

DESIGNING INNOVATIVE LIQUID COOLING SOLUTIONS:

From The
Data Center
to The Edge



More Data Means More Cooling Needs

Data is growing faster than ever before in all parts of the world. In these exciting times, advanced technology is fueling game-changing innovations that are furthering the role technology will play in shaping and enabling human potential.

With the advances in genome sequencing, disease treatments, smart factories and more comes a need for greater processing power and storage. New server platforms are helping drive innovation across industries. Equipped with the most powerful processors and accelerators to date, servers can create, mine, arrange and process ever-increasing amounts of data faster than ever before. As a result, data centers have more computing power packed into smaller spaces to accommodate processing-intensive applications and consolidate workloads. Each machine in these data centers consumes more energy and generates more heat, putting greater pressure on cooling systems to ensure safe and efficient operations!¹

Processing these ever-increasing amounts of data creates a challenge. Data has gravity, and companies need to process data closer to where it is generated—often where space is at premium or thermal conditions are not favorable. The growing number, size, complexity and density of data servers due to the increasing demand for storage, networking and computation is a challenge from an energy consumption perspective. Data centers account for about 1-1.5% of the global electricity consumption. Several energy consumption models predict that data center energy usage could engulf over 10% of the global electricity supply by 2030.² Cooling energy consumption accounts for a major portion of the total energy consumption of data centers. This is increasingly becoming a threat to the environment and adding up to the Total Cost of Ownership (TCO) of data centers. Therefore, data center owners are becoming more considerate about energy saving and implementing eco-friendly solutions. Data center liquid cooling solutions reduce cooling energy consumption by 40–50% and improve power usage effectiveness (PUE).²

The global data center liquid cooling market is expected to reach USD 6.4 billion by 2027, growing at a CAGR of 24.8% during 2022-2027.²

With these challenges in mind, Dell Technologies OEM Solutions incorporates new technologies into our offerings, including cooling technologies as part of the PowerEdge server portfolio. Dell Technologies OEM Solutions also works with OEM customers and partners to design new, innovative solutions such as solutions for immersion cooling.



Types of Cooling Solutions

Dell Technologies helps enable customers on all facets of cooling solutions.

Air Cooling

Dell combines the latest air-moving solutions with sophisticated software control algorithms to efficiently cool the full range of server configurations.

Liquid Cooling

Direct liquid cooling (DLC): Dell offers this technology, sometimes called cold plate liquid cooling, in many of our platforms. As direct liquid cooling undergoes innovation, Dell Technologies OEM Solutions enables customers to design second generation direct liquid cooling solutions.

Immersion cooling: Dell Technologies OEM Solutions empowers solution providers to bring industry-leading immersion products to market.

Air Cooling

Air is cheap and readily available. To increase the potential of air cooling, Dell invented Multi-Vector cooling. It is comprised of control algorithms, thermal and power sensors, component mapped fan zoning, and airflow channeling shrouds to balance and intelligently direct airflow across a symmetrically arranged group of key sub-systems.

Key Sub-Components Include:

Fans: In addition to cost-effective standard fans, multiple tiers of high-performing, Dell-designed fans are supported to increase system cooling. The high-performance silver and gold fans can be configured into next-generation PowerEdge servers to support increased compute density.

Heatsinks: The improved Dell CPU heatsink design not only improves CPU cooling capability but also helps to streamline airflow and air temperature distribution across the chassis. Innovative heatsinks 'armed' with high-performance heat pipes and optimized fin spacing achieve this goal.

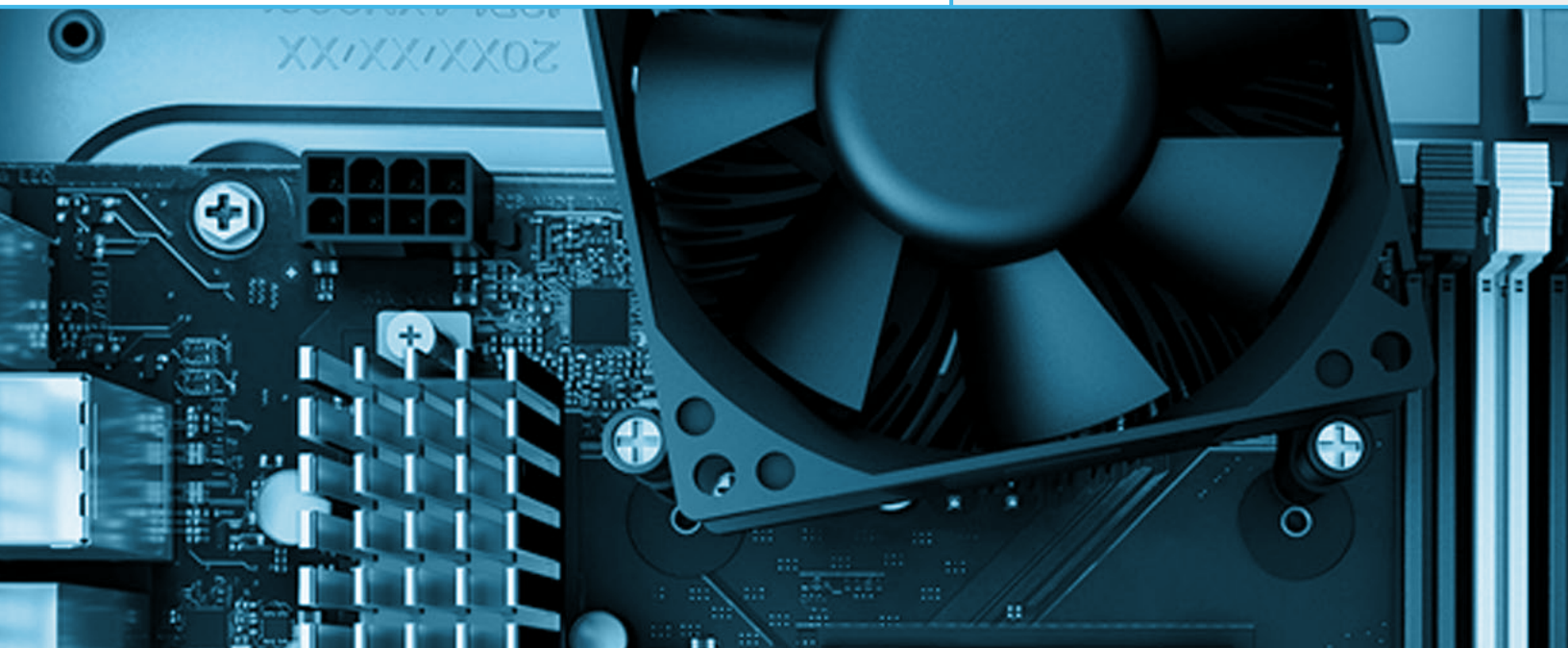
System Design: The T-shaped system motherboard layout, and PSUs that are located at each corner of the chassis allow for improved airflow balancing and system cooling, subsequently driving more efficient system cooling. This layout improves power supply unit (PSU) cooling due to reduced risk from high pre-heat coming from CPU heatsinks. The streamlined airflow helps with PCIe cooling as well, enabling support for PCIe Gen4 adapters. And finally, it creates a better cable routing experience on the PDU side of the racks where power cables are generally separated by grid assignments for redundancy.

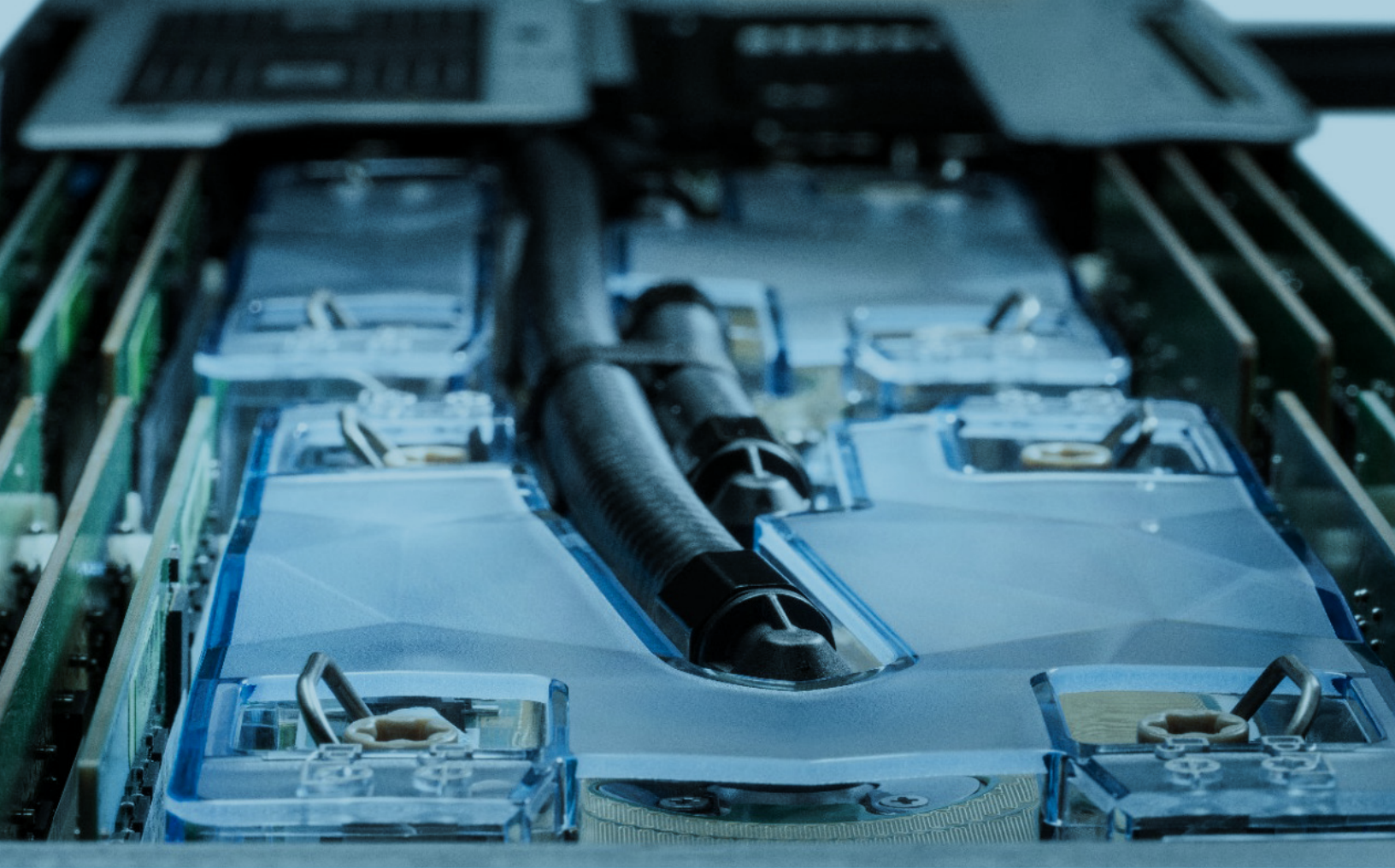
Key Benefits

- Air is inexpensive, plentiful, and easy to access.
- It is not a specific feature but a collection of key components that work harmoniously together to cool your servers.
- Dell custom-designed fans and advanced heatsinks double thermal and airflow management delivering powerful, sustained system performance.
- Dell fans and heatsinks are qualified using mandated and extensive reliability and qualification processes to run at full speed for the life cycle of the server minimizing costly downtime.
- For customers whose workloads are more compute rather than storage-intensive, Dell's new "Low-Z" configurations have airflow channels that replace some of the storage to maximize the flow of air resulting in better-sustained performance over time.

Considerations

- Inability to meet some of the higher modern workload demands.
- Represents significant percentage of data center OpEx.
- In hotter data center environments rack-door chillers may be needed to reduce the air temperature entering or exiting servers.





Direct Liquid Cooling (DLC)

Liquid cooling is an evolutionary step for data center cooling, offering significantly better effectiveness and efficiency compared to air. While it's not new, it's been the realm of supercomputing clusters or home enthusiasts for a number of years. The caveat is that projects required the owners to have technical expertise, and a comfort level with complexity and risk. Liquid cooling addresses internal components as they become even more powerful and hotter and is an effective way to cool extremely dense server solutions, based on the most powerful next-generation processors and accelerators. Dell's Direct Liquid Cooling offer is now a mainstream offer and available factory direct. As innovations in direct liquid cooling emerge, Dell Technologies OEM Solutions and our partners work with customers to design second generation liquid cooling solutions.

Direct Liquid Cooling (DLC) uses the exceptional thermal capacity of liquid to absorb and remove the heat created by new high-power processors. Cold plates are attached directly to the processors and then coolant captures and removes the heat from the system to a heat exchanger located in the rack or row. This heat load is removed from the data center via a warm water loop or any cool water supply, potentially bypassing the expensive chiller system. By replacing (or supplementing) conventional air-cooling with higher-efficient liquid cooling, the overall operational efficiency of the data center is improved.

Leak Sense Technology is a new feature now included with all Dell DLC solutions, providing customers with the knowledge that potential issues will be found and reported quickly. If a coolant leak occurs, the system's leak sensor will log an alert in the iDRAC system. Three errors can be reported: small leak (warning), large leak (critical), and leak sensor error (warning—indicates an issue with the leak detection board). These error detections can be configured to take meaningful actions, such as raising an alert or powering off a server.

Key Benefits

- **Increased System Cooling Capacity:** DLC enables system configurations that cannot be cooled by only air, such as high TDP CPUs, dense storage and/or add-in cards.
- **Improved Energy Efficiency (PUE):** The DLC cold plate solution reduces energy costs by up to 45% relative to cooled air and helps extend the life of existing air infrastructure.†
- **Higher Compute Density:** For the Dell PowerEdge C6520 server, DLC cooling supports up to 25% more cores per rack.‡ For the Dell PowerEdge C6525 server (with backplane configuration supporting storage drives), DLC cooling enables 2x the core count over air cooling alone.‡‡
- **Swift Serviceability:** The CPU DLC cold plate solution attaches with four screws, making service quick and simple.

Considerations

- Requires upfront setup investment and maintenance costs.
- Does not completely remove the need for system-level fans.

Immersion Cooling

Immersion Cooling is another option that uses liquid to cool servers for niche applications where conditioned air is scarce or not available. This approach completely submerges the system in a vat of liquid requiring no fans or air movement whatsoever to cool the system. Since no air is required to cool systems, it eliminates the need for any type of raised floor or air-handling equipment. Dell supports, through the OEM Solutions team and OEM Solutions partners, both single-phase and two-phase immersion projects.

Single-Phase Immersion places systems in a fluid-filled tank, and it can cool most high temp CPUs, memory, add-in cards, etc. For fluid supply, it connects to the customer facility water CDU (same as DLC).

Two-Phase Immersion uses dielectric fluid and has a very similar approach to Phase 1, except that the Phase 2 approach incorporating phase-change is a more powerful way to manage heat and provides a higher thermal load capability.

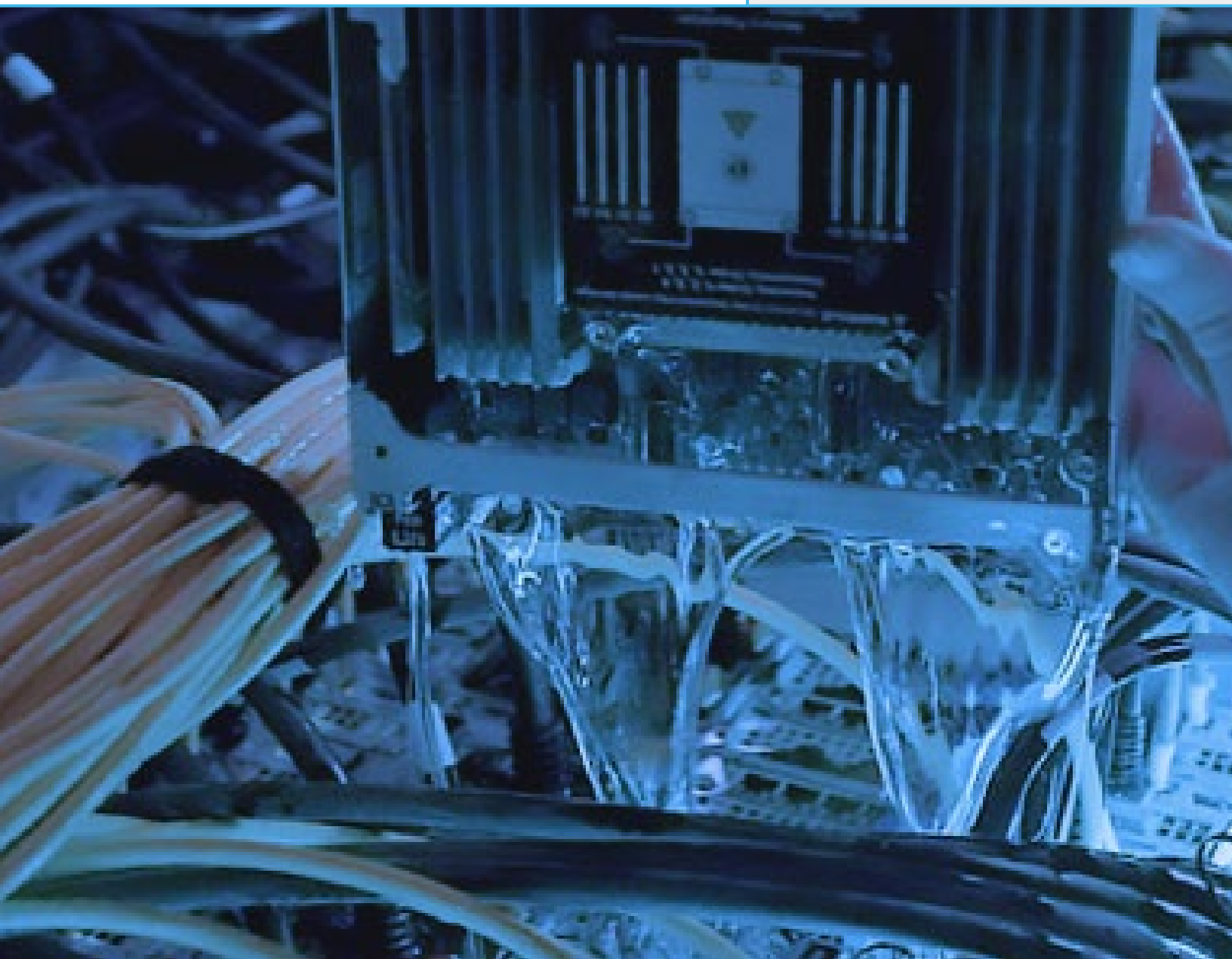
100% heat capture to these non-conductive fluids minimizes the cooling overhead for a rack of servers. In some extreme thermal loads, it may also be combined with DLC for better performance. For certain customers, immersion may be an attractive cooling option for a given environment and set of workloads.

Key Benefits

- 100% heat capture to liquid. Air is not required.
- Sealed system deployments—no dust/ingress. Enhanced dust resistance. Ideal for edge deployments.
- Manages high TDP components in dense server systems.
- Uses non-conductive liquid.
- Fluid is reusable indefinitely if properly filtered and maintained.

Considerations

- Requires upfront set up investment and maintenance costs.
- Two-phase immersion is more complex because it requires a sealed box to prevent evaporation of the expensive fluid.





Liquid Cooling Benefits



Cost Reduction

Reduce cooling energy consumption by 40-50%²

Improve the PUE²

Reduce TCO (lowering transmission cost, lowering the grid and reusing the heat)

Help reduce OpEx and CapEx



Operational Benefits

More compute power in less space

Deploy in hard to access areas, such as harsh environments at the rugged edge

Reduce server downtime and improve disaster recovery capabilities



Environmental Impact/Employee Safety

More eco-friendly solutions mean a reduction in carbon footprint

Immersion cooling solutions utilize specially engineered fluids that are nontoxic, nonflammable and dielectric

Immersion cooling saves water³

Noise-free solutions enhance comfort

Customers Who Will Benefit

Companies capitalizing on emerging technologies such as AI, blockchain, HPC and telcos which leverage high computational power to process data in real time

Companies operating at the rugged edge in deserts, military bases and regions with dramatic weather and seismic activity

Companies looking to lower TCO/costs of data center operations

Companies that require high density cooling, such as HPC, and require minimum space



Advantages of Working With Dell Technologies OEM Solutions

Dell Technologies OEM Solutions helps solution builders and product development organizations bring their products to market by incorporating Dell products with their own Intellectual Property (IP). We work with customers to enable various types of cooling solutions depending on their needs.

- We have a portfolio of liquid cooling products with DLC technology that is now offered as a factory-installed solution in Dell PowerEdge servers.
- We work with technology leaders in the space who design enhanced solutions from DLC all the way through immersion.

Companies designing solutions for liquid cooling are at the forefront of industry innovation and need leading technology partners who can help them design cutting edge solutions and provide the right technology and capabilities.

OEM Solutions has the broad, innovative portfolio, unique capabilities such as design, engineering, program management, world-class services and a reliable, resilient and secure supply chain. We have a dedicated OEM team comprising Product Group, Engineering, Program Management, Procurement, Sales, Marketing and more, as well as a broad partner ecosystem—and we've been doing it for more than 20 years.



Helping customers accelerate their journey at the edge

20+ Years of experience designing for operational technology (OT) and edge



Ready-to-ship tailored and distinct custom solutions



Off the shelf
Dell Standard



De-branded,
Re-brand Ready
OEM-Ready



Stability, Longevity
& Visibility
XL | XE



Industrialized
Durability
Industrialized



Making Your Ideas
a Reality
Custom

Our customers can choose from a wide range of components—from standard off-the-shelf and tailored products to OEM-Ready products to unique, customized solutions. Our extended life OEM XL and XE platforms come with in-advance visibility to key product transitions and changes that effectively help customers maximize resources and budget. We offer a suite of OEM services, including a dedicated OEM queue. We also offer Modular Data Centers that pre-integrate liquid-cooled IT and can act as a stand-alone data center wherever new projects are initiated. All these capabilities enable Dell Technologies OEM Solutions to address a wide range of customer needs.

Customers designing for immersion cooling benefit from our unique customization capabilities. For example, we work with customers and identify the right product for immersion cooling based on customer requirements. We then work on the manufacturing instructions for how to modify standard products that must be immersed. This can include custom firmware and custom BIOS, and we advise our customers on some mechanical changes. Then, the customer integrates the product into their chassis, and it goes to market as an immersed solution. This can be done at a customer's location or at any second-touch partner's facility.

Solution builders can provide support for end users on their newly created immersion cooling solutions by leveraging custom support options offered through Dell Technologies OEM Solutions.

Through our partners, we offer rack and stack solutions for turnkey liquid-cooled deployments, including properly installed manifolds—pumps and heat exchangers as a right sized and efficient solution.

Liquid cooling technologies can help drive transformational outcomes. To discover how, contact your [sales representative](#) or visit Dell.com/oem.

Early adopters are driving new, innovative use cases

Dell Technologies OEM Solutions worked with a customer to provide a highly efficient cooling infrastructure for a large university's research center. This liquid immersion cooling solution has proved to be cost-effective from both an energy and operations perspective. The solution enabled a consistent thermal environment while reducing the amount of energy consumed by cooling. As a result, the university's compute has allowed the customer to use the most intensive applications like AI/ML for their cutting-edge research.

“The key aspect of this is that it improves the heat transferring much more efficiently than transport to air. It only takes about 300 watts to cool 10 kilowatts of power. Even during the high temperatures we've been having all summer, we've been able to run the system.”

- Director Of Advanced Computing Systems at a University's Research Center

¹ Sheldon, R. (2022). Liquid cooling vs. air cooling in the data center. TechTarget.

² MarketsandMarkets™ Data Center Liquid Cooling Global Forecast to 2027, May 2022.

³ MarketsandMarkets™ Immersion Cooling Market Global Forecast to 2026, July 2021.

[†] Based on Dell internal analysis, March 2021, comparing hypothetical air-cooled data center with a cooling PUE of 0.62 to a hybrid data center with a cooling PUE of 0.34. A PUE of 0.21 was assigned to all overhead not attributed to cooling. Operating costs and other factors will cause results to vary. RS Means industry standards cost basis was used to measure typical cooling infrastructure costs and determine projected savings.

[‡] Based on internal Dell analysis, comparing the highest performance air-cooled Intel Ice Lake CPU (8352Y) to the highest performance DLC-cooled Ice-Lake CPU (8380) in a PowerEdge C6520 system, 25% more cores can be supported with DLC cooling.

^{‡‡} Based on internal Dell analysis, comparing the highest performance air-cooled AMD Milan CPU (7513) to the highest performance DLC-cooled Milan CPU (7763) in a PowerEdge C6525 system, twice as many Milan CPU cores can be supported with DLC cooling.