Large Enterprises, Communications Services Providers

Intel and e& UAE Collaborate on Sustainable Modular Data Centers

Intel and e& UAE have developed a blueprint for the service provider's first sustainable modular data center that uses renewable fuels, liquid cooling and CPU efficiency, and power management

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Executive Summary

The rapid expansion of AI-driven workloads and cloud computing has significantly increased power consumption in data centers. As more organizations rely on data-heavy applications like machine learning, natural language processing, and advanced analytics, servers must process vast amounts of data in real-time, which requires more electricity.

As a result, data centers now consume an estimated 1-2% of global electricity[i], a figure that could rise dramatically if current growth trends continue. Additionally, the UAE data center market is experiencing significant growth, driven by rapid digital transformation, increased cloud adoption, and governmental initiatives to enhance digital infrastructure. Projections indicate that the market will expand from approximately 495.7 MW in 2025 to 917.7 MW by 2030, reflecting a compound annual growth rate (CAGR) of 13.11%[ii]. This surge in demand has put substantial pressure on power grids and has raised concerns about energy efficiency and reliability.

Cooling challenges are also a critical issue, as AI-driven hardware generates considerably more heat than traditional IT infrastructure. To maintain optimal server performance and prevent overheating, data centers often implement energy-intensive cooling systems, including traditional air cooling or water cooling.

Given the substantial environmental footprint of data centers, improving sustainability has become a priority. e& UAE and Intel are committed to developing data center technology that improves sustainability, including the first sustainable modular data design.

Introduction

e&, the global technology group, has declared a goal of achieving net-zero carbon emissions for scope 1 & 2 in its UAE operations by 2030 and global operations by 2050 including scope 1, 2 and 3. e& UAE is an industry leader in technology and the telecommunications arm of e&. Like other tier 1 communications service providers, e& UAE's sustainability goals must contend with rapid growth in cloud and artificial intelligence (AI) services that require new power-hungry data centers.

Intel has a goal of achieving net-zero carbon emissions by 2040. As part of this initiative, the company is working with its data center customers to implement efficiency and power management strategies involving Intel® architecture-based data center servers.

With this joint concern for the environment, Intel and e& UAE embarked on the development of a blueprint for a sustainable modular data center.

Data Centers are Big Energy Consumers

Globally, AI is a major catalyst for the increasing demand for data center computing power, necessitating significant investments in the expansion of data center infrastructure.

This rapid expansion comes with significant growth in power consumption and a resulting increase in greenhouse gas emissions. AI alone is expected to drive a 160% increase in data center power consumption by 2030, according to a report published by Goldman Sachs[iii]. The increase in power consumption is creating a critical need for more sustainable approaches to data center operations.

The environmental impact of data center operations has become a focal point for stakeholders across industries, including governmental and regulatory bodies who are tightening restrictions on carbon emissions, making net-zero emissions commitments an imperative.

At the same time they are focused on their environmental impact, data center operators must maintain the performance and reliability required for a digital-first world.

Reducing energy consumption and improving sustainability in a data center takes a combination of infrastructure changes, cooling improvements, and CPU efficiency and power management.

In this paper, Intel and e& UAE, an Intel® Industry Solution Builders Partner, join to present the strategies and technologies they are using to develop the e& UAE Sustainable Data Center Project built on Intel® Xeon® 6 processors.

e& UAE Sustainable Data Center Project

To meet data center sustainability goals, the companies have developed the e& UAE Sustainable Data Center Project, aiming for a near net-zero carbon footprint. For this project, e& UAE chose a modular data center because these mobile data centers are playing an increasingly vital role in augmenting traditional physical data centers by adding flexibility and minimizing deployment timelines. Rather than constructing new facilities, which can take years and substantial investment, e& UAE can use a modular data center to expand capacity in weeks.

The companies are designing the data center with three separate zones to support various workloads with various rack power and cooling technologies and those are as follows:

AI-Aware: To support the growth of AI, the data center architecture features 100 high-powered racks supporting up to 50 kW each to accommodate more power-hungry AI accelerators, supported by compute and storage nodes utilizing direct-to-chip (cold plate) cooling.

Standard Compute: The standard compute section is also designed with 100 racks, each supporting a power load of up to 25 kW. This section is specified to match the number of CPU cores and the amount of RAM as the AI Aware section.

Appliance Racks: The specs for this section call for 50 racks each supporting up to 15 kW to be used for appliance hosting.

The design has specified a Power Usage Effectiveness (PUE) range of 1.22 (AI-Aware) to 1.46 (Standard Compute and Appliance Racks).

e& UAE Embraces Renewable Power and Infrastructure Innovation

The sustainable data center blueprint is a natural outcome of e& UAE's comprehensive commitment to sustainability and positive societal impact.

The company has launched a 360-degree approach to sustainability. Some of the key telecom infrastructure initiatives the company is taking include:

IT Infrastructure Right-Sizing	Leverage advanced analytical tools to optimize workloads, automate scalability and elasticity and subsequently reuse or phase-out obsolete/legacy infrastructure.
New High Power-Efficiency Network and IT Equipment	Replace existing equipment with more capacity and efficient power consumption; for example, choose a 100GbE interface to replace multiple 10GbE interfaces.
Green/Renewable Energy Solution	Utilize hybrid solar solution, photovoltaic panels, microgrids, wind turbines, and hydrogen generators, in addition to battery storage.
High-Efficiency Power System Implementation	Implement or replace low efficiency legacy power systems (DC plants, UPSes, and inverters) with high-efficiency power systems throughout the network.
New High-Efficiency Cooling System Implementation	Switch to low global warming potential (GWP) refrigerants, liquid cooling, and cold and hot aisle containment.
Energy Storage	Adopt superfast-charging supercapacitors for capturing excess distributed generation power.

Reducing Greenhouse Gases with Renewable Energy

The use of renewable energy sources plays a key role in improving the sustainability of the e& UAE Sustainable Data Center Project specification. The energy sources detailed in the specification are:

- High-efficiency hydrogen fuel cells that offer nearly zero carbon emissions.
- Multiple wind turbines each with a 3 MW capacity to be a direct source of power for the data center. This specification is designed to provide power for up to 50% of the energy needs of the planned data center.
- Monocrystalline silicon photovoltaic panels to power the data center or charge the battery pack. To be beneficial, the design specifies panels with an efficiency of >22% and multi-string inverters with a maximum efficiency of >98%.
- A 5 MW energy storage system is specified as a backup power solution to ensure data center uptime in case of power loss.

Reducing Energy Consumption

The sustainable data center blueprint offers two ways to reduce power consumption in the data center: embracing new cooling techniques and using CPU efficiency and power management technologies.

Compute requirements are increasing faster than the available energy to power them using traditional air cooling. Data center server cooling is estimated to consume between 25% and 40% of all data center power[iv].

Today's servers have increasingly higher thermal design power (TDP) limits and are stacked closely together on racks. Reducing cooling power consumption allows the data center operator to redistribute that energy to the servers to get more compute performance out of the same power window.

Air cooling, using fans within the server blades, is the predominant method for cooling servers. Air is an effective coolant due to its dielectric nature, non-toxicity, abundance, and lack of ancillary greenhouse effects. All servers come with fans, making air cooling simple and accessible. But it consumes a lot of energy and has limitations as temperatures rise. Air cooling systems are available to handle high TDP CPUs and AI accelerators but require escalation in airflow from high-powered fans that may cause noise exposure.

Other cooling technologies utilize liquid as a coolant to manage the heat of the modern data center with less power consumption. These include:

"Sustainability is not just a goal; it's a responsibility we take seriously at e&. The sustainable modular data center, developed in collaboration with Intel, represents a significant step forward in reducing carbon emissions while supporting the UAE's ambitions for a net-zero future. By integrating renewable energy sources, AI-powered optimization, and innovative cooling solutions, this project highlights how we can meet the escalating demands of digital transformation while protecting our planet. This is more than just infrastructure; it's a blueprint for responsible innovation, ensuring that progress and sustainability go hand in hand for a better tomorrow."

- Harrison Lung, Group Chief Strategy Officer, e&

Liquid Immersion Cooling

This cooling mechanism involves submerging the whole server in a tank filled with a dielectric liquid. This fluid is engineered to gather and dissipate heat more efficiently than water. This method is particularly effective for managing high heat levels from CPUs and GPUs because it offers better thermophysical properties of the cooling liquids. Immersing a server in liquid requires an enclosure that will not let the liquid ruin the CPU and other systems in the server.

Direct to Chip (Cold Plate) Cooling

Direct liquid cooling is a technology where cooling liquid flows into a special heat sink atop a processor, absorbs residual heat, and then the hot liquid moves to a passive cooling area before repeating the process. This system uses cold plate heat exchangers to directly cool electronic components. Cold plates typically have a low thermal resistance, eliminating the need to chill the coolant, as the system remains effective even with above-ambient temperatures for the cooling fluid.

Intelligent Monitoring Provides Complete Data Center Management

The system specifies using an intelligent unified management and control system comprised of a building automation system (BAS) integrated with server management and orchestration systems. By adding in telemetry data from the BAS, which includes power management and cooling management among other things, data center operators can see how changes impact the entire data center and better understand how to optimize both the servers and the building systems.

Intel® Xeon® 6 Processors – Addressing the Needs of Today's Data Centers

The AI market size and opportunity are expected to grow 400%[v] in the next five years, fueled by changes like workload automation and generative AI. A growing number of enterprise applications are adding inferencing code, which requires processing large vectors of data with data-parallel computing requirements that favor performance per core.

Meanwhile the cloud microservices market is also expected to grow by 500%[vi], fueled by the redesign of monolithic applications with cloud-native principles. For these applications, the workloads are task parallel, which benefit more from efficient, scalar processing than from added complex compute capabilities.

In recognizing these market shifts, Intel has developed the Intel® Xeon® 6 processor family with a new class of Efficient cores (E-cores) to address the single-threaded microservices market, with a second class of processor that features Performance-cores (P-cores) that deliver hyperthreaded performance for best-in-class AI inferencing performance.

Energy efficiency is a critical consideration for the e& UAE modular data center, and the Intel Xeon 6 processors with E-cores used for this data center deliver exceptional performance per watt, offering distinct advantages for workloads that demand high throughput.

CPU Power Management for Optimized Performance

In data centers, servers historically have been run at their full clock frequencies regardless of workload levels. This means the servers consume their maximum power levels during both busy times of the day as well as when workloads are light, resulting in a low ratio of processor performance per watt during slack times.

Using CPU power management techniques offers an opportunity to either reduce power consumption without affecting system performance or redirect that saved power to enhance system performance within existing power levels.

Modern processors, including the Intel Xeon 6 processor, have several key power management capabilities that enable reductions in performance, more fine-grained sleep mode levels, and the ability to schedule workloads to energy-efficient states without compromising on performance.

These features are exposed to standard orchestration software, thereby enabling feature management to be integrated into existing integration flows.

Performance state (P-state): A P-state is an operating state in a CPU where a core is operating at specific frequency and voltage levels to execute instructions. As that core moves to different P-states, the frequency and associated voltage drops or increases, allowing the server's power consumption and performance to move up or down as workload levels change.

P-states can be either managed by hardware through the hardware-controlled performance states (also known as hardware p-state or HWP), allowing much faster and finer adjustments of the frequency and voltage based on each core load, or by software through a user plane application via the Linux kernel system.

"At Intel, we believe that innovation and sustainability must go hand in hand. Our collaboration with e& UAE on the sustainable modular data center is a testament to our commitment to driving technological advancements while addressing environmental challenges. By integrating green fuels, advanced liquid cooling, and efficient power management, we are setting a new standard for data center operations. This project not only showcases our leadership in innovation but also our dedication to creating a more sustainable future for the industry and the planet."

- Renu Navale, Vice President and General Manager, Cities & Critical Infrastructure, Intel

There are two technologies that use P-states to add additional functionality:

- Intel® Speed Select Technology (see details in Table 1) enables the operating system (OS) and application software to select different P-states.
- Intel® Turbo Boost Technology lets some cores or threads run at a speed higher than their designated frequency in a CPU that is operating at a reduced P-state. This technology provides the ability to balance performance and energy efficiency.

Idle power-saving states (C-states): A C-state is a power state that a CPU can use to reduce power consumption on a per-core level, or on a CPU package level, by powering down portions of the core, package, or both. Disabling portions of the core allows for more power savings but prevents the core from executing instructions. C-states can be either managed by hardware, through the CPU power control unit (PCU) responsible for autonomously coordinating core and package C-states, or by software through the operating system as defined by the Advanced Configuration and Power Interface (ACPI) specification.

Platform Power Management Features for Energy Efficiency

E-cores and Intelligent Platform Management reduce CPU core power consumption, but the Intel Xeon 6 processors also have technology to reduce the power draw of other uncore features and platform components. The following table provides a list of key power management enhancements for Intel Xeon 6 processors that help to increase platform energy efficiency for the data centers:

Feature	Description
Active Idle Mode	A power recovery strategy that lowers uncore frequency in low activity scenarios. Developers can set minimal utilization points and thresholds to minimize impact to workload performance. Power saving is increased when customers disable low power states and are in idle condition.
Core C6 (CC6) Enumeration	Allows the OS to differentiate CC6 and Package C6 (PC6) low power modes when using the monitor WAIT instructions. Enables fine grain control of CC6 and PC6 to select states independently using existing Intel idle driver interfaces. Lower CC6 exit latency means the OS can increase CC6 requests, improving CC6 residency and resulting in better energy efficiency and TCO.
Fast C1e	Per core low power state with better reliability and responsiveness than legacy package level C1e. Significantly lowers exit latency compared to legacy package C1e and does not require package level idleness, enabling voltage reduction in SoC.
Fast Fabric Frequency Scaling	Provides efficiency improvements by dynamically changing voltage and frequency of compute and IO domains to eliminate down time for transactions contained within a domain.

Intel® Speed Select Technology (Intel® SST)	Intel SST supports different workloads by varying CPU performance. This technology empowers users to optimize their service performance according to specific workload demands. The following is the list of various Intel SST capabilities to optimize user workloads:
	▪ Intel SST-Performance Profile: Allows multiple optimized performance profiles per system (defined by core count, base frequency, TDP and more).
	  • Intel Xeon 6 CPUs with P-cores have up to five Dynamic Intel SST-PP profiles.
	  • Intel Xeon 6 CPU with E-core and future CPU have up to three static Intel SST-PP profiles.
	▪ Intel SST-Base Frequency: Enables some CPU cores to run at a higher base frequency and other cores to run at a lower base frequency.
	▪ Intel SST-Core Power: Allows distribution of power among cores when there is a power constrained scenario.
	▪ Intel SST-Turbo Frequency: For high priority workloads, some cores can be configured to get high turbo frequency in exchange for low turbo frequency for other cores.

Figure 1. Key power management enhancements for Intel Xeon 6 processors that help to increase platform energy efficiency.

Additionally, Intel has developed key software capabilities that further provide workload-based power optimization and intelligent scheduling that make the infrastructure more power efficient. Some of these capabilities are listed below:

Intel® Infrastructure Power Manager

Intel® Infrastructure Power Manager is reference software that dynamically matches runtime server power consumption with data traffic without compromising key performance indicators such as throughput, latency, and packet drop.

"We are excited to partner with e& UAE to build sustainable digital infrastructure. Our collaboration on the modular data center leverages Intel architecture to deliver energy-efficient solutions. By combining Intel's advanced technologies with e& UAE's commitment to sustainability, we are setting a new standard for responsible innovation. Intel remains dedicated to ensuring that technological progress and environmental care go hand in hand."

- Dermot Hargaden, Vice President & General Manager, EMEA Region, Board Member, Intel

Converged Edge Media Platform

Intel® Converged Edge Media Platform is a reference architecture that provides container-based cloud-native foundational capabilities for providers to deploy multiple media services quickly, efficiently, and cost-effectively to capitalize on fast-growing edge computing opportunities.

Intent-Driven Orchestration

Today's main container orchestration engine solutions promote a model of requesting a specific quantity of resources (for example, number of vCPUs), a quantity range (for example, minimum/maximum number of vCPUs), or not specifying them at all for supporting the appropriate placement of workloads. This applies at the cloud and the edge using Kubernetes (although the concept is not limited to Kubernetes-based systems). With Intent-Driven Orchestration (IDO), the end-state for the resource allocation is declared, but that state is an imperative definition of what resources are required. The intent-driven orchestration is aligned with the service-level objectives (SLO)-based telemetry and results in the desired outcome of the intent.

Conclusion

The collaboration between Intel and e& UAE marks a significant step forward in the evolution of sustainable data centers. By leveraging innovative solutions such as modular designs, renewable fuels, advanced liquid cooling, and energy-efficient processors, the partnership offers a blueprint for achieving near net-zero carbon emissions in data center operations. This initiative demonstrates how industry leaders can align sustainability goals with cutting-edge technology to address the environmental challenges posed by the rapid growth of AI and cloud computing.

A key highlight of this blueprint is the integration of Intel Xeon 6 processors, which bring enhanced power management and CPU efficiency to the design. These processors optimize energy usage while maintaining high performance, enabling the data center to handle the demands of AI-driven workloads and cloud applications without compromising environmental objectives. Additionally, the adoption of liquid cooling technology reduces the energy footprint associated with traditional cooling methods.

This modular data center design not only showcases a path to achieving carbon neutrality but also provides scalability and adaptability for future growth. As AI workloads and data-heavy applications continue to expand, this blueprint ensures that sustainability does not come at the expense of operational reliability or performance. The focus on renewable energy sources further reinforces the commitment to reducing greenhouse gas emissions and driving progress toward global sustainability goals.

The joint efforts of Intel and e& UAE demonstrate how collaborative innovation can tackle the dual challenge of increased computing demand and environmental responsibility. By developing this sustainable modular data center, the partnership has set a precedent for the industry, providing a practical, scalable model for others to follow.

"As we continue to lead in innovation and connectivity, e& UAE's collaboration with Intel on the sustainable modular data center is a reflection of our commitment to aligning technological progress with environmental responsibility. Leveraging advanced solutions such as green hydrogen fuel cells, liquid cooling systems, and AI-driven infrastructure, this initiative exemplifies our leadership in sustainable innovation. By addressing the increasing energy demands of AI and cloud workloads, we are not only meeting today's challenges but also paving the way for a greener, smarter future. This project underscores our vision to blend cutting-edge technology with sustainability, reinforcing the UAE's position as a global leader in digital transformation and environmental stewardship."

- Marwan Bin Shakar, A. Chief Technology and Information Officer, e& UAE

About e& UAE

e& UAE is the flagship telecom arm of e& in the UAE, built on a 5-decades legacy of connectivity excellence. Our mission is to deliver world-class superior connectivity experiences that fuel the UAE's future-focused innovation.

Leveraging the latest world-class technologies, e& UAE aims to transform lives and industries, turning every connection into an opportunity for growth and every interaction into a transformative possibility.

We are focused on expanding our core services and digital marketplaces by enriching consumer value propositions that cater to new lifestyles and emerging demands beyond core telecom services, including health, insurance and gaming.

As a trusted enterprise partner, e& UAE continues to power entire industries with 5G and AI, delivering tailored a ecosystem of solutions to meet their connectivity needs and more, empowering them to automate, innovate, transform, and scale.

Strengthening our leadership position as an AI-powered telco, e& UAE delivers seamless connectivity, cutting-edge AI solutions, and sustainable innovation to uplift people and communities, and empower businesses and industries, so everyone thrives in a digital-first world.

To learn more about e& UAE, please visit: https://www.etisalat.ae.

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e& Climate Transition Plan - Ambition to Action (2024-2030)

How technology investment is underpinning e&'s global techco strategy

White Paper 2024 - Unleashing the Power of AI: How e& UAE is shaping the future of AI in telecommunications and beyond

e& unveils GCC Innovation Hub at COP28

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Overview of Intel Power Saving Technologies

Intel: Our Progress Toward Net-Zero Greenhouse Gas Emissions

Intent-Driven Orchestration: Simplifying Cloud and Edge Deployments

Intel Industry Solution Builders

[i] https://www.goldmansachs.com/insights/articles/AI-poised-to-drive-160-increase-in-power-demand
[ii] https://www.mordorintelligence.com/industry-reports/united-arab-emirates-data-center-market?utm_source=chatgpt.com
[iii] https://www.goldmansachs.com/insights/articles/AI-poised-to-drive-160-increase-in-power-demand
[iv] https://www.energy.gov/eere/iedo/energy-efficient-cooling-control-systems-data-centers
[v] Fortune Business Insights. "Artificial Intelligence Market Size, Share & Industry Analysis …." April 2024. fortunebusinessinsights.com/industry-reports/artificial-intelligence-market-100114.
[vi] Fortune Business Insights. "Cloud Microservices Market Size, Share & COVID-19 Impact Analysis …." April 2024. fortunebusinessinsights.com/cloud-microservices-market-107793.

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