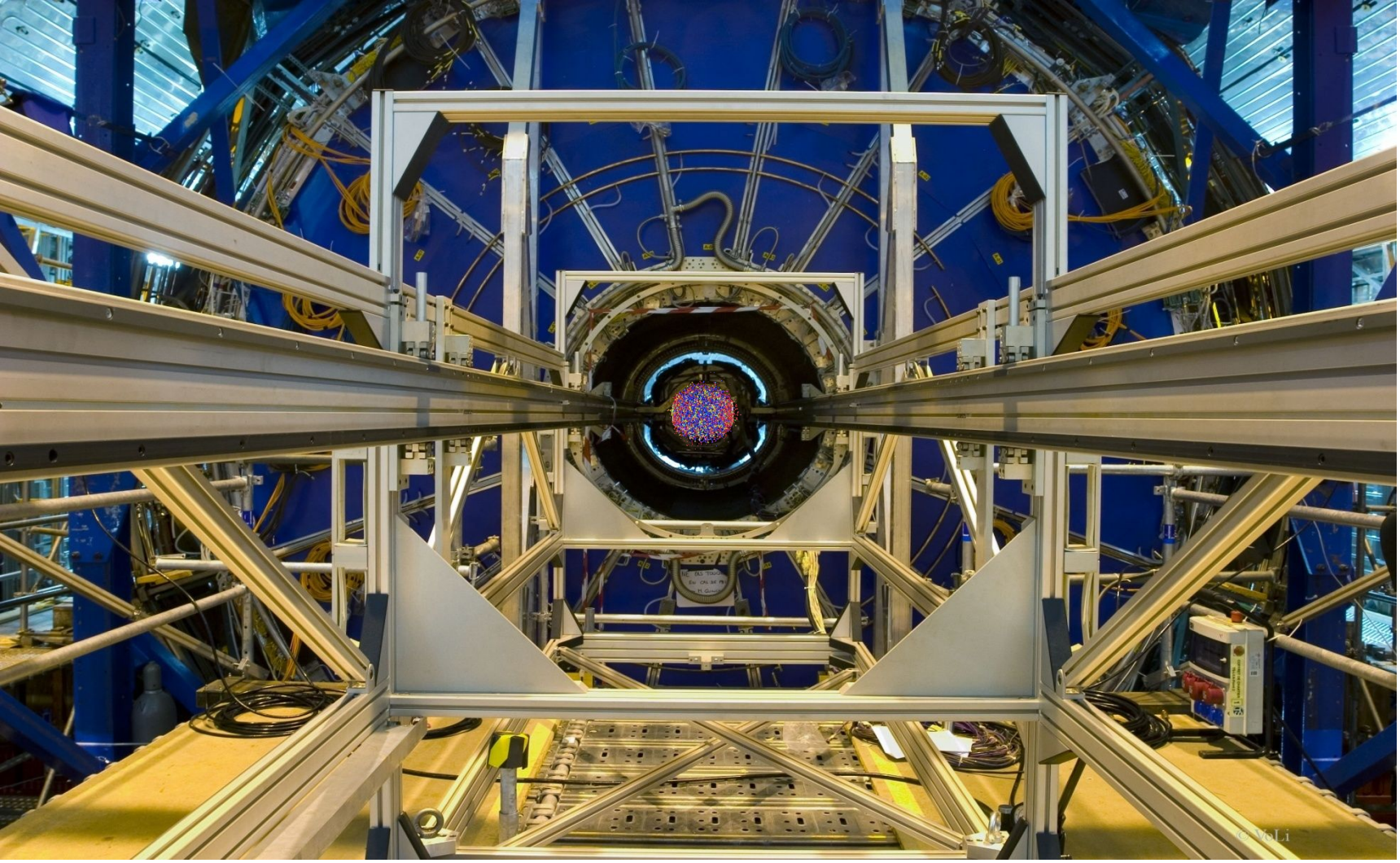


HEPIX Spring
2011 Workshop

FAIR 3D Tier-0 Green-IT Cube

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

GSI GmbH

FAIR GmbH

Programm	2010 CPU # cores	2010 On-line PB	2010 Tape PB/a	2013 CPU # cores	2013 On-line PB	2013 Tape PB/a	2016 CPU # cores	2016 On-line PB	2016 Tape PB/a
APPA	100	< 0,1	0,1	200	1,0	2,0	1.000	1,0	2,0
CBM	250	< 0,2	0,2	7.000	15,0	11,0	60.000	15,0	11,0
NUSTAR	100	< 0,1	0,0	300	2,0	2,0	2.000	2,0	2,0
PANDA	250	< 0,2	0,2	8.000	12,0	12,0	66.000	12,0	12,0
ALICE	3.000	1,5	0,0	6.600	3,5	0,0	14.500	8,0	0,0
FOPI	200	0,1	0,2	400	0,2	0,3			
HADES	1.000	1,0	1,5	1.000	2,0	3,0			
Gitter-QCD	2.500	< 0,3	0,3	20.000	0,5	0,5	100.000	1,0	2,0
Theorie	1.000	< 0,2	0,2	5.000	0,5	0,5	20.000	1,0	2,0
rest	500	< 0,3	0,3	2.000	1,5	1,5	10.000	3,0	3,0

Obs

USA

Austria China Finnland France Germany Greece India Italy Poland Slovakia Slovenia Spain Sweden Romania Russia UK

An Alarming Truth

World wide air-traffic causes around 2 % of the global CO2 emission –

just as much as commercial IT!

[Gartner]

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

Heat Transmission via Air and Water

Required Volumetric Current: $$Q = \dot{V} = \frac{P}{c_\mathrm{p} \cdot \rho \cdot \Delta T}$$

P : Thermal Power Loss
ΔT : Temperature Difference

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

Example: Notebook-Computer (30 W)

$\Delta T = 25\,\mathrm{K}$

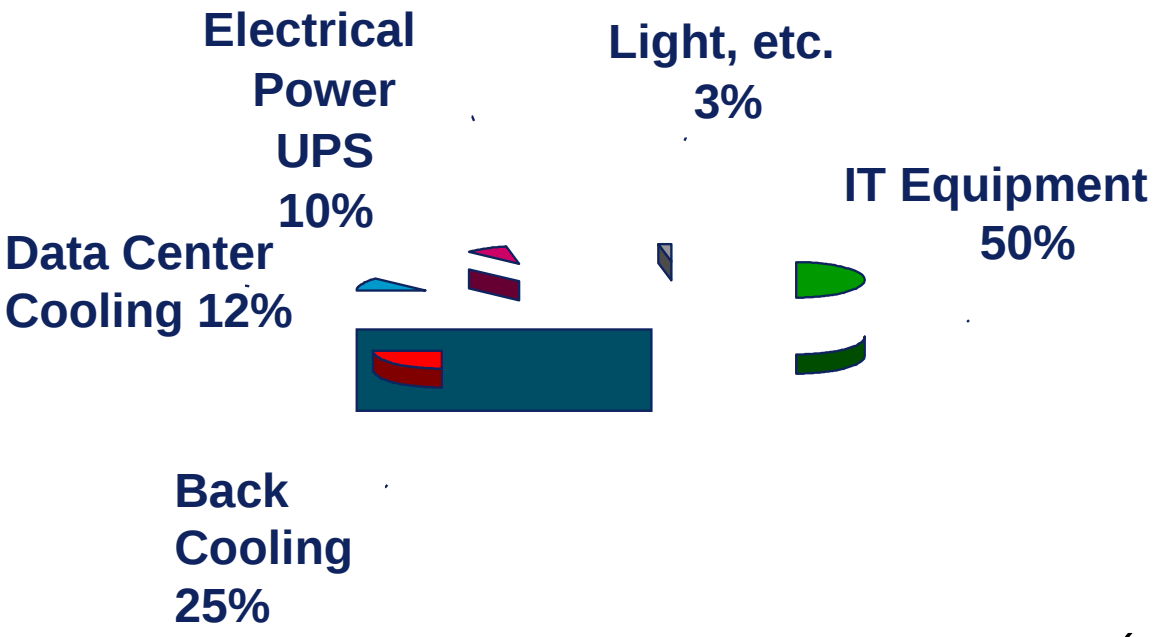
Example: Data Center (1 MW)

$\Delta T = 25\,\mathrm{K}$

Water Specific Heat Capacity:

Example: Data Center (1 MW)

Data Center State of the Art



the green grid

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

Power Usage Effectiveness

PUE = 2

(typical PUE = 1,6 to 3,5)

Note: 12C/kWh ≙ 1W = 1,05€/a

Source: EYP Mission Critical Facilities Inc., New York

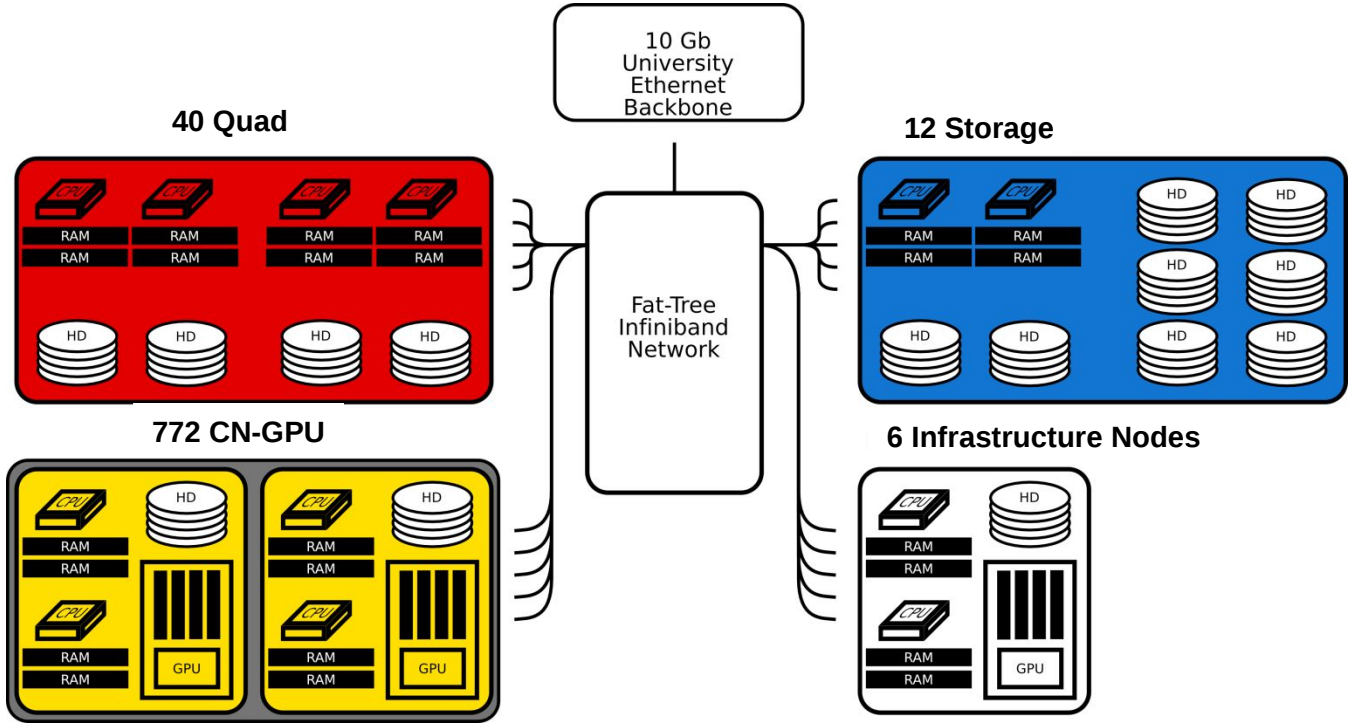
Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

LOEWE-CSC 2011
Green500: 8
Top500: 22 (21)
Cost: 200 €/core
CO2 neutral

Volke

LOEWE-CSC

Local had drives	1.62 PB
Core memory	55,8 TB
Nodes	830
Mass storage	420 TB (net)
CPU cores / GPUs	20880 / 772
Power	450 kW
Cost	4200 k€ net; 200 €/Core



Cool-Overhead 8%

DGEMM GPU 494 Gigaflop/s (90.8% peak) world wide fastest

System LINPACK 299 Teraflop/s

Compute power/W 736.8 Megaflops/w

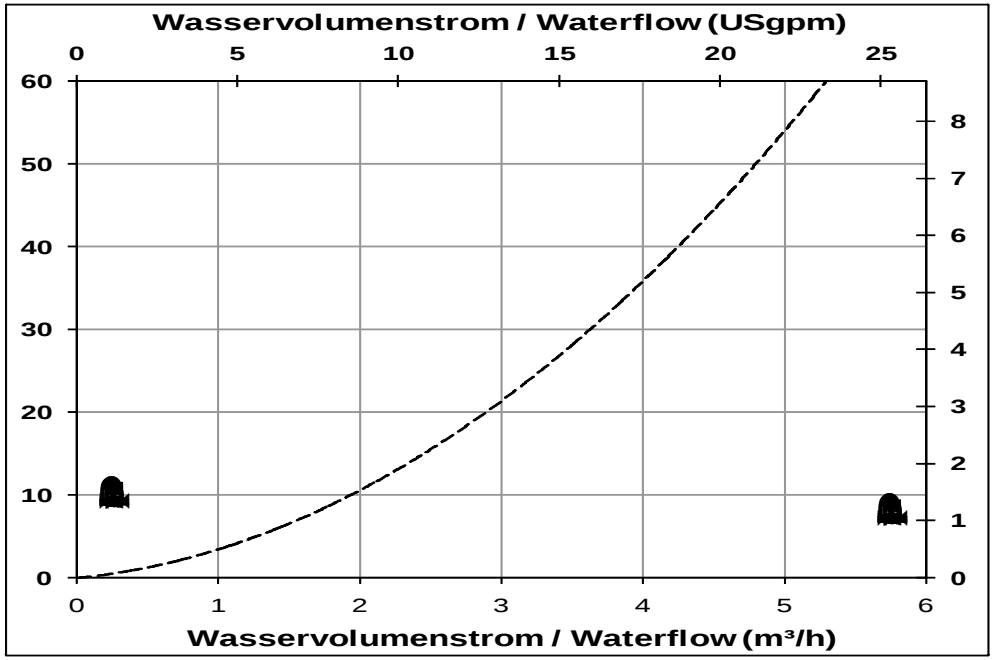
Green500: 8

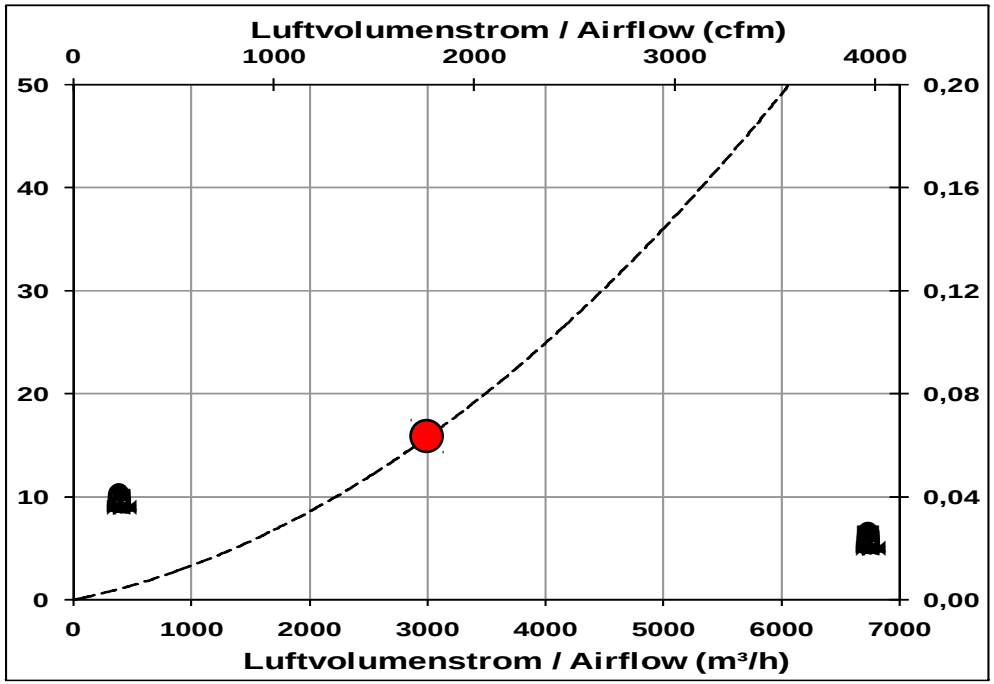
Top500: 22

CO2 Saving / year: 8.000 T

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten



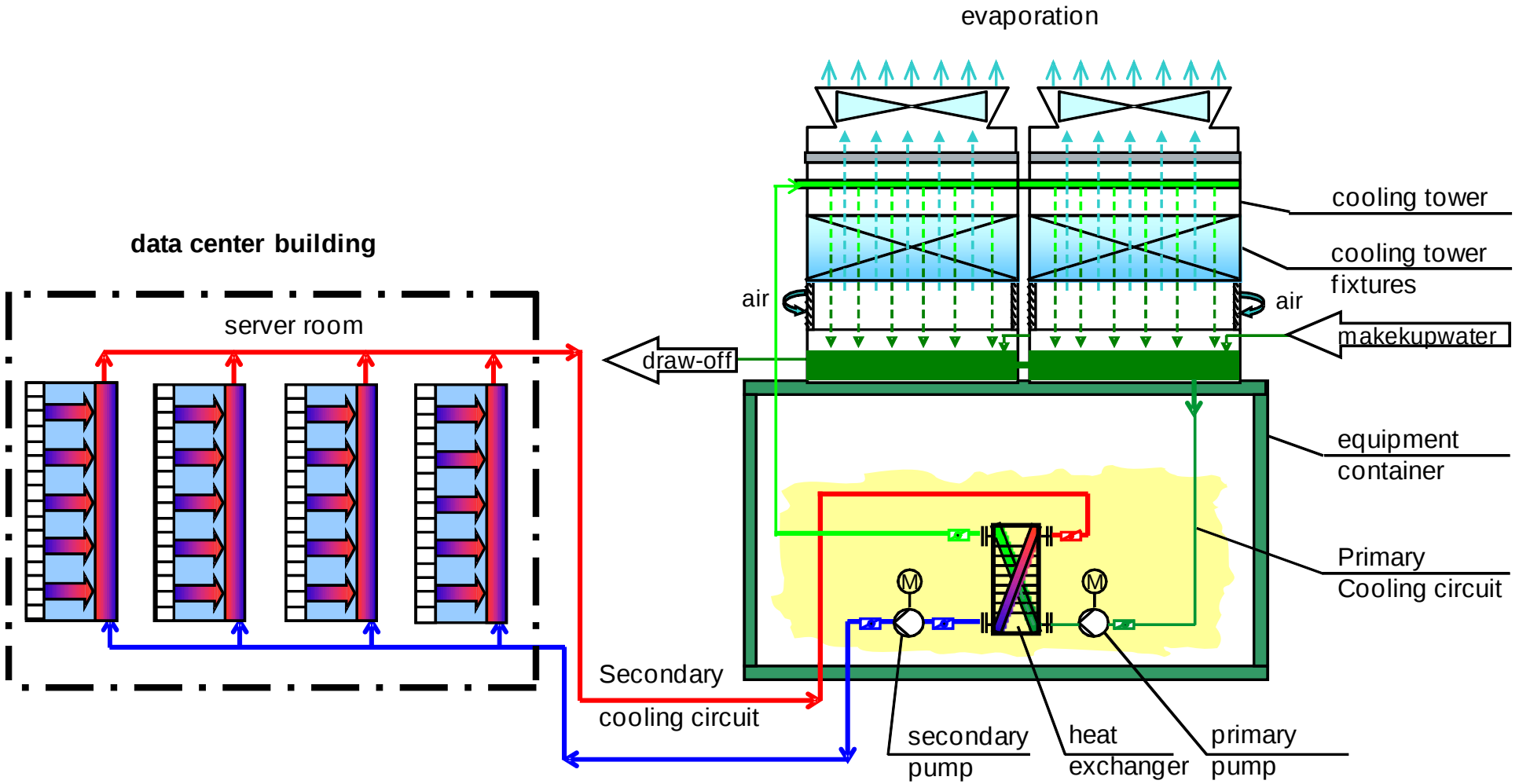


knürr
environments for electronics

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

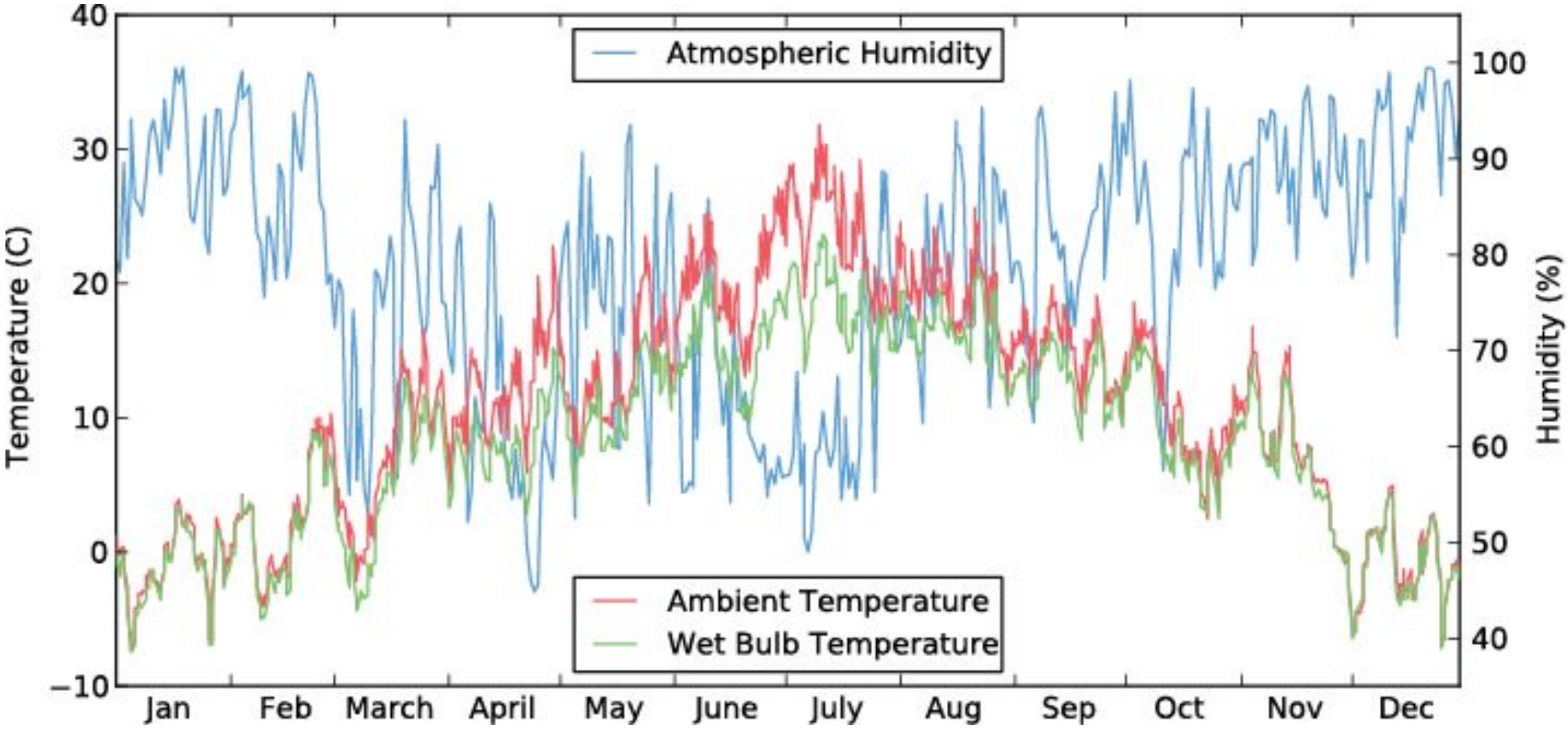
Heiko Ebermann

Cooling System Architecture



Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

Feuchtkugeltemperatur 2010



Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

LOEWE-CSC Cooling

- **Max cooling power 600 kW**
- **Secondary pump 27 kW**
- **Primary pump 5 kW**
- **Cooling tower Fans 2x4.5 kW**
  not required if outside temperature below 15 °C

à **PUE (best) 1.062**

à **PUE @ 450 kW 1.082**

- **Server fan overhead 6%**

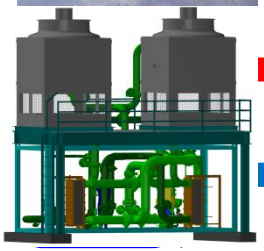
Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

bouillon cube

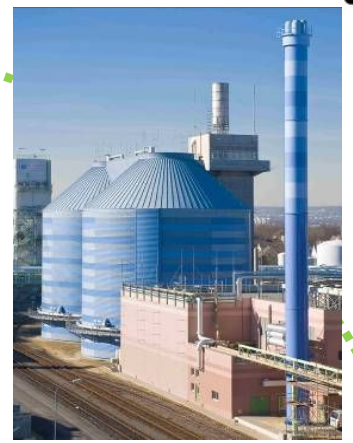
LOEWE-CSC Green-IT

infraserv höchst
Dienst. Leistung.

Klärschlamm-verbrennungs-anlage



CSC Loewe



Biogasanlage

Chemie-produktion

Ersatzbrenn-stoffanlage (EBS)
In Umsetzung

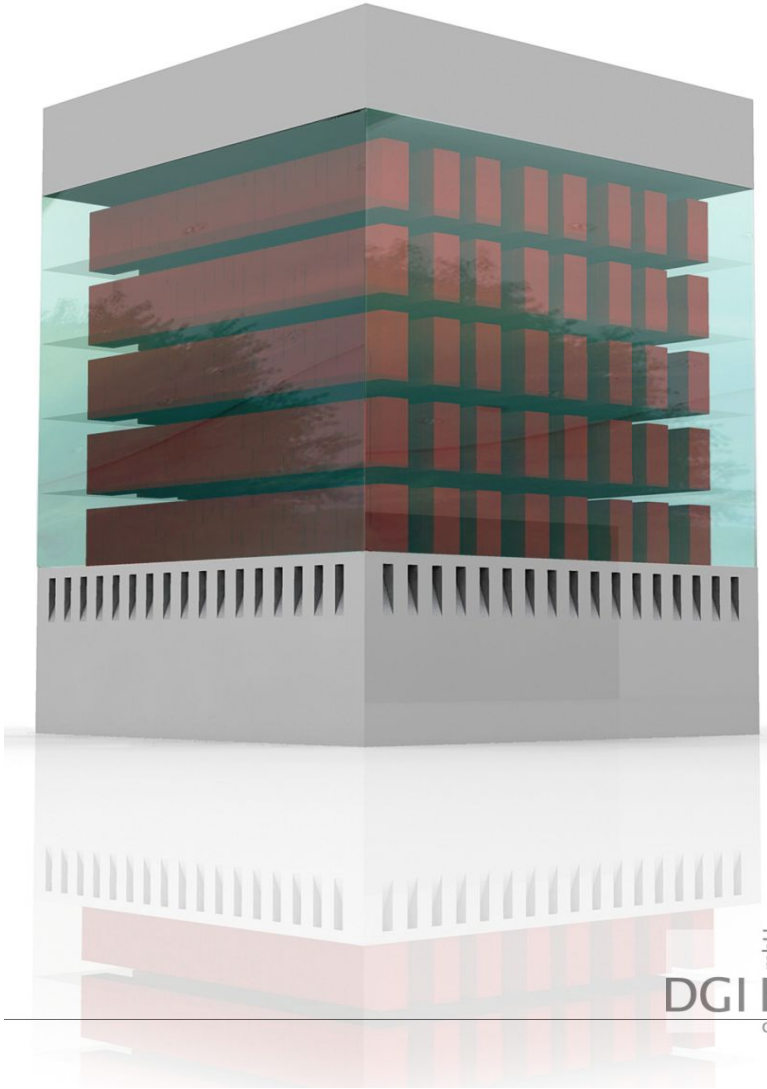
2. & 3. Gasturbine
In Umsetzung

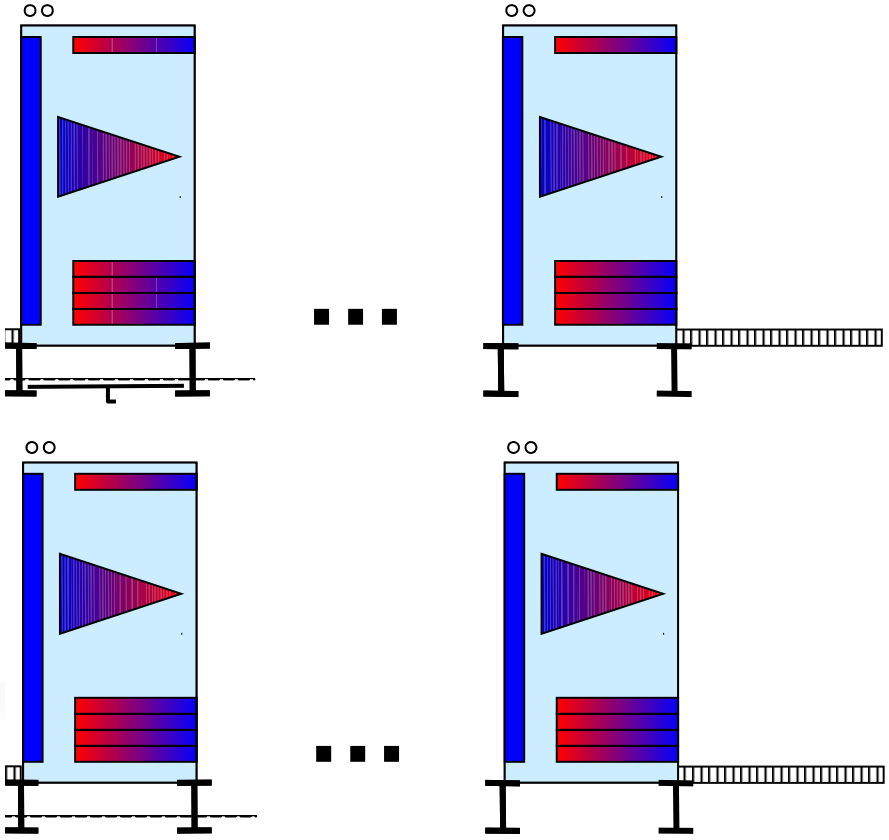
CO2 neutral

PUE 1,08

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

Next Generation Data Center

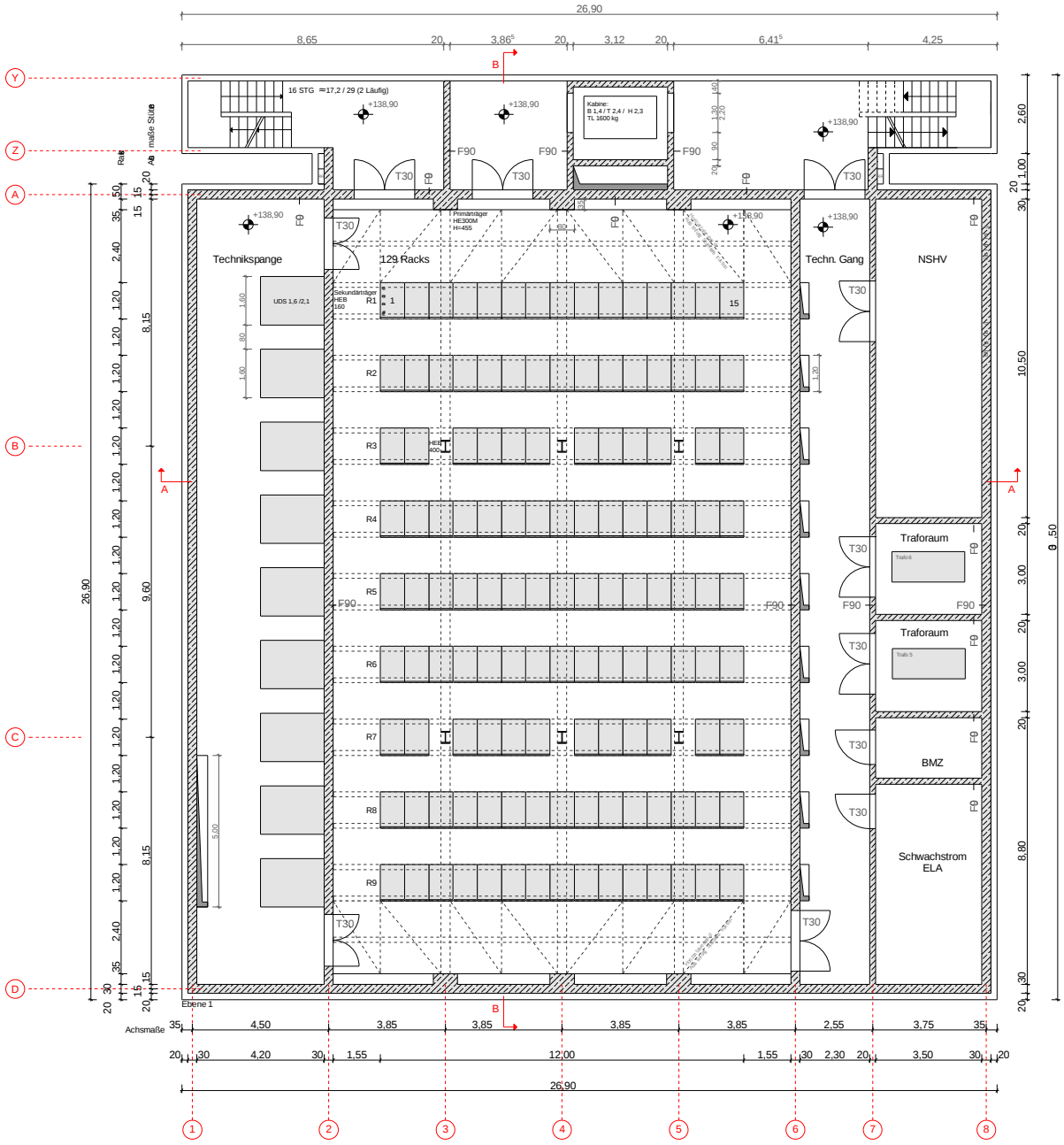




DGI Bauwerk mbH
Gesellschaft von Architekten

FIAS Patent submitted @ DPMA 5.7.2008
(Lindenstruth, Stöcker)

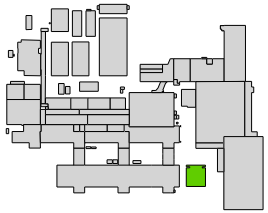
Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten



Bauvorhaben	Phase	Planart	Bauteil	Status	Index
Green IT	3				

Änd.-Datum	Änderungsbeschreibung	geä.	gepr.

Green IT
Rechenzentrum



Vorabzug

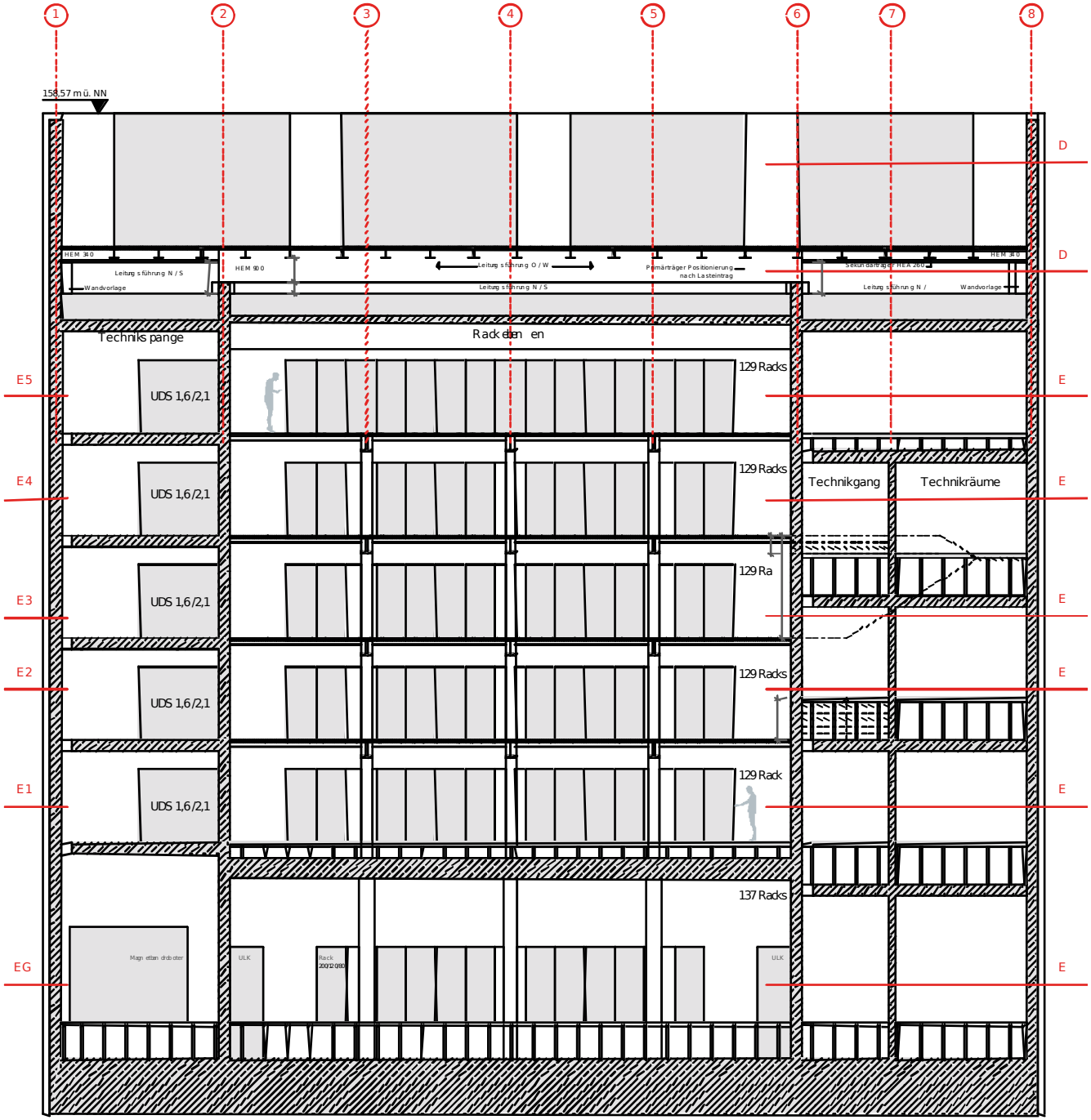
Bauherr **GSI** Gesellschaft für Schwerionenforschung GmbH Darmstadt	Planckstr. 1, 64291 Darmstadt Tel.: (06221) 549809 Fax: (06221) 549809
Architekt **DGI Bauwerk** Gesellschaft von Architekten mbH	Schillstraße 9, 10785 Berlin Tel.: (030) 26 49 43 - 0 Fax: (030) 26 27 93 - 4
Tragwerksplanung **BUNG Ingenieure AG**	Englerstr. 4, 69126 Heidelberg Tel.: (06221) 3060 Fax: (06221) 306172
TGA HLSK **Ebert Ingenieure GmbH & Co.KG**	Hanauer Landstr. 182, 60314 Frankfurt a.M. Tel.: (069) 299905-43 Fax: (069) 299905-10
TGA ELT **Müller & Bleher GmbH & Co.KG**	Fritz- Reichle-Ring 10, 78315 Radolfszell Tel.: (07732) 953911 Fax: (07732) 953910

Entwurfsplanung

Datum	22.01.2010	bearbeitet	WB
Blatt-Gr.	DIN A2	geprüft	CT
Plan-Nr.		Maßstab	M. 1:100

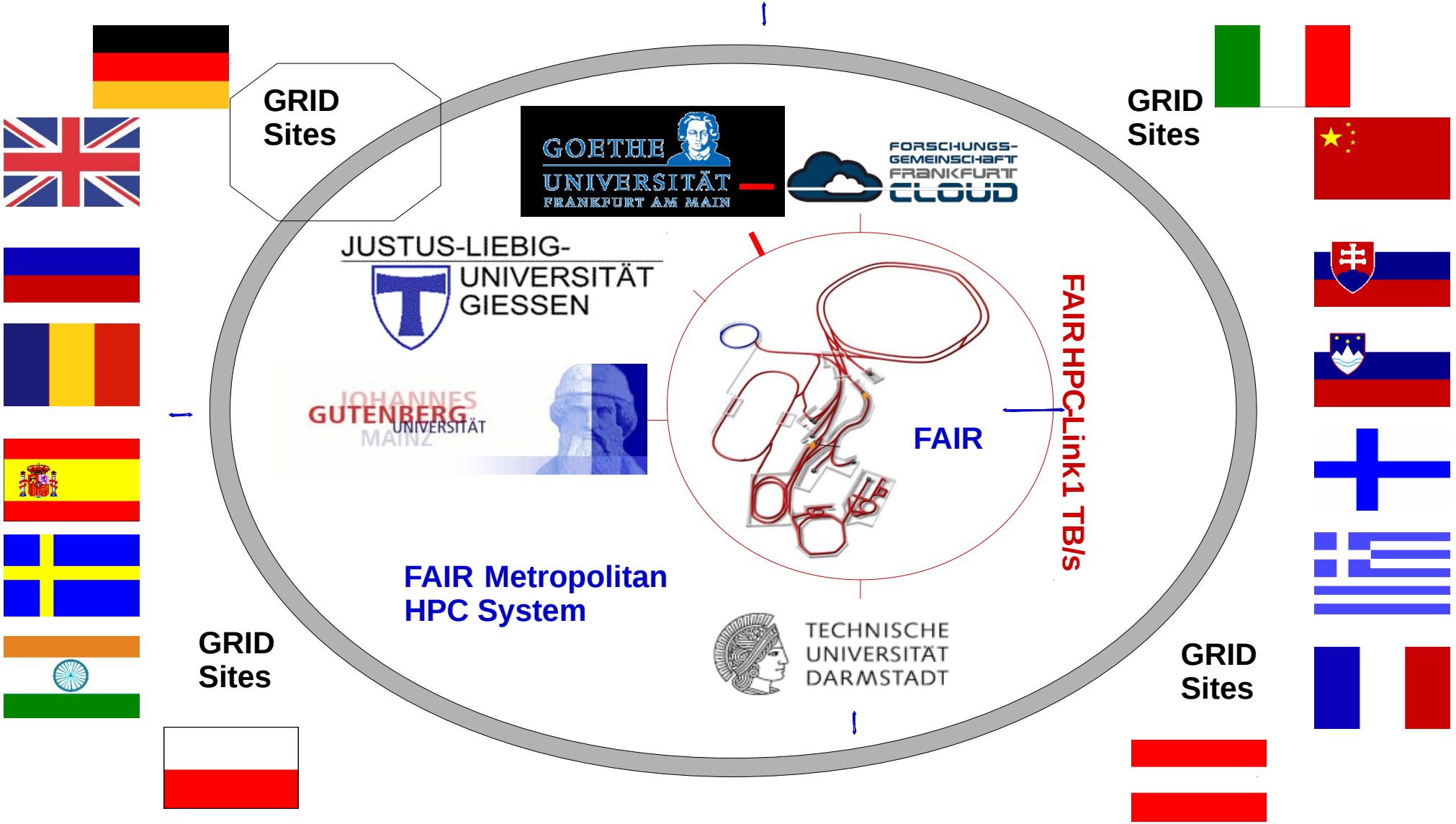
Bauvorhaben	Phase	Planart	Ebene	Status	Index
Green IT	3				

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten



Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

FAIR HPC Backbone 1TB/s



Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten

Volker Lindenstruth (www.compeng.de) 03.05.11— Copyright ©, Goethe Uni, Alle Rechte vorbehalten