DCD > eBook

>> Cooling transformation

Examining the future of data center cooling

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A New Wave of Cooling Solutions.

Get efficient thermal management to support the increase in high-density data center equipment.

Learn more about liquid cooling options now.

With cooling accounting for up to 40 percent of a data center's total energy bill, the importance of finding a best fit solution cannot be understated.

But today, "best" encompasses not only performance and efficiency, but sustainability credentials too, giving operators much to consider. And as densities continue to increase, so does the speculation as to which method of cooling reigns supreme.

In this eBook, we hear from the experts to find out what the future of data center cooling really looks like.

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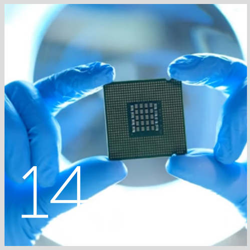
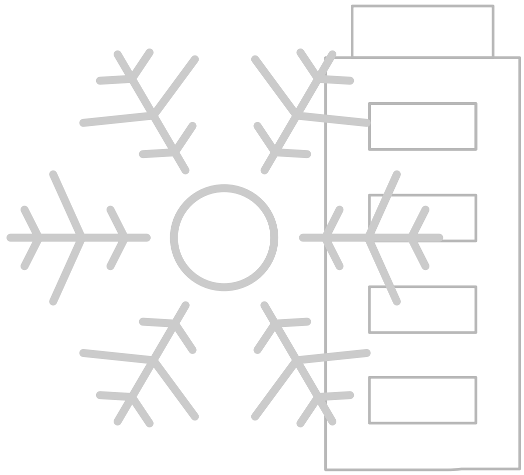




Chapter one:

What's next for data center cooling?

Is air cooling soon to be a thing of the past? Are we headed for a liquid future? Can an old data center handle new cooling solutions? And how is the climate imperative driving innovation? In this chapter we examine what's next for data center cooling.

Air today, gone tomorrow?

We talk with Vertiv's Greg Stover on what the future holds for data center cooling

Georgia Butler,
DCD

As Vertiv's global director of Hi-Tech Development, Greg Stover is closely involved in the latest technology used for cooling data centers, and there is an awful lot.

From two-phase immersion, to single-phase, to chilled water, to traditional air cooling, the high-energy use sectors (which therefore often produce a lot of waste heat) have been long looking for the most efficient solution available. But what that is, and what the future of cooling really looks like, remains something of a mystery.

Greg Stover attempted to uncover this mystery for us at our recent DCD>Connect Virginia event.

"The first question people always ask is whether air [cooling] is going to go away, and the answer is absolutely not. Air is going to be here for a long time," says Stover. "It took 10 years for people to adopt virtualization, and that was obviously a no-brainer from day one, and I think you're going to see that kind of transition with the cooling space."

In other words, we can expect the change to be slow-and-steady, and then to happen all at once. But what is driving this transition? According to Stover, while in the past it was mostly coping with the increasing densities, that has since undergone a shift.

> *There are some huge advantages to liquid cooling for sustainability, and not just because the cooling medium itself is maybe as much as 80 percent more efficient than traditional solutions*
>
> *> Greg Stover*
> *Vertiv*

"For the last two years there have been new technologies, chips specifically, that require new technology, and there have been servers that require new infrastructure to power and cool them. That's been the primary driver for all my activity for the last two years until about six months ago when I started getting calls from sustainability people.

"Obviously, there are some huge advantages to liquid cooling for sustainability, and not just because the cooling medium itself is maybe as much as 80 percent more efficient than traditional solutions, but you can think about shrinking the footprint and still consolidate or maybe grow 10x without having to knock down new walls and build new spaces."

But, as mentioned above, there are several different liquid-cooling


Getty image

solutions available, so which technologies do Vertiv think have legs?

"Vertiv has its fingers in all of the technologies, but the four basic technologies that we're involved in are single-phase immersion, two-phase immersion, single-phase direct-to-the-chip, and refrigerant direct-to-the-chip," says Stover.

Beyond that, the technology used is driven by customer needs. Data centers, while similar in the basic principles, can differ vastly and as a result, cannot be cooled in exactly the same way.

But there are a couple of trends that Vertiv is seeing in the cooling space, and which Stover thinks might be here to stay.

"On air cooling going away, I see instead a hybrid environment being built. We're seeing a lot of activity right now where people say, hey, my densities are going up but I want to stay in my existing space.

"Rear doors are becoming a very big answer, so let's bring in a CDU and a rear heat exchanger. From there we have options. We can do a passive door, we can do a machine-assisted or fan-assisted door.

"We've got a couple of very large customers in America deploying this technology. What's unique about it is you can literally configure your environment. You can say 'I'm gonna go to 30 or 40, or 50Kw', whatever the design is. I've got customers doing 20-kilowatt racks with rear doors, because to them, it's more efficient. They like that design.

"Plus, if you do it right, the next step is to go strictly direct to the chip. So I've got my CDU out on the floor, I can take the manifolds out, I can take the rear door off, I can put manifolds in, I can put in the circuit center so I can control the primary side flow and do the adjustments to the equipment, and now I can leverage stuff I've already installed to be my first step into liquid-to-the-chip cooling."

When it comes to cooling, the industry has not yet reached its point of stasis, and it is likely this back-and-forth and changeability will continue for some time to come. On the positive side, one thing is for sure is that we are finding increasingly sustainable methods of cooling, and the industry is improving its carbon footprint one step at a time.

>Zero Downtime Podcast:

Immerse yourself in liquid cooling with NAAT CTO Julius Neudorfer

Breathing new life into your data center

How to retrofit using disruptive technologies

Nigel Gore
Vertiv

There's no doubt the data center landscape is changing— from the rise of large public cloud service providers to the expansion of colocation operators. And despite consistent growth at the Edge, on-premises data centers aren't going away. In fact, a recent What's Your Edge global survey showed that nearly half of IT infrastructure remains on-premises.

Against this backdrop, enter the proliferation of mission-critical applications requiring high-density, high-performance computing (HPC). Take healthcare as just one example. A recent survey of Medi-Cal providers in California showed a 20 time increase in the number of telemedicine visits in just the first year of the pandemic, from two percent of visits prior to the pandemic to 45 percent.

Additionally, telehealth claims as a percentage of all medical claims increased 11 percent from November to December 2021, amid the Omicron surge.

We're seeing these high-density use cases across nearly all industries. According to IDC, augmented and virtual reality will increase in value by more than 68 percent by 2025, driven by both businesses and everyday consumers.

The continued proliferation of these HPC applications begs the question: Can your data centers keep up?

What's old can be new again

It's not always possible or cost-effective to build new facilities. At the same time, space is often at a premium and you need to make the most of your current floorspace.

Rather than giving up on your existing data center, now is the time to give it new life. An upgrade can help you accommodate the increased processing power and rack densities these applications require.

Retrofit solutions can help extend the lifespan of your existing data centers and make sure they are ready to handle future growth.

According to Gartner, "Although continued investment in an older, more traditional data center may seem contradictory to current trends, if done wisely, it can yield significant benefits to short- and long-term planning."

When you are ready to embark on a retrofit journey to extend the life of your existing data center, I recommend focusing on these key areas: enhancing delivery, reinventing your infrastructure, and maximizing space.

Enhance IT delivery and reinvent your infrastructure

It's no secret that the power needed to cool a data center is significant, and higher density racks can often require more than 1.5 kilowatts (kW) of cooling load for every 1 kW of IT load.

If you are retrofitting your data center for higher densities in a small footprint, liquid cooling can be a viable option. Liquid cooling leverages the higher thermal transfer properties of water or other fluids to support efficient and cost-effective cooling of high-density racks.

Here's a simplified explanation of how it works: A cool liquid is circulated to cold-plate heat exchangers embedded in the IT equipment. This provides efficient cooling, since the cooling medium goes directly to the IT equipment rather than cooling the entire space.

The density enabled by liquid cooling also eliminates the need for expansions or new construction, or to build smaller-footprint facilities. It also enables processing-intensive Edge applications to be supported where physical space is limited.

Liquid cooling is currently available in a variety of configurations, including rear door heat exchangers (RDHx), direct-to-chip cooling, and immersion

Liquid cooling leverages the higher thermal transfer properties of water or other fluids to support efficient and cost-effective cooling of high-density racks

> Nigel Gore
Vertiv

cooling. All three configurations can increase your data center's efficiency and reliability, boost sustainability, lower the total cost of ownership, and improve utilization.

Although a RDHx doesn't bring liquid directly to the server, it utilizes the high thermal transfer properties of liquid to increase the efficiency of racks. In a passive RDHx, a liquid-filled coil is installed in place of the rear door of the rack, and as server fans move heated air through the rack, the coil absorbs the heat before the air enters the data center.

In an active design, fans integrated into the unit pull air through the coils to increase unit capacity. The RDHx allows power that was once used for cooling to be reused to support other building systems.

By contrast, direct-to-chip liquid cooling uses cold plates that sit atop a server's main heat-generating components to draw off heat through a single-phase or two-phase process. In a single-phase process, cold plates use a cooling fluid looped into the cold plate to absorb heat from server components.

In the two-phase process, a low-pressure dielectric liquid flows into evaporators, and the heat generated by server components boils the fluid. The heat is released from the evaporator as vapor and transferred outside the rack for heat rejection.

The third option for liquid cooling— and perhaps the most innovative— is immersion cooling. With immersion cooling, servers and other components in the rack are submerged in a thermally conductive dielectric liquid or fluid.

In a single-phase immersion system, heat is transferred to the coolant through direct contact with server components and removed by heat exchangers outside the immersion tank.

In two-phase immersion cooling, the dielectric fluid is engineered to have a specific boiling point that protects IT equipment but enables efficient heat removal. Heat from the servers changes the phase of the fluid, and the rising vapor is condensed back to liquid by coils located at the top of the tank.

Adoption of liquid cooling is only expected to grow. According to the Vertiv Edge survey, six percent of data center managers around the world are currently using liquid cooling in Edge deployments, a figure that's nine percent when considering North America alone. And by 2025, Gartner predicts, "data centers deploying specialty cooling and density techniques will see 20 percent to 40 percent reductions in operating costs."

Small space? No problem

In addition to making better use of your space through liquid cooling, HPC applications may also benefit from a micro data center.

Micro data centers have all the same components you would find in a typical data center, but on a much smaller scale, including an uninterruptible power supply (UPS), rack power distribution unit (rPDU), rack cooling unit, and remote monitoring sensors and software. Micro data centers typically support critical loads of no more than 100-150 kW.

The entire system is enclosed into the size of one standard IT rack, making the micro data center a good fit for an existing network closet or small server room. We also see micro data centers work well at the Edge, particularly in open office spaces, retail stores, and healthcare clinics.

While they may not address every computing challenge, micro data centers can provide an affordable, reliable IT solution when you need critical applications in a small or contained footprint.

Retrofit done your way

If there are increasing demands on your infrastructure to maintain the reliability of critical applications, a retrofit of your existing data center may be in order. You can bring new life to your data center to keep it running productively and cost-effectively for years to come.

Your retrofit could include a combination of liquid cooling or a self-contained micro data center, but it's important to remember there's no one-size-fits-all approach. All environments and use cases are unique, so you should take time to closely examine your organization's needs and goals before you make this investment.

It's also appropriate to take your time, rather than starting an overhaul all at once. A phased retrofit with the help of an expert or trusted services partner can be a path toward improving your infrastructure in a more manageable way.

No matter how you choose to retrofit, the upgrades to your data center can lead to many organizational benefits in the near- and long-term.

DCD >Panel:

How is the climate imperative stimulating innovation?

Chapter two:

Performance

With our increasingly digital lives wholly reliant on data centers, they have become a hot topic in recent years both literally and figuratively. But with high performance applications such as streaming and gaming now commonplace, and emerging technologies such as AI on the rise, how do operators best handle the heat?

High performance? No problem

Fred Rebarber
Vertiv

How liquid cooling can help organizations overcome high performance computing-related infrastructure challenges, and which method is right for you

Three years removed from the beginning of the pandemic, the data center industry has seen an unprecedented boom in digital demand across all industries in order to maintain the functions of our day-to-day lives.

According to Gartner, end-user spending on public cloud services is slated to reach $482 billion in 2022. In a Harvard Business Review survey, 86 percent of respondents said that artificial intelligence (AI) has become a mainstream technology at their organization, and 67 percent expected to accelerate AI adoption in 2021. These services continue to be as essential as ever, and they only scratch the surface for what's to come in terms of network complexity.

As today's networks get more complicated and more distributed, and the augmented and virtual reality applications become more prominent, the need for real-time computing and decision-making becomes more critical. This real-time need is sensitive to latencies, and under the increasingly common hybrid model of enterprise, public and private clouds, colocation, and Edge, full-time manual management has become increasingly difficult.

Therefore, AI and machine learning (ML) will be critical to optimizing the performance of these networks and making way for more remote monitoring solutions. Adding to our digital demand is the continued rollout of 5G, which promises to be 500 percent faster than its 4G predecessor.

These advances inevitably come at a price – in the form of increased computing and heat densities. High performance computing (HPC) has rapidly accelerated to support AI, ML, and 5G, and it solves numerous enterprise business challenges. For many data center operators, this will soon create the necessity for high density cabinets and data centers that will require infrastructure changes to cool these critical systems.

As rack densities approach and exceed 30 kilowatts (kW), air cooling systems may not be sufficient, no matter how the system is optimized. Despite air cooling's considerable evolution to address rising densities efficiently, there is a point at which air simply does not have the thermal transfer properties required to provide sufficient cooling to high-density racks. Organizations who ignore these limitations should anticipate higher energy costs, reduced performance and, eventually, delayed implementations.

The most viable alternative to air cooling is bringing liquid cooling to the rack. Liquid cooling leverages the higher thermal transfer properties of water or other fluids to support efficient and cost-effective cooling of high-density racks. Liquid cooling is available in a variety of configurations that use different technologies, including rear-door heat exchangers, direct-to-chip cooling, and immersion cooling.

While liquid cooling is often regarded as a niche application that is years away from mainstream adoption, technology think tanks such as the Open19 Foundation and the Open Compute Project bring together industry leaders to address the challenges presented by continued increases in compute density. Through these collaborations, industry leaders have made great advances and developed several products that help make liquid cooling technology a viable solution for a broader audience.

Liquid cooling can be up to 3,000 times more effective than using air, enabling the central processing units (CPUs) and graphics processing units (GPUs) in densely packed racks to operate continuously at their maximum voltage and clock frequency without overheating.

Despite air cooling's considerable evolution to address rising densities efficiently, there is a point at which air simply does not have the thermal transfer properties required to provide sufficient cooling to high-density racks

> Fred Rebarber
Vertiv

This, combined with the reduction or elimination of fans required to move air across the data center and through servers, can create significant energy savings for liquid-cooled data centers. Additionally, the pumps required for liquid cooling consume less power than the fans needed to accomplish the same cooling.

Types of liquid cooling

Rear-door heat exchangers are a mature technology that doesn't bring liquid directly to the server but does utilize the high thermal transfer properties of liquid. In a passive rear-door heat exchanger, a liquid-filled coil is installed in place of the rear door of the rack, and as server fans move heated air through the rack, the coil absorbs the heat before the air enters the data center. In an active design, fans integrated into the unit pull air through the coils for enhanced thermal performance.

In direct-to-chip liquid cooling, cold plates sit atop a server's main heat-generating components to draw off heat through a single-phase or two-phase process. Single-phase cold plates use a cooling fluid looped into the cold plate to absorb heat from server components. In the two-phase process, a low-pressure dielectric liquid flows into evaporators, and the heat generated by server components boils the fluid. The heat is released from the evaporator as vapor and transferred outside the rack for heat rejection.

With immersion cooling, servers and other components in the rack are submerged in a thermally conductive dielectric liquid or fluid. In single-phase immersion systems, heat is transferred to a coolant via direct contact with server components and removed by heat exchangers outside the immersion tank. In two-phase immersion cooling, the dielectric fluid is engineered to have a specific boiling point that protects IT equipment but enables efficient heat removal. Heat from the servers changes the phase of the fluid, and the rising vapor is condensed back to liquid by coils located at the top of the tank.

Liquid cooling as a roadmap for continued success

If an organization plans to use liquid cooling to support new HPC-related infrastructure requirements and challenges, there are several other benefits beyond efficiency and reliability. Those benefits include:

Improved performance

A liquid cooling system will not only enable the desired reliability, but also deliver IT performance benefits. As processor case temperatures approach the maximum safe operating temperature, as is likely to occur with air cooling, processor performance is throttled back to avoid thermal runaway.

Sustainability

Not only does liquid cooling create opportunities to reduce data center energy consumption and drive power usage effectiveness (PUE) down to near 1.0, it provides a more effective approach for re-purposing captured heat to reduce the demand on building heating systems. The return-water temperature from the systems can be 140 degrees Fahrenheit (60 degrees Celsius) or higher and the liquid-to-liquid heat transfer is more efficient than is possible with air-based systems.

Maximize space utilization

The density enabled by liquid cooling allows a facility to better use existing data center space, eliminating the need for expansions or new construction, or to build smaller-footprint facilities. It also enables processing-intensive edge applications to be supported where physical space is limited.

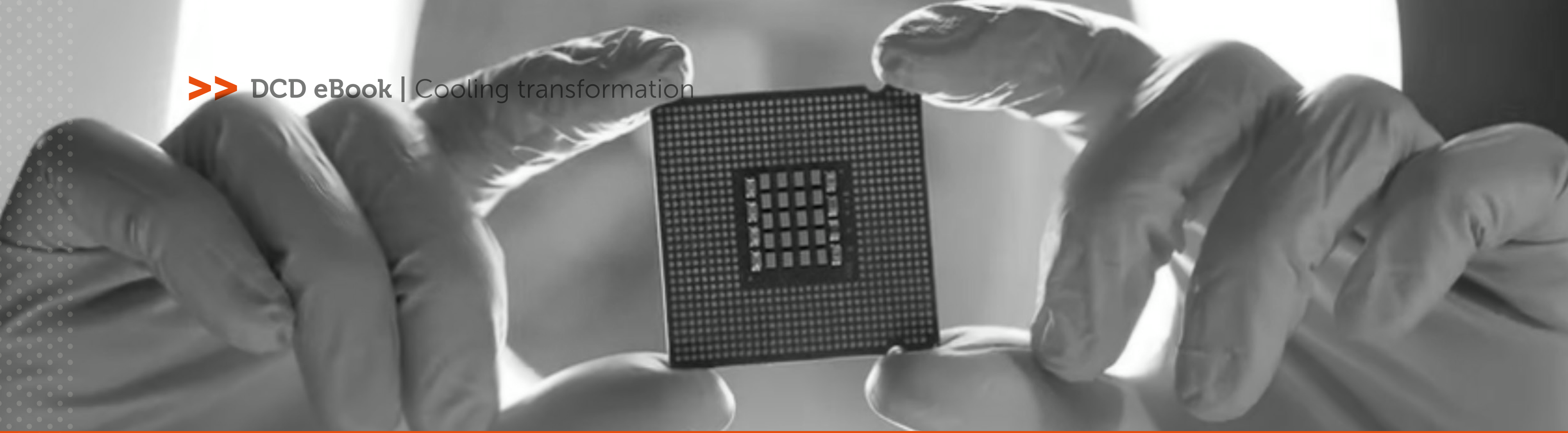
Lower total cost of ownership (TCO)

In the report 'Liquid-cooled IT equipment in data cenetrs: Total cost of ownership', ASHRAE conducted a detailed cost of ownership analysis of air-cooled data centers versus a hybrid (air- and liquid-cooled data centers) model and found that, while a number of variables can influence TCO, "liquid cooling creates the possibility for improved TCO through higher density, increased use of free cooling, improved performance and improved performance per watt."

For organization leaders dealing with the challenges of increasing rack densities, it may be time to recognize the limits of air cooling and consider using liquid cooling to help meet energy and sustainability goals. For those deploying extremely high-density racks (greater than 30 kW), there may be no other choice.

The most viable alternative to air cooling is bringing liquid cooling to the rack

> Fred Rebarber
Vertiv



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The innovative Vertiv™ Liebert® XDU 450 and Vertiv™ Liebert® XDU 1350, available in North America, Europe, the Middle East, and Africa, are redefining data center liquid cooling, providing new solutions to your data center cooling challenges.

Specifically designed to address high-density cooling needs where air cooling technologies are no longer viable, the liquid coolant distribution units empower you to confidently integrate high-efficiency data center liquid cooling into your IT environment.

Where other data center cooling technologies have presented barriers to adopting liquids, the Liebert® XDU delivers answers. First, the data center cooling system is completely flexible, supporting rear door heat exchange or direct contact liquid cooling with 60 kW+ of powerful, reliable heat rejection.

Second, it meets all requirements for introducing liquids in the data center environment with features that ensure essential separation of primary facility water from the IT heat load while keeping the supply water clean and providing immediate notification of leaks.

Finally, the Liebert® XDU 450 and Liebert® XDU 1350 offer the redundancy, visibility, and control you need to confidently support mission-critical applications in increasingly high-density environments.

As the next generation in data center liquid cooling technology, the Liebert® XDU delivers efficiency, flexibility, reliability, and peace of mind in a powerful, high-density cooling solution engineered for today's and tomorrow's data center cooling challenges.

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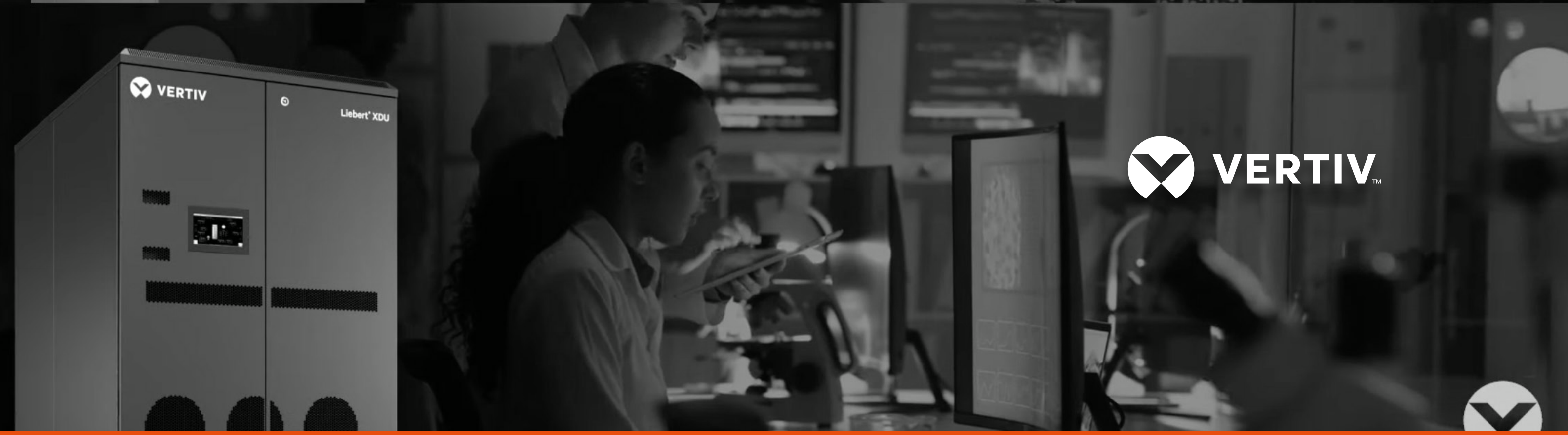
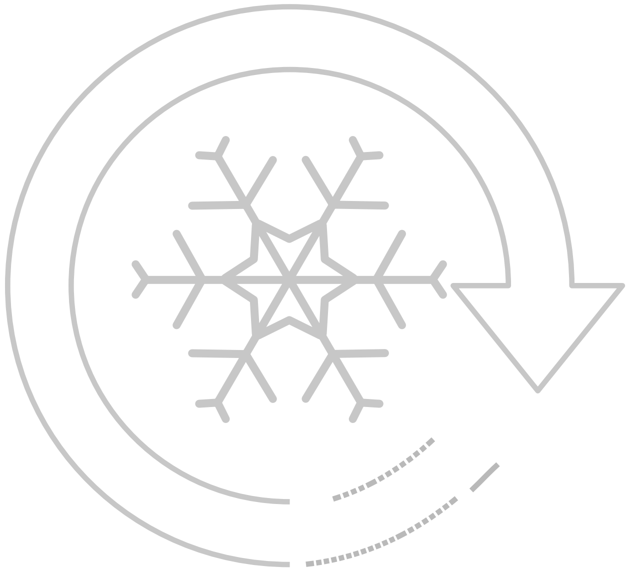


Data center cooling solution:

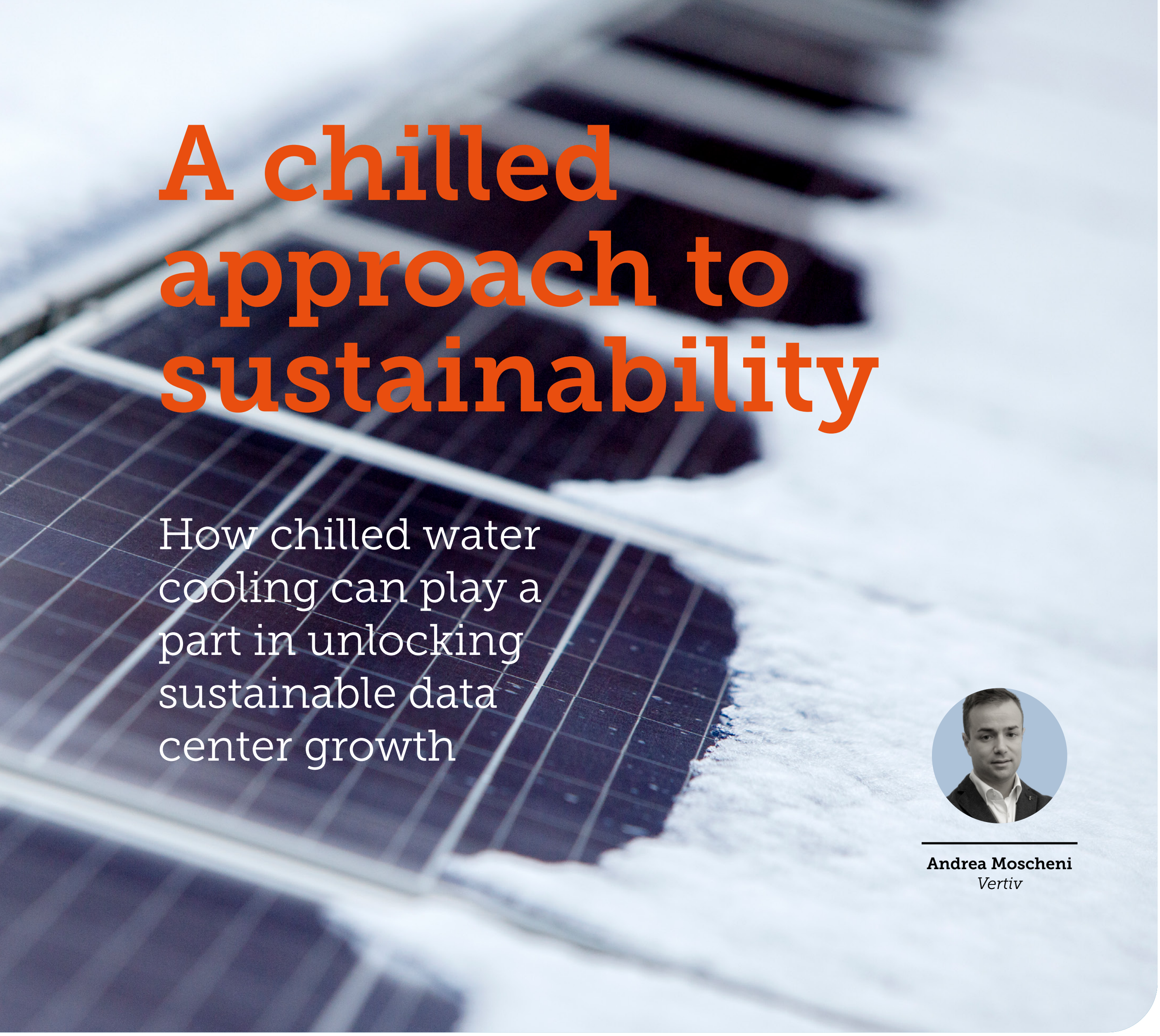
Introduce liquids with confidence



Chapter three:

Sustainable cooling

Today, despite being as important as any other utility, data centers are under increasing scrutiny, from customers, end users, and the wider population to prove they are operating in a sustainable way with many governments now joining in the close examination. In this chapter, we take a look at efficiency and beg the question: How can our industry continue to grow without impacting our planet?



A chilled approach to sustainability

How chilled water cooling can play a part in unlocking sustainable data center growth

Andrea Moscheni
Vertiv

The role of the data center is rapidly evolving. With our reliance on digital services growing, and the prospect of a future virtual world, this demand is not expected to slow down.

There's already plenty of attention on the role that data centers will play. It's no surprise then, that providers are recognizing the wealth of opportunities, with cloud and colocation being forecasted by Omdia to grow at a five-year CAGR of 16.6 percent and 8.3 percent, respectively.

At the same time, data center providers are embracing strict policies to drastically reduce their carbon emissions in order to help achieve sustainability targets.

Data center sustainability

Major data center operators have signed The Climate Neutral Data Center Pact, and many more are moving in the same direction. The industry has committed to climate neutrality by 2030, ensuring that sustainability is now a key element of any business process.

With this in mind, chilled-water systems are a viable way for data center providers to not only support their growth cost-effectively and with minimal disruption, but also reduce their carbon footprint and help meet sustainability objectives.

The reduction of emissions goes through two fundamental aspects: the reduction of direct emissions and the reduction of indirect emissions.

Reduction of the direct emissions (refrigerant GWP)

Global warming potential (GWP) describes the relative impact of a greenhouse gas, and the timespan that it remains active in the atmosphere, compared to a base of carbon dioxide (CO_2). The lower this metric, the lower the atmospheric impact.

Traditional refrigerants can now be replaced by modern HFO refrigerants, which have a lower GWP; it is expected that this will prevent the emissions of up to 105 million tons of equivalent CO2 by 2040

> Andrea Moscheni
Vertiv

The traditional refrigerants can now be replaced by modern HFO (hydrofluoro-olefin) refrigerants, which have a lower GWP; it is expected that this will prevent the emissions of up to 105 million tons of equivalent CO_2 by 2040.

However, most of these new refrigerants are classified by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) as mildly flammable therefore requiring a new design for the cooling system, potentially impacting the broader data center design.

Chilled-water systems offer an excellent solution as the refrigerant is contained within chiller units and, in most applications, these are installed outside of the data center, thus simplifying the use of flammable fluids.

Chilled-water systems are one of the first cooling technologies to apply low-GWP refrigerants in data center applications and therefore are an example of a valid alternative for reducing direct environmental impacts.

Reduction of the indirect emissions (cutting energy consumption)

Reducing carbon footprint also means cutting the electricity consumed by a data center during its operation. This is where chilled-water systems can play a big role. In recent years, they have applied a range of cooling system efficiency improvements that allow a reduction of electricity usage.

For example, in a chilled-water system, the chiller compressor is the greatest consumer of electricity, and the warmer the external climate, the greater the electricity demand of the compressor.

Recently, there has been an increased use of inverter-driven compressors which help to achieve higher efficiency levels, especially at partial loads. Chillers equipped with inverter driven screw compressors, or oil-free centrifugal compressors, are now available to drastically cut down electricity consumption compared to the previous technology available.

Over the past few years, ASHRAE has increased the recommended operating temperature of data centers equipment up to 27°C. This has allowed subsequent increases to the water temperatures within chilled-water systems and has enabled an extended use of freecooling chillers, even in countries where freecooling was not previously feasible.

Freecooling technology has an important advantage as it allows for the cooling of the system without activation of the compressor.

The adiabatic technology can additionally improve the efficiency of a chilled-water system. In these systems, the ambient air is cooled down by passing through wet pads. The air is then delivered at a lower temperature, achieving a higher freecooling capacity of the chiller and a more efficient operation of the compressor.

The core of this solution is the onboard controller of the unit. It enables the use of water whenever strictly needed, according either to redundancy, efficiency or cooling demand needs.

The controller has the main responsibility in preventing water from being wasted, improving the WUE (water usage effectiveness) of the data center. The application of water is always a matter of balancing different aspects and constraints.

Further improvements to data center efficiency can be made through the optimization of chilled-water systems controls. Chilled plant manager technology can coordinate the operation of all the units and main components of the chilled-water systems.

This allows an integration and coordination of the working mode between units and the main components, enabling improved efficiencies and performance at partial loads or, in the unlikely event of failure, finding the best way to react and grant cooling continuity to the system.

Combining all the technology optimizations, chilled water systems can significantly reduce the direct and indirect emissions.

The following table summarises an example of the results in London, where the system never fully works in direct expansion mode, thus granting excellent system efficiency and reducing costs.

London 12MW	pPUE	WUE [l/kWh]	TEWI (10y) - total ton of CO_2			Freecooling hours [h]	FC + Mixed mode [h]
			Direct	Indirect	Total		
Baseline	1.212	0.000	689	102277	102966	0	0
Increasing air and water temperatures	1.114	0.000	344	55248	55592	5416	8515
Optimization of the chilled water system control	1.100	0.000	344	48493	48837	5416	8678
Improved compressor technology and low-GWP refrigerant	1.094	0.000	1	45231	45231	5416	8678
Adiabatic system	1.082	0.162	1	39805	39805	6849	8760

Scaling with confidence

An example of how chilled-water systems can achieve these benefits is in the case of Green Mountain, a Norwegian hydro-powered data center where the thermal management system plays a big role.

Green Mountain gained five megawatts of additional cooling capacity after the installation of Vertiv's chilled-water units, demonstrating how these systems, as part of a broader strategy, can facilitate carbon neutral data center configurations.

Many hyperscale and colocation providers are now embracing the opportunity chilled-water systems present, not only from a cost and speed of deployment perspective, but with sustainability front and center.

This needs to continue as we move into the next phase of the race for expanding capacity and improving the data center carbon footprint.

With such rapid expansion and increasing pressure to achieve net-zero, data center providers must rely on new technologies to meet the requirements of both today and tomorrow. ■

How sustainable are chilled water systems?

A closer look at the sustainability credentials of chilled water systems

Andrea Moscheni
VERTIV

As data center operators take actions to reduce or neutralize the impact of capacity growth on climate change, they'll face a refrigerant challenge similar to what occurred with chlorofluorocarbons (CFCs). The issue then was ozone depletion, and the solution was the transition to hydrofluorocarbons (HFCs).

Now, alternatives to HFCs are required due to global warming concerns. The UN Kigali Amendment to the Montreal Protocol calls for an 80-85 percent reduction in the use of HFC refrigerants by the end of 2040 due to the high global warming potential (GWP) of these refrigerants.

As operators increase their focus on sustainability while continuing to expand capacity, many are looking to accelerate the transition away from HFCs as part of their sustainability strategy.

By doing so they take an important step in lowering the Total Equivalent Warming Impact (TEWI) of data center cooling systems. TEWI captures the total carbon emissions of a cooling technology by combining the direct and indirect effect of a system through its operating cycle.

By using refrigerants with a low GWP in cooling systems that are highly energy efficient, operators can drive the TEWI of cooling systems to new lows. Chilled water systems represent an ideal solution for accomplishing this goal as they are effective at reducing both direct and indirect emissions.

How chilled water systems reduce direct emissions

The direct component of TEWI relates to the impact on global warming of a refrigerant leak. HFCs have a relatively high GWP (above 1500), while newer hydrofluoro-olefins (HFO) and HFO blends offer a much lower GWP. R1234ze, for example, has a GWP close to zero.

Chilled water systems facilitate the transition to these new refrigerants by minimizing the risks associated with the flammability of some HFO

> *Chilled water systems facilitate the transition to these new refrigerants by minimizing the risks associated with the flammability of some HFO refrigerants because the chiller is installed outside the data center*
>
> *> Andrea Moscheni*
> *Vertiv*

Chilled water systems have proven effective in both raised floor and non-raised floor data centers, which is particularly important today as much of the capacity being added is in the form of large, non-raised floor data centers

> Andrea Moscheni
Vertiv

refrigerants because the chiller is installed outside the data center.

Chilled water systems are also effective at reducing the risk of leaks because systems are installed with a ready-to-use refrigerant circuit that is tested for leaks at the factory, tested again after installation, and often includes monitoring capabilities that can shut down the system if a leak occurs.

Together, the ability to isolate low-GWP refrigerants from IT systems and the reduced risk of refrigerant leaks enables chilled water systems to minimize direct emissions.

How chilled water systems reduce indirect emissions

The other half of the TEWI calculation is indirect emissions, or the emissions created by the energy used by the cooling system when carbon-based energy sources are used.

The most common metric for evaluating cooling system efficiency is partial power usage effectiveness (pPUE).

This represents the ratio between the energy used by the IT load plus that used by the cooling system divided by the energy used by the IT load. A pPUE of 1 represents a data center in which the cooling system uses no energy.

Today's chilled water systems can support pPUE values below 1.1 in cities like London. This is enabled through various optimization strategies such as raising air and water temperatures, implementing system-level controls and using an adiabatic system to extend the use of free cooling.

The Vertiv white paper, 'How chilled water systems meet data center availability and sustainability goals', provides more detail on optimization strategies and includes simulations showing the impact of various strategies.

When water is used to improve energy efficiency, controls should also be employed to prevent water from being wasted. As a result, chilled water systems are able to balance energy and water efficiency to achieve a low pPUE and low water usage effectiveness (WUE).

Applicable for raised floor and non-raised floor environments

Chilled water systems have proven effective in both raised floor and non-raised floor data centers, which is particularly important today as much of the capacity being added is in the form of large, non-raised floor data centers.

Raised floor data centers typically use perimeter chilled water CRAH units, but non-raised floor data centers require a different approach due to the absence of the underfloor plenum that helps balance air pressures across rows.

In non-raised floor data centers, perimeter chilled water systems designed specifically for that environment are used in concert with thermal wall units with designs that are based on air handling units, improving air distribution and reducing the risk of negative pressures at the front of racks.

Airflow control based on pressure measurements across the larger space of the data center is more challenging than in raised floor environments but implementing a control strategy based on temperature differential (Delta T) reduces reliance on pressure measurements and enables more precise and efficient thermal management.

The future of data center thermal management

For data center operators planning to expand capacity, chilled water systems provide the ideal solution to support sustainability and availability goals.

With effective use of low-GWP refrigerants, minimal risk of leaking, and a low pPUE and WUE, chilled water systems provide low impact thermal management for raised floor and non-raised floor data centers.

VERTIV™

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Next Generation Liquid Cooling Technology

Confidently manage high-density thermal loads with Vertiv™ Liebert® XDU.

Discover reliable and efficient Vertiv™ Liebert® chilled water systems now.