

ABLECOOL™

Rear Door Heat Xchanger (RDHx)



Empowering Data Centers for
Sustainability & Cost Savings

White Paper

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Ablecom AbleCool helps data centers achieve sustainability and cost savings

RDHx cooling systems offer high-efficiency, cost-effective data center upgrades with low CapEx and minimal operational disruption.

Executive summary

Rack heat density has increased dramatically in data centers, driven by a rise in AI and high-performance computing (HPC) workloads. In many cases, thermal management demands exceed the capabilities of traditional air-based cooling architectures. At the same time, sustainability concerns are prompting governments around the world to implement energy efficiency standards for data centers, adding to the urgency of the situation. This includes stringent compliance mandates reshaping the industry, such as the European Union's Energy Efficiency Directive (EED).

A move to liquid cooling is the logical next step for most data center operators, but immersion and direct-to-chip (DTC) systems have high deployment costs and long retrofit timelines. Rear door heat exchangers (RDHx) avoid these drawbacks. They can handle heat loads of up to 80 kW per rack, require low CapEx, and have minimal operational impact during installation, slashing Power Usage Effectiveness (PUE) to an ideal 1.2–1.3 range while protecting existing server hardware investments.

The Ablecom AbleCool RDHx series delivers strong cooling performance as well as sensor-driven monitoring and intelligent control. And Ablecom's 30 years of precision server rack engineering experience means that its engineers are able to support clients who need challenging custom configurations.

The end of air-based cooling

AI and HPC applications are driving an unprecedented surge in server hardware loads, increasing data center heat density. This structural shift has dramatically increased processor power consumption and thermal dissipation requirements per rack. In many cases, heat-dissipation requirements now exceed what computer room air conditioner (CRAC/CRAH) and standard server air cooling can handle, creating serious financial and operational problems.

Air-based cooling already accounts for up to 40% of data center energy consumption. But because the efficiency of these systems starts to fall off beyond thresholds of 20 kW per rack, server and room fans must use even more power to compensate for poor airflow, driving operating costs and energy consumption beyond acceptable limits. This triggers a rapid expansion of parasitic fan power, forcing system internal fans to spin at extreme velocities to compensate for insufficient macro-airflow circulation.

In many instances, air-based cooling architectures will be unable to meet heat-dissipation requirements no matter how much energy they use. And because gray space is limited, installing extra CRAC units in the room to compensate is often not feasible.

There are also social and political pressures to consider. Public anxiety surrounding data center sustainability has sparked widespread pushback and opposition against new facility construction projects globally. Many countries are proposing stricter energy efficiency regulations for the industry; in some cases, new regulations are already coming into effect.

In short, air-based cooling must be viewed as legacy technology. Data center operators should start considering their upgrade options without delay.

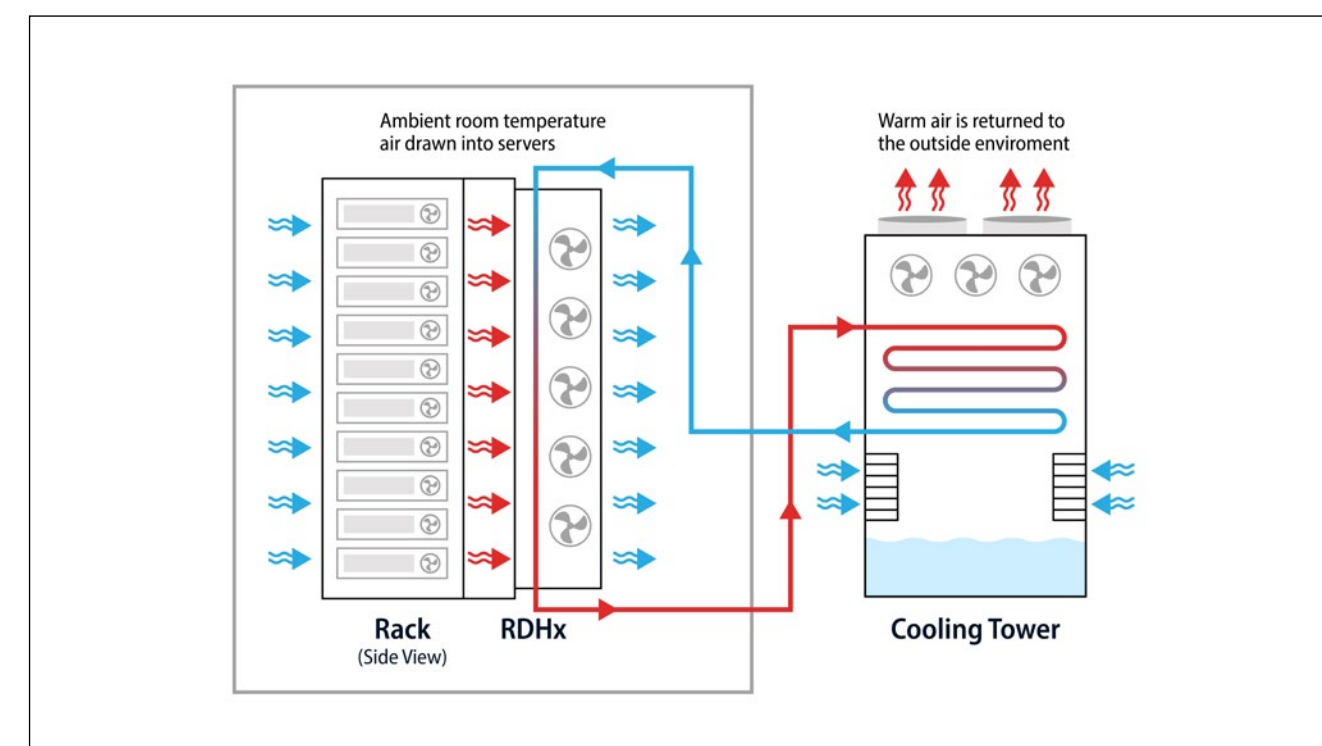


Figure 1: RDHx cooling system architecture. Hot exhaust air from high-density server racks is absorbed at the rear door heat exchanger via internal liquid coils and discharged through the data center cooling loop.

Regulatory pressure on data centers : a global trend

Sustainability is shifting from being an ethical ideal to an objective compliance requirement around the world:

Europe

In the EU, the revised [Energy Efficiency Directive \(EED\)](#) makes it mandatory for data centers to monitor and report energy efficiency.

EU member states are also allowed to set their own requirements for data centers—and some have already begun to do so. [In Germany](#), for example, new facilities must meet a power usage effectiveness (PUE) target of 1.2. Facilities exhibiting subpar PUE ratings face legal remediation orders, heavy financial penalties, or operational shutdowns—making high-efficiency systems like AbleCool RDHx, which drops PUE to 1.2–1.3, an essential defensive investment.

United States

[California](#) legislators are proposing laws to mandate reporting of power and water use metrics for data centers and are also considering formal water efficiency standards. Beyond energy limits, local power grid operators are rejecting expansion or grid-connection permits for data centers lacking high-efficiency closed-loop thermal designs.

Asia-Pacific

In Singapore, the government's [Infocomm Media Development Authority](#) has laid out a roadmap to achieve a PUE of ≤ 1.3 and a water usage effectiveness (WUE) ratio of 2.0 for all data centers by 2034.

Understanding the physical limitations of air cooling

Data center engineers understand the technology behind the often-cited 20 kW/rack limit of air-based cooling. But for non-engineers, it can be helpful to understand the physical background supporting that figure.

Fortunately, it's not necessary to get into technical terms like “fan affinity laws” or “volumetric heat capacity.” It's enough to say that this kind of cooling has a few hard practical limits due to a.) the properties of air as a cooling medium and b.) the physical limitations of server fans themselves:

- In general, air is bad at carrying and transferring heat. That's why it's a great insulator—think double-pane windows and goose down jackets. In a traditional server room environment, that limitation is manageable. But beyond 20 kW/rack, as air-based cooling starts to falter, heat is removed from dense components unevenly, resulting in localized hotspots that degrade processor performance.
- As rack heat increases, fans have to work harder to move enough air to cool servers. But due to the physical principles determining how fans are able to move air, this happens in a non-linear fashion, causing a disproportionate rise in the power drawn by the fans.
- Server fans are size limited by the internal chassis. They cannot endlessly increase airflow and pressure. As rack heat increases past the 20 kW threshold, the fans simply aren't capable of moving enough air to carry all of that heat away.

As HPC computing becomes the norm in data centers, liquid-based cooling solutions are the future of daily operations. That future is here today.

RDHx systems : a pragmatic path to liquid cooling

The pivot to liquid-based cooling solutions is already underway. Liquid-based architectures possess the superior thermal transfer capacity required to support modern HPC and AI data centers while radically improving overall facility energy efficiency.

However, site upgrades that rely on complex liquid-based cooling solutions—most notably immersion and direct-to-chip (DTC) systems—encounter some significant obstacles:

- High deployment costs that can stretch CapEx budgets and slow ROI.
- Lengthy downtime due to disruptive retrofits that require primary backbone re-piping and server board teardowns.
- Warranty complications when server hardware manufacturers refuse to cover some products immersed in liquid cooling mediums.
- Increased equipment complexity that creates a skills gap among facility staff.

In contrast, rear door heat exchanger (RDHx) cooling offers a pragmatic, balanced approach to thermal management. RDHx solutions use a liquid-cooled coil mounted at the back of a server rack to capture heat directly from exhaust air. This offers the benefits of liquid cooling without the drawbacks of DTC or immersion systems:

Excellent heat dissipation capacity : RDHx systems can easily handle heat dissipation loads up to 75 kW/rack, aligning with modern HPC and AI deployment demands.

Energy savings : Compared to traditional air-cooled data centers, RDHx systems achieve up to 30% reduction in total cooling energy consumption.

Efficiency : The efficiency of RDHx cooling helps facilities achieve power usage effectiveness (PUE) ratios in the 1.15–1.3 range.

Low deployment costs : RDHx is an extremely cost-effective liquid cooling option that requires little to no modification to facility infrastructure. This eliminates the need for disruptive building remodeling and drastically reduces deployment capital expenditures.

Near-zero footprint : Mounted directly on the back of the server racks, RDHx cooling has a negligible impact on floor space.

Easier maintenance : Less complex than other liquid-based systems, with modular, hot-swappable fan modules to streamline service operations.

Future-ready : If a facility wants to implement DTC cooling later on, RDHx infrastructure can still be used with DTC solutions as part of a hybrid cooling approach.

Not every cooling solution is right for every scenario. But when better thermal management is urgent and non-negotiable, RDHx systems offer a rapid, non-disruptive, and affordable upgrade path.

AbleCool : High-performance RDHx for heat loads of up to 75 kW per rack

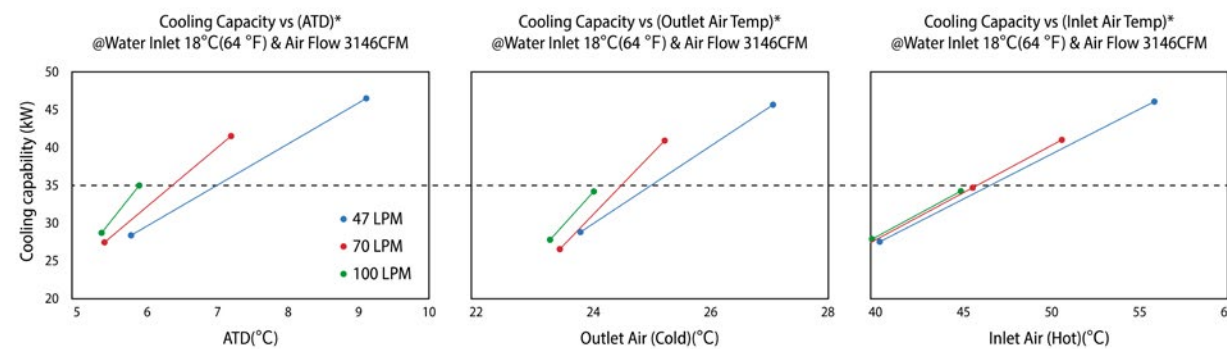
The AbleCool series of RDHx systems delivers up to 65 kW of heat load dissipation per rack. Along with the series' other features, this makes them an excellent fit for HPC and AI data center deployments.

Model	CDR52 (EC)	CDR42 (EC)	CDA42 (DC)
Cooling Capability*	50k W / 75 kW approach temperature difference @ (ATD) = 15° C	25kW / 50 kW @ATD = 15° C	35 kW / 50 kW @ATD = 15° C
Form Factor	48U – 52U	42U – 52U	48U – 52U
Width	750 – 800 mm (29.53" - 31.50")	600 – 800 mm (23.62" - 31.50")	600 – 800 mm (23.62" - 31.50")
Depth (excluding frame)	390 mm (15.35")	337 mm (13.3")	235 mm (9.25")
Active Air Flow (adjustable via PWM control)	5,030 CFM (142 CMM)	3,900 CFM (110 C MM)	2,500 CFM (70 CMM)
Design Water Flow (adjustable via RS485 interface)	Max: 90 LPM (23.78 GPM)	Max: 70 LPM (18.5 GPM)	Max: 70 LPM (18.5 GPM)
Power Consumption (Max)	2.1 kW	1.7 kW	1.2 kW
Operating Ambient Temperature	15° C – 45° C (59° F – 113° F)		

*Test condition: 23.9° C (75° F) room temperature, 45% RH, supply water at 12.8° C (55° F).
* ATD = 15° C values represent theoretical extrapolation (Theoretical Max).

Tested to ensure empirically validated thermal dissipation performance, the AbleCool series delivers complete engineering coverage for next-generation AI servers such as NVIDIA HGX or AMD MI series high-density accelerator cabinets.

Performance (Cooling Capacity) - 25kW

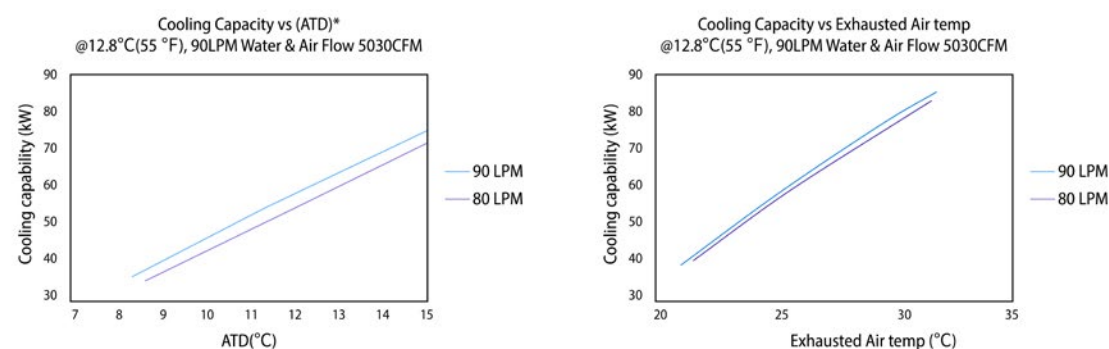


- With a 18° C water inlet temp and 25° C air outlet temp (ATD = 7° C), the cooling capacity reaches up to 35kW.
- Water Flow Rate $\geq$ 47 LPM , Air Flow Rate = 3146 CFM
- Inlet Water = 18° C , Outlet Air = 25° C , ATD = 7° C

*Note : Air flow rate with floating pressure in front of the DUT

*Note : ATD = Air Outlet Temp - Water Inlet Temp. Data points represent empirical measurements with no fitting/extrapolation.

Performance (Cooling Capacity) - 52RD



- Ablecom CDR52 RDHx cooling capacity could reach 80kW at ATD 15° C
- Condition meet 80KW cooling capability:
 - Water side with 90LPM @ 12.8° C (55° F), water supply into RDHx.
 - Air side with 5030CFM air flow through RDHx.

*Note : ATD = Air Outlet Temp - Water Inlet Temp

*Note : ATD = Air Outlet Temp - Water Inlet Temp. Data points represent empirical measurements with no fitting/extrapolation.

Figure 2: AbleCool RDHx performance curves showing cooling capacity vs. ATD & exhaust air temperature. Empirical thermal dissipation performance charts demonstrating variable cooling capacities scaling up to 80kW based on water flow rates (80–100 LPM), airflow volume (5030 CFM), and air-to-fluid temperature differentials (ATD).

Design features that reduce TCO and speed ROI

The AbleCool series is built for high-performance cooling—and also offers benefits that simplify operation and reduce total cost of ownership (TCO) :

Fast, low-cost deployment : By eliminating the need for extensive structural redesigns, floor strengthening, and expensive pipe-welding work, data centers can reduce capital expenditures and enjoy faster payback on their investment.

High-quality sensor data : Onboard sensors track temperature, differential pressure, condensation, and leakage, making it possible to monitor system health and implement intelligent hardware control. The system integrates precision-engineered industrial sensors that continuously track exhaust air temperatures, supply/return water temperature differentials (ΔT), and dynamic static pressure parameters, visualizing real-time metrics via an HMI Touchscreen and remote WebUI.

Cooling on demand : AbleCool also delivers OpEx savings via intelligent control features. Sensor data computes thermal loads in real time, modulating fan speed and water flow accordingly and eliminating unnecessary energy usage. Driven by an embedded microcontroller running PID regulation algorithms, the system leverages Pulse Width Modulation (PWM) to dynamically modulate fan velocity and water flow rates, generating up to a 30% direct reduction in annual cooling electricity expenses and curtailing parasitic power draw during off-peak hours.

Leak prevention : Moisture-sensing cables trigger an instant alarm and automated valve closure upon detecting even microliter-scale leaks. The high-sensitivity fiber-optic/electrode cables are deployed along rack bases and RDHx chassis to guarantee instant automated protection.

Ease of service : Drip-free, self-sealing quick disconnect couplings (QDCs) prevent coolant leaks during routine maintenance.

Maximum uptime : Hot-swappable fan modules, built in N+1 or N+2 redundancies, enable toolless replacement without downtime if an individual fan fails to guarantee continuous cooling operation.

Faster ROI : For a typical 2MW (50-rack) high-density AI deployment averaging 40kW per rack, pairing substantial annual electricity savings with eliminated civil overhaul CapEx enables full ROI within 12 to 18 months, yielding an exceptional internal rate of return (IRR).

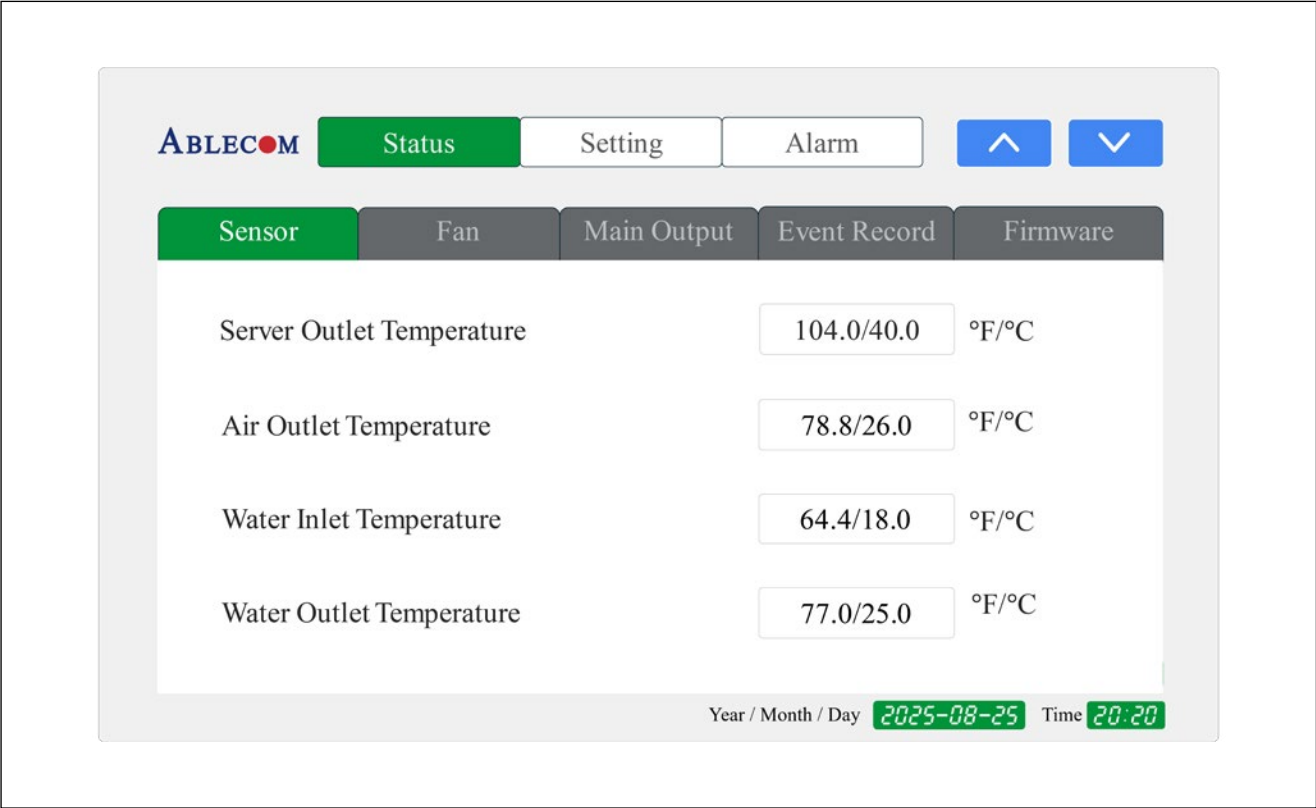


Figure 3: AbleCool dynamic control and monitoring interfaces. An HMI touchscreen and remote WebUI enable real-time visualization of multi-point dynamic sensor tracking, including inlet/outlet water temperatures, airflow dynamics, fan RPM modulation, and water valve control percentages for automated cooling on demand.

Liquid cooling trade-offs: a buyer's comparison matrix			
Evaluation Dimension	Immersion Cooling	Direct-to-Chip (DTC) Cooling	AbleCool RDHx Series
Capital Expenditure (CapEx)	Extremely High (Requires custom tanks, specialized dielectric fluids, and heavy lifting hoists)	High (Requires internal cold plates and manifold retrofitting per server)	Low (Modular rear-door bolt-on installation utilizing existing racks)
Operational Cost & ROI	Excellent thermal transfer, but fluid maintenance and top-off costs are high	Strong operational efficiency, but fluid loop maintenance is complex	Superior , with a rapid payback period of 12 – 18 months
Deployment Complexity & Downtime	Extremely High (Requires full plant shutdown and structural floor/drainage retrofits)	Medium-High (Requires motherboard uninstallation and internal routing)	Extremely Low (Hot-swappable, zero destructive civil restructuring required)
Hardware Warranty & Maintenance Risk	Some OEMs may void server warranties due to immersion fluid contact	Requires deep OEM coordination; internal leak risks are centralized	Preserves server component warranties (Heat exchange occurs externally at the rear door)
Transition Readiness (Hybrid)	Standalone dead-end architecture	Requires dedicated internal modifications	Hybrid-Ready , serving as a reliable first-step upgrade path for future DTC migration

Solving custom design challenges with Ablecom

RDHx cooling solves the heat dissipation challenges of modern data centers. But what about specialized use cases that require tailored engineering?

This is where Ablecom differentiates itself with specialized hands-on engineering support and extensive customization, whether its partners need non-standard equipment or are deploying in the most sensitive of manufacturing environments.

Case Study : Cooling in a Cleanroom

Background : To support advanced process control, a leading semiconductor manufacturer needed to build an edge computing and data analytics room in its manufacturing plant.

Challenge : In a semiconductor cleanroom environment, there is zero tolerance for airborne particulates because of the risk of wafer contamination. Most RDHx units use copper cooling pipes, which oxidize (forming patina) or shed micro-particles over time under humidity shifts, directly risking wafer yield loss. At the same time, substituting copper with compliant metals like stainless steel causes severe thermal conductivity issues in RDHx coils, producing heat-transfer and micro-welding fabrication challenges.

Custom Solution : Leveraging 30+ years of precision mechanical experience, the technical expertise of Ablecom’s team was fundamental to overcoming these stainless steel thermal transfer and manufacturing challenges. The company’s engineers designed a custom anti-oxidation stainless steel cooling loop architecture with robust heat-dissipation capabilities.

Results : The result was a cleanroom-compliant RDHx system that mitigated micro-contamination risks and delivered high kW-density heat dissipation, successfully safeguarding production wafer yield rates while solving high-density thermal constraints.

Case Study : DC-Only Deployment Timeline Cut from Months to Weeks

Background : Driven by a sudden surge in AI workloads, a data center faced a severe thermal bottleneck. However, the facility was running on a 100% direct current (DC) electrical architecture to minimize transmission conversion losses—complicating cooling equipment procurement.

Challenge : While AI heat loads spiked instantly, off-the-shelf RDHx solutions on the market were exclusively AC-powered and incompatible with the facility’s electrical grid. Developing a native DC-compatible RDHx system in-house would take six to nine months—unacceptable given the urgency of the situation.

Custom Solution : Deploying rapid engineering capabilities, the Ablecom engineering team leveraged its fully validated RDHx unit as the basis for a custom solution, the Ablecom engineering team integrated a high-performance DC-AC inverter at the unit’s power input—making it compatible with the facility’s electrical system.

Results : Delivered a custom RDHx solution that functioned seamlessly in a 100% DC-powered facility—slashing the deployment timeline to just a matter of weeks. This allowed the client to seize market AI opportunities immediately while avoiding expensive non-recurring engineering (NRE) costs.

Customized solutions don’t have to mean protracted R&D or exorbitant engineering costs. By building on a proven platform, Ablecom adapts existing designs to specific requirements without starting from scratch. By working with Ablecom, data center operators get a strong RDHx foundation that can readily be tailored to their individual needs.

Conclusion

Rack power densities will continue to rise as data center operators navigate the challenging intersection of escalating AI thermal densities and tightening global sustainability regulations. For this reason, it’s increasingly urgent for data centers to find practical solutions to these financial, operational, and regulatory pressures.

RDHx systems offer an immediate and cost-effective approach to liquid cooling upgrades. The AbleCool RDHx series offers an exceptional balance of high cooling capacity (up to 75 kW/rack), rapid non-disruptive deployment, and significant PUE reduction (slashing PUE to an ideal 1.15–1.3 range). And working with Ablecom offers the added benefit of an experienced engineering partner to enable challenging custom deployments.

To discuss an AbleCool upgrade or a custom engineering project, [contact the Ablecom engineering team](#).

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