EBOOK

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Is Liquid Cooling Right for Your Data Center?

Who Should Read This eBook?

- Senior management of data center operations
- Data center designers and consultants
- Engineers working in IT and facilities

Introduction

Today's data center industry grapples with various challenges, from soaring chip densities pushing the limits of high-performance computing to rising energy costs amidst environmental concerns. Securing approvals for new facilities has become tougher, exacerbated by community objections and grid supply issues.

However, advancements in cooling technologies, particularly liquid cooling, offer a beacon of hope. Initially met with skepticism and fear, liquid cooling has evolved significantly since its first iterations. Data center vendors are now exploring closer-to-source liquid cooling methods, including hybrid systems using direct-to-chip cooling and whole-system immersion cooling, acknowledging its potential to meet today's demanding infrastructure needs.

Read our eBook to explore the ins and outs of liquid cooling in data centers - uncover the advantages, limitations, and whether it's the right fit for your facility.

Data Center Liquid Cooling

Liquid cooling in data centers uses liquid to remove heat from chips, reducing or eliminating air as as an intermediary medium for transferring the heat and making the cooling of higher power densities more feasible than with air alone. There are several approaches, but these two main categories offer a quick overview of this cooling technology.

- Direct-to-chip liquid cooling – hybrid air-assisted/liquid cooling technology that exposes the hot components to liquid (via cold plates) to remove most of their heat and the remainder being taken by air
- Liquid immersion cooling – cooling technology that submerges all the server components into liquid to remove heat

These technologies can be implemented using single-phase or two-phase fluids. Single-phase fluid remains liquid throughout, while two-phase fluid turns to gas during cooling. Despite its complexity, two-phase fluid's efficiency potential is driving research towards easier implementation and broader future use.

Air cooling is generally accepted as sufficient for capturing the heat flowing from servers at densities below 20 kW, although this is challenging if all racks are at those power levels because of the air volume required. However, implementing liquid cooling in data centers will become crucial for handling rising power densities and heat. When server rack densities surpass 20-25 kW, direct liquid cooling combined with precision air cooling becomes a more economical and efficient solution than standard air cooling.

Data Center Liquid Cooling Benefits

Liquid cooling can support the increased densities of high-performance computing and create an opportunity to establish greener operations. Simply put, liquid cooling:

- Supports increased computing densities and heat generation of high-performance data centers effectively
- Allows for increased computing throughput for applications like AI
- Boosts energy efficiency*, aligning with sustainability and ESG goals and can reduce the data center's carbon footprint
- Generates waste heat that can be repurposed for residential communities or crop cultivation
- Has a higher cooling capacity than air, removing more heat efficiently
- Uses less water than many air-cooling technologies
- Facilitates a greener data center by reducing energy consumption

> Using liquid cooling, data center professionals can get more compute through for applications like AI. We should not just look at what's happening with a data center's PUE but also examine how much more processing throughput we can get out of the data center when implementing liquid cooling. The benefits of liquid cooling are evident when one analyzes it in terms of increased productivity.
>
> *Mark Seymour, Distinguished Engineer at Cadence*

Data Center Liquid Cooling Limitations

Psychological barriers can hinder liquid cooling adoption in data centers due to historical fears of electrical hazards and lack of flexibility. However, innovations such as negative pressure systems and dripless connectors have minimized these risks, enhancing safety. Despite these available technologies, many operators still hesitate to implement liquid cooling.

In turn, legacy data centers primarily use air cooling. Cost is a major concern with liquid cooling when adapting data centers already equipped with air cooling. It may introduce unnecessary complexity and expense, especially for smaller data centers or those with less compute-intensive workloads, without significant benefits. Liquid cooling's complexity may also disrupt air cooling efficiency because the new liquid cooling technology may disturb the anticipated hot air output.

> The fear of change and risk slow us down due to the high-stakes nature of our industry. That said, the inevitable spread of liquid cooling for data centers with compute-intensive workloads isn't a question of if, but when.
>
> *Mark Fenton*
> *Sr. Product Engineering Manager at Cadence*

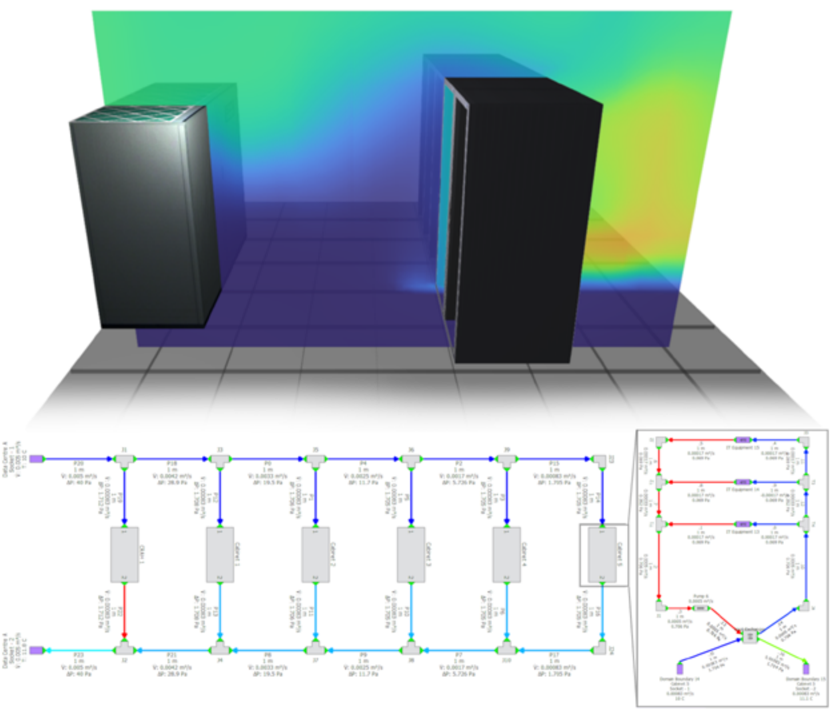
Assessing if Liquid Cooling is Right for Your Data Center

Before adopting liquid cooling, designers and operators must understand its impact on data center performance. Cadence data center digital twins, powered by computational fluid dynamics (CFD), simulate airflow and temperature to support critical design choices. CFD-powered digital twins provide a framework to assess how the data center will react to new technologies, including those as complex as liquid cooling.

Given liquid cooling's complexity, relying only on 3D models can be computationally heavy. Cadence data center software uniquely links 3D models to flow networks for faster solve times and more complete thermal analysis. Additionally, Cadence data center software calculates the heat capture ratio using static pressure drop and thermal resistance curves from cold plates' CAD models. After completing the IT-level analysis, the IT model can be used in the rack-level model, and, in turn, the rack-level model can be used in the digital twin model to complete the solve.

Cadence data center software can virtually test how liquid cooling will support performance in your data center before you implement it. Request a software demo to see the software in action.

> Digital twins are key to understanding how new technology will perform in a data center. Cadence digital twin solutions can show side-by-side simulations of air-cooling technologies versus liquid cooling technologies that compare energy use, risk, capacity, and the interconnected nature between these parameters.
>
> *Mark Fenton*
> *Sr. Product Engineering Manager at Cadence*

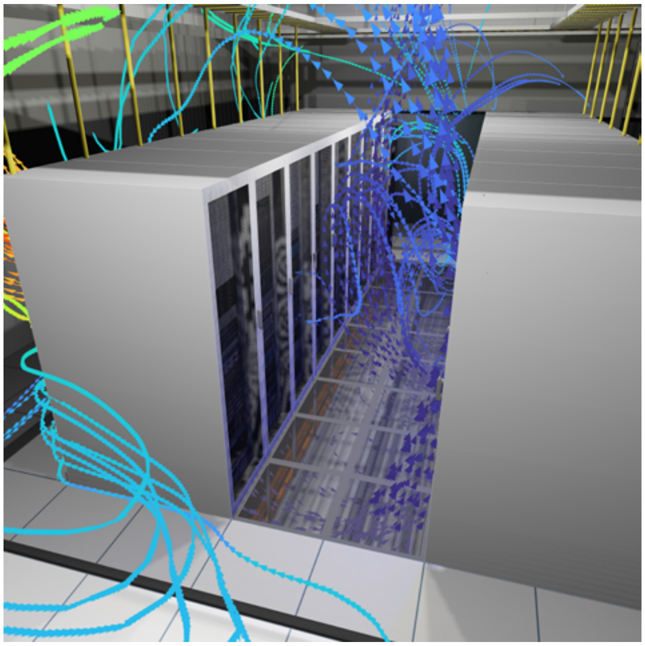


Taking the Next Step

It seems like every year we discuss "the new age of computing," as if this is the year or moment that computing will really, truly change. The thing is, though, that we're always in the new age of computing. Densities are rising, cooling technologies are developing, and budgets are constantly shifting.

At this stage, you might ask yourself: Is my data center capable of handling a variety of heat rejection systems? What would liquid cooling implementation look like in my data center? These are valid questions, and CFD-powered data center digital twins offer a clear framework to validate whether implementation is right for you.

However, we would argue that what comes next doesn't really matter. What matters is whether your data center is flexible enough to handle the coming changes. CFD-powered data center digital twins help evaluate ever-changing scenarios to ensure effective decisions and a robust, resilient data center, both now and in the future.



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