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STTelemedia Global Data Centres

LIQUID COOLING SOLUTIONS AT STT GDC INDIA:

Insights into Evolving Cooling Technologies that Help Run AI-Ready Data Centres Sustainably and Efficiently

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1. INTRODUCTION

Data centres are the backbone of the digital age, housing critical IT infrastructure that supports various applications. As computing power demands rise, so does the heat generated by servers. Traditional air-cooling struggles to manage these high heat loads effectively, leading to inefficiencies, increased energy consumption, and potential performance limitations.

The rapid growth of high-performance computing (HPC) and artificial intelligence (AI) workloads is driving heat densities in data centres beyond the capacity of conventional air-cooling systems. Liquid cooling has emerged as a more efficient and scalable alternative to address these thermal challenges. This whitepaper presents the concept and design of STT GDC India's Liquid Cooling Innovation Lab, created to evaluate, benchmark, and compare multiple liquid cooling technologies for diverse high-density data centre environments.

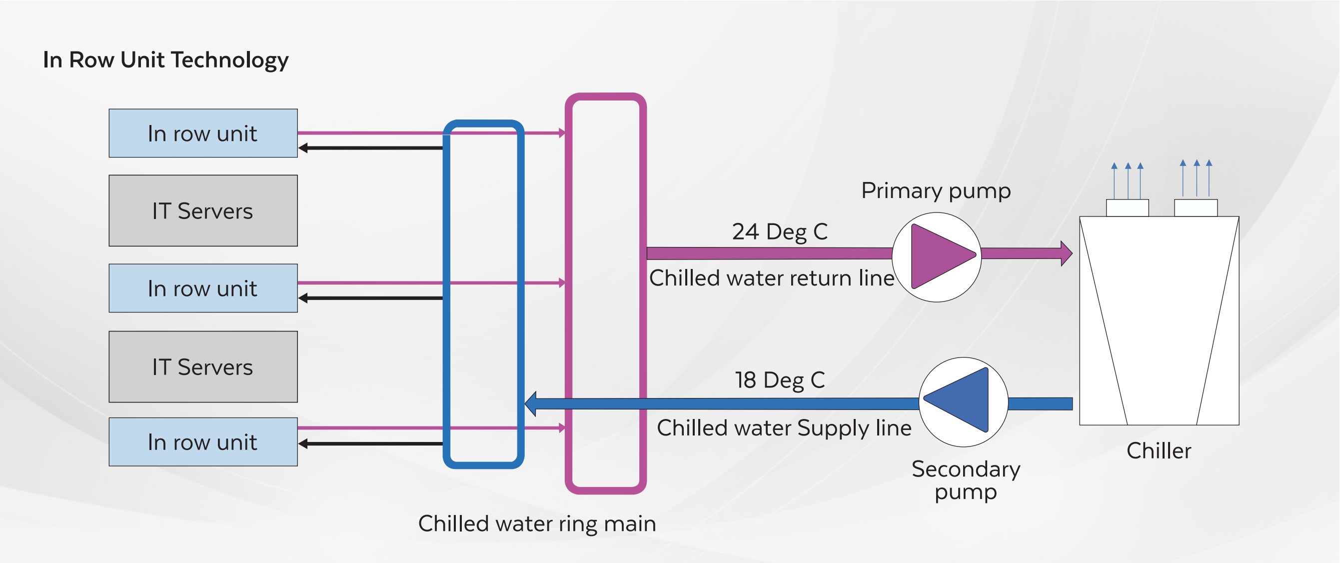
2.TYPES OF LIQUID COOLING TECHNOLOGIES

Several liquid cooling technologies are available today, each designed to address specific thermal challenges. While every approach offers distinct advantages, such as efficiency, scalability, or ease of integration, they also come with certain limitations that must be carefully evaluated before deployment. Introducing 4 types of Liquid Cooling Technologies below:

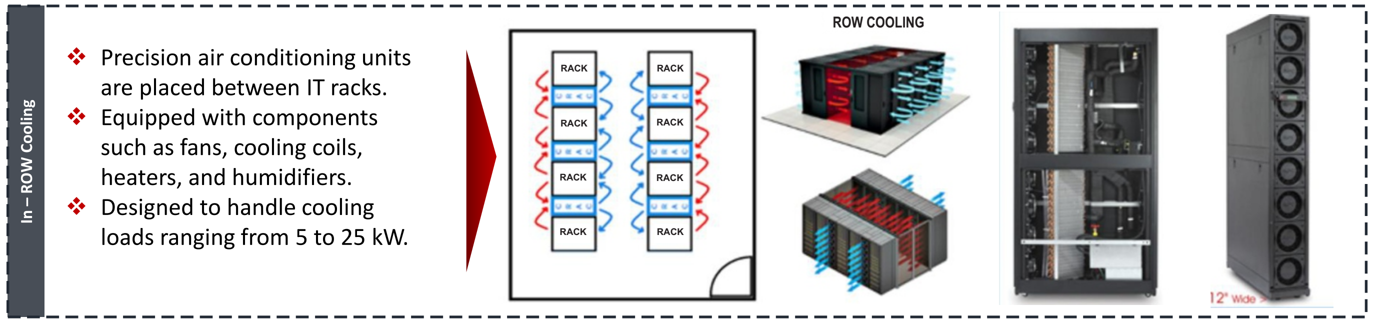
A) In-Row Cooling: This approach utilises self-contained cooling units placed within rows of server racks.

These units, placed between Server racks, enhance the cooling efficiency of servers with close proximity by reducing heat generation compared to traditional perimeter air cooling. They achieve 95% efficiency by minimising air mixing losses in the server hall. These units are connected with chilled water piping, which rejects the heat through the heat exchanger.

Chilled water based in-row units are used for high-density racks where traditional Peripheral cooling is not sufficient. They can achieve localised cooling at the rack level, ranging from 5kW to 25kW.



IN-ROW UNIT TECHNOLOGY



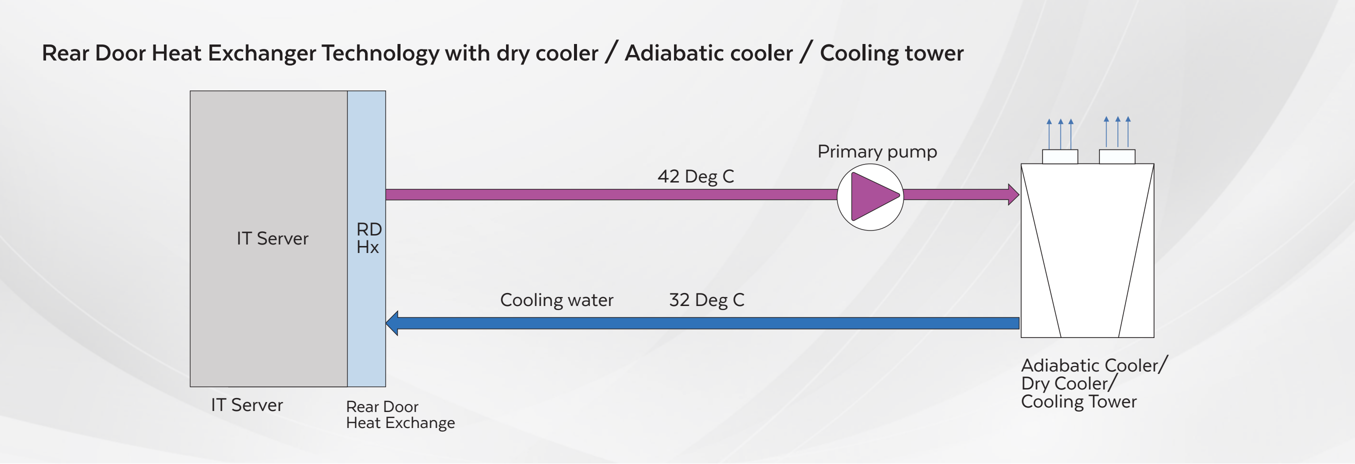
QUICK-BRIEF ON IN-ROW COOLING

B) Rear Door Heat Exchangers (RDHx): RDHx systems replace the standard server rear doors with units containing heat exchangers. Coolant flowing through the exchangers absorbs heat from exhaust air expelled by servers. RDHx offers a modular approach, integrating with existing air-cooled infrastructure.

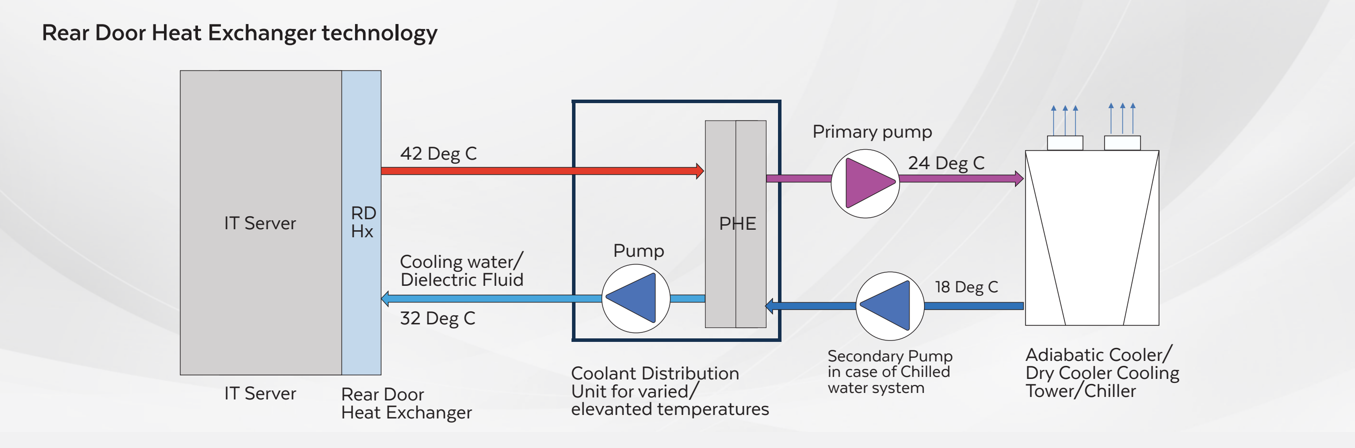
Cooling water across RDHx is circulated through CDUs (Cooling Distribution Unit) or directly connected through a pipeline.

They are often retrofitted onto existing server racks, providing a liquid cooling solution without significant infrastructure changes.

Suitable for a range up to 20kW with passive RDHx & up to 50kW with active RDHx



RDHx WITH COOLING EQUIPMENT

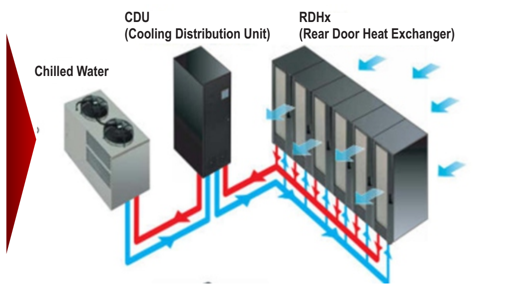


RDHx WITH CDU

Rear Door Heat Exchanger

Available in both **passive** and **active** configurations:

- Passive systems include only a cooling coil and support 10–30 kW loads.
- Active systems incorporate both a cooling coil and fans, handling 25–50 kW loads.



QUICK-BRIEF ON RDHx

C) Direct-to-Chip Liquid Cooling (DCLC): DCLC removes heat directly from the CPU or processor package using microchannel cold plates or integrated heat exchangers. This method offers highly efficient cooling for high-performance processors.

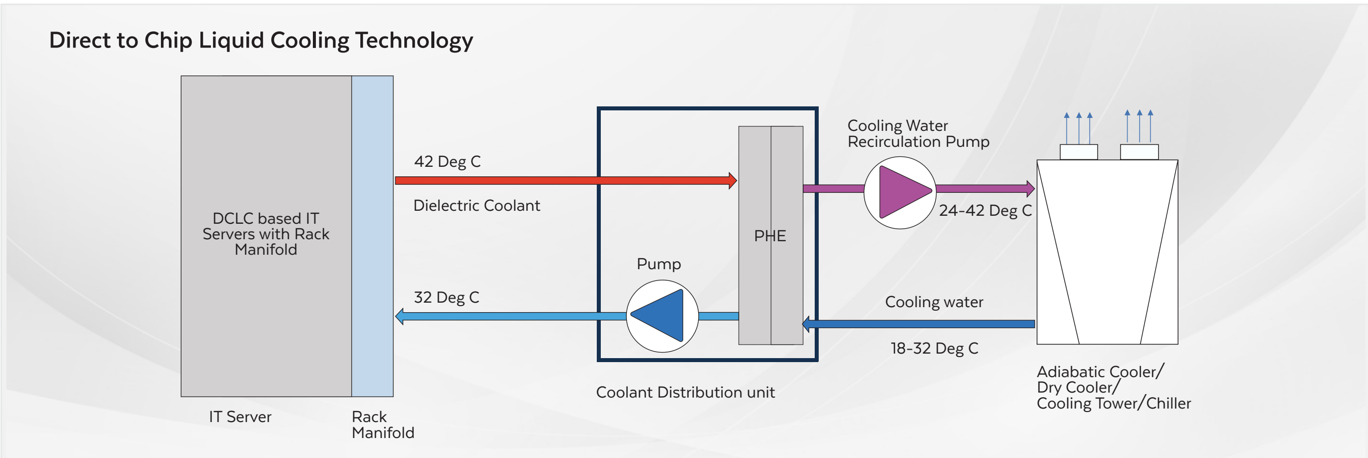
The DCLC technology includes a Cooling distribution unit with a facility cooling water inlet on one side of a plate type heat exchanger & the dielectric fluid at the other side which moves in contact with servers, taking away the heat from the IT components more efficiently at a higher density.

The dielectric fluid is distributed through an SS manifold at the IT server rack with necessary antileakage & safety measures.

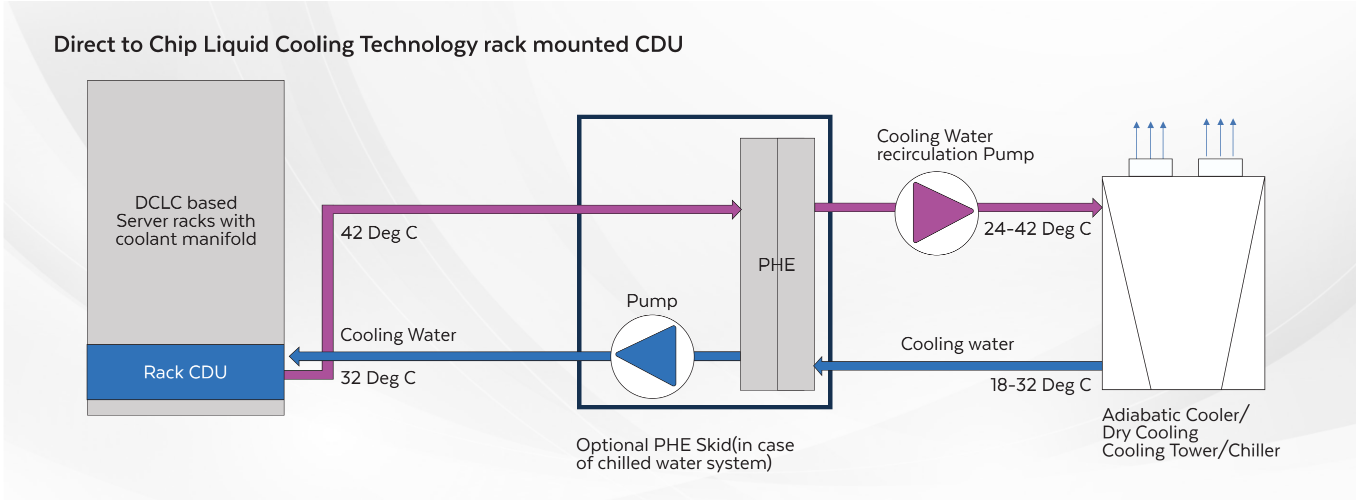
25% Propylene Glycol is used as a dielectric fluid in the majority of cases due to easy availability and better heat transfer capability.

There are rack-mounted CDUs as well as common row-based CDUs available in the market for serving the dielectric fluid to IT servers.

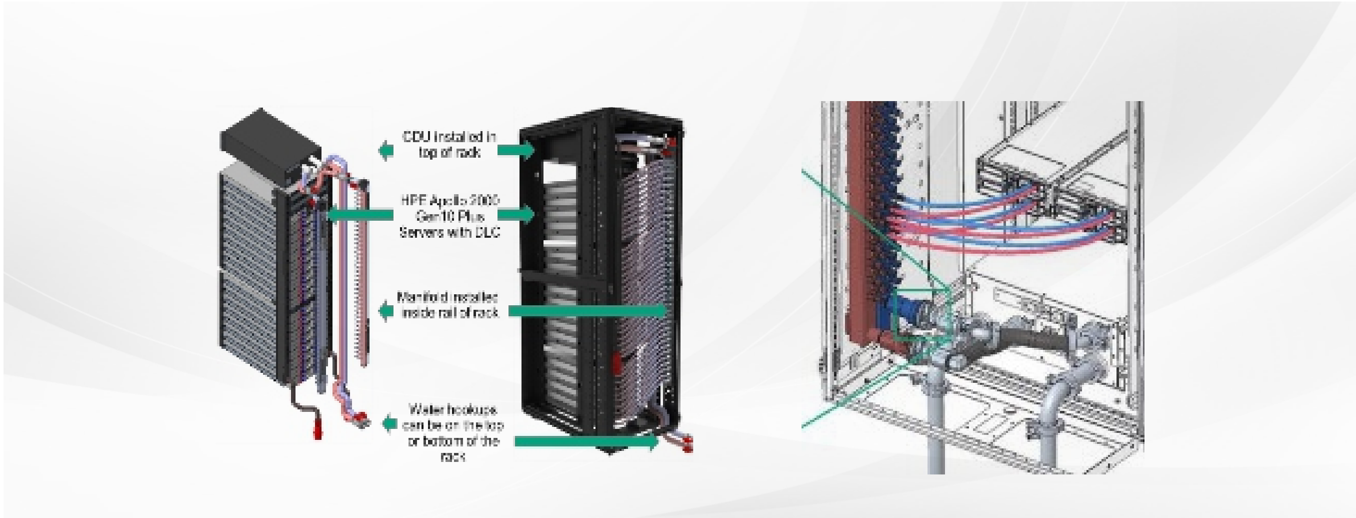
This solution is ideal for high-density, high-compute setups upto 1200kW per rack where every degree counts.



DCLC WITH FLOOR MOUNTED CDU



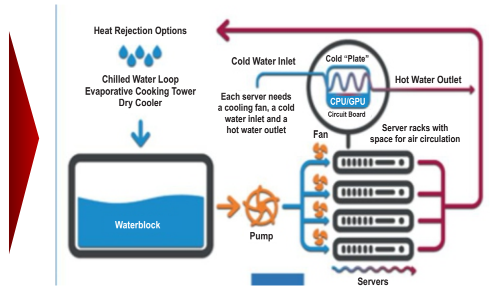
DCLC WITH RACK MOUNTED CDU



TYPICAL DCLC SERVER RACK SET UP WITH RACK CDU & COOLANT PIPING

Direct-to-Chip Cooling

- Utilizes dielectric liquid circulated directly through IT components for targeted cooling
- Supports thermal loads between 20 to 50 kW
- Coolant Distribution Units (CDUs) are used to manage and circulate the coolant.

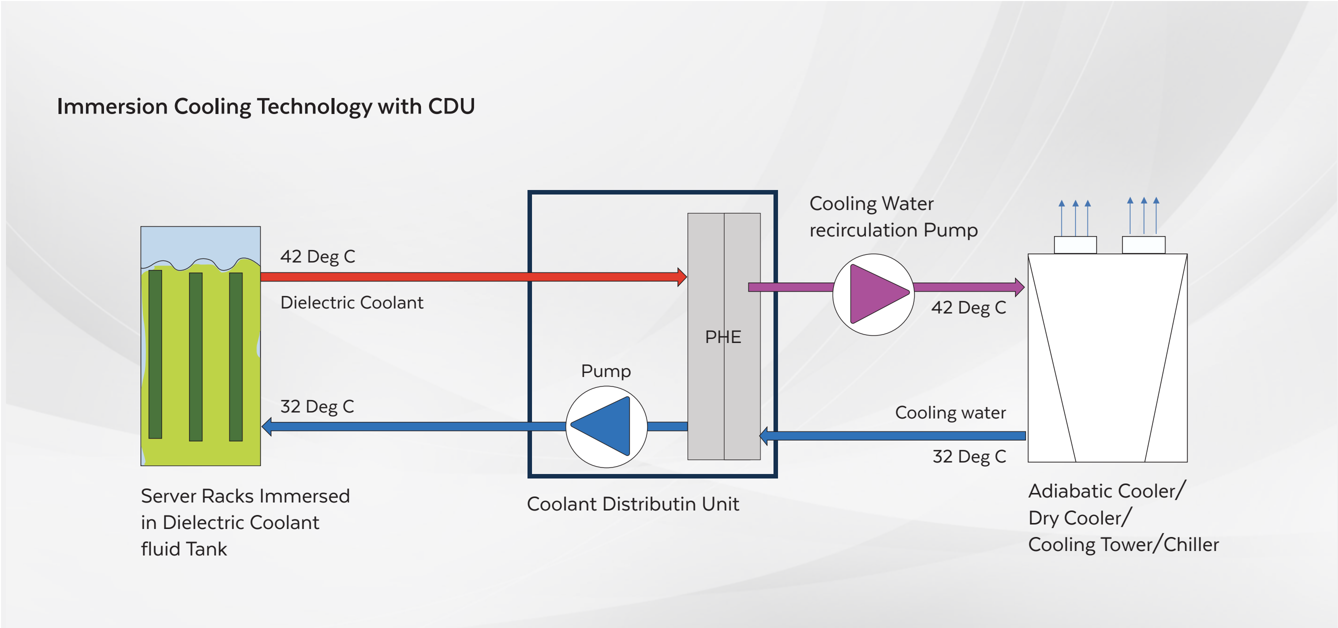


QUICK-BRIEF ON DCLC TECHNOLOGY

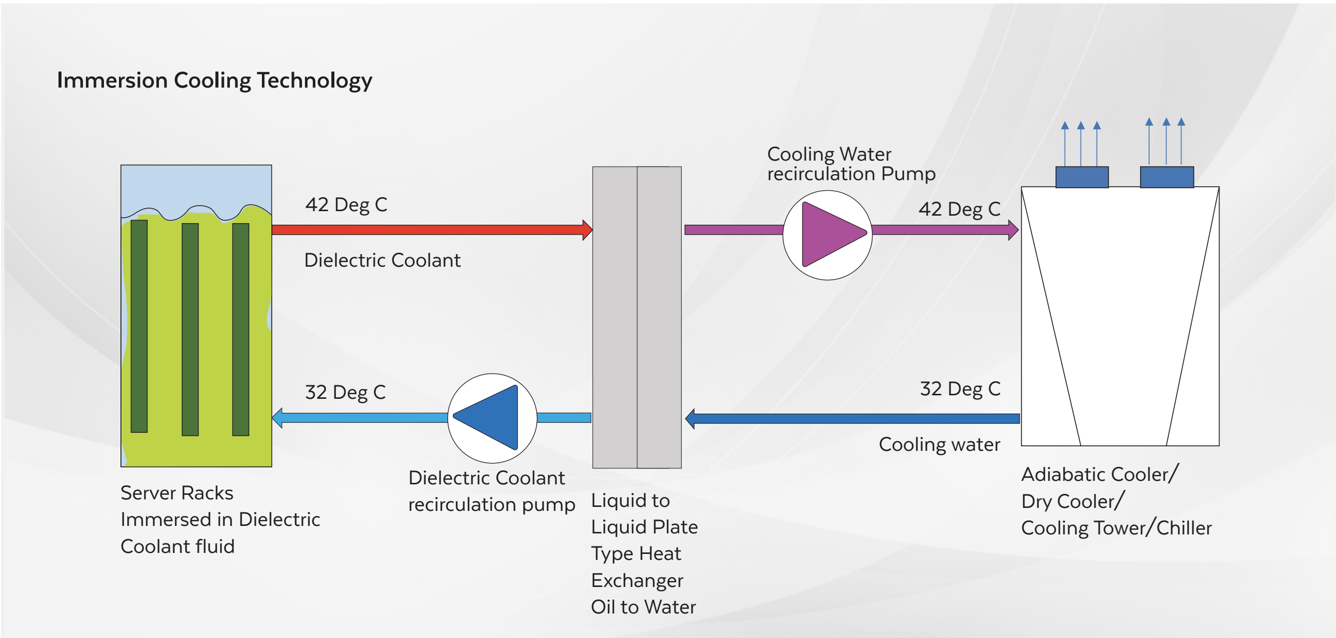
D) Liquid Immersion Cooling: This technique involves submerging complete servers in a dielectric liquid with high thermal conductivity. Heat generated by the servers is directly transferred to the liquid, providing excellent cooling performance.

The heated liquid is then circulated through a cooling distribution unit or heat exchanger, where it transfers heat to a facility's cooling water system.

This system operates at elevated temperatures, around 32°C, maximising efficiency.



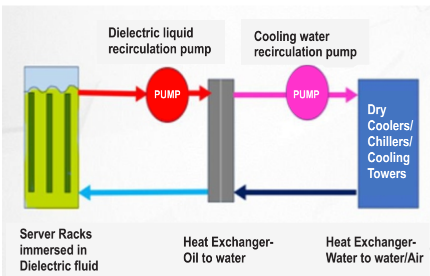
IMMERSION COOLING TECHNOLOGY WITH CDU AND FACILITY COOLING SYSTEM

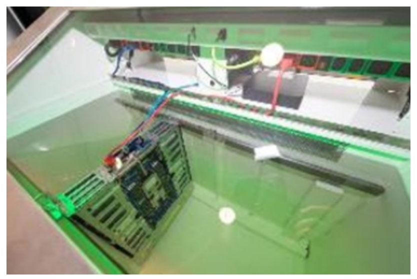


IMMERSION COOLING TECHNOLOGY WITH PRIMARY LIQUID COOLING AND SECONDARY FACILITY COOLING SYSTEM

Liquid Immersion Cooling

- IT components are fully submerged in a dielectric liquid for efficient heat dissipation
- Suitable for high-density environments, supporting 30 to 100 kW per unit
- CDUs manage the distribution and circulation of the coolant





QUICK-BRIEF ON LIQUID IMMERSION COOLING SYSTEM

3. BENEFITS OF LIQUID COOLING TECHNOLOGIES

Liquid cooling solutions offer wide-ranging advantages that extend beyond just heat removal. They deliver technological, financial, and operational benefits, making them an essential strategy for next-generation data centres.

A. Technological

- **Superior Cooling Performance**: Maintains safe operating temperatures even under extreme AI, HPC, and GenAI workloads.
- **Hyperscale Readiness**: Supports rack densities of up to 120 kW per rack, ensuring advanced workloads run without thermal constraints.
- **Energy Efficiency**: Reduces cooling overhead, lowering overall PUE (e.g., from 1.65 down to 1.15) and enabling up to 8–10% energy savings in production environments.
- **Improved Uptime**: Delivers up to 20% improvement in equipment uptime through more consistent thermal management.
- **Scalability**: Systems can be expanded easily to accommodate future increases in heat loads.

B. Financial

- **Optimised Space Utilisation**: Enables 3–4x more IT capacity within the same footprint, reducing the need for additional real estate.
- **Lower Operating Costs**: Achieves around 10% reduction in OPEX through optimised cooling efficiency.
- **CapEx Efficiency**: Removes the need for large-scale mechanical infrastructure, lowering initial deployment costs compared to high-capacity air-based systems.
- **Energy Savings**: Significant reductions in energy bills due to improved cooling efficiency and reduced power draw for auxiliary equipment.

C. Operational Benefits

- **Productivity Gains**: Up to 300 person-hours saved per month by reducing manual interventions through automated and reliable cooling operations.
- **Environmental Impact**: Lowers carbon footprint by reducing facility power consumption and water usage, aligning with sustainability and ESG targets.
- **System Reliability**: Dedicated cooling loops with precise control enhance resilience and consistency in operations.

4. APPLICATIONS OF LIQUID COOLING TECHNOLOGIES

Liquid cooling is particularly well-suited for next-generation, high-density computing environments:

- **Artificial Intelligence (AI) and GenAI Workloads**: Enables consistent performance for GPU-intensive tasks such as model training and inference.
- **High-Performance Computing (HPC)**: Provides the thermal stability required for large-scale simulations and scientific workloads.
- **Large Language Models (LLMs)**: Manages extreme compute requirements of training and running advanced AI models.
- **Hyperscale and Enterprise Data Centres**: Delivers scalability, reduced footprint, and sustainability benefits for large IT estates.

5. SUSTAINABILITY THROUGH LIQUID COOLING STRATEGIES

In alignment with STT GDC India's latest Environmental, Social, and Governance (ESG) commitments, liquid cooling strategies are designed for operational efficiency and broader sustainability goals. The integration of ESG-aligned principles ensures that every cooling innovation contributes to reducing carbon footprint, enhancing energy and water efficiency, and supporting circular economy practices.

A. Performance & Sustainability Metrics

Liquid cooling contributes to achieving a Power Usage Effectiveness (PUE) as low as 1.5, representing a 2% improvement from the FY 2021 baseline. Additionally, it supports integration with renewable energy sources, which accounted for 132.8% renewable energy usage from the FY 2021 baseline.

PUE Range: Efficiency of Cooling Solutions for IT Server Racks

S No.	Cooling Solutions for IT server racks	PUE
1	❖ Conventional Peripheral Air cooling with DX CRACs with 24 deg C Cold aisle temperature	1.7 to 2
2	❖ Conventional Peripheral **Air cooling with Air Cooled Chillers** with elevated water temperature at 20 deg C inlet to CRAHUs	1.5 to 1.8
3	❖ Conventional Peripheral **Air cooling with Air Cooled Chillers having free cooling** Hybrid option with elevated water temperature at 20 deg C inlet to CRAHUs	1.45 to 1.65
4	❖ Conventional Peripheral **Air cooling with Water Cooled Chillers**	1.5 to 1.65
5	❖ **Inrow cooling** in combination with peripheral cooling for high density racks upto 35kW	1.5 to 1.65
6	❖ **Passive Rear Door Heat Exchangers** upto 20KW	1.45 to 1.65
7	❖ **Active Rear Door Heat Exchangers** upto 50kW	1.45 to 1.65
8	❖ **Direct to Chip Liquid Cooling** of servers upto 100kW with combination of **peripheral air cooling for network racks, Air cooled chillers**	1.35 to 1.5
9	❖ **Direct to Chip Liquid Cooling** of servers upto 100kW at elevated temperatures using **Dry Coolers with combination of peripheral air cooling for network racks**	1.25 to 1.45
10	❖ **Single phase Liquid Immersion Cooling** with Hybrid cooling having free cooling from Dry coolers & Air-cooled chillers	1.15 to 1.4
11	❖ **Single phase Liquid Immersion Cooling** with free cooling adiabatic Dry coolers at elevated temperatures	1.1 to 1.3

B. Water Efficiency

In combination with water reuse and chiller hybridisation strategies, such as those implemented at STT Chennai 2 and STT Pune 1, liquid cooling aids in lowering water withdrawal rates. These initiatives have contributed to a 46.7% reduction in Water Usage Effectiveness (WUE) compared to the FY 2021 baseline.

C. Green Facility Design

Liquid cooling technologies form part of a holistic green-building strategy. STT GDC India's facilities, including STT Bengaluru 3, are examples of data centres achieving IGBC Net Zero Energy Operations, demonstrating the synergy between innovative cooling and sustainable design.

D. Innovation & Controls

The deployment of IoT-based monitoring systems for both energy and water management ensures precise control over cooling operations. For liquid cooling systems, these technologies optimise temperature regulation, flow rates, and pump energy use to deliver maximum efficiency.

E. Sustainable Operations & Circularity

STT GDC India aligns its operations with a robust waste hierarchy, prioritising reduction, reuse, and recycling. In the context of liquid cooling, this includes responsible management of coolant materials, reusing components where feasible, and safe disposal practices for end-of-life equipment.

6. STT GDC INDIA’S LIQUID COOLING INNOVATION LAB IN PUNE

The Liquid Cooling Innovation Lab in Pune is a controlled environment dedicated to testing, benchmarking, and comparing the performance of advanced liquid cooling technologies for data centres. It is fully operational and designed to simulate diverse high-density workloads in real-world conditions.

- **Test Racks**: Multiple server racks are equipped to accommodate different cooling technologies, including in-row cooling, rear door heat exchangers (RDHx), direct-to-chip liquid cooling (DCLC), and immersion systems, enabling side-by-side testing and comparison.
- **Heat Load Simulators**: The Lab uses specialised devices to mimic the heat output of actual servers, creating realistic test scenarios at varying densities.
  - Rack-mounted heat load banks are installed on in-row and RDHx-cooled racks.
  - Specialised liquid-based heat load banks, explicitly designed for DCLC setups, are deployed, the first of their kind in India.
  - Immersion-type heat load banks are integrated for testing servers submerged in dielectric fluids.
- **Cooling Systems**: Each technology operates on a dedicated cooling loop, with independent control over coolant flow rate and temperature.
  - Dry Coolers with adiabatic pads run at warm water temperatures of 32/42°C, enhancing efficiency and sustainability. They can also operate without adiabatic pads at 42/52°C for better PUE and WUE outcomes.
  - Cooling water is circulated via redundant vertical inline pumps with automated control valves for reliability.
  - Precision air-conditioning units provide peripheral cooling for air-cooled network racks.
- **Monitoring and Instrumentation**: The Lab is fully equipped with IoT-enabled sensors that continuously track temperature, pressure, flow rate, and power consumption across systems. This data is captured and analysed to provide insights into the efficiency, scalability, and sustainability of each liquid cooling solution.
- **Data Acquisition and Analysis System**: A comprehensive data acquisition system collects and analyses data from sensors, allowing for performance evaluation and comparison of different cooling solutions.

7. STRATEGIC PARTNERSHIPS

Strategic partnerships with liquid cooling technology Partners are essential for this kind of innovation lab setup, focused on liquid cooling technologies. By carefully selecting partners and leveraging their expertise, organisations can overcome thermal challenges, optimise energy efficiency, and accelerate AI innovation.

We have selected Partners who are already established in the market with necessary research and development centres built across their facilities, for example, Vertiv, Schneider, Stulz, Johnson Controls, etc. for the different types of cooling solutions, including conventional peripheral air cooling to liquid cooling with RDHx, Direct to chip liquid cooling, Liquid Immersion Cooling etc.

8. CONCLUSION

Liquid cooling represents a promising solution for addressing the challenges of cooling in modern data centres and for the readiness of future generation AI compute. The technology offers notable benefits in terms of energy efficiency, thermal management, and environmental sustainability.

The Liquid Cooling Innovation Lab in Pune provides a valuable platform for evaluating and comparing different liquid cooling solutions for data centres. By analysing performance, efficiency, and cost factors, the lab will guide data centre operators in selecting the most suitable liquid cooling technology for their specific high density heat load requirements.

This lab setup serves as a valuable resource for conducting a range of simulations focused on IT compute load, customer orientation, and training.

It aims to empower data centre operations staff by enhancing their skills, ensuring they are well-prepared for the future demands of AI technologies.

To explore our capabilities and experience these technologies first hand, visit our Liquid Cooling Technology Lab or connect with us at

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