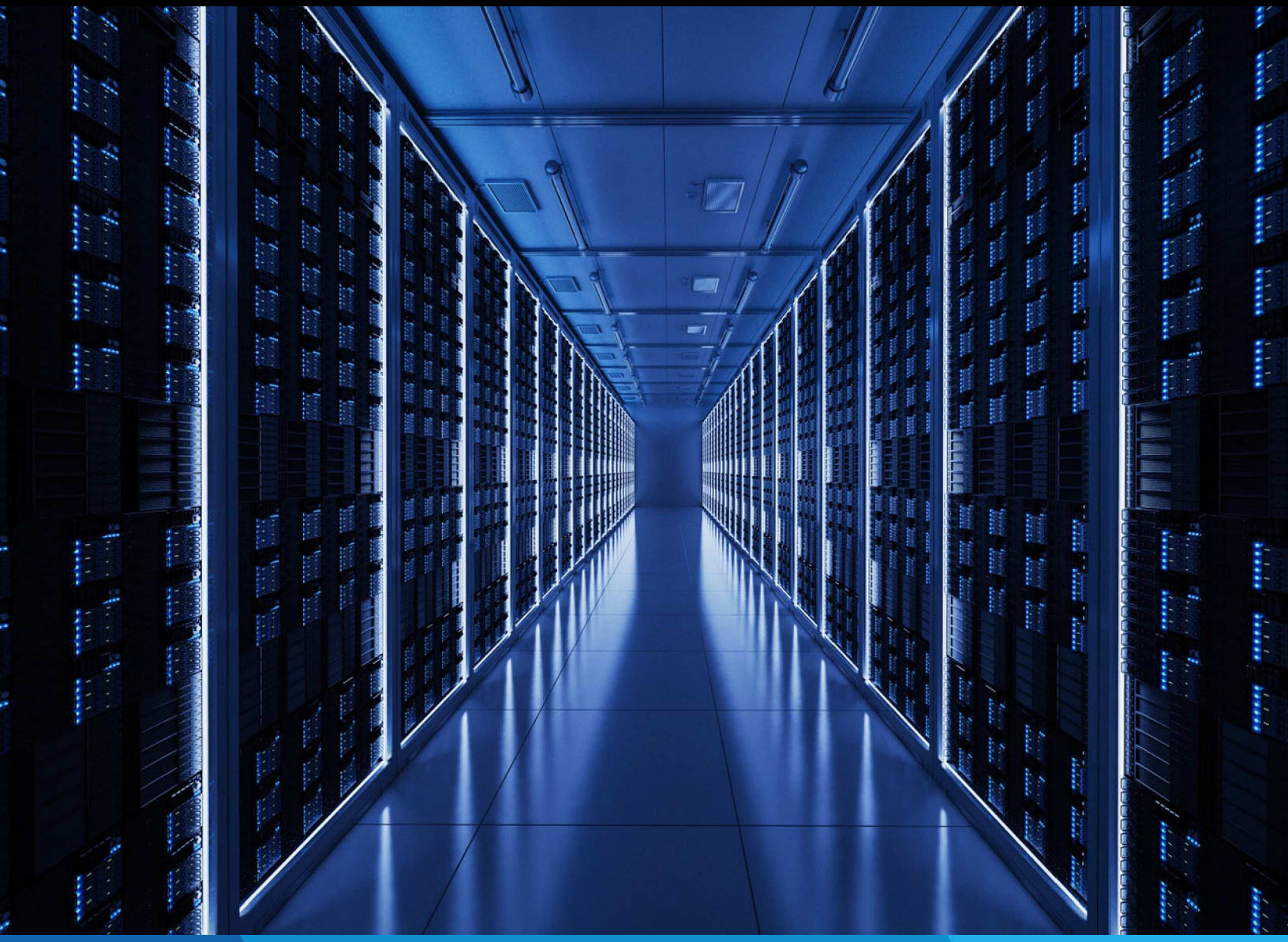
jetcool

Drive Faster Compute Sustainably with Microconvective Cooling®

How Microconvective Cooling® Technology Provides Future-Ready Flexibility Meeting Data Centers Where They Are Today



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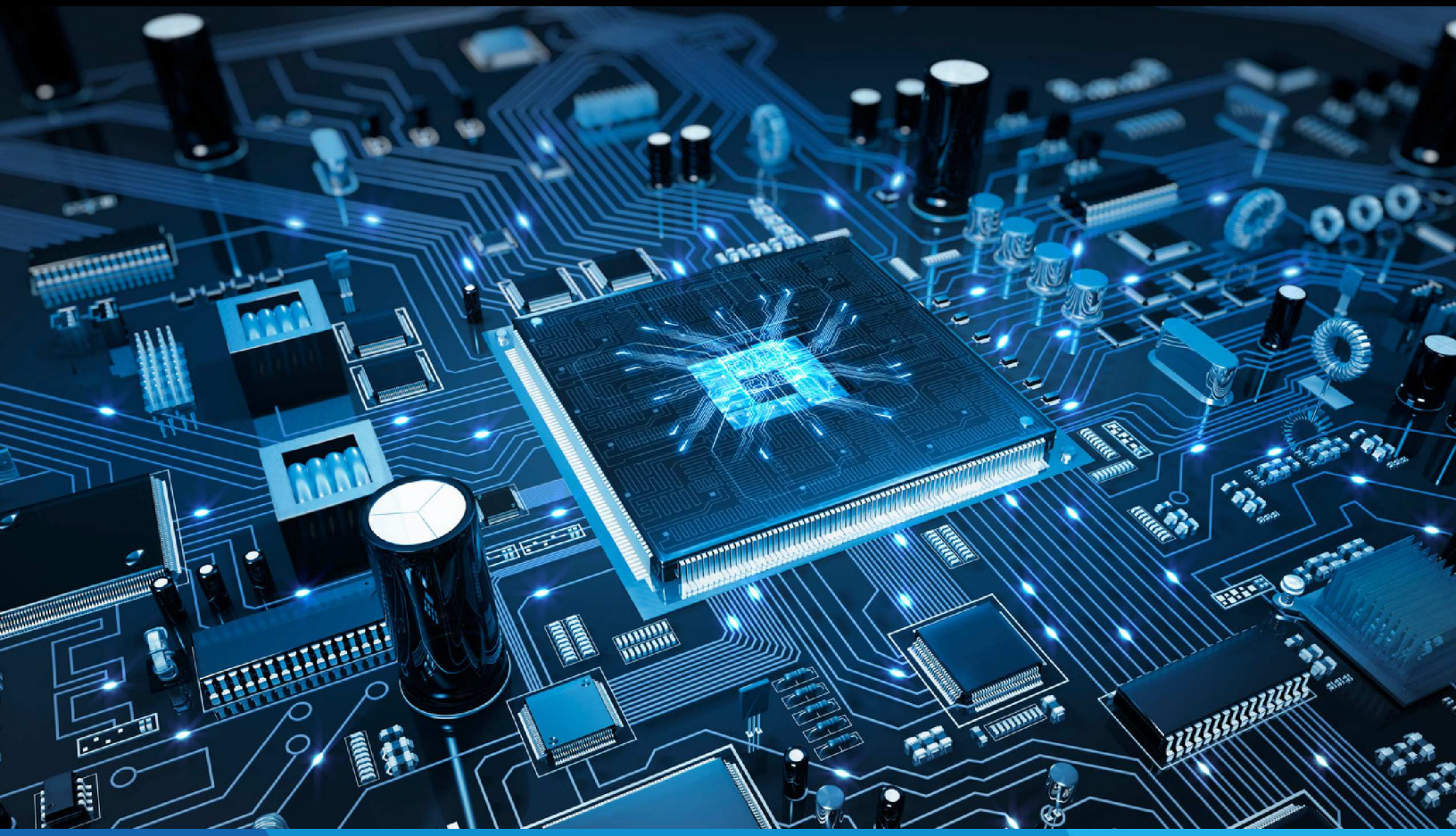


State of the Data Center

Data centers have become a critical part of our global infrastructure, and their importance is only increasing as we become more reliant on digital technologies.

"In this white paper, we will explore the state of liquid cooling while discussing how widespread adoption of microconvective cooling® in the United States could save up to 11.1BkWh in electricity and 150 billion liters of water per year while averting 35 million metric tons of CO2 emissions globally."

Executive Summary

Data centers have become a critical part of our global infrastructure, and their importance is only increasing as we become more reliant on digital technologies. By 2025, the global volume of data will reach 175 zettabytes (ZB), which is ten times the amount of data generated in 2016 [1]. This increase in data volume is being driven by a wide range of factors, including the growth of the Internet of Things (IoT), the rise of artificial intelligence (AI), and the expansion of streaming services such as Netflix and Amazon Prime. In order to keep up with demand, data centers must become more efficient in their use of energy and resources. The traditional data center model, which relies on air cooling to remove heat from servers and other equipment, is no longer sufficient. These hubs of internet traffic consume vast amounts of energy and water, with the associated carbon emissions negatively contributing to climate change. According to the United States Department of Energy, data centers in the United States consume 2% of national electricity and have a carbon footprint equal to 2% of worldwide emissions[2].

In conjunction with the increase in data consumption, semiconductor manufacturers are developing smaller devices with denser circuitry pattern capabilities. This new generation of powerful chips, such as those used in artificial intelligence (AI) and cryptocurrency mining, can consume up to four times the amount of power as traditional chips. The result of these trends is that data centers are being asked to do more with less – compute faster while using less energy.

Recognizing the need for sustainability in data centers, many government agencies and leading technology companies have established sustainability goals for data center operations. To meet these goals, a variety of technologies will have to be implemented across all elements of data center infrastructure. Data center cooling is one such element. With better cooling technologies and architectures, significant savings may be realized in energy usage, water usage, and carbon footprints.

In this white paper, we will explore the state of liquid cooling while discussing how widespread adoption of microconvective cooling® in the United States could save up to 11.1BkWh in electricity and 150 billion liters of water per year while averting 35 million metric tons of CO2 emissions globally. Information in this whitepaper was collected from JetCool commissioned surveys and external research, as footnoted.

Power Density is Rising

The Shift to Liquid Cooling

Rack power densities in data centers have grown substantially. After a decade of plateaued chip power, new processor chips in AI and ML applications have TDPs (thermal design power) that exceed 500W[3]. Higher power chips mean power densities can reach 30kW per rack, with some facilities pushing past this number. To maintain optimal equipment performance and prevent downtime, data center operators must ensure their cooling systems can handle increased power densities.

One way to increase cooling capacity is to increase the airflow rate. Forced air over passive heat spreaders and cooling fins that dump waste heat into a facility's hot aisle has been the 'go-to' data center thermal management strategy. However, this method is not energy efficient as it requires more fans and consumes more electricity. Additionally, it does not scale well for very high power densities.

Types of Liquid Cooling Solutions

While dielectric liquid immersion has made a splash in industry headlines, it requires a significant data center infrastructure change, and it's uncertain how many future TDP generations it will be able to cool.

Cold plates, on the other hand, are an easier transition from forced air with less disruption to the existing facility layout and operations. They also offer a cooling roadmap for multiple generations of high-power density devices. Designed using low thermal impedance material such as copper or aluminum, cold plates sit on top of the high TDP semiconductor device. The thermal energy generated by the underlying semiconductor device is initially extracted through conduction into the cold plate body and then carried away by the convection of the cooler liquid stream that is continuously pumped through the plate's internal manifold. While this basic cold plate description represents a general category, there are dramatic differences between vendor designs that can greatly affect the cooling performance and market acceptance.

Liquid Cooling Enables Faster Compute

Liquid cooling is not a new technology, but its use in data centers has been limited largely to high-performance computing (HPC) applications, where the need for speed has outweighed other considerations. However, that is changing, as liquid cooling is now being recognized as a key enabler of both faster data center performance and increased sustainability.

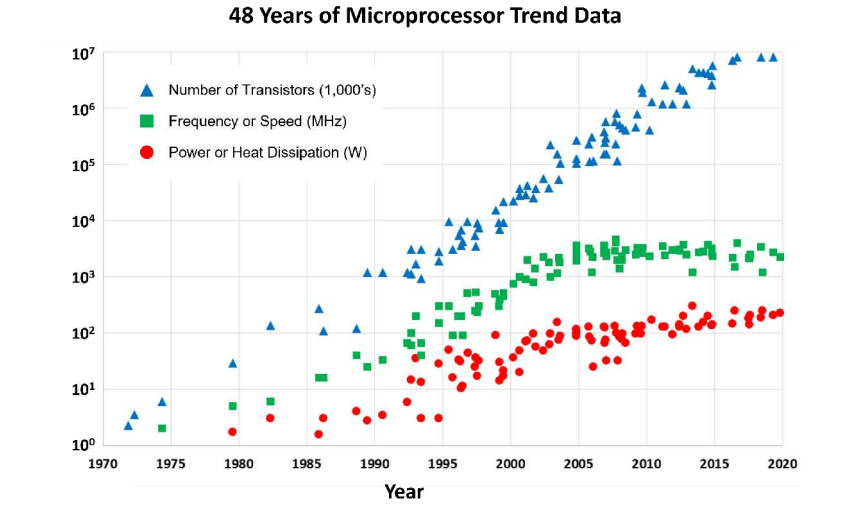


Fig.1: 48 Years of Microprocessor Trend Data; Data from Karl Rupp [4]

Liquid Cooling Survey Results

Liquid Cooling Adoption Accelerates

In the 2022 Uptime Institute survey, "Data Center Liquid Cooling; Major Power and IT Outages," respondents were asked about their plans for liquid cooling. The results showed that 61% of respondents do not use direct liquid cooling (DLC) but would consider using it in the future [4]. **A telling sign of industry interest, more than three-in-five operators who don't use DLC today are considering it for future data center designs.**

The data from Uptime Institute is substantiated by JetCool's "Data Center Trends: Liquid Cooling Adoption" survey, which sought opinions on the future of liquid cooling and gathered remarks from 42 data center experts employed by an original equipment manufacturer (OEM), original design manufacturer (ODM), or system integrator (SI). According to the survey, **71% of respondents require higher power processors in the next year, with 36% stating that the highest TDP chip in the next 12 months will exceed 500W.** This power density increase directly impacts cooling strategies, with **57% of respondents stating that liquid-cooled devices are on their product roadmap in the next year.**

The primary reasons for early adopters of in-rack liquid cooling were to improve operational efficiency and increase rack power density, but they are no longer the only considerations.

Does your business require the use of higher power processors in the next 12 months?

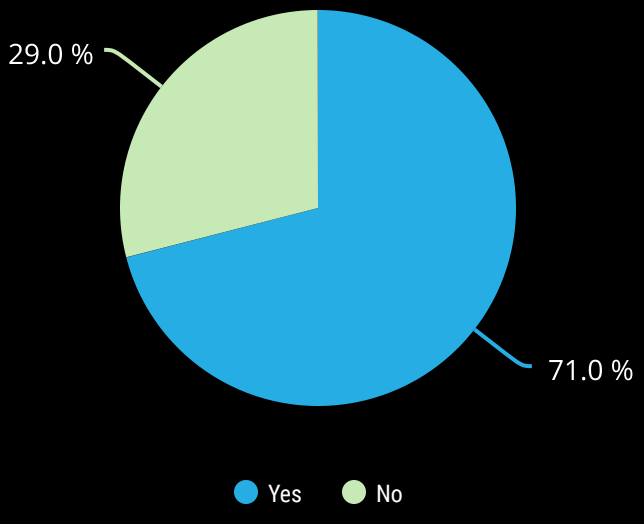


Fig. 2: JetCool's Data Center Trends - Liquid Cooling Adoption Survey Results Depicted in Pie Chart
Base: All respondents, 2022 (n= 42)

What's the power level of your highest TDP chip in the next 12 months?

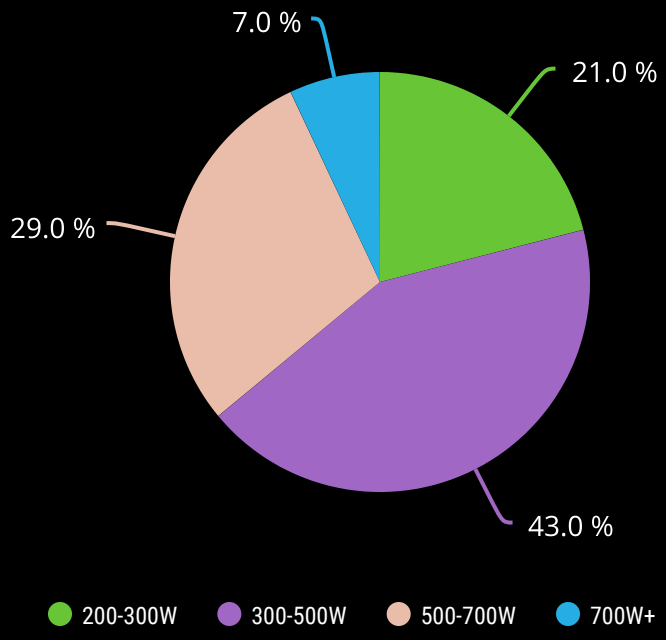


Fig. 3: JetCool's Data Center Trends - Liquid Cooling Adoption Survey Results Depicted in Pie Chart
Base: All respondents, 2022 (n= 42)

Liquid Cooling Survey Results

Sustainability Critical to Adoption

Sustainability has become a key factor in the adoption of liquid cooling technology. In JetCool's "Data Center Trends - Liquid Cooling Adoption" survey, when asked which factors are most important when selecting a liquid cooling solution, respondents cited cost (64%), sustainability (60%), maintenance (40%), and simplicity, ease of installation (38%) as the top key factors to consider when adopting liquid cooling. Participants searching for new liquid cooling solutions expressed interest in a compact, simple, low-maintenance system that meets both high-density and sustainability requirements. Based on this market research, JetCool developed a simple, scalable, and sustainable in-rack direct-to-chip (D2C) closed-loop water cooling solution - without the infrastructure hassles.

Which factors are most important when choosing a liquid cooling solution (choose all that apply)?

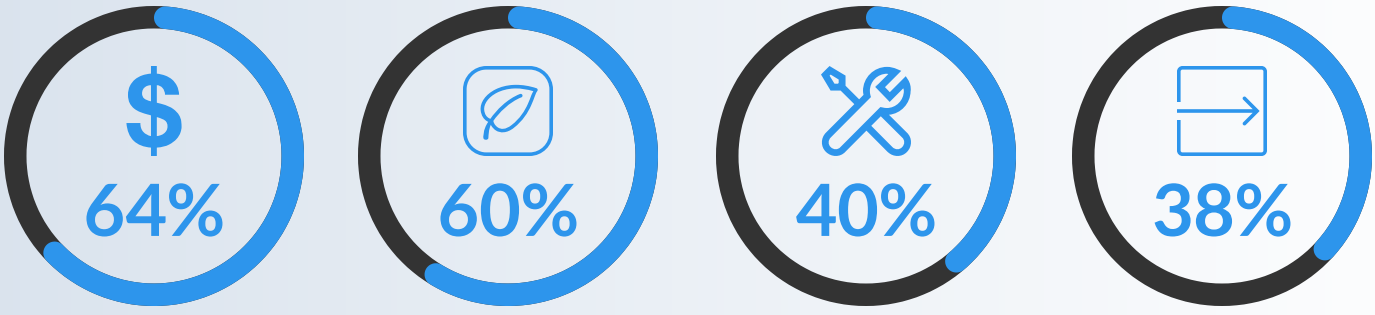


Fig. 4: Representation of the top four responses to the question, "Which factors are most important when choosing a liquid cooling solution (choose all that apply)?"
Source: JetCool's Data Center Trends - Liquid Cooling Adoption Survey
Base: All respondents, 2022 (n= 42)

Microconvective Cooling®

Unrivaled Liquid Cooling Solution for Data Centers

Driving Data Center Capabilities Further

JetCool Technologies has integrated its Microconvective Cooling® technology into a **novel cold plate design with performance advantages for today's data center, HPC, and AI applications demonstrating extensibility beyond 1,000 Watts TDP.** This is accomplished by aiming an array of small fluidic nozzles to directly impinge on an integrated packaging lid. The bottom of this cold plate module is also the de facto device's packaging lid. This architecture mitigates thermal resistance by reducing the conductive heat transfer path through unwanted materials and pastes from the power source to the cold plate's fluid transport. The advanced fluid dynamics from microconvective cooling® create unmatched heat transfer coefficients with direct impingement specifically targeting hotspots (Figure 8).

Better Physics

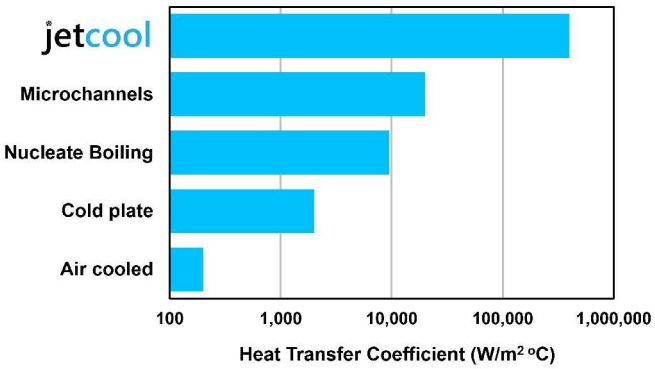


Fig. 5: Comparison of JetCool Liquid Cooling to Competing Cooling Technologies

Better Architectures

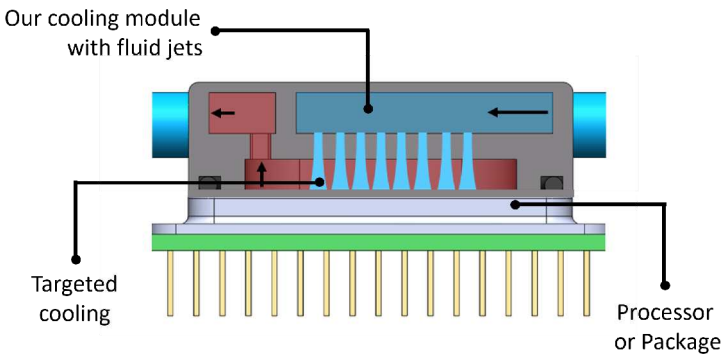


Fig. 6: Graphic of the inner architecture of the SmartPlate module

SmartPlate

Simple, Scalable, and Sustainable Liquid Cooling for Data Centers

SmartPlate: The Most Efficient Liquid Cooling

SmartPlate uses intelligent coupling to target the heat source on an integrated lid with microconvective cooling® and deliver the highest cooling performance and reliability for demanding applications. The thermal efficiency advantages of the SmartPlate provide a performance margin that can be applied to a data center's key objectives. For instance, a facility may focus on reducing its carbon footprint and water consumption. These sustainability goals can be realized by operating the SmartPlate at an elevated inlet temperature, negating the need for chilled inlet water or costly outdoor evaporative heat exchangers. Alternately, if maximizing server processor lifecycle, one could choose to run the processor at the lowest temperature possible.

Some HPC applications require the processor to be pushed to its limits and require the extra cooling margin available when driving these systems with high power. These operating regimes are often impossible with standard cold plates or immersion tanks. SmartPlate delivers premier performance and superior sustainability for the most advanced data center, HPC, and AI semiconductor systems.

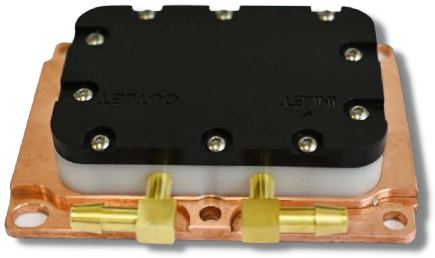


Fig. 7: Image of the SmartPlate Cooling Module

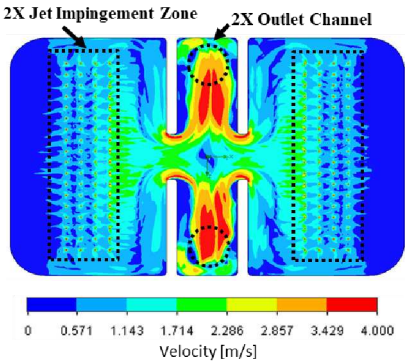
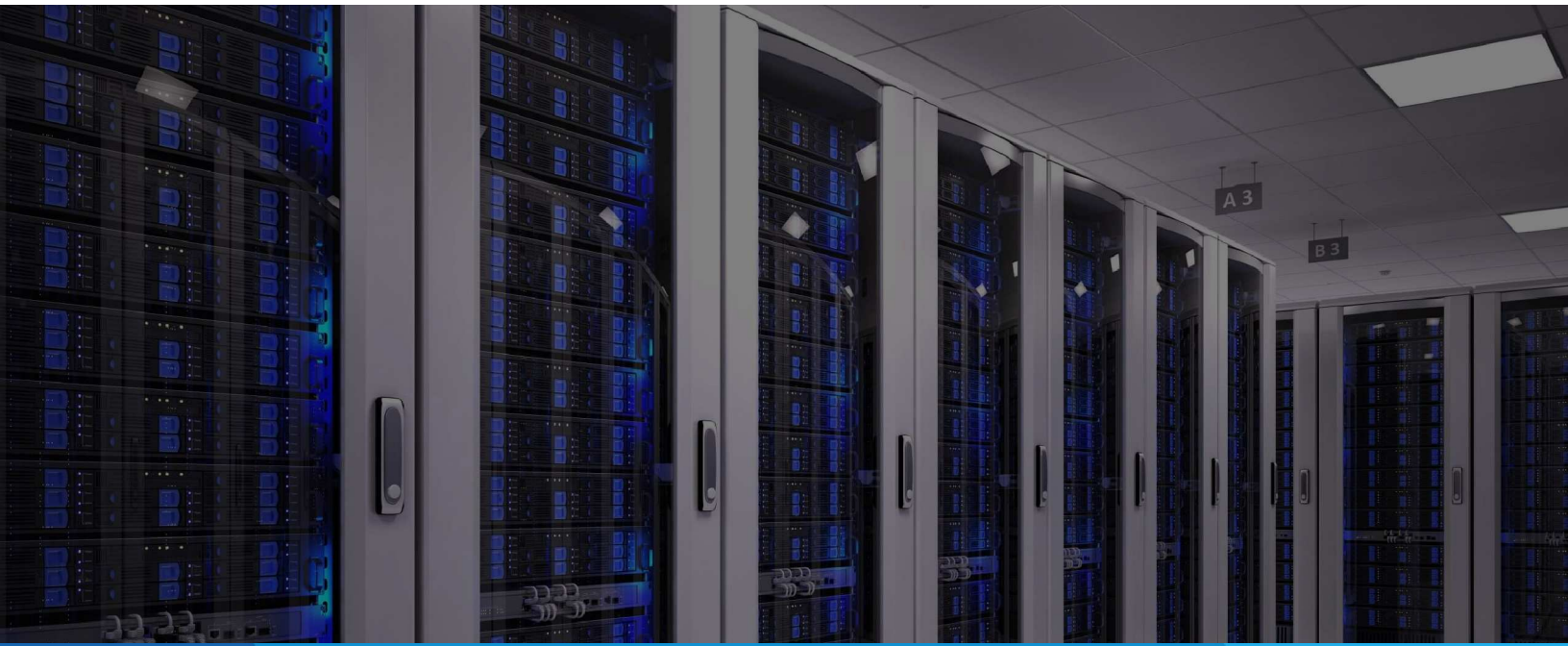


Fig. 8: Image of the cut section taken above the no-slip zone of the impingement surface of the JetCool cooling module. The microconvective cooling® arrays are located over the four core chiplet dies of the CPU.



SmartPlate

Simple, Scalable, and Sustainable Liquid Cooling for Data Centers

Performance and Sustainability Gains

SmartPlate performance was tested against a leading manufacturer's copper microchannel cold plate, delivering a 3X reduction in thermal resistance. The test was performed (Figure 9) on an Intel Xeon Platinum 8268 processor using a PG25 coolant. Such a significant improvement in thermal resistance is a major step toward driving performance in higher TDP processors.

Furthermore, because of efficient flow dynamics and hot spot targeting, SmartPlate achieved these performance levels with less pumping power than the competition, providing a more sustainable solution. SmartPlate not only improved performance but also produced sustainability gains.

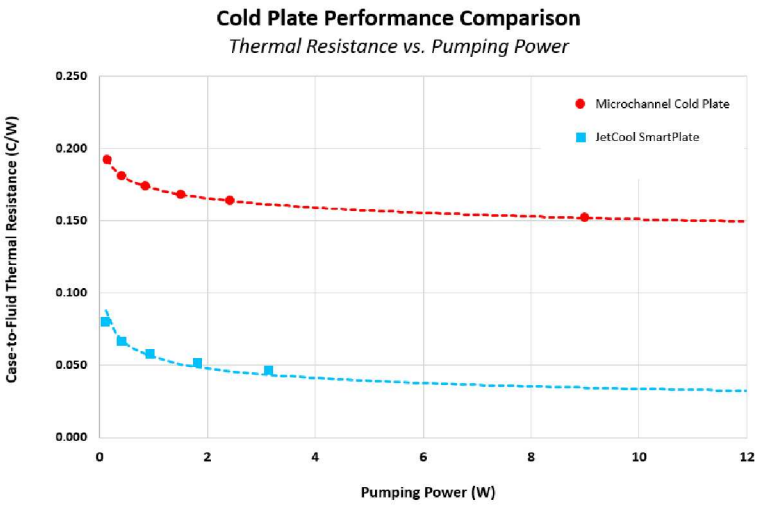


Fig. 9: Cold Plate Performance Comparison Chart

Use Case: Data Center Deployments

A US national laboratory that operates data centers for mission-critical applications, including cyber security and nonproliferation, was tasked with coming up with a more sustainable liquid cooling solution to manage the rapidly growing heat loads associated with their intensive computing workloads.

JetCool's SmartPlate technology was chosen to meet these aggressive compute and sustainability goals. Leveraging SmartPlate liquid cooling technology, the data center's servers could be adequately cooled while eliminating the need for evaporative cooling, with outdoor ambient air temperatures up to 125°F. Eliminating the need for evaporative cooling can save up to 10,000 gallons of water per day for each MW of compute.

Fig. 10: SmartPlate technology in a server system

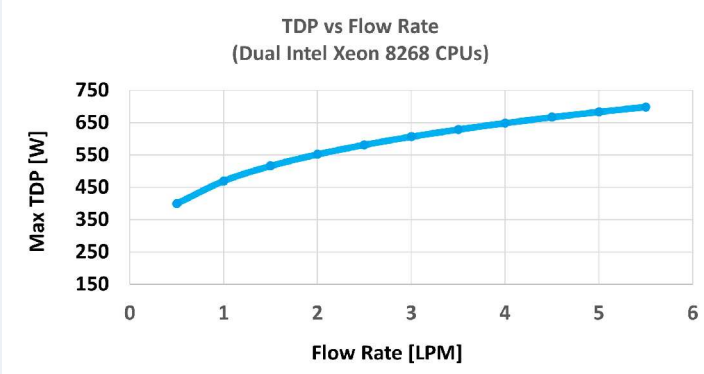


Fig. 11: TDP vs. Flow Rate Chart

SmartPlate

Simple, Scalable, and Sustainable Liquid Cooling for Data Centers

SmartPlate Drives Performance and Sustainability Initiatives

SmartPlate has a tremendous effect on sustainability in data center applications, eliminating the need for evaporative cooling and its associated water consumption. This not only conserves freshwater resources but also reduces the load on local wastewater treatment facilities. Using SmartPlate, **data centers can achieve a 90% reduction in water usage, and an 18% lower electricity consumption, averting 35M metric tons of CO2 emissions annually.**

SmartPlate's cutting-edge technology and plug-and-play architecture allow data centers of all sizes to meet their unique demands. SmartPlate, which can cool processors with over 1,000W of heat dissipation, delivers unrivaled thermal performance in a tiny footprint. SmartPlate is a cost-effective alternative for data centers because it eliminates the need for chillers and cooling towers and doesn't require a facility cooling hookup. This direct-to-chip in-rack liquid cooling solution meets data centers where they are today.

SmartPlate Performance Comparison

	JetCool	Immersion	Air
Chip Temperature	39 °C	44 °C	68 °C
Fluid Cost per MW	$1,200	$45,700	$0
Cooling Energy per MW	33 kW	72 kW	283 kW
Portable	Yes	No	Yes

Fig. 12 :Comparison chart of JetCool's SmartPlate, Immersion, and Air Technologies

Achieve Your Sustainability & Performance Goals with JetCool

37%
Cooler Operation

Our simple water cooling system easily outfits your processors with a **fully-sealed, drop-in replacement cooling solution that lowers chip temperature 37%.**

30%
Faster Compute

You're pushing the limits of performance. We can help you achieve those benchmarks by extracting **30% faster processing** and support for **TDP over 1,000W.**

50%
Less Energy

Achieve business and sustainability goals with ultra-efficient cooling. Our liquid cooling uses **50% less energy** than the competition and over **90% less water** consumption.

References

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[3] https://www.nvidia.com/content/dam/en-zz/Solutions/Data-Center/a100/pdf/nvidia-a100-datasheet-nvidia-us-2188504-web.pdf

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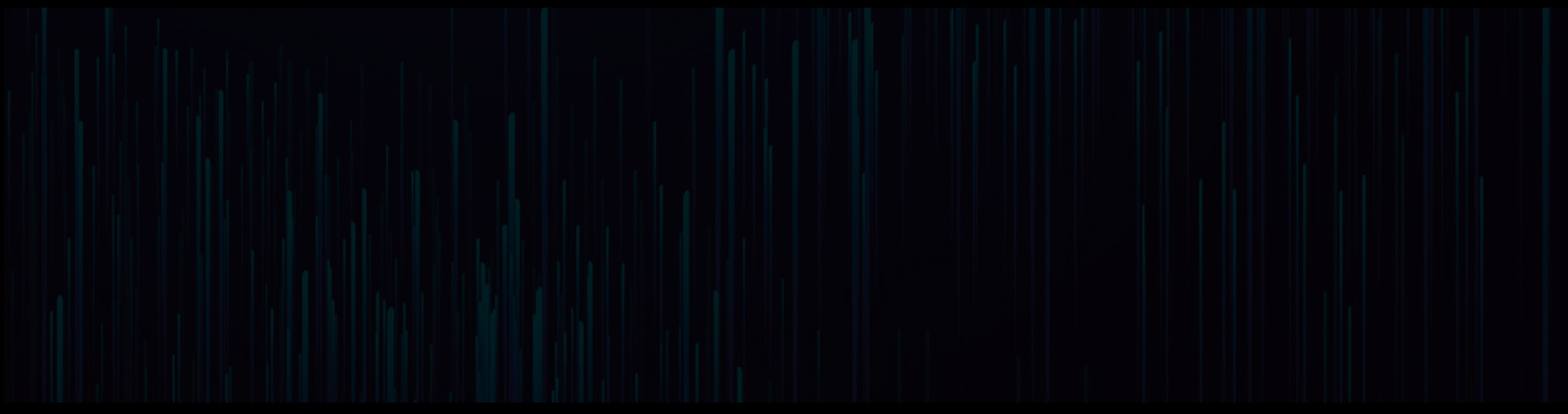

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