



Tecnologie delle Infrastrutture dei Data Center per la sostenibilità Energetica e l'IA

*Caso di studio: un'esperienza di liquid cooling ad immersione in una
grande azienda europea, sfide e risultati*

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Agenda:

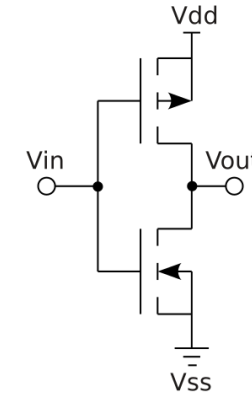
- Customer's concerns and motivation to change:
 - The power density challenge
 - Why liquid cooling
- Use case: immersion cooling with production workloads
 - Implementation details
 - Findings and outcomes



The Power Density Challenge

Semiconductor Physics Drives Power Density Up

- CMOS is the dominant (99%) standard fabrication process for semiconductor devices in VLSI chips (introduced in 1963)
- CMOS features low static power consumption but not while switching state
- The ongoing increase in number of transistors on chipsets has impacted their power density

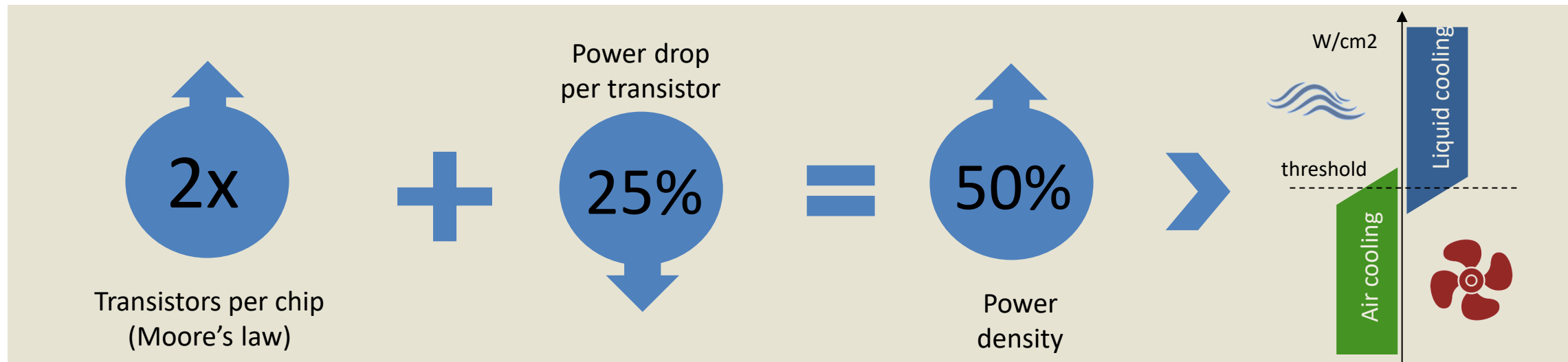


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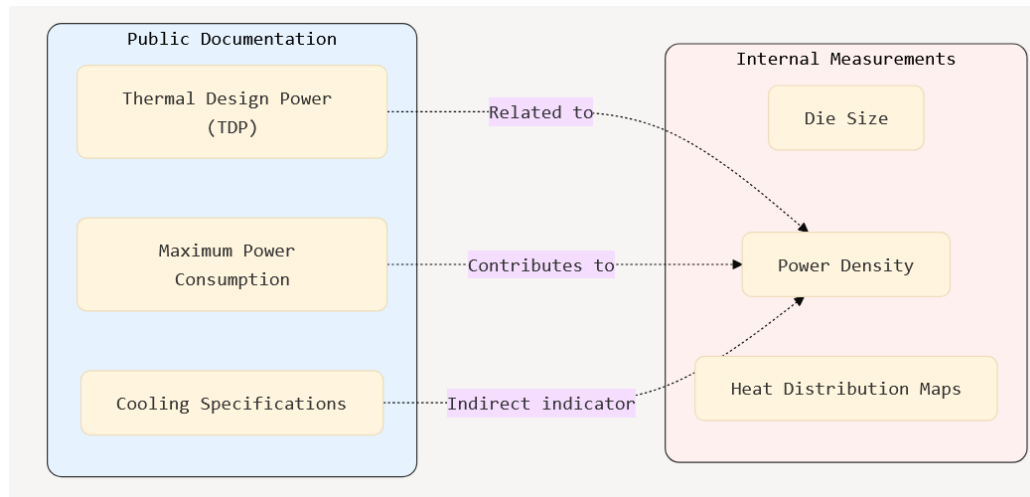
From 2010 to 2020:

- the TDP of chipsets has doubled
- the power density is creating challenges



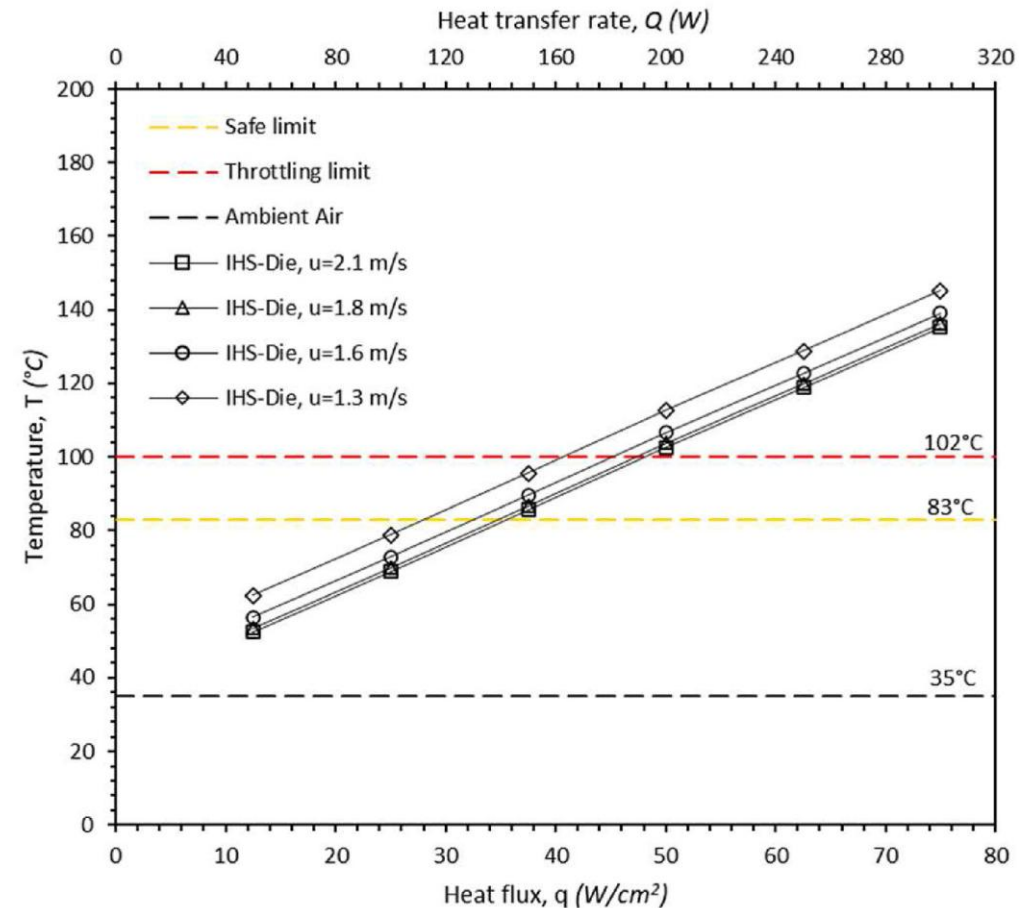


Power Density Limit of Air Cooling



Air-cooling limit has many variables:

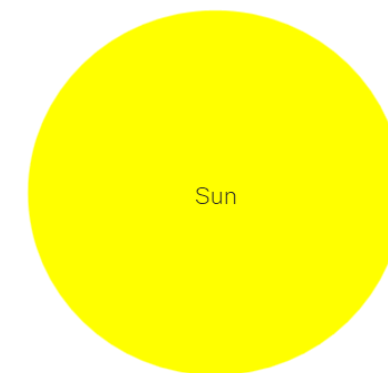
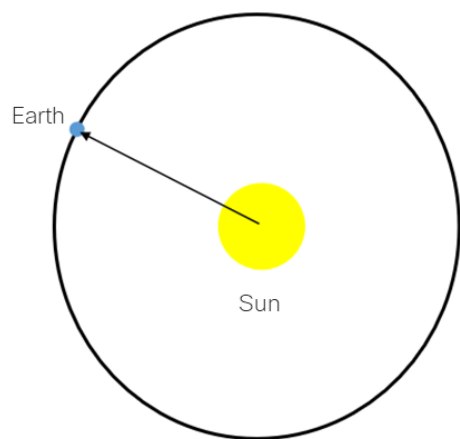
- fan size and speed
- heatsink configuration and materials
- Integrated heat spreader (IHS)
- Inlet air temperature and max Tcase



Source: [Sciencedirect.com](https://www.sciencedirect.com), 2023



Chipset Heat Flux in Perspective



0.137 W/cm²

10-80 W/cm²

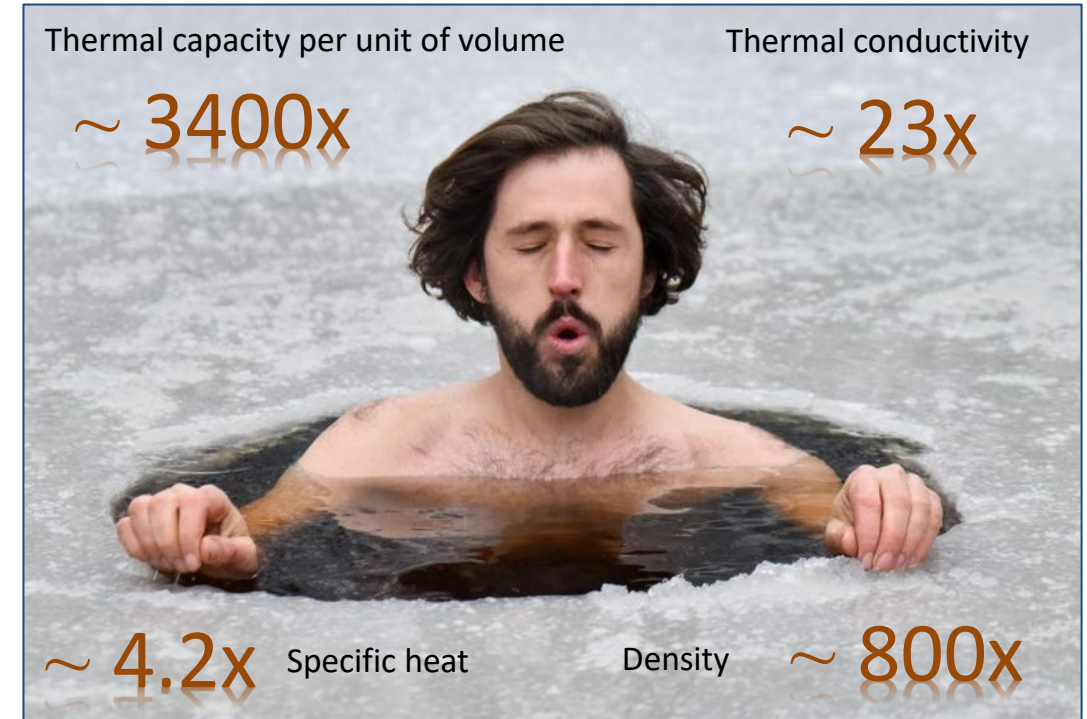
300 W/cm²

6330 W/cm²



Air vs Water

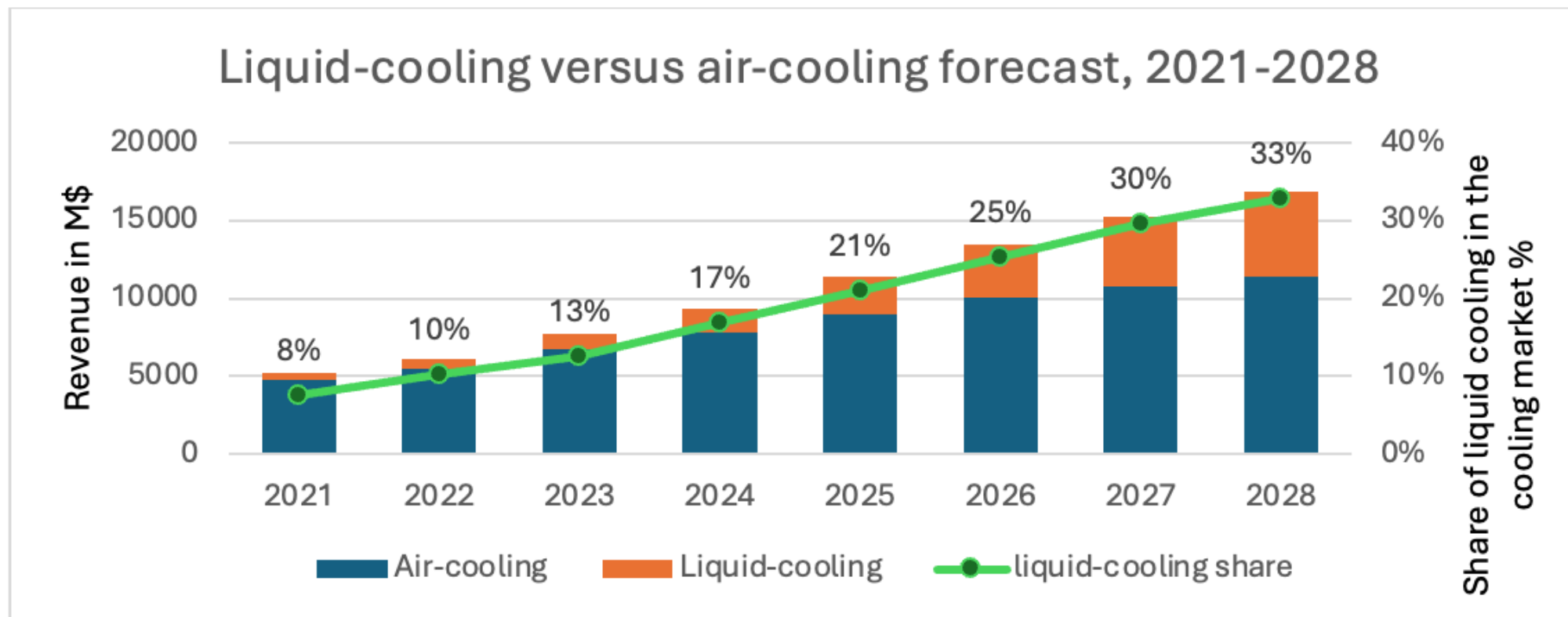
Specific Heat, Density, Thermal Conductivity, Thermal Capacity



Here, heat transfer happens for both natural conduction and natural convection
In what situation can you survive the longer and avoid death from hypothermia?



Liquid Cooling Raising Adoption

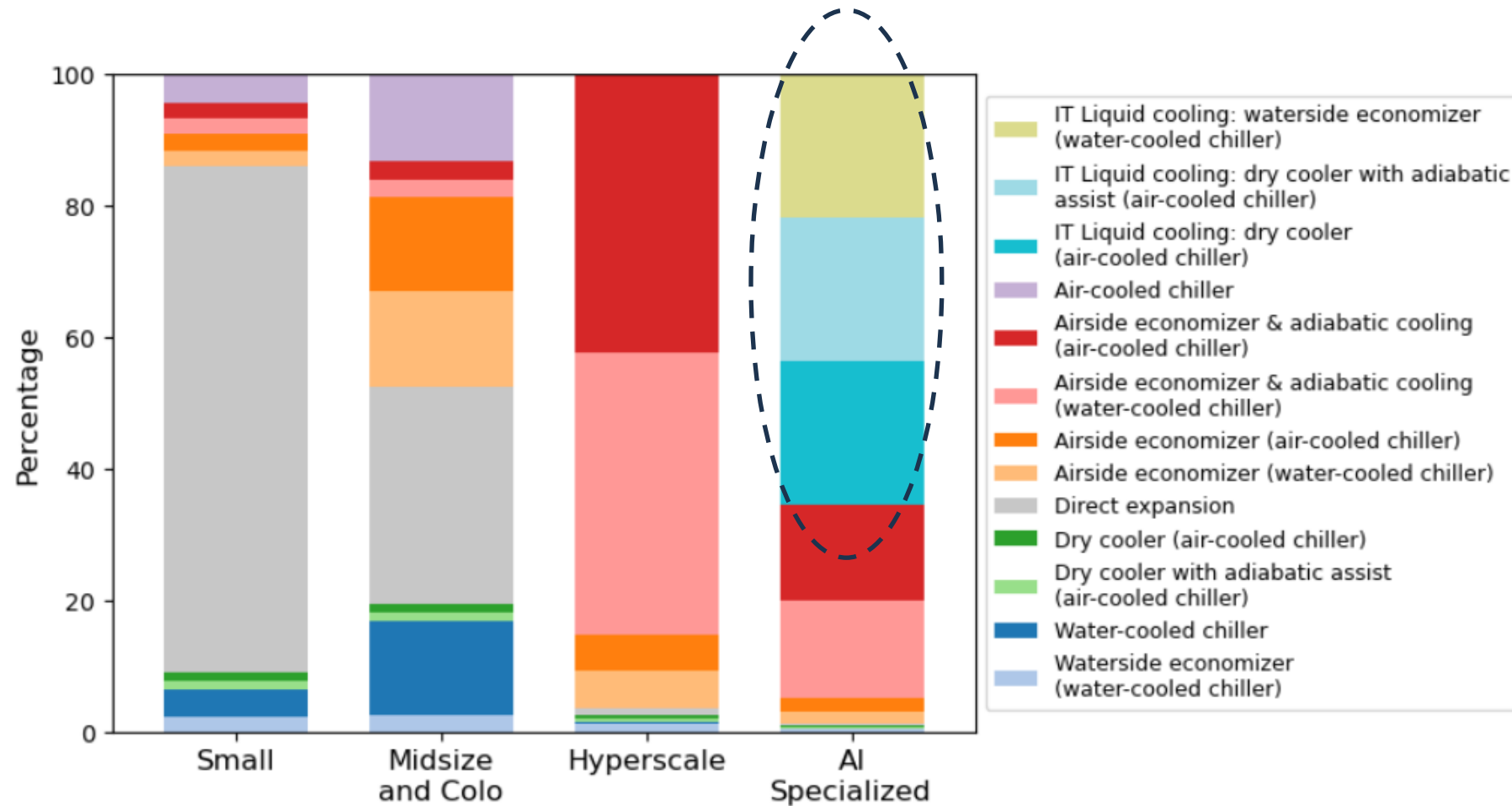


Source: Omdia



Data Center Cooling Systems Distribution

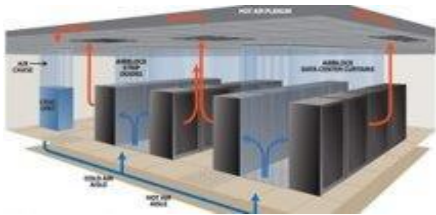
Year 2023, North America



Source: [Lawrence Berkley National Lab](#), 2024



Cooling Methods in the Datacenter



Air-to-Air

Traditional datacenter cooling with hot and cold aisle separation

Struggling to keep up with current IT hardware cooling requirements

Cooling delivered by AC and air-handler units

Large amounts of power required for cooling (system fans, datacenter cooling units)

Requires lower ambient air temps



Rack Heat Exchangers

Rack based cooling with a hybrid of air and liquid

Air intake and exhaust same temperature

No changes to IT equipment or rack required

Liquid loop arrives at RDHx

Medium heat dissipation capacity

Easy to implement bolts on to existing racks



Direct Liquid Cooling

Delivers liquid to server chips via cold plates

Air cooling still required

High heat dissipation capacity

Complexity higher and reliability impacts change vs air

Risk of leaks into IT HW

No industry standards limits choice

Requires engineering and custom solutions, leads to vendor lock-in



Immersion Cooling

IT equipment immersed in dielectric fluid tank

Disruptive to existing DC design and maintenance procedures

High heat dissipation capacity

Little change required to IT equipment no vendor lock-in

HW warranty implications

No noise

Eliminates existing IT cooling requirements

Multiple players and startups, conflicting marketing messages, lack of standards

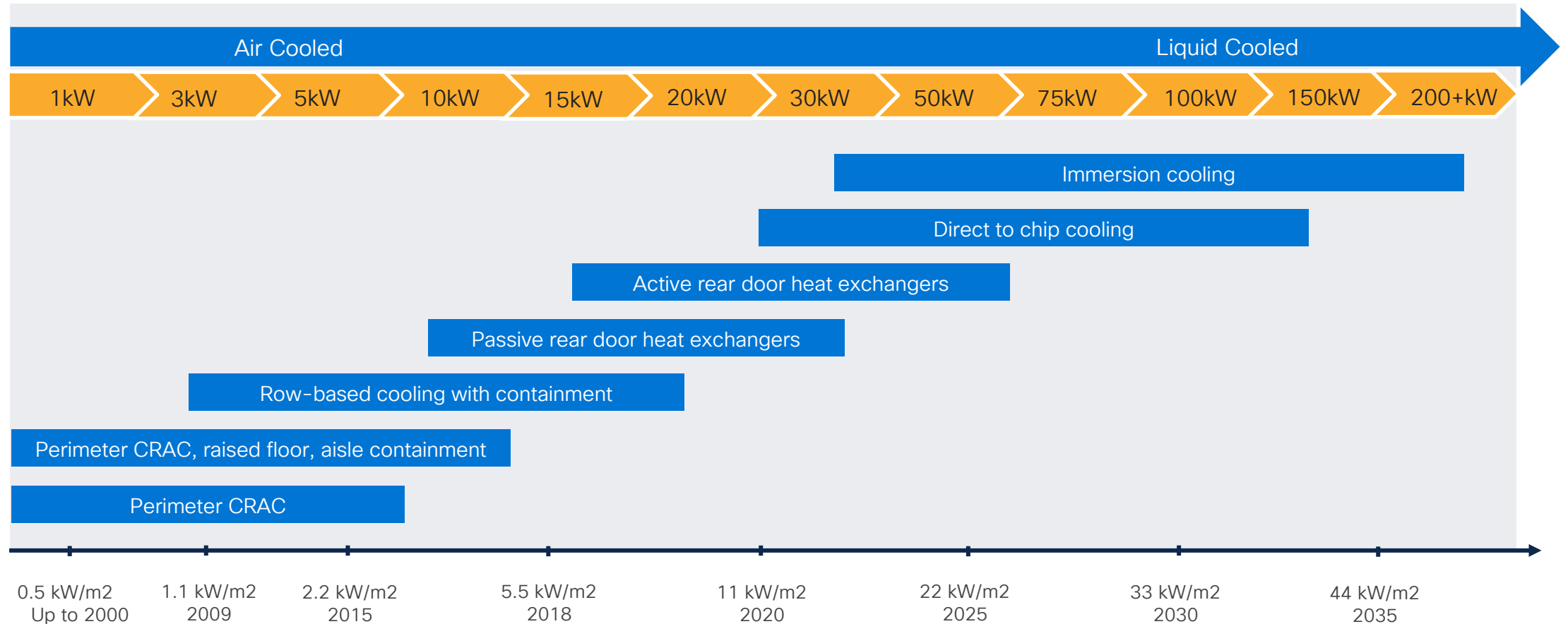
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Thermal Management Systems Evolution

Rack densities and cooling options



* Numbers are indicative only, each vendor provides its own version

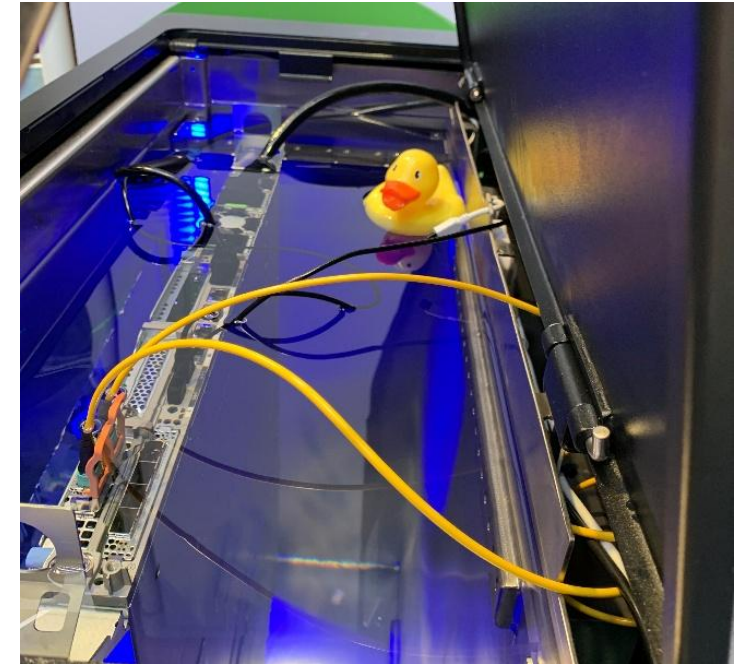
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Immersion Cooling

- High heat dissipation capacity 50-250kW per tank
- Natural or forced convection
- Entire IT system is immersed in a dielectric fluid in a tank
- All server components are liquid cooled, no dependency on air cooling, no fans, no noise (unless forced convection is used)
- Heat from CDU is rejected to the data center chilled primary loop or to ambient air
- The solution comes with its own set of challenges (weight, footprint, maintenance of refrigerant, degradation of materials while immersed, CPU/GPU certification, warranty coverage, mechanical extractors, etc)

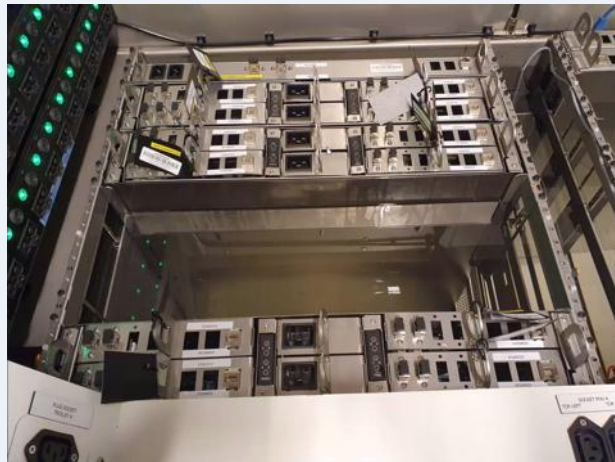




Large EMEA Corporation adopting Immersion Cooling with Cisco

Why Immersion Cooling?

- **Reduce Data Center's PUE** from ~1.5 to ~1.05
- DC has no space nor power constraints, but only air-cooling constraints
→ **Drastically reduces air conditioning requirements**
- **Known technology**, but early testing with other vendors not fully satisfactory



Why Cisco UCS?

- **Large UCS install base** (~3,000+ servers) with very positive feedback (simplicity)
- **UCS simplified cabling** with only 2 ports per server compared to 7 for other vendors (~5,000 less network ports required)
- **Cisco's unique direct support** of the solution – identical to air-cooled servers (no OEM)



How?

- **Cisco commitment** to support the customer for the entire lifecycle
- **Ecosystem play:** Cisco UCS servers, leading immersion cooling vendor, local partner for onsite qualification, deployment and testing, customer's feedback at all stages
- Partner in charge of doing **physical preparation of the servers** before shipping





Immersion Cooling with Cisco UCS – Implementation Details

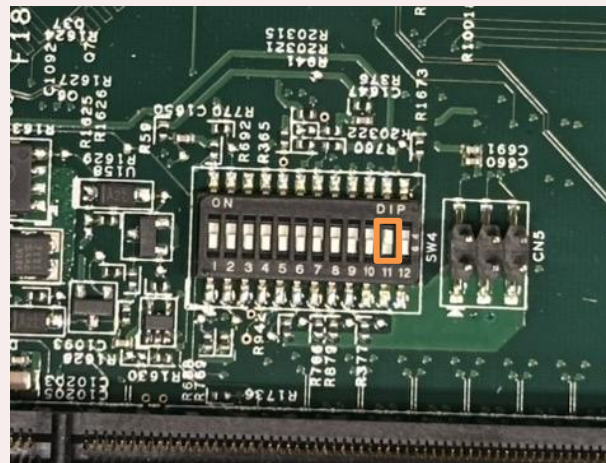
Which products?

- **C220 M7 servers (M8 planned)**
- **Any CPU model** (can support >300W TDP SKUs)
- Any RAM quantity
- VIC 15427 (mLOM 4x25G)
- SSD drives only (no HDD)
- **2300W PSUs** only, Titanium rated



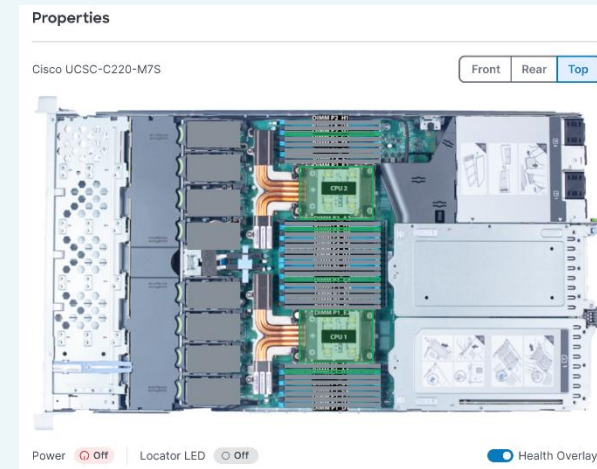
Physical changes

- Removal of **all motherboard fans & VIC fan**
- Removal of **thermal grease** between CPU and heatsink
- Change of **CPU heatsink**
- Removal of foam & stickers
- **Custom brackets** for better operability
- Setting DIP switch to ON



Software changes

- Disable all **motherboard & VIC fans control & faults**
- **Change PSU firmware** to disable internal fan
- Detect DIP switch setting and report cooling mode via Redfish
- **Intersight support** & display of server cooling mode in UI, required 4.3(6)+ release



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Findings and Outcomes:

- Immersion cooling comes with its own challenges, it is not a solution for all needs
- Immersion cooling can be adopted starting at low power densities
- Maintenance and operations need proper planning and tools
- Heat exchangers on high power components still have value, but should be different than traditional heat sinks
- SSD only for local storage, prefer boot from SAN to eliminate any need for local storage
- Unified fabric as a significant benefit: less cables
- Sustainability merit but uncertain TCO benefit
 - PUE of 1.05 achieved, energy savings demonstrated
 - Economical evaluation to be revalidated in the long run