

Can the Nordics Keep Up? Power, Cooling and the Race for AI Capacity.

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Chair of Future Technologies Symposium of OCP**

AGENDA

- Nordic data center growth story.
- The strengths around energy and climate.
- Funded projects with RISE.
- Looking at heat recovery potential.
- Focussing on AI.
- Brief look at the Nordic potential.



The story begins with the Greenpeace
whitepaper in April 2011.



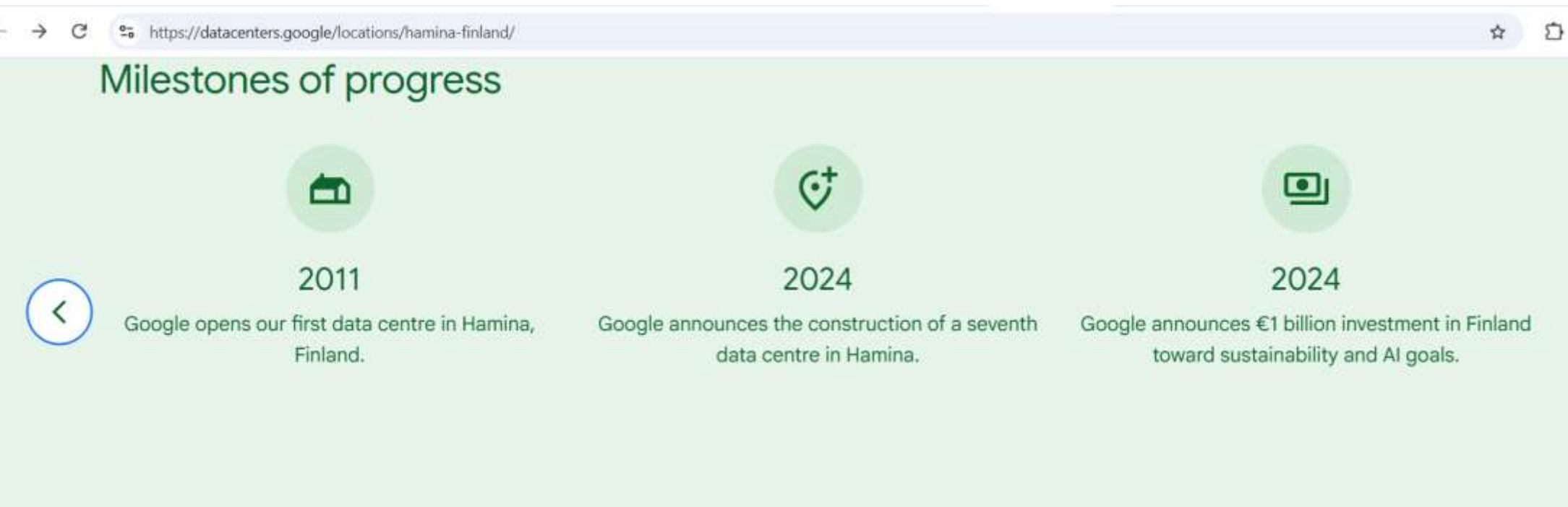
The whitepaper highlighted the heavy use of fossil fuels and lack of transparency.

Clean Cloud Power Report Card

Company	Clean Energy Index*	Coal Intensity	Transparency	Infrastructure Siting	Mitigation Strategy
	N/A	N/A	B	D	C
	26.8%	28.5%	F	D	D
	6.7%	54.5%	C	F	C
	13.8%	53.2%	D	F	D
	36.4%	34.7%	F	C	B

Source: <https://www.greenpeace.org/international/publication/7196/how-dirty-is-your-data/>

Resulting in the first hyperscale data center in the Nordics.



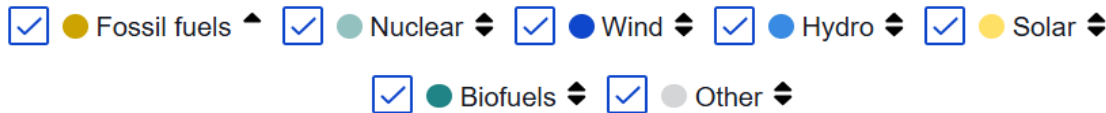
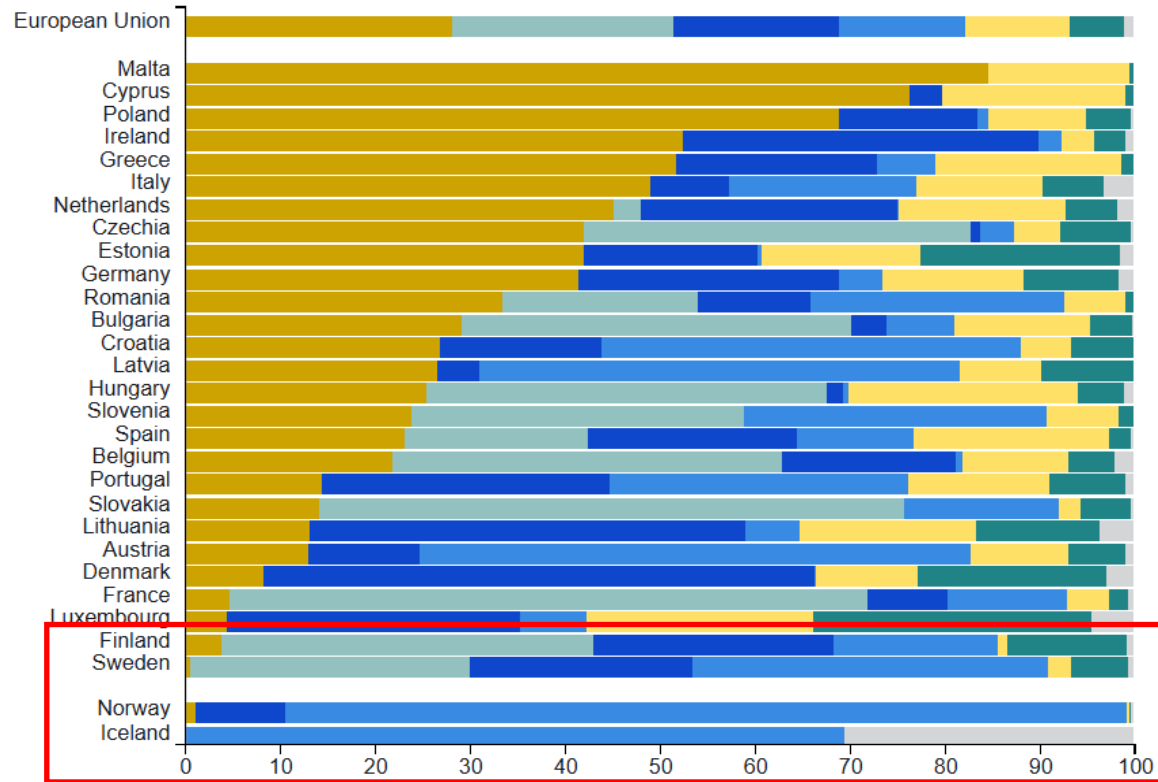
Source: <https://datacenters.google/locations/hamina-finland/>

Followed by Facebook in Luleå.



Construction started October 2011
Operation began in June 2013

EUROSTAT Production of electricity by source 2024.



Information

Electricity produced in pumped hydro plants from water previously pumped uphill and electricity discharged from batteries is excluded from total electricity production.

Low carbon electricity in the Nordic grid.

Source: <https://ec.europa.eu/eurostat/web/interactive-publications/energy-2026#electricity-production>



- 30+ projects, from the ground to the cloud, chip to chiller
- 24 employees
- 4 MEUR turnover
- Established 2016

www.ri.se/ice

RISE ICE Data Center



DATA CLOUD
GLOBAL AWARDS
2019



EARTO Innovation
Awards 2022
Holistic Cooling

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A full-scale research data centre and test environment with the objective to increase knowledge, strengthen the AI & DC ecosystems and attract researchers.

1600m² of laboratory space.
2 production DC modules.
Multiple testbeds.

2000 physical servers
250 kW
200 TB RAM
10 PB storage
50 000 cores
240 GPUs
1,1 M cuda cores
HDFS clusters
OpenStack ECC
Kubernetes cluster
ICE Connect



Current Official Partners in the Partner Program

Premium partners:



Collaborators:



Academic:



Focussing on energy

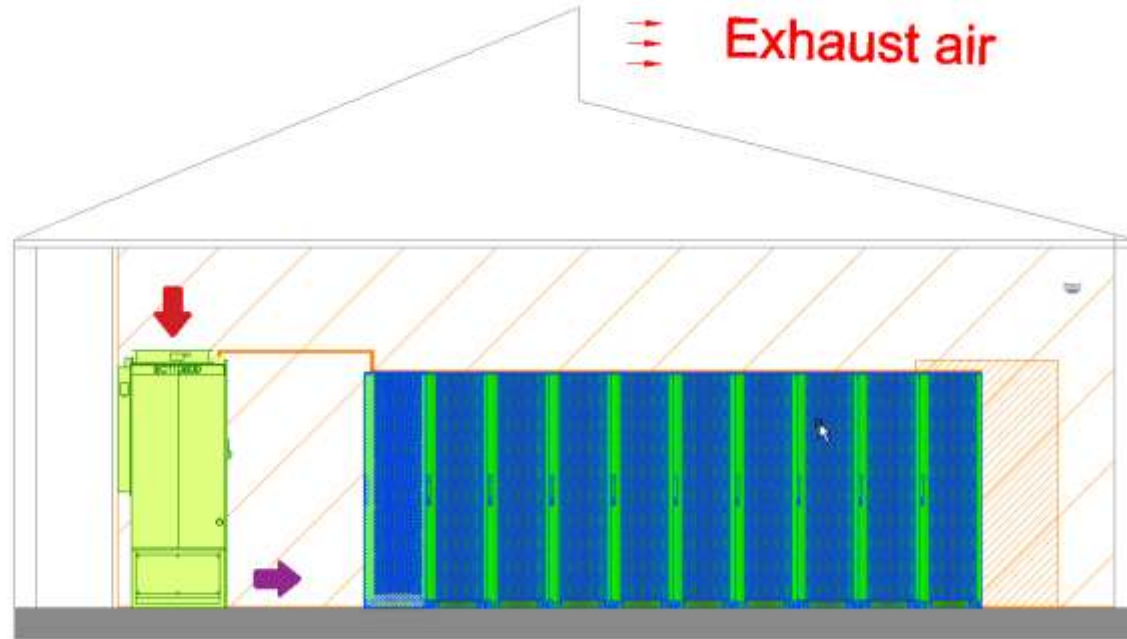


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The BodenType DC – an EU funded project for efficient and low cost DC.



GA 768875



The BodenType DC – an EU funded project for efficient and low cost DC.



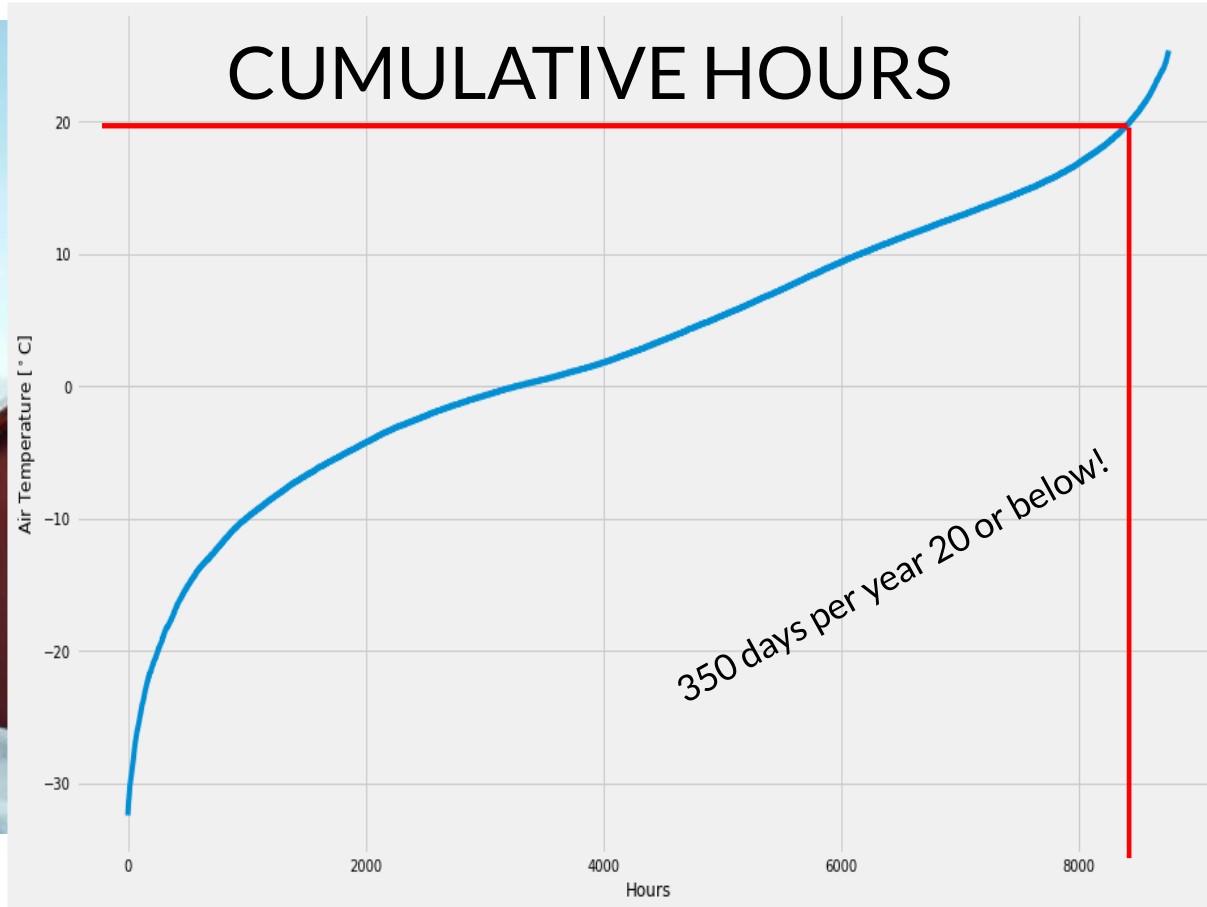
GA 768875



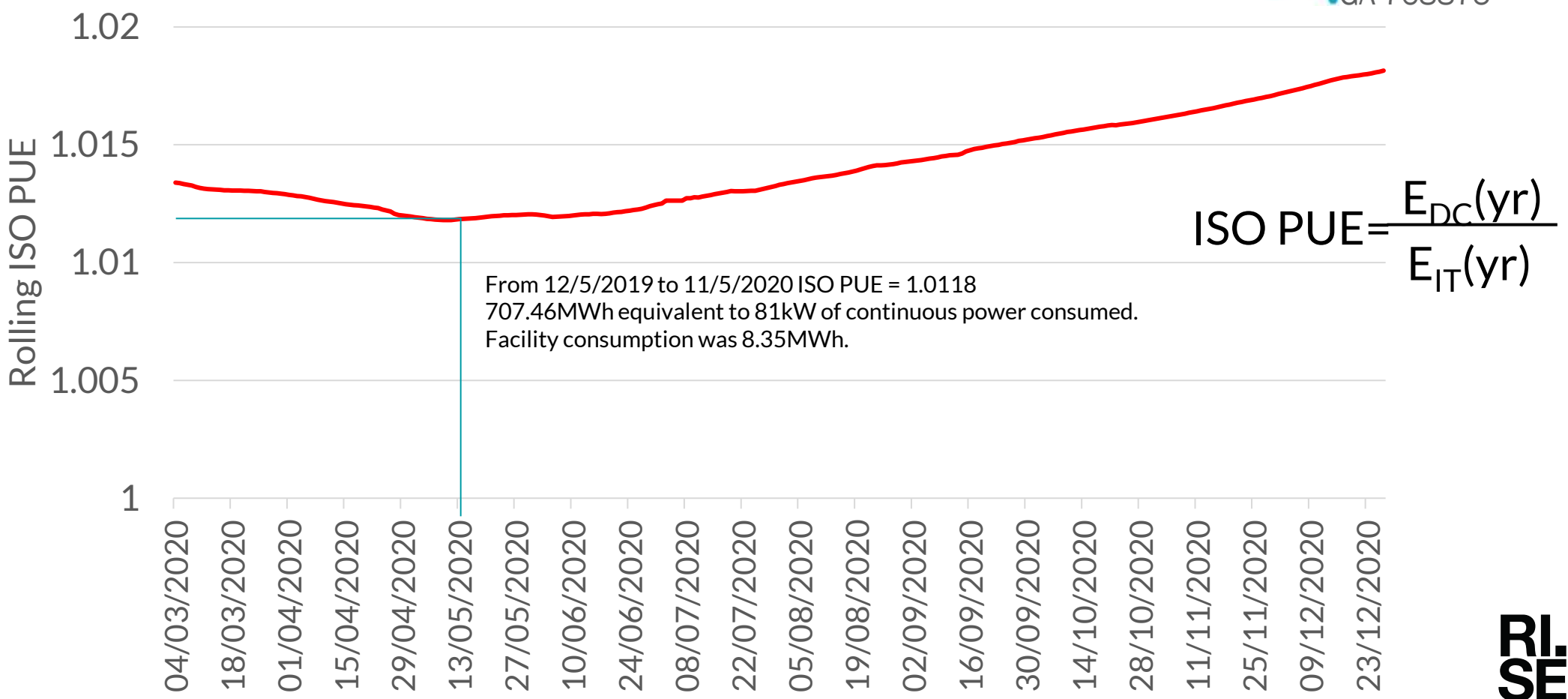
The BodenType DC – an EU funded project for efficient and low cost DC.



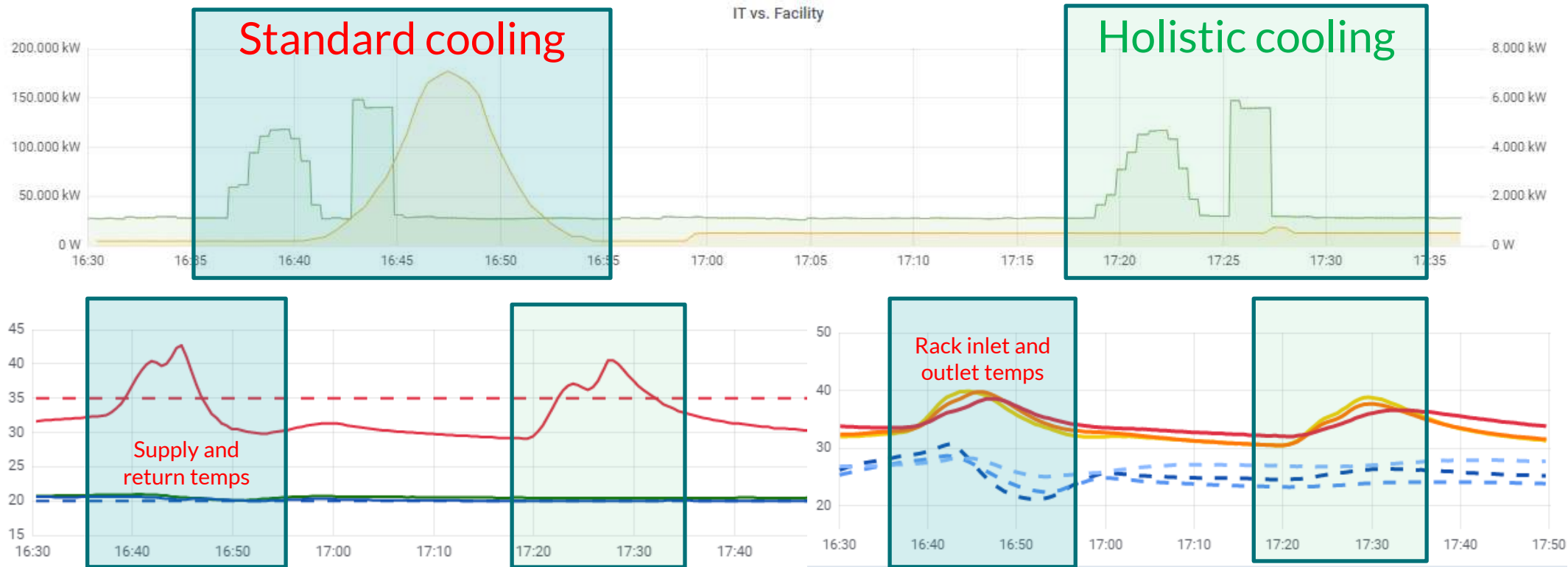
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Rolling ISO PUE based on 1 year of data before date.

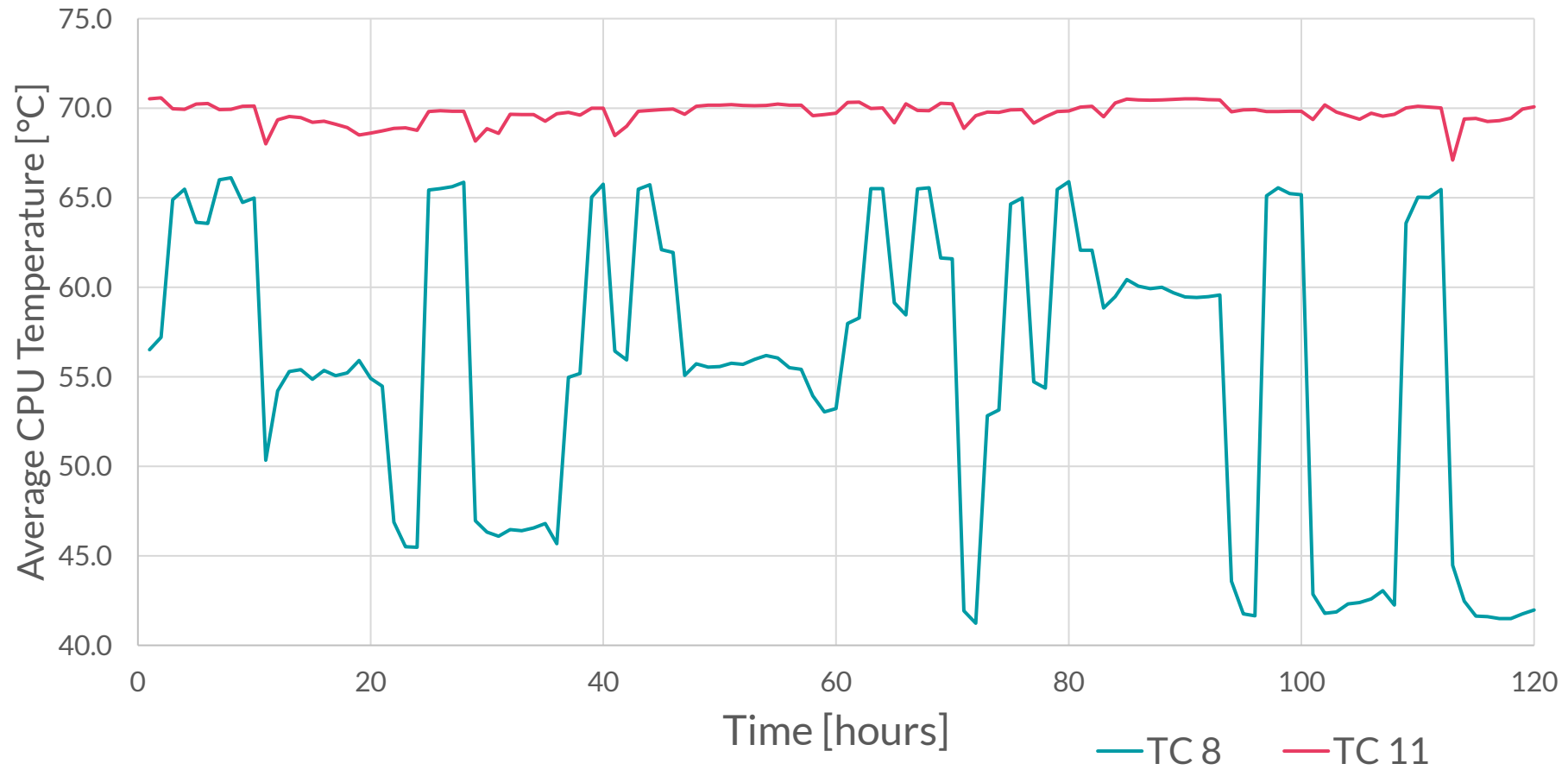


Holistic air-cooling control.



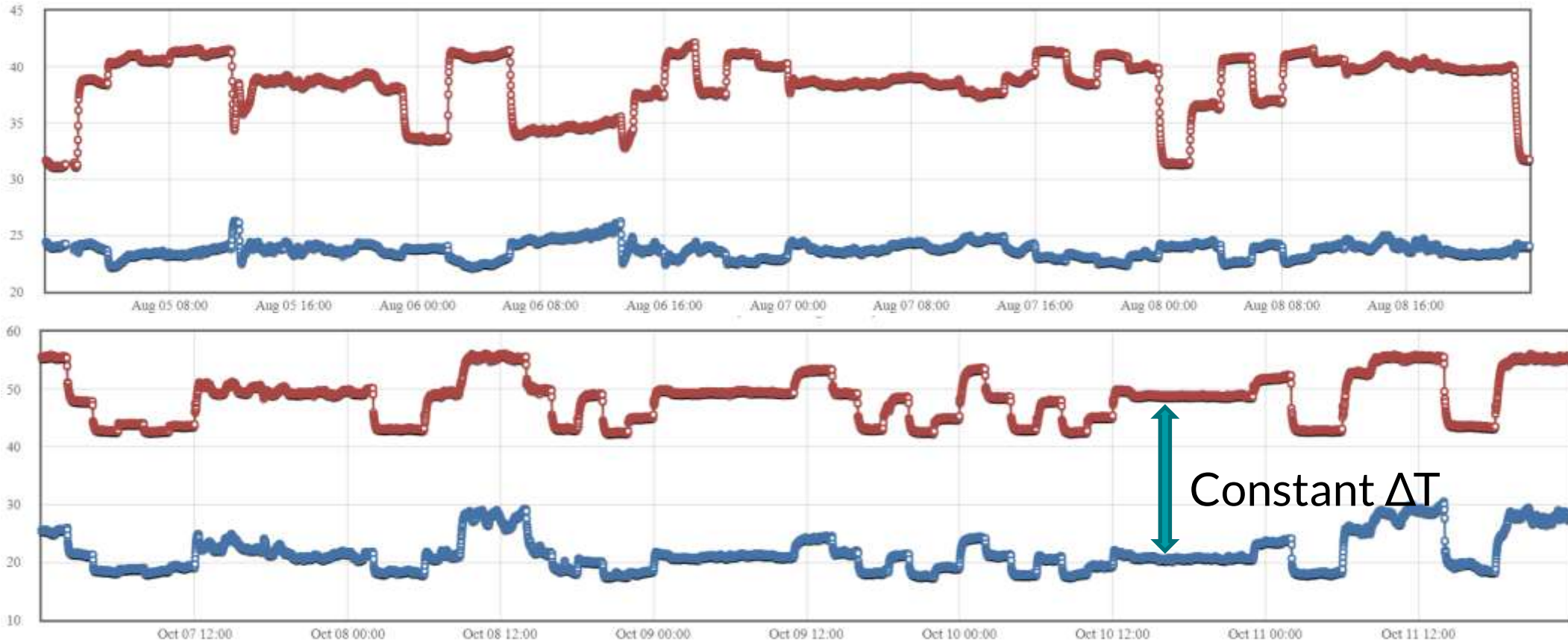
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°768875.

Results of targeted air flow thermal management.



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Results of targeted air flow thermal management.



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The extreme case of PUE optimisation.



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	CPU Temp	ΔP	IT Power	Facility	Total Power	Instantaneous PUE
Factory	43°C	0 Pa	40.110 kW	965 W	41.075 kW	1.0241
Custom	68°C	1 Pa	41.087 kW	972 W	42.059 kW	1.0236
Δ	+25°C	+ 1 Pa	+977 W	+7 W	+984 W	-0.0005

	CPU Temp	ΔP	IT Power	Facility	Total Power	Instantaneous PUE
untuned	68 °C	1 Pa	41.087 kW	972 W	42.059 kW	1.024
tuned	73 °C	0 Pa	41.698 kW	637 W	42.335 kW	1.015
Δ	+5 °C	- 1 Pa	+611 W	-335 W	+276 W	-0.009

	CPU Temp	ΔP	IT Power	Facility	Total Power	Instantaneous PUE
22°C	72 °C	0.2 Pa	41.602 kW	641 W	42.243 kW	1.015
15°C	72 °C	0 Pa	41.647 kW	418 W	42.065 kW	1.010
Δ	0 °C	- 0.2 Pa	+45 W	-223 W	-178 W	-0.005

1.38% drop in iPUE
For a 2.41% increase
in power
consumption



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°768875.

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Consequence of trends in processing data



3 million times more efficient like doubling every 2.5 years.

Energy value of data stream has gone from 0.000000001% (1970) to 0.03% (today)



Electrical



Waste Heat



Today **99.97%** of input energy is in the thermal stream.

Based on:
Rolf Landauer, "Irreversibility and Heat Generation in the Computing Process," **IBM J Res. Dev. 5, 183 (1961)**.
<http://dx.doi.org/10.1147/rd.53.0183>

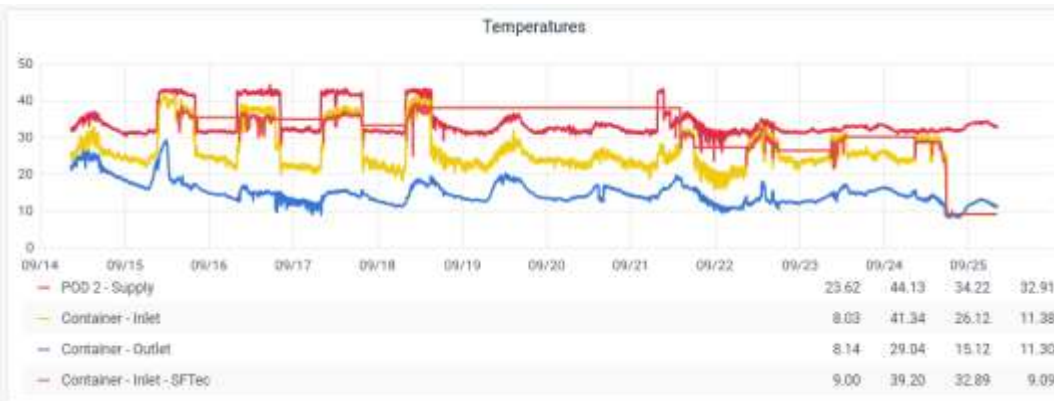
GPUs in POD2 used for biomass drying.

Conclusions

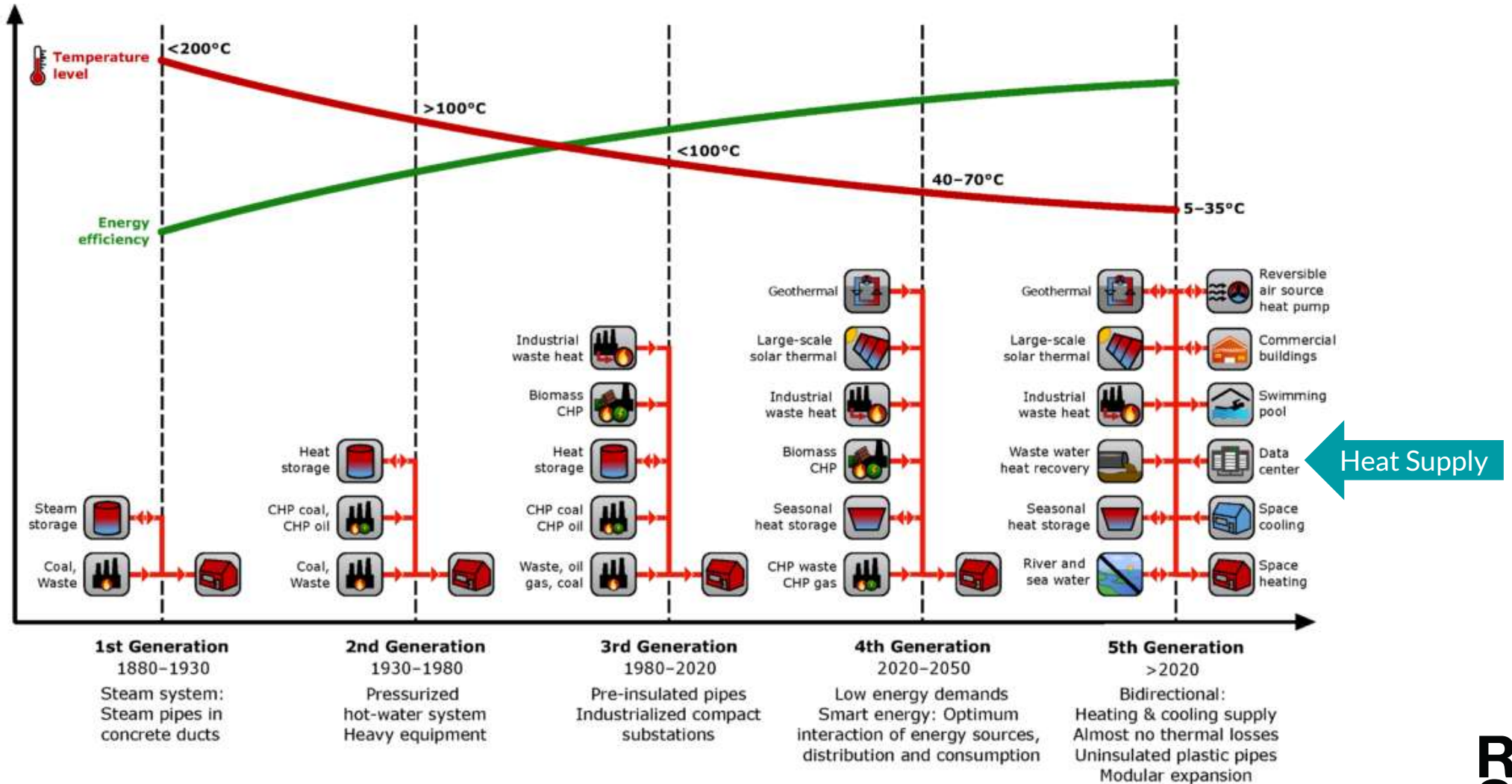
- 8% reduction of moisture content
- 42 % **ERF** (Energy Reuse Factor)
- 8 year for return of investment



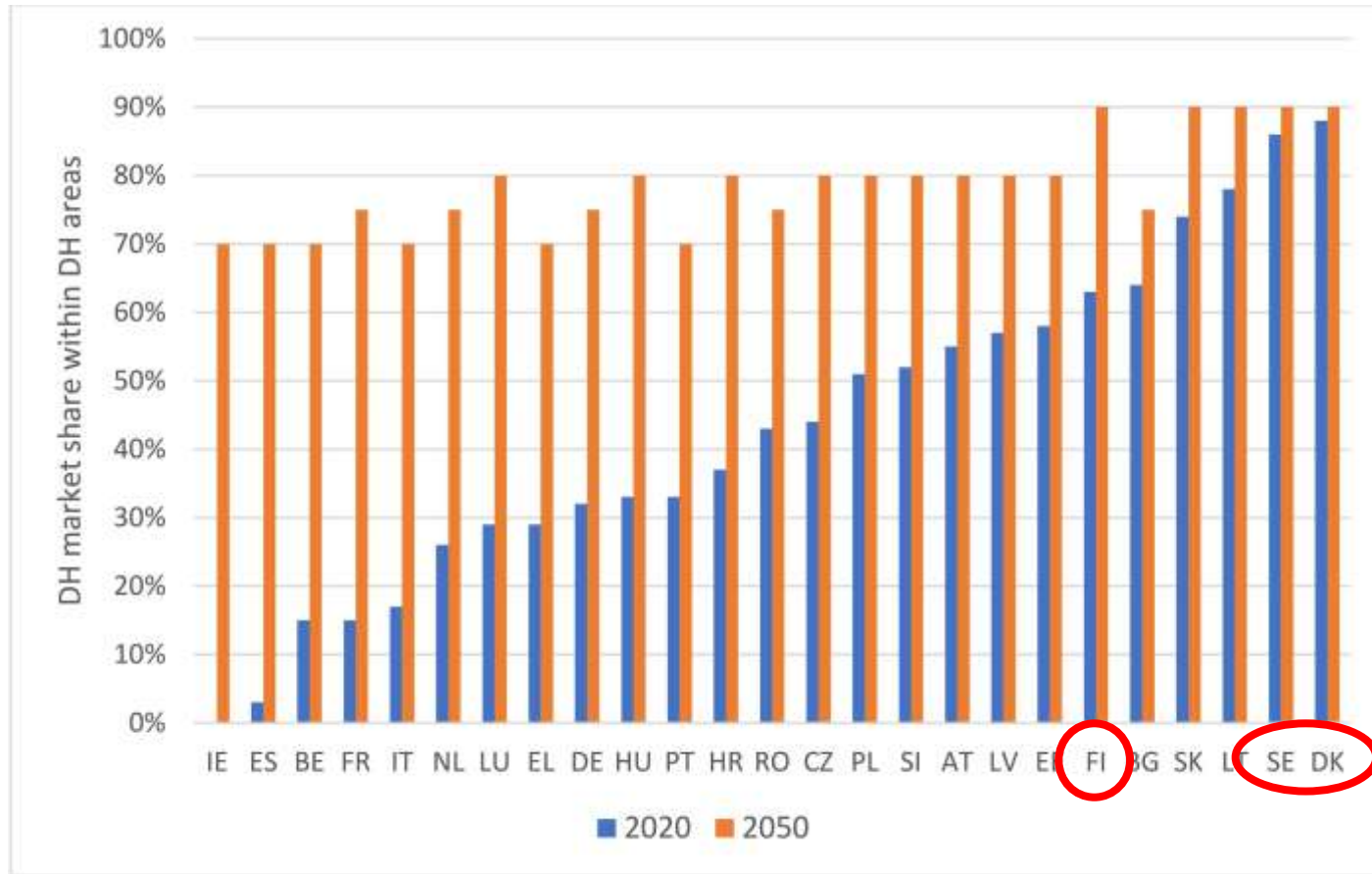
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Evolution of District Heating



DH market shares within DH areas

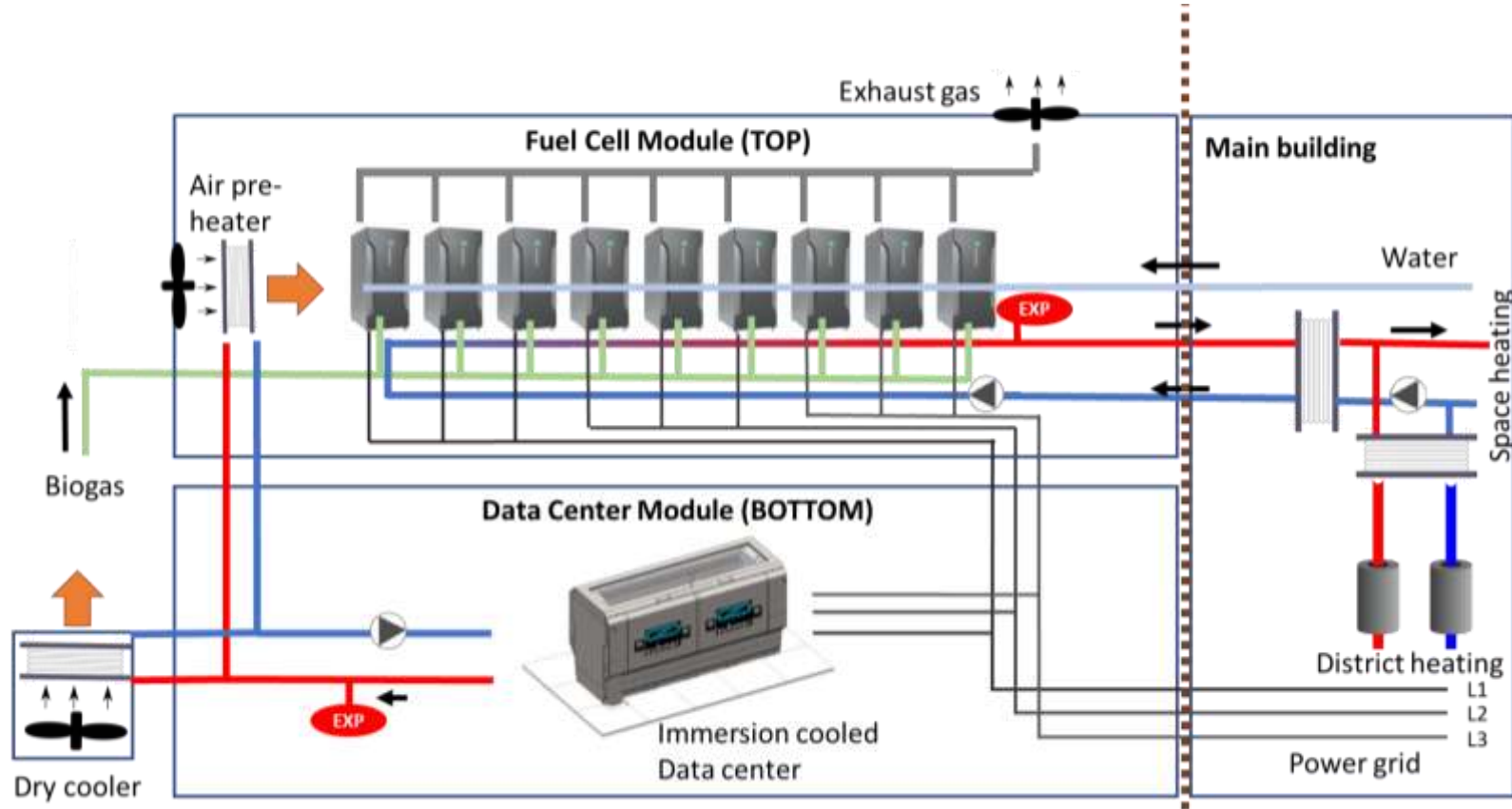


Source: *Mostafa Fallahnejad et al*, District heating potential in the EU-27: Evaluating the impacts of heat demand reduction and market share growth, *Applied Energy*, Volume **353**, Part B, 2024

The EU funded WEDistrict: Luleå demo



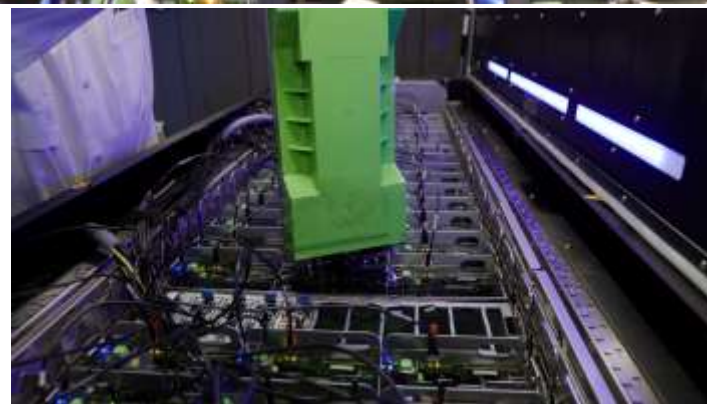
Data Centre and Fuel Cell container setup



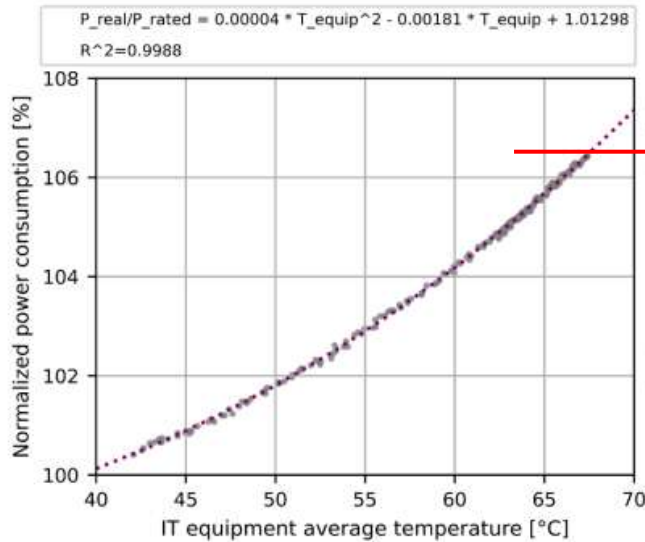
Inside the Fuel Cell container



Inside the Data Center container

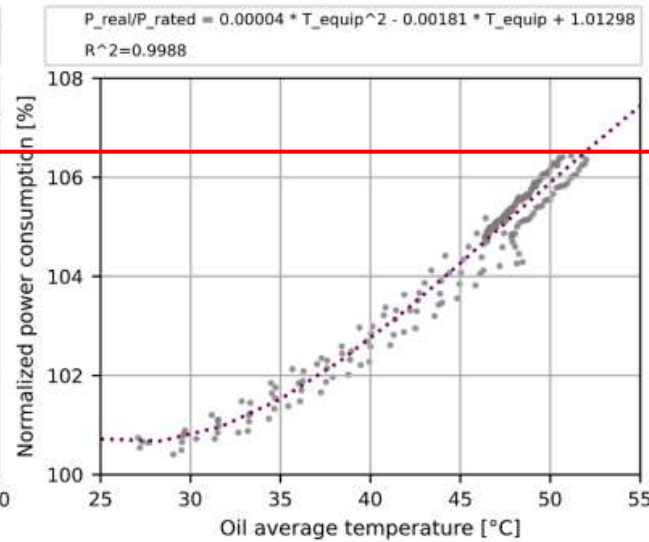


Controlled tests of immersion cooling



(a)

Increased power draw as a function of the average CPU temperature in (a) and as a function of the tank coolant temperature. Running hotter consumes more power.



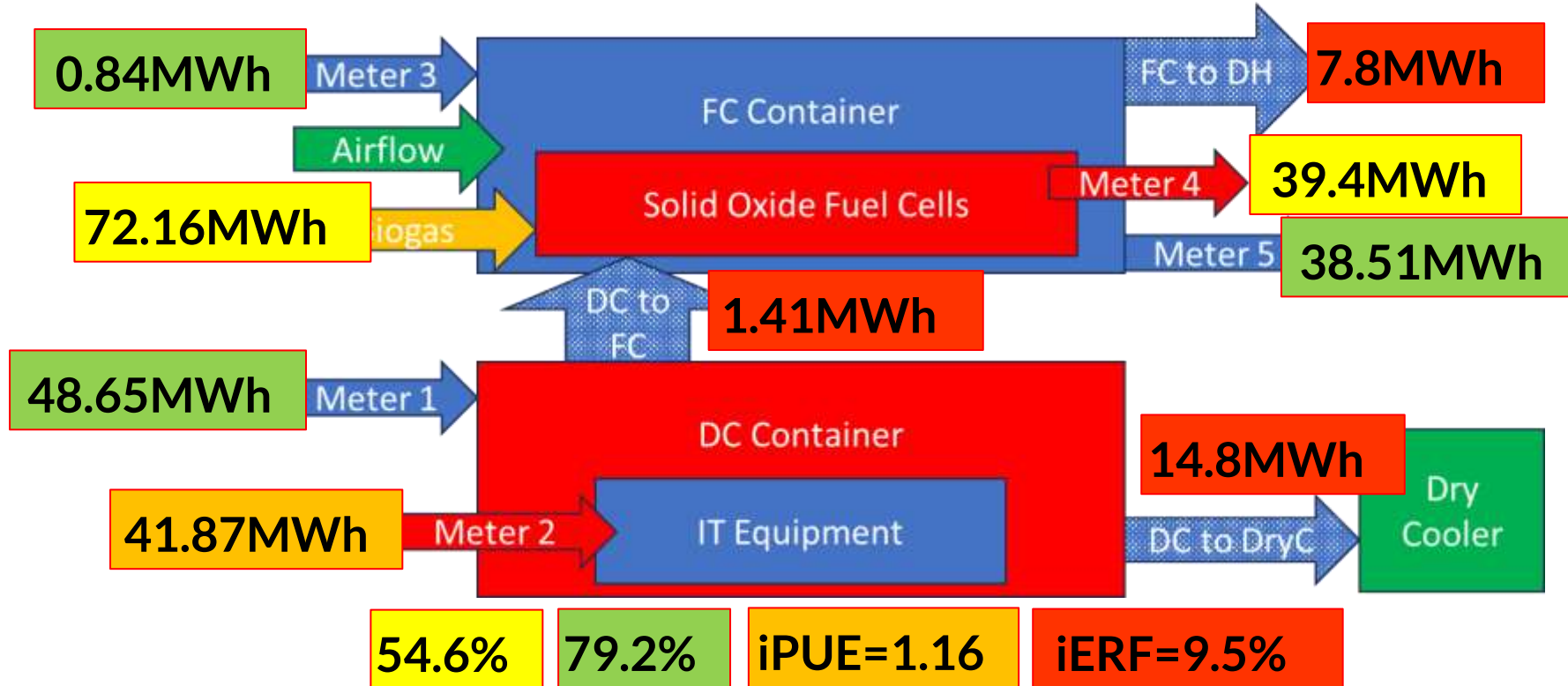
(b)

Around 6.5% increase in power draw when letting the tank temperature rise to nearly 55°C.



Energy flows during monitored period.

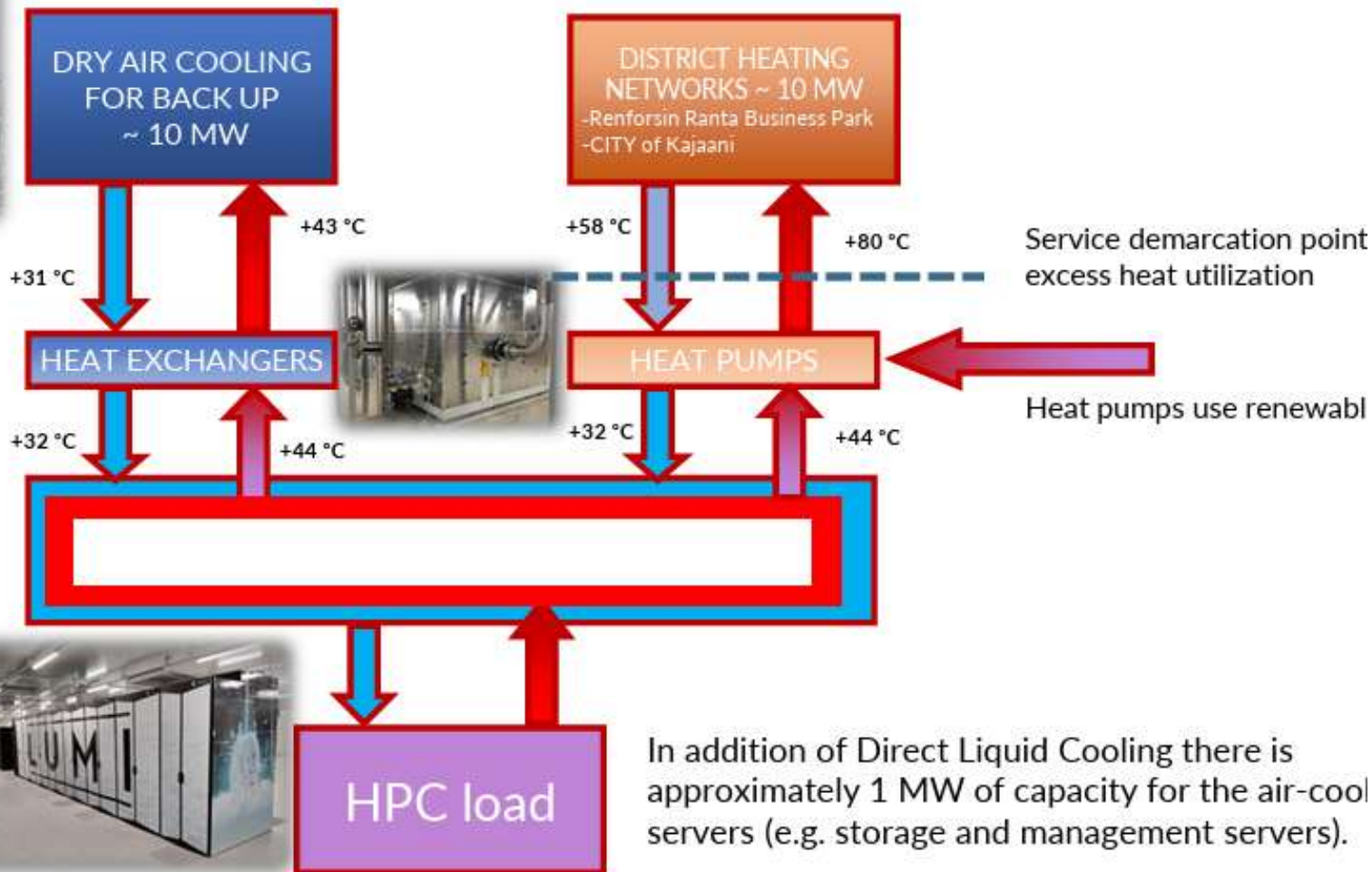
Complete operational datasets from 11/01/2023 to 16/06/2023



LUMI: Excess Heat Utilization Process Overview



Annual CO₂ savings around 6.000 tonnes



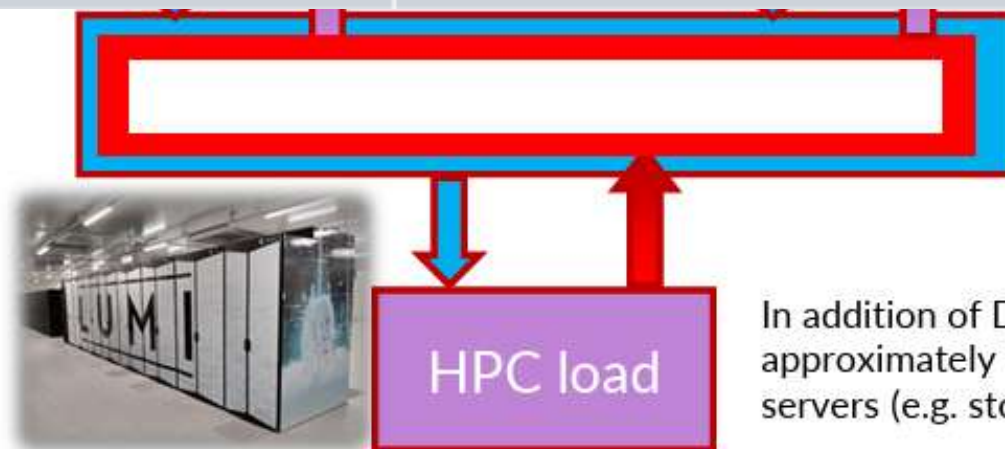
LUMI: Excess Heat Utilization Process Overview



LUMI data center statistics for 2023

Metric	LUMI (values from 2023)
Free cooling PuE	<1.05
PuE with heat re-use	1.31
Heat re-use COP	4
ERE	0.52
ERF	0.57

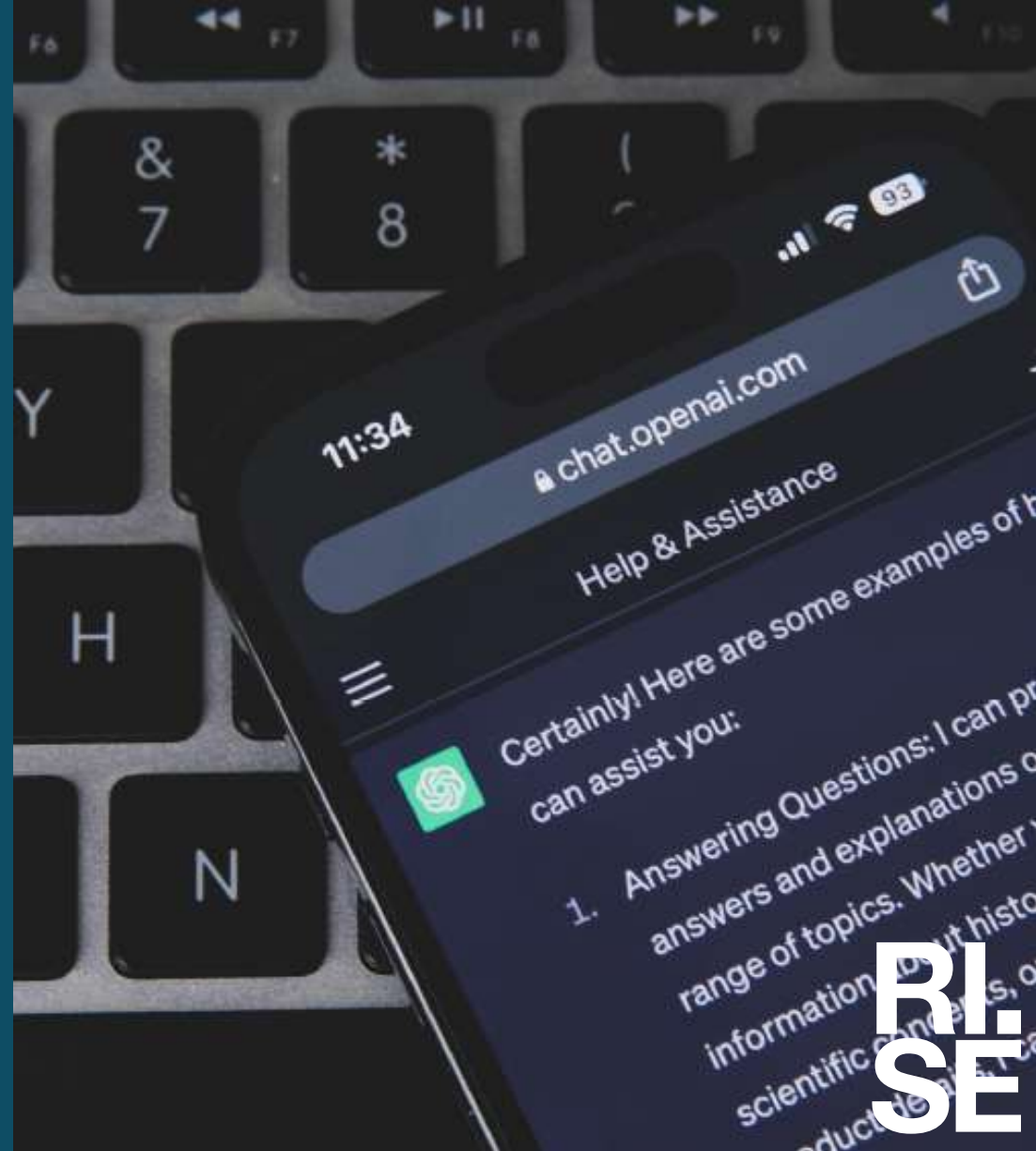
$$\text{ERE} = (1 - \text{ERF}) \times \text{PUE}$$



In addition of Direct Liquid Cooling there is approximately 1 MW of capacity for the air-cool servers (e.g. storage and management servers).

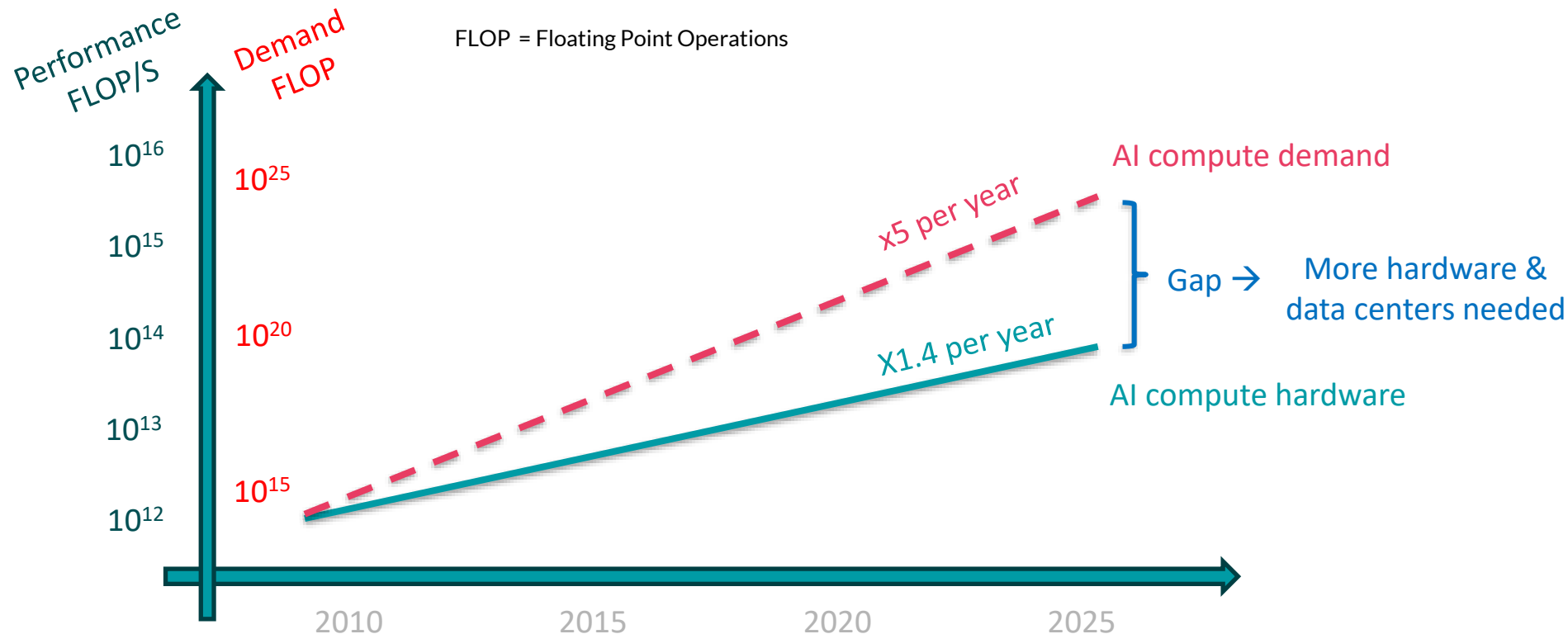
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Focussing on AI



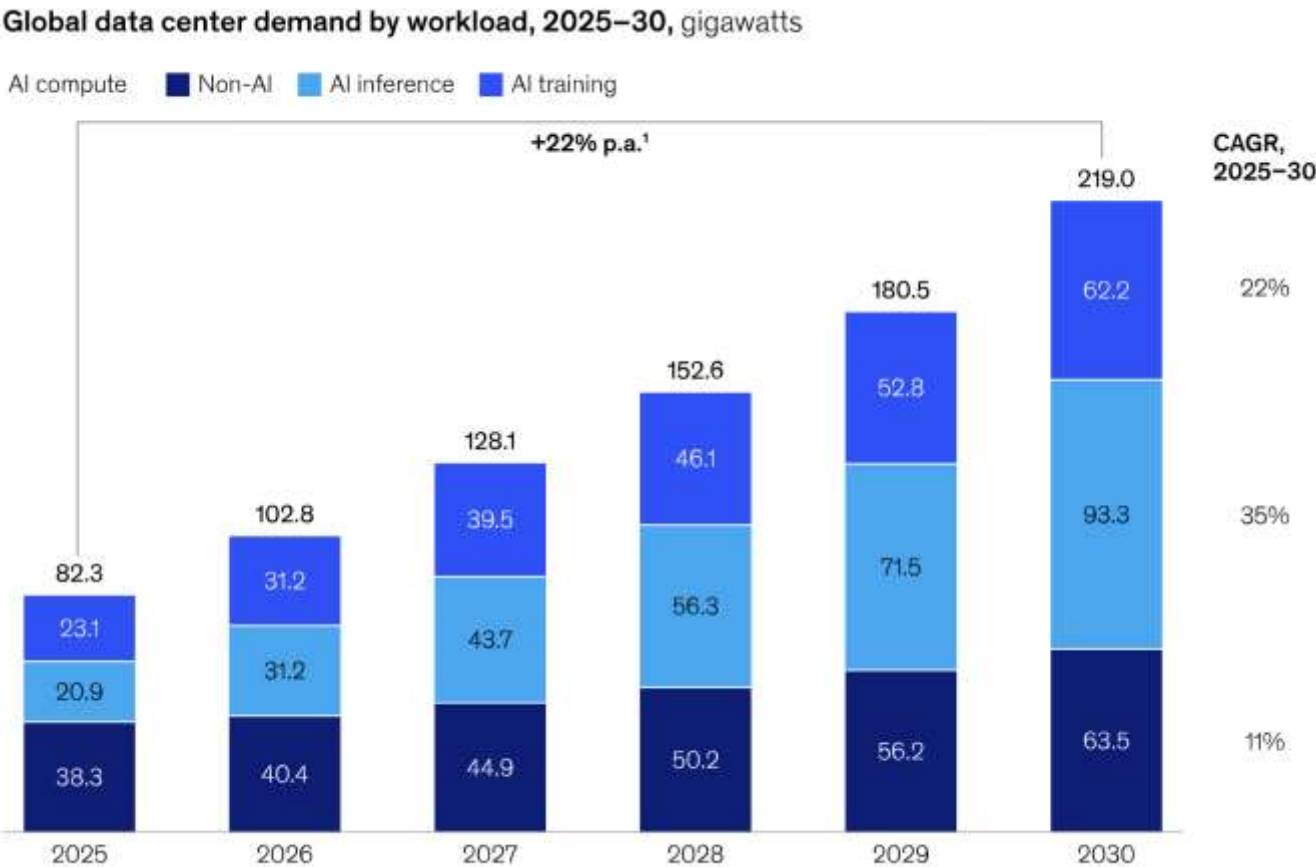
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AI compute demand & hardware capability



Message: The widening gap between AI compute demand and the pace of hardware performance improvements is a key driver behind rising energy use and the surge in data center investments.

Data center demand by application 2025

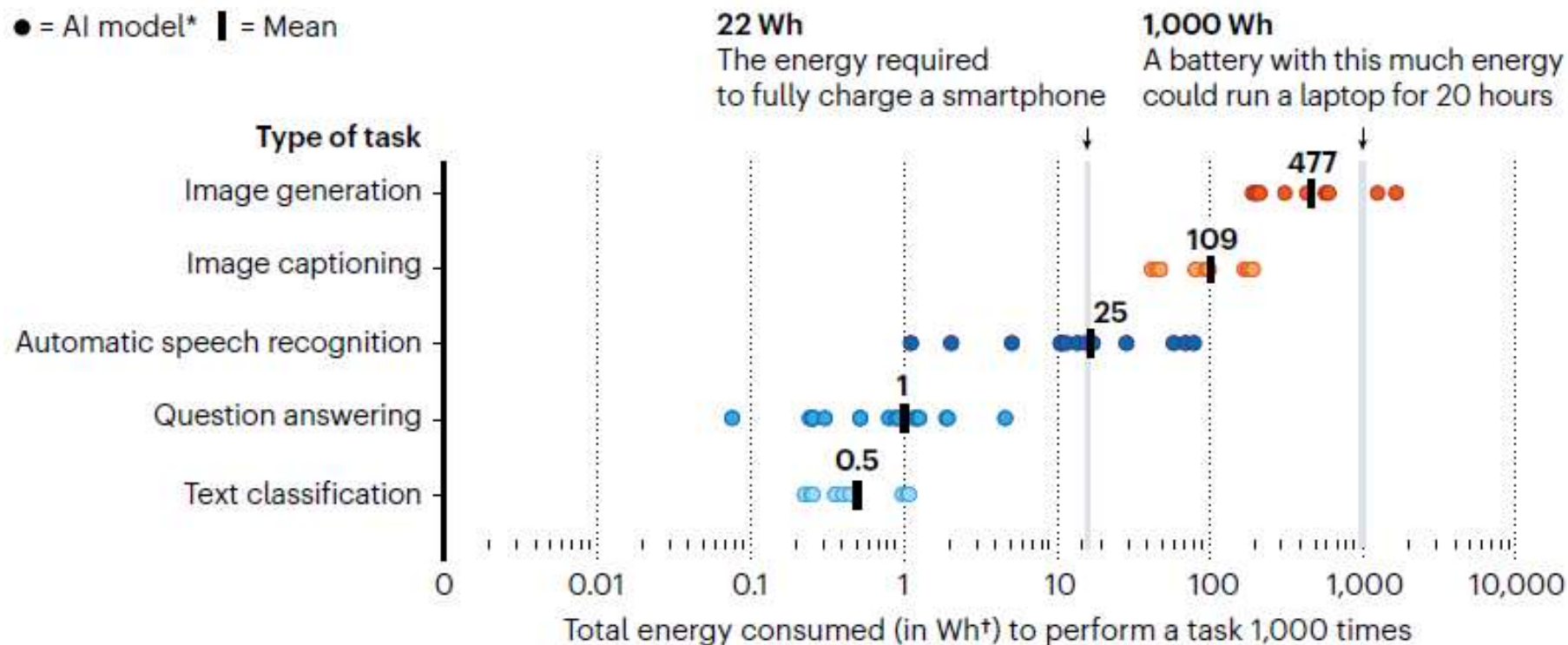


Source: McKinsey 2025



AI model inference energy requirements

● = AI model* | = Mean



*Tests conducted on 20 popular open-source models. Each dot represents one model; *1 Watt-hour represents power consumption of 1 W extended over 1 hour.

The Environmental Cost of AI is high on the agenda.



UNU-INWEH Report: Aczel, M., Chamanara, S., Matin, M., Farsi, A., Marwala, T., Madani, K. (2026). *Environmental Cost of AI's Energy Use: Carbon, Water and Land Footprints*. United Nations University Institute for Water, Environment and Health (UNU-INWEH), Richmond Hill, Ontario, Canada. doi: [10.53328/INR26RMA002](https://doi.org/10.53328/INR26RMA002)

The challenges with AI data centers.

Power density



Load variability



Energy storage



Power distribution



Heat density



Weight



Hitting five walls at the same time!

The **scaling wall**: pure lithography-enabled scaling is slowing down, and quantum effects begin interfering with the operation of microchips.

The **memory wall**: system performance is confronted with data path limitations between the cores and the memory.

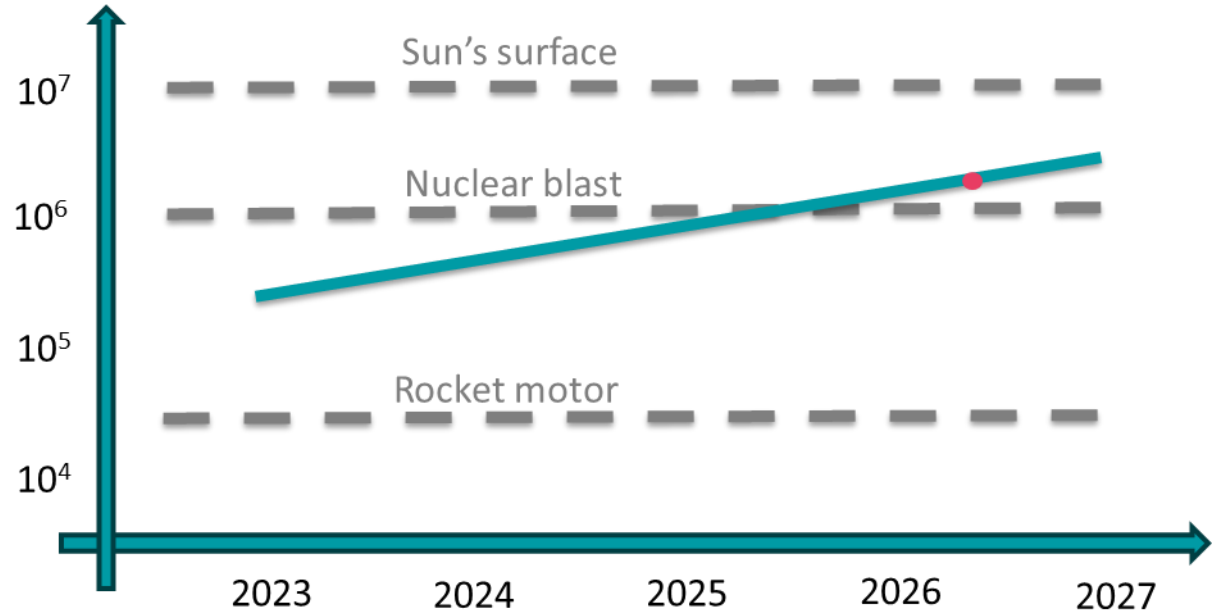
The **power wall**: it is becoming more challenging to bring power into the chip and extract heat from the chip package.

The **sustainability wall**: the manufacturing of semiconductor devices contributes to an increasing environmental footprint.

The **cost wall**: chip manufacturing costs may explode with the complexity increase, together with the costs for design and process development.

Challenges of thermal management

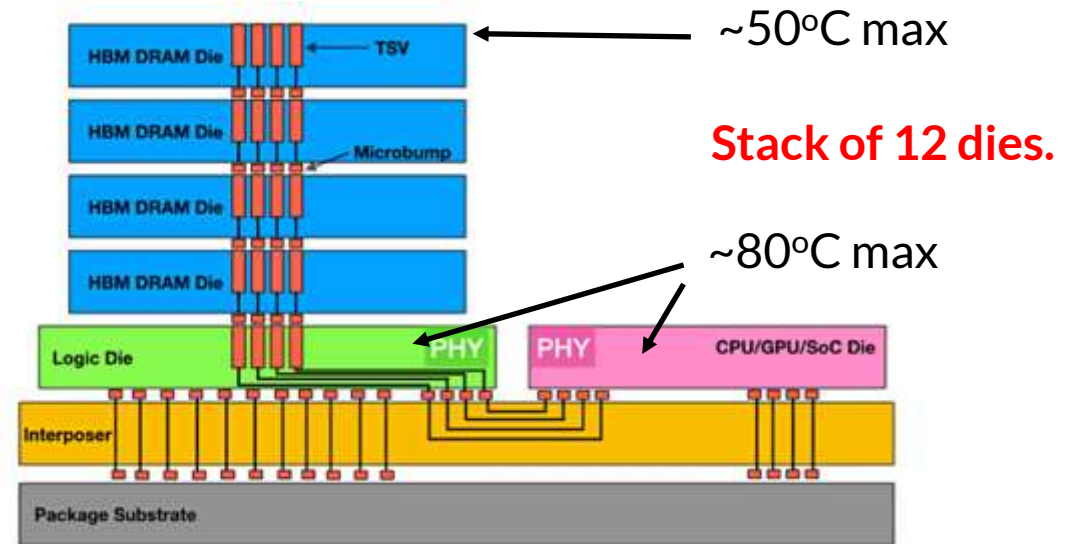
- **How to get the heat out?**
 - GPU die size of $\sim 800\text{mm}^2$
 - Thermal design power $\sim 1800\text{W}$
 - Heat flux = $2,25\text{MW/m}^2$



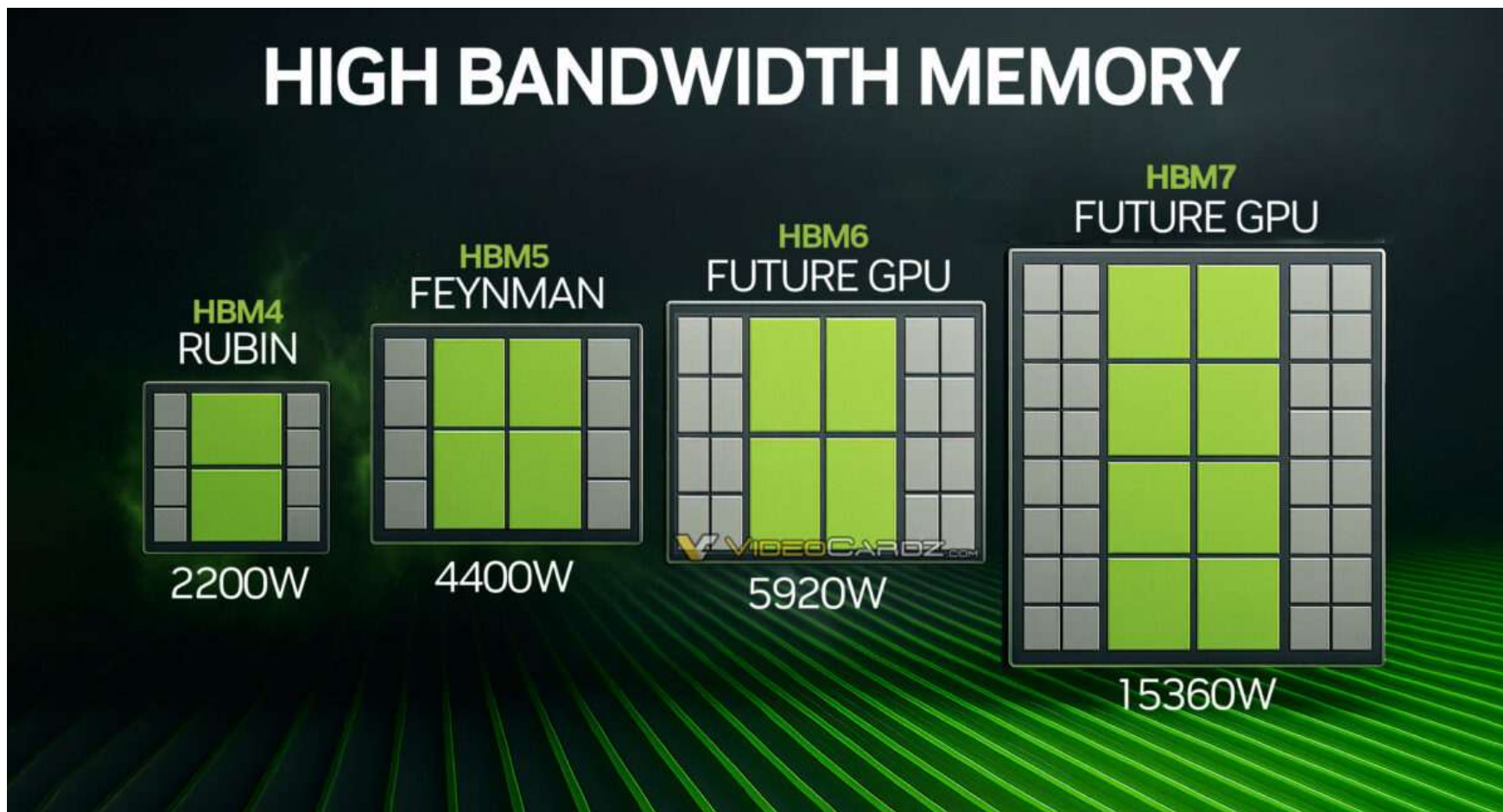
Message: Increasing transistor density in next-generation microprocessors leads to extreme heat flux levels, potentially exceeding those found at the edge of a nuclear blast, and thus posing significant challenges for cooling and thermal management.

Further challenges

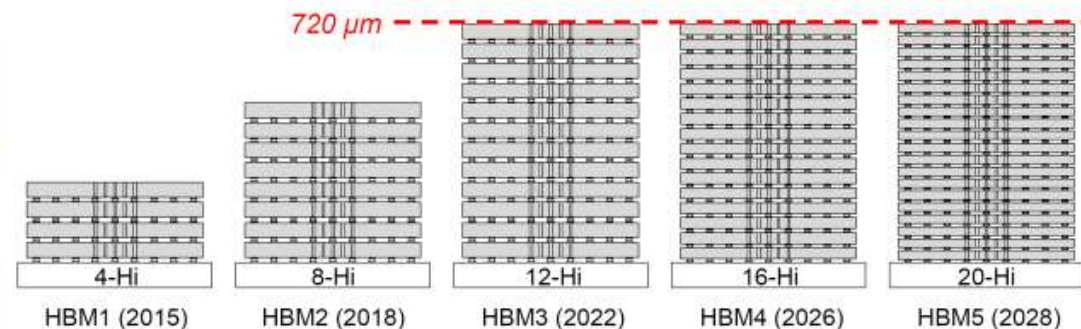
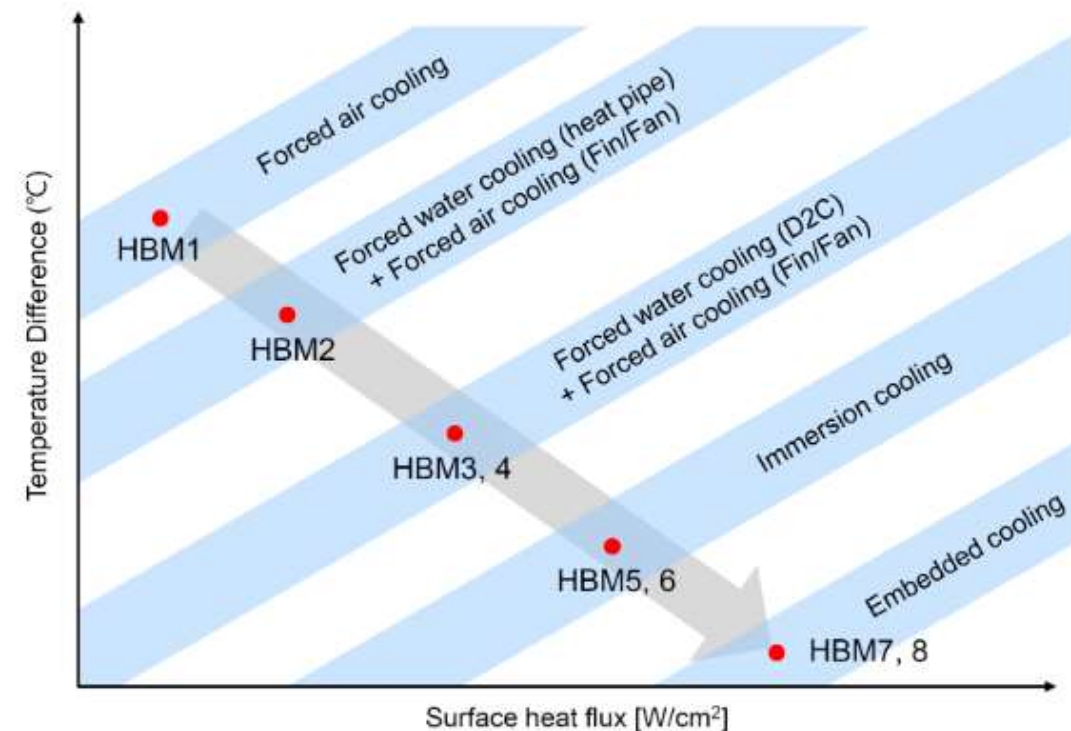
- Stacked High Bandwidth Memory!
- Several layers of silicon stacked on top of each other.
- Heat needs to be conducted through the stacked layers.
- Silicon top layer must be much colder.



Development of power for Nvidia GPUs

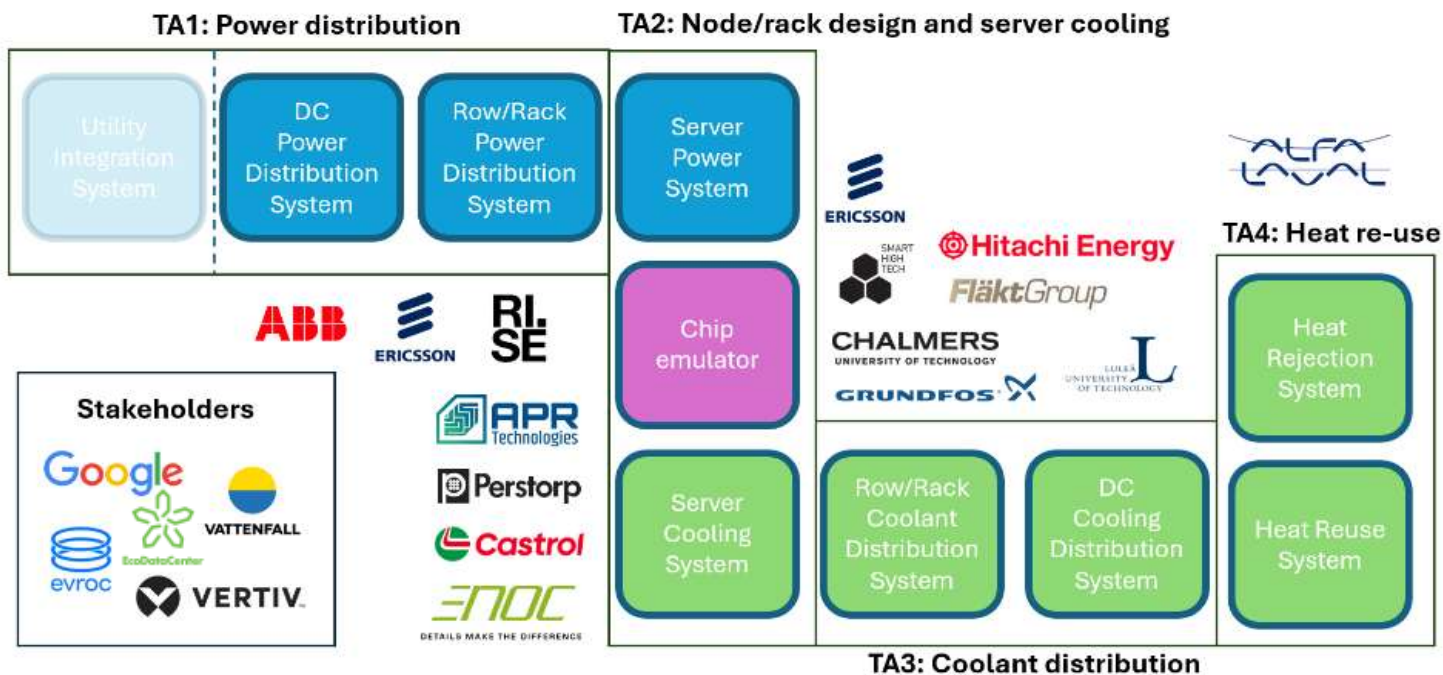


Roadmap of HBM specifications



< Thermal Management & Cooling Methods for Next-Generation HBM >

The H-DINI project – The European 1 MW “rack”



Goals

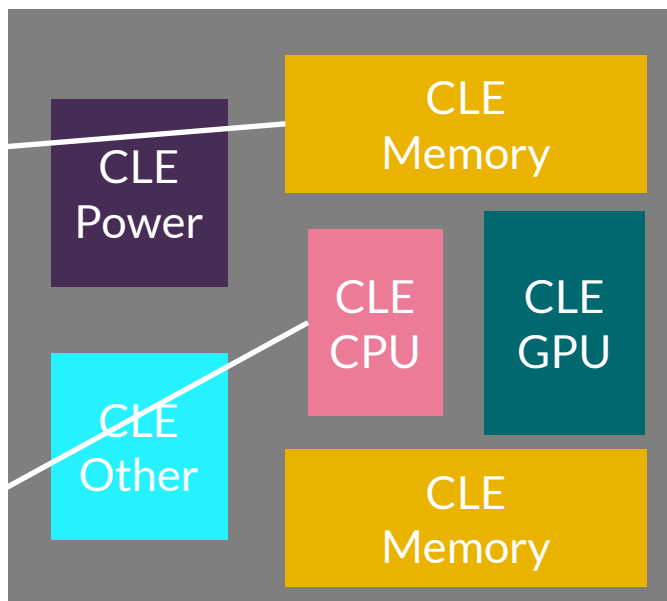
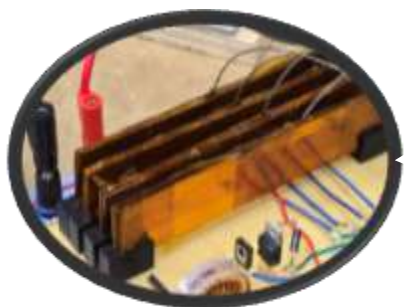
- *The project goal is to develop technologies and systems for power-dense AI compute with efficient power delivery and thermal performance.*
- *Demonstrate system solutions for selected technology areas*
- *Total budget €6M*

Funded with help from

VINNOVA

RISE

Emulators – A tool for R&D and commissioning

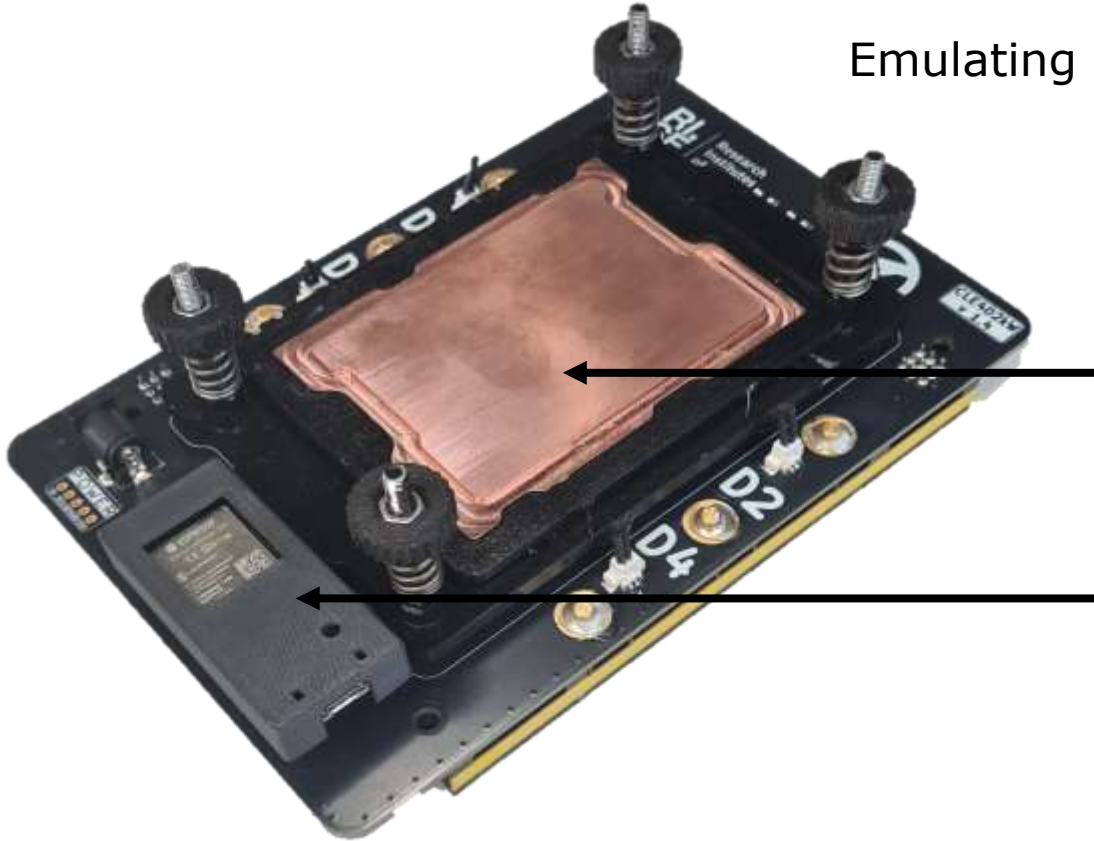


- Look like a chip, server or rack
- Accurately emulating real chip
- High power density
- Compatible with different cooling technologies
- Modular server design
- Can meet future standards

A server emulator consists of one or more CLE, Chip Load Emulators

RISE Chip Load Emulator single unit

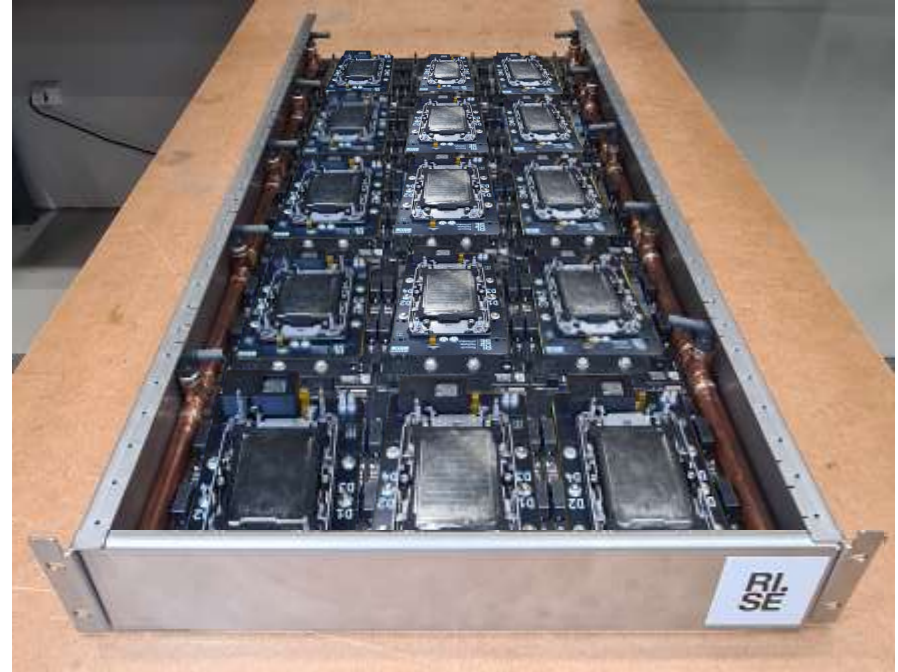
Emulating LGA4677-1 Sapphire Rapids form factor



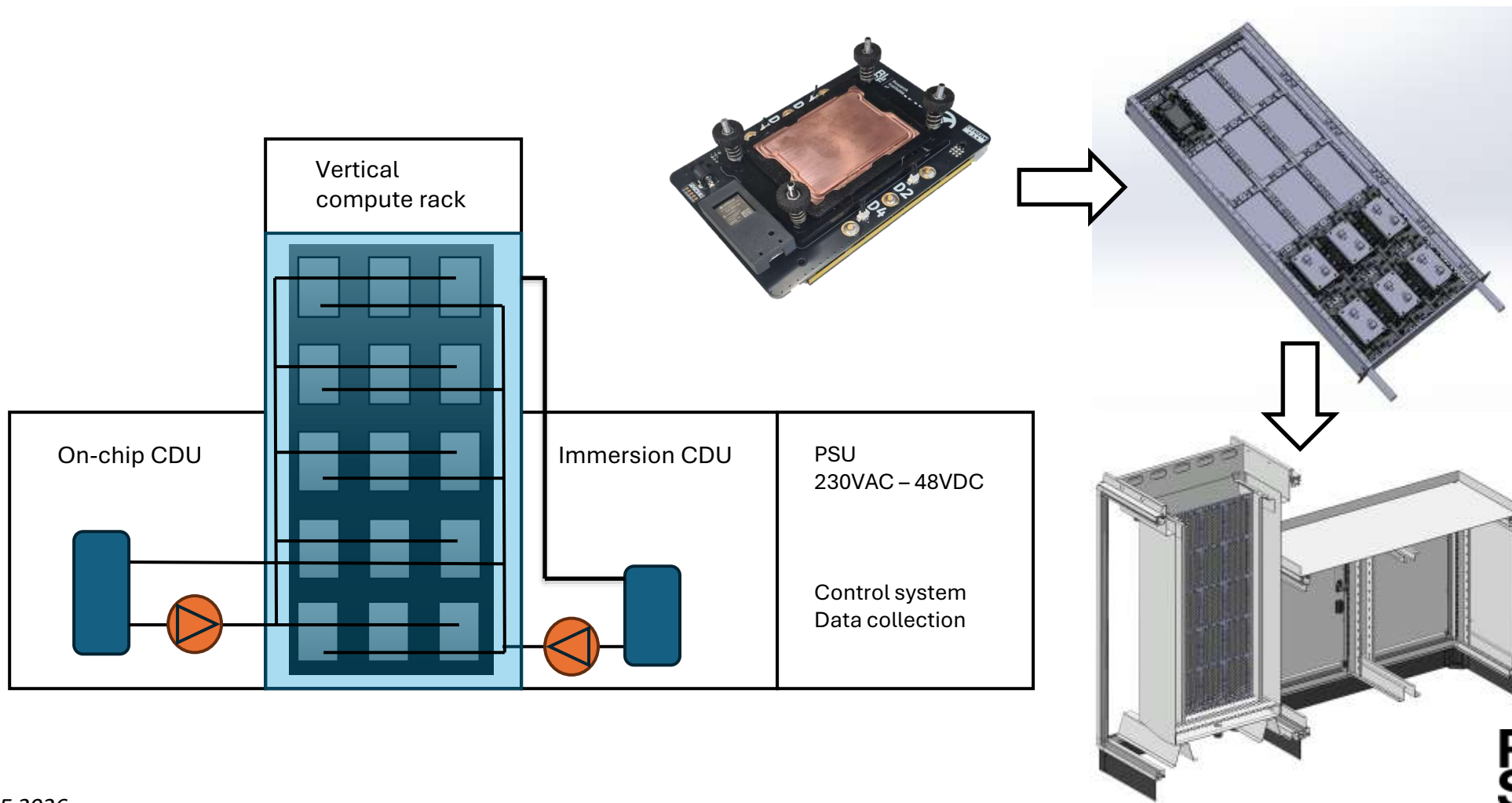
- Power (0-2000W)
- Temperature (0-100°C)
- Integrated control
- Built in safety features

RISE Server Emulator single unit

- Power (0-30kW)
- Temperature (0-100°C)
- Individual load profile control
- Built in safety features



Test-rig for Hybrid on-chip/immersion cooling – POC 1

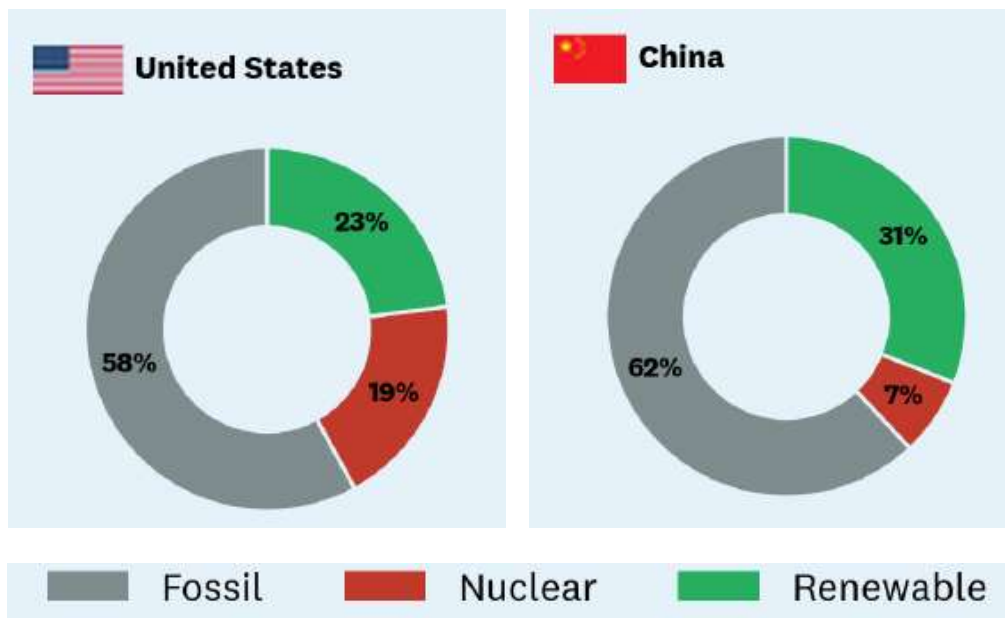


**Focussing
on the
Nordic
potential.**



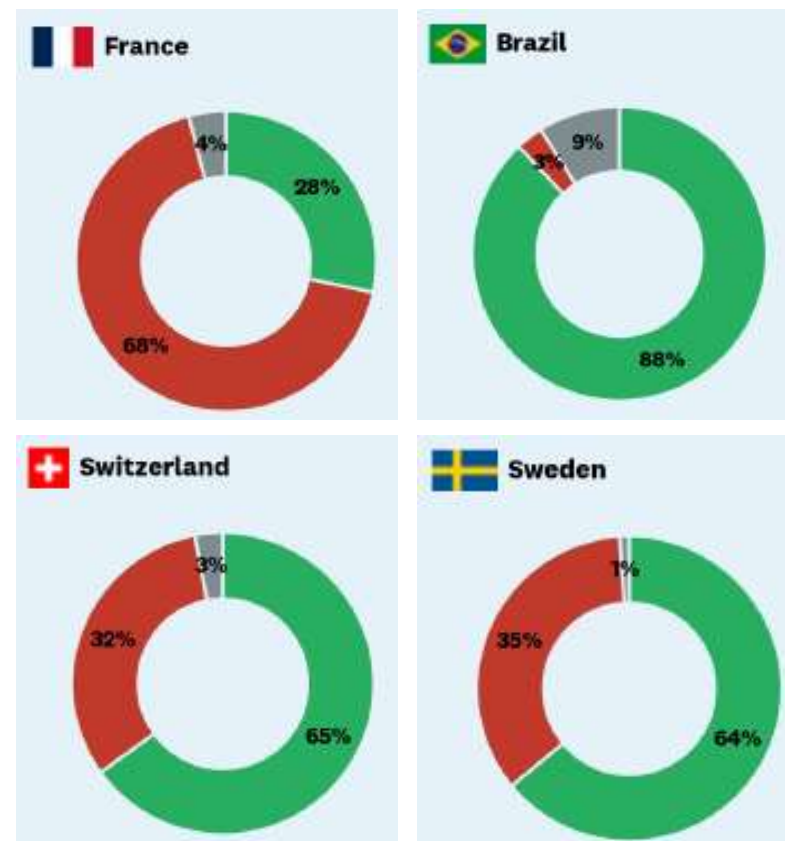
Where is the power for AI coming from.

90% of AI specialized compute in 2 countries.



Source: Electricity supply mixes in major data center host locations.

Aczel M., Chamanara S., Matin M., Farsi A., Marwala T., Madani K. (2026) Environmental Cost of AI's Energy Use: Carbon, Water and Land Footprints, United Nations University Institute for Water, Environment and Health (UNU-INWEH), Richmond Hill, Ontario, Canada, doi: 10.53328/INR26RMA002



Of the top 20 data center hubs, 4 countries have less than 10% of fossil fuel in their grid.

Headroom for AI data centers – physical and society.

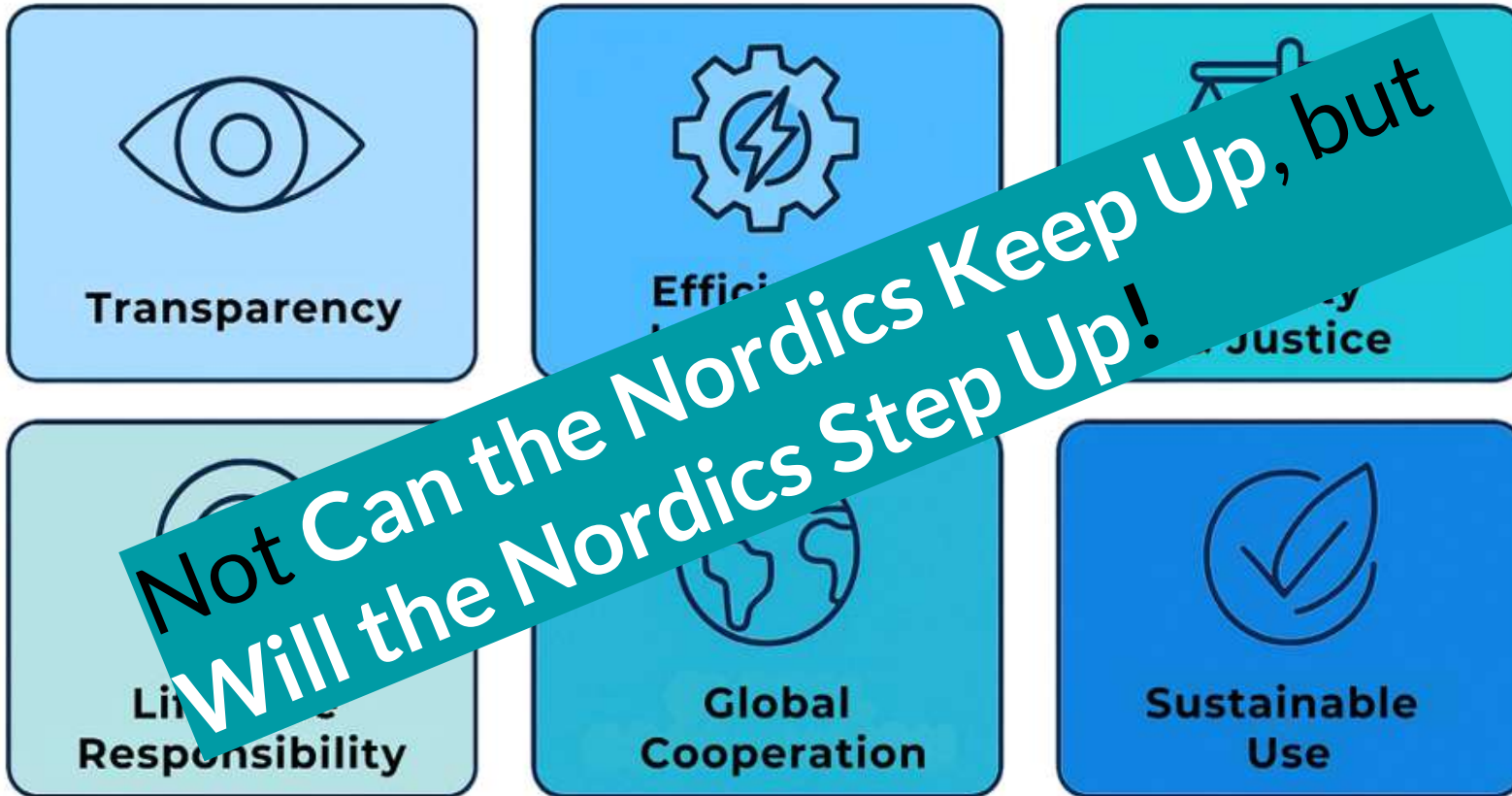
Table 3.
Top Data Center Consumption Levels (% of Grid)

Country	Global Energy Report (2026)	% of Grid
 Ireland	The Infrastructure Paradigm Shift: From Reversible to Irreversible Decisions By Mehdi Paryavi, Roger Strukhoff, Mark Thiele, Robert Cavey Chairman & CEO, Chief Research Officer, Entrepreneurship Counsel, Global Head of Strategic Relations    	21.0%
 Singapore		19.5%
 Lithuania		11.1%
 Netherlands		8.7%
 Denmark		8.4%
 Estonia		6.9%
 Luxembourg		6.3%
 Germany		6.1%
 Hong Kong		6.0%
 United States		6.0%

Current data center demand of electrical grid in:

Sweden is at around **2.4%**, **Finland** is at around **1.8%**, and **Norway** is at around **1%**.

Principles for a Responsible AI Ecosystem



Source: Electricity supply mixes in major data center host locations.

Aczel M., Chamanara S., Matin M., Farsi A., Marwala T., Madani K. (2026) Environmental Cost of AI's Energy Use: Carbon, Water and Land Footprints, United Nations University Institute for Water, Environment and Health (UNU-INWEH), Richmond Hill, Ontario, Canada, doi: 10.53328/INR26RMA002

Thanks for listening.

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