Cooling options for AI/GPU loads in Telia Helsinki Data Center

Whitepaper

26.9.2024

Michael Holm

Table of Contents

Cooling Options for AI/GPU Loads in Telia Helsinki Data Center

Whitepaper by Michael Holm

Introduction

Liquid cooling improves energy efficiency by efficiently dissipating heat from AI servers. It reduces reliance on traditional air-cooling methods, which can be less effective for high-density workloads.

Effective cooling ensures consistent server performance. Liquid cooling solutions maintain optimal operating temperatures, preventing thermal throttling and enhancing overall system performance. New NVIDIA chips will be 15-20% more effective if using liquid cooling compared to using air cooling for the same GPU model.

Liquid cooling also contributes to sustainability by efficiently managing heat, reducing the environmental footprint of data centers, and aligning with green initiatives. Two main liquid cooling architectures are direct-to-chip (cooling at the processor level) and immersion cooling (immersing servers in a non-conductive liquid).

Telia Helsinki Data Center supports GPUs with traditional air-cooled solutions up to 30 kW per rack, with rear door heat exchangers capable of up to 50 kW, and with liquid cooling up to 100 kW. Layouts and equipment are reference designs, subject to change in final customer implementations

Special thanks to **Mr Kalle Hasu** (LinkedIn) from Telia, **Mr Matti Sinisalo** (LinkedIn) from Granlund and **Mr Freddy Briffitt** (LinkedIn) from Inova DC for their contribution to this document.

Telia Helsinki Data Center (Telia HDC)

Telia Helsinki Data Center, one of the largest open data centers in the Nordics, is located in Pitäjänmäki, Helsinki, Finland, less than 20 minutes from the airport. Opened in 2018, with a total power capacity of 100 MW and an IT capacity of 24 MW, it is a modern modular facility that can be easily modified for various AI loads.

Telia Helsinki Data Center provides data center, cloud, and infrastructure services for both Finnish and international companies. With its modular design, Telia offers services from 12U racks up to dedicated data halls and floors with a capacity of 8 MW each.

The data center operates sustainably, using carbon-neutral, renewable energy. Waste heat from servers is collected and utilized in the district heating system in the City of Helsinki. The data center has a closed-loop water-based cooling system with a Water Usage Effectiveness (WUE) of less than 0.1 liter per kWh. Even rainwater is collected and used for flushing toilets.

The data center is designed based on TIER III and EN50600 standards and holds LEED Data Center v.4.0 and CEEDA Design-Operate gold certificates, ensuring quality and eco-friendliness. Additionally, it holds the following ISO certificates: 9001, 14001, 22301, 27001, 45001, and 50001.

Telia Helsinki Data Center is the second most connected site in Helsinki and offers multiple network operators, global connections, and secured fiber optic networks

https://telia.fi/datacenter

https://youtu.be/fV_XdRd5hg8?si=BVhkndWu8wmAspr1

#TeliaHDC

Excess (waste) heat reuse

Overview

The first 5 MW Heat Recovery Module building started in H1 2022 and has been in production since April 2023. The 5 MW cooling capacity produces 6.5 MW of heating capacity. The full-built recovery plant, planned at this moment, is 4x5 MW (cooling capacity), adding up to 26 MW in heating capacity. This is equivalent to the need of 25,000 normal households (8% of the need in the City of Helsinki).

The main objective for the project is to utilize heat coming mostly from server capacity. Because of the significant amount of heat energy, the end-user must have the capability to take all that heat into use. The best choice is, therefore, a large energy company that can use it fully for heating. Telia Helsinki Data Center is located in an urban area where there are a lot of homes and other buildings with a natural need for heat. Local energy company Helen has a wide district heating network, which can transfer heat from the data center without any separate building project. Helen owns heat pumps installed in the data center facility and buys external heat energy from their point of view.

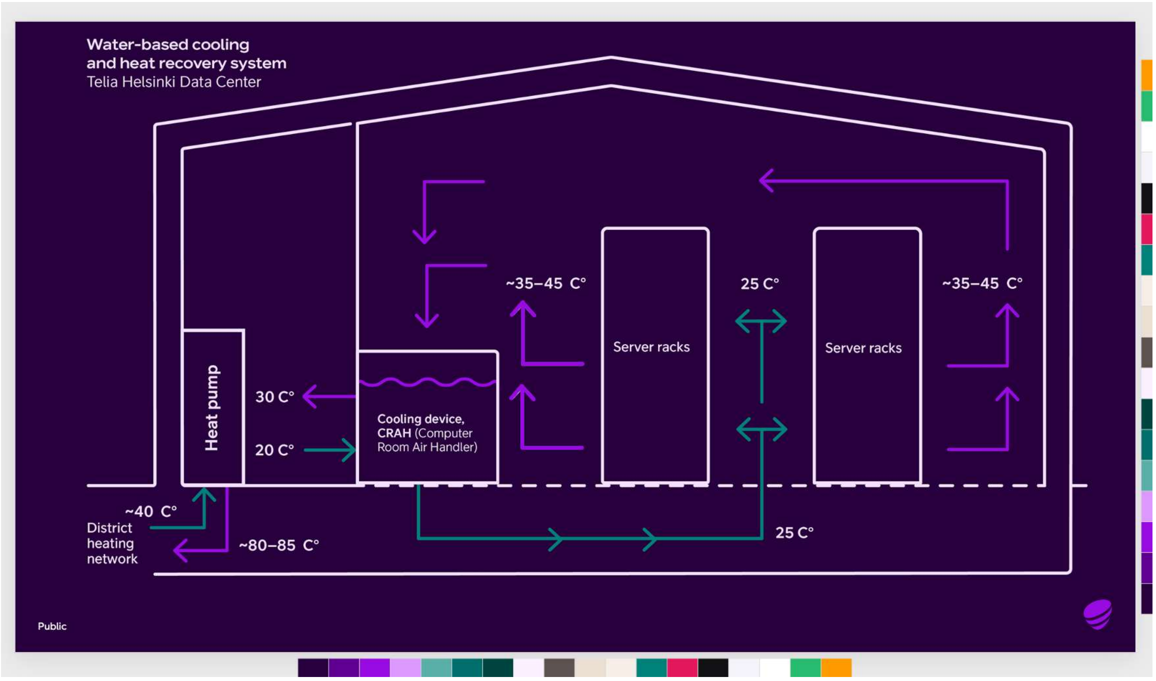
An additional advantage for the data center is a lower electricity tax level because of recycling heat. Additionally, heat recycling has a significant positive impact on Power Usage Effectiveness (PUE), especially in the summertime. Heat pumps decreased the use of chillers by 25% compared to the previous summertime without pumps. Also, the energy company has a positive direct impact when they can decrease the use of fossil energy sources in their own production

Cooling and excess heat reuse setup

Telia HDC has a closed loop water-based cooling system in place with an inlet water temperature of 20 °C and return of 32 °C. The systems include following base components:

a) **Data hall cooling systems** – Computer Room Air Handlers (CRAH) units, Rear door heat exchangers, or Liquid cooling (direct-to-chip)
b) **Excess heat pumps** – the heat pumps use the return water at 32°C and with additional energy, the return water to the district heating grid is pumped up to 75-85°C
c) **Dry coolers** – based on the roof of the data center. The data center can run on free cooling if the temperature is below 19°C. On average, we can run on free cooling around 8000 hours per year (approximately 95% of the time).
d) **Chillers** – if additional cooling is needed to assure TIER III operational standard of the data center

Principal overview



Data snapshot.

As of 29.5.2024

• Waste heat:	4.11 MW
• Added energy:	1.45 MW
• Total capacity back to the district heating:	5.65 MW
• Coefficient of Performance (COP) for the pumps:	3.9
• Power Usage Effectiveness (PUE):	1.152
• Energy Reuse Factor (ERF):	0.75

• Monthly PUE in July 2024:	1.17

GPU cooling options in Telia Helsinki Data Center

The data center, designed with a highly adaptable infrastructure, offers three different cooling solutions for AI GPU racks to cater to varying customer requirements. These solutions include:

- Air-cooled: Capable of handling up to 30 kW, this method uses ambient air to dissipate heat from the GPU racks.
- Rear door cooled: This approach can manage up to 50 kW by utilizing a cooling unit attached to the rear door of the racks, enhancing heat removal efficiency.
- Liquid to chip cooled: The most advanced option, supporting up to 100 kW, involves direct liquid cooling at the chip level, providing superior thermal management for high-performance computing needs.

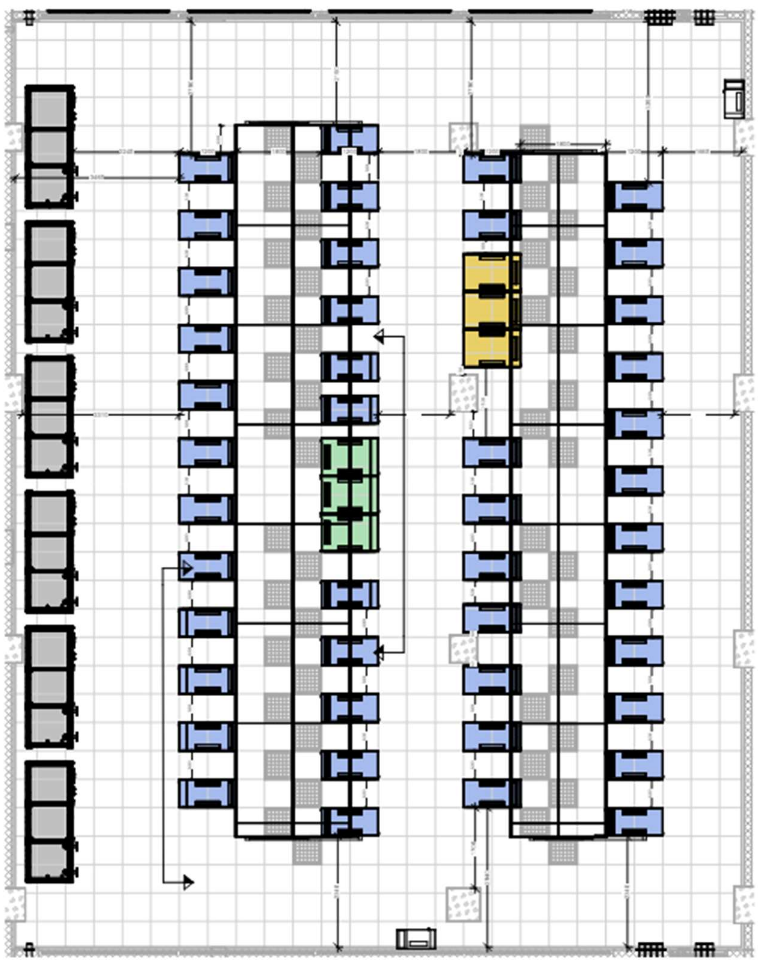
These options are explained on upcoming pages.

Air cooled racks supporting up to 30 kW / rack

This setup has three GPU servers with a total load of 30 kW per rack. This setup is possible to use in all our existing data halls with fast implementation. The racks can be W600 or W800 and we leave a space between every rack of 400-600 mm to assure maximum airflow. The power feed to the racks is redundant 3 phase 32A and can have either 2 (A+B) for a maximum of 21 kW or 4 x (A+B) for a capacity of up to 30 kW

Data hall layout

Rack dimensions are W800 x D1200 x H52U This setup have 44 GPU racks and 6 network rack a total load of 1200 kW

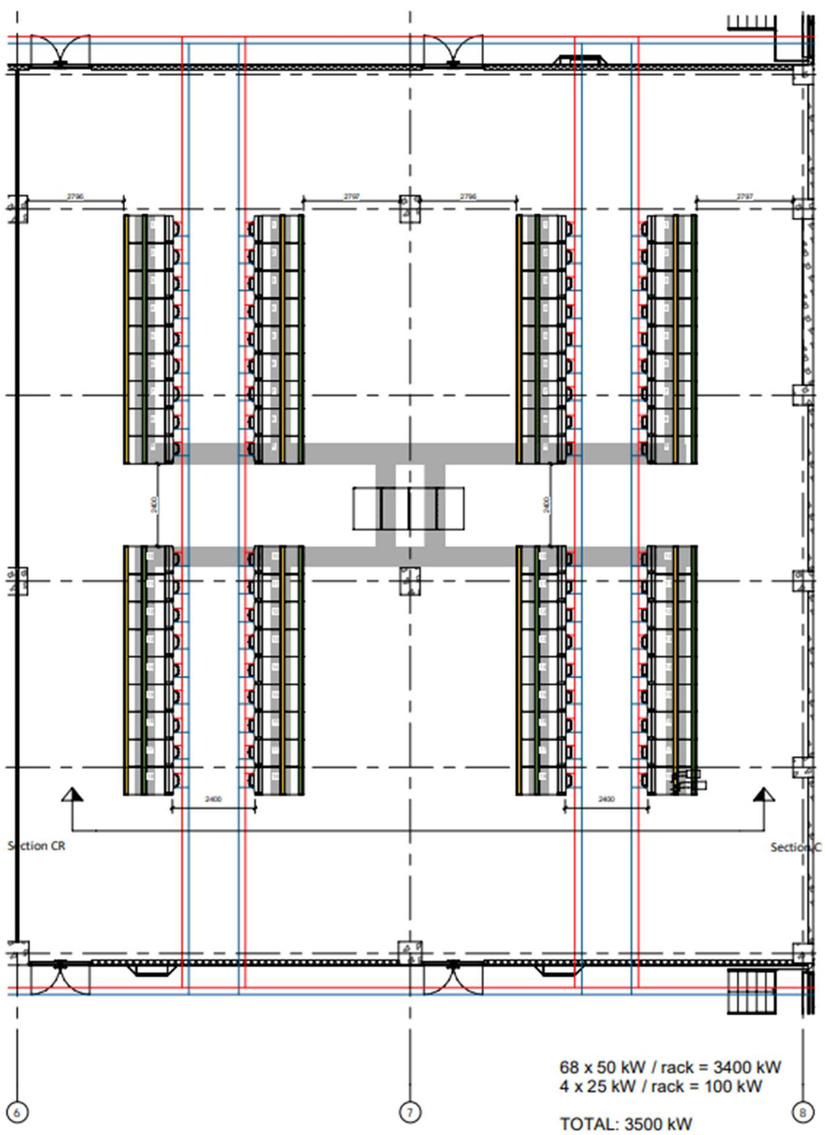


Rear door heat exchangers cooled racks up to 50 kW / rack

This setup has six GPU servers with a total load of 50 kW per rack. In the future, it is most likely that there will be five or four GPU servers per rack since it is estimated that a normal AI-cooled GPU server load will increase to approximately 10 kW and then up to approximately 12-13 kW. The total load in this case is 3500 kW in 68 GPU racks and four network racks. The power feed to the racks is redundant 3 phase 63A

Data hall layout

Rack dimensions are W800 x D1200 x H48U, corridor space between racks have been set to 1800 millimetres



Rack cooling capacity

The following simulation is done based on inlet water temperature of 20 °C, outlet 32 °C and the server out temperature of max 50 °C.

Performance Simulations – 1.0 – 48U 800w option

Description	Unit	Server Racks	Network Racks
Cooling Duty (Total)	**kW**	**55**	**26.5**
Cooling Duty (Sensible)	**kW**	**55**	**26.5**
Condensate volume	[L/H]	0	0
Air Onto Coil Temperature	[°C]	50	45
Air Onto Coil RH	%	15	15
Air Off Temperature (±1)	[°C]	23.5	22.5
Air Off Coil RH	%	64.2	52.8
Airflow Volume	[m³/h]	6800	3800
Airflow Volume (max)	[m³/h]	8200	8200
Air Pressure Drop	[Pa]	56.4	22.3
Fluid Flow Temperature	[°C]	20	20
Fluid Return Temperature	[°C]	32	32
Fluid Flow Volume	[m³/h]	3.97	1.91
Fluid Flow Velocity	[m/s]	0.65	0.31
Fluid Pressure Drop (coil)	[kPa]	14.6	3.8
Fluid Pressure Drop (estimate incl. hoses, std valve)	[kPa]	32	10
Power Draw est.	[W]	600	200

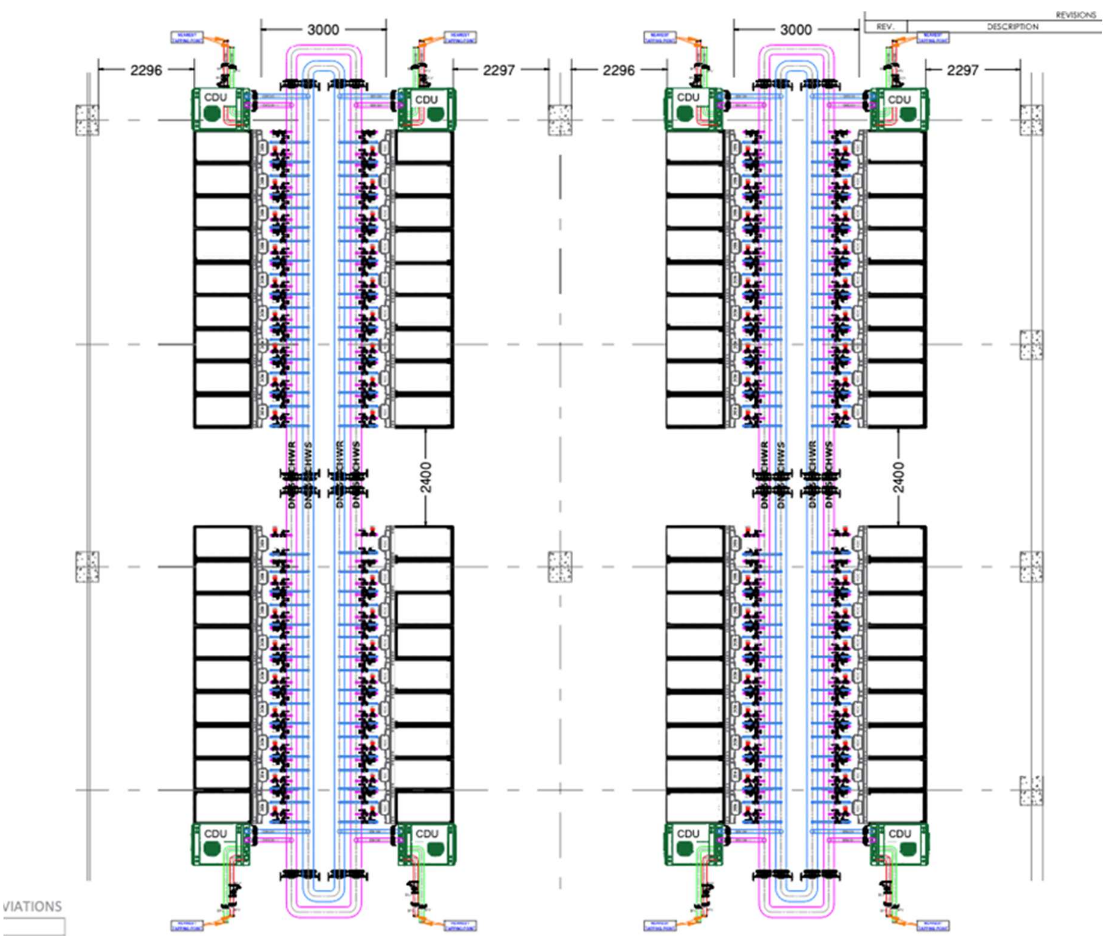
Liquid cooling direct-to-chip supporting 100 kW / rack

For this setup, we are using a hybrid cooling system, 50% direct-to-chip level cooling and 50% rear door cooling. This method enables us to cool effectively the higher wattage GPUs (when airflow becomes a challenge). The rest of the heat load (produced by CPU, PSU, etc.) is cooled effectively at the source with a rear door heat exchanger.

We utilize row-based cooling distribution units to provide the client with an isolated secondary loop, providing precise temperature and flow control to the cabinets

Data hall layout

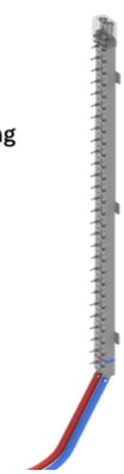
A 100 KW in rack CDU and manifold are also deployed in specialist 1400mm deep AI ready cabinets. Total capacity 7,2 MW



CDU specification

MODEL PN: INVCDU2000	
Nominal Cooling Capacity	1368 kW at 7.2 °F (4.0 °C) approach temperature difference
Maximum Cooling Capacity	2052 kW at 9.0 °F (5.0 °C) approach temperature difference
Electrical Power Supply - Available Options	400V/3PH/50HZ 480V/3PH/60HZ 208V/3PH/60HZ
Power Feeds	Redundant A/B, Inbuilt ATS
Maximum Power Consumption	18.5 kW at maximum flow and pressure drop
Pump	
Pump type	Single Stage, End Suction
Pump Configuration	Dual pump (N+1), triple pump (N) run modes
Maximum pump flow - 2 pumps running	554 GPM
Integrated Variable Speed Drives	Included
External Pressure capability	2.88 bar (42.0 psi)
Primary Loop	
Hydraulic Connection	4" Victualic groove, Top or Bottom
Filtration	1 x 50 microns
Cooling fluids	ASHRAE W1 to W4
Coolant Fluid Type	Water, Water/Glycol
Secondary Loop	
Hydraulic Connection	4" Victualic groove, Top or Bottom
Filtration	3 x DN80 strainers (allowing for 50 or 25 micron filters)
Coolant Fluid Type	Water, Water/Glycol

- Cooling capacity 100kW+ at 4K ATD
- 19" 4U Rack mount chassis
- Compatible with ASHRAE W4 warm water cooling
- Redundant pumps
- Redundant power supplies
- 4.3" LCD screen with touch functionality
- Dew Point monitoring and control logic
- Internal and external leak detection system
- Optional dry-break quick disconnects



Abbreviation

ERF	Energy Reuse Factor
PUE	Power Usage Effectiveness
WUE	Water Usage Effectiveness
AI	Artificial Intelligence
GPU	Graphical Processor Unit
COP	Coefficient Of Performance
kW	Kilo Watt
MW	Mega Watt
CDU	Cooling Distribution Unit

About the author

Michael Holm (LinkedIn) serves as the Global Sector Lead for Data Centers at Telia. In this role, he is responsible for expanding Telia's data center and colocation footprint, as well as growing the customer base across Telia's home market in the Nordics and Baltics. With over 15 years of experience in the IT industry and an additional 10 years in other sectors, Michael is a strong advocate for certifications as evidence of effective business practices. He is also an active speaker at data center and sustainability events. Additionally, Michael has contributed to early-stage customer development, basis-of-design projects, and data center expansions.