

ACTIONABLE INSIGHTS FROM INDUSTRY EXPERTS

GREENER

DATA | VOLUME THREE



FOREWORD BY DEAN NELSON
INTRODUCTION BY JAYMIE SCOTTO CUTAIA

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TWENTY-ONE

Accelerating Data Center Transformation and Sustainability with Prefabricated Modular Solutions

Alick Wan, EPG Data Center Module

As national energy grids strain from the demand of data centers and campus owners struggle to meet ESG performance targets, there is a growing appetite for innovation around how these complex infrastructure projects are conceived, built, and operated. Consequently, we are seeing a move away from traditional, site-based construction to factory-built, prefabricated modules and components. Global research backs this up, predicting that the market size for prefabricated data center solutions will reach \$14.7bn by 2034, rising from a valuation of \$4.4bn in 2024¹.

The buzz around modular construction is not just about faster build times; it represents a structural shift toward sustainability through industrialization. Within this shift, EPG has carved out a distinctive role as both an integrator and manufacturer in the data center value chain, applying industrialized processes to improve asset reliability and environmental performance at the point of construction. This approach is underpinned by sustained investment in R&D, particularly in advanced liquid cooling technologies and a long-term ambition to take PUE to below 1.1.

Prefabricated modular solutions can offer sustainability benefits by reducing on-site waste, energy consumption, and environmental disturbance, while shortening construction timelines from the traditional two

to three years to around 9-12 months, cutting project time by 40-55%, with the potential to deliver further reductions in embodied and construction-related carbon. These modules are standardized and containerized for global transport yet engineered with a high degree of customization to meet specific client, site, and regulatory requirements.

More broadly, prefabrication supports the shift toward reusable materials that are more sustainable, where solutions are designed to evolve into standards, not end at delivery.

Reaping the Benefits of Prefabrication

Beyond speed and scalability, prefabrication is increasingly recognized as a lever for reducing environmental impact across the full data center lifecycle. Six principal reasons are driving the growing demand for prefabricated, factory-built modules:

1. Repeatable, scalable designs enable right-sizing and avoid overbuilding.

Standardized capacity blocks allow operators to deploy infrastructure in line with actual demand, rather than building excess capacity upfront. This has the potential to reduce embodied carbon, minimize idle equipment, and improve long-term energy efficiency, while unified layouts simplify operations and maintenance.

2. A “factory-first” approach reduces waste and rework that may increase on-site emissions.

By shifting labor-intensive activities away from the construction site, prefabrication mitigates labor shortages and congestion between trades, while reducing material waste, installation errors, and the carbon footprint associated with extended on-site construction activities.

3. Controlled factory environments enable higher-quality, lower-impact system integration.

Moving complex system integration into a factory setting allows for repeatable QA/QC processes, Factory Acceptance Testing (FAT), and pre-validated assemblies. This reduces commissioning risk, avoids energy-inefficient rework, and ensures systems operate at designed efficiency levels from day one.

4. Advanced manufacturing improves component durability and operational efficiency.

The use of advanced factory equipment and standardized manufacturing processes enhances consistency and precision. Higher-quality components improve sealing, alignment, and thermal performance, reducing energy losses and extending asset life, which directly supports sustainability goals.

5. Pre-tested solutions simplify regulatory compliance and support regional sustainability requirements.

Factory-built modules can be pre-tested, certified, and customized prior to shipment to meet local regulatory and environmental standards. This reduces on-site modifications, shortens commissioning timelines, and supports more predictable energy and water performance once operational.

6. Lifecycle flexibility reduces stranded assets and supports circular infrastructure models.

Container sizes can be customized for different shipping needs; prefabricated modules can be expanded, reconfigured, or even relocated as business demands change. This adaptability extends useful life, reduces demolition waste, and aligns with circular economy principles by enabling reuse rather than replacement of infrastructure.

Powering the Digital Age with Prefabrication

By organizing infrastructure into clear, standardized product categories, data centers can shift from one-off construction projects to repeatable, manufactured systems. This shift is where sustainability moves from aspiration to execution – enabling predictable performance, lower environmental impact, and scalable growth by design. Enabling this are prefabricated solutions that deliver measurable efficiency, right-sized capacity, and lifecycle flexibility, balancing performance, speed, and environmental responsibility.

Right-size IT Capacity with Integrated Modules and Skids

By integrating racks, structured cabling, monitoring, and ELV systems into different types of modules and skids, IT capacity becomes a standardized, repeatable environment rather than a custom-built room. Right-sizing is much easier with operators able to deploy exactly the number of units required for current demand; scaling incrementally as workloads grow, avoiding the common inefficiency of overbuilding. High-density readiness, including support for GPU clusters and cold-plate liquid cooling, means more compute power can be delivered per square meter, reducing the overall building footprint and carbon per megawatt of IT load.

Make Power Usage Predictable and Reduce Losses

Power infrastructure is one of the most complex and resource-intensive elements of a data center. Prefabrication is a way to consolidate transformers, UPS systems, switchgear, and busbars into pre-engineered units. Electrical efficiency and safety are improved through verified protection coordination, standardized layouts, and FAT.

On site, installation is reduced to positioning and connecting busbars, which lowers error rates and commissioning risk. From an energy perspective, modular power architecture allows operators to match redundancy levels (2N or DR architecture) precisely to business and sustainability objectives, avoiding unnecessary equipment oversizing and associated standby losses.

Mitigate the Environmental Impact of Backup Generators

While diesel generators are traditionally viewed as a sustainability challenge, their environmental impact can be mitigated through modular design. By integrating generators, exhaust, cooling, and fuel systems onto a single steel base, controlled factory assembly and testing are much easier to achieve.

This reduces the need for extensive on-site mechanical work, lowering construction emissions and environmental disturbance. Compliance with recognized emissions standards and efficient transient performance ensures that backup power is delivered responsibly, while modular deployment allows capacity to be scaled in line with actual resilience requirements rather than being installed all at once.

Reap the Environmental Benefits of Prefabricated Cooling Modules

Cooling is where modular product categories most strongly influence sustainability outcomes. Modules provide interoperable building blocks that support air cooling, liquid cooling, or hybrid architectures. Prefabricated cooling stations integrate chillers, pumps, valves, and controls into compact pods with optimized hydraulic and thermal performance. Liquid cooling pipeline skids, designed off-site, reduce material waste and installation complexity.

By supporting extended operating ranges, hot-water liquid cooling, and sequential heat-transfer pathways, these modules enable lower PUE, reduced water consumption, and opportunities for waste-heat recovery. Crucially, prefabrication makes these advanced systems easier to deploy consistently across multiple sites, as opposed to siloed, bespoke, high-risk designs.

Achieve Architectural Sustainability by Design

Beyond individual modules, fully prefabricated AIDC (AI Data Center) and IDC (Internet Data Center) solutions can combine into a holistic, sustainable architecture. AIDC zones are the bigger challenge, having to integrate IT, power and cooling pods into repeatable reference

designs that address extreme rack densities while maintaining efficiency and reliability.

Features such as hybrid air-liquid cooling, integrated cooling sources, magnetic levitation refrigeration and waste-heat recovery are not add-ons but embedded into the modular system design. This ensures sustainability is addressed at the architectural level, not retrofitted later at higher cost and risk.

Advanced Customization and Precision Engineering

Prefabricated solutions enable greater customization because modules can be manufactured to the exact requirements of the customer. And because they are manufactured in controlled factory environments, components can benefit from precision engineering that is hard to achieve on a construction site.

The strength of prefabricated cooling systems, for example, lies in the manufacturer's ability to design and deliver modules that incorporate whichever solution – or combination of solutions – the customer requires. By engineering ceiling-mounted, under-floor, or hybrid arrangements into pre-assembled skids, cooling solutions can be precisely aligned to the technical needs, site condition, and architectural priorities, rather than forcing a one-size-fits-all design.

Rack density may be the deciding factor. With greater densification expected in the future because of AI and HPC (High Performance Computing), data centers often default to overhead prefabs, because it's easier to add in-row cooling and liquid-assisted systems. Prefab overheads also tend to win if time is an issue, because they are usually easier to install. Underfloor and raised floor works best when the owner is not chasing density escalation, when the priority is operational stability over future flexibility.

Where data centers have a high level of customization or local compliance requirements, a risk-aware path to deployment works best, starting with factory prefabrication and testing, followed by a controlled on-site pilot before full-scale deployment. Prototyping, compatibility testing, and safety planning should be treated as integral parts of the process, not an afterthought. Most EPG projects do not require a

prototype-testing and approval; they just go into production when design is finalized.

Lower PUE can also be achieved through prefabricated system-level integration. Unlike standard builds where cooling is often "bolted on," prefabrication allows for a hybrid liquid-cooling system to be integrated directly into the architecture. Modules are made in a controlled factory environment, enabling HVAC and electrical pathways to be optimized to a level that's nearly impossible on a construction site. By combining modules with EPG's Intelligent Energy Management System (I-EMS), we have been able to reduce overall energy consumption by 15%-20% and use microgrid controls to ensure the system maintains thermal stability and minimal electrical inefficiency.

Another benefit of prefabrication is precision. Factory prefabrication with tight tolerance control ($\leq \pm 2$ mm) replaces on-site assembly variability, improving construction accuracy by approximately 60%. This translates directly into greater mechanical stability and long-term reliability for the infrastructure.

Innovation in manufacturing becomes a major differentiator, particularly when deploying liquid-cooled, high-power AI infrastructure racks. Welding stability, for example, directly affects sealing performance, vibration tolerance, and long-cycle availability. Last year we activated our first non-standard automated welding line, a key step in upgrading the quality and predictability of our global manufacturing system. By bringing weld qualification rates above 95% with reduced variance, we make sure large modules can endure long-distance sea transport, high-salinity climates, and always maintain the same level of performance.

Supporting the Development of Green Computing Infrastructure

Rising AI and high-performance computing densities are forcing a fundamental rethink of how sustainable data center infrastructure is designed and delivered. Performance, resilience, and environmental responsibility must now be addressed together, through approaches that consider the full infrastructure lifecycle.

Modular, industrialized design supports this shift by reducing

construction-related emissions, improving operational efficiency, and enabling scalable growth without overbuilding. At higher power densities, structural reliability becomes a first-order design variable, directly influencing efficiency, cost, and sustainability – particularly as liquid-cooled architectures move into the mainstream.

Ultimately, sustainable digital infrastructure will depend less on individual technologies and more on system-level, industrialized design that integrates performance and environmental outcomes by default. As demand for AI-ready data centers accelerates, this model is becoming essential to delivering efficiency, resilience, and sustainability at scale.

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1. InsightAce Analytic. Prefabricated and Modular Data Centers Market. <https://www.insightaceanalytic.com/report/prefabricated-and-modular-data-centers-market/2965>

About the Author

ALICK WAN

As Founder and Chairman of EPG Group, Alick Wan has more than 20 years of experience in the data center and power systems industries.

He founded EPG in 2004. By 2014, the company had grown into a leading integrated provider of backup power systems. In March 2021, he established EPG Integrated Equipment (Shanghai) Co. Ltd., where he serves as Chairman, further advancing the company's capabilities in integrated data center solutions. As the organization has expanded rapidly, Alick has also remained committed to strengthening its internal governance and operational standards, continuously guiding EPG toward more sustainable, responsible, and structured growth.

Over the course of his career, Alick has focused on the continuous development and optimization of data center products and solutions. His work has contributed to reshaping traditional approaches to data center construction, emphasizing efficiency, system integration, and long-term performance. With deep industry expertise and a forward-looking perspective, he is committed to promoting green and low-carbon data center development, supporting the industry's transformation and sustainable growth.

Since the beginning of his entrepreneurial journey, Alick has recognized the importance of ESG principles, consistently advocating environmentally responsible and low-carbon solutions in IDC construction to create sustainable value for both the industry and society. In recent years, he has further extended this commitment beyond the business sphere by actively engaging in philanthropy and public welfare initiatives, leveraging his leadership and influence to advance corporate social responsibility efforts and support communities in need.

Greener Data: Volume Three is a timely, industry-driven guide to advancing sustainability across digital infrastructure—from data centers to global networks.

Featuring insights from leaders across the ecosystem, this volume explores how we scale responsibly in the age of AI.

Visit GreenerData.net to learn more and purchase the full book on Amazon.