An introduction to enhancing efficiencies in data centre construction:

A Middle Eastern Perspective

Author: Joe McCaffrey, CEO & Managing Director Middle East

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About the author:

Joe McCaffrey is the founder of DMC Global Partners and the driving force behind establishing DMC Global in the Middle East. With over two decades of experience as a Chartered M&E Quantity Surveyor, Joe is a specialist and leading voice in the viability of data centre design and construction. Since founding DMC's presence in the region, he has led numerous high-profile projects, including those within the pioneering NEOM development, positioning the company as a leader in data centre consultancy and project management.

Joe has an extensive track record of delivering complex data centre projects across Europe, the United States, and the Middle East, working with global funds, developers, hyperscalers, and owner-operators such as Batelco, Keppel Data Centre REIT, Digital Realty, Global Switch, and Serverfarm Realty. His strategic insight and dedication to progress in the industry have reinforced his reputation as a thought leader, particularly in addressing the unique challenges and opportunities in both emerging and established markets.

His expertise extends to navigating the complexities of skilled professional shortages and utilising global expertise to drive innovation and ensure successful project delivery in the dynamic GCC region. Joe continues to share his knowledge at prominent industry events such as TouchDown Middle East (TDME), contributing to the future of data centre investment and development.

Joe McCaffrey
CEO, DMC Global Partners

Introduction:

Today, data centres are critical to the globe's digital transformation, enabling vast amounts of data transfer and storage. This insatiable demand for data, the growth of Internet of Things (IOT), autonomous cars, AI and so much more has led to an explosion of data centre development across the world. Data centres are energy-intensive facilities, consuming 10 to 50 times the energy per floor area compared to typical commercial buildings. As the Middle East positions itself as a key player in the global data centre market, it is important developers and investors learn from the potential risks now experienced by Europe for two key aspects - Power and Cooling.

In addition, efficiency is essential to balancing high operational costs driven by these cooling demands and energy use. In this paper, we discuss Power Usage Effectiveness (PUE), a key metric that has been used by the data centre industry for decades. The purpose of using this metric is to highlight the challenges investors, developers and operators face when it comes to designing, building and operating facilities that literally 'do not cost the earth'. This practical advice is designed to support the early stages of development from design concept through planning the total cost of ownership.

PUE was introduced in 2006 by The Green Grid (a non-profit organisation of IT professionals). In 2016 PUE was published as a global standard under ISO/IEC 30134-2:2016. It become commonly used for reporting the energy efficiency of data centres. Although it is named "power usage effectiveness", it actually measures the energy use of the data centre.

Chapter 1:

PUE's role within a broader efficiency strategy

How is PUE calculated?

PUE shows how much of the energy entering a data centre is actually used for running the IT equipment (like servers) compared to the energy used for other purposes, such as cooling, lighting, and power distribution.

Formula to calculate PUE:

PUE = Total Facility Energy/IT Equipment Energy

- Total Facility Energy is the amount of electricity used by the entire data centre.
- IT Equipment Energy is the electricity consumed by the IT systems alone.

Ideally, the PUE score would be as close to 1.0 as possible, indicating that nearly all the power drawn by the facility is directed toward IT systems rather than overheads like cooling, lighting, or security systems.

Why is efficiency important?

The growing demand for data centre capacity magnifies the importance of building efficiently. As global industries become more reliant on cloud computing, AI, and data storage, operators are under increasing pressure to expand their capacity while keeping costs manageable.

Achieving optimal PUE plays a significant role in this equation, directly impacting energy consumption and operational expenses. A facility with a poor PUE will see significantly higher energy bills, reduced sustainability metrics, and diminished competitiveness.

Lowering PUE can lead to:

Reduced operational costs:

Improving energy efficiency directly impacts the cost per megawatt, which is a critical metric for any construction economist evaluating the financial feasibility of data centre projects.

Environmental benefits:

A lower PUE means less energy wasted, which contributes to the sustainability of construction projects, contributing to broader GCC goals, for example by 2050, the UAE is targeting an energy mix that includes 44% clean energy.

Benchmarking performance:

PUE is a helpful internal indicator for monitoring energy efficiency trends within a data centre. Direct comparisons between different data centres using PUE can be challenging due to variations in size, infrastructure composition, and operational requirements.

Potential risk of PUE calculation:

PUE (Power Usage Effectiveness) calculations can vary and be impacted by data availability. The accuracy of these calculations depends on having comprehensive and precise data on both total energy consumption and the energy specifically consumed by IT equipment. If data is incomplete or not up-to-date, it can lead to skewed results, misrepresenting how efficient the facility truly is.

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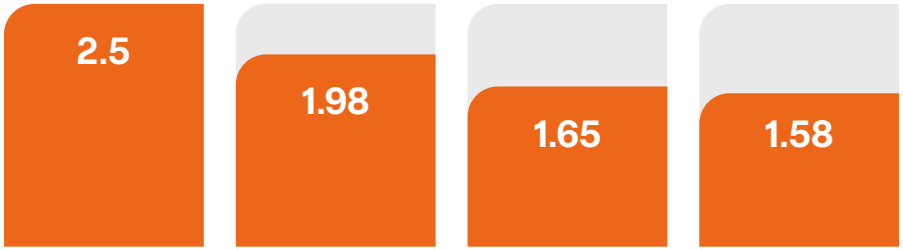
Achieving efficiencies in the Middle East

The Middle East presents unique challenges when it comes to keeping PUE down.

Trying to navigate a hot climate where more energy is required for cooling, can drive up the PUE value compared to data centres in cooler climates[1]. To design and build a data centre according to an optimum PUE value can increase the cost per megawatt significantly, resulting in higher CapEx and OpEx once the building is up and running. The average PUE in the Middle East is currently around 1.8[2], compared to global benchmarks like 1.56[3] and even 1.2[4] in the Microsoft Ireland data centres. This highlights a significant opportunity for efficiency improvements, which are crucial from both an operational and economic standpoint.

For construction economists and industry leaders focused on developing in the Middle East, reducing PUEis will be the key to addressing long term energy costs and enhancing the viability of data centre projects.

Data Centre average annual PUE worldwide 2007-2018



23.27%

Average cost difference between 2.50 - 1.58[5]

Source: Mohammed bin Rashid Al Maktoum Solar Park

[1] Uptime Institute Silicone Heatwave Report
[2] Uptime Institute "Which Regions have the most energy efficient data centers?"
[3] UPTIME July 2024 Annual Data Center Survey
[4] Microsoft Datacenters in Ireland
[5] Calculation on 100MW data centre based in Dubai at 2024 DEWA electricity tariff rates + fuel surcharges

Chapter 2:

The regional challenge: Higher construction costs in the Middle East

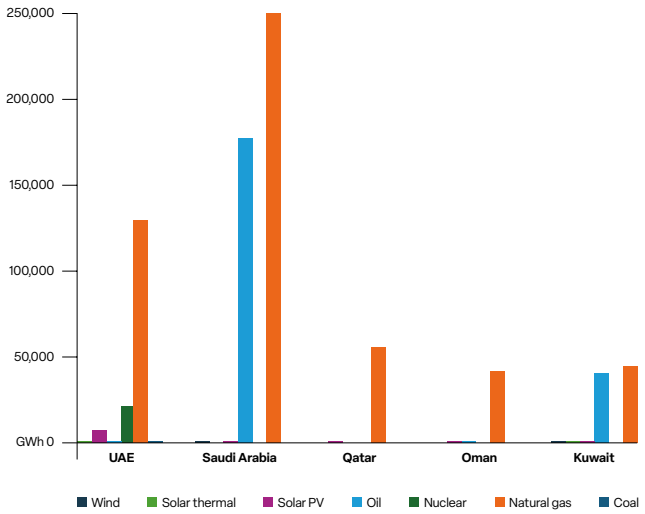
The Middle East presents unique and diverse challenges that impact the construction and operation of data centres. Many countries like UAE, Saudi and Qatar have advanced infrastructure in pockets e.g. Dubai, Doha or Riyadh while the remote cities are still in the early stages.

Extreme climate and cooling requirements

- High temperatures: In Saudi Arabia, temperatures can exceed 50°C[6] in summer, which requires high-capacity cooling systems year-round. This makes Saudi data centres reliant on air conditioning systems that can significantly increase energy consumption - far above the global average.
- Humidity and dust: In Oman, the combination of high humidity and frequent dust storms demands advanced air filtration and humidity control systems, which add both to construction costs and ongoing operational maintenance requirements. The Sohar Data Centre in Oman, for example, incorporates multi-stage filtration systems to handle dust, which adds around 10% to cooling infrastructure costs.
- Essentially construction economists have to build in resilience for the environment, increasing electrical infrastructure which draws more energy & power.

Energy supply and sustainability initiatives

- Renewable Energy Integration: Nearly 95% of the electricity generated in the Middle East comes from natural gas and oil[7] , while strides are being taken to improve this for example in the UAE, the Mohammed bin Rashid Al Maktoum Solar Park is one of the largest solar parks in the world, aiming to provide 5,000 MW of energy by 2030. Data centres like Khazna Data Centres are increasingly tapping into this renewable energy source to help reduce their carbon footprint, though availability is still variable. This reliance impacts energy costs, especially when renewable capacity is not sufficient to meet peak demand.
- Grid Stability: The power grid in the UAE is highly stable, with Dubai Electricity and Water Authority (DEWA) providing uninterrupted power supply supported by diverse energy sources, including solar. This stability, however, comes at a cost; DEWA's infrastructure investments have raised electricity tariffs to ensure reliability, impacting the operational cost of data centres in the region.



IEA - Electricity generation by source 2022 ME GCC Countries

[6] Arabia Weather Dammam 51% July 2024
[7] Middle East – Countries & Regions - IEA

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The regional challenge: Higher construction costs in the Middle East

Logistical and material constraints

- Material sourcing and cost: Saudi Arabia imports specialised steel and heat-resistant materials for data centre construction. The Riyadh Metro Data Centre, for instance, faced an increase in project costs due to delays in importing fire-resistant materials and structural steel from Europe, driven by both supply chain constraints and regional import regulations.
- Heat-resistant construction materials: Oman's data centres require the use of specialised materials, such as heat-resistant concrete, to cope with the high temperatures. This requirement adds an estimated 15%[8] premium to construction costs, particularly in areas like Muscat, where temperatures reach extremes that can degrade standard materials.

Local regulations and workforce

- Government regulations: The Saudi Vision 2030 initiative includes directives to increase sustainability across industries, including data centres. Regulation trends will start to follow global PUE averages of 1.58.This necessitates additional design and certification processes, leading to increased construction timelines and costs.
- Workforce availability and cost: In the UAE, the construction workforce is primarily expatriate-based, and recent changes to labour laws have increased the minimum wage requirements for skilled workers.

Geopolitical considerations

- Regional instability: Although the GCC is exceptionally stable, geopolitical risks in the wider Middle East region indirect have an impact. These costs are factored into overall construction expenses, making data centre projects more expensive compared to other regions with less geopolitical risk. This can also impact investment appetite into the region.

Seismic activity in Oman

- Seismic Design Requirements: Oman lies near tectonic plate boundaries, necessitating the integration of seismic reinforcement in data centre construction. The Oman Telecommunications Data Hub in Salalah has been designed to withstand moderate seismic activity, structural reinforcements, specialised materials, and engineering expertise required to meet seismic safety standards drives cost up.

Water scarcity and cooling solutions

- Water-cooled systems: In Saudi Arabia, where water is scarce and mostly sourced from desalination, water-cooled data centre systems have a higher operational cost. The King Abdullah Financial District (KAFD) Data Centre uses an innovative hybrid cooling system that has managed to reduce water usage compared to traditional water-cooled systems, but with an additional capital expenditure.
- For example: Free cooling is not possible for majority of the year in Saudi where instead, there is a need for whole water based cooling infrastructure. As we know, 60-70% cost of a data centre is from cooling, hence the cost impact.

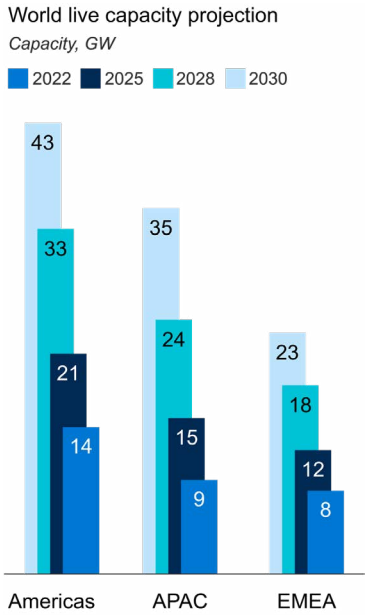
[8] MEED Oman Construction Cost Outlook Report

Chapter 3:

Current PUE levels: Benchmarking the Middle East vs. Global Standards

PUE Benchmarks: Middle East vs. Global

The average PUE of data centres in the Middle East is approximately 1.8[9], which is significantly higher compared to global average of 1.56. In a region coveting hyperscale level companies, this could act as a barrier to entry for the likes of eg Google, known to pride themselves on their highly efficient DCs boosting a global average of 1.06[10]. With countries such as Ireland achieving averages of 1.2.



Source: IDC 2022, Principal Real Estate, December 2023

- **Global Standards:** Globally, many data centres are able to maintain lower PUE values due to the favourable climate, more advanced infrastructure, and greater access to energy-efficient technologies. These factors help to reduce the energy needed for cooling and other non-IT functions, leading to a more efficient use of power.
- **Middle East average:** The average PUE of 1.8 in the Middle East indicates that a significant portion of energy is used for non-IT functions, primarily cooling. This higher PUE reflects the additional challenges and costs that come with operating data centres in a hot environment.

Key contributors to higher PUE in the Middle East

There are several factors that contribute to the higher PUE values seen in the Middle East:

- **Cooling requirements:** The region's extreme temperatures mean that cooling systems must work harder to maintain safe temperatures for IT equipment. This high demand for cooling is one of the primary reasons for the increased PUE.
- **Water scarcity:** Technology needs to be adapted. Forces companies to look at a hybrid approach when really the ME needs to develop its own new technology based on their climate.
- **Energy infrastructure:** In parts of the Middle East, energy infrastructure may not be as advanced, leading to inefficiencies. However, in countries like the UAE and Qatar, the power grid is highly stable, and infrastructure is modern. This highlights the variation in energy stability across the region.
- **Technology and design limitations:** Data centres in the Middle East may not always have access to the latest cooling technologies or efficient design practices that could help reduce energy consumption. This limits their ability to achieve lower PUE values compared to regions where such technologies are more readily available.

[9] Reference Uptime Institute "Which Regions have the most energy efficient data centres?"
[10] Google Data Centres

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Comparing PUE values between the Middle East and Europe

Power Usage Effectiveness (PUE) is has been the standard benchmark metric for understanding data centre efficiency, but comparing PUE values between the Middle East and Europe requires a nuanced approach that considers regional differences in operational practices, technology adoption, and enegry availability. In this chapter, we compare key factors that influence PUE in the Middle East and Europe, highlighting the common practices that contribute to differing PUE levels.

PUE Factor	Cost per MW construction $
1.2	10,000,000
1.5	12,000,000
1.8	15,000,000
2	18,000,000

Cooling technologies

Middle East

Cooling represents a significant amount of total energy consumption due to extreme heat. **Air-cooled chillers** and **direct expansion (DX) cooling** systems are most common, contributing to an average PUE of **1.8**.

Europe

Free cooling is widely used, especially in northern Europe, reducing cooling energy use significantly. Countries like **Norway** and **Finland** use free cooling for up to **90%** of the year, with average PUE values around **1.3-1.2**[11] or lower.

Solution

Examining technical space temperatures and increasing them from the local standard of **21°C** to international benchmarks of **27°C**[12] or even **30°C** could yield energy savings of approximately **1%** for each degree raised.

Availability of clean energy

Middle East

The **UAE** is making progress with solar energy initiatives like the **Mohammed bin Rashid Al Maktoum Solar Park**, but overall renewable energy availability is still limited. Most data centres rely on **natural gas** and **oil** for power.

Europe

Extensive renewable energy infrastructure, including **hydropower** in **Norway** and **Iceland**, provides clean and affordable energy. Many European data centres are almost **100% renewable-powered**, contributing to lower PUE values.

Solution

With 2030 sustainability targets in mind, data centres must aim to operate with at least **30% renewable energy**. This presents a significant opportunity, as nearly one-third of the carbon challenge stems from related infrastructure, with data centres playing a critical role due to their high energy consumption. In the Middle East, we have a unique chance to design more sustainable data centres from the ground up by integrating solar energy, utilising biofuel-powered generators, and exploring emerging technologies like hydrogen-powered generators.

[11] Green Mountain Data Centers Power
[12] German Data Center Association

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Infrastructure & energy efficiency initiatives

Middle East

Modern data centres, like those in **NEOM** in Saudi Arabia, are designed with energy efficiency in mind, but existing infrastructure is inconsistent across the region. **District cooling** is used in some areas but is not widely adopted for data centres.

The NEOM project exemplifies the use of offsite fabrication and modern methods of construction (MMC), supported by advanced manufacturing facilities and MMC project management. This approach emphasises preventative maintenance over reactive maintenance, integrating systems like Building Management Systems (BMS), Electrical Management Systems (EMS), and Data Centre Infrastructure Management (DCIM) for enhanced efficiency and reliability.

Europe

Smart energy management systems and stricter **EU energy efficiency standards** drive the adoption of efficient technologies. **Heat reuse** from data centres is also common, as seen in **Denmark**, where waste heat is used for district heating.

Data Centre design and site selection

Middle East

Site selection focuses on power availability and connectivity rather than climate considerations. Facilities like the **Etisalat Tier IV Data Centre** use enhanced insulation to minimise heat gain, but cooling requirements remain high.

Data centre locations are often selected based on land availability rather than considering the broader strategic needs. Instead, data centres should be built in urban areas where data demand is highest, as exemplified by facilities like Canary Wharf's data centres and Moro Hub. Smarter site selection is essential to ensure data proximity aligns with urban demand.

Europe

Site selection prioritises **ambient cooling**, such as in **Luleå, Sweden**, where naturally cool air helps achieve a PUE of **1.07. Modular design** is more common, allowing scalable and efficient expansions.

Solution

Consider developing a Data City in Dubai, with its own power ecosystem that integrates renewable energy, innovative cooling solutions, and urban data proximity to create a sustainable and efficient data centre network.

Regulatory environment & sustainability goals

Middle East

Regulations are evolving, with initiatives like the **Saudi Green Initiative** aiming for **50% renewable energy** by 2030, but many existing facilities lack advanced energy efficiency measures.

Europe

The **EU** mandates stricter regulations on energy use and emissions, with incentives for data centres achieving a PUE below **1.3**. The **Climate Neutral Data Centre Pact** commits operators to net-zero emissions by **2030**, pushing for greater efficiency.

Solution

Adopt a 30-year planning horizon with regulatory frameworks that incentivise data centre operators to incorporate **30-50% renewable energy** into their operations. These frameworks should establish progressive benchmarks to drive innovation in data centre design. For example, Norway's 2021 National Data Center Strategy sets a precedent by aligning national goals with industry advancements.

Chapter 4:

Improving efficiencies: Practical solutions for the Middle East

Improving efficiency in Middle Eastern data centres requires a multifaceted approach that comprehensively addresses the region's unique environmental challenges and the broader inefficiencies in current operations. Achieving meaningful reductions in PUE can translate to substantial operational savings, as even a fractional improvement in PUE—such as moving from 1.8 to 1.7 - can save millions of dollars annually in energy costs per megawatt.

Source: Mohammed bin Rashid Al Maktoum Solar Park

Advanced cooling technologies

Given the region's extreme temperatures, cooling is naturally the largest contributor to energy consumption in Middle Eastern data centres. While effective in maintaining optimal temperatures, traditional air conditioning systems are inefficient and costly. Operators should, therefore, consider transitioning to more advanced cooling technologies tailored to the region's climate.

Liquid cooling systems

Liquid cooling is one of the most promising solutions for data centres in hotter climates. Unlike traditional air-based cooling systems, liquid cooling uses water or other coolants to absorb and remove heat directly from IT equipment. This method is far more efficient than air cooling, as liquids have a much higher thermal conductivity than air, allowing faster heat transfer. By implementing liquid cooling, data centres can significantly reduce their reliance on air conditioning and lower overall energy consumption, leading to a more favourable PUE score.

Several data centres in the Middle East are beginning to experiment with liquid cooling technologies, and early results are promising. However, widespread adoption has been slow due to high upfront costs and the need for specialised equipment, even though PUE reduction's long-term energy cost savings demonstrably make liquid cooling a worthwhile investment for many operators.

Free cooling solutions

While free cooling is traditionally more effective in cooler climates, hybrid solutions can be adapted for the Middle East. Free cooling systems use external air to reduce the need for mechanical cooling. In the Middle East, operators can use nighttime free cooling when temperatures drop or combine free cooling with evaporative cooling to enhance efficiency.

AI-driven energy management systems

Energy management is another critical area where Middle Eastern data centres can improve efficiency and lower PUE. Artificial intelligence (AI) and

Improving efficiencies: Practical solutions for the Middle East

machine learning (ML) technologies offer real-time monitoring and control of energy usage, optimising power distribution to match actual demand. AI-driven systems can predict fluctuations in energy needs based on data such as temperature, humidity, and server load, adjusting cooling systems and other energy-intensive operations accordingly.

For instance, AI algorithms can identify patterns in energy consumption that would otherwise go unnoticed, allowing operators to make proactive adjustments and prevent inefficiencies. This kind of predictive energy management is already being used in leading data centres worldwide, and its implementation in the Middle East could result in substantial energy savings and improved PUE.

Several AI-driven platforms also offer the added benefit of integrating renewable energy sources into data centre operations, dynamically shifting between grid power, solar, and wind energy based on availability and cost-effectiveness.

Optimising facility design

The design and layout of a data centre can profoundly impact its PUE. In the Middle East, where cooling costs are a significant concern, designing facilities with energy efficiency in mind from the ground up is critical. This includes strategically placing IT equipment to optimise airflow, using insulated walls and roofs to minimise heat absorption, and integrating energy-efficient lighting systems.

Modular data centres

Modular data centres are an emerging trend that offers a flexible and energy-efficient alternative to traditional builds. These facilities are prefabricated offsite and designed to be easily assembled and expanded as needed. They are highly customisable, allowing operators to incorporate energy-efficient designs and cooling technologies specifically suited to the Middle Eastern climate. Their compact design also minimises energy loss, contributing to a lower PUE.

Collaboration with industry experts

Collaborating with industry experts, including energy consultants and construction economists like Joe McCaffrey, can help data centre operators develop tailored strategies for reducing PUE. By leveraging industry knowledge and proven best practices, operators can identify the most cost-effective solutions for their needs.

DMC Globals' recent work with several large data centres in the Middle East has resulted in significant PUE improvements. In one case, his team reduced a facility's PUE from 1.8 to 1.7 by combining liquid cooling, optimised facility design, and AI-driven energy management. This reduction translated to millions of dollars in annual savings for the operator, proving the financial benefits of investing in energy efficiency.

Financial implications and ROI

Investing in PUE reduction strategies is not just an environmental imperative—it's a sound financial decision for the life time of a facility. The initial capital required for advanced cooling technologies or AI energy management systems may seem high, but the long-term savings far outweigh the costs. For example, a data centre that reduces its PUE from 1.8 to 1.7 can save approximately $1 million per megawatt of power annually, depending on the size of the facility.

As energy prices in the Middle East continue to rise and regulatory pressures around sustainability increase, the financial case for improving PUE becomes even more robust. Operators who take proactive steps to reduce energy consumption will lower operational costs and enhance their competitive advantage in the market.

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Author: Joe McCaffrey, CEO & Managing Director Middle East

T: +974 3069 9252
E: joseph.mccaffrey@dmcglobalpartners.com

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