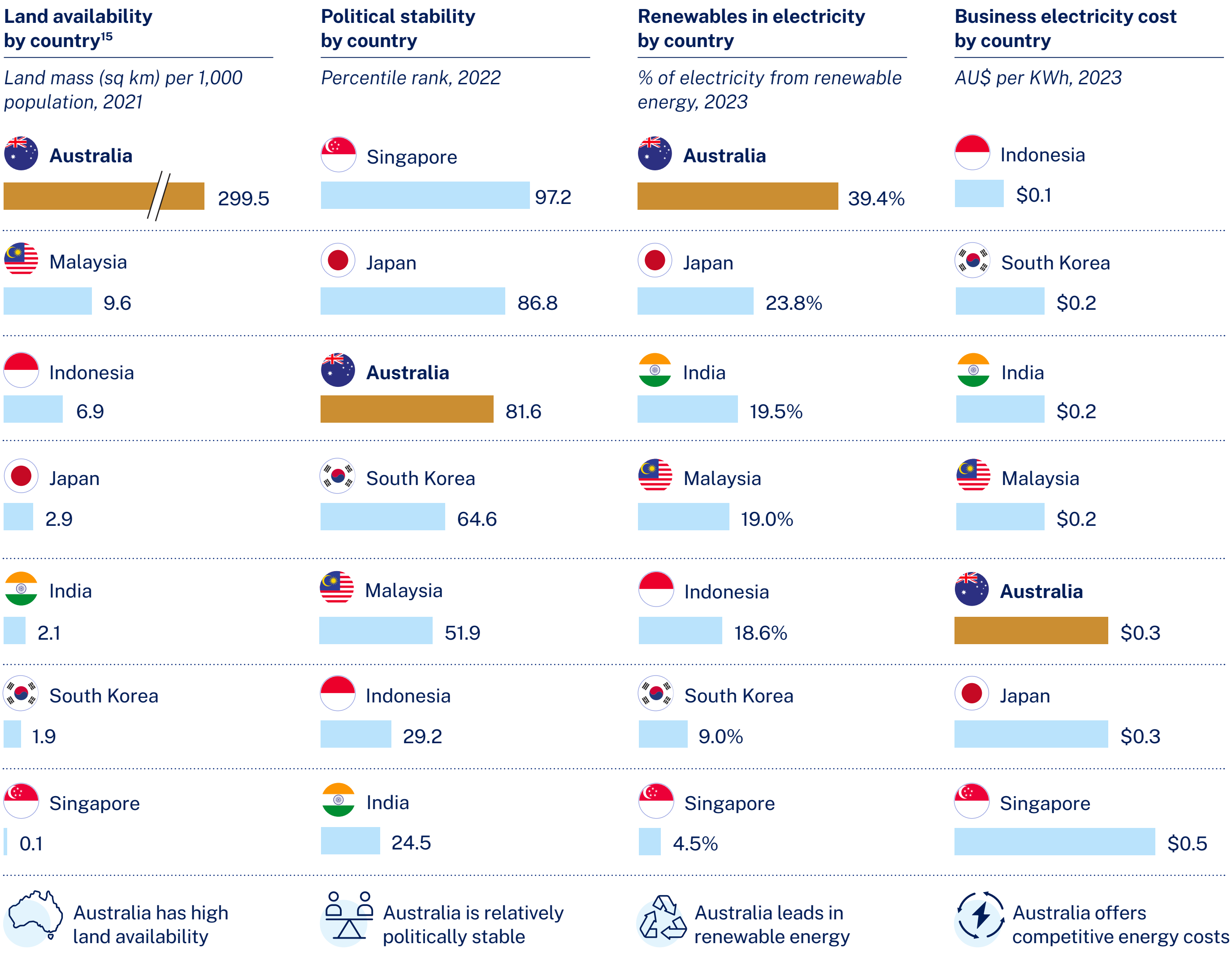
Firstly, Australia has abundant land availability compared to densely populated Asian cities, providing ample space for large-scale data centre facilities. Secondly, Australia's stable political environment and robust regulatory framework offer security and certainty for long-term infrastructure investments.

Thirdly, Australia leads in generating renewable energy, particularly in solar and wind power. Finally, Australia can offer competitive energy costs, especially as it transitions to more renewable sources.

These factors combine to mean Australia has advantages compared to other markets for AI and cloud computing operations seeking to expand or relocate data centre capacity.[14]

EXHIBIT 8:

Australia has advantages for AI data centre operations in comparison to other markets



AEMO sees data centres in Australia as an important export opportunity, driven by global demand for low-emission, energy-intensive sectors[16]

Note: These countries are the largest in the Asia Pacific region by GDP size and data centre offer, excluding Hong Kong and China.
Source: World Bank; CloudScene (2024) *APAC Region; Clean Energy Council* (2024) *Clean Energy Australia*; Energy Institute (2023) *Statistical Review of World Energy*; GlobalPetrolPrices (2024) *Electricity Prices*; Mandala analysis.

14 AEMO (2024) *Integrated System Plan – For the National Electricity Market: A roadmap for the energy transition*; Australian Trade and Investment Commission (2024) *Australia: APAC's rising regional hub for green data centres*.
15 Data centre locations are constrained by factors such as proximity to metropolitan areas, infrastructure availability and environmental conditions. While Australia has high land availability, not all of it is suitable for data centre development. Nonetheless, the average land mass per 1,000 population for Australia's Greater Capital City areas is still relatively high at 3.05 sq km.
16 AEMO (2024) *2024 Integrated System Plan.*

3.

Data centres make the digital economy more energy efficient and are catalysing Australia's energy transition

3.1 Data centres aggregate the digital economy's electricity use

Data centres aggregate the electricity demand that supports and enables our digital lives. Every swipe, tap, and click contributes to this demand, which data centres efficiently consolidate and manage. Rather than the energy use being distributed amongst businesses, and homes and consumers, it is aggregated in the data centre where the computers are housed.

As a crucial part of Australia's digital infrastructure, data centres consume 3 terawatt hours (TWh) of electricity each year, or 1 per cent of Australia's total electricity consumption (see Exhibit 9). In comparison, Australian households account for approximately 30 per cent of total electricity consumed each year, equating to 74 TWh.

Meanwhile, other industrial activities, such as metal manufacturing, other manufacturing and mining make up 33, 29, and 23 TWh of electricity consumption each year. Collectively, these four groups make up approximately 65 per cent of total electricity consumption each year.

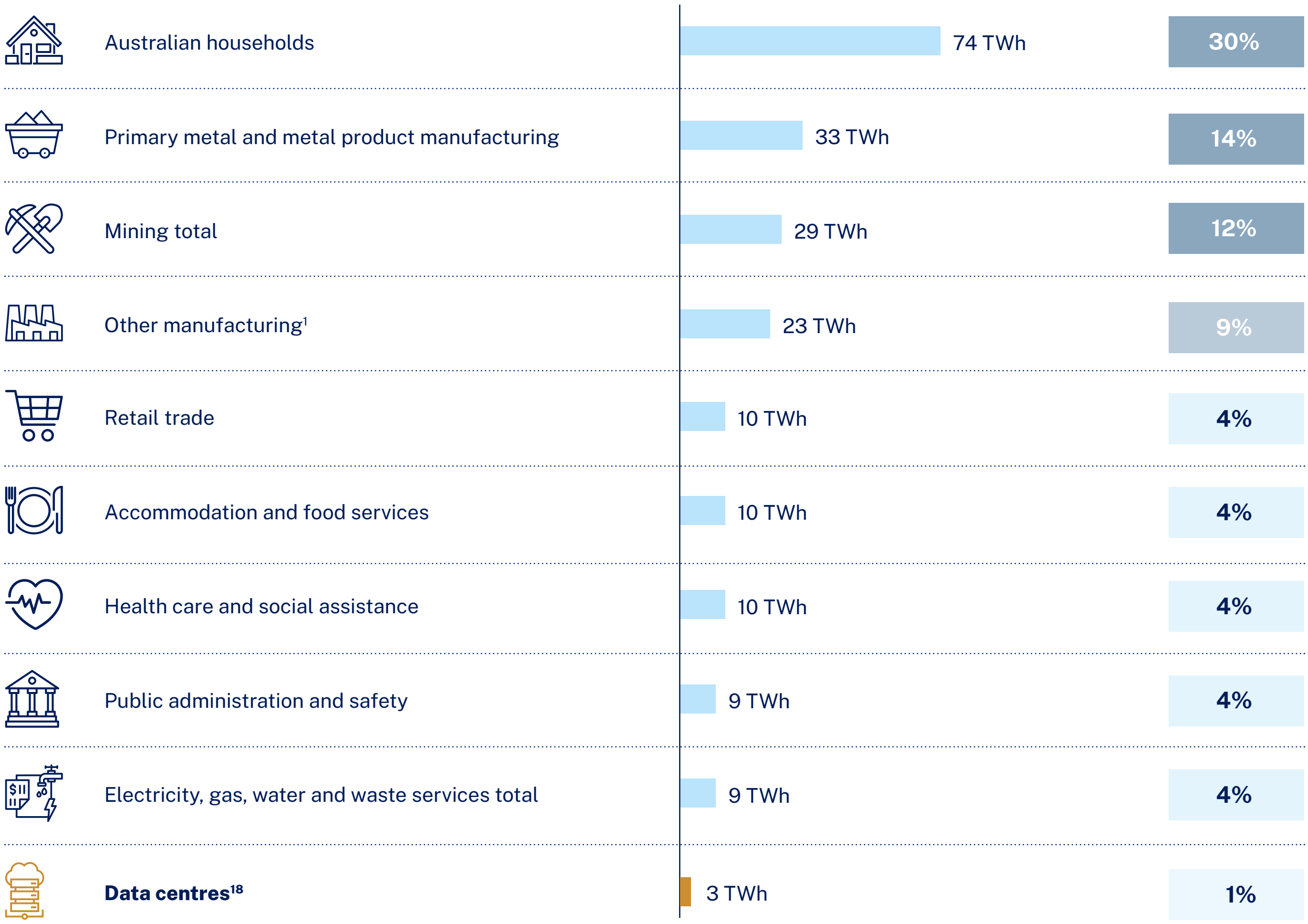
Digital infrastructure is unique from these other sectors. It is a vital enabler of our digital economy, for which data centres aggregate the energy required to support operations and innovation. They require a stable and consistent power load which makes them predictable. Centralised power usage allows data centres to more efficiently manage the energy footprint created by our growing demand for digital services.

EXHIBIT 9:

Data centres use 3 TWh of electricity to power our digital economy

Annual electricity usage in Australia by select industries, Terawatt hours (TWh), 2023[17]

% of electricity consumption



Note: This excludes total energy usage (e.g., coal, oil products, natural gas or biofuels and waste). *Australia-Electricity*; S&P Global (2024); Mandala analysis.
Source: ABS (2023) *Energy Account, Australia*; AEMO (2024) *Electricity Statement of Opportunities*; AER (2024) *Annual electricity consumption–NEM*; DCCEEW (2023) *Electricity generation*; Enerdata (2024) *Australia Energy Information*; IEA (2024)

17 Includes petroleum and chemical products, wood, paper, printing, food, beverages, and textiles manufacturing.
18 Power usage for data centres is based on AEMO data, and has separately been estimated based on 2024 deployable capacity of 1,350 MW, an average committed capacity of 80% and a median PUE of 1.3. See appendix for more details.

Data centres require electricity for two primary purposes: (1) to power their IT load; and (2) to power the infrastructure load that runs efficient support systems of the data centre (see Exhibit 10).

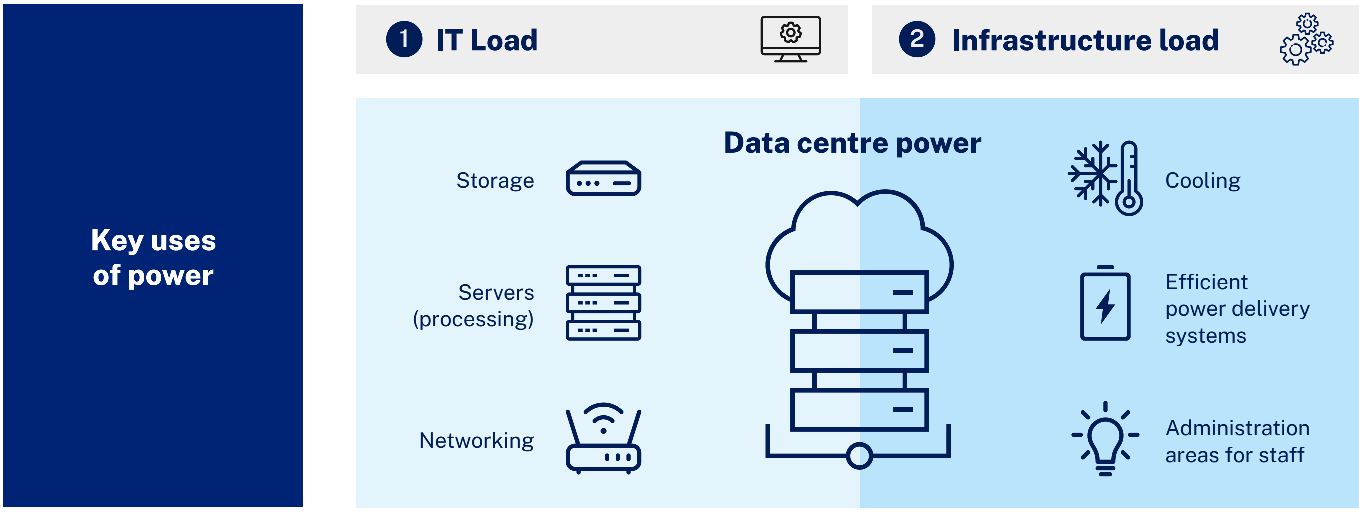
Customer and end-user demand for digital services drive a data centre's IT load and electricity consumption. Our increasing reliance on digital services, cloud computing, and data-intensive applications continues to grow while emerging technologies such as AI are expected to further increase demand. Global data centre workloads and compute instances increased more than six-fold between 2010 and 2018, before the rapid growth in compute-intensive AI applications.[19]

Data centre's IT load generates heat, which must be managed to ensure the reliability and longevity of the IT equipment. Similar to a fan in a household laptop, managing this heat requires cooling. This is achieved by either cooling the air in the data halls itself or cooling the chips directly. For the latter, this is done through direct to chip liquid cooling or immersion liquid cooling. Given the innovation to date, we expect data centre design to continue to improve.

Data centres are constantly balancing a growing IT load, and the associated demands on infrastructure load, with the need for greater energy efficiency. This has led to significant investment in cutting-edge cooling and power-supply technologies (see Exhibit 17).

EXHIBIT 10:

Data centres use electricity to power their IT load, which is growing, and associated cooling requirements



	1 IT Load	2 Infrastructure load
Definition	▪ **IT load** is the power consumed by the computing, storage, and networking equipment. ▪ This electricity use powers computing and data processing tasks.	▪ **Infrastructure load** is the power consumed by non-IT systems required to power the data centre. ▪ This includes power for cooling, lighting, and power delivery systems.
Key drivers	▪ IT load is primarily driven by the demands of data centre customers and end users. ▪ They increasingly rely on digital services, cloud computing, and data-intensive applications which run off new, more powerful chips.	▪ Infrastructure load is influenced by IT load, but data centre operators have more control over the power consumed by non-IT systems, implementing efficient technologies and optimising data centre design to reduce it.

Source: Vimal (2023) *Power Usage Effectiveness (PUE) in Data Centers*; Zhang (2024) *PUE (Power Usage Effectiveness): Optimizing Data Centers*; Mandala analysis.

19 Masanet et al. (2020) *Recalibrating global data center energy-use estimates.*

3.2 Data centres are becoming more and more efficient

Data centres have become significantly more efficient over the last two decades. This is typically measured by power usage effectiveness (PUE). PUE is calculated by dividing the total amount of power used by the data centre by the power used specifically by the IT systems. This helps quantify the proportion of a data centre's power used directly for computing versus support infrastructure like cooling. A lower PUE indicates a more energy efficient facility.

Globally, data centres have an average PUE ratio of 1.58, which is a 37 per cent decrease from 2006. Data centres in Australia are even more efficient, with PUEs as low as 1.15 and a median value of 1.30. The improvements in the PUE of data centres have been driven by the development of high-tech and more efficient hyperscale data centre facilities.

Across the Asia-Pacific region, hyperscale data centres can be up to five times more efficient than large-scale on-premise servers.[20] Meanwhile, hyperscale data centres in Australia are up to 27 per cent more efficient relative to large-scale on-premise servers.[21]

More broadly, data centre operators are improving the energy efficiency of their facilities by implementing innovative technologies, such as advanced liquid cooling systems and AI-driven power management.[22]

EXHIBIT 11:

Data centres are becoming more efficient, requiring less electricity to power the same IT loads

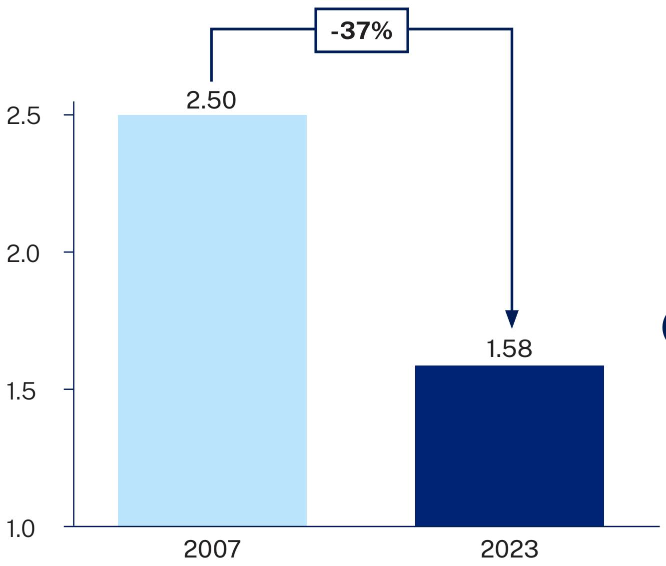
Global average power efficiency of data centres over time

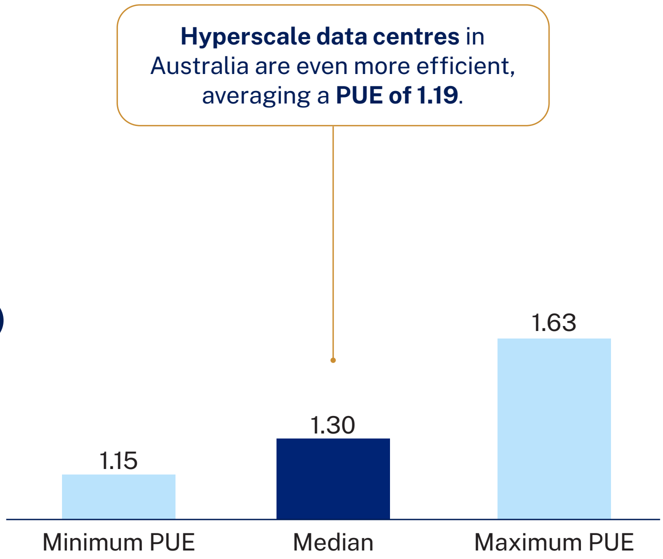
Power usage effectiveness (PUE), 2007–2023

Australian power efficiency of data centres[23]

Power usage effectiveness (PUE), 2024

Power Usage Effectiveness (PUE) is a measure of energy efficiency that compares how much power a data centre uses for its IT load (or computing) relative to its infrastructure load.





Globally, data centres have improved by 37% in efficiency over the last decade and a half, with an average PUE of 1.58

Data centres in Australia are even more efficient, with PUEs as low as 1.15 and a median value of 1.30

Source: Uptime Institute (2023) *Global Survey of IT and Data Centre Managers*; DataCenterMap; Mandala analysis.

20 S&P Global (2021) *The Carbon Reduction Opportunity of Moving to the Cloud for APAC.*
21 DataCenterMap; Based on a comparison of the PUE of a large-scale on-premise server of a leading telecommunications company (1.62) relative to the average PUE of hyperscale data centres in Australia (1.19).
22 Aurecon (2024) *Chilling out with liquid cooling in data centres.*
23 Based on a sample of co-location data centres in Australia that have publicly disclosed PUE values; DataCenter Map.

Co-location and hyperscale data centres have significantly reduced power consumption by centralising computing, storage, and cooling systems compared to dispersed, on-premise servers. This centralisation eliminates the need for duplicate systems across multiple smaller facilities, resulting in substantial power savings. Server rooms are usually retrofitted to existing buildings and so are not built with the high specifications of a data centre hall optimised for energy efficiency.

Modern digital services, such as cloud computing, rely on the large-scale processing capabilities of data centre facilities. Without data centres, these services simply could not exist, at least at the scale and speed we now expect.

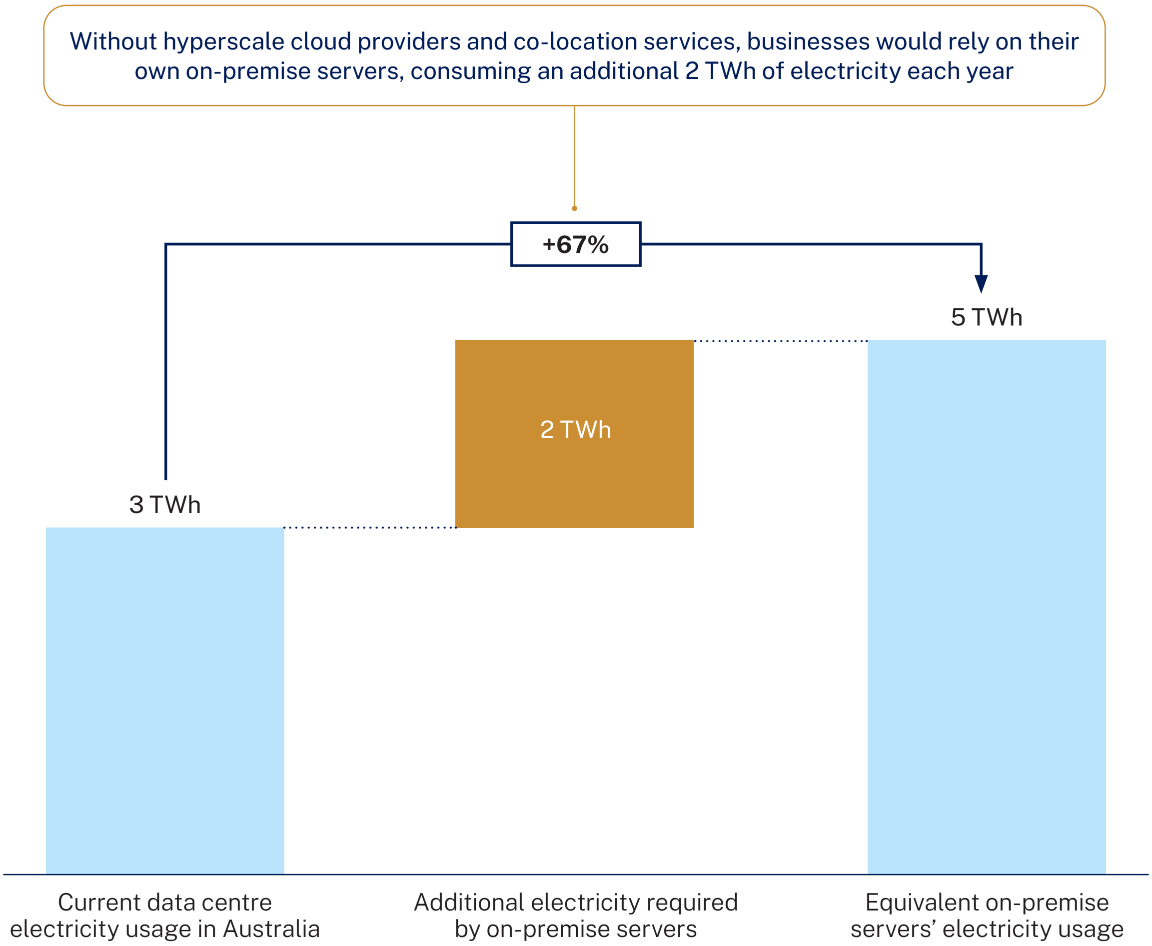
Data centres consume 3 TWh of electricity each year. Without data centres, businesses would need to house their own servers. On-premise servers typically operate much less efficiently than data centres. If on-premise servers were to support digital services and cloud applications, they would consume an additional 2 TWh or more of electricity each year. This amount equals the electricity 280,000 Australian households require.

As new technologies improve co-location and hyperscale data centres' efficiency, savings will be compounded while our lives become increasingly digital.

EXHIBIT 12:

Data centres save electricity due to their efficiencies and role in aggregating processing capacity

Electricity consumption comparison: on-premise servers vs current data centres in Australia,[24] TWh, 2024



Source: AER (2024) *Annual electricity consumption – NEM*; DCCEEW (2023) *Electricity generation*; Enerdata (2024) *Australia Energy Information*; S&P Global (2024); Mandala analysis.

24 Calculated using current capacity (1,350 MW) at 80% committed capacity. Assumed PUE: 1.3 for current data centres, 2.1 for on-premise data centres.

3.3 Data centres are catalysing the energy transition by underwriting renewable energy projects

Power purchase agreements (PPAs) have been a powerful tool for bringing clean energy into the grid in the US and Europe, and there is growing momentum for PPAs in the Asia-Pacific region.[25] PPAs are accelerating the build-out of renewable energy by providing long-term stable revenue streams for project developers. This allows those project developers to secure project finance to start renewable energy projects sooner and at a lower cost of capital. PPAs strengthen the bankability of projects, securing investor confidence in developing renewable energy projects worldwide.[26]

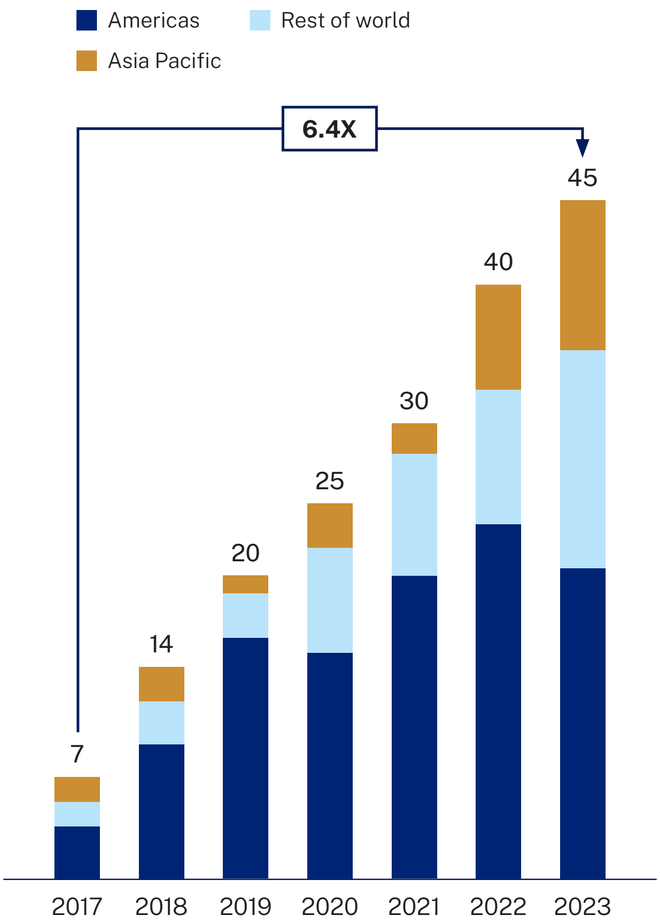
Businesses have increased their total PPAs for renewable energy projects more than six-fold globally since 2017, signing 45 gigawatts in PPAs in 2023. The Asia Pacific region accounted for almost a quarter (22 per cent) of the new PPAs in 2023.

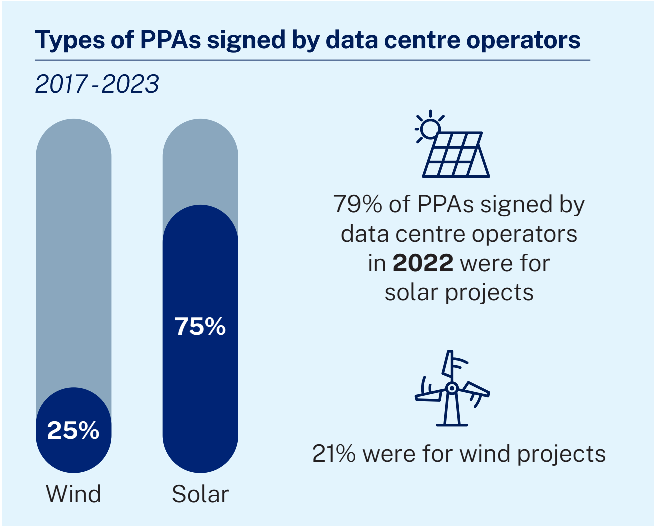
Data centre operators, such as AWS, Microsoft, and many others, have contributed significantly to this global development. These operators accounted for 45 per cent of PPAs, unlocking 18 gigawatts in new renewable energy projects globally in 2022. Since 2017, data centres have agreed to PPAs primarily for solar power (75 per cent), with wind power accounting for the remaining 25 per cent. In more recent years (2022), solar projects have grown faster than wind projects, now comprising 79 per cent of PPAs.

EXHIBIT 13:

Data centres are underwriting renewable energy projects in pursuit of net zero targets and to manage growing demand

Global renewable energy power purchase agreements (PPAs), Gigawatts (GW), 2017-2023





Source: BloombergNEF (2023) *Corporations Brush Aside Energy Crisis, Buy Record Clean Power*; IEA (2022) *Cross-Cutting Technologies & Infrastructure*; IEA (2023) *Data Centres and Data Transmission Networks*; Expert interviews; Mandala analysis.

25 McDonnell, T. (2024) *Net Zero.*
26 PwC (2023) *Key bankability issues for renewable energy projects.*

In Australia, data centre operators are also actively driving the expansion of renewable energy capacity in the country's electricity grid through PPAs.

Microsoft has entered a 15-year PPA for a 300 MW solar farm in Walla Walla of New South Wales, capable of powering 83,000 households. AWS partnered with Vena Energy to develop a 125 MW solar project in Queensland through a PPA, set to provide enough clean energy capable of powering 60,000 homes. AirTrunk is working with various parties to add 25 MW of renewable energy capacity in the Riverina region of NSW. NEXTDC has become a principal partner in the Melbourne Renewable Energy Project, Crowlands Wind Farm, supporting the construction of an 80 MW wind farm in Victoria through a PPA. It started generating renewable energy into the national grid in January 2019, enough to power 35,000 homes. CDC Data Centres is leveraging large generating certificates (LGCs) to offer customers 100 per cent net zero carbon electricity, fuelling investment in renewables.

These initiatives demonstrate the data centre sector's commitment to sustainability and its significant role in accelerating Australia's transition to renewable energy sources.

EXHIBIT 14:

Data centre operators in Australia are using various mechanisms, including PPAs, to accelerate the addition of renewable energy to Australia's grid

Select initiatives by data centre operators	Location	Power capacity of initiative	Power capacity equivalent for households[28]
Microsoft entered a 15-year **PPA** with **Fotowatio Renewable Ventures** (FRV) Australia for the Walla Walla Solar Farm in 2022.	Walla Walla, NSW	300 MW	**83,000 households**
AWS and **Vena Energy** announced the Solar Project Australia – Wandoan in 2024, which is set to generate 125 MW of renewable energy through a **PPA**.	Woleebee, QLD	125 MW	**60,000[29] households**
Google, AirTrunk, and **OX2** have entered a long-term **PPA**, which is projected to add 25 MW of renewable energy capacity to Australia's energy grid by 2025.	Riverina, NSW	25 MW	**7,000 households**
CDC offers its customers across Australia 100% net zero carbon electricity by retiring **large generating certificates** (LGCs), driving investment into renewable energy generation.[27]	Australia	300 MW	**90,000 households**
NEXTDC has been a Principal Partner in the **Melbourne Renewable Energy Project** (MREP), collaborating in a consortium to support **Pacific Blue's** (formerly Pacific Hydro) construction of the Crowlands Wind Farm through a **PPA,** which started generating power in 2019.	Glenlofty, VIC	80 MW	**35,000 households**

Source: AirTrunk (2023) *Google, AirTrunk and OX2 to add renewable energy capacity in Australia*; Equinix (2024) *Equinix signs its first renewable energy PPA in Australia with TagEnergy*; CEFC (2022) *Powering Microsoft data centres with Walla Walla sunshine*; NEXTDC (2022) *FY22 ESG Report*; Vena Energy (2024) *Amazon and Vena Energy announce 125 MW solar project in Queensland*; Mandala analysis.

27 LGCs are tradable certificates created for eligible large-scale renewable energy power stations. The certificates represent the amount of renewable energy generated by these facilities.
28 Based on an average household electricity usage of approximately 7.1 megawatt hours per year.
29 Household figure quoted from VenaEnergy.

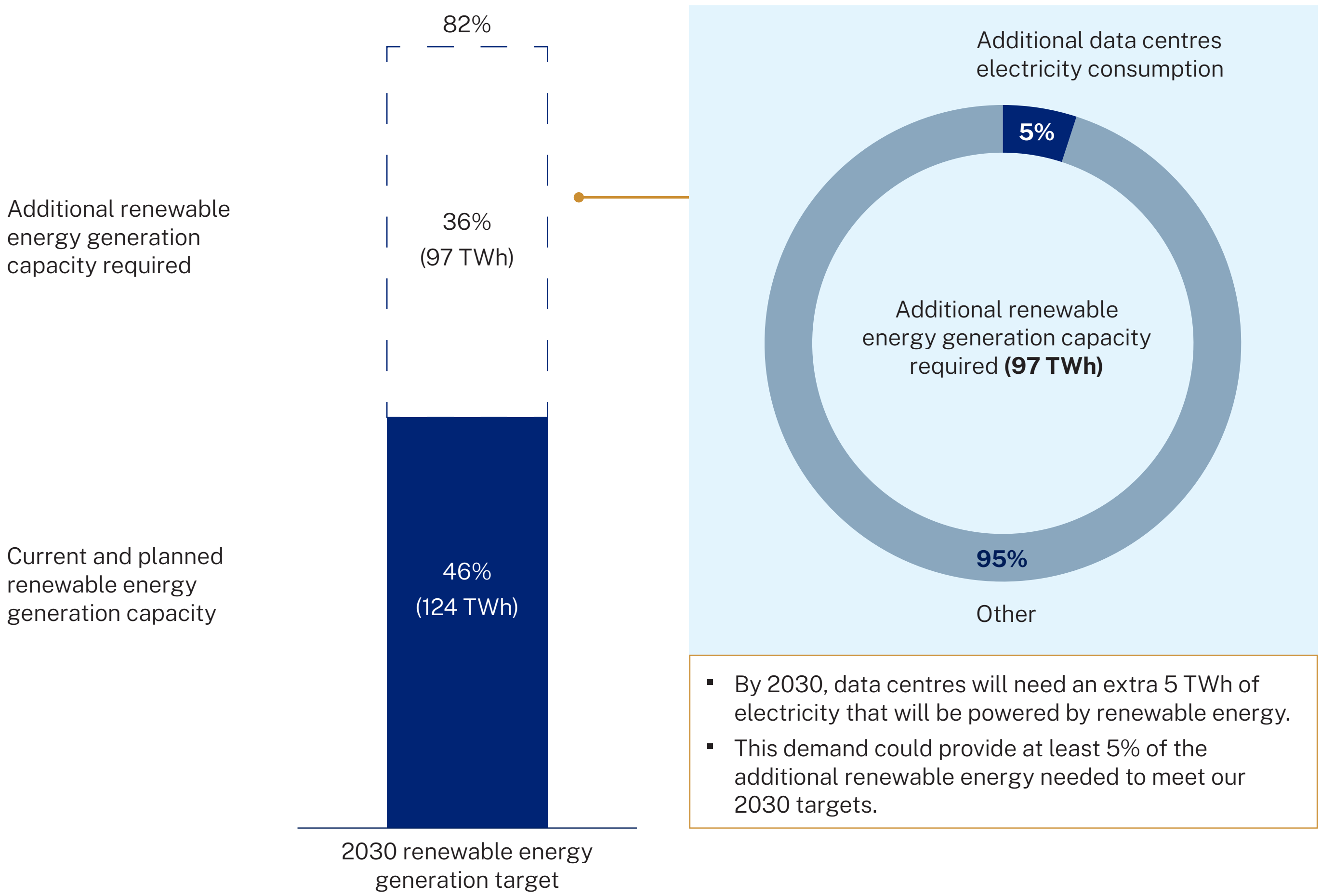
Australia has a national target of generating 82 per cent of its electricity from renewable sources by 2030.[30] This is supporting its broader goal to reduce emissions by 43 per cent from 2005 levels by 2030.[31] Existing and planned renewable projects account for 46 per cent of all electricity generated. Australia needs an additional 36 per cent of its electricity to be generated by renewable energy to reach our 2030 target.

Data centres can contribute to this 2030 target. Their capacity is expected to more than double to 3,100 MW by 2030, and operators plan to match their electricity consumption for these facilities with 100 per cent renewable energy. This growth could provide additional renewable energy generation capacity equivalent to at least 2 per cent of electricity generated in Australia in 2030. This is approximately 5 per cent of the electricity that needs to be generated by renewable energy to meet the 2030 target.

EXHIBIT 15:

Data centres will play a key role in procuring the renewable energy generation required to meet Australia's 2030 targets

Contribution of data centres towards Australia's 2030 renewable energy generation targets. % of total electricity generated in Australia, 2030



- By 2030, data centres will need an extra 5 TWh of electricity that will be powered by renewable energy.
- This demand could provide at least 5% of the additional renewable energy needed to meet our 2030 targets.

Source: AEMO (2024) *2024 Integrated Business Plan*; Clean Energy Council (2024) *Clean Energy Australia*; Clean Energy Council (2023) *Bridging the gap to 82% renewable electricity generation by 2030*; Mandala analysis.

30 Australian Energy Council (2023) *The 82 per cent national renewable energy target – where did it come from and how can we get there?*.
31 Climate Change Authority (May 2024) *2035 Emissions Reduction Targets*.

3.4 Further investments are required for energy storage systems

Data centres are in a unique position to drive investments in energy storage technologies. They require constant power to ensure their services remain available 24/7, unlike many other industries.

The continuous and growing power requirements of data centres signal the need for energy storage technologies. These technologies capture and store surplus electricity generated from renewables for use in the grid during periods when renewable energy may not be available otherwise.

Data centre operators around the world are actively exploring solutions, including battery-based technologies, to support their facilities.[32] In Australia, developers are currently constructing a renewables-powered hyperscale data centre and battery energy storage system in Queensland.[33]

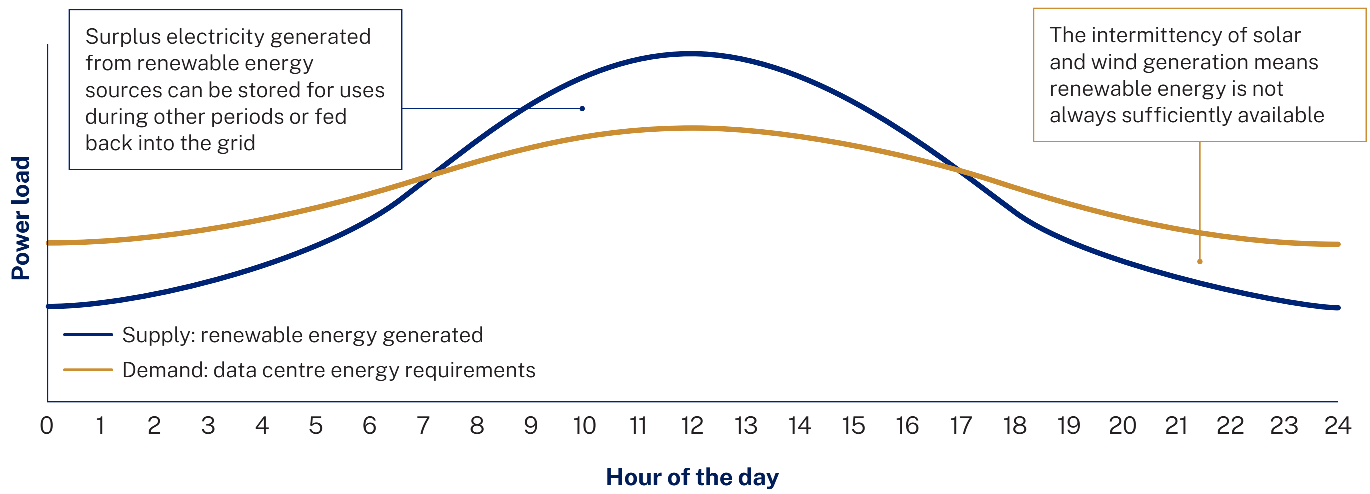
Australia is also exploring other energy storage solutions, such as pumped hydro, compressed air energy storage, and thermal energy storage.

Data centres stabilise the power grid more effectively than households or heavy industry, as their energy needs fluctuate less with weather or customer use. Cloud data centres maintain a steady energy demand, even during nights, weekends and public holidays. While most people

EXHIBIT 16:

Illustration of typical power usage of a data centre by hour of the day

Average power consumption of a data centre in watts by hour of the day



Technologies to support ongoing clean energy requirements of data centres[34]

Battery Energy Storage Systems

Energy storage systems, such as lithium or flow (commonly vanadium) batteries, provide the capabilities to deploy renewable energy during periods of low generation.

Pumped hydro

Pumped hydro can provide electricity during periods of low demand for a continuous period of up to 12 hours. This is done by pumping water from a lower reservoir to a higher reservoir.

Compressed air energy storage

Pressurises and stores atmospheric air in underground caverns, which is then released and expanded through a turbine generator to produce energy for up to 12 hours.

Thermal energy storage

Utilises the ability of different materials to hold heat as a means of storing energy. The heat is later used to generate electricity for up to 24 hours.

Source: Arthur Little (2023) *Green data centers: opportunities for decarbonization*; Clean Energy Council (2024) *The future of long duration energy storage*; ARENA (2024) *Knowledge Bank*; ARENA (2024) *Battery storage*; ARENA Wire (2022) *Compressed air to secure power supply for Broken Hill*; Geoscience Australia (2023) *Hydro Energy*; AirTrunk (2022) *Powering a clean energy future*; Mandala analysis.

32 Microsoft has commissioned battery energy storage systems in its Swedish data centres. Murry (2023) *Data centre backup power BESS news.*
33 Queensland Government (2024) *Construction to begin on one of Queensland's biggest Battery Energy Storage System.*
34 Non-exhaustive; other long duration energy storage solutions that may become prominent in future include sodium-ion or metal-air batteries, gravity energy storage and hydrogen storage.

understand the need to reduce energy use during peak times like heatwaves, low demand can also destabilise the grid. The increasing adoption of household solar and other renewables creates new challenges. For example, AEMO recently had to issue a low-demand warning and shut off rooftop solar in Victoria during mild, sunny conditions on a public holiday. In such situations, grid operators must either increase demand or curtail renewable energy sources. Data centres, with their consistent energy consumption, can help manage grid stability more effectively

Data centre operators in Australia are also actively investing in innovative technologies to enhance the sustainability of their facilities. These advancements are primarily focused on improving energy efficiency and reducing environmental impact.

AirTrunk is harnessing new liquid cooling technology to deploy high-density racks and reduce its energy consumption by up to 20 per cent. For over 17 years, CDC has been using an innovative closed-loop liquid cooling design that enables it to achieve world-leading water efficiency. AWS has invested in more efficient processors that require up to 60 per cent less energy. Microsoft is designing its data centre facilities to be greener overall, with more efficient use of energy as well as using renewable hydrotreated vegetable oil biofuels to reduce their carbon emissions. NEXTDC leads the market in energy efficiency and sustainability through Australia's first 5 star NABERS (National Australian Build Environment Energy Rating System) data centre in Melbourne and Sydney. NEXTDC has also deployed highly efficient MW-scale direct-liquid cooled racks with energy saving free cooling systems to multiple sites.

At the same time, data centres are highly secure facilities, often regulated by critical infrastructure legislation. Regulations dictate security around data halls and building perimeters. There are trade-offs to balance the need for reliability, security, and sustainability, that are being improved over time.

EXHIBIT 17:

Data centre operators are making their facilities more sustainable through investments in innovative technologies

AIRTRUNK **Liquid cooling innovations**	▪ AirTrunk is harnessing liquid cooling technology at its JHB1 facility in Malaysia. ▪ This solution enables customers to deploy high density racks, reducing energy consumption by up to 20 per cent. ▪ Liquid cooling offers superior heat dissipation compared to traditional air cooling. It ensures optimal operating temperatures for high-density servers and improves performance and reliability. ▪ Following successful deployment in Malaysia, AirTrunk is currently planning liquid cooling designs for future Australian data centres.
CDC **Leading water usage efficiency**	▪ Since 2007, CDC has been using a closed-loop liquid cooling system that delivers world-leading water efficiency for its purpose built facilities. ▪ This system saves CDC almost 5 billion litres of water per annum, or approximately 2,000 Olympic swimming pools. ▪ This technology also enables CDC to host AI and high power density workloads natively across its entire footprint.
aws **More efficient processors**	▪ AWS is improving power efficiency in its data centres with more energy efficient chips. ▪ AWS has introduced the Graviton3 processor. It uses up to 60 per cent less energy for the same performance relative to comparable processors. ▪ With enhanced compute performance, Graviton3 processes tasks more quickly and efficiently, reducing the overall energy required.
NEXTDC **Tech-driven performance efficiencies**	▪ NEXTDC has been an Australian industry leader for high energy efficiency liquid-to-chip and energy saving economy cycle free cooling, having deployed 80kW with indirect free cooling racks since 2016 (compared to the average rack size of 1-3kW, requiring greater cooling). ▪ NEXTDC co-developed the data centre NABERS (National Australian Building Energy Rating System) methodology with government to provide an accurate and standardised measure of the operational energy efficiency and environmental impact of data centres in Australia. ▪ NEXTDC developed Australia's first 5 star NABERS co-location infrastructure rated data centre in Melbourne and was also the first to achieve this across multiple data centres. This is an industry-wide and leading recognition of NEXTDC's high efficiency and sustainable facilities.
Microsoft **Green building certification**	▪ Microsoft's new data centres are designed for LEED (Leadership in Energy and Environmental Design) Gold certification, for being highly efficient. This includes the use of natural lighting, efficient heating and cooling systems, and green materials in construction. ▪ Microsoft's Australian data centres will be designed for their backup generators to be powered by a renewable hydrotreated vegetable oil biofuel that reduces net carbon emissions.

Source: AirTrunk (2023) *AirTrunk enters Malaysia with new 150+MW hyperscale data centre in Johor Bahru*; AWS (2022) *New – Amazon EC2 C7g Instances, Powered by AWS Graviton3 Processors*; NEXTDC (2023) *ESG Report*; CDC (2024) *Stable Planet*; AFR (2017) *Canberra Data Centres building $150 million facility*; Microsoft (2022) *Microsoft takes another key step to reduce data centre emissions in ANZ*; Mandala analysis.

4.

Government and industry collaboration will unlock Australia's digital opportunity

4.1 Three key recommendations for industry and government

Government and industry must collaborate in three key areas to fully capture Australia's digital opportunity. This includes:

1. **Streamline planning and approval processes for development permits and power allocation to help Australia capitalise on the data centre growth opportunity, and create greater certainty for operators.**

2. **Enable further investment and accelerate the construction of renewable energy projects, energy storage projects, and transmission infrastructure to support digital infrastructure demand and transition to net zero.**

3. **Prioritise workforce development and training to provide the skills for a robust data centre workforce, to strengthen Australia's digital infrastructure capabilities.**

Streamlining approvals, including for developing permits and power allocation, can create greater certainty for data centre operators. The UK Government, for example, has been working to streamline future focused development and planning, including for data centres. The US White House has launched an AI Data Center Infrastructure Task Force to coordinate policy across government, aligning with economic, national security, and environmental goals. The task force includes a Permitting Council to work with developers on timelines for AI data center projects. For Australia, there is an opportunity for government working with industry to establish a robust framework for ensuring approvals can be streamlined across Local, State, and Territory Governments, and multiple agencies.

Co-investment and engagement on planning from government and industry can help to unlock firmed renewable projects and the necessary transmission infrastructure to support emerging digital infrastructure demands and beyond. This involves government working closely with the IT industry and digital infrastructure providers to ensure continued investments and innovation in renewables across Australia, including in solar, wind, pumped hydro, and storage. The US Department of Energy is creating an AI data centre engagement team to support AI data centre development by coordinating with operators, clean energy providers, grid operators, and other stakeholders. Additionally, there are opportunities to jointly develop best practice standards that optimise environmental, social, and economic needs, and to support research and innovation.

Supporting the development of necessary skills for a strong data centre workforce will strengthen Australia's overall digital infrastructure capabilities. This involves governments working closely with the tech sector and data centre operators to understand the key skill requirements, and supporting education and training pathways to facilitate skills acquisition and create a diverse workforce that meets security requirements.

With the right policy settings and industry partnerships, Australia can position itself as a leading digital economy and accelerate its clean energy transition.

5.

Appendices

5.1 Appendix A: Methodology

EXHIBIT 18:

We used a bottom-up approach to aggregate data from multiple sources to estimate the deployable capacity and electricity consumption for data centres in Australia

Deployable capacity (megawatts)

Approach

We used a bottom-up approach to aggregate data from multiple sources and arrive at the national-level deployable capacity.

This included:

- Proprietary data shared by data centre providers
- Public information available on data centre projects and expansions
- Estimates based on industry proxies for maximum design vs deployable capacity.

Key Inputs

Input	Value	Source
Fitted % of design capacity for hyperscale	89%	Estimated and tested with experts
Fitted % of design capacity for non-hyperscale	15%	Estimated and tested with experts

Additional notes

- Hyperscale cloud providers lease fitted space and operate their own data centres. To avoid double counting, we did not consider leased operating capacity.
- For undisclosed locations, capacity is divided equally across provider's footprint.

Electricity consumption (terawatt hours)

Approach

We estimated current and projected electricity consumption by data centres based on deployable capacity, with the following steps:

- Take deployable capacity and assume a non-vacant space and a committed capacity (or non-vacant rate) to calculate active IT load
- Apply a PUE ratio for support systems to calculate power consumption
- Convert total power drawn into annual electricity usage in terms of terawatt hours
- Calculate data centre's share of electricity consumption by dividing electricity consumption by total Australian electricity consumption.

Key Inputs

Input	Value	Source
Committed capacity (non-vacant space)	80%	Industry reports; Morgan Stanley (2024) *Data Centre Handbook*
Median PUE in Australia	1.3	DataCenterMap; Expert interviews
Power drawn load	25% (2024) 30% (2030)	Desktop research; Expert interviews
Electricity consumption in Australia (TWh)	245	AEMO (2024) *2024 Electricity Statement of Opportunities; Clean Energy Council (2023) Bridging the gap to 82% renewable electricity by 2030*

Model structure

- Data centre's share of electricity consumption = $\frac{\text{Annual electricity consumption}}{\text{Electricity consumption in Australia}}$
- Annual electricity consumption = Electricity consumption **x** Hours per year
- Electricity consumption = Active IT load **x** PUE
- Active IT load = Deployable capacity **x** Committed capacity **x** Power drawn load

EXHIBIT 19:

Future demand for data centres in Australia is estimated based on cloud adoption curves, adjusting for growing AI adoption and the time to construct data centres

Projected demand of data centre

Approach

We measured demand using data centre deployable capacity. To project future demand, we followed these steps:

- Fit S-curve to historical cloud adoption data
- Create new S-curve scenario with increased slope to reflect AI impact
- Establish linear relationship between deployable capacity and cloud adoption (5-year lag)
- Use AI-boosted S-curve to project future cloud adoption
- Project future data centre demand based on adoption projection and established relationship.

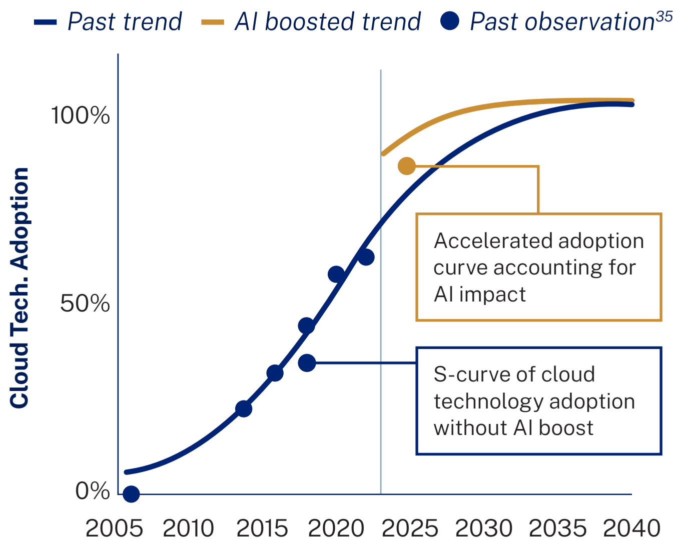
Key Inputs

Input	Value	Source
Years to construct data centre	5	Expert interviews
Introduction of cloud tech in Australia	2006	RBA (2024a) *Adoption of GPT in Australia*
AI cloud tech boost	30%	McKinsey (2024) *In search of cloud value*

Key assumptions

- Linear relationship between cloud adoption and data centre deployable capacity.
- 5-year lag between cloud adoption and reflection in data centre capacity.
- AI impact can be modeled as an increase in the S-curve slope.
- Current deployable capacity accurately reflects historical cloud adoption.

S-curve modelling



Model structure

For cloud technology adoption, we represent the S-shaped adoption as a logistic function

$$A(t) = \frac{1}{1 + e^{-k(t-t_0)}}$$

Where:

- *A (t)* is the adoption rate, *t* years after the technology is introduced
- *k* is the logistic growth rate of the curve
- t_0 is the inflection point, which is where the curve is the steepest.

We estimate the parameters *k* and t_0, which are uniquely defined. We then apply a shock to parameter *k* to represent the AI boost.

35 For more information see ABS (2024) *Use of Information Technology.*

EXHIBIT 20:

We model various economic metrics to assess the impact and skill requirements of data centres in Australia, combining industry data with labour market analysis

Economic modelling

Investment (AU$)

To estimate investment required, we followed these steps:

- Estimate capital expenditure required to fit each MW of deployable capacity in US$
- Project total investment based on current and future deployable capacity
- Apply CPI growth to future investment figures
- Converted US$ figures to AU$.

Employment (FTE)

We estimated employment impact using two methods:

1. Bottom-up: Direct jobs from deployable capacity, verified with ABS census data
2. Top-down: Applied employment multiplier (4.73) for total job impact.

We then projected future jobs based on capacity growth, which included:

- Separating ongoing from construction jobs
- Adjusting for efficiency and automation trends.

Skills required (positions)

To assess skills required in the data centre industry, we followed these steps:

- Analyse current workforce composition using ABS Census occupation codes
- Categorise these roles based on skill types and areas of expertise
- Collect and analyse job postings from data centre providers and other industry players
- Identify the most common job roles across different categories
- Quantify the frequency of each skill category in job postings
- Compare identified skills to the Australian National Skills Priority List to identify gaps
- Cross-reference findings with industry standards and expert opinions.

List of key inputs and sources for economic modelling

Input	Value	Source
Capital expenditure	US$10 million per MW of deployable capacity	Expert interviews
CPI growth rate for future investment projections	Upper bound of RBA inflation target: 3% per annum	RBA(2024b) *Statement on monetary policy*
Exchange rate	Inverse of the daily average for the first half of 2024: 1 AU$ = 0.66 US$	RBA (2024c) *Exchange rates*
Employee growth rate	Based on 2017-2021 CAGR: 3.5% per annum	IBIS (2022) *Cloud Storage Services in Australia*
Employment multiplier for indirect and direct jobs	Employment multiplier that relates to $1 million of output: 4.73	Calculated
Efficiency and automation factor	Based on 2017-2021 decay of employees per operating: 10% average	IBIS (2022) *Cloud Storage Services in Australia*; Morgan Stanley (2024) *Data Centre Handbook*

5.2 Appendix B: Reference list

Abril-Martorell, J. et al. (2023) Green data centers, opportunities for decarbonization, available at: https://www.adlittle.com/en/insights/viewpoints/green-data-centers-opportunities-decarbonization.

AEMO (2024) 2024 Electricity Statement of Opportunities, available at: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2024/2024-electricity-statement-of-opportunities.pdf?la=en&hash=2B6B6AB803D0C5F626A90CF0D60F6374.

AEMO (2024) 2024 Integrated System Plan (ISP), available at: https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2024-integrated-system-plan-isp.

AER (2024) Annual electricity consumption – NEM, available at https://www.aer.gov.au/industry/registers/charts/annual-electricity-consumption-nem.

AirTrunk (2022) Powering a clean energy future, available at: https://airtrunk.com/wp-content/uploads/2023/08/2023-Powering-a-Clean-Energy-Future-Report.pdf.

AirTrunk (2023) AirTrunk enters Malaysia with new 150+MW hyperscale data centre in Johor Bahru, available at: https://airtrunk.com/airtrunk-enters-malaysia-with-new-150mw-hyperscale-data-centre-in-johor-bahru/.

AirTrunk (2023) Google, AirTrunk and OX2 to add renewable energy capacity in Australia, available at: https://airtrunk.com/google-airtrunk-and-ox2-to-add-renewable-energy-capacity-in-australia/.

AWS (2021) Building skills for the changing workforce, available at: https://assets.aboutamazon.com/45/39/5ab8d17149a1bab0011202552bb6/aws-en-fa-onscn.pdf.

AWS (2022) Amazon's First Solar Projects in Australia Start Producing Clean Energy, available at: https://www.aboutamazon.com.au/amazons-first-solar-projects-in-australia-start-producing-clean-energy.

AWS (2022) New – Amazon EC2 C7g Instances, Powered by AWS Graviton3 processors, available at: https://aws.amazon.com/blogs/aws/new-amazon-ec2-c7g-instances-powered-by-aws-graviton3-processors/.

AWS (2024) What is a Data Center?, available at: https://aws.amazon.com/what-is/data-center/.

AWS (2024) AWS Graviton Processors, available at: https://aws.amazon.com/ec2/graviton/.

AWS (2024) How Cloud Can Help Reduce IT Costs for Small and Medium Businesses, available at: https://aws.amazon.com/smart-business/savings/.

Anderson, K. (2024) The role of GPU architecture in AI and machine learning, available at: https://telnyx.com/resources/gpu-architecture-ai.

ARENA (2022) Compressed air to secure power supply for Broken Hill, available at: https://arena.gov.au/blog/compressed-air-to-secure-power-supply-for-broken-hill/.

ARENA (2024) Knowledge Bank, available at: https://arena.gov.au/knowledge-bank/.

ARENA (2024) Battery storage, available at: https://arena.gov.au/renewable-energy/battery-storage/.

Arts, J. (2023) How Is Generative AI Changing Data Center Requirements?, available at: https://blog.equinix.com/blog/2023/11/08/how-is-generative-ai-changing-data-center-requirements/.

Aurecon (2024) Chilling out with liquid cooling in data centres, available at: https://www.aurecongroup.com/insights/towards-sustainable-infrastructure/liquid-cooling-data-centres.

Australian Bureau of Statistics (2015) Business Use of Information Technology, 2013-14 financial year, available at: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8129.0Main+Features12013-14?OpenDocument.

Australian Bureau of Statistics (2017) Business Use of Information Technology,2015-16 financial year, available at: *https://www.abs.gov.au/statistics/industry/technology-and-innovation/business-use-information-technology/latest-release.*

Australian Bureau of Statistics (2021) Census of Population and Housing, available at: *https://www.abs.gov.au/statistics/people/population/population-census/latest-release.*

Australian Bureau of Statistics (2023) Characteristics of Australian Business, 2021-22 financial year, available at: *https://www.abs.gov.au/statistics/industry/technology-and-innovation/characteristics-australian-business/2021-22.*

Bailey, M. (2024) NBN Co hopes for enterprise saviour after $2 billion blowout, available at: *https://www.afr.com/politics/federal/nbn-co-hopes-for-enterprise-saviour-after-2-billion-blowout-20180831-h14rlv.*

Basalisco, B., Haanperä, T., & Hansen, M. (2019) Google's hyperscale data centres and infrastructure ecosystem in Europe, available at: *https://copenhageneconomics.com/publication/googles-hyperscale-data-centres-and-infrastructure-ecosystem-in-europe/.*

BloombergNEF (2023) Corporations Brush Aside Energy Crisis, Buy Record Clean Power, available at: *https://about.bnef.com/blog/corporations-brush-aside-energy-crisis-buy-record-clean-power/.*

Carbon Leadership Forum (2021) Carbon storing materials, available at: *https://carbonleadershipforum.org/carbon-storing-materials/.*

Centersquare (2021) A Brief History of Data Centers and Modern Colocation, available at: *https://www.evoquedcs.com/blog/a-brief-history-of-data-centers-and-modern-colocation.*

Check Point (2024) What is a Colocation Data Center?, available at: *https://www.checkpoint.com/cyber-hub/cyber-security/what-is-data-center/what-is-a-colocation-data-center/.*

Cisco (2024) What Is A Data Center?, available at: *https://www.cisco.com/c/en_au/solutions/data-center-virtualization/what-is-a-data-center.html.*

Clean Energy Council (2023) Bridging the gap to 82% renewable electricity by 2030, available at: *https://assets.cleanenergycouncil.org.au/documents/Bridging-the-gap-to-82-per-cent-renewables-by-2030_Final_August-2023.pdf.*

Clean Energy Council (2024) Clean Energy Australia 2024, available at: *https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/Clean-Energy-Australia-2024.pdf.*

Clean Energy Council (2024) The future of long duration energy storage, available at: *https://assets.cleanenergycouncil.org.au/documents/The-future-of-long-duration-energy-storage.pdf.*

Clean Energy Finance Corporation (2022) Powering Microsoft data centres with Walla Walla sunshine, available at: *https://www.cefc.com.au/case-studies/powering-microsoft-data-centres-with-walla-walla-sunshine/.*

Cloudscene (2024) APAC Region, available at: *https://cloudscene.com/region/datacenters-in-asia-pacific.*

CNET (2023) Apple A17 Pro, The New Chip Brain in the iPhone 15 Pro, Pro Max, available at: *https://www.cnet.com/tech/mobile/apple-a17-pro-the-new-chip-brain-in-the-iphone-15-pro-pro-max/.*

Commonwealth Bank of Australia (2022) CBA introduces leading AI technology to protect more customers from scams, available at: *https://www.commbank.com.au/articles/newsroom/2022/07/scams-fraud-artificial-intelligence.html.*

DataCenterMap, available at: *https://www.datacentermap.com.*

DataReportal (2015) Digital 2015, Australia, available at: *https://datareportal.com/reports/digital-2015-australia.*

DataReportal (2024) Digital 2024, Australia , available at: https://datareportal.com/reports/digital-2024-australia.

Deloitte Access Economics (2021) The Cloud Imperative, available at: https://www2.deloitte.com/in/en/pages/technology/articles/the-cloud-imperative-executive-summary.html.

Department of Climate Change, Energy, the Environment and Water (2024) Australian Energy Statistics, available at: https://www.energy.gov.au/energy-data/australian-energy-statistics.

Department of the Prime Minister and Cabinet (2021) Digital Economy Strategy 2030, available at: https://apo.org.au/sites/default/files/resource-files/2021-05/apo-nid312247.pdf.

Enerdata (2024) Australia Energy Information, available at: https://www.enerdata.net/estore/energy-market/australia/.

Energy Institute (2023) Statistical Review of World Energy, available at: https://www.energyinst.org/__data/assets/pdf_file/0004/1055542/EI_Stat_Review_PDF_single_3.pdf.

Epoch AI (2024) Tracking Large-Scale AI Models, available at: https://epochai.org/blog/tracking-large-scale-ai-models#there-are-few-models-at-the-leading-edge-but-the-frontier-advances-rapidly.

Equinix (2024) Equinix Signs its First Renewable Energy PPA in Australia with TagEnergy, available at: https://www.equinix.com.au/newsroom/press-releases/2024/02/equinix-signs-its-first-renewable-energy-ppa-in-australia-with-tagenergy.

GlobalPetrolPrices.com (2024) Electricity prices, available at: https://www.globalpetrolprices.com/electricity_prices/.

Geoscience Australia (2023) Hydro Energy, available at: https://www.ga.gov.au/scientific-topics/energy/resources/other-renewable-energy-resources/hydro-energy.

Gutierrez, K. (2023) The Future of Australia's Transport System Hinges on AI & Digital Transformation, available at: https://www.informa.com.au/insight/the-future-of-australias-transport-system-hinges-on-ai-digital-transformation/.

IBIS (2022) Cloud Storage Services in Australia.

IBM (2024) What is a hyperscale data center?, available at: https://www.ibm.com/topics/hyperscale-data-center.

International Energy Agency (2022) Cross-Cutting Technologies & Infrastructure, available at: https://www.iea.org/reports/cross-cutting-technologies-infrastructure.

International Energy Agency (2023) Data Centres and Data Transmission Networks, available at: https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks.

Jobs and Skills Australia (2024) Skills Priority List, available at: https://www.jobsandskills.gov.au/data/skills-shortages-analysis/skills-priority-list.

Lai, L., & Francis, L. (2022). Public cloud services, Opportunities and dividends to the Australian and New Zealand economies, available at: https://news.microsoft.com/wp-content/uploads/prod/sites/66/2023/04/IDC-WP_MSFT_FINAL_17.04.pdf.

Microsoft (2022) Microsoft and FRV Australia team up to add renewable energy to the grid, available at: https://news.microsoft.com/en-au/features/microsoft-and-frv-australia-team-up-to-add-renewable-energy-to-the-grid/.

Microsoft (2022) Microsoft takes another key step to reduce data centre emissions in ANZ, available at: https://news.microsoft.com/en-au/features/microsoft-takes-another-key-step-to-reduce-data-centre-emissions-in-anz/.

Morgan Stanley (2024) Data Centre Handbook.

Morgan, S. (2024) The World Will Store 200 Zettabytes Of Data By 2025, available at: *https://cybersecurityventures.com/the-world-will-store-200-zettabytes-of-data-by-2025/.*

NBN Co (2024) Australians feel the need, the need for speed, nbn reveals plan to turbo-charge high-speed tiers, available at: *https://www.nbnco.com.au/content/dam/nbn/documents/media-centre/media-statements/2024/nbnco-media-release-nbn-plans-to-accelerate-highest-speed-tiers.pdf.coredownload.inline.pdf.*

NEXTDC Limited (2020) FY20 Environmental, Social and Governance Report, available at: *https://www.nextdc.com/hubfs/23251048/Downloadable%20PDFs/2104840-FY20-ESG.pdf.*

NEXTDC Limited (2023) FY23 Environmental, Social and Governance Report, available at: *https://www.nextdc.com/hubfs/ASX%20Announcements/2597210-%20NXT%20-%20FY23%20Environmental%2C%20Social%20%26%20Governance%20Report.pdf.*

OECD (2023) ICT Access and Usage by Businesses, available at: *https://stats.oecd.org/Index.aspx?*DataSetCode=ICT_BUS.

OECD (2024) Share of businesses purchasing cloud services, available at: *https://goingdigital.oecd.org/indicator/25.*

Omnitron Systems Technology, Inc. (2024) Data Center Fiber Connectivity, available at: *https://www.omnitron-systems.com/blog/data-center-fiber-connectivity-unveiling-the-backbone-of-seamless-operations#:~:text=Backbone%3A%20The%20backbone%20is%20the,distances%20with%20minimal%20signal%20loss.*

Our World in Data (2024) Artificial Intelligence, available at: *https://ourworldindata.org/artificial-intelligence.*

Potter, B. (2024) How to Build an AI Data Center, available at: *https://www.construction-physics.com/p/how-to-build-an-ai-data-center.*

PwC (2023) Key bankability issues for renewable energy projects, available at: *https://www.pwc.com.au/energy-transition/papers/11-bankability-issues-renewable-energy-projects.pdf.*

RBA (2024a) Adoption of GPT in Australia, available at: *https://www.rba.gov.au/publications/bulletin/2023/sep/adoption-of-general-purpose-technologies-gpt-in-australia-the-role-of-skills.html.*

RBA (2024b) Statement on Monetary Policy, available at: *https://www.rba.gov.au/publications/smp/2024/may/.*

RBA (2024c) Exchange Rates, available at: *https://www.rba.gov.au/statistics/historical-data.html#exchange-rates.*

Redrup, Y. (2017) Canberra Data Centres building $150 million facility, available at: *https://www.afr.com/technology/canberra-data-centres-building-150-million-facility-20170822-gy1ri5.*

S&P Global (2024) Improving datacenter efficiency in Europe – the role of PUE, available at: *https://www.spglobal.com/marketintelligence/en/news-insights/research/improving-datacenter-efficiency-in-europe-the-role-of-pue.*

S&P Global (2021) The Carbon Reduction Opportunity of Moving to the Cloud for APAC, available at: *https://d1.awsstatic.com/institute/The%20carbon%20opportunity%20of%20moving%20to%20the%20cloud%20for%20APAC.pdf.*

McDonnell, T. (2024) Net Zero, available at: https://www.semafor.com/article/06/19/2024/google-is-reinventing-the-clean-power-market.

Services Australia (2016) Annual Report, 2015-16, available at: https://www.servicesaustralia.gov.au/sites/default/files/8802-1610-annualreport2015-16.pdf.

Services Australia (2023) Annual Report, 2022-23, available at: https://www.servicesaustralia.gov.au/annual-report-2022-23?context=22.

Turner & Townsend (2023) Data centre cost trends, available at: https://reports.turnerandtownsend.com/dcci-2023/data-centre-cost-trends.

United States Census Bureau (2024) Business Trends and Outlook Survey, available at: https://www.census.gov/hfp/btos/data_downloads.

Uptime Institute (2023) Uptime Institute's Global Data Center Survey Results 2023, available at: https://uptimeinstitute.com/resources/research-and-reports/uptime-institute-global-data-center-survey-results-2023.

Vena Energy (2024) Amazon And Vena Energy Announce 125 MW Solar Project In Queensland, available at: https://www.venaenergy.com/news/amazon-and-vena-energy-announce-125-mw-solar-project-in-queensland/.

World Bank (2024) Population density, available at: https://data.worldbank.org/indicator/EN.POP.DNST.

MANDALA

mandalapartners.com

admin@mandalapartners.com
media@mandalapartners.com