WHITE PAPER: EXECUTIVE SUMMARY

Evaluating External Heat Rejection Options for Liquid-Cooled Data Center Applications

Study Overview

As direct-to-chip liquid cooling becomes standard in high-density data centers, selecting the right external heat rejection technology has become a critical infrastructure decision. This study evaluated four external heat rejection technologies across six global climate zones to understand how climate, water availability, energy costs, and operational priorities influence performance. The analysis confirms there is no universally optimal solution, and the best option depends on site-specific conditions and business objectives.

Heat Rejection Technologies Evaluated

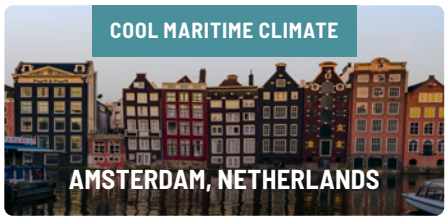
Air-Cooled Chillers
with Integrated Air-Cooled Condensers (ACC)
Rejects heat entirely to ambient air with no process water consumed.

Water-Cooled Chillers
with Adiabatic Dry Coolers (WCC + ADAC)
Adds selective evaporative pre-cooling to the dry cooler, used only when demanded by ambient conditions.

Water-Cooled Chillers
with Dry Coolers (WCC + DAC)
Combines a water-cooled chiller with dry cooler heat rejection. No evaporative water consumption.

Water-Cooled Chillers
with Closed Circuit Cooling Towers (WCC + CCCT)
Rejects heat through continuous evaporative cooling.

Climate Zones



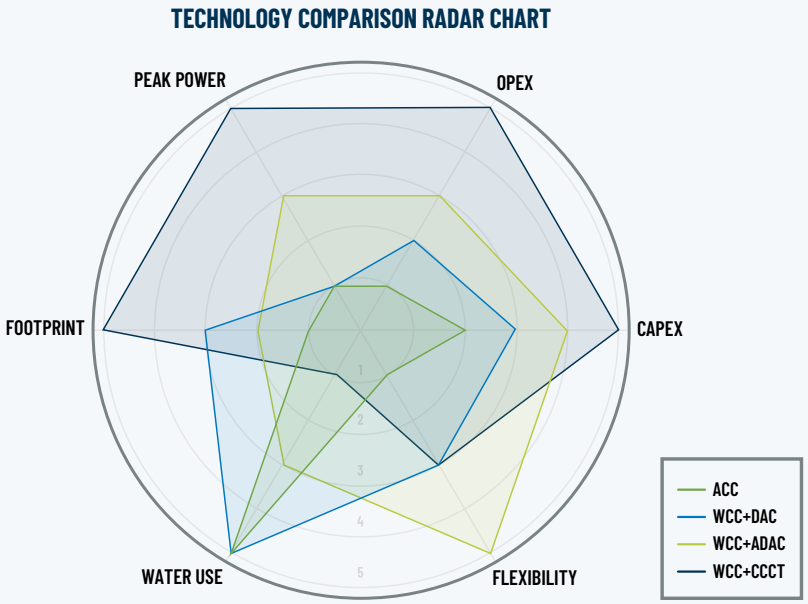
Modeling Approach

Each technology was modeled using an 18 MW liquid-cooled data center module operating continuously throughout the year, using ASHRAE 2025 weather data for each location. Performance was measured by capital cost, operating cost, peak power demand, water consumption, free cooling potential, footprint, and overall climate suitability.

Study Findings

No single technology is optimal across all metrics and all locations; each involves tradeoffs between energy, water, cost, and infrastructure as illustrated below.

- **Evaporative systems (WCC + CCCT)** consistently minimize energy use and peak demand across all climates, though with the highest associated water consumption.
- **Dry systems (ACC and WCC + DAC)** eliminate on-site water consumption at the cost of higher energy use and infrastructure requirements.
- **Adiabatic systems (WCC + ADAC)** offer a flexible middle ground, particularly in drier climates.



Each axis represents relative performance on a scale of 1 to 5, from the inner ring (1) to the outer ring (5), where a higher score indicates a more favorable outcome for that metric. The shape traced by each technology highlights its relative strengths and tradeoffs. Please note: Water Use scores reflect water efficiency relative to other configurations, not absolute consumption.

Strategic Implications

The study results demonstrate that heat rejection system selection should be treated as a site-specific optimization exercise. The right choice depends on each location's climate, water availability, utility costs, and electrical infrastructure capacity, as well as the operator's sustainability goals and long-term growth plans. Operators who design around their site's conditions and constraints, rather than a preferred technology, will ultimately build and operate the most efficient and resilient facilities.

To read the full white paper, visit **https://baltimoreaircoil.com/data-centers.**

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