ACTIONABLE INSIGHTS FROM INDUSTRY EXPERTS

GREENER DATA

VOLUME THREE

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From Energy Consumer to Energy Contributor: The Circular Future of the Data Center

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For decades, data centers have been designed around an unwavering principle requirement: reliability. Every watt consumed, and every system engineered, served a single goal — uptime. Cooling, power, and compute systems were built in isolation, optimized within their silos but rarely in concert. The result was infrastructure that worked flawlessly, yet operated inefficiently, consuming vast amounts of energy and water that simply vanished as waste heat.

That model no longer fits the world we live in. As artificial intelligence (AI) and high-performance computing (HPC) reshape industries, the thermal intensity of data centers is soaring. Modern processors for accelerated computing draw hundreds or even thousands of watts each, turning that energy into heat. The question is no longer how to get rid of it—it's how to use it. Efficiency, once a narrow operational metric, has evolved into a strategic capability. Additionally, sustainability is no longer just about consuming less; it's about contributing more.

The next generation of data centers is emerging as part of a circular ecosystem — combining systems that capture the energy from the waste heat created, reuse it, and return it to the grid or community. When designed as unified, intelligent infrastructures, these facilities can transform from silent power consumers into active participants in the global energy transition.

From Waste to Resource

Practically speaking, every watt of electricity that drives computation becomes an equal watt of heat. For decades, that heat energy was considered waste — an unavoidable byproduct of progress. But what if heat itself could become a resource?

The answer lies in heat reuse: a concept that treats waste energy as an asset. Power feeds compute, compute generates heat, and that heat, when captured effectively, powers something else — buildings, processes, or even new electricity generation. In this model, the data center becomes a continuous energy loop rather than a wasteful one-way system of consumption and rejection.

The most promising advances in this field begin at the chip level. The closer we capture heat to its source, the higher its quality and the greater its potential for reuse.

Two-Phase Cooling: Efficiency at the Source

Traditional air and liquid-cooling systems are reaching their limits under the pressure of AI-scale compute. Fans, chillers, and compressors consume enormous amounts of energy to move and condition air, and conventional liquid cooling still requires significant pumping and temperature management.

Two-phase, direct-to-chip, pool-boiling cooling changes the equation. In this system, a coldplate filled with a dielectric fluid is placed in direct contact with the chip. This fluid vaporizes as it absorbs heat. That phase change from liquid to vapor carries away vast amounts of energy with exceptional efficiency. The vapor then travels to a condenser, releases its heat, and returns to liquid — closing the loop with minimal energy input.

Because boiling occurs at a constant temperature, the chip remains in an almost perfectly isothermal environment, maintaining consistent performance even under fluctuating workloads. This stability not only extends hardware life but also produces a predictable thermal output.

Two-phase cooling doesn't just prevent overheating — it turns cooling into a thermal engine. The very mechanism that protects the hardware now becomes the foundation for sustainable energy reuse.

Heat Recovery and Natural Flow

Once captured, that energy can be reclaimed with remarkable simplicity. The vapor generated during cooling naturally flows — without pumps or compressors — to a CDU (Coolant Distribution Unit), where it condenses and releases its stored energy through a heat exchanger. Gravity or low-power pumping returns the liquid to the chips only at the rate that the fluid is evaporating, demonstrating an on-demand, only when needed cycle.

This elegant thermodynamic loop enables new forms of energy recovery. By integrating with methods that can harness hot vapor such as Organic Rankine Cycle (ORC) or other thermoelectric systems, the recovered heat can generate electricity within the data center. Alternatively, it can feed district heating, warm adjacent buildings, or power agricultural systems like greenhouses and aquaponics.

In each case, the heat once lost becomes useful work. The data center transforms from a passive consumer of power into an active producer — a dynamic, every-ready energy resource of the local grid.

Waterless Cooling and Environmental Independence

Energy is only part of the sustainability equation. Water is fast becoming the other vital resource. Traditional evaporative cooling systems, long valued for their efficiency, are increasingly untenable in a world facing drought and water regulation. A hyperscale data center can consume millions of gallons daily just for heat rejection.

Paired with dry-cooler systems, two-phase cooling achieves complete water independence (WUE = 0). Closed-loop heat rejection eliminates evaporation, chemical treatment requirements, and biological growth concerns, while simplifying maintenance and regulatory compliance. The system's compatibility with hot or arid climates also expands where sustainable data centers can be built.

Combined with its ability to achieve ultra-low Power Usage Effectiveness (PUE < 1.05), two-phase cooling delivers a rare alignment: high performance, low energy, and zero water consumption. Sustainability is no longer a compromise — it's engineered into the design itself.

Integration Over Isolation

The success of energy reuse depends on breaking down silos between systems that have traditionally operated independently. Cooling, power distribution, and compute management must become interconnected functions, guided by a shared control and data layer.

As an integrated approach emerges, the various domains of power, cooling, and compute have an opportunity to find new operational optimization points and dynamically realign these optimization points to achieve a desired outcome. Whether it's maximum performance or maximum energy efficiency, this integration allows thermal and electrical subsystems to respond dynamically to workload changes. AI-driven control systems can forecast thermal loads, redirect cooling, and adjust heat recovery targets in real time. The result is an adaptive environment that continuously optimizes its operation for the desired outcome, especially efficiency. In this paradigm, efficiency emerges not as a static design metric but as a living process — one that evolves with the compute it supports.

Economics that Reward Sustainability

For efficiency to scale, it must make business sense—and it does. Data centers that integrate heat recovery can improve Energy Use Effectiveness (EUE) by 10–15% and achieve capital payback within three to five years. In dense urban regions, where heat reuse offsets municipal or industrial heating, the returns are even faster.

As global carbon markets mature, every kilowatt-hour of reused heat translates to verifiable reductions in Scope 3 emissions, unlocking tax credits, regulatory advantages, and ESG recognition. Sustainability ceases to be a moral imperative alone—it becomes a financial performance driver.

Proven Technologies, Real Results

The shift from theory to practice is already happening. ZutaCore, in collaboration with Munters, has commercialized closed-loop, two-phase systems that capture high-grade heat from chips and reject it efficiently without water. ZutaCore's platforms have cooled GPUs exceeding 2,500 watts each while maintaining PUEs between 1.05 and 1.07, proving that performance and sustainability can coexist.

Industry pioneers such as SoftBank and Foxconn are incorporating these technologies into large-scale deployments, establishing a new standard for high-density, low-environmental-impact computing. These examples illustrate that energy circularity isn't a futuristic concept—it's an achievable reality, shaping the architecture of the modern data center today.

From Silent Consumer to Visible Contributor

Historically, data centers have been invisible, monolithic facilities consuming energy behind secure walls. The next generation will be visible contributors to their communities. By redistributing recovered heat to schools, residential complexes, or local industries, data centers can directly support the sustainability of the regions they inhabit.

This shift changes perception as much as performance. A data center that gives back heat or power is not just efficient — it's participatory, part of the civic energy fabric. Efficiency, in this new light, is not simply a technical measure but a social contract: proof that digital infrastructure can coexist with environmental stewardship and community resilience.

Toward the Net-Positive Data Center

All these advances point toward a single outcome: the net-positive data center — one that produces more value than it consumes. Such a facility cools without water, reuses every watt of heat, and generates part of its own power. Its systems are orchestrated by AI, ensuring that no energy is wasted and every output has purpose.

This is more than optimization — it's transformation. When cooling, compute, and power form a closed loop, data centers stop being endpoints of consumption and become engines of regeneration. Each watt serves multiple purposes, cascading through the system in a continuous flow of value.

The goal is not merely to reach carbon neutrality, but to go beyond it — to turn digital infrastructure into a net contributor to the planet's energy balance. That is the essence of circular sustainability: not to reduce harm, but to expand benefit.

Conclusion: The Circular Future of Compute

The data center has always been the heart of the digital world. Now it must become its conscience. By unifying thermal, electrical, and digital systems into one intelligent ecosystem, we can transform one of the planet's most resource-intensive infrastructures into one of its most regenerative.

When energy consumption becomes energy contribution, efficiency evolves from a constraint into a catalyst. Every watt of power, every degree of heat, every drop of water becomes part of a larger equation — one that balances technological advancement with environmental renewal.

The circular data center represents more than a technical breakthrough; it's a philosophical one. It proves that digital progress and planetary health can advance together. As we design the infrastructure that powers the world's intelligence, we also design the systems that will sustain it.

The data center of the future will not just run the digital economy — it will help power a sustainable one.

Resources

1. "Harnessing Data Center Heat into Reusable Energy: A Sustainability Game Changer." *HPCwire*, August 19, 2025.
2. "Marching Towards Zero PUE in AI Factories." Manfreid Chua, *ZutaCore Blog*, January 8, 2025.

3. "Data Centers Are Getting Thirsty: The Drive for Waterless Cooling." *ZutaCore Blog*, October 14, 2024.
4. "Next Wave of AI Growth Is Here and ZutaCore Is Expanding," *PR Newswire*, April 15, 2024.
5. ZutaCore–Munters Collaboration on Two-Phase Cooling Architecture, *ZutaCore Blog*, 2025.

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Manfreid Chua is Vice President, Business Development – AI & Sustainability at ZutaCore, where he leads the strategic direction and partnerships bridging advanced cooling, AI infrastructure, and climate accountability.

Prior to joining ZutaCore, Manfreid spent 27 years at Intel in leadership roles across sales, marketing, operations, and product planning. His most recent role at Intel was Global Director of Strategic Business Development for Product Sustainability in the Data Center & AI (DCAI) group, where he developed and executed engagements to reduce carbon, water, and waste footprint across Intel's data center ecosystem. He has also held regional leadership assignments spanning Asia, Europe, and North America, combining technical vision with operational discipline.

Manfreid holds a B.Sc. from Carnegie Mellon University and an MBA from Thunderbird School of Global Management. He is deeply committed to evolving data center design from infrastructure cost centers toward nodes of energy circularity, and he frequently contributes to industry forums and publications on sustainable cooling and energy reuse strategies.

About the Author

ALISON DEANE, ZUTACORE

Alison Deane is Vice President of Marketing at ZutaCore, where she leads global marketing strategy, driving brand positioning and go-to-market execution for advanced waterless liquid cooling solutions supporting AI and data center infrastructure.

Prior to joining ZutaCore, Alison held senior global marketing leadership roles at Borland, Data Domain (EMC), and Datrium (VMware), where she developed and executed strategic marketing programs across enterprise technology markets. She brings deep expertise in product marketing, demand generation, partner ecosystems, and brand development across SaaS, storage, and developer-focused solutions.

Alison is focused on advancing AI-driven infrastructure and enabling more sustainable, high-performance data center solutions through innovative, energy-efficient cooling technologies.

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.