Data Centers: The New Super Offtakers of Clean Energy

Middle East as a prime location for sustainable data centers

Contents

Executive Summary

The global digital economy is accelerating at historic speed, led by the exponential growth of artificial intelligence (AI), cloud computing, and connected devices. This digital transformation is straining traditional data center hubs in North America, Europe, and Asia, where power availability, grid congestion, and permitting delays have become severe bottlenecks. At the same time, the growing urgency of climate action demands that power-hungry data centers reduce their emissions. This creates a dual crisis of power and sustainability for the data center industry.

The Middle East is exceptionally placed to solve this global challenge. It combines the world’s lowest-cost renewable energy, vast tracts of available land, and unmatched speed of execution. Unlike other global hubs, the Gulf states are already deploying giga-scale renewable projects at unprecedented speed, underpinned by state-driven strategies and national visions such as Saudi Vision 2030 and UAE Vision 2031.

This convergence is positioning the Middle East as a leading digital hub for net-zero data centers. While the low cost of renewables in the Middle East is a key advantage, securing financing for giga-scale projects can face challenges without a guaranteed and creditworthy offtaker. Data centers, due to their sustained high-power needs, are becoming key customers who can drive such investments. By leveraging long-term Power Purchase Agreements (PPAs), hyperscale data centers can act as “super offtakers,” de-risking massive renewable investments and triggering multi-billion-dollar clean energy buildouts. This model also supports tech companies' pursuit of 24/7 emission-free energy by combining large-scale renewables with green hydrogen in the region.

This paper highlights how the Middle East can lead the digital world into the next era of sustainable infrastructure, from grid-connected facilities with clean backup to fully autonomous off-grid hubs. The study concludes that Off-Grid Net-Zero Islands are the optimal pathway for new, large-scale developments in the Middle East. It also highlights that fuel-flexible power generation is essential for reliability and reaching net-zero emissions. As a result, the Middle East is uniquely placed to become the clean data center powerhouse of the future, fueling both the AI revolution and the global energy transition in one move.

Highlights

The Middle East is rapidly emerging as a global hub for data center development, driven by the exponential growth of AI and national digitalization agendas. This study analyzes the critical intersection of this digital expansion with the region's clean energy transition, outlining pathways to power this new infrastructure sustainably.

Data centers: The new super offtakers enabling the energy transformation

- Middle Eastern data center market capacity is projected to more than double by 2028, with Saudi Arabia (KSA) and the United Arab Emirates (UAE) leading this growth.
- Data centers are emerging as ideal "super offtakers" for giga-scale renewable projects, providing the long-term stable cash flows needed to make these projects bankable and creating a symbiotic relationship that accelerates the green transition.
- Data centers serve as immediate offtakers for substantial quantities of low-emission electricity, hence further accelerating the ongoing energy transition. This is especially important for emerging clean energy sources, such as hydrogen, that may require additional time to scale.

The "new green currency" of energy and speed

- The foundation of the region's strategy is its ability to offer the world's lowest-cost solar and wind energy. This "new green currency," serves as the primary tool to attract energy-intensive industries, with data centers being a key future growth sector.
- Unlike traditional hubs in Europe and the US, which are hampered by grid constraints and long permitting queues, the Middle East offers unmatched speed. The region has a proven track record of deploying giga-scale renewable, battery, and green hydrogen projects in record time, thanks to streamlined permitting and strong state backing.

A synergy of vision and leadership and net-zero commitments

- The growth of data centers in the region is fully aligned with ambitious national agendas like Saudi Vision 2030 and UAE Vision 2031, which prioritize economic diversification and the goal of becoming global tech hubs.
- GCC states like UAE, Oman and KSA are committed to net-zero targets. New projected clean energy demand from data centers adds scaling up benefits to existing national clean energy programs deployment.
- Development is a strategic, state-driven initiative, led by emerging local champions like G42 and its data center subsidiary Khazna in Abu Dhabi, which also attracts major private equity investors or companies like Microsoft to co-invest.
- Sovereign wealth funds like the Public Investment Fund (PIF) in Saudi Arabia and the UAE's Mubadala are key enablers of the digital transformation, backing the expansion of hyperscalers – the large, global technology companies that provide cloud, networking, and internet services, such as Microsoft, AWS, and Google – and funding the localization of entire manufacturing chains to create a stable and cost-effective ecosystem.
- Visionary private investors are also coming forward. For instance, Mohammad Abnunayyan, the founder of ACWA Power (the largest developer of clean energy in the Middle East and North African region (MENA) and the No.1 desalination plant owner and operator), is backing a front-runner in data centers, Data Volt. Similarly, Hussain Sajwani, founder of the real estate development company DAMAC, has launched Edgnex, a data center company that is expanding from the UAE and KSA into the US market.

Strategic co-location of energy and data

- The Middle East sits at the crossroads of the world's most critical fiber optic cable routes, and developers are strategically matching green energy production sites with locations that offer robust connectivity.
- The strategic co-location of data centers with the region's emerging green hydrogen hubs (e.g., in NEOM, Salalah, and Yanbu) is a key enabler for achieving 100% emission-free operations.
- Regional challenges such as high ambient temperatures and water scarcity act as catalysts for innovation, positioning the Middle East as a global testbed for advanced cooling technologies, such as cooling with seawater as well as climate-resilient data center design.

From vision to a net-zero reality

- This vision is already becoming reality through a series of concrete giga-projects, such as 1.5 GW (300 MW by 2028) NEOM's Net-Zero AI Data Center and the 5 GW UAE-US AI campus in Abu Dhabi.
- The study identifies three primary sustainable scenarios for data centers: Grid-Connected with Clean Backup, Hybrid "Bridging Power", and the Off-Grid Net-Zero Island.
- The Off-Grid Net-Zero Island model is identified as the optimal pathway for new, large-scale developments in the region. This model involves creating fully autonomous, emission-free digital infrastructure by co-locating data centers with dedicated renewables (solar and wind) and on-site clean hydrogen production for 24/7 reliability, leveraging the region's abundant land and lowest-cost renewables.
- Select gas engines can being engineered to run on any blend of natural gas and hydrogen (up to 100% hydrogen). That allows data center operators to invest in infrastructure today that can be seamlessly transitioned to a zero-emission fuel source as it becomes available, without requiring significant equipment changes.

Global growth drivers and energy demand increase

Data centers are growing at an extraordinary pace, with the global demand being propelled by several macro and technology-specific trends:

- **AI and high-performance computing:** The rapid growth of AI requires immense computational power for two key processes: training, which involves feeding massive datasets to an AI model to teach it a skill, and inferencing, which is the process of using that trained model to make predictions or generate new content. Both tasks require dense clusters of graphics processing units (GPUs) and high-throughput systems, leading to the construction of specialized AI data centers to meet these unique performance requirements.
- **Cloud and multi-cloud strategies:** Enterprises are transitioning toward hybrid and multi-cloud environments, which involves using a mix of private and public cloud services. This increases the need for hyperscale facilities (extremely large data centers built for companies like Amazon and Google) across various geographies.
- **Digital transformation:** Enterprises and governments worldwide are undergoing aggressive digitalization. This is often reinforced by data localization policies (or "digital sovereignty"), where governments mandate that citizen and corporate data be stored within a country's borders, directly fueling the demand for in-country data centers.
- **Edge computing and Internet of Things (IoT):** The proliferation of edge devices (like smart sensors and cameras) and latency-sensitive applications (services that require near-instantaneous response times, such as autonomous vehicles, telemedicine) is creating demand for smaller, decentralized micro data centers located closer to users.
- **Media, gaming, and e-commerce:** High-bandwidth and low-latency applications, such as video streaming, social platforms, and digital payment systems, are major contributors to data volume growth.

From an energy perspective, data centers are power-intensive facilities, converting vast amounts of electricity into heat as they process, store and compute data. Globally, as the demand for data centers increases at an exponential rate, so does the power required to run these facilities. Global data center energy demand is projected to grow from 59 GW in 2024 to 93 GW by 2028 (Figure 1). AI-related computing alone could increase energy consumption threefold within the same period. Some even predict about 400 GW demand for data centers in the coming ten years[1].

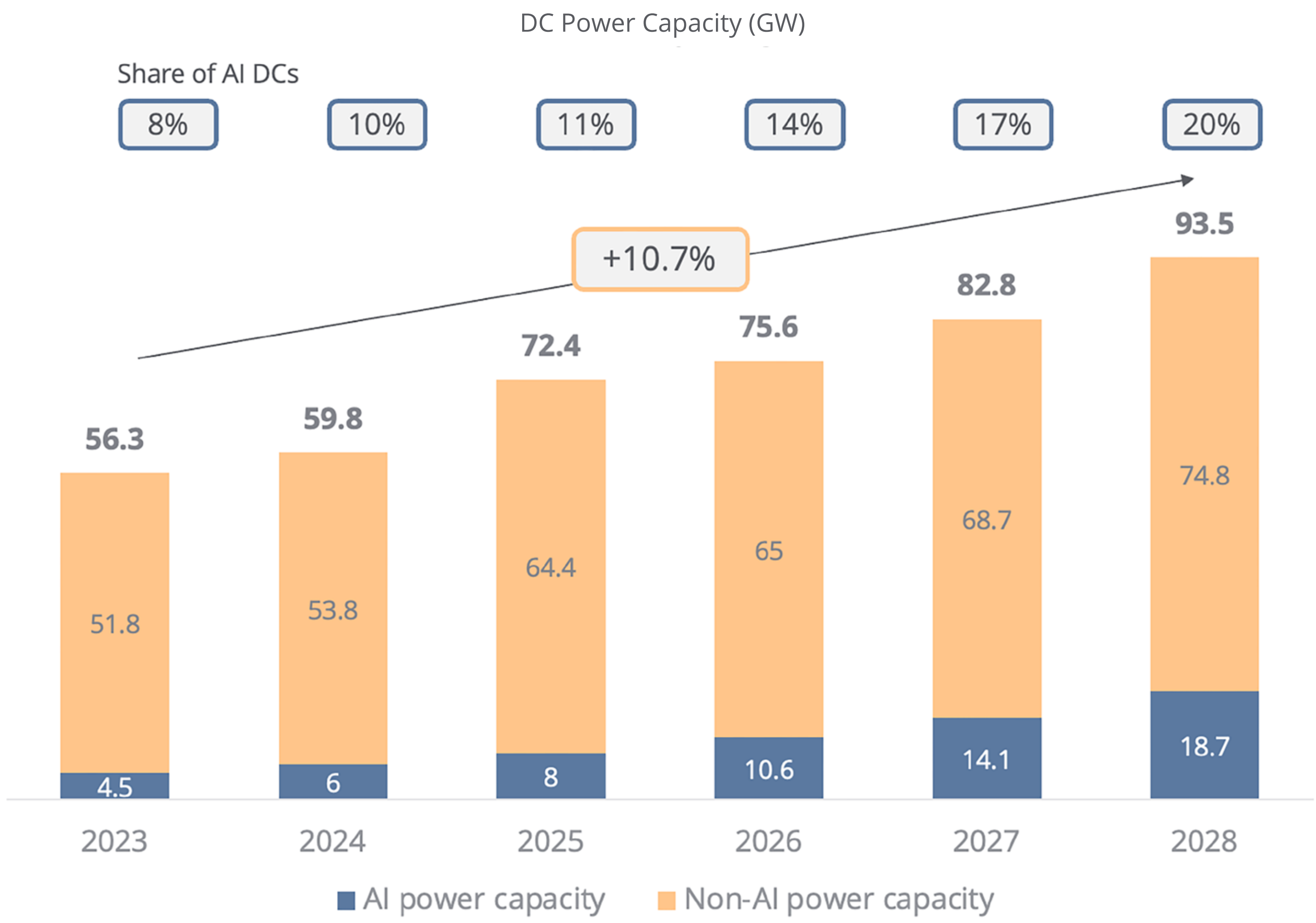


Figure 1: Global Power Capacity in GW projected to 2028. *Source: Roland Berger.*

This creates a tripartite challenge for the industry. First, traditional data center hubs in the US and Europe face power capacity and grid availability constraints, leading to long connection queues in many countries[2] and even moratoriums on new projects in jurisdictions as is seen in Ireland[3] and Singapore[4]. Second, the hyperscale companies driving this growth are bound by ambitious climate pledges to achieve net-zero emissions. As data centers constitute a huge part of their carbon footprint, powering them with green energy is pivotal to meeting these targets. Third, the lead time for securing a grid connection and power supply is now often the longest item in the development timeline, becoming the primary bottleneck that dictates how quickly new data center capacity can be brought online.

A parallel trend: the rise of decentralized AI

Alongside the push for massive, centralized AI hubs, a significant parallel trend is emerging: decentralized AI. This model utilizes a network of smaller, geographically distributed data processing nodes instead of a single, monolithic facility. This approach is particularly well-suited for remote areas, such as deserts, where smaller, autonomous AI nodes can be directly powered by dedicated and co-located renewable energy sources like solar and wind. The key drivers for this trend include the need for low-latency processing for local applications, enhanced data security and greater operational resilience.

While the primary focus of this paper remains on the challenges and opportunities of large-scale data centers, understanding this decentralization trend is crucial to seeing the full picture of future digital infrastructure. The Middle East's emergence as a global data center hub

The Middle East is rapidly emerging as a global hub for data center development. According to research work carried out by Roland Berger, KSA and the UAE are leading the way, with their combined capacity projected to reach almost 1 GW by the end of 2025. This figure is then set to more than double to over 2 GW by 2028, with AI data centers accounting for a significant share (Figure 2). Founded in 2012 as one of the UAE's first data center companies, regional market leader Khazna holds a market share of approximately 75% in UAE and 30% in the Gulf Cooperation Council (GCC) region.

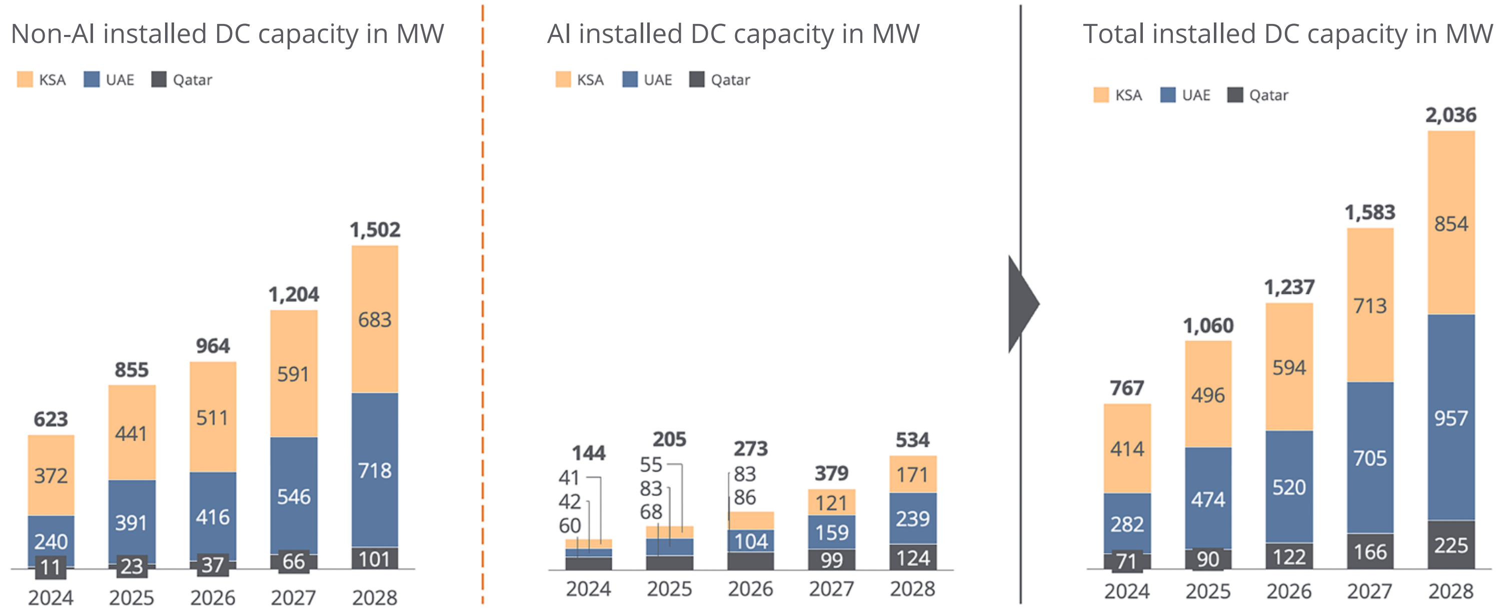


Figure 2: Projected growth of data center (DC) installed capacity in megawatts (MW) for Saudi Arabia (KSA), the UAE, and Qatar from 2024 to 2028, with a breakdown of AI vs. Non-AI workloads. *Source: Roland Berger.*

This anticipated surge is underpinned by the convergence of ambitious national strategies, strong investor confidence, and the strategic entry of global technology leaders.

Key growth drivers include:

- **Lowest-cost clean energy:** The region offers one of the world's lowest-cost solar and wind energy, which has become a "new green currency" for attracting investment into energy-intensive industries.
- **Unmatched speed of deployment:** The Middle East has proven its ability to deploy giga-scale renewable, battery and other complex projects in record time, for example through a streamlined permitting system.
- **National digital agendas:** Saudi Vision 2030, UAE 2031, and similar strategies across the GCC prioritize digital transformation, AI, and sovereign data capabilities.
- **Economic diversification and sovereignty:** Data infrastructure now is seen as a pillar of economic security and independence.
- **Hyperscaler expansion:** Major global players (e.g., Microsoft, AWS, Google, Oracle) are entering the market, often in joint venture with sovereign wealth funds like PIF, ADQ, and Mubadala.
- **Investment momentum:** More than $12 billion in new data center investments is expected in the region by 2027, with accelerating growth from new entrants like DataVolt, Pure Data Centres, and regional operators (Khazna, center3, GDH).

To put this regional growth into a global perspective, recent research from McKinsey estimates a staggering capital requirement of nearly $7 trillion for data center expansion worldwide by 2030[5].

Most of this investment, approximately $5.2 trillion, is projected to be for facilities equipped to handle AI workloads, with the remaining $1.5 trillion needed for traditional IT applications.

Crucially, this wave of development in the region is unfolding in parallel with robust national and corporate decarbonization commitments that are shaping the industry's trajectory from the outset:

- UAE net-zero 2050 and Saudi net-zero 2060 commitments already are influencing data center planning and procurement decisions.
- Operators such as Equinix have pledged 100% climate neutrality by 2030, targeting a power usage effectiveness (PUE) - the ratio of a data center's total energy consumption compared to its computing energy consumption - closer to 1.4 to 1.5, even in the region's extreme climate.
- Projects like DataVolt's Net-Zero AI Data Center in NEOM are pioneering new approaches to sustainable digital infrastructure, for example by developing a highly efficient seawater-cooled system and water treatment[6].

Although the region faces challenges, these challenges are simultaneously serving as catalysts for innovation:

- High ambient temperatures increase the energy load for cooling, but they also incentivize the adoption of advanced, energy-efficient cooling technologies that can position the region as a global testbed for climate-resilient data center design.
- While the technical complexity of integrating vatiable renewables remains a challenge, both in the Middle East and globally, it presents a significant opportunity to advance solutions that help ensure grid stability and 24/7 reliability. This includes deploying large-scale energy storage, hybrid systems, clean backup power from sources like green hydrogen, and AI-powered energy management solutions.
- Variation in regulatory clarity and incentive structures across jurisdictions reflects different starting points but also opens the door for cross-border policy innovation - where neighboring countries learn from each other's successes and collaborate to create harmonized regulations - and the emergence of best-practice frameworks that can set regional and global standards.

High-profile strategic partnerships driving digital transformation

Data centers are rapidly evolving into strategic geopolitical assets, with their development now frequently anchored in high-profile international partnerships. A prominent example is the 5 GW UAE–US AI campus recently announced in Abu Dhabi. The first phase of this initiative is the 1 GW Stargate UAE, a next-generation AI infrastructure cluster developed through a global tech alliance including G42, OpenAI and Oracle. This new capacity will be fully grid-connected, with the first batch of 200 MW scheduled to be energized by the end of 2026[7].

Similarly, Saudi Arabia has announced several major international collaborations to bolster its AI and digital capabilities. The Public Investment Fund (PIF) has launched HUMAIN[8], a new company focused on the AI value chain, while DataVolt has entered into a strategic partnership with the US-based Supermicro to develop advanced data center solutions in the Kingdom[9].

Qatar is also moving ahead, securing a major partnership with Quantinuum, a leader in quantum computing, to bring cutting-edge quantum capabilities to the country[10].

Renewables and hydrogen hubs in the Middle East

Achieving a true net-zero footprint for data centers in the Middle East rests on two key energy pillars: the massive scaling of renewable energy and the development of a low-emission hydrogen economy. These two elements work in tandem to solve the dual challenge of providing immense volumes of low-cost, clean electricity while ensuring the 24/7 reliability that digital infrastructure demands.

The very low levelized cost of electricity (LCOE) makes the region highly attractive for energy-intensive operations (Figure 3). As such, the total cost of compute power and ownership for hyperscalers can be very competitive, driven by low infrastructure costs, favorable financing and economies of scale. Notably, Saudi Arabia and other Middle Eastern countries also benefit from some of the world's lowest-cost renewable hydrogen (Figure 4), further strengthening their competitiveness for clean, large-scale compute power.

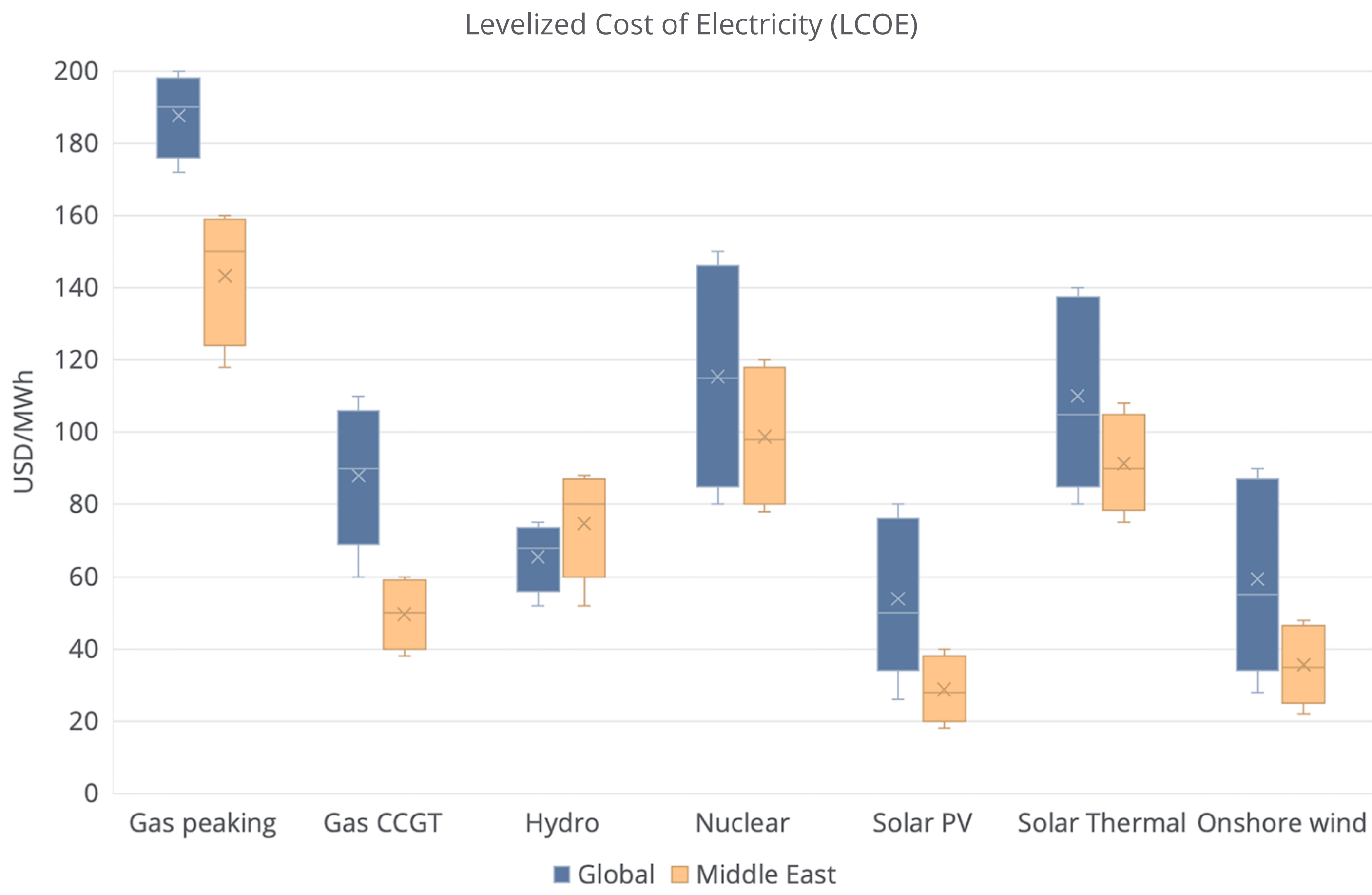


Figure 3: Levelized cost of electricity (LCOE) as of 2024. *The LCOE is calculated for a capacity of more than 100 MW and based on a time range 2019-2024. Source: Rystad Energy[11].*

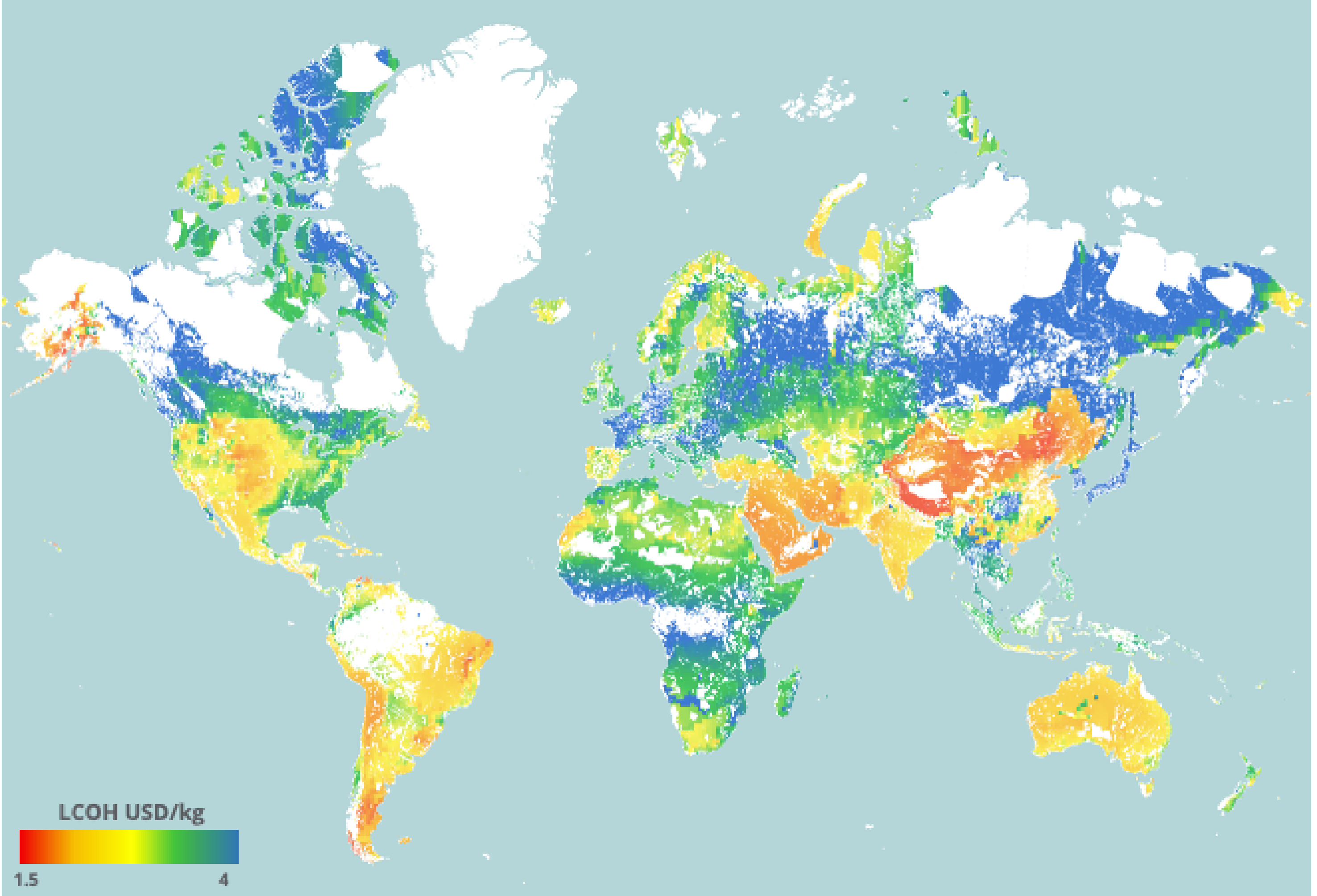


Figure 4: Map of levelized cost of hydrogen (LCOH) production from solar PV and onshore wind proposed by IEA. *The optimal capacities for generation, electrolyzers, and storage were calculated for each location using the ETHOS model from the Institute of Energy and Climate Research - IEK-3 at Research Centre Jülich. Source: IEA12.*

Central to this value proposition is the rapid development of large-scale green hydrogen hubs, which double as massive renewable energy generation zones.

Using the world's lowest-cost renewable energy as a "new green currency" is a key strategy to attract energy-intensive industries, create local value, and drive major economic shifts over the coming decade.

A prime example is in Oman, where excess electricity from renewables built for hydrogen hubs will be sold to power local industry.

As of July 2025, a pipeline of more than 50 hydrogen projects had been announced in the Middle East, mostly focused on green hydrogen production (Figure 5).

These projects are creating specific geographic clusters ideal for co-locating energy-intensive industries, including data centers. Key development areas include:

- NEOM (Saudi Arabia), where a giga-project was 80% completed as of July 2025[13].
- Yanbu (Saudi Arabia), recently announced and developed by ACWA Power in partnership with Germany's Energie Baden-Württemberg (EnBW)[14]. It aims to establish a "hydrogen bridge" to Germany in collaboration with Securing Energy for Europe (SEFE), with an initial target of supplying 200,000 metric tons of green hydrogen annually by 2030.
- Duqm and Salalah in Oman, where eight major projects have been awarded via two government-led bidding rounds (a third is in progress).
- Aqaba Special Economic Zone (ASEZ) in Jordan, where dedicated land has been allocated for green hydrogen and green ammonia projects.
- Hydrogen oases promoted by the UAE government as part of its national strategy.

However, not all green hydrogen sites are suitable for an adjacent data center. Many of these remote locations are chosen for their strong wind and solar resources but may lack the necessary fiber optic infrastructure.

The "sweet spot" for a data center and green hydrogen co-location is where these two critical infrastructures overlap: giga-scale renewable generation and high-bandwidth connectivity from terrestrial or submarine cable routes.

These hubs represent the most promising locations for deploying data centers that can directly leverage low-cost, locally produced clean energy. The final section of this paper investigates this strategic matching in greater detail.

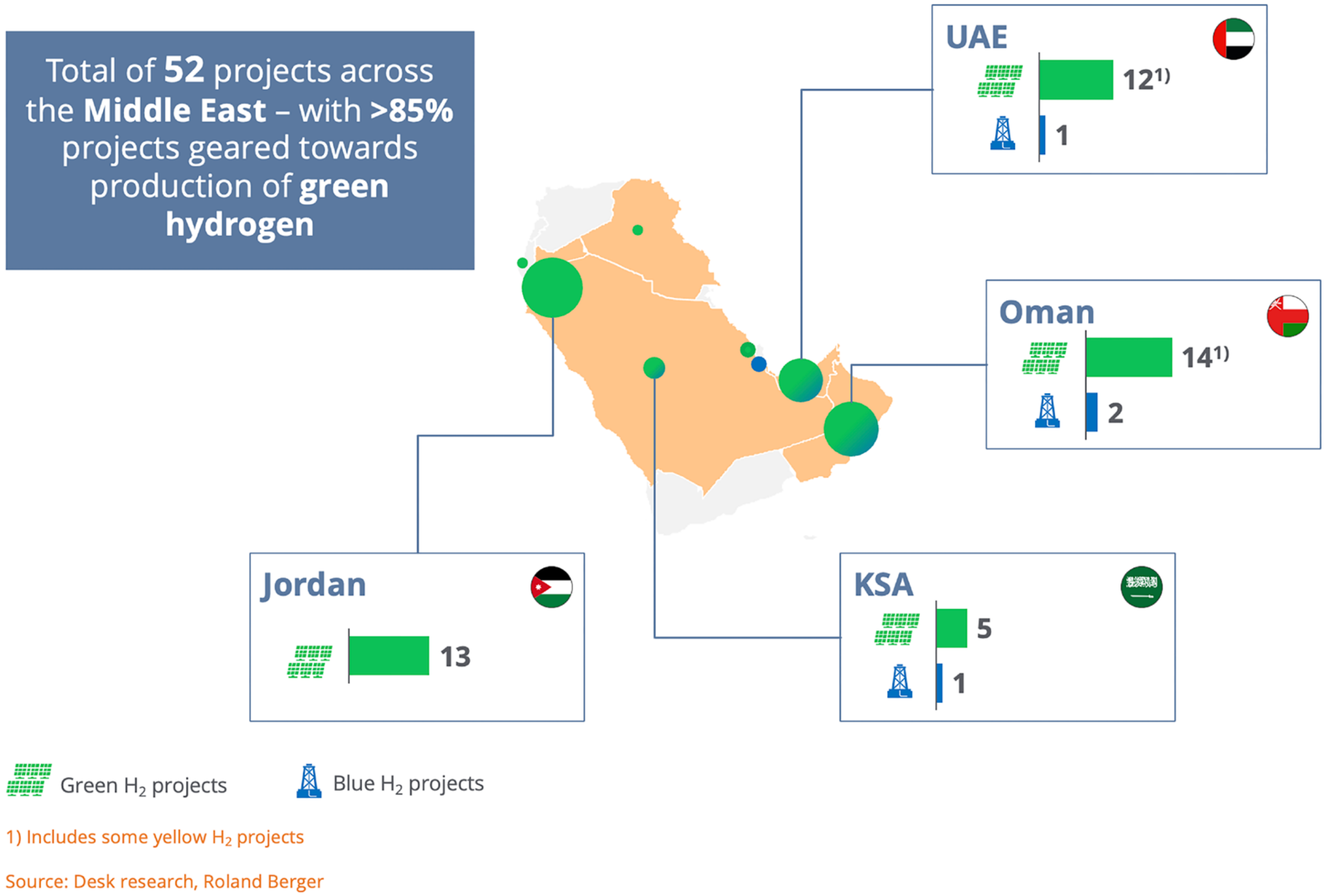


Figure 5: Overview of hydrogen project announcements in the Middle East. *Countries with only one project announced are represented by a single dot on the map. This includes Israel, Iraq, Qatar and Bahrain.*

Strategic drivers of data center investment in the Middle East

Local AI development and data localization as demand drivers

Governments are driving demand through their own digital transformation agendas in two primary ways: the development of sovereign AI capabilities and the enforcement of data localization.

First, the push to create hyper-efficient, AI-driven government services is necessitating a massive local expansion of high-performance computing, including GPU capacity and proprietary large language models (LLMs). This drive is foundational to building national AI ecosystems that can power everything from smart city management to personalized public services.

Second, this ambition is reinforced by data localization policies, though this trend presents both opportunities and challenges. On one hand, many countries now mandate that sensitive government and citizen data be stored and processed within their geographical boundaries. This strategic focus on "digital sovereignty" directly fuels the demand for regional data centers, creating a secure foundation for innovation. On the other hand, this can also be a headwind to the region's ambition to become a global data export hub. This emerging trend may limit the ability of a single data center to serve multiple countries, potentially requiring the duplication of infrastructure to comply with each government's specific rules. Furthermore, for the region to successfully export data center capacity, high data protection standards are essential. International data transfers often require a host country's data protection regime to be regarded as "equivalent" to international standards, a key factor for building a favorable and trusted regulatory environment.

The tangible results of this top-down push are evident in daily life, with the region offering services that are light years ahead in digitization.

For instance, in countries like the UAE[15] and Saudi Arabia[16], self-service kiosks in public spaces like malls and government centers allow residents to print official documents, such as a driving license or vehicle registration, in just a few minutes, eliminating the need for lengthy visits to administrative offices. This level of on-demand service is seamlessly integrated with platforms like Qatar's Metrash[17], KSA's Absher[18] and UAE Pass[19], which provides a single, secure digital identity. This unified ID gives citizens and residents access to thousands of federal and local government services directly through their smartphones, from digitally signing official documents to instantly verifying their identity for transactions.

The success of these initiatives is quantified by key performance indicators (KPIs) that track digital maturity, such as the Digital Citizen Engagement (Figure 6) and GovTech Enablers (Figure 7) indices developed by the World Bank. The first index measures the public's adoption and use of these digital government platforms, while the second evaluates the underlying technological and policy frameworks that make them possible. Significant advancements took place in the region between 2020 and 2022, providing a comprehensive view of progress in both citizen-facing services and foundational government technology.

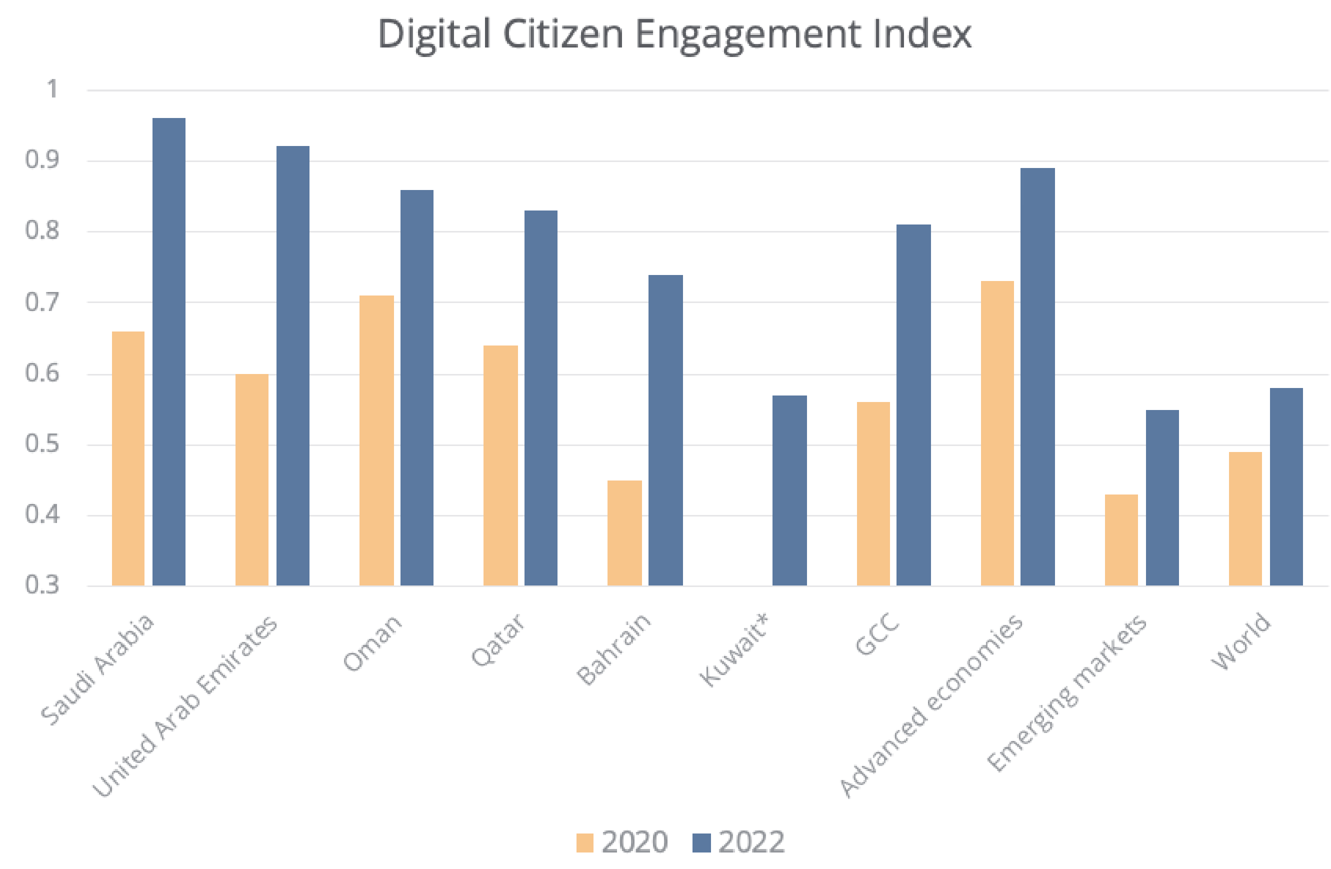


Figure 6: A comparison of the Digital Citizen Engagement Index for selected Middle Eastern countries, benchmarked against global averages (2020 vs. 2022). *Source: Data from World Bank, compiled by IMF20. *There are no data available for 2020 for Kuwait.*

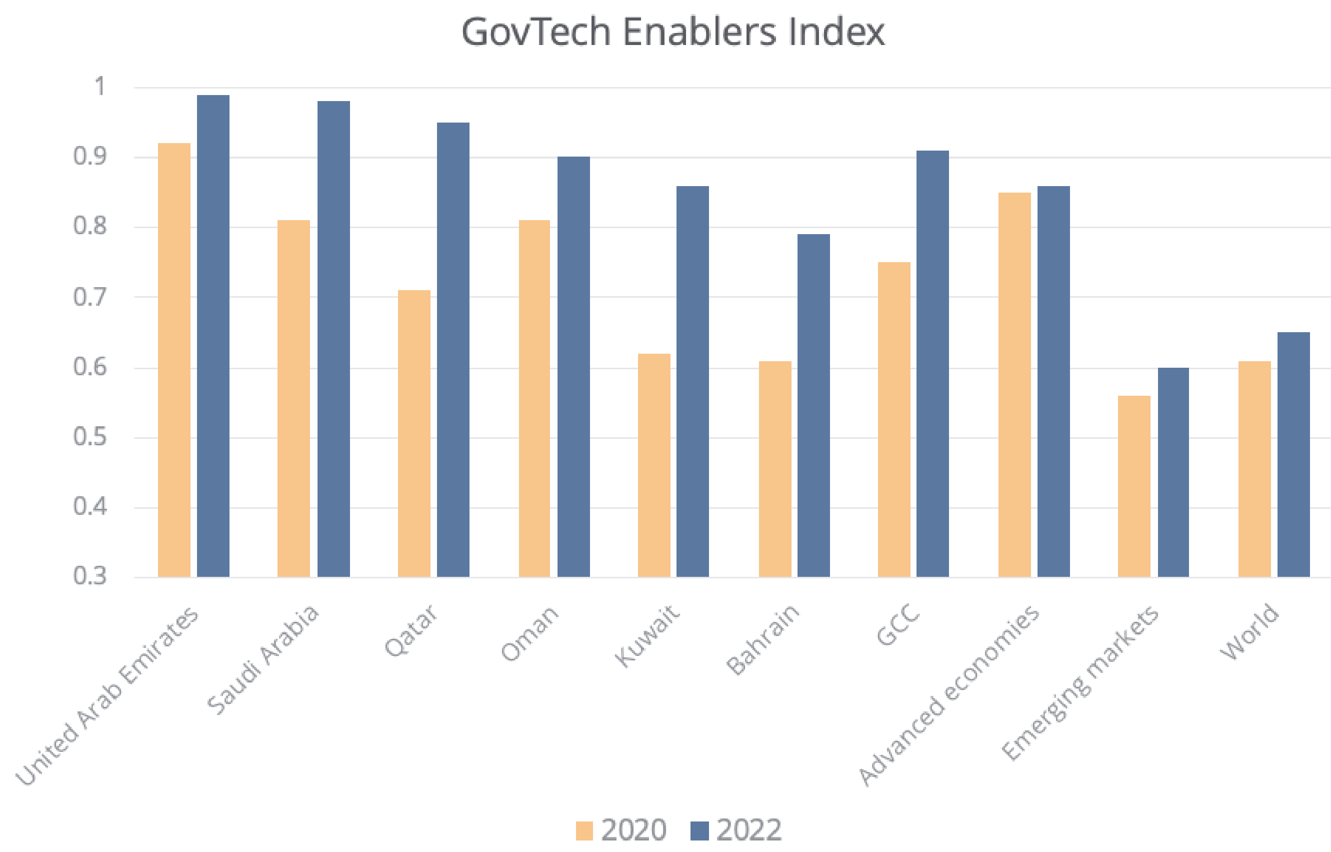


Figure 7: A comparison of the GovTech Enablers Index for selected Middle Eastern countries, benchmarked against global averages (2020 vs. 2022). *Source: Data from World Bank, compiled by IMF.*

Role of government strategies

Government support in the region to enable the digital transformation and develop a robust digital infrastructure is strong (Table 1). In many instances, national agendas already contain a vision for digitalization. Building on that, the majority have developed dedicated strategies to promote digital technologies and artificial intelligence. Furthermore, targeted policies aimed at developing digital technologies and infrastructure have been promoted across the region, as well as initiatives to establish digital hubs (e.g., the Aqaba Digital Hub in Jordan), smart cities (e.g., Masdar City and Smart Dubai in the UAE, NEOM in Saudi Arabia) and key infrastructure projects (e.g., Kuwait's National Data Center).

The table below summarizes national strategies, key authorities, and selected policies and initiatives that actively contribute to promoting the digital transformation in the Middle East.

	National Strategies	Authority	Selected Policies & Initiatives
Jordan	Jordan Economic Modernisation Vision	MoDEE - Ministry of Digital Economy and Entrepreneurship	Jordanian AI Policy
			National Digital Transformation Strategy and Implementation Plan 2021-2025
	Jordan Artificial Intelligence Strategy (2023-2027)		Aqaba Digital Hub
KSA	Saudi Vision 2030	MCIT - Ministry of Communications and Information Technology	Digital Government Strategy
	National Strategy for Data & AI	Saudi Data & AI Authority	Cloud Computing Special Economic Zone (CCSEZ)
		CST - Communications, Space & Technology Commission	
Kuwait	Kuwait Vision 2035	CITRA - Communication and Information Technology Regulatory Authority	National Data Center
	Kuwait National AI strategy	CAIT - Central Agency for Information Technology	Cloud First Policy
Oman	Oman Vision 2040	MTCIT - Ministry of Transport, Communications and Information Technology	Data Centers and Cloud Computing Regulation
	National Program for AI and advanced digital technologies	TRA – Telecommunications Regulatory Authority	e.Oman Strategy
Qatar	Qatar National Vision 2030	MCIT - Minisitry of Communications and Information Technology	Cloud Policy Framework
	Qatar Digital Agenda 2030	CRA - Communications Regulatory Authority	
UAE	We the UAE 2031 vision	Ministry of State for Artificial Intelligence, Digital Economy and Remote Work Applications	Fourth Industrial Revolution (4IR) Strategy
	UAE Digital Government Strategy 2025		
	UAE Strategy for Artificial Intelligence		Digital Customer and Digital Government Service Policy

Table 1: Summary of national strategies, key authorities and selected policies and initiatives to accelerate digital transformation in the Middle East.

While individual nations have strong national strategies, there is not yet a formal, coordinated regional framework for digital infrastructure. The lack of harmonized regional policies for issues like data protection, cross-border data flows, and system interoperability remains a key challenge. However, it is worth exploring the concrete examples in which targeted national policies were implemented and incentives provided in KSA and the UAE to accelerate data center development.

In Saudi Arabia, the Ministry of Communications and Information Technology (MCIT) actively champions the data center industry[21], for example offering a reduced energy tariff of 18 halalas (4.8 USD) per kWh for the first eight years to registered cloud service providers[22].

Furthermore, the establishment of a Cloud Computing Special Economic Zone (CCSEZ)[23] provides a favorable regulatory and investment environment. These efforts are part of a broader strategy led by the Public Investment Fund (PIF) to localize entire manufacturing chains for key industries. This includes establishing in-kingdom manufacturing for solar and wind components, which helps ensure a stable and cost-effective ecosystem for powering the country's growing digital infrastructure.

In Abu Dhabi, the development of data centers is a strategic, state-driven initiative, with entities like G42 and its data center hosting subsidiary, Khazna, leading the market with plans for massive capacity additions.

A key competitive advantage for Abu Dhabi is the government's unique willingness to accelerate development and procurement of multi-gigawatt power and transmission infrastructure, enabling a much faster project timeline than in other jurisdictions. One prominent example is the 5 GW UAE-US AI campus, where the first 200 MW phase is scheduled to be energized by the end of 2026, just two years after the project's announcement[6]. This exceptionally ambitious timeline is made possible by this state-backed model.

Investing in data centers in the Middle East

The growth of digital infrastructure is led by the UAE and increasingly by Saudi Arabia. Major US hyperscalers - including Microsoft, Google, AWS and Oracle - are actively deploying cloud data centers. Beyond factors like data sovereignty, their entry is driven by two critical advantages the region offers over traditional hubs. First, the availability of reliable power which avoids grid constraints and long connection queues now common in Europe and the US. The second key enabler is the speed of development: the process to secure land, permits and grid connections is significantly faster and more streamlined, allowing for much shorter project timelines. This has been demonstrated over the past ten years with many major energy and infrastructure projects delivered in record time.

The investment model for data centers facilities is distinct as developers typically do not build speculatively but operate under a colocation or build-to-suit model. While the build-to-suit model requires a tenant to be secured before construction, the current market is characterized by a significant shortfall of AI-enabled capacity. This intense demand means that finding tenants for these specialized facilities is less of a challenge at present. In practice the developer builds the "shell and core" - the building, security, cooling, and power infrastructure - and then leases that space to tenants.

The tenant, such as a hyperscaler, commits to a long-term contract and is responsible for installing and managing their own compute servers, chips, and IT infrastructure. The key difference between a traditional data center and an "AI-ready" data center, whose demand is rapidly growing, is in the design specification. While typical data centers are designed for a wide range of standard computing tasks with lower power densities, "AI-ready" data centers are highly customized for AI workloads. They have specific designs requiring much higher energy densities and more advanced liquid cooling technologies to manage the intense heat generated by clusters of high-performance GPUs.

Case study: Salalah Free Zone as a next-generation data center hub

Oman's Salalah Free Zone (SFZ) is strategically positioning itself as a prime location for hyperscale data centers, capitalizing on a unique convergence of connectivity, renewable energy, climate advantages, and investor incentives.

Salalah can count on strategic connectivity, being a major landing hub for global submarine cables, including 2Africa, G2A, and the new India Europe Xpress (IEX) and Raman systems. The region's geopolitical stability, combined with ongoing tensions in the Red Sea, increases Salalah's importance, with new terrestrial routes planned from Salalah through Saudi Arabia to Europe. This is further enhanced by Oman's political neutrality, making it an attractive base for hyperscalers serving diverse nations.

Complementing this digital infrastructure is a unique environmental and energy proposition. Data centers in Salalah can benefit directly from the massive renewable energy capacity being built for adjacent green hydrogen giga-projects, which will be allowed to sell excess power to local industries. Salalah's climate offers a rare mix of solar and high-capacity wind that peaks at night, enabling up to 18 hours of continuous renewable power generation. During the summer "Khareef" monsoon season, ambient temperatures drop to around 25°C, drastically reducing the energy load for cooling compared to other GCC locations. Furthermore, the unique access to deep, cold seawater presents a major opportunity for highly efficient seawater cooling solutions[24].

Furthermore, to attract investment, the SFZ offers a 30-year tax exemption, zero VAT, 100% foreign ownership and customs duty exemptions, all managed through a streamlined "One-Stop Shop" for licensing and permits.

Potential synergies between cryptomining and hydrogen production

While often grouped with data centers due to their high energy consumption, large-scale cryptomining operations have their own operational models that present unique opportunities and challenges for the energy transition, such as the use of stranded electrons. In fact, unlike traditional data centers that require near-perfect uptime, cryptomining facilities are uniquely flexible, while also being very sensitive to price. That differs from data centers, where energy cost has so far not been a main driver.

This flexibility allows miners to create symbiotic relationships with energy systems by seeking out underutilized or stranded electrons. Marathon Digital Holdings (MARA Group), a Bitcoin miner, has put into practice some solutions to make use of these stranded electrons at competitive rates.

For example in Abu Dhabi, Marathon, in a joint venture with Zero Two, has partnered with the local utility Emirates Water and Electricity Company (EWEC)[25]. They receive a preferential rate to power their two cryptomining sites, for a total capacity of 250 MW, with electricity generated from excess solar and baseload nuclear power. In exchange, they agree to shut down their operations during periods of peak demand, freeing up capacity for the grid.

Due to the extreme price sensitivity, powering mining operations directly with low emission hydrogen as the primary energy source is not considered economically viable. However, an interesting synergy may exist with hydrogen production.

If a low emission hydrogen facility has contracted for large amounts of electricity but has operational downtime (e.g. overnight, or when hydrogen storage is full), miners could take advantage of this stranded power capacity. In turn, this would help improve the economics of the electrolyzer plant, by creating a revenue stream from electricity that would otherwise be wasted. The waste heat from the mining computers also potentially could be repurposed for the hydrogen production process.

Powering data centers with clean energy

Reducing data centers emissions with renewables and hydrogen

The emission footprint of data centers poses a significant challenge for hyperscalers aiming to achieve their corporate net-zero targets. In fact, as the number of data centers surges, so do their emissions, prompting companies to extend their scrutiny up the entire value chain, including Scope 3 emissions generated during construction. In some cases, hyperscalers insist that contractors replace traditional diesel generators with solar and battery power, thus covering a significant portion of the construction site's energy needs.

In this perspective, using renewables as primary power for data centers is an ideal solution to reduce operational (Scope 2) emissions. A practical example in the region is provided by Khazna, which is actively integrating distributed solar power, with one of its latest data centers featuring a 7 MW solar installation connected directly to the facility. This is part of a broader strategy to install solar on rooftops and adjacent lands where possible. However, renewables and batteries currently face challenges in guaranteeing the multi-day, 100% availability that hyperscalers demand. To cover this gap and meet the typical requirement for 72 hours of guaranteed backup power, a dispatchable, emission-free energy source is needed. This can be a low-carbon fuel, such as 100% hydrogen, or another form of Long-Duration Energy Storage (LDES), aligning with the strategic interests of companies like Amazon and Microsoft who have joined the LDES Council to advance these technologies[26].

An exemplary model is the Datavolt AI factory being developed in NEOM. It targets net-zero operation by sourcing more than 95% of its primary power from integrated solar, wind and battery storage. The remaining gap is planned to be filled with dispatchable green hydrogen, leveraging the proximity of the NEOM Green Hydrogen Company (NGHC). This integration demonstrates a viable path to a solution supporting net-zero goals.

At a global level, the Edisun Power's Fuencarral project in Spain is a 941 MW solar initiative specifically designed to supply green, reliable energy to the growing cluster of energy-intensive data centers in the Madrid region[27]. By developing dedicated, large-scale solar farms, the project directly addresses the immense power needs of AI and cloud computing, demonstrating in concrete terms that digital expansion is not reliant on fossil fuels.

H_2 logistics – virtual pipeline vs. on-site H_2 production

The logistics of supplying hydrogen depends entirely on the scale of demand. As such, for data centers where only small volumes of hydrogen are envisioned, the data center's location will be of primary importance. Locating several data centers in proximity acting as off-takers could in turn contribute – together with other energy-intensive industries - to the development of hydrogen hubs.

In general, for backup power using small volumes of hydrogen the preferred solution is using high-pressure tube trailers. In this instance, a supplier can rent out one or more fully stocked tube trailers to be kept on site, helping ensure immediate availability. This approach offers lower OPEX and higher reliability.

As investments in data center and AI capacities accelerate across the Middle East, the choices made today will define the long-term carbon footprint of IT infrastructure. Reciprocating gas engine technology is well positioned as a power solution ready for hydrogen. The engines are engineered for flexible operation on a range of energy sources - including natural gas, biogas, and, crucially, hydrogen - making this technology a future-ready choice for data center operators seeking to decarbonize their backup and prime power infrastructure. For operators navigating this transition, three principal de-fossilization scenarios are emerging from pragmatic, grid-reliant models with clean backup to fully autonomous, off-grid net-zero solutions. This flexible approach allows data center operators to adopt a staged decarbonization strategy that aligns with their specific location, grid availability, and long-term sustainability targets.

The table below summarizes these three key scenarios for powering data centers with cleaner energy:

	Primary Power Source	Backup Power Solution	Use Case
Clean Backup Power	Grid or on-site power generation with a wide range of cleaner technologies	Ready for H_2 gas engines (replacing diesel generators) or 100% hydrogen engines	Data centers aiming to eliminate backup emissions and achieve net-zero compliance
Hybrid "Bridging Power"	On-site ready for H_2 gas engines (can transition to backup-only)	Ready for H_2 gas or 100% hydrogen engines serve as backup (no separate diesel system needed)	New facilities awaiting full grid connection, sites with insufficient grid capacity, or operators seeking to sell power back to the grid
Off-Grid Net-zero Island	Co-located, dedicated renewables (solar/wind) balanced by clean hydrogen	On-site hydrogen production and storage with ready for H2 gas engines or 100% hydrogen engines	Remote, large-scale AI factories or data centers aiming at full energy independence and a 100% carbon-free footprint from the onset

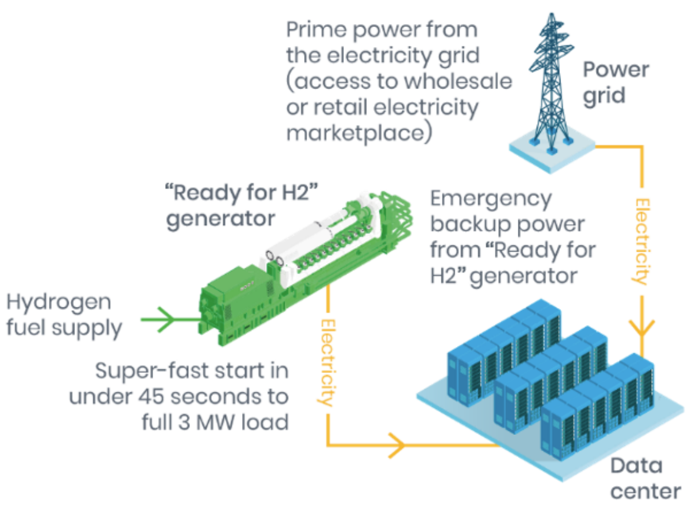
For the Middle East, the Off-Grid Net-Zero Island represents the most feasible and cost-effective pathway for deploying new, large-scale data centers. This approach involves building fully autonomous facilities where dedicated, co-located renewables are seamlessly integrated with on-site, long-duration energy storage, such as clean hydrogen, to ensure 24/7 carbon-free reliability.

This model is exceptionally advantageous in the region for three key reasons:

1. **Cost:** The Middle East has access to some of the world's lowest-cost solar and wind power, which is the single largest factor in the total cost of ownership for a data center.
2. **Feasibility:** Unlike in other regions, vast and available land makes it possible to co-locate massive data centers with the equally massive renewable energy farms required to power them, simplifying transmission and creating a truly integrated, independent system.
3. **Speed to Market:** By being completely independent of the existing power grid, this model bypasses the multi-year queues and complex regulatory hurdles required to secure a grid connection, dramatically accelerating deployment timelines.

1. Clean backup power

Diesel generators traditionally have served as the primary backup power solution for data centers. However, with increasing emphasis on de-fossilization efforts, many data center operators are reassessing this approach.



Select gas engine power plants can be modified to run on a wide spectrum of natural gas hydrogen blends up to 100% hydrogen. NO_x emission reductions of more than 90% are possible compared to diesel generators and can be even higher with pure hydrogen.

In addition to providing backup readiness, gas engines also can be used for ancillary services, and full data centers can be taken off the grid for longer periods of time in case of grid curtailments. For these reasons, investors often see favorable grid electricity prices if gas engines are installed on site.

Gas engine power plants often are chosen over gas turbines for emergency backup, as turbine startup times (around 5 minutes) are much slower than those of diesel generators (45 to 60 seconds) and gas generators. Some of the most advanced modern gas engine technology features a super-fast-start option that accepts load in 15 seconds and full load under 45 seconds.

As green hydrogen becomes more accessible, data centers have the option to switch from pipeline gas to 100% hydrogen without the need for significant changes to existing equipment.

Thus, green hydrogen in backup generators can fully eliminate any remaining source of data center emissions. This is critical for achieving a truly net-zero data center footprint.

Emission-free emergency backup power at NorthC Datacenters at Eindhoven, Netherlands

NorthC Datacenters proved its commitment to an emission-free future with the first 100% green hydrogen emergency backup power solution with engines[28]. The configuration includes six INNIO Group's Jenbacher hydrogen engines, with a total output of 6 MW, that generate backup electricity during grid outages using green hydrogen stored on site.

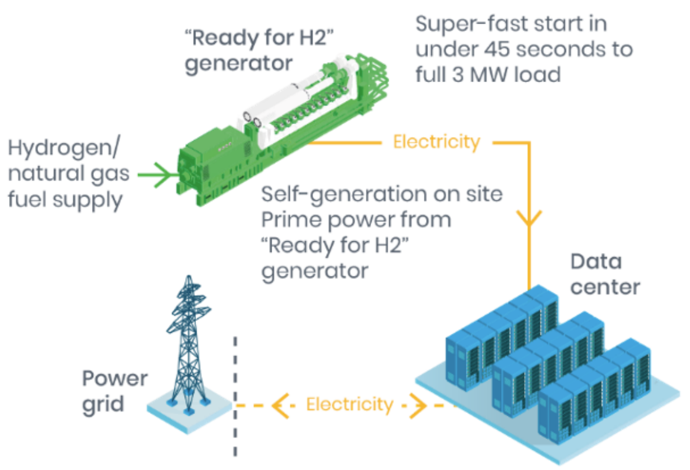
The dual-gas engines can also operate on natural gas if hydrogen supplies are interrupted, thus enabling high reliability. The system is supported by INNIO's cloud-based myPlant Performance platform for real-time monitoring, aligning with NorthC's goal to achieve carbon neutrality by 2030 and supporting the Netherlands' broader strategy for a sustainable energy future.

It is also important to highlight the potential role of hydrogen for long-duration energy storage (LDES). While battery storage is effective for daily cycling (e.g., 4 to 8 hours), hydrogen can provide long-duration or even seasonal storage to help ensure 100% power availability. Most clients require 72 hours of backup power – an amount that currently is not feasible with batteries.

Scan the QR code for more information

2. Hybrid “Bridging Power”

The Hybrid “Bridging Power” model uses gas engine power plants to provides both primary and backup power to a facility, eliminating the need for separate backup diesel generators. It is normally designed to "bridge" a temporary period such as the wait for a permanent grid connection. Once the grid is available, the system transitions into an exclusive backup role. This model can also serve as a primary power source for years at sites where grid capacity is insufficient, before eventually switching to backup mode. Additionally, transitioning to 100% hydrogen use is possible as hydrogen supply infrastructure develops, for both prime and backup applications.



This adaptable approach supports staged decarbonization strategies, making it particularly advantageous for new projects or facility expansions where supporting long-term investments is essential. Furthermore, data center developers can reduce expenditures on supplementary backup systems (such as diesel generators) when gas engines are integrated into the data center facility for both prime and backup functions at the design phase.

Moreover, a hybrid setup involving both backup and prime power supply can be an attractive source of additional revenue for a data center. Data center power supply systems are typically designed with redundant capacity to maintain the availability of critical loads during maintenance. This redundant capacity may also be used to generate electricity for sale on the market during periods of peak demand.

Hydrogen generators also can be used for grid curtailing during peak periods when the data center is disconnected from the grid and power is supplied internally. To address the requirements of a hybrid operations setup, dedicated gas engine models designed for base load efficiency and reduced starting time are available.

3. Off-Grid Net-Zero Island

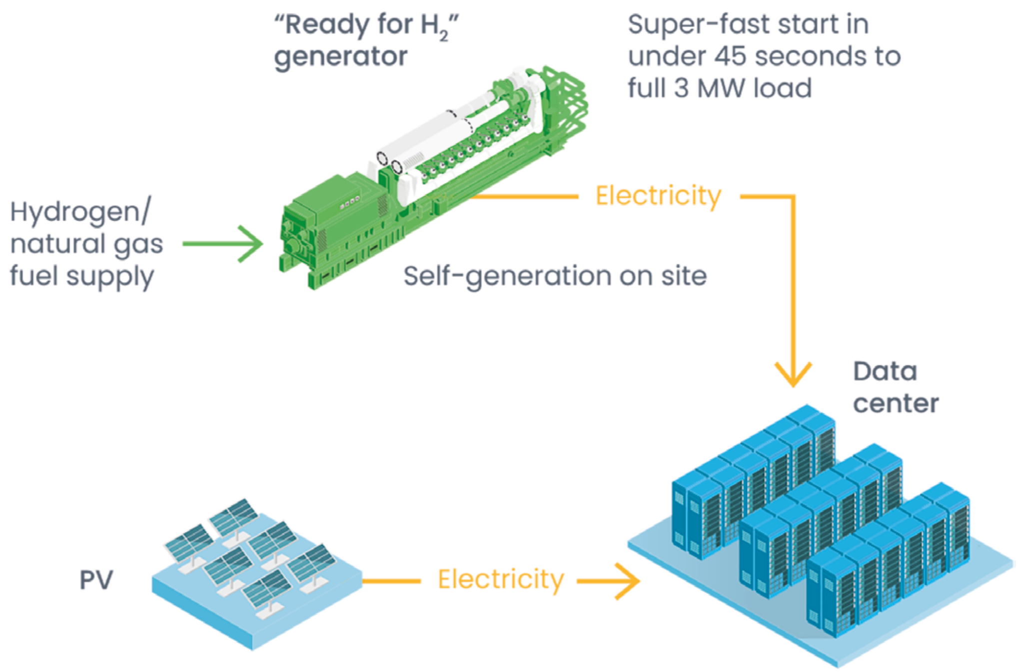
For AI factories in remote areas – such as the deserts in the Middle East - direct connection to adjacent renewable projects is feasible. For urban cloud data centers, wheeling power from remote solar or wind farms is an option in countries where wheeling is allowed, such as Jordan.

Wheeling power involves the transmission of electric power over someone else's transmission facilities, allowing a generator or supplier to deliver electricity to a load or customer located on a different utility's network.

When it comes to hydrogen use in remote or off-grid locations, gas engine power plants' ability to operate on hydrogen - either blended or pure - means that even the most isolated data centers can achieve zero-carbon operations.

This involves strategically placing solar panels or wind turbines to harness a significant amount of available renewable energy, and integrating hydrogen production, the gas network, energy storage systems, and solutions such as 100% hydrogen or “Ready for H_2” generators.

These likely positions gas engine technology as the main pathway for future data center development in the Middle East as well as for operators committed to sustainability, regardless of location.



Location-based emission accounting: the clear path to transparent climate impact in data centers

The methods described above to significantly reduce emissions focus on reducing actual emissions generated at data center facilities However, to report their operational carbon footprint, data centers employ two main philosophies: market-based accounting (claiming clean energy through certificates) and location-based accounting (calculating emissions based on the actual carbon intensity of the local power grid the facility is physically connected to). Some experts argue that location-based accounting provides a more transparent and accurate assessment of a data center's true climate impact, however market-based mechanisms are the primary tools used by data centers, in particular:

- **Virtual de-fossilization via Certificates:** These voluntary systems allow companies to purchase certificates that transparently verify that their electricity consumption is matched with renewable energy generation feeding into the grid. For example, Dubai[29], Saudi Arabia and Oman[30] have developed national schemes based on the I-REC[31]; and Abu Dhabi uses a Clean Energy Certificate (CEC) scheme[32]. However, a major challenge in the region is the inability to enter into long-term Power Purchase Agreements (PPAs) that bundle renewable energy with its associated certificates. Instead, companies must purchase certificates on the short-term market (often annually) which creates significant price uncertainty and complicates long-term financial planning.
- **24/7 Renewable Energy Matching:** Moving beyond simple Renewable Energy Certificates (RECs), some organizations (e.g. Google[33] and Microsoft[34]) have targets to move towards 24/7 carbon-free energy, where consumption is matched with clean power generation on an hourly basis. This could be achieved using renewables, on-site energy storage or hydrogen.

Reliable power and substantial cost savings in hot climates

When compared to gas turbines, gas engines provide a more reliable, efficient, and cost-effective option for hot climates such as those found in the Middle East, lowering both operational expenses and resource usage. Their robust design and operational adaptability make them particularly well-suited to address the region's demanding environmental conditions.

- **Performance stability:** Gas turbines depend heavily on intake air density, meaning hotter air reduces efficiency and output. To counter this, they often need active air inlet cooling, which adds costs and consumes critical resources such as water. Gas engines, on the other hand, can sustain full load output even above 45 °C (113 °F) without the need for external cooling systems.
- **Efficiency advantage:** At 45 °C (113 °F) or above, gas turbines can suffer power output derates of 10% to 20%, directly driving up fuel costs and reducing available capacity. In contrast, gas engines typically experience little derate and can run at full load power output at ambient temperatures well above 45 °C, thanks to advanced two stage turbocharging and optimized control systems.
- **Fuel savings:** Gas engines require 15% to 25% less fuel than open-cycle turbines under the same hot conditions.
- **Cost impact:** For a 100 MW primary power supply solution, those differences in fuel consumption and derating translate into annual savings of 10 to 15 million USD[1], a compelling advantage in data center operations where fuel costs dominate lifecycle expenditures.

Cooling innovations and efficiency

Cooling accounts for a substantial portion of data center energy requirements. A common metric used to assess a data center's energy efficiency is its Power Usage Effectiveness, PUE, which is the ratio of a data center's total energy consumption compared to its computing energy consumption. PUEs have decreased dramatically over the past two decades with efficiency improvements, with typical PUE for large data centers globally close to 1.5, down from 2.5 in 2007[35]. However, as computing density increases to service next-generation AI and high-performance computing, cooling efficiency remains a challenge, particularly in warm climates such as the Middle East, where PUEs tend to be higher[36].

Related to energy efficiency, water resource efficiency is a major consideration for data center development. In many regions, data center cooling involves the evaporation of large amounts of water in cooling towers. In water-stressed areas, like much of the Middle East, this is not viable, and cooling systems are typically already designed to reduce water consumption, using refrigerant-based cooling and closed-loop chilled water systems.

Innovative cooling systems for data centers in the Middle East are emerging that can offer greater energy efficiency with little to no water use. Traditionally, data centers have used air cooling methods – in which air is the medium of heat transfer in contact with the IT systems – such as Computer Room Air Conditioning (CRAC) and Computer Room Air Handling (CRAH). While these systems remain widely used and are relatively simple, their energy efficiency is comparatively low. This challenge is exacerbated as computing power density increases, requiring higher air flow rates.

To service the high cooling demand of modern facilities, data center developers around the globe are turning to liquid cooling technologies – in which a liquid is the heat transfer medium in contact with the IT systems – which offer greater cooling power with lower energy costs. Direct-to-chip cooling, in which cooling liquids are circulated to pass directly over the heatsinks of CPUs and GPUs, is becoming widespread. Immersion cooling, which entails submerging entire servers in a dielectric fluid used as the cooling medium, is also gaining traction[37].

Another example comes from Khazna, which uses adiabatic free cooling[38], a technology that involves combining warm air with small amounts of water that then evaporates, having a cooling effect on the air. This can reduce energy consumption with significantly lower water use compared with conventional evaporative cooling towers. For its new 100 MW facility designed specifically for high-density AI workloads, the company is deploying next-generation liquid-to-liquid cooling. These solutions are complemented by operational efficiencies, such as maintaining a higher indoor data center temperature of 25°C to 26°C and leveraging free air cooling during the milder winter months to further reduce the energy load.

Strategic selection of the data center location can also bring benefits for cooling efficiency. For example, a seawater-cooled data center is being developed by DataVolt for NEOM on the Red Sea coast[39], using a highly efficient cooling system paired with plate heat exchangers to reject heat into the sea. Access to seawater is likely to be a requirement for large-scale hydrogen production in the Middle East, meaning that seawater cooling may be a viable option for data centers co-locating with hydrogen clusters at coastal locations. Approaches of this kind will need to balance the additional challenges, such as local impacts on seawater temperature and salinity.

Another promising cooling approach where thermal power generation is available on site is trigeneration using absorption chillers to produce cooling, heating, and power simultaneously. In a recent INNIO study, simulations demonstrated approximately 25% annual energy cost savings with trigeneration compared to conventional grid configurations. This method also improves energy efficiency and lowers PUE[40]. In other locations as diverse as India and Sweden, solid oxide fuel cells, which operate at relatively high temperatures, are being used to provide decentralized power for data centers in conjunction with absorption cooling or waste heat recovery[2].

[1] This is based on a comparison between a simple cycle solar turbine Taurus60 or BH's LT16 models run at 29% or 32% electrical efficiency compared with an INNIO's Jenbacher Type 6 gas engine with 43% eta, assuming gas costs of 4 USD/MMBTU @ 40°C ambient temperature and 8,000oph.
*[2] **www.jenbacher.com/en/news-media/media-center/factsheets/how-trigeneration-technology-can-boost-data-center-efficiency-and-reduce-your-pue***

Conclusion

Matching the markets – green fuel production sites vs. strategic data center locations

Global data center expansion is no longer only about connectivity and latency, it is increasingly about access to abundant, low-cost, and clean energy and this at speed! For next-generation AI workloads, where computational dimension outweighs geographical proximity, the Middle East offers a decisive advantage: it can pair robust digital infrastructure with vast, dispatchable renewable energy at an unprecedented pace and scale.

The region's "sweet spots" - where submarine cable routes (Figure 8) intersect with giga-scale renewable and green hydrogen projects - are emerging as the world's strategic locations for AI factories and hyperscale cloud clusters. By combining abundant solar and wind resources with visionary government strategies and sovereign wealth fund investment, the Middle East can deliver what traditional hubs cannot: a future of 24/7 emission-free digital infrastructure, built faster and at lower cost.

The decision of where to locate a data center is complex, mainly depending on the following factors[2]:

- **Network connectivity:** Proximity to key digital infrastructure has historically been the most critical factor. This means being close to major submarine cable landing stations and terrestrial network nodes to ensure high-bandwidth, and low-latency connectivity to global and regional networks.
- **Energy and power availability:** This is becoming an increasingly important driver and includes access to reliable and low-cost power from the grid, as well as the potential for direct connection to giga-scale renewable energy projects.
- **Speed of execution:** The ability to move quickly is a key differentiator. This includes streamlined permitting processes and the proven ability to secure land and grid connections much faster than in other global hubs, which are often hampered by multi-year queues.
- **Proximity to demand hubs:** The location must be strategic to serve concentrations of end-user and enterprise demand, particularly for latency-sensitive applications like financial services and real-time cloud computing.
- **Data Sovereignty and Regulation:** The legal framework is a crucial consideration. This includes data localization laws that mandate in-country data storage, as well as a country's data protection standards, which must often be equivalent to international norms to enable the transfer of personal data.
- **Supportive policy and permitting:** This includes favourable government policies, streamlined permitting processes for construction and grid connection and attractive investment incentives.
- **Skilled labour:** Access to a local pool of skilled technical and engineering talent is necessary for the facility's construction and long-term operation.
- **Corporate strategy:** The location must align with the company's broader market positioning, expansion goals, and client requirements.

The impact is significant. The Middle East is no longer just an energy exporter to the world: it is becoming a powerhouse of clean digital infrastructure, drawing global hyperscalers, investors, and innovators.

By strategically aligning its digital ambitions and its clean energy potential, the Middle East can offer the world a unique value proposition: the opportunity to power the future of AI with 100% emission-free energy.

This alignment represents a significant growth opportunity, securing the region is well positioned in both the digital and the energy transformations.

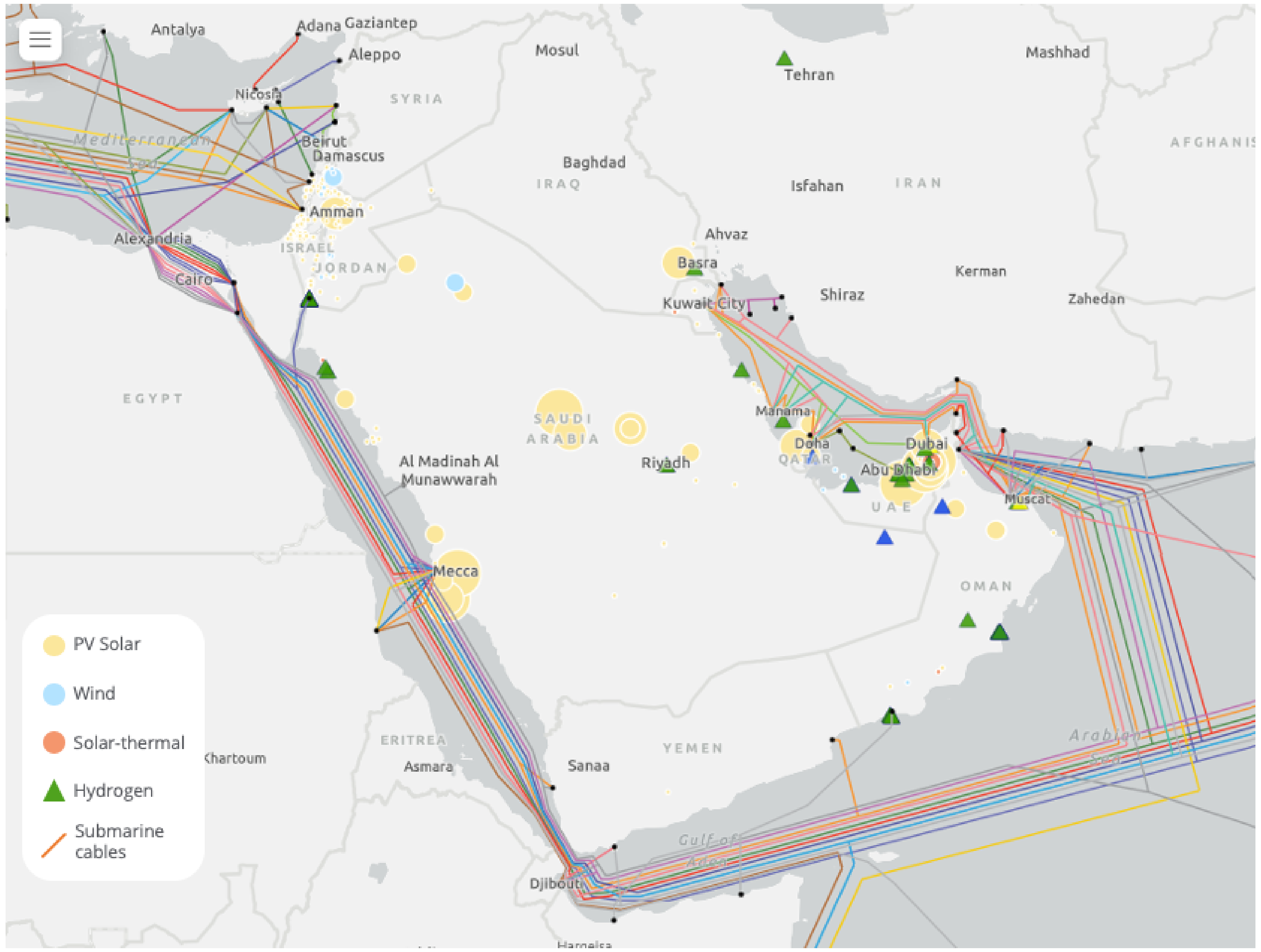


Figure 8: Map of existing renewable energy projects and planned hydrogen projects alongside submarine cables. *The size of each circle corresponds to the relative capacity of the renewable energy project. The different colours of the submarine cables visually distinguish the various cable systems. Source: Dii Desert Energy databases, Submarine Cable Map41.*

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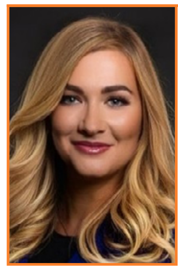

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Roland Berger and ERM - Environmental Resources Management provided foundational market data and key strategic insights for this study.

The authors would like to thank Chetan Anand (ME Digital & TMT, Roland Berger), Hugo Carreira (ME Digital, Roland Berger), Omar Kalaawi (ME Digital, Roland Berger), Tom Houghton (ERM), Masi Nagdee (ERM), Sam Foster (ERM) Nazir Hadaya (ERM) for their significant contributions.

Acknowledgements

The authors would like to thank the following experts who generously shared their time and industry knowledge through a series of expert interviews or by providing valuable feedback during the peer review process:

Danny Achkar (Dii Desert Energy); Elie Adaimy (Gulf Cryo); Leena Al Kathiri (ASYAD SFZ); Christian Aound (Roland Berger); Elisabetta Baronio (Khazna Data Centers); Douglas Caskie (EWEC); Bruce Chen (Addleshaw Goddard); Marton Eorsi (Addleshaw Goddard); Khalid Jaboub (ASYAD); Sami Kamel (Dutco Cleantech); José Maria Llopis (Edisun Power Europe AG); Fadi Maalouf (Dii Desert Energy); Andy Solberg (Jacobs); Thomas Spencer (IEA); Adam Swick (MARA Group); Ahmed Tabook (ASYAD SFZ); Paul van Son (Dii Desert Energy); Frank Wouters (Dii Desert Energy); Maro Turner (Datavolt).

Dii Desert Energy

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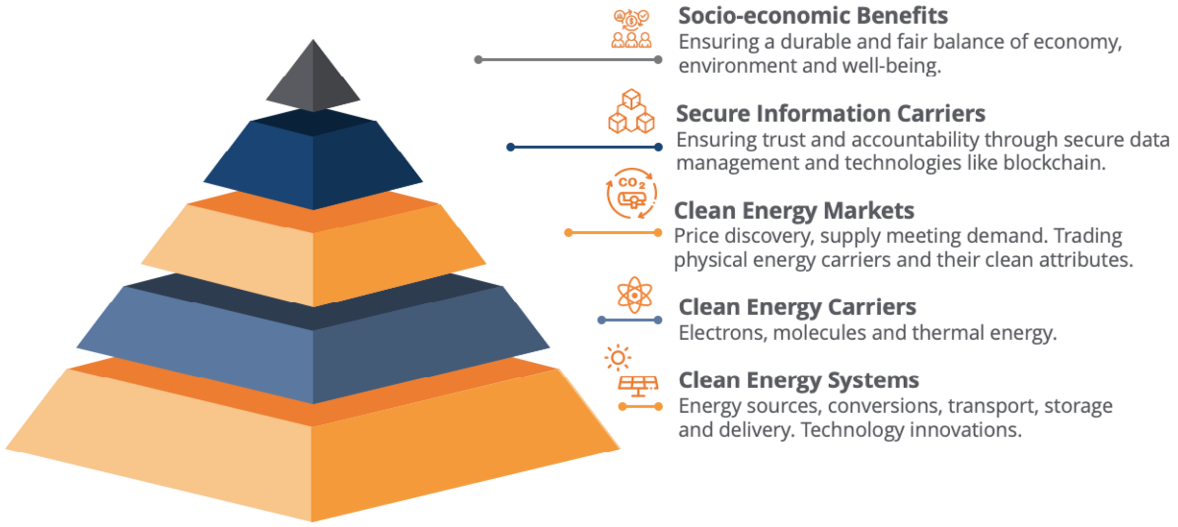
As part our vision and mission, Dii Desert Energy in collaboration with ZETA Global, provides impartial guidance to the development MENA as a clean energy 'Power House' for local benefits and for exporting into the global energy markets. Our Clean Energy Pyramid highlights the five fundamental building blocks of this vision.



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