DATA CENTER COOLING: The Best Methods for Different Needs

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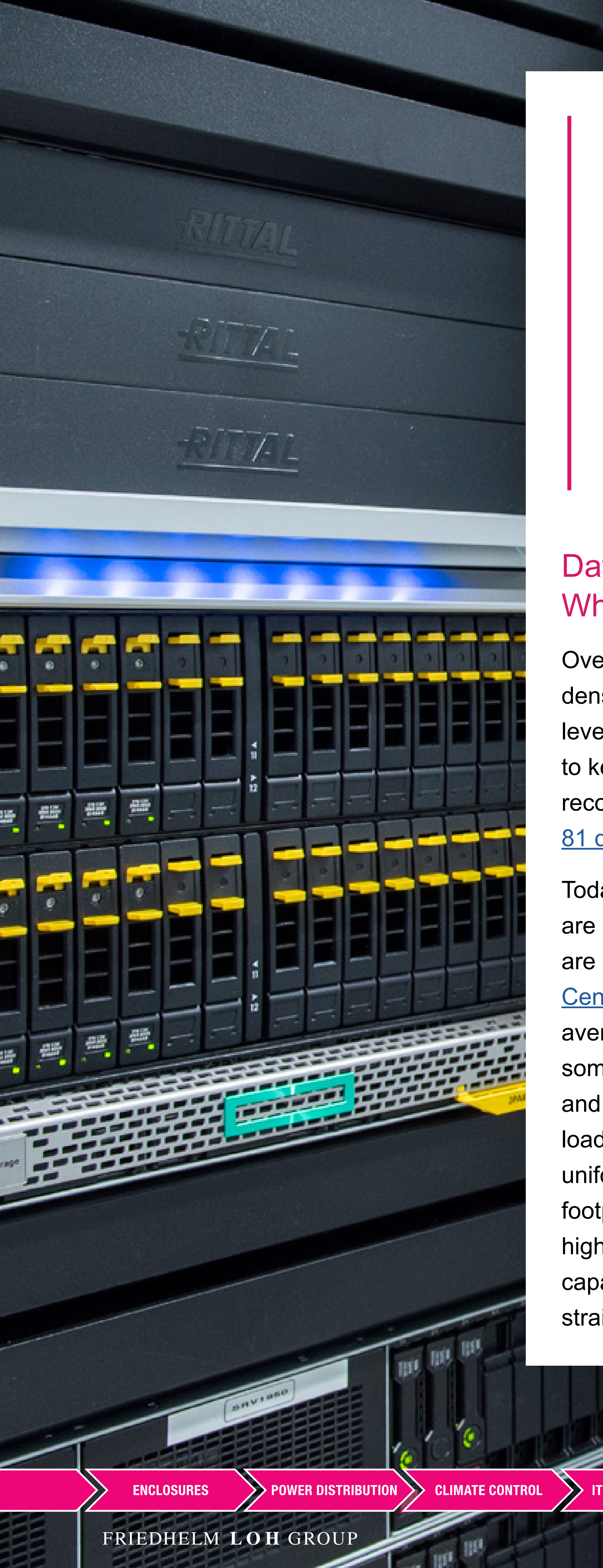
FRIEDHELM LOH GROUP

The Best Cooling for Different Density & Data Center Needs

Data center IT equipment generates a significant amount of heat within the small footprint of the IT enclosures, and operators understand that heat must be removed or temperatures will rise beyond equipment specs, eventually leading to equipment failure. When more servers (or more powerful servers) are added to the rack, density, wattage and heat all increase, too.

The traditional way to cool equipment has been to simply pump massive amounts of refrigerated, conditioned air into rows of cabinets – a limited and inefficient way to remove heat, to be sure. But, as demand for and volume of data continues to increase, requiring faster and more powerful servers, so too does the amount of heat generated. The industry is looking for heat removal methods that go beyond the limitations of air-cooled systems to more precisely target the equipment…and one of the most innovative and efficient is liquid cooling.

And as long as we are considering new methods of heat removal, we must also consider how we plan and measure this capacity. The traditional air cooled data center was planned on so many watts per square foot: 50, 100, 200 Watts/sq. ft. This is fine if we are trying to remove 3 - 5 - 10Kw per IT footprint. But, as heat densities increase, measuring the total white space capacity will be futile. Who cares about removing 50-100 watts/sq. ft. when those square feet are in corners of the room, aisles, service areas, etc. – that is not where the heat is coming from! When looking at higher density solutions, the IT footprints must be the starting point, not the whole room.



As an example: take a space at 300 watts/sq. ft.; install a standard 24"/600mm wide x 48"/1200mm deep enclosure. Now do the math: 8 sq. ft x 300w/sq ft = 2.4kW. Now, stack the same footprint with 42RU worth of appliances, with a total load of 8-10kW. Divide by the same 8 sq. ft. Now, support 1000-1250 Watts/sq. ft. 3-4 times the room capacity of 300w/sq. ft. When looking at and comparing the technologies discussed below, keep these values in mind...and plan for the footprints, not for the total floor space.

Data Center Cooling: Why We're Turning To Liquid

Over the past 10 to 15 years, the average power density of server racks was stable at 3 to 5kW; at that level, traditional air-cooled methods were sufficient to keep the equipment and facilities within the recommended temperature range (between 64 and 81 degrees F).

Today, however, processor capacities and wattages are requiring more cooling than traditional methods are capable of delivering. According to Lifeline Data Centers, the low density is 8-10kW per rack, the average is 15-16kW per rack and, on the high end, some racks are going beyond 20kW. As more devices and applications are added to the IT space, thermal loads will increase as well. And probably not in a uniform manner – there may be areas with low density footprints; other parts of the space may need to support higher footprint loads. Add them all up and you will find capacities of legacy air cooling systems will be severely strained, if not exceeded.

As rack densities continue to grow – some estimates predict a high of 100kW per footprint – liquid cooling will be one of the most efficient and cost-effective ways to remove heat. Liquid cooling allows data center operators to better utilize valuable floor space and increase processing-per-square-foot.

Types of Liquid Cooling

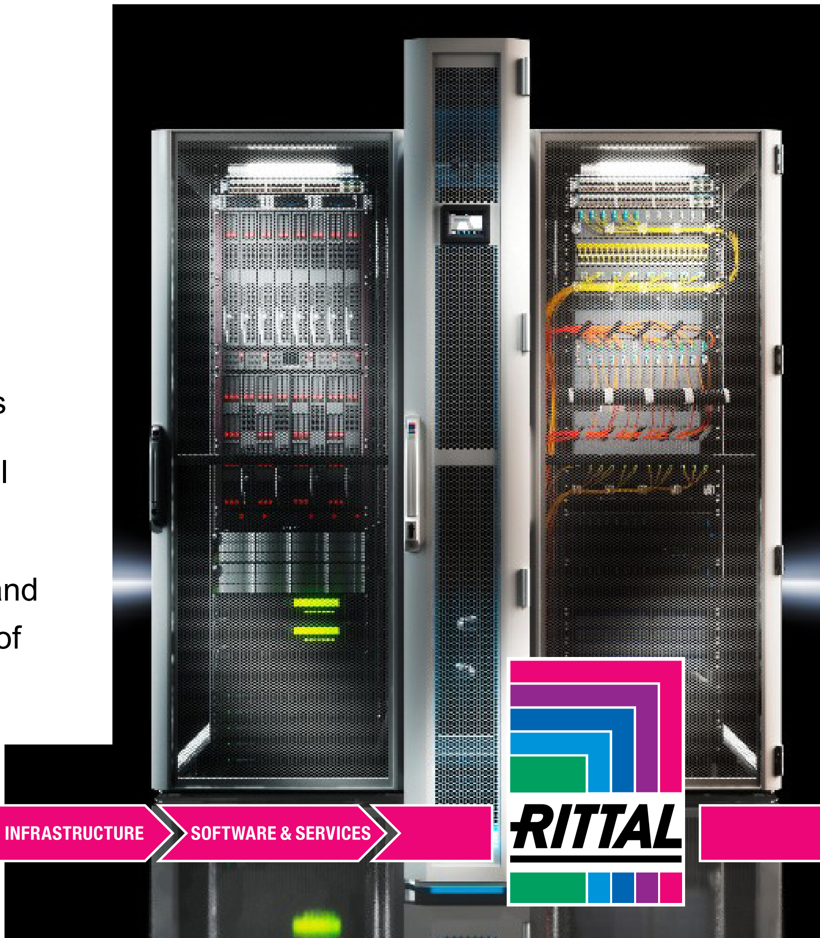
To address the cooling needs of today's – and tomorrow's – IT equipment, liquid cooling brings heat removal closer to servers by placing the heat removal systems and components within rows or integrating them directly into devices installed in the individual racks. Because of their proximity to the heat being generated by appliances, these types of systems are generally referred to as "close-coupled."

ROW-BASED COOLING

- With a row-oriented architecture, cooling units are dedicated to cooling one row of racks
- Often described as In Row/Closed Loop or In Line/ Open Loop cooling
- Compared to room-based cooling, airflow paths are shorter and more clearly defined
- Cooling can be targeted to the needs of specific rows: one row of racks could run high density applications while another runs lower power density applications
- In Row/Closed Loop removes heat directly from one or two adjacent IT enclosures. Using sealed cabinets, no cold air is wasted in spaces where it is not needed and all hot air is captured and removed before getting out into the room
- In Line/Open Loop brings the heat removal off the perimeter and directly to the row

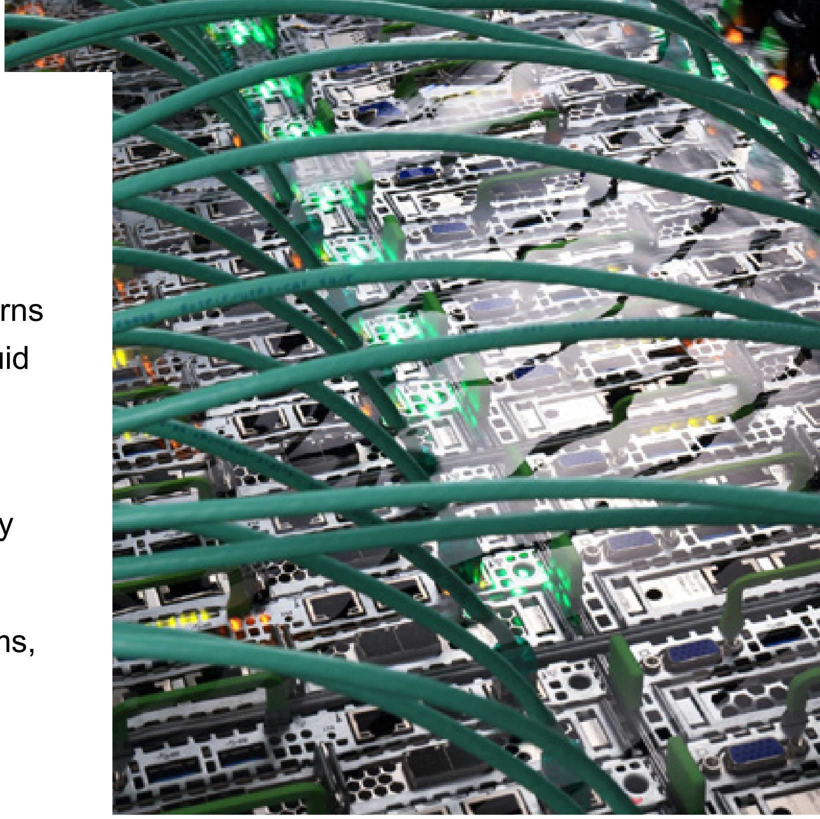
RACK-BASED COOLING

- In rack-oriented cooling, the climate control is dedicated to one or two server racks and are units directly mounted on or within the racks
- Rack-oriented airflow paths are even shorter and more precisely defined than row-oriented architectures, allowing for even higher densities
- Shorter airflow paths and targeted heat removal can lead to further reductions of fan power
- Rack-oriented cooling allows cooling capacity and redundancy to be targeted to the actual needs of specific racks of servers



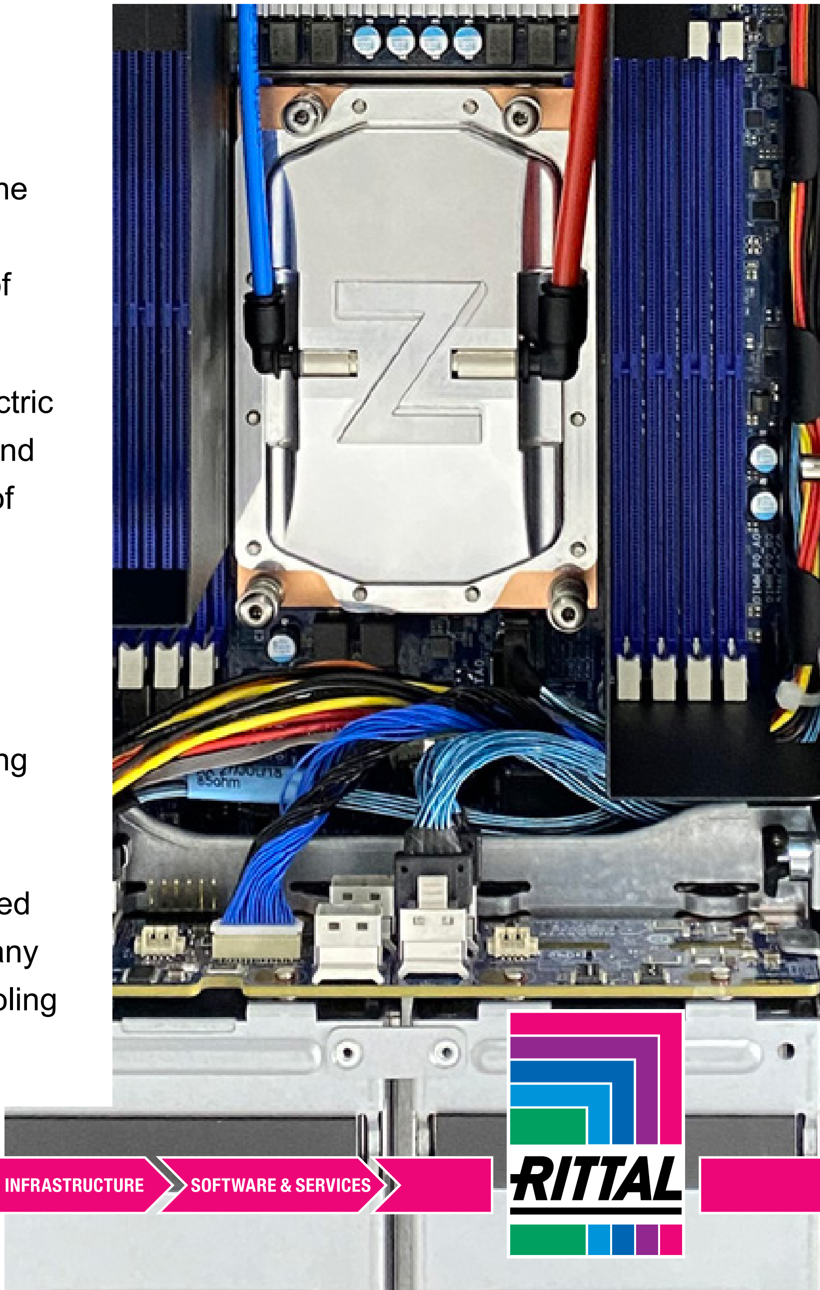
IMMERSION COOLING

- Immersion systems are designed to completely submerge hardware in non-conductive, non-flammable dielectric fluid. As the heated fluid turns to vapor, it condenses and falls back into the fluid to assist in cooling
- Because server cooling fans are unnecessary, power consumption can be reduced significantly compared to traditional methods
- Available in single phase and two phase systems, immersion cooling allows for greater server densities within the same installation space, further reducing total cost of ownership (TCO)



DIRECT TO CHIP COOLING

- A liquid coolant is brought via tubes directly to the chip, absorbing heat and removing it from the chassis. Because this system cools processors directly, it is a very effective and efficient form of data center heat removal
- Waterless, two-phase liquid cooling using dielectric fluid uses a highly efficient, two-phase boiling and condensation process to move large amounts of heat off chips and away from servers, enabling operators to cool chips pushing to 1,000W and beyond
- Both rear-door-air (RDA) and in-rack Edge solutions are available. RDA incorporates cooling directly into the rear door, saving rack and data center space; in-rack Edge is available in air-cooled and water-cooled versions. The air-cooled option can be installed into any rack in almost any environment; the water-cooled option offers cooling of up to 70kW of processors in a single rack



Design Considerations

Once the decision is made to move beyond air and implement a high density system, there are several considerations to address:

Applications: Are high performance applications used in your business – digital rendering, high frequency trading, On Line Gaming (MMORPG), High Performance Computing (HPC) or similar high demand applications? The more processor horsepower you need, the hotter it will get

Space Savings: High density systems can save precious floor space by allowing end users to consolidate IT appliances into fewer footprints; there may not be a need to spread out servers as would be done in low density sites

Facility Systems: Is there chill water available? What additional infrastructure upgrades would be required? Is there enough power to support increased server loads?

Installation Space: Raised or slab floor? What climate control and power distribution exists? If there is chill water on site, is there enough to go around?

Floor Space: Even though a high density system can be used in locations with limited floor space, is there enough to support a proposed system? Can you add In Row units to existing rows? Is there enough room for immersion systems (these are horizontal instead of vertical)?

Efficiencies, CAPEX vs. OPEX, PUE: How much will it cost vs. how much will be saved over the life of the installation? Be aware of what any savings claims are based on, especially operational parameters: air temperatures, DeltaT's, water temperature, energy costs, etc. Make sure you're doing an "apples to apples: comparison"

DID YOU KNOW?

Fast facts related to data center cooling:

- According to Data Center Knowledge, small to midsize data centers house the lion's share of the world's IT equipment and use the majority of energy consumed by the industry as a whole
- Humidity is often overlooked in discussions about data center climate control, yet if the humidity level is too low, it can lead to electrostatic discharge that can damage equipment; if too high, it can cause condensation and corrosion
- IDC reports that annual energy consumption per server is growing by 9% globally
- According to the Institute of Electrical and Electronics Engineers (IEEE), hot spots on today's processors can reach power densities of 1kW per square centimeter – higher than the heat inside a rocket nozzle

<table>
<tr><th>INSTALLATION TYPE</th><th>THERMAL LOAD PROFILE</th><th>CHALLENGES</th><th>RECOMMENED COOLING SOLUTIONS</th><th>BENEFITS</th></tr>
<tr><td>Spine/Edge Data Center
4 - 16 Cabinets</td><td>5 - 20kW
per cabinet
200kW
Total Load</td><td>Definition of The Edge
Lack of supporting infrastructure
Thermal loads exceed installed climate control capacities
Remote installation locations
Uncontrolled installation environments</td><td>Close Coupled
Rack/Row/Space Level
Ex: LCP DX, LCP CW</td><td>Flexibility
Installation capable for most Space, Environment, Application requirements
Scalability
Increase heat removal capacity as thermal load increases
Closed Loop Row Airflow Paths
Eliminate need for aisle containment or dedicated room
Redundancy
Can be provided IF required</td></tr>
<tr><td>Small to Medium Size IT Space/Data Center
20 - 100 Cabinets</td><td>5 - 30kW
per cabinet
500kW
Total Load</td><td>Deployments in limited floor space
Repurposing of space from something else into a data center
Limited or shared infrastructure - power distribution and climate control
Exceeding capacity of legacy climate control systems</td><td>Close Coupled
Row or Room Level
Ex: LCP DX, LCP CW,
Direct to Chip</td><td>Flexibility
Type of Floor, Cable Routing Pathways, Space Constraints
Scalability
Add footprints and heat removal to support higher density appliance installations
Monitoring
Local and Remote monitoring and control of cooling and power
Cost Efficiency
Deploy in existing spaces. Reduce need to build new spaces</td></tr>
<tr><td>Large Data Center (Enterprise)
100 - 1000 Cabinets</td><td>10 - 50kW
per Cabinet
5mW
Total Load</td><td>The IT Refresh Cycle
Existing legacy infrastructure - limited climate control and poor airflow management
Insufficient capacity - Exceeding available system capabilities
Multiple vendor platforms</td><td>Row/Rack Based
Close Coupled
Ex: LCP CW/HD,
Direct to Chip</td><td>Flexibility
Support any IT appliance: Server, Network, Infrastructure
Scalability
Add capacity as needed per footprint, per row or per zone
Adaptability
Deploy various solutions based on specific needs in common space
Efficiency
Expanded operational parameters to improve energy usage. Maximize number of IT appliances with increased installation density</td></tr>
<tr><td>Hyperscale/ Cloud Data Center
>1000 Cabinets</td><td>10 - 100kW
per Cabinet
>10mW
Total Load</td><td>Keep up with the demand
Multiple customers under one roof
Widely varying thermal loads based on individual customer deployments
Support new and emerging applications
Manage hyperscale heat loads - 50-100kW per FOOTPRINT
Deployment of next generations of more powerful IT appliances</td><td>Row/Rack Based
Close Coupled
Ex: LCP CW/HD,
Direct to Chip,
Immersion Systems</td><td>Flexibility
Standard components configured to individual end user specifications
Scalability
Operate at Scale; Duplicate systems as demand increases
Adaptability
Support wide range of individual densities - at the footprint, row, cage, zone
Reliability
Local and Remote monitoring and control of climate control systems
Efficiency
Higher density installations supported by Direct to Chip or Immersion systems reduce power demand on supporting infrastructure</td></tr>
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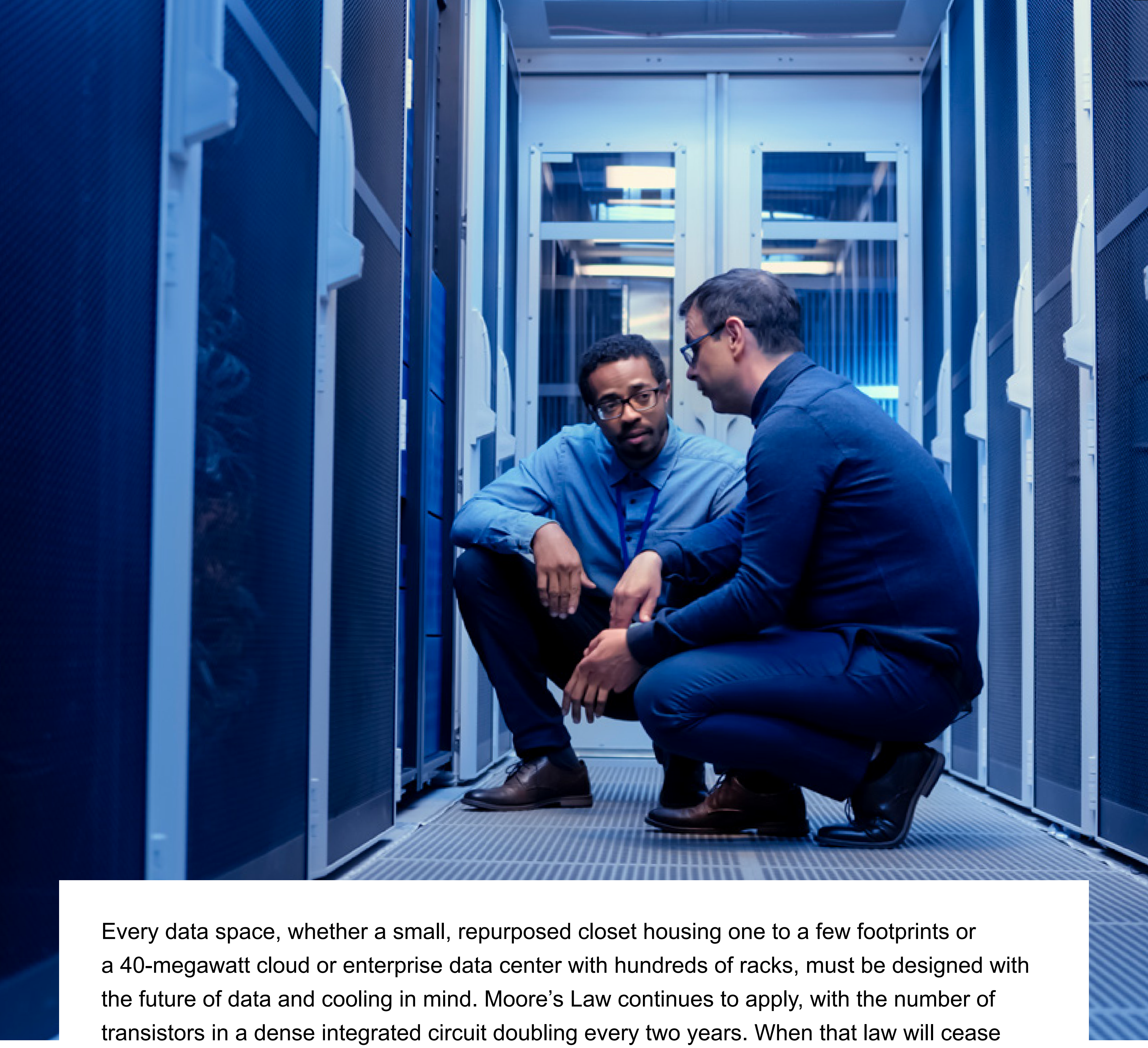

Every data space, whether a small, repurposed closet housing one to a few footprints or a 40-megawatt cloud or enterprise data center with hundreds of racks, must be designed with the future of data and cooling in mind. Moore's Law continues to apply, with the number of transistors in a dense integrated circuit doubling every two years. When that law will cease to apply we don't know – but for the foreseeable future, we can expect power and densities to increase, and the need for reliable, efficient cooling to be a top priority. IT professionals continue to become enthusiastic advocates of liquid cooling because of its targeted heat removal, ability to scale easily, small footprint and other features, all of which deliver increased efficiency and lower operating costs.

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