Liquid Cooling System for AIDC

The Challenge of Thermal Management

Today's AI data centers face unprecedented cooling challenges. The latest GPUs and CPUs generate significantly more heat than their predecessors, while rack densities continue to climb as more processing units are packed into tighter spaces to power demanding AI applications.
With rack power consumption now exceeding 30 kW, traditional air cooling has reached its physical limits. Air cooling simply cannot dissipate heat efficiently enough to maintain safe operating temperatures in these high-density environments.

Liquid Cooling: The Optimal Solution

Cold plate cooling (direct-to-chip technology) has emerged as the leading solution for AI data centers. This approach delivers coolant directly to heat-generating components, efficiently removing approximately 75% of thermal load and offering both flexibility and practical deployability.
For environments with varying density requirements, hybrid cooling combines the best of both worlds. These air-liquid hybrid systems can be customized to address specific thermal zones within your data center, optimizing both performance and efficiency.

Key Implementation Considerations

Space Planning

While liquid cooling equipment typically requires less floor space than traditional air handlers, careful planning is essential. Your layout must accommodate coolant distribution infrastructure and ensure adequate access for maintenance activities.

Investment and Returns

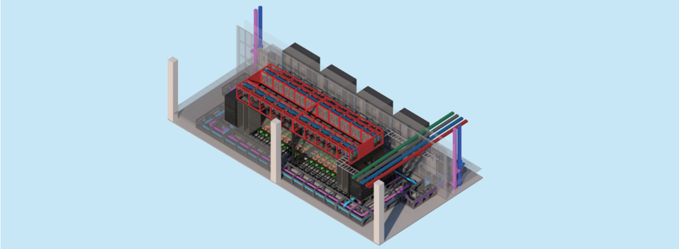
Though initial costs may exceed those of conventional air-cooling systems, liquid cooling delivers compelling returns through enhanced energy efficiency, significantly higher computational density, and potential simplifications to your overall infrastructure.

System Maintenance

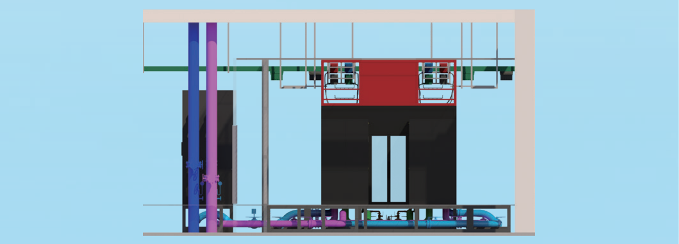
Operating a liquid cooling system involves routine monitoring of fluid levels, pump performance, and system integrity. Regular maintenance prevents leaks, ensures optimal efficiency, and protects against costly downtime.

Finding the right balance between these factors is essential to creating the ideal cooling solution for your AI data center's specific requirements.

Underfloor Integrated Liquid Cooling Solution

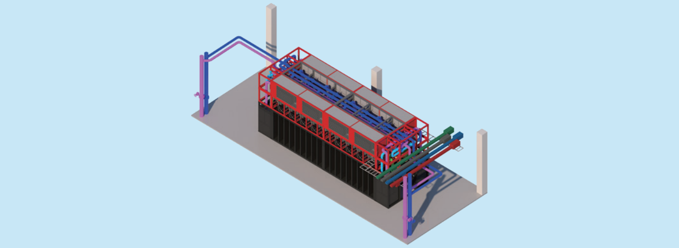


This data hall implements a sophisticated underfloor liquid cooling module design. The configuration features dual rack skids positioned on each side of the hot aisle containment, with liquid cooling pipeline skids housed beneath the raised floor and bus duct skids installed above the rack skids.
The secondary side of liquid cooling system utilizes redundant coolant distribution units (CDUs) in an N+1 (3+1) configuration, strategically positioned on dedicated CDU skids at the row endpoints. Both primary and secondary coolant distribution loops are integrated within the engineered pipeline skids beneath the floor.
Supplementary air cooling is provided through fan wall units (FWUs) installed within dedicated air conditioning corridors flanking the data hall. The ceiling design incorporates a suspended plenum structure to facilitate optimized return airflow patterns. The comprehensive overhead infrastructure integrates track busway power distribution systems alongside extra-low voltage (ELV) cable pathways within unified cable tray assemblies.

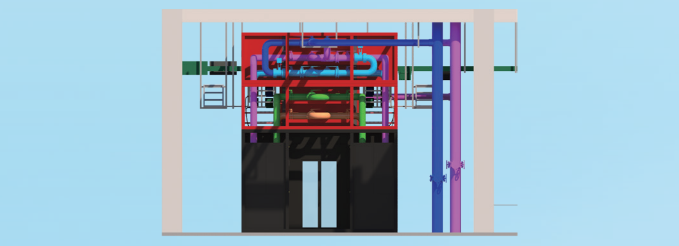


The chilled water supply is first routed through the air conditioning corridor to the FWUs, which provide ambient cooling for rack equipment. Instead of returning directly to the central chiller plant, the return water from FWUs is redirected to serve as the primary cooling source for the CDUs. This sequential design maximizes heat transfer efficiency by cascading cooling capacity across multiple thermal management stages.
Within the CDUs, the primary loop extracts heat from the secondary cooling circuit via plate heat exchangers before returning to the central cooling system. The primary loop piping is strategically positioned within floor-mounted pipe skids.

Overhead Integrated Liquid Cooling Solution

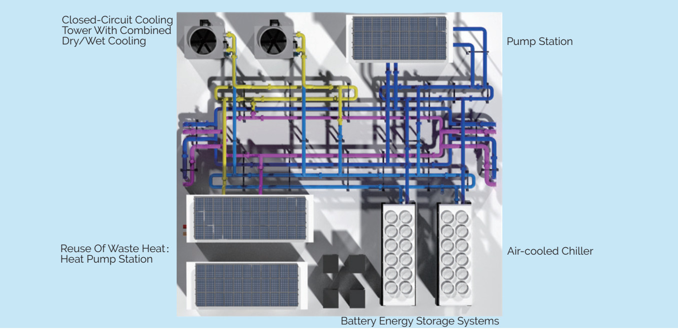


The top-mounted liquid cooling implementation differs significantly from the underfloor design in two key aspects:
1.The liquid cooling distribution infrastructure is entirely elevated, with both primary and secondary loop pipelines integrated within overhead pipeline skids. This tiered configuration positions the primary facility water circuit in the upper section of the skids, while the secondary technical water circuit occupies the lower section. This vertical separation maintains clear demarcation between the two systems while consolidating all fluid distribution overhead.
2.The supplementary air-cooling methodology transitions from Fan Wall Units (FWUs) to Fan Coil Units (FCUs), with these modules strategically positioned atop the cable tray infrastructure. This overhead cooling arrangement eliminates the need for a suspended ceiling plenum, as the system incorporates integrated aisle containment structures that efficiently manage airflow patterns directly within the designated cooling zones.



The facility water supply first routes through the Fan Coil Units (FCUs), providing targeted air cooling to rack equipment. After this initial thermal exchange, the facility water continues directly to the Coolant Distribution Units (CDUs) of the liquid cooling system, creating an efficient sequential cooling pathway.
This integrated overhead design eliminates the need for both raised floors and suspended ceilings, making it ideal for facilities with uniform floor heights. By consolidating FCUs and pipeline skids in the overhead space, the system significantly reduces the footprint required for air conditioning equipment and distribution piping, maximizing usable space. This space-efficient approach is particularly valuable for supporting compute-intensive edge applications in environments where physical real estate is constrained.

Improving the Efficiency of Liquid Cooling System



Liquid cooling technology enables expanded thermal operating ranges for chilled water, supply air, and secondary inlets, thereby maximizing infrastructure efficiency. Hot water-cooling systems are particularly advantageous in this context. The secondary inlet temperature can be elevated to 45°C, which not only achieves desired thermal management results but also creates expanded opportunities for waste heat recovery and utilization.
The control system strategically distributes return facility water through the main loop, directing it partially or entirely into heat recovery systems. Based on regional requirements or environmental conditions, organizations can implement prefabricated thermal recovery stations to effectively repurpose waste heat for heating applications.
Following heat recovery processes, facility water is directed to a closed-circuit cooling tower. By utilizing specialized closed-circuit cooling towers designed specifically for liquid-cooled systems with dry/wet hybrid cooling capabilities, water can sequentially pass through dry coil elements before entering wet coil components. This engineered flow pattern enhances thermal dissipation efficiency while simultaneously reducing water consumption.
If the cooling tower process does not sufficiently reduce water temperature to meet required supply specifications, facility water can be routed through an air-cooled chiller unit for additional refrigeration. The chilled water supply is transported to data halls via dedicated chilled pump stations.
Integrating all-in-one Battery Energy Storage Systems (BESS) with UPS functionality ensures continuous cooling operations while delivering superior electrical performance. This system achieves power factor correction to 0.95-1.0, operates in eco mode with efficiency exceeding 99.5%, and provides peak shaving capabilities with grid services readiness. The BESS-UPS configuration eliminates the need for complex thermal storage solutions while maintaining critical cooling functions during power disruptions, offering a streamlined approach that enhances both thermal and electrical infrastructure reliability and efficiency.

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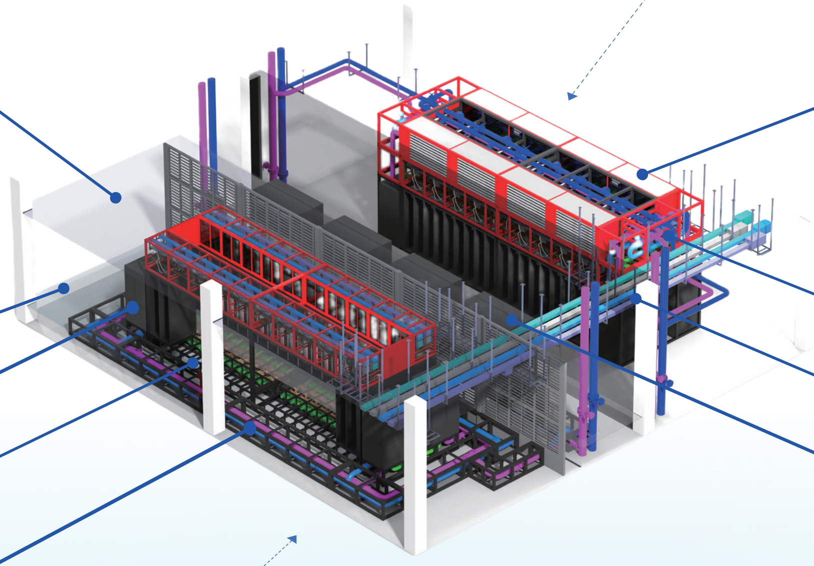
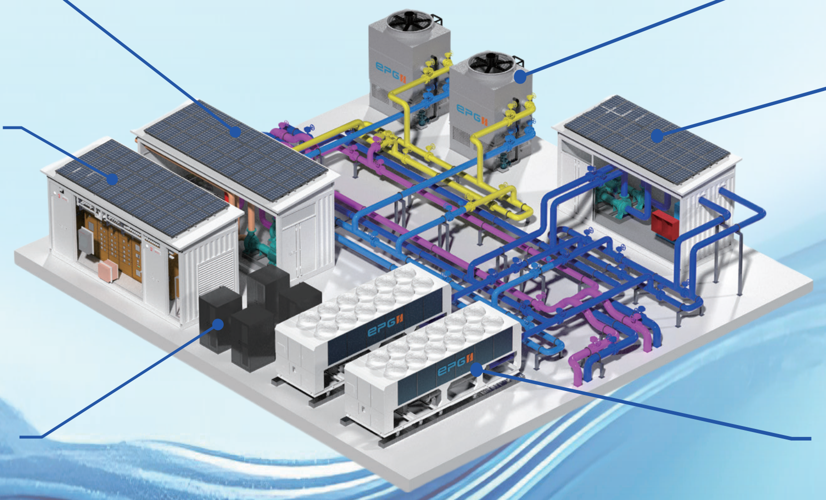
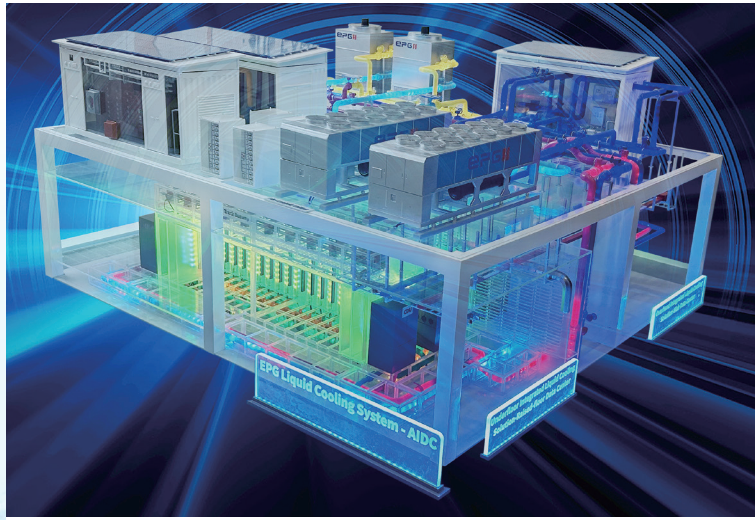
DATA CENTER MODULE



Overhead Integrated Liquid Cooling Solution
Slab Data Center

Underfloor Integrated Liquid Cooling Solution
Raised-floor Data Center





Liquid Cooling Modular AIDC

EPG's Pre-engineering and Prefabricated Data Center Solution