NAVIGATING TRENDS AND TECHNOLOGIES IN LIQUID COOLING FOR THE DATA CENTER

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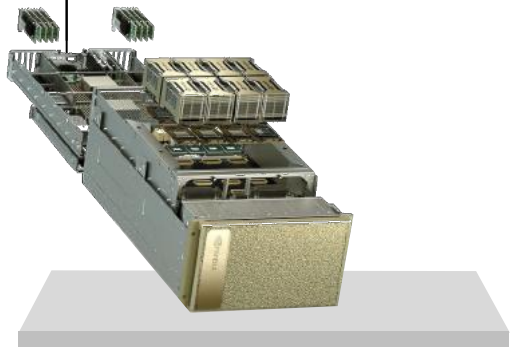
Agenda

- Nexus Between Artificial Intelligence, High Density applications and Energy Efficiency
- Implications of High Density for the Data Center
- Liquid Cooling Solution Options
- Liquid Cooling at scale

The Nexus Between High Density and Energy Efficiency

- Increasing power and performance - Hotter chips
- Digital economy- Increase in data volume and velocity
- Increased focus on sustainability
- Navigating regulatory changes



Sustainability

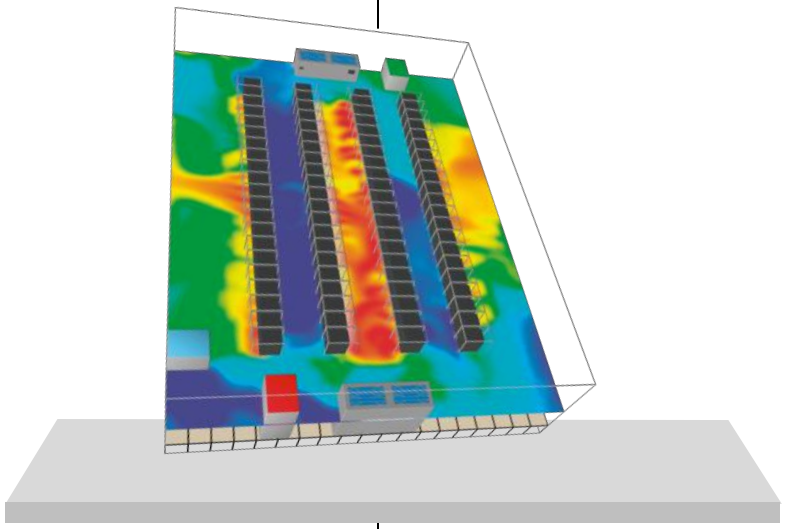
Regulations

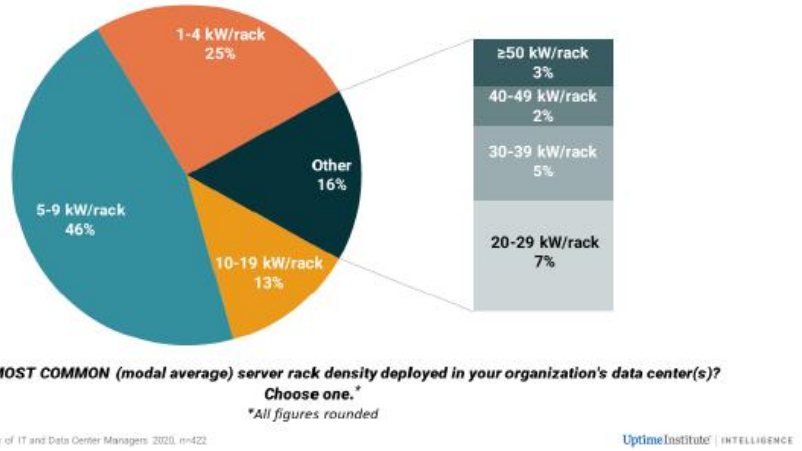
Artificial Intelligence

Automation

- IoT (Internet of Things)
- Smart City
- Healthcare
- Media and Entertainment
- Data Infrastructure for Autonomous Vehicles
- Finance-Trade automation Fraud detection
- Manufacturing – simulation and testing
- AI for Big Data

Implications for the Data Center- Thermal





*What is the MOST COMMON (modal average) server rack density deployed in your organization's data center(s)? Choose one.**

**All figures rounded*

Source: Uptime Institute Global Survey of IT and Data Center Managers 2020, n=422

Uptime Institute | INTELLIGENCE

Challenges

- Managing airflow with dynamic loads (Hot Spots)
- Reduced inlet temperature for High Density IT Equipment
- High return temperatures from High Density IT Equipment
- Managing Energy efficiency and sustainability goals

Solutions

- Deploy cooling in close proximity to heat source
- Air flow management; containment, in-row, in-rack
- Direct to chip liquid cooling - cold plate
- Immersion cooling

Liquid Cooling –Market Drivers, Size & Growth

Market Drivers

Hot Chips

CPU and GPU server components increasing in power resulting in higher Thermal Design Power beyond air cooling capability

Low Latency

Interdependency of components bringing them closer together = compaction of components making it difficult to cool with air

AI & HPC

Adoption beyond science labs. HPC going into mainstream adoption including cloud based HPC, Finance, Online Gaming, Media & Entertainment

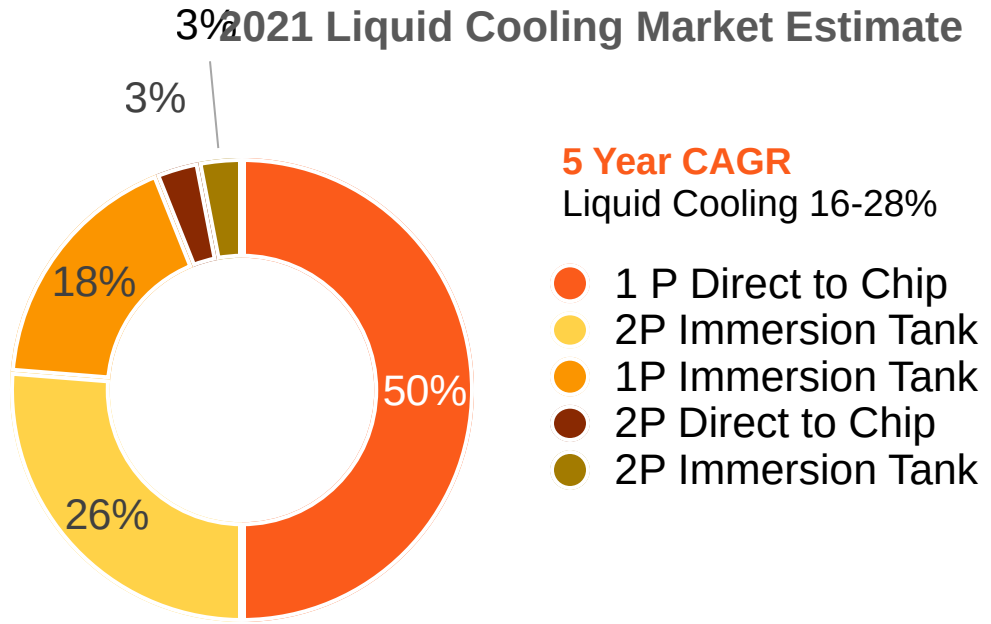
Environment/Efficiency

Reduced power consumption eliminating fans and compressors. No Noise

Edge environments

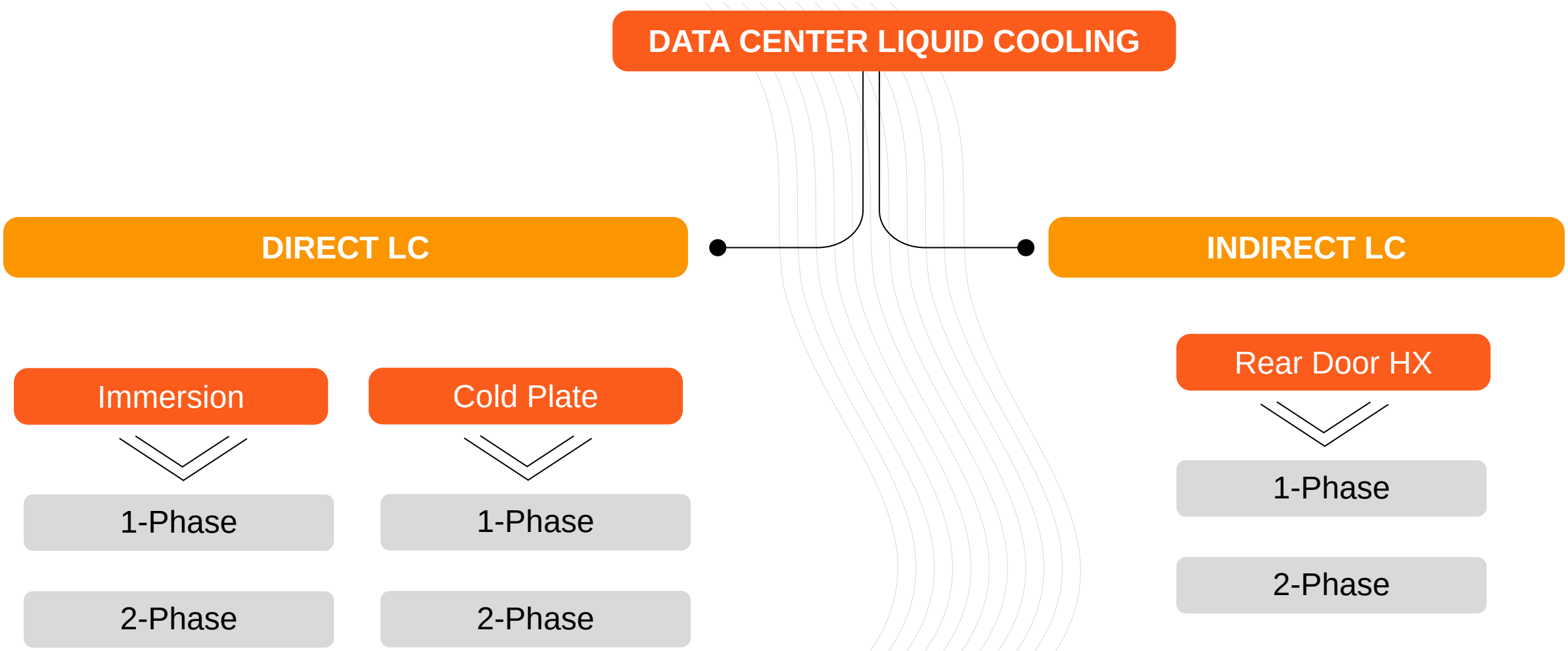
Distributed systems deployed close to community

Market Size & Growth



- Major server OEMs offer SKUs supporting Direct to Chip Liquid Cooling
- Intel recently announced a focus on immersion cooling

Liquid Cooling Technology Overview



Technology Overview: Immersion Cooling

Sustainability in High Density

Sustainability Metrics

Direct to Chip

Immersion

Additional benefits

PUE:

$$\frac{\textit{Total Energy Consumption}}{\textit{IT Energy Consumption}}$$

- Reduction in fan power
- Component cooling at source
- 70%+ Heat to liquid

- Eliminates server fans
- Component cooling at source
- 100% Heat to liquid

✓ Facility footprint reduction (Power distribution)

✓ Reduced need for cold aisle (Immersion)

✓ Easier to manage dynamic loads

✓ Support for high density applications

✓ Reduction of energy consumption in low density

✓ Flexible for Edge or Modular DC deployments

WUE:

$$\frac{\textit{Annual water use}}{\textit{IT Energy Consumption}}$$

- Highest liquid temperatures
- Use of dry coolers in most climates
- Reduces water use

- High liquid temperatures
- Increased potential for dry coolers
- Reduces water use

ERE:

$$\frac{\textit{Cooling} + \textit{Power} + \textit{Lighting} + \textit{IT Reuse}}{\textit{IT Energy Consumption}}$$

- Use of high temperature return water
- Pre-heating for boiler or electricity supply
- District or domestic heating

✓ Increased use of free cooling

✓ Heat re:use potential

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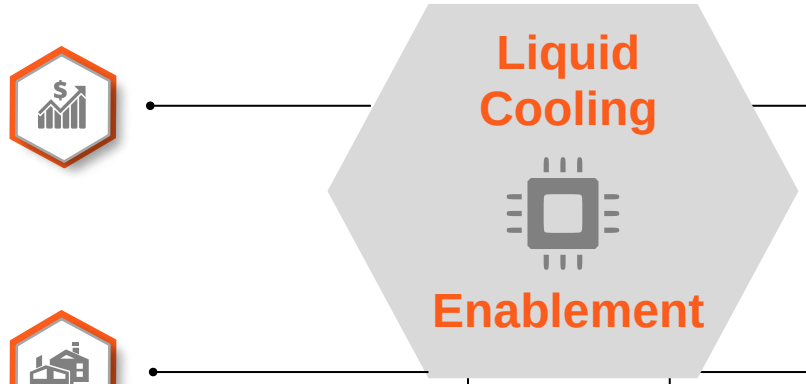
Liquid Cooling Technologies - Preparing for Adoption

Strategies for Effective Design, Build, Deployment and Maintenance



Design Goals

Energy Use Effectiveness.
Water Use Effectiveness.
Total Cost of Ownership.

Distribution Infrastructure

Infrastructure to support effective transport of liquids through the Data Center

Global Deployment

Best practices deployed globally

Learning

Establishing best practices to adopt liquid cooling

Ease Of Integration

Install, Commission & Operation.

Services Coverage

Enabling Installation, commissioning and Maintenance

Industry enablement to deploy liquid cooling at scale to support growth in high density

Overview of the Data Ce Liquid Cooling Eco System

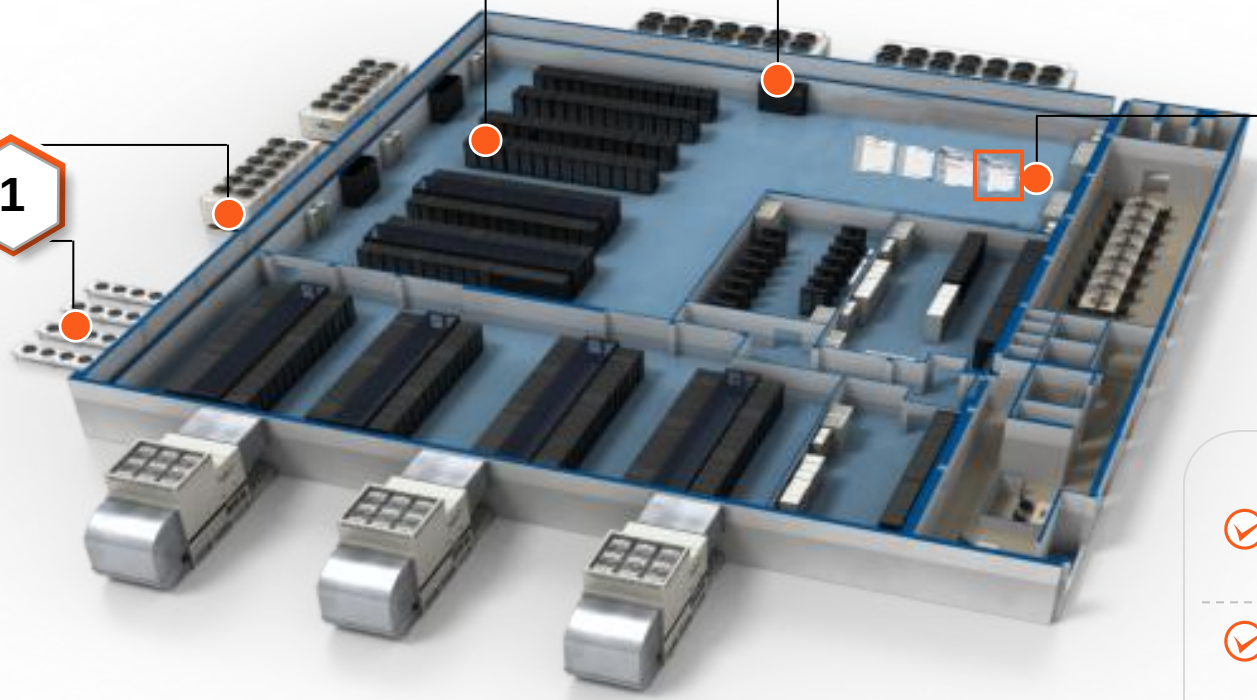
Covering the needs for Liquid Cooled IT

Coolant Distribution Unit 2

Centralized & Rack mounted CDU's to distribute and manage liquid to servers for Direct to Chip Cooling

Indoor Chiller 3

Drop in Chiller to replace CRAC units to leverage the efficiency and flexibility to move from air to liquid using existing infrastructure



Heat Rejection 1

Fluid Cooler & Chillers to reject heat outdoors

Immersion 4

Immersion Racks to support server compaction and IT that can no longer be cooled with air or direct to chip

Key components

- **Coolant Distribution Units** (maintain liquid integrity)
- **Heat Rejection** (Operate in high ambient temperatures)
- **Liquid Loop** (Secondary loop to rack and cold plate)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