Data Centers
Essential Infrastructure or Environmental Challenge?

Market Overview

Growth in the UAE

If AI is the industrial revolution of our age, data centers are the engine driving this transformation. While the revolution started in Silicon Valley, the Middle East, particularly the UAE, has been gaining momentum as a hub for data center growth, with expectations to double the market size by 2030. Key factors contributing to this growth include:

Central Geographical Location
Facilitates better connectivity and lower latency.

Government Support
Initiatives and investments from the government bolster infrastructure development.

Data Sovereignty
Increasing demand for local data storage due to regulatory requirements.

Increased Digitalisation
Growing reliance on digital services fuels the need for robust data infrastructure.

The UAE boasts the fastest-growing data center industry in the Middle East, with active projects amounting to US$1.2 billion and a future project pipeline of US$433 million[1]. In Dubai alone, with 99% of the population already active online, initiatives such as Smart Dubai have accelerated digital transformation, boosting the demand for advanced digital infrastructure. Enablers for this market include robust fibre connectivity, a reliable power grid, and a streamlined construction permit process. Additionally, the UAE remains competitive regarding data center construction costs, ranking 11th globally in 2023[2].

The UAE data center industry

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1. Turner & Townsend (2024) An in-depth look at data center development in the Middle East.
2. Statista (2023) Global data center markets ranked by cost of construction

Expansion of Data Centers in Saudi Arabia

In 2021, Saudi Arabia launched an ambitious USD 18 billion strategy to establish a nationwide network of large-scale data centers[1]. The Kingdom currently hosts 22 active co-location facilities with over 40 more under construction, primarily concentrated around Riyadh, Jeddah, and Dammam[1]. Notable giga projects like Neom emphasise the development of reliable infrastructure to position Saudi Arabia as a leading ICT hub. Factors supporting this expansion include:

Strict Data Protection Laws
Enhance trust and compliance for data storage.

Sizeable Domestic Market
Large and growing market demands robust data infrastructure.

1. Turner & Townsend (2024) An in-depth look at data center development in the Middle East.

Environmental Impacts

Energy Consumption

Data centers are significant energy consumers, often operating behind the scenes without visible emissions. According to the International Energy Agency (IEA), data centers consumed 460 terawatt-hours of electricity in 2022[3]. To contextualise, this is more than the annual energy usage of Spain. Globally, data centers account for approximately 3% of all electricity usage and up to 1% of all greenhouse gas emissions[3]. The rapid growth of IoT devices is projected to drive technology industries to account for between 7% to 20% of global energy demands by 2030[4].

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Water Usage

Beyond electricity, data centers require substantial water for cooling systems. A typical small one-megawatt data center using traditional cooling methods consumes over 26 million litres of water annually[5], equivalent to filling more than 10 Olympic-sized pools.

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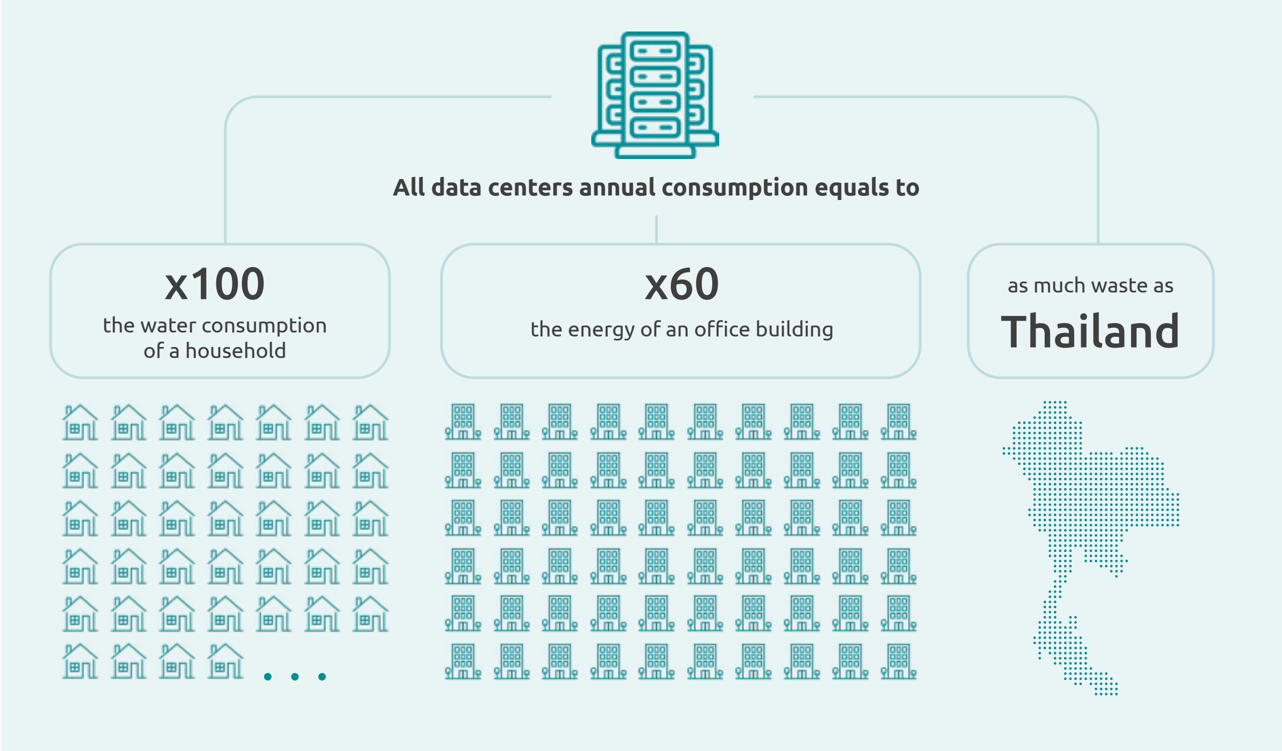
E-Waste Generation

Advancements in chip design and faster servers result in significant electronic waste. E-waste is one of the fastest-growing waste streams globally, with annual production expected to reach 75 million metric tons by 2030[6]. While global e-waste holds roughly $60 billion-worth of raw materials such as gold, palladium, silver, and copper, only 17% is documented to be collected and properly recycled each year[6].

Global e-waste contains about $60 billion in raw materials, but only 17% is collected and recycled each year[6]

3. *World Economic Forum (2024) Data growth drives ICT energy innovation.*
4. *Forbes Councils (2023) Pioneering the future of sustainable data centers.*
5. *Arup (2023) How can we cut water consumption in data centers?*
6. *Statista (2024) Generation of electronic waste globally forecast.*

ENVIRONMENTAL IMPACT OF DATA CENTERS VISUALISATION



Key Environmental Impacts

Energy Consumption
High electricity usage contributes to significant carbon emissions.

Water Usage
Intensive cooling processes lead to massive water consumption.

E-waste
Rapid technological advancements result in increased electronic waste.

Greenhouse Gas Emissions
Data centers contribute up to 0.3% to 1% of global emissions.

Data Centers and Sustainability

Despite the critical role of data centers, sustainability often takes a backseat to uptime, redundancy, and security. However, there is potential for significant environmental improvements without compromising performance.

Leading tech giants like Microsoft, Google, and Facebook have pledged to achieve net-zero goals by 2030. Regional providers too have made ambitious commitments:

etisalat and

Committed to zero carbon emissions (scope 1 and 2) by 2040[7]

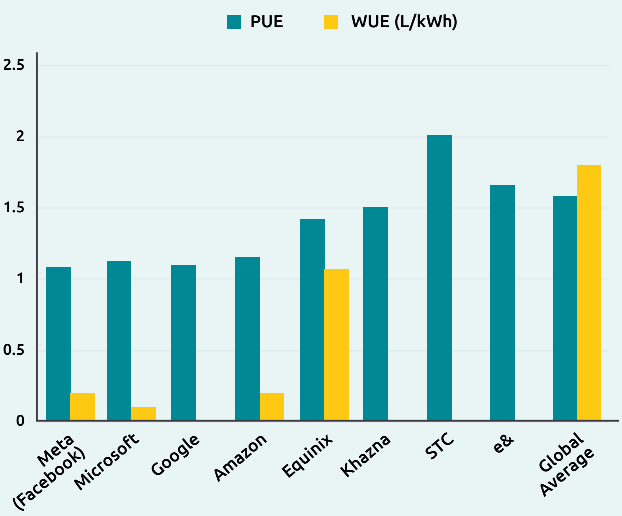
Khazna stc

Aim for carbon neutrality by 2050[8]

Current initiatives include targeting LEED certification and improving Power Usage Efficiency (PUE), with new builds aligning with sector averages. However, reporting on water efficiency and waste management remains limited.

COMPARISON IN WATER AND ENERGY PERFORMANCE OF DATACENTRE PROVIDERS GLOBALLY AND IN MIDDLE EAST [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]

Company	PUE	WUE (L/kWh)
Meta (Facebook)	1.09	0.2
Microsoft	1.125	0.1 (in Middle East)
Google	1.1	Not Available
Amazon	1.15	0.19
Equinix	1.42	1.07
Khazna	1.5	Not Available
STC	2.0	Not Available
e&	1.65	Not Available
Global Average	1.58	1.8



7. Etisalat (2023) About us: Media centre
8. STC (2022) Sustainability Report 2022.
9. Atmeta (n.d.) Data centers.
10. Microsoft (2015) Microsoft cloud infrastructure: Data center and network fact sheet.
11. Google (n.d.) Data center efficiency.
12. Equinix (n.d.) Operational sustainability.
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16. Statista (2024) Data center average annual PUE worldwide.
17. TechTarget (2024) How to manage data center water usage sustainably.
18. Azure (2022) How Microsoft measures data center water and energy use to improve Azure cloud sustainability.
19. TechTarget (2024) How to manage data center water usage sustainably.
20. Equinix (2024) How we worked to build a better future in 2023.

Sustainable Approaches to Climate Resilient Data Centers

Energy Improvement Strategies

Adiabatic Cooling

Utilises evaporation instead of mechanical air conditioning, reducing electricity use by up to 90% compared to traditional systems[21]. Depending on local conditions and the availability of reclaimed water, it can be implemented using both indirect evaporative cooling (IDEC) and direct evaporative cooling (DEC). Adiabatic free-cooling chillers were employed in the Khazna Abu Dhabi 6 (AUH 6) data center in Masdar, which achieved LEED Gold and Estidama 4-Pearl certifications.

Adiabatic cooling reduces electricity use by up to

90%

compared to traditional systems[21]

Liquid Cooling

Liquid cooling is significantly more efficient than air cooling, as liquids can transmit up to 22.4 times more energy than air. This enhanced efficiency has driven the adoption of liquid cooling in recent years, with configurations varying from full immersion of servers to the use of liquid heat exchangers directly mounted on heat-generating equipment. While liquid cooling offers superior performance, especially in high-performance computing environments and data centers with high power density, it requires a higher initial investment compared to traditional air cooling systems. The ideal use case for liquid cooling is in scenarios where air systems are insufficient to meet the cooling demands, ensuring optimal performance and energy efficiency.

Liquid cooling is highlighted as being significantly more efficient than air cooling, capable of transmitting up to 22.4 times more energy than air.

Optimised Operating Parameters

Data centers have traditionally maintained strict temperature and humidity controls to ensure the reliability of IT equipment. However, these stringent measures have led to excessive energy consumption. Recent research conducted by Facebook, Intel, The Green Grid, and ASHRAE indicates that higher operating temperatures are not as detrimental to IT equipment as previously believed[22]. According to the new ASHRAE guidelines, Class A3 devices can safely operate at temperatures up to 104°F (40°C) , provided that these increases remain within the recommended and allowable limits.

Increasing server inlet temperatures by just 1°F (-17.22°C) can lead to a 4% to 5% reduction in energy costs[23]

21. Cooling Best Practices (2017) Adiabatic cooling keeps pace growing data center heat density.
22. US Department of Energy (2013) Data center efficiency and reliability at wider operating ranges.
23. TierPoint (2023) Data center energy efficiency.

While increasing operating temperatures presents benefits, several factors must be considered, including personnel safety, server fan power, and the potential for hot spots. Despite these considerations, the potential energy savings make it a worthwhile strategy. For instance, every 1°F (-17.22°C) increase in server inlet temperature can result in a 4% to 5% reduction in energy costs[23].

Reflecting this shift, Equinix announced last year its plan to raise the operating temperature in its data halls to 80°F (26.667°C), which is warmer than the traditional range of 68°F to 72°F (20°C - 22.22°C) 24. This adjustment underscores the industry's move towards more energy-efficient practices without compromising equipment performance.

Backup Power Alternatives

Given the importance of uptime on profitability, it is no surprise that data center owners continue to rely on tried-and-true technologies like diesel generators as a source of backup power. It is estimated that there are more than 20 gigawatts of backup diesel generators in service globally across the data center industry today[25]. While some developers have turned to natural gas-fired generators to reduce their carbon footprint, these alternatives remain incompatible with net-zero ambitions. Additionally, natural gas generators do not eliminate NOx (nitrogen oxides NO and NO2) and SOx (sulfur oxide) emissions, and their noise levels are similar to those of diesel generators.

With over 20 gigawatts of diesel generators currently powering data centers worldwide, the urgent need for sustainable backup power solutions has never been clearer.

Hydrogen-powered fuel cell generators present a promising alternative for data centers seeking to move away from diesel-based backup power. These fuel cells offer a cleaner and quieter solution, aligning better with sustainability goals. However, the central challenge lies in balancing the use of different power backup technologies:

UPS (Uninterruptible Power Supply
Provides immediate power to critical loads during short-term outages.

BESS (Battery Energy Storage Systems)
Offers mid-duration energy storage and backup power, bridging the gap between immediate and long-term power needs.

Fuel Cells
Serve as a long-term backup power solution, ensuring continuous operation during extended outages.

Achieving an optimal balance among UPS, BESS, and fuel cells is crucial for data centers aiming to eliminate the reliance on diesel generators entirely. This integration will pave the way for a future where backup power is both reliable and sustainable, supporting the industry's transition towards net-zero emissions.

23. TierPoint (2023) Data center energy efficiency.
24. Equinix (2022) Equinix to adjust the thermostat to optimize data center energy use.
25. Arcadis (2024) Sustainable data centers.

Commissioning

Technical commissioning plus detailed failure scenario testing are essential for reducing energy consumption and ensuring uptime in any data center. In data centers, it becomes increasingly important to ensure the optimised operation and performance of energy systems. Effective commissioning management throughout the design, construction, and installation phases, as well as ongoing monitoring-based commissioning during operations, ensures that systems continuously perform as required.

Effective commissioning is essential for ensuring that systems in data centers consistently perform reliably and efficiently.

Water Conservation Strategies

Water usage in data centers can be optimised through:

Water Monitoring

The data available on water consumption in data centers is limited, especially when compared to energy usage. Monitoring water consumption—whether for direct usage, cooling, or process applications—is essential for establishing targets, setting benchmarks, and tracking overall consumption. Implementing advanced water metering and monitoring systems enables prompt detection and correction of leakages or inefficiencies, thereby optimising water use and reducing waste.

Water consumption data in data centers is often overlooked, yet effective monitoring is crucial for optimising usage, setting benchmarks, and minimising waste.

Alternative Water Sources

Data centers can use numerous water supply sources, including potable water, treated effluent, or reclaimed/recycled water. The quality of the cooling water, however, can affect the equipment's useful life. Reclaimed water, for example, can cause more corrosion, scaling, and microbiological growth in the equipment than potable water. This depends on the specific properties of the available water supply.

Using its own purpose-built system, a Google data center in Georgia, USA, takes treated effluent from the local water and sewer authority's treatment plant and further treats the effluent to make it reusable[26]. Another example from Google is a data center in Hamina, Finland, where seawater was used to cool equipment[27].

Data centers can enhance sustainability by utilising alternative water sources, but the quality of water used is crucial for protecting equipment longevity.

26. Data center Dynamics (n.d.) Google uses recycled water at Georgia data center.

27. Google (2012) Hamina data center location.

Waste Management Practices

Effective waste management in data centers includes:

Server Technology

Server infrastructure providers and vendors, such as Intel and Dell, are developing solutions that enable the dynamic composition and decomposition of disaggregated systems. These solutions aim to maximise efficiency and extend the lifespan of server components. Instead of dismantling and replacing entire units, these companies are striving to simply replace the host processing unit (HPU), or “main brain,” thereby reducing power consumption.

Intel and Dell are pioneering disaggregated systems to boost efficiency and reduce power consumption.

Server Reuse

The circular approach to server disposal involves maintaining servers for as long as possible, refurbishing components for future reuse, reusing or reselling components following a rigorous security process, and recycling any components that cannot be reused. Google is at the forefront of this initiative, with 38% of its owned and operated data centers achieving Zero Waste to Landfill. In 2022, Google resold nearly 5 million components, and 21% of the components used for server deployment, maintenance, and upgrades were refurbished inventory[28].

Google's circular strategy promotes server reuse, achieving Zero Waste to Landfill in 38% of its data centers and reselling nearly 5 million components in 2022.

Modular Design

Modular design involves constructing data centers using prefabricated standardised modules. This approach offers flexibility, scalability, and efficiency. Different types of modules are available, with the most common being IT, power, and cooling modules. Additionally, modular design can be applied to the building envelope, where prefabricated modules are connected on-site. This method reduces waste during deconstruction, particularly when the connections between modules are reversible. Furthermore, all-in-one modules that combine IT, power, and cooling infrastructure into a single scalable unit are also available.

Modular design enhances data centers with flexible, scalable, and efficient prefabricated modules that reduce waste and streamline construction.

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28. Google (n.d.) Circular economy.

Building Reuse

Most of the embodied carbon from the construction of a data center is concentrated in the foundation, structure, and envelope. Repurposing vacant buildings into data centers presents an opportunity to reduce this carbon footprint. Successful examples of such conversions can be found around the world, particularly in Hong Kong, where land availability is limited. Warehouses and large retail spaces are ideal for conversion, however, offices can also be considered under certain circumstances. Key considerations when evaluating a building conversion include available power, clear height to accommodate installations, and the structural integrity of the building to support racks, backup power, and cooling systems.

Repurposing vacant buildings into data centers presents a strategic opportunity to minimise carbon footprints while optimising urban space.

Future Outlook

The future of data centers hinges on ongoing technological advancements and evolving regulatory measures aimed at minimising environmental impacts and promoting sustainability. Providers like Intel and Dell are developing solutions for dynamic system composition to maximise efficiency and extend equipment lifespans, while innovations in cooling technologies, such as adiabatic and liquid cooling, are crucial for enhancing energy efficiency. Concurrently, regulatory frameworks must evolve to support sustainable growth by implementing local and regional policies that mandate energy and water efficiency, as well as establishing consistent international standards to harmonise sustainability efforts.

The future of data centers hinges on harnessing innovative technologies and adaptive regulations to tackle environmental challenges while powering the digital economy.

In closing, data centers are essential for powering the digital economy, enabling technologies like AI and IoT. However, they also present significant environmental challenges, including high energy and water consumption and substantial e-waste generation. To address these issues, the industry must adopt innovative cooling technologies, optimise operational parameters, and implement effective waste management practices. Additionally, repurposing existing buildings and enhancing water conservation strategies can further mitigate environmental impacts. Regulatory measures at all levels are crucial to ensure sustainable growth. Balancing the indispensable role of data centers with their environmental responsibilities is essential.

AESG is here to help data centers achieve these sustainability goals. Contact us today to learn how we can support your efforts in creating more efficient and environmentally responsible operations.

References

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How AESG can help

AESG is an international Consultancy, Engineering and Advisory firm committed to driving sustainability in the built environment and beyond. With the highest calibre leadership team in our field, we pair technical knowledge with practical experience to provide hands-on, bespoke strategic solutions to our clients.

We have one of the largest dedicated specialist consultancy teams working on projects within the building, urban planning, infrastructure and strategic advisory sectors. With decades of cumulative experience, our team offers specialist expertise in sustainable design, sustainable engineering, MEPF, fire and life safety, façade engineering, commissioning, digital delivery, waste management, environmental consultancy, strategy and advisory, security consultancy, cost management and acoustics. Our prestigious portfolio demonstrates our extensive capabilities and our ability to consistently deliver best in class solutions to some of the industry's most complex technical challenges.

How AESG can help

Sarah Jaber

Senior Associate Sustainability Consultant, AESG

Sarah Jaber is a Senior Associate Consultant in Sustainability at AESG where she manages the delivery of complex projects in the built environment throughout design and construction and leads on developing sustainability frameworks and guidelines for clients. Sarah has over 13 years of experience working on various projects across the middle east and Europe. Some of her latest projects include developing sustainability guidelines for the design, construction and operations of Dubai Holding assets, leading the circular economy strategy for SEVEN (Saudi Entertainment Ventures) and delivering multiple sustainability strategies for developments in UAE and KSA. Sarah has worked on numerous sustainable projects in the region. She was also a lecturer on sustainable development as part of The Circular Hub.

Sarah holds a MEng in Applied Energy and a BEng of Mechanical Engineering. She is also a LEED Accredited Professional, a BREEAM International Assessor, an Edge expert a Certified Energy Manager. Sarah is also one of the few professionals in the region with a certification in circular economy for the built environment.

For further information relating to specialist consultancy engineering services, feel free to contact us directly via info@aesg.com

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