LIQUID COOLING — GUIDE

Direct-to-Chip vs Immersion vs Rear-Door Cooling Compared

Compare the three main liquid cooling approaches for AI and high-density data centers: direct-to-chip cold plates, single-phase and two-phase immersion, and rear-door heat exchangers.

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Three liquid cooling approaches dominate AI and high-density data centers: **direct-to-chip cold plates**, **immersion cooling** (single-phase and two-phase), and **rear-door heat exchangers**. Each has distinct density limits, retrofit characteristics, and operational requirements.

Quick comparison

Aspect	Direct-to-chip cold plates	Single-phase immersion	Two-phase immersion	Rear-door heat exchangers (RDHx)
Typical rack density	30-150+ kW	50-150+ kW	100-200+ kW	30-75 kW
Coolant	Water / glycol (facility loop)	Dielectric hydrocarbon fluid	Dielectric fluorocarbon fluid	Water / glycol (facility loop)
Server modification	Cold plates replace air heatsinks	Remove fans, immerse fully	Remove fans, immerse fully	No server modification
Facility loop	CDU separates IT and facility loops	CDU or tank-integrated HX	CDU or tank-integrated HX	Connects to facility water
Retrofit difficulty	Moderate (server downtime)	High (full immersion)	High (full immersion)	Low (no server changes)
PUE potential	1.05-1.15	1.02-1.08	1.01-1.05	1.15-1.30
OEM warranty	Increasingly supported	Limited, case-by-case	Limited, case-by-case	No impact

Sources: NVIDIA GB200 NVL72 specs (NVIDIA, 2026); Mordor Intelligence Data Center Liquid Cooling Market Report (2026); CoolIT Systems CDU Guide (2025); Allied Control PUE 1.02 claim (Wikipedia PUE, 2026).

Direct-to-chip cold plates

Cold plates mount directly on CPUs, GPUs and other high-heat components. A coolant distribution unit (CDU) circulates water or water-glycol through the plates, transferring heat to a facility water loop via a heat exchanger. The IT loop and facility loop remain separate.

- **Density**: Supports the highest rack densities. NVIDIA GB200 NVL72 racks reach ~140 kW using direct-to-chip cooling (TrendForce, 2024; NVIDIA, 2026).
- **Retrofit**: Requires server downtime to replace heatsinks. Cold-plate loops and manifolds must be installed in each rack.
- **Warranty**: Growing OEM support. Accelsius offers server-level warranties for two-phase direct-to-chip systems (Mordor Intelligence, 2026).
- **Fluid**: Typically water-glycol on the facility side; some vendors use dielectric fluid in the IT

loop.

Immersion cooling

Servers are fully submerged in dielectric fluid. Heat transfers directly from components to fluid.

Single-phase immersion

Fluid stays liquid. Pumped through a heat exchanger (CDU or tank-integrated) to reject heat to the facility loop.

- **Density**: 50-150+ kW per rack/tank.
- **Fluid**: Synthetic hydrocarbons (PAO), esters. Shell S3 X uses GTL-based hydrocarbon (Mordor Intelligence, 2026).
- **Operating temperature**: 15-65°C typical (Wikipedia Immersion Cooling, 2026).
- **Advantage**: No cold-plate machining; entire server cooled uniformly.

Two-phase immersion

Fluid boils at low temperature (typically 30-50°C). Vapor rises to a condenser, returns as liquid.

- **Density**: 100-200+ kW per tank.
- **Fluid**: Fluorocarbons (for example Chemours Opteon). Chemours and Navin Fluorine agreed to manufacture Opteon two-phase fluid, with capacity from 2026 (Chemours, 2025). Confirm current supply with the fluid maker — 3M exited fluorochemical production, so Novec fluids are being phased out.
- **Advantage**: Highest heat flux; passive phase change drives circulation.
- **Challenge**: Fluid loss, sealed tanks required, higher fluid cost.

Rear-door heat exchangers (RDHx)

A heat exchanger replaces the rear door of an air-cooled rack. Facility water circulates through the door; rack fans push air through the coil. Heat transfers from air to water without changing the servers.

- **Density**: 30-75 kW per rack. Limited by air-side heat transfer.
- **Retrofit**: Easiest. No server modification. NorthC installed Legrand USystems ColdLogik RDHx at Münchenstein while the site stayed live (Legrand/NorthC, 2025).
- **Use case**: Brownfield sites, incremental density increases, mixed air/liquid rows.
- **PUE**: Higher than direct-to-chip or immersion because rack fans remain.

Choosing an approach

- **New-build AI cluster, 100+ kW/rack**: Direct-to-chip or two-phase immersion. NVIDIA GB200 NVL72 uses direct-to-chip (NVIDIA, 2026).
- **Retrofit, limited downtime, up to 75 kW/rack**: Rear-door heat exchangers.
- **Maximum density, PUE priority, willing to qualify fluids**: Two-phase immersion.
- **Operational simplicity, hydrocarbon fluid preferred**: Single-phase immersion or direct-to-chip.

Sources

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Frequently asked questions

Which cooling method is best for a 100 kW rack?

Direct-to-chip and immersion cooling both support 100 kW+ racks. Rear-door heat exchangers typically handle up to 50-75 kW per rack. The choice depends on retrofit constraints, fluid compatibility and OEM warranty requirements.

Does immersion cooling void server warranties?

It can. Some OEMs now offer warranties for validated immersion configurations. Accelsius reported offering server-level warranties for two-phase direct-to-chip cooling in March 2025 (Mordor Intelligence, 2026). Always confirm with the OEM before immersing servers.

Can rear-door heat exchangers be added without downtime?

Yes. Rear-door heat exchangers are often used as a retrofit because they can be installed on existing rack rows without interrupting operations. NorthC deployed Legrand USystems rear-door units at Münchenstein without interruption in November 2025 (Mordor Intelligence, 2026).