Data Center Cooling Trends for Small to Medium Data Centers

- Liquid Cooling Explained
- Immersion Cooling in the rack and outside the data center
- Direct to Chip Cooling allows for higher density racks
- Retrofit options for Edge, Network Closet, Branch Office Cooling
- Hot-Aisle/Cold-Aisle Cooling increases efficiency in legacy data centers

---

EXECUTIVE SUMMARY:

Demanding technologies such as AI, Big Data and Edge Computing, are challenging Data Center managers to add computing power without increasing footprint. To achieve this goal, facilities are increasing rack densities. This, in turn, is driving new, more efficient cooling technologies. Liquid Cooling includes both direct to chip and immersion cooling and is trending with data centers of all sizes as rack density increases to the point that air cooling is no longer cost effective.

The burdens on small to medium data centers and network closets are numerous. Demanding technologies such as AI, Big Data and Edge Computing, are challenging Data Center managers to add computing power and keep it temperature controlled while remaining on budget and within the existing floor space. These demands, along with others, such as increasing rack densities and the use of non-traditional locations for IT equipment, are driving new cooling technologies that are more efficient than ever.

Most data centers struggle with maintaining ideal temperature ranges. And that everyday struggle can be more challenging as equipment ages or new equipment is added. As your data center adds more capacity, you may be increasing rack density and inadvertently creating hot spots. Adding IT equipment to existing available RU space is a popular solution when other factors, such as floor space, limit options. However, the additional heat of the new equipment needs to be considered and effectively removed to maintain the ideal environment.

What is Driving the Increase in Rack Density?

The main driver for the increase in rack density is the rapid growth of emerging technologies. Namely the Internet of Things (IOT), Edge Computing, and Big Data. Connected devices are everywhere; phones, tablets, sensors, security systems, heating and cooling systems, environmental sensors, and hundreds more. Edge computing is proliferating to meet the need for low latency, higher speeds, bandwidth, and security. Big Data, the ability to analyze large amounts of information, is another trend that will become a bigger part of everyday life and require more computing power. The more connected and data-driven your facility becomes, the more computing power it will need. Increasing rack densities will provide the computing capacity required, but the cooling requirements for the space will change.

According to a 451 study of 750 enterprise users, forty-five percent of companies said they expect an average density of 11kW per rack or higher over the next year. “One of the key things we’re seeing is a change in density,” said Kelly Morgan, VP of Datacenter Infrastructure & Services at 451 Research. “Density is finally rising. We’ve been hearing this for a long time, but until recently, the average has been 5kW a rack.”

With the number of IoT devices predicted to reach 75 billion by 2025, companies everywhere will be struggling with how to best cool their data centers, edge computing centers and network closets. The most promising cooling trend to answer the call is Liquid Cooling.

Liquid Cooling Methods

Liquid Cooling includes both direct to chip and immersion cooling and is trending with data centers of all sizes as rack density increases to the point that air cooling is no longer cost effective. There are two leading types of liquid cooling, direct to chip and immersion, and both can be single-phase, in which the liquid does not change form, and two-phase, in which the liquid changes from liquid to gas form.

IMMERSION COOLING

Liquid Cooling includes both direct to chip and immersion cooling and is trending with data centers of all sizes as rack density increases.

In immersion cooling applications, the liquid coolant is in direct contact with the IT electronic components. The liquid is slow to react to external changes in temperature and shields the components from the influence of humidity and pollutants giving the system the ability to operate without fans in near silence. Immersive cooling uses dielectric fluid and can be implemented in single-phase or two-phase.

Single phase immersion cooling encapsulates the server in a sealed chassis and the system can be configured in rackmount or stand-alone format. In rackmount form, the electronic components are cooled by dielectric fluid passively, via conduction and natural convection, or actively as it is pumped within the servers. Heat exchangers and pumps can be located inside the server or to the side of the rack where heat is transferred from the dielectric liquid to the water loop. In the tub format of immersion, single-phase cooling, also called open bath, the IT equipment is completely submerged in the fluid. In a tub, the racks are not stacked vertically, but horizontally, like a rack on its back. The heat within the dielectric fluid is transferred to a water loop via heat exchanger using a pump or natural convection.

Two-phase immersion cooling places the server in the liquid but the liquid changes state during the cooling process. As the fluid heats up and turns to a

gas and then cools again to condensation, the water circuit and heat exchanger remove the heat.

DIRECT TO CHIP COOLING

All direct to chip cooling methods are used in rackmount form.

Direct to chip cooling features coolant directed to the hotter components using a cold plate on a chip within the server. All direct to chip cooling methods are used in rackmount form. The electronic components of the IT equipment are not in direct contact with the liquid coolant. Fans are still required to provide airflow, meaning that reliance on conventional air-cooling infrastructure is reduced, but still utilized. Water or dielectric liquid can be used as the coolant. The single-phase, direct-to-chip cooling fluid does not change from liquid to gas while cooling. In the two-phase version the liquid turns to gas as it cools the system and requires additional system controls. Most often, dielectric fluid is used in a two-phase system, which reduces the risk of water damage to the equipment. The dielectric vapor can be transported to a condenser outside or the heat can be ejected through a building water loop.

Why Consider Liquid Cooling?

- Rising chip and rack densities paired with lower latency requirements and the increasing use of Graphics Processing Units (GPUs) and rising CPU power consumption all demand more efficient and effective cooling.
- The pressure to reduce energy consumption has data center managers evaluating every aspect of cooling and its impact on the budget.
- As floor space becomes a premium in your facility, liquid cooling can allow you to add more computing power in less space. Liquid cooling can also help facilities use network closets, grey space or non-traditional IT space.
- Harsh environments can still house IT when you use immersive liquid cooling that isolates servers from the environment. Without fans there is inherent protection against dust and debris.
- Water is no longer something that can be taken for granted and liquid cooling greatly reduces the need for water, and the added budget hit.

Liquid Cooling for Network Closets, Branch Offices and Edge Computing

IT installed in non-traditional data centers, such as network closets or branch offices, face multiple demands, but the most challenging is adequate cooling.

As more IT migrates out of the data center and into grey space, liquid cooling can ensure that your equipment investment is protected.

Liquid cooling is an ideal solution, specifically direct to chip cooling which can be implemented in rackmount form. These non-traditional IT spaces are often poorly ventilated, remote and/or unmanned, leaving equipment vulnerable to damage by high temperatures. As more IT migrates out of the data center and into grey space, liquid cooling can ensure that your equipment investment is protected, and cooling costs kept to a minimum.

The realities of implementation and retrofits

Liquid Cooling is more efficient than existing cooling methods, but the upfront costs are higher. Ideally, liquid cooling would be designed for new data centers or as additional cooling for some racks in an existing data center.

Direct to chip cooling is ideal for retrofits that have existing air-cooled systems. With relatively minor changes, and the addition of cold plates and tubing, a rackmount system can be converted to liquid to the chip cooling. Water or a dielectric fluid can be used, and facilities can retrofit one rack at a time. There would be a learning curve and a possible increase in man hours as staff figures out how to maintain the new system.

Implementing immersion cooling is a bigger upfront cost because of the cost of the bath or tub in which the chassis is immersed and the expensive dielectric fluid in that bath. But the benefit of adding a tub-based immersion system, is that it does not have to be housed in a data center and can operate in grey space or harsh environments. Since it is quiet, it is a great option for areas where a noisy cooling system would not be welcome.

The long-term benefits of liquid cooling, such as low water usage, higher efficiency, reduced noise, and flexibility to be used almost anywhere, may be worth the higher buy-in cost of retrofitting with direct to chip or an

immersion cooling system. In many cases, the total cost of ownership (TCO) for liquid cooling is lower than traditional perimeter cooling.

Budget Friendly Cooling Solutions

Completely reconfiguring your data center space to make the cooling more efficient is not practical from either a cost or down-time perspective but upgrading your cooling to support denser racks can deliver a better ROI and the power that your facility demands. So how can you deliver more efficient cooling now and improve the bottom line?

A hot aisle/cold aisle layout design for cooling can conserve energy and lower cooling costs by better managing air flow. The hot aisle/cold cooling format involves lining up server racks in alternating rows, with cold air intakes facing each other and hot air exhausts facing each other. The rows with the front of the racks are facing the cold aisles and the heated exhausts from the back of the racks face the hot aisle. Usually the cold aisles face air conditioner output ducts while warm exhaust air flow toward air conditioner return ducts.

Hot aisle/cold aisle arrangements lower cooling costs by better managing airflow, requiring lower fan speeds and increasing the use of airside or water-side economizers. Row cooling can replace a mix of cooling systems, such as perimeter and row when used in the proper layout. When utilized in an ideal architecture, row cooling can reduce hot spots and cooling costs, protect your equipment and free up space for more racks.

Once the ideal rack cooling layout has been determined, ideally through modeling software, such as EcoStruxure Asset Advisor or with a Computational Fluid Dynamics (CFD) Study, perimeter cooling can be removed and more racks can be added to the existing footprint, all while improving the efficiency of the data center. When thermal containment is added, overall cooling efficiency is increased, and costs drop.

The APC by Schneider Electric Uniflair Chilled Water InRow and the Uniflair Direct Expansion InRow cooling systems use intelligent controls to meet the load and improve predictability and efficiency. In the majority of cases and with the proper layout, row cooling can cool the entire data center eliminating the need for perimeter cooling.

The Uniflair Chilled Water InRow system closely couples the cooling with the heat source while intelligent controls actively adjust to match the load. Available in various configurations, these units are ideal for meeting the diverse requirements of medium to large data centers.

The Uniflair Direct Expansion InRow system uses air, water, and glycol for cooling network closets, server rooms, and data centers. The InRow Direct Expansion family closely couples the cooling with the heat source and is available in air-cooled, self-contained and fluid cooled configurations. IT operators looking to improve efficiency or deploy higher density equipment will benefit from the modular design.

APC by Schneider Electric Uniflair InRow Cooling allows for hot-aisle/cold-aisle cooling layout. With more control over air distribution through a shorter path between the hot air and the heat removal, this cooling method is efficient and predictable and can easily be implemented into existing data centers. If hot air containment is added, the system is even more efficient.

Benefits of Hot-Aisle/Cold-Aisle Layout for Cooling

- Allows for higher supply temperature
- Elimination of hot spots
- Economizer mode hours are increased
- Humidification/Dehumidification costs are reduced
- Better overall infrastructure utilization

Conclusion

While liquid cooling will be a big player in the future, the initial cost may drive most existing data centers to stick with more traditional cooling methods. But as demand for low latency and high-speed computer power increases for new technologies, liquid cooling might be the only way forward for data centers of tomorrow.

For more details about liquid cooling or hot/cold aisle cooling, contact Power Solutions. 800-876-9373 or sales@power-solutions.com

Power Solutions | PO Box 100 | Barrington | RI | 02806

power solutions