



GreenCube.pptx

The Green Cube Datacenter

Economy meets ecology

Prof. Dr. Volker Lindenstruth
FIAS, IfI, LOEWE Professur
Chair of HPC Architecture
University Frankfurt, Germany
GSI Helmholtzcenter
Phone: +49 69 798 44101
Fax: +49 69 798 44109
Email: voli@compeng.de
WWW: www.compeng.de

Heat Transmission via Air and Water

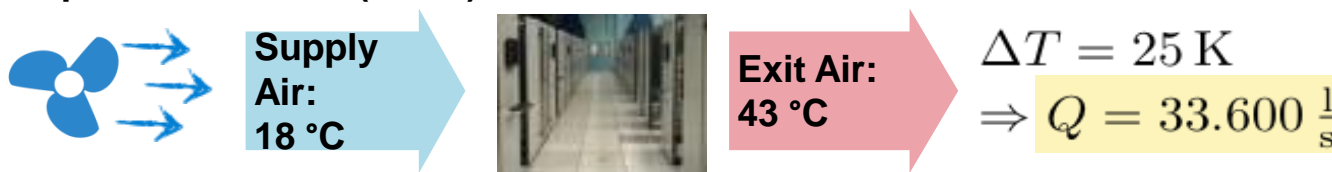
Required Volumetric Current: $Q = \dot{V} = \frac{P}{c_p \cdot \rho \cdot \Delta T}$ P : Thermal Power Loss
 ΔT : Temperature Difference

Air Specific Heat Capacity: $c_p = 1,005 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$ Density: $\rho = 1,184 \frac{\text{kg}}{\text{m}^3}$ (Standard Conditions)

Example: Notebook-Computer (30 W)



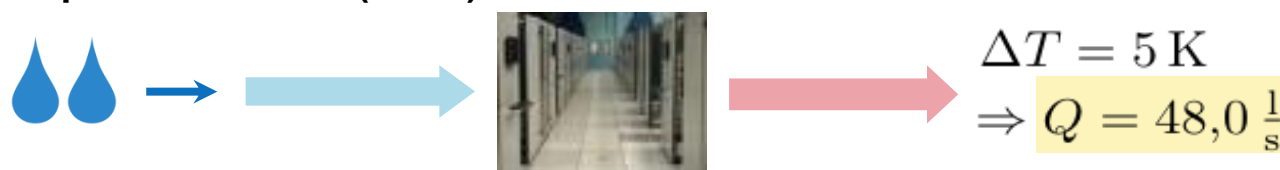
Example: Data Center (1 MW)

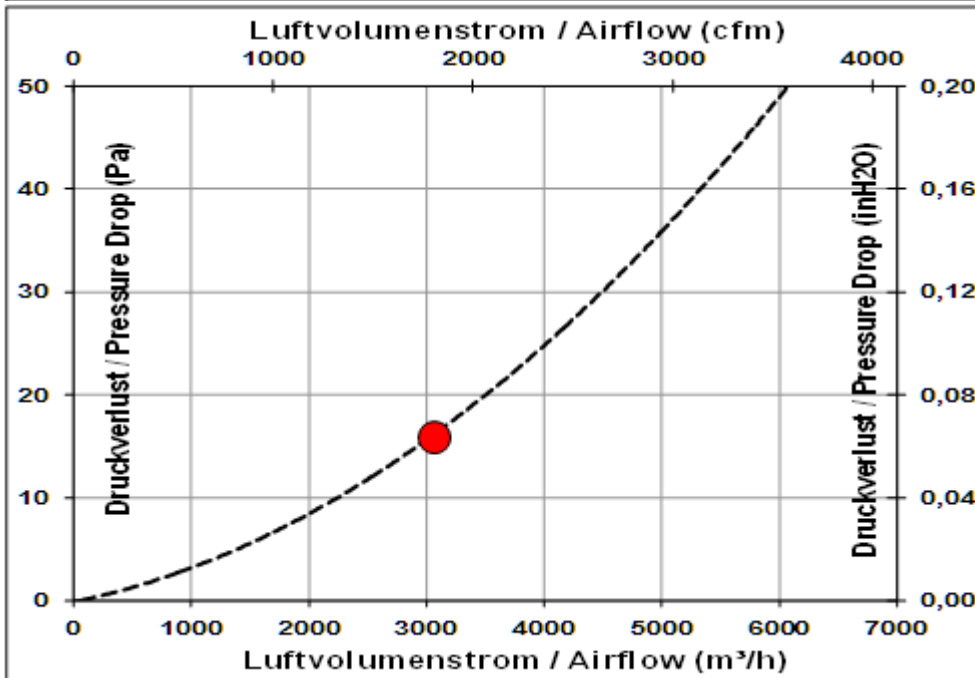
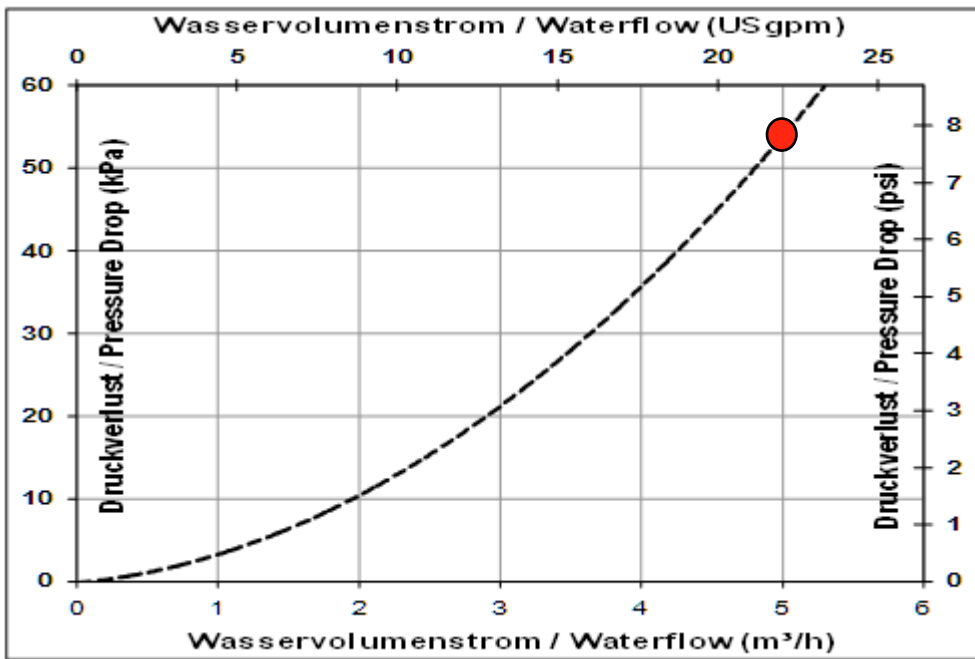


BEAUFORT FORCE 12
 WIND SPEED: 64 KNOTS
 SEA: SEA COMPLETELY WHITE WITH DRIVING SPRAY,
 VISIBILITY VERY SERIOUSLY AFFECTED. THE
 AIR IS FILLED WITH FOAM AND SPRAY

Water Specific Heat Capacity: $c_p = 4,183 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$ Density: $\rho = 997,0 \frac{\text{kg}}{\text{m}^3}$ (Standard Conditions)

Example: Data Center (1 MW)



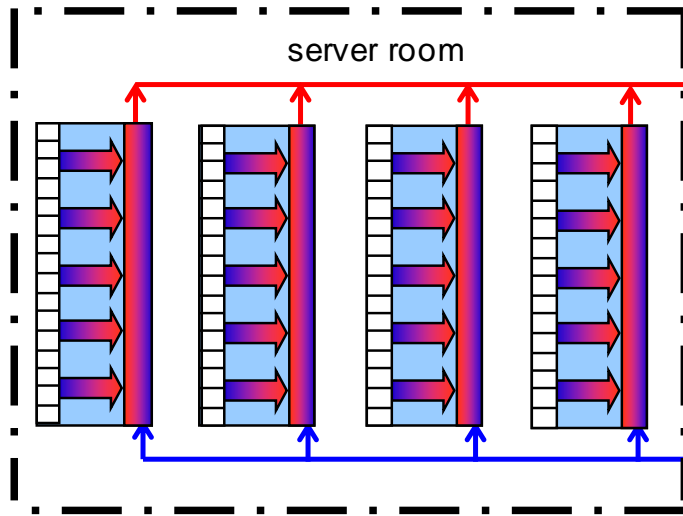


70+ kW/rack

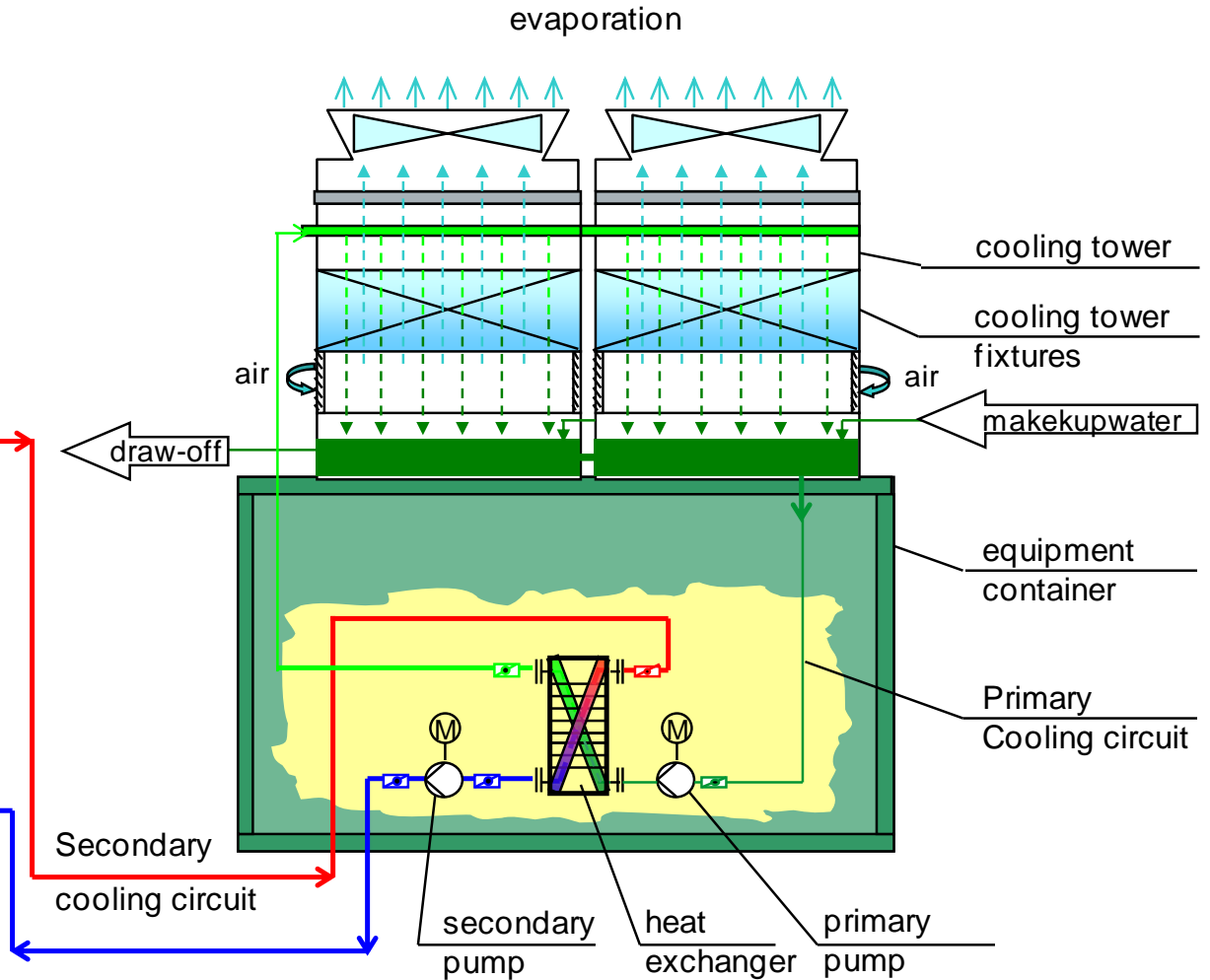
Innovative Cooling Architecture

Cooling Overhead
5% of computer power

data center building



Works with every
commercial computer

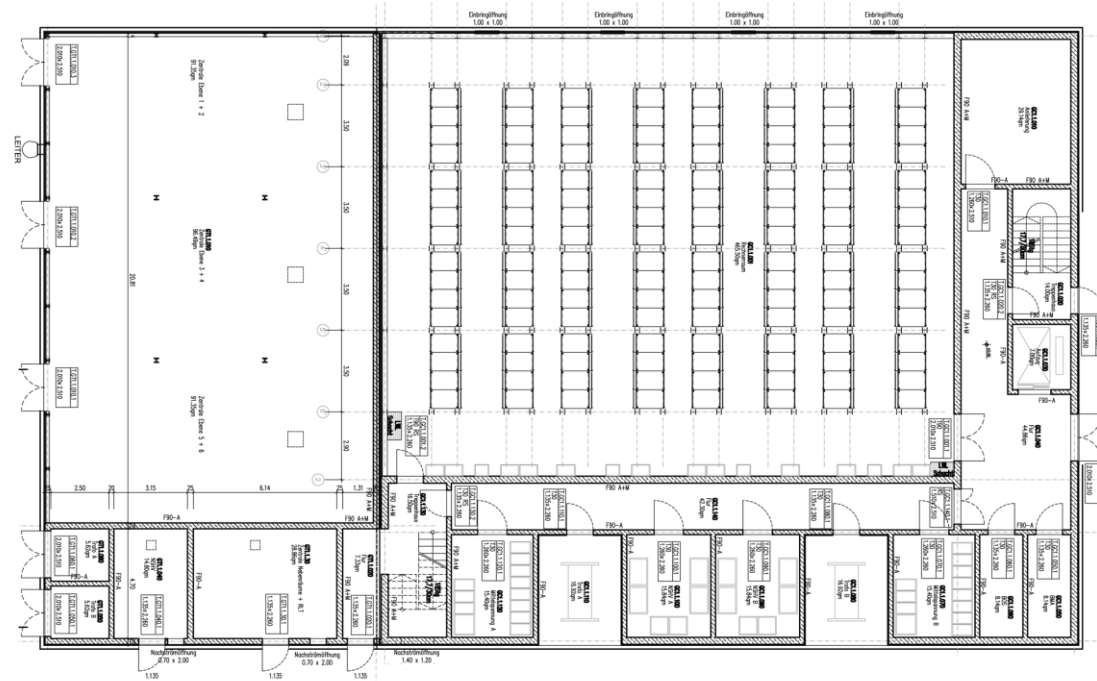






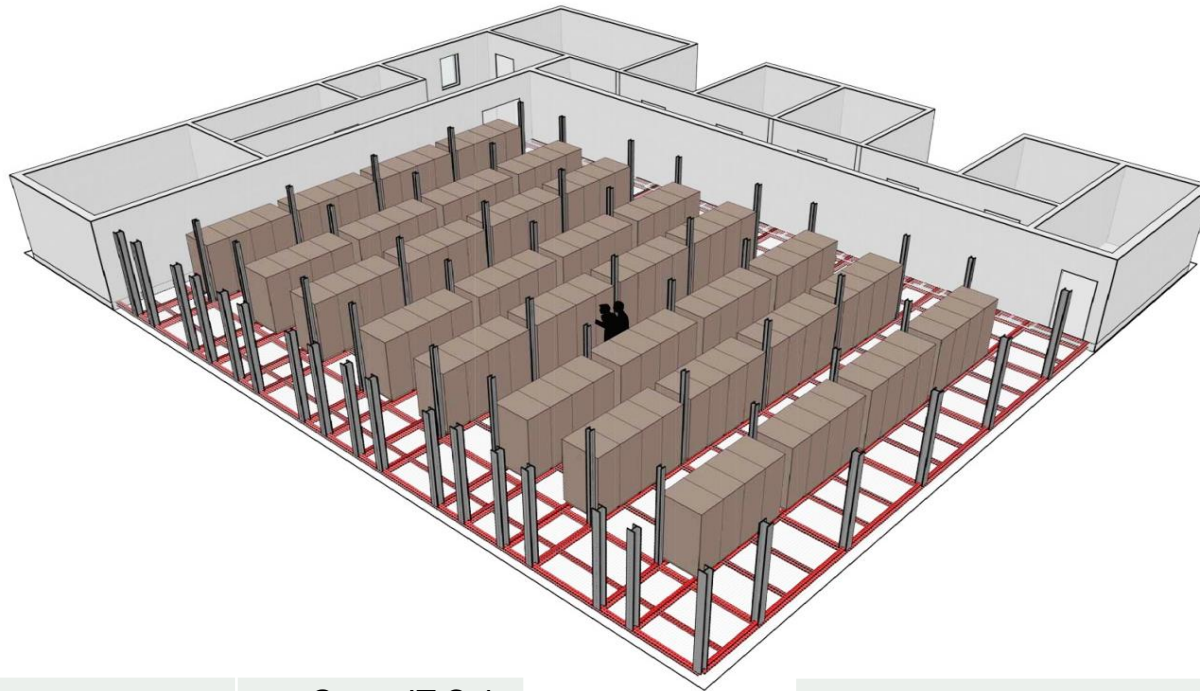


The FAIR Data Center @ GSI (Green Cube)



- Space for 768 19" racks (35000 HE)
- 2 MW cooling per floor
- Max cooling power 12 MW
- Fully redundant (N+1 / 2N)
- Can be used for any commercial IT
- PUE < 1.07
- Average PUE in Germany 1.5
- Construction building cost 18 M€
1,5 €/W





Kennzahl	Green IT Cube
Floor space (BGF)*	5.180 m ²
Volume(BRI)*	18.960 m ³
Number of Racks	768
Whitespace (WS)*	2.790 m ²
BGF/WS	1,86

* 6 floors together / incl. Cooling annex building

Construction Code	Cost in T€
CGR 300 (construction)	4.334
CGR 400 (technical infrastructure)	12.284
440 (electro)	4.180
470 (cooling)	7.135
CGR 500 (outside)	118
Total	16.737

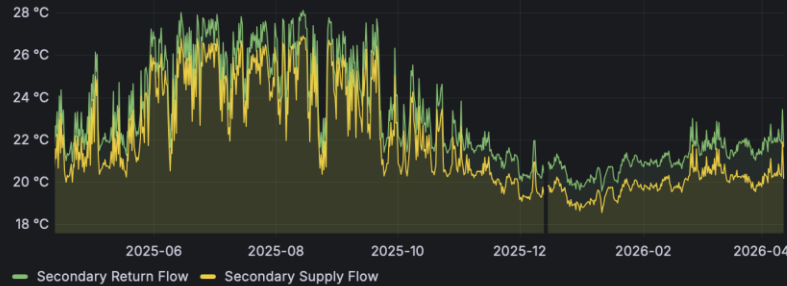
Schedule

- **Dec 1st, 2015: Begin Construction**
- **Jan 28, 2016: Begin installation cooling towers**
- **June 8, 2016: Begin installation of cooling and electro**
- **August 31, 2016: Installation of Racks**
- **October 10, 2016: sign off data center (TGA and electro a few weeks later)**

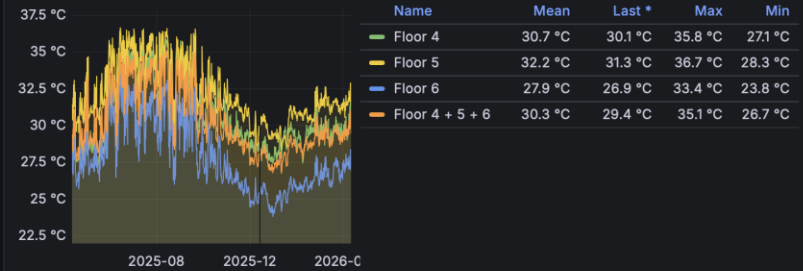
Performance April 12th 2026

Average Rack Temperature: **33.0 °C**
 Highest Rack Temperature: **53.7 °C**
 Highest Rack Power: **23.4 kW**
 Water Temperature Supply Flow: **20.2 °C**
 Water Temperature Return Flow: **21.7 °C**
 IT Power Usage: **1.35 MW**
 Cooling Power Usage: **43.8 kW**
 IPUE: **1.03**
 PUE: **1.04**

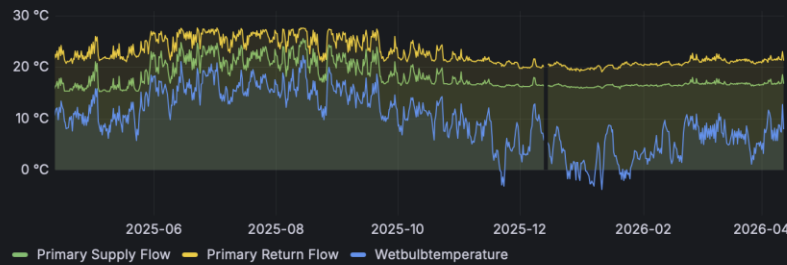
Temperature overview



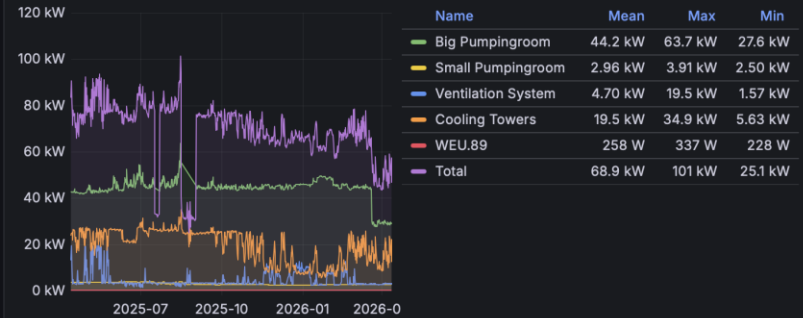
Average Rack Temperature



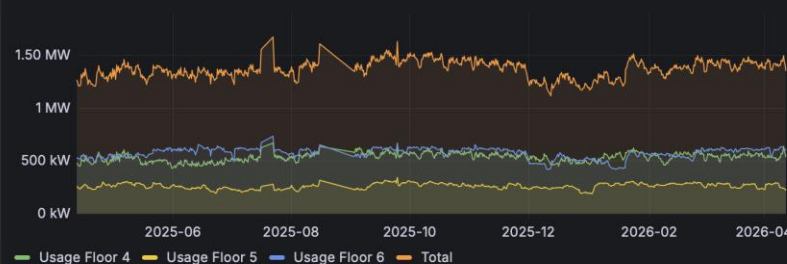
Cooling Water Temperature Primary Side



power usage cooling



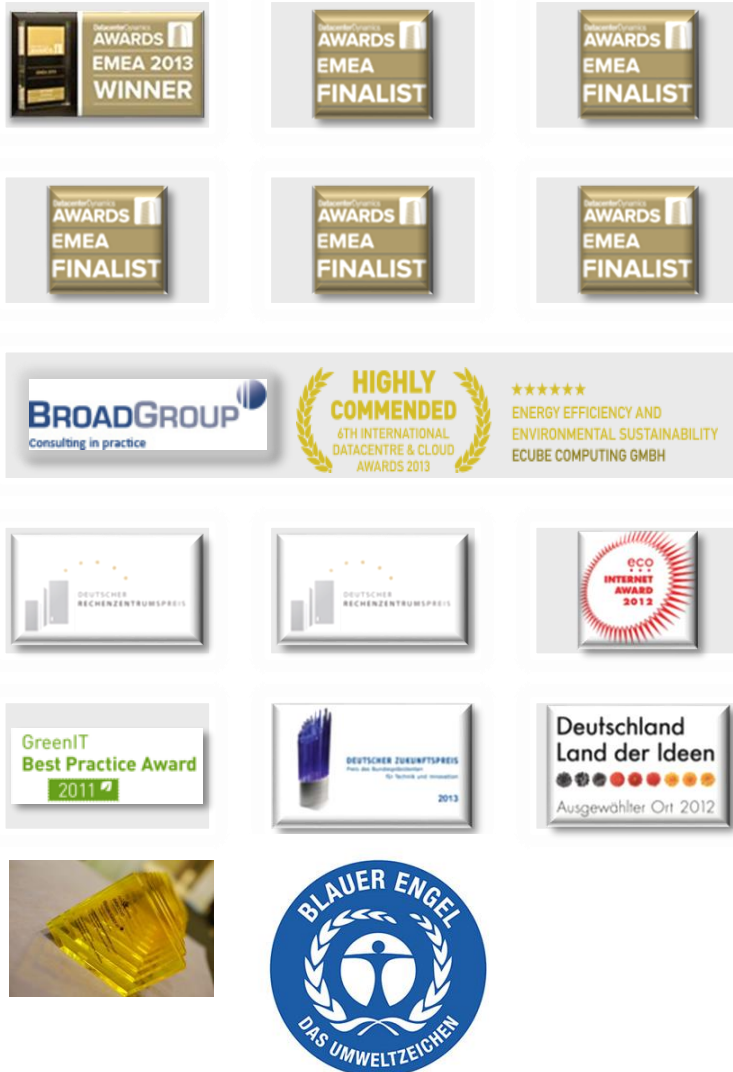
Power Usage IT



IPUE



Awards



- Green-IT Award Bundesregierung „Visionäre Gesamtkonzepte“
- German data center price 2012 – energy efficiency
- German data center price 2013 – Visionary data center architecture
- Nominated for German data center price 2014 – energy efficiency
- DataCenterDynamics EMEA Award 2013 – Data Center Blueprint
- BroadGroup EMEA Awards Special Commendation – Energy Efficiency
- „Land of Ideas“2012 for LOEWE-CSC
- *Green Cube* Project the Month, BMBF
- 5 nominations with 4 second positions for Data Center Dynamics EMEA Awards – 2011, 2012, 2013
- 2. rank at German Internet award 2012
- 1. rank DataCloud Awards 2015, Monaco
- ...

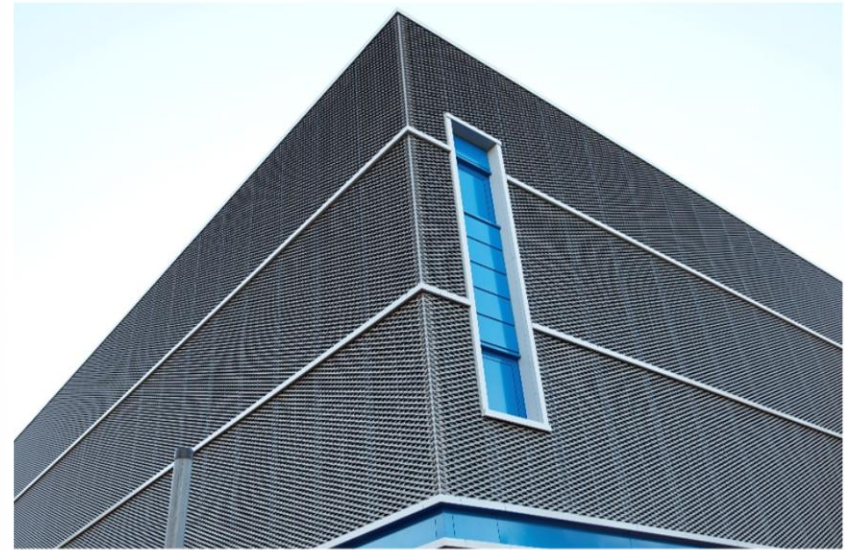
Cube References

- **LOEWE-CSC data center of Goethe Uni, since 2010**
- **MiniCube RZ @ GSI Helmholtzcenter for heavy ion research, 2012-2015**
- **Uni-Rechenzentrum @ University Heidelberg, since 2013**
- **GreenCube @ GSI Helmholtzcenter for heavy ion research, since 2016**
- **Data center of Max-Delbrück Center in Berlin, since 2015**
- **Data center of Airbus Defence and Space, since 2016**
- **Data center of kubus IT since 2017**
- **Nixdorf Datacenter**
- **...**

Airbus



Defence & Space



Summary

- **3D Green Cube Data Center**
 - **Data center architecture allows cost significant savings:**
 - » **CAPEX: 1.5 €/W for Tier-3 like data center**
 - » **OPEX: PUE < 1.1**
 - » **Very small foot print, Green Cube: >30 kW/m²**
 - **No assumptions about computer hardware required**
 - **Backup power can be avoided with redundant energy supplies**
 - **Indirect free cooling most cost effective**
- **Unique and unprecedented cost (CAPEX/OPEX)**
- **Unprecedented performance (works much better than anticipated)**
- **World wide savings 10 GW or 10 B\$/a**
- **Many potential issues originally believed to exist, which are no problem. Result not obvious, patent pending**
- **Many copies (Airbus, MDC, Uni Heidelberg, ...)**
- **The Green Cube works perfect for any commercial IT including NVIDIA DGX**
- **Operating experience with this technology for a decade without any problems**