100% Warm-Water Cooling with CoolMUC-3

No chillers, no fans, no problems…

Axel Auweter – MEGWARE CTO

Workshop on Energy Efficiency in HPC

May 30, 2018, Ljubljana

MEGWARE Computer Vertrieb und Service GmbH

Company Overview

- Provider of turn-key solutions for compute, storage, and accelerator clusters
- More than 1,200 HPC deployments since 1990
- ~50 employees
- Strong focus on R&D
- More than 8 years experience in liquid cooling technologies for energy efficiency!

A Joint Vision...

... for Green Data Centers of the Future

- Chiller-Free
- Maximum Heat Reuse
- 100% Liquid Cooled

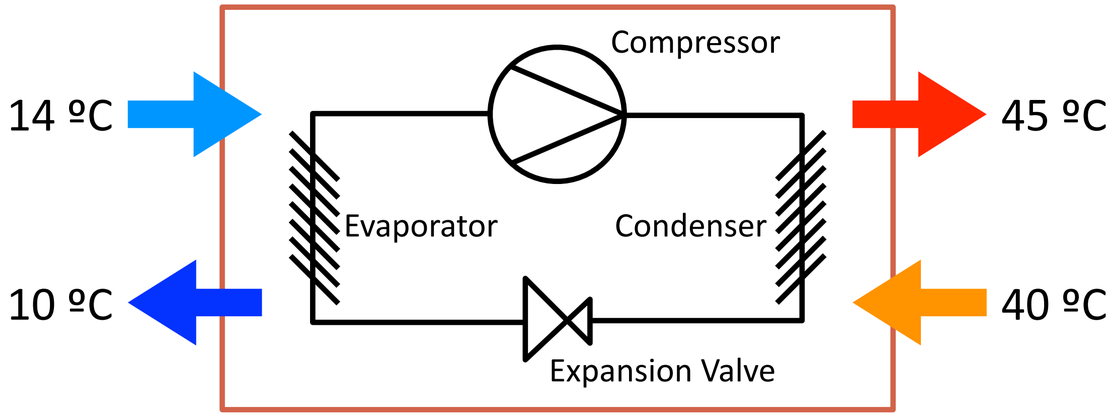
Technology Partners

Early Adopters

Chiller-Free Cooling

… for improved energy efficiency ratio (EER)

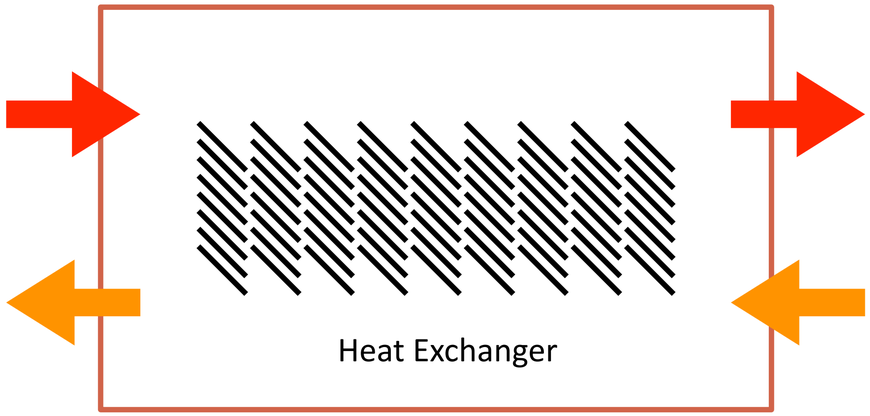
Vapor-Compression Refrigeration



Data Center — Outside Air

EER: ~5

Chiller-Free Cooling



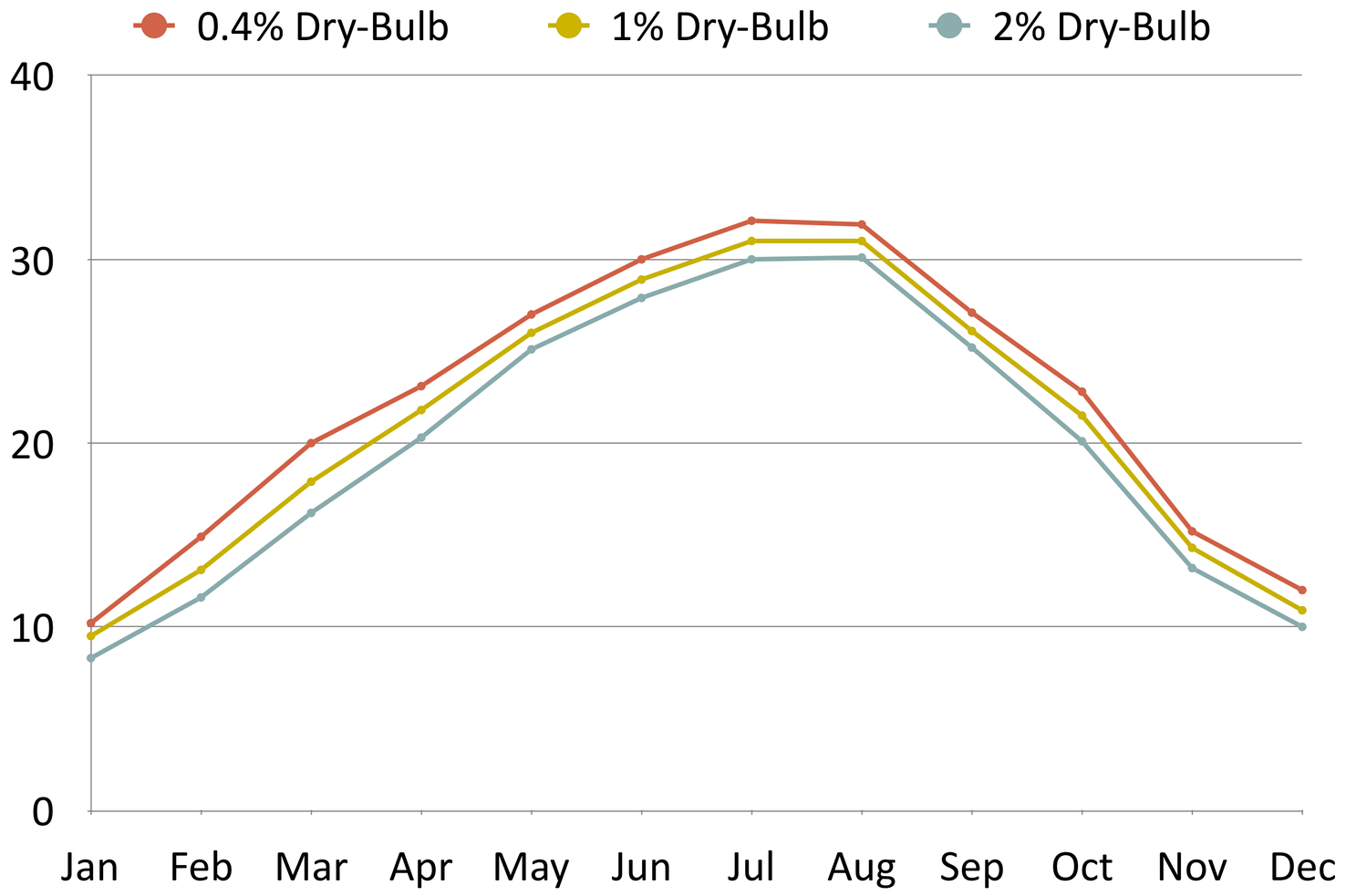
Data Center — Outside Air

EER: ~20

Temperature Design Point Charts

Ljubljana, Slovenia

- ASHRAE specifies design points for cooling equipment
- Use of percentiles: specified value is reached or exceeded for a total of 3 hours (0.4%), 7 hours (1%), or 14 hours (2%)



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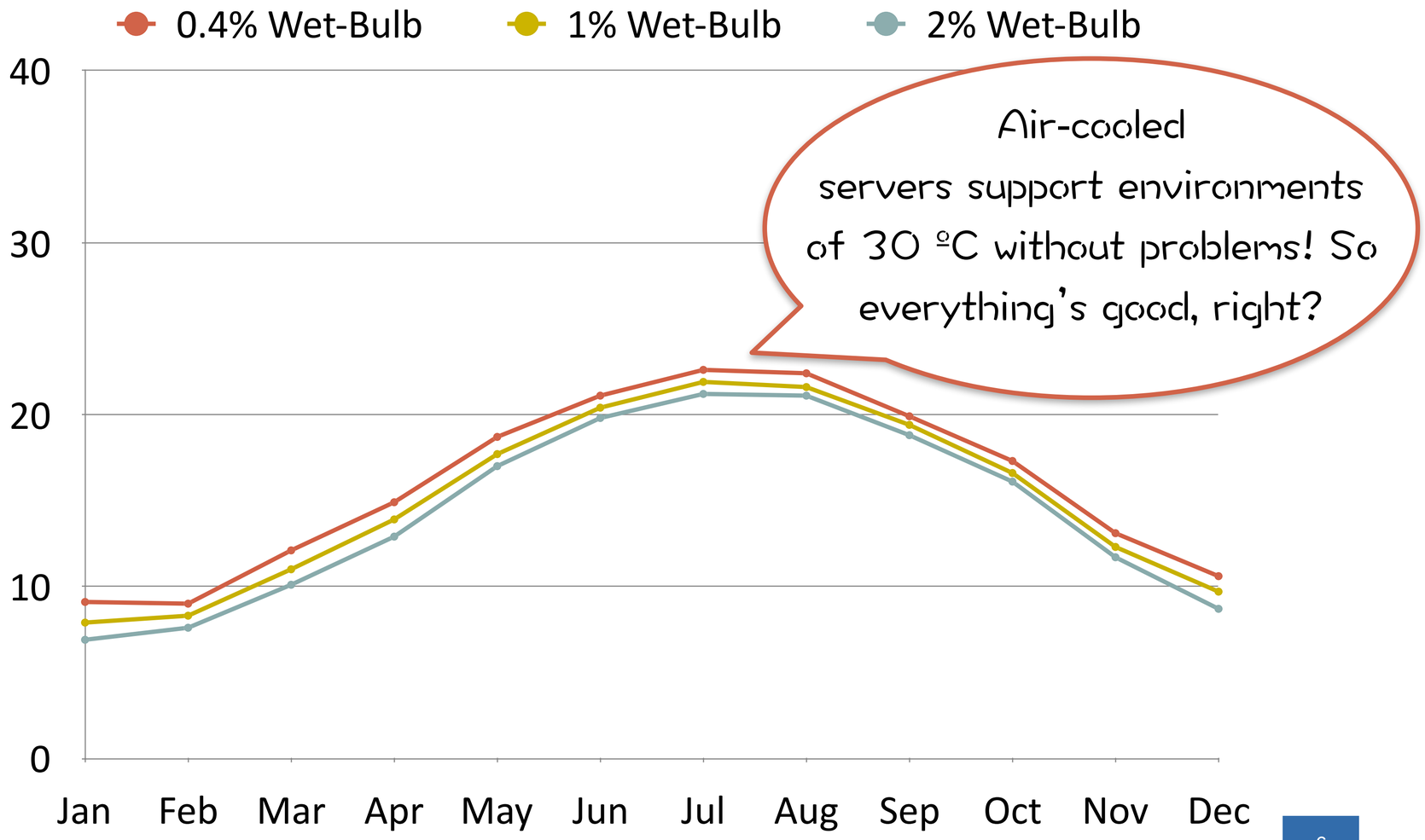


Transferring Heat

… in theory and practice!

Thermal Conductivity depends on:

- ΔT between heat source and sink
- Geometry (transfer surface A & distance d)
- Material

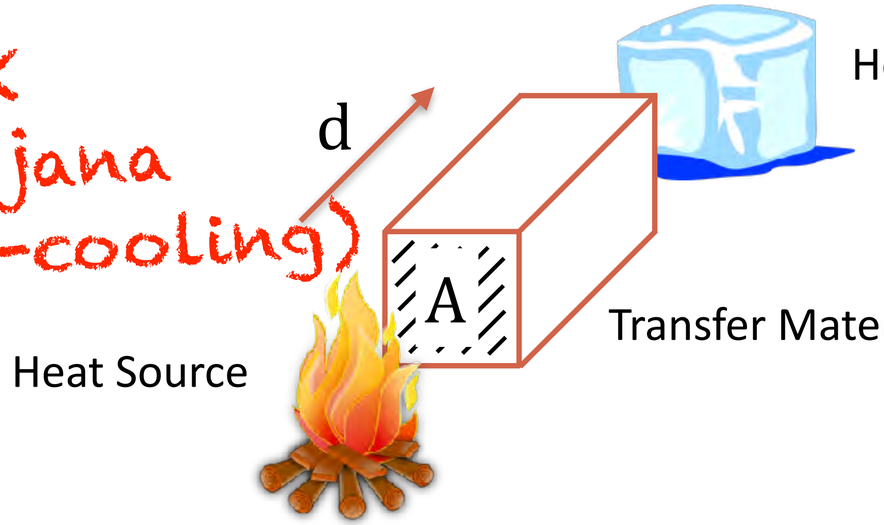
max. 7 K in Ljubljana (for air-cooling)

Air (0.0026 W/mK)

Water (0.598 W/mK)

Copper (401 W/mK)

Aluminum (237 W/mK)

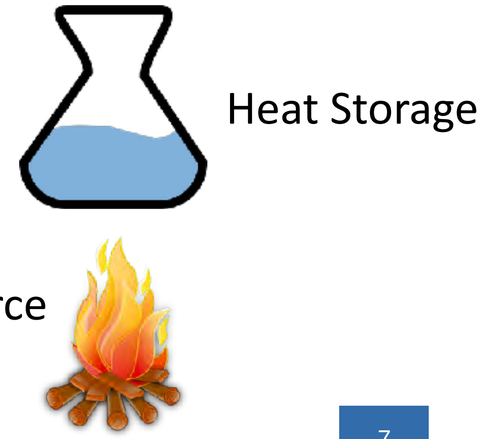


Thermal Capacity depends on:

- Mass
- Material

Air (1.005 J/kgK) = 1.2 kJ/m³K

Water (4.128 J/kgK) = 4178 kJ/m³K



Waste Heat Reuse

… you've already paid for the power - use it!

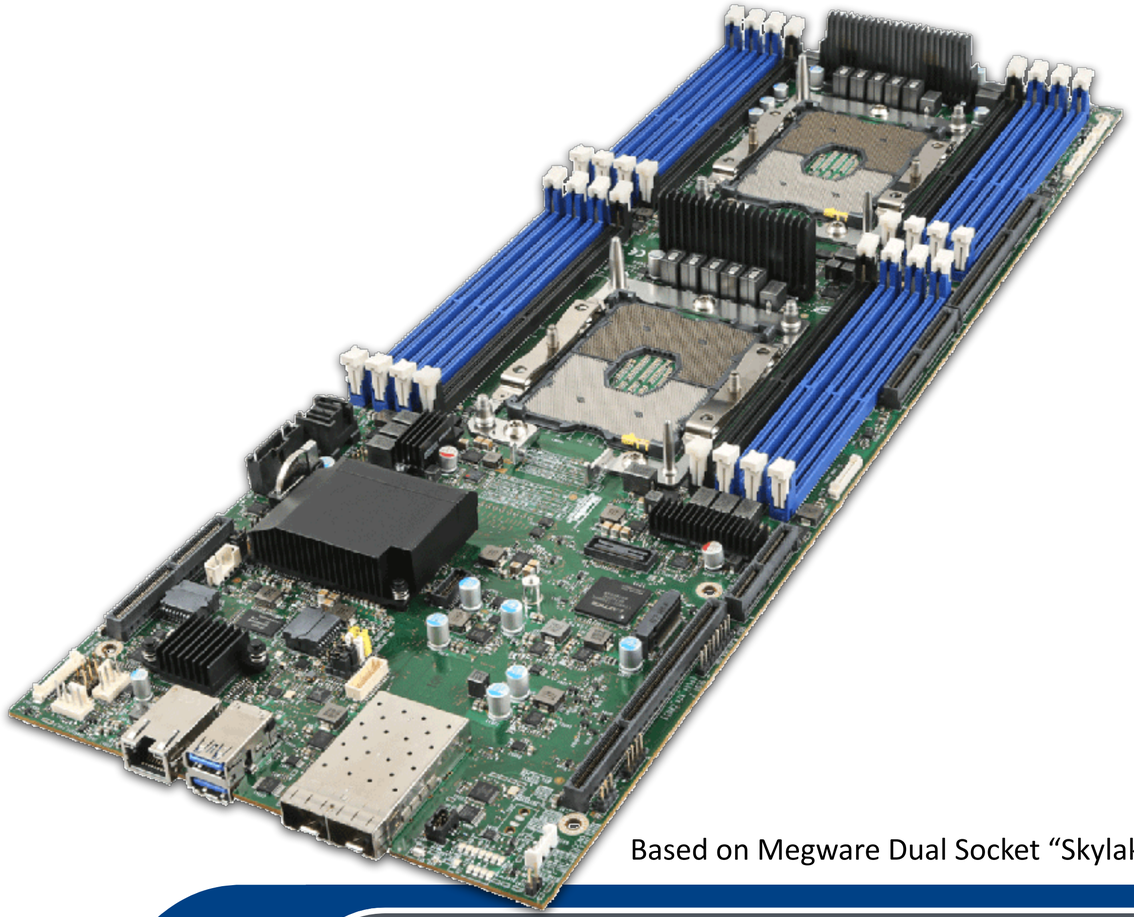
- Going to water-cooling significantly facilitates waste-heat reuse
- Higher temperatures enable more options

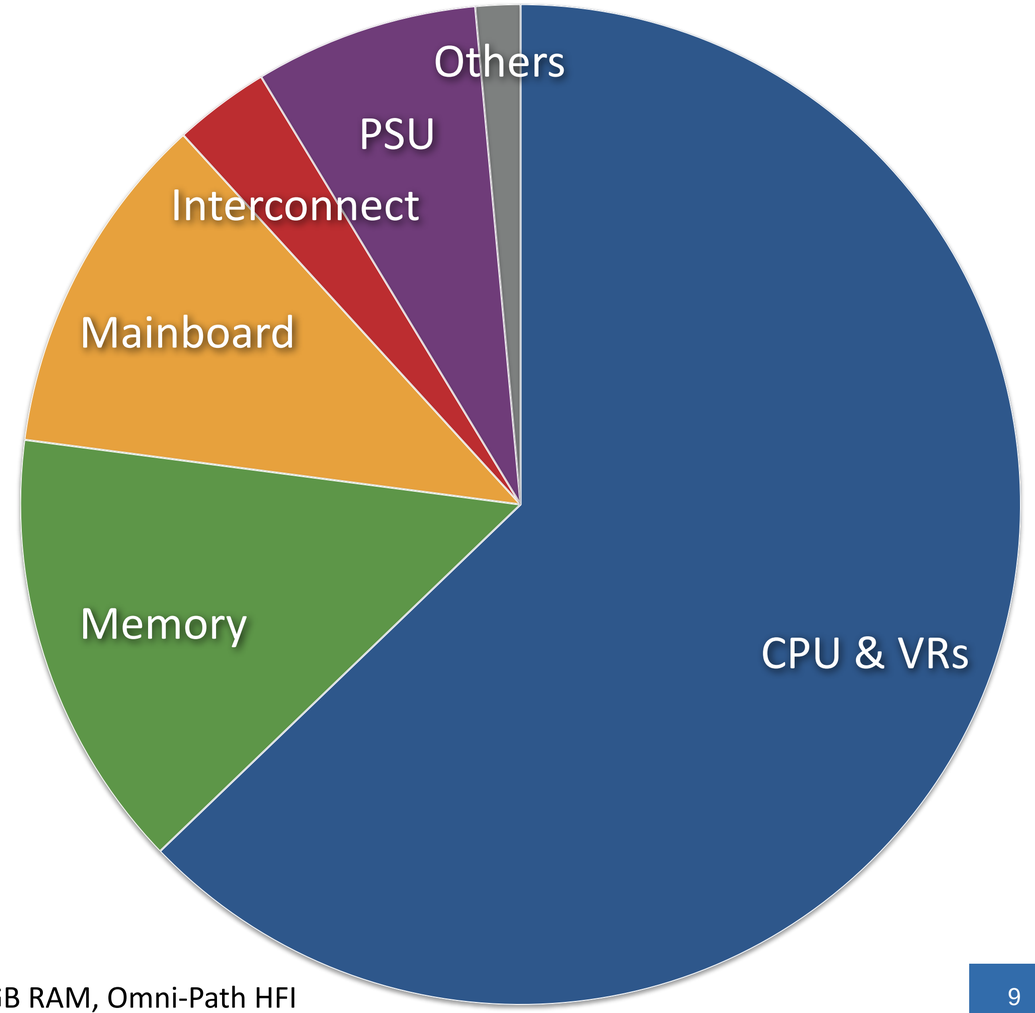
District Heating	> 70 ºC
Household Radiator	60 ºC
Underfloor Heating	35 ºC
Absorption Chiller	> 70 ºC
Adsorption Chiller	> 50 ºC

MEGWARE CooLMUC Supercomputer (2012) with SorTech ACS08 adsorption chiller.
Photo courtesy of Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities.

Power Break Down of a Typical Compute Node

… according to component max TDPs





Based on Megware Dual Socket “Skylake” 6140, 192GB RAM, Omni-Path HFI

Evolution of MEGWARE ColdCon®

Direct Liquid Cooling since 2011

ColdCon® 2011

Liquid cooling for
- CPUs
- VRs

Max inlet temp: 40°C

ColdCon® 2013

Liquid cooling for
- CPUs
- VRs
- DIMMs

Max inlet temp: 40°C

ColdCon® 2015

Liquid cooling for
- CPUs
- VRs
- DIMMs
- I/O

Max inlet temp: 50°C

ColdCon® 2017

Liquid cooling for
- CPUs, VRs
- DIMMs
- I/O
- Power supplies
- Network Switches

100% Liquid Cooled

Max inlet temp: 55°C

MEGWARE SlideSX-LC

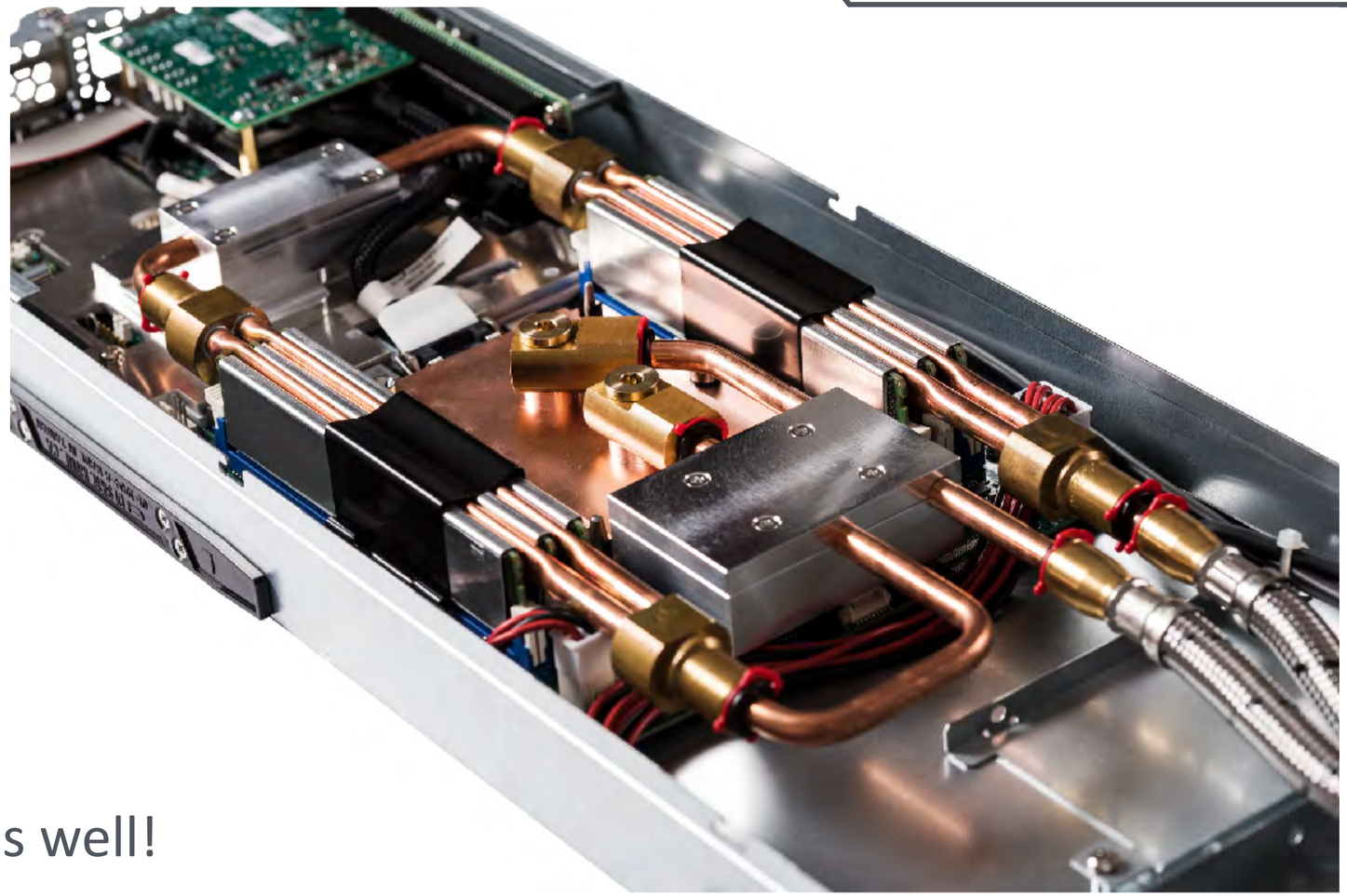
Fully integrated chassis solution for direct liquid cooling!

- **Up to 10 nodes with your choice of**
  - Intel® Xeon® Scalable
  - Intel® Xeon® Phi™ x200
  - Intel® Xeon® E5 v4
- **High performance network**
  - Intel® Omni-Path Fabric
  - IB FDR, EDR
- **Integrated chassis management**
- **Hot pluggable, easy maintenance**

MEGWARE ColdCon®

… for Compute Nodes

- **High Performance Heat Sink**
  - e.g. CPUs
- **Direct Attach Copper**
  - e.g. DIMM Cooling
- **Cold Plate**
  - e.g. NICs
- **Passive Cooling**
  - Your mainboard conducts heat as well!



MEGWARE ColdCon®

… for Power Supply Units

- 1620W per PSU
- Up to 5 PSUs per SlideSX Chassis
- 80 Plus Platinum Certified
- Liquid Cooling with hot-plug support

MEGWARE ColdCon®

… for Omni-Path High Performance Network Switches

- Refit of Intel® OPA switch 48-port for ColdCon® direct liquid cooling

- 12V DC power supply via MEGWARE liquid cooled power bank

The New ColdCon® in Action

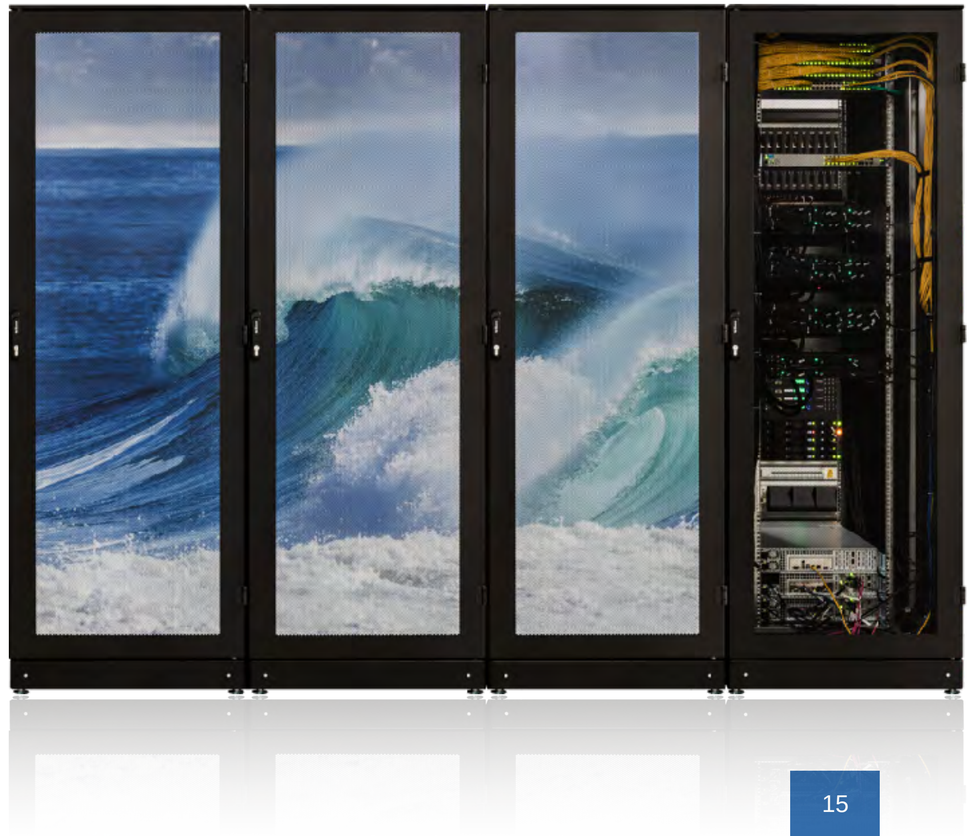
CooLMUC-3 Supercomputer @ Leibniz Supercomputing Centre

- 15 MEGWARE SlideSX-LC® chassis
- 148 compute nodes with Intel® Xeon® Phi™ Processor 7210F
- Dual 100 GBps links to Intel® Omni-Path fabric

- MEGWARE ColdCon® for power supplies
- MEGWARE ColdCon® for Intel® OPA switch
- MEGWARE EnergyMeter for high-frequency power and energy measurements & Intel® NodeManager integration

- Thermal insulation for racks
- Less than 3% heat loss to computer room air

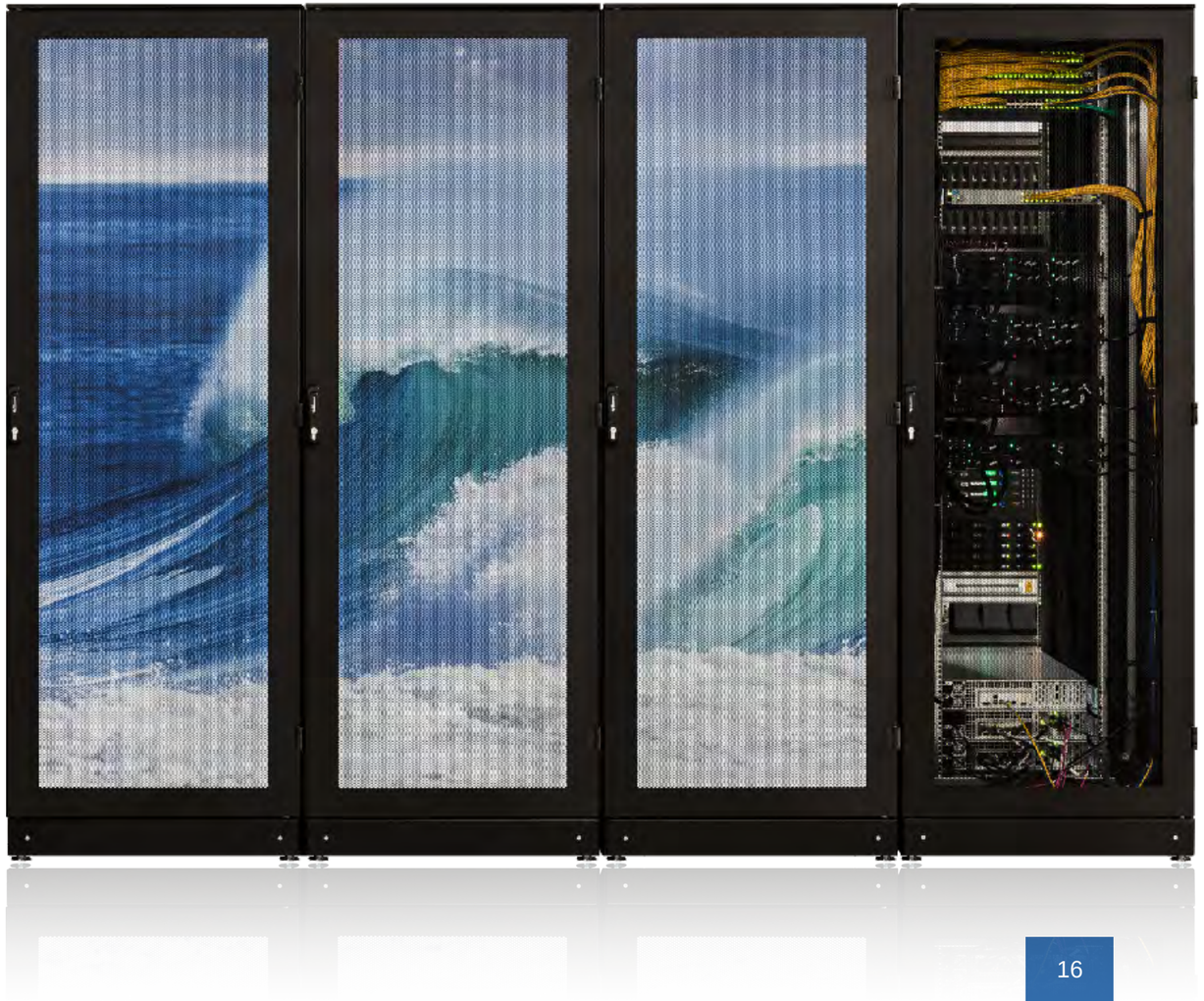
Leibniz Supercomputing Centre
of the Bavarian Academy of Sciences and Humanities



100% Warm-Water Cooling

… why you need it, too…!

- Year-round chiller-less cooling for the entire system
- High outlet temperatures for optimal heat-reuse
- Insulated racks for close to zero heat emission to room air
- Additional power savings due to removal of fans



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Thank you!