POWER AND COOLING CONSULTANTS MASTER CLASS 2016

HITTING THE GREEN MARK:

BEST PRACTICES IN DATA CENTER OPTIMIZATION

EMERSON
Network Power

Improving PUE through Rack Cooling and Cold Room Concept

Heiko Ebermann
Global Product Manager Rack Cooling
Emerson Network Power

EMERSON
Network Power

Global warming



Energy Efficient Data Center Cooling

Objectives for Rack Cooling Products



Goal:

- **Increase of chilled water temperature**
- **Evenly cooling air distribution**
- **No cooling air leakage**
- **Lowest pressure resistance**

Energy Efficient Data Center Cooling

The DNA of Rack Cooling matched perfect to a best score at the **BCA-IDA GREEN MARK Award**



- Designed for PUE optimisation
- Best option upgrading of existing data centres
- Energy efficient operational parameters

Components of Rack Cooling Solutions



Server Cabinet with
Rear door heat exchanger
Knürr DCD



Server Cabinet with
lateral rack cooling unit
Knürr DCL



Server cabinets with
Cold Aisle Containment
Smart Aisle

Energy Efficiency

Objectives for Rack Cooling Products:

1. Increase of chilled water temperature

- Improvement of EER for chiller
- *Extent the option for free cooling*
- *Enable the option for adiabatic cooling*

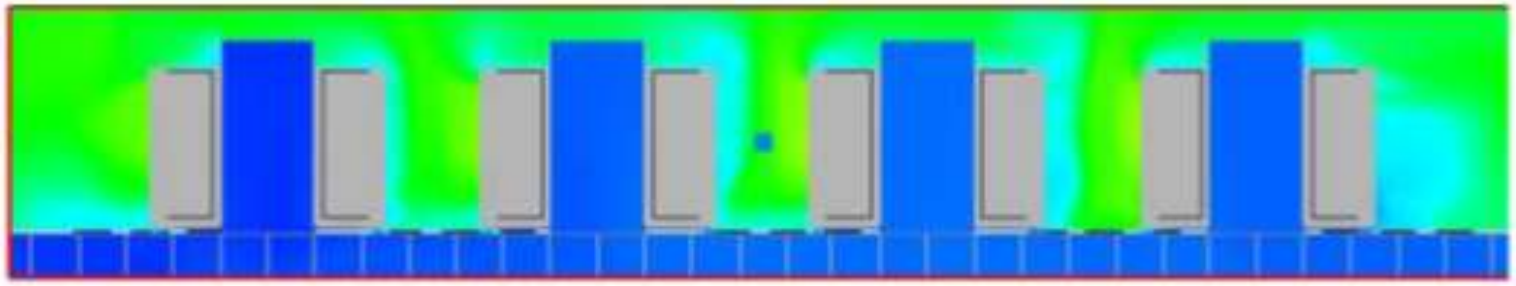


Energy Efficiency

Objectives for Rack Cooling Products:

2. Evenly cooled air distribution

- No hot spots
- Minimized temperature spread of cooling air
- No restriction for equipment placement



Energy Efficiency

Objectives for Rack Cooling Products:

3. No cooling air leakage

- Air separation
- Low pressure difference
- No “waste” of cooling air



Energy Efficiency

Objectives for Rack Cooling Products:

4. Lowest pressure resistance

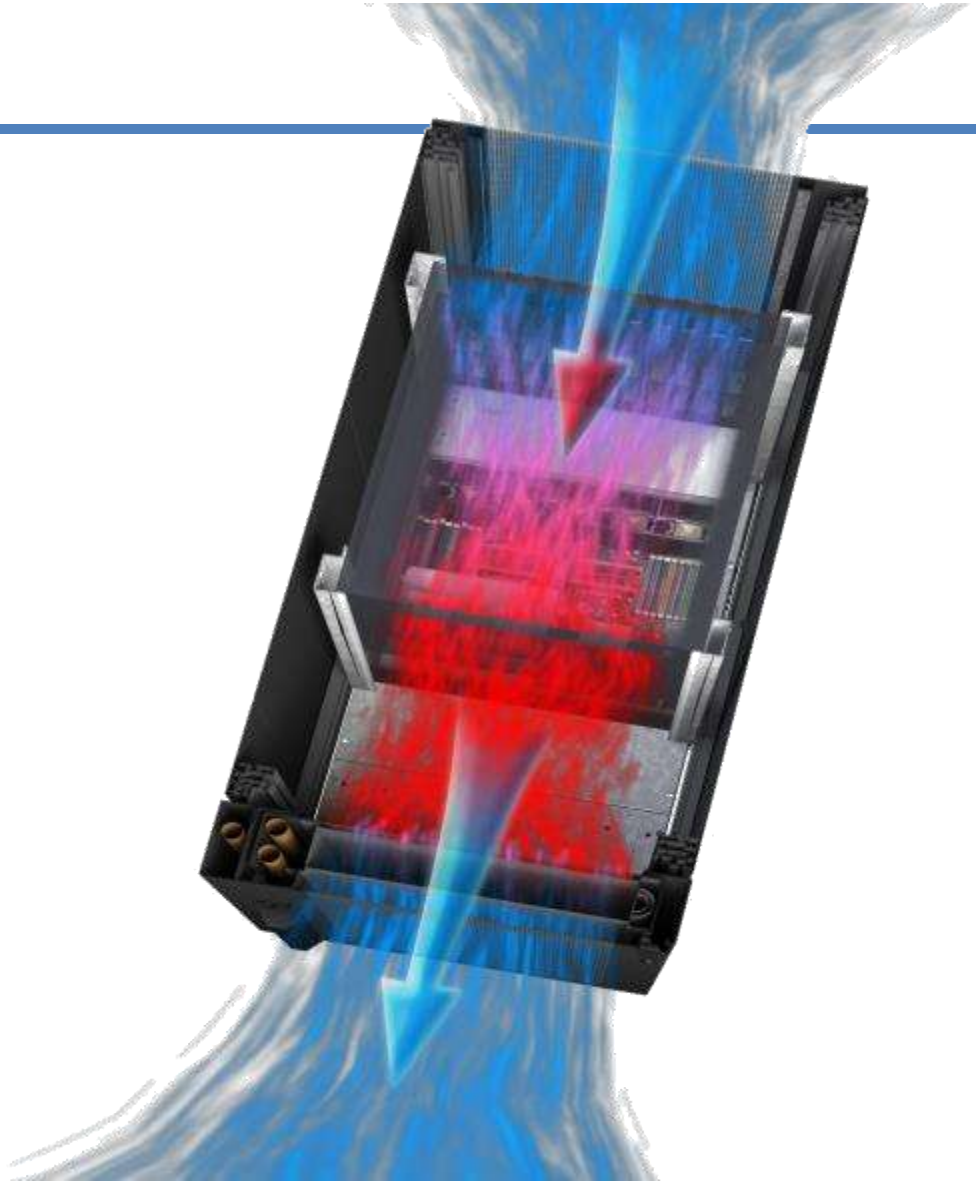
- Optimized heat exchanger design
- Low air velocity
- Generous sizing
- Straight chilled water pipe arrangement



Best Practice Solution Spotlight:

Knürr DCD





Best Practice Solution Spotlight:

Knürr DCD

Proofed 35kW cooling capacity



- **Optimal cooling capacity 10 to 20kW**

- **High CW temperature possible**
- **No fans**
  (less failure points,
  no additional head load to the room)
- **Our conditions for best PUE**

- Minimized air and water pressure drop

- **One product with Knürr DCM Cabinet - Perfect fit**

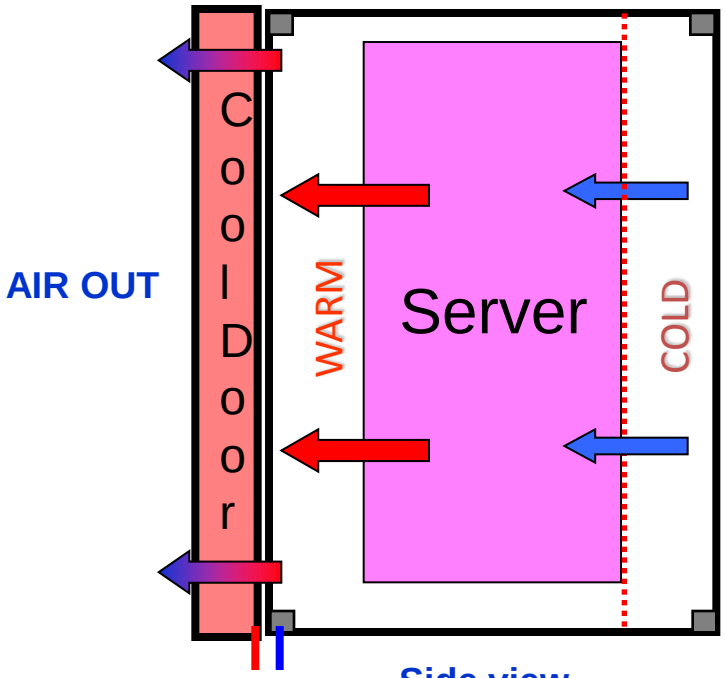
Knürr DCD - Rear door HEX

Cold room concept

- Increase of “warm” cooling air temperature possible
- Heat neutralization of the room
- No hot zone in the data center
- Minimized hot air plenum

Rear view





Side view

Top view



Knürr DCD - Rear door HEX

Cabinet adaptation

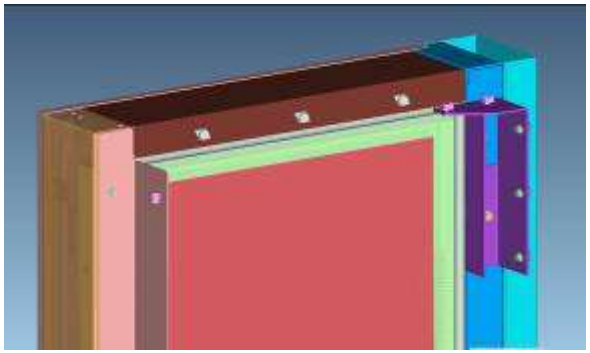
- strict warm / cold air separation at front and rear 19” rails
- bottom cover
- air tight cable inlet (top and bottom): foam
- cable management integration is highly recommended
- air tight plenum between server air outlet and air inlet of HEX

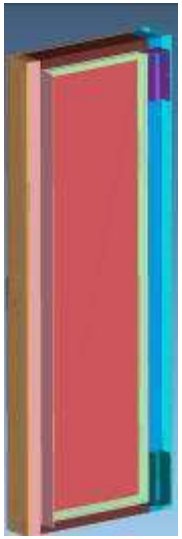


Knürr DCD - Rear door HEX

3rd party cabinet adapter

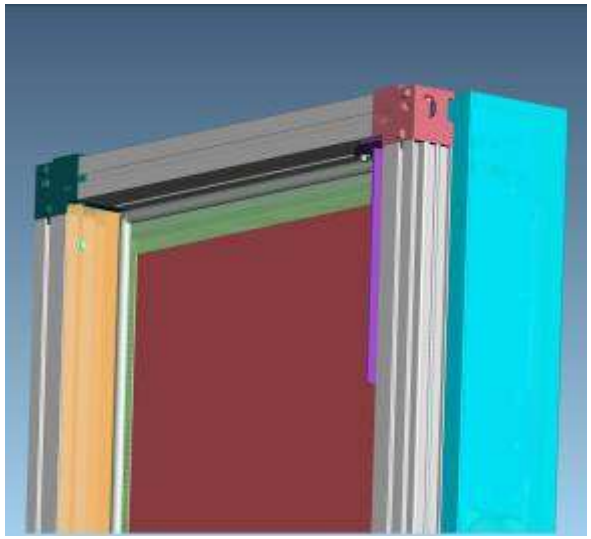
- Data center upgrade
- Knürr DCM for 3rd party rack
- Standard design with frame
- Adapter brackets necessary





Upgrade for air tightness of the existing cabinet is required

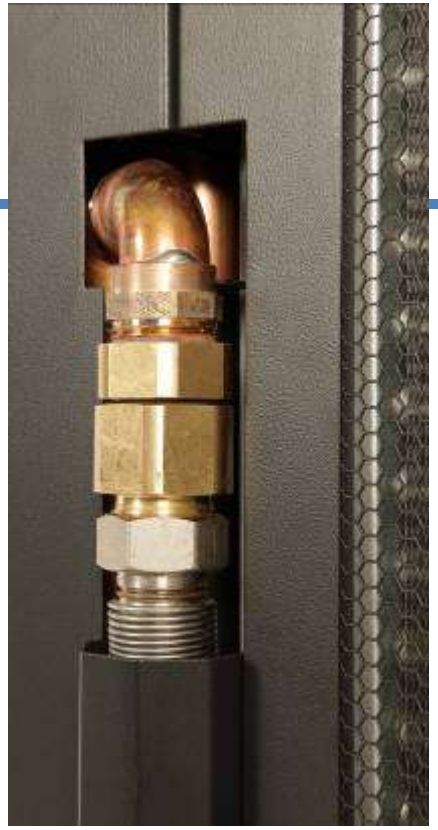
- Cable inlet
- Cold / warm air seperation





Knürr DCD - Rear door HEX

- **Swivel joint**
  - no flexible hose
  - hard pipe connection
- In-house stress test with 10,000 cycles
- Viton quad ring seal
- Tests up to 25 bar at the manufacturer









Knürr DCD - Capacity control

Chilled water flow regulation



- **Central valves for row or zones**
  - Best practice for room temperature control
  - Average or maximum room air temperature based chilled water flow rate control

- **Valve for Knürr DCD**
  - static flow regulator (only for low fluctuation in heat load)
  - flow regulation according constant chilled water return temperature (costly)

Knürr DCD - Rear door HEX

Back Pressure Air
tested by ebmpapst

ebmpapst

ebmpapst Mulfingen GmbH & Co. KG
Postfach 11 61 · 74671 Mulfingen
Telefon 0 79 38 / 81-0
Telefax 0 79 38 / 81-1-10

Messprotokoll für Ventilatoren
Installationskategorie A nach ISO 5801, DIN 24163, DIN EN ISO 5167-1

Datum:	02.09.2010	Bearbeiter:	CH_3351/TS_4131	IdNo.:	128272
Kunde:	Knürr-Elektronics Gm	Kundengerät:		Projekt-Nr.:	49569
Fördernichtung:				Motormuster:	
Typ:	KENNLINIE-01A	Motor:		Meßnummer:	16547
Spannung:	V	Frequenz:	Hz	Gehäuse:	
Stator:				Berechnungsnr.:	
Statorschnitt:		Statornutzahl:		Statorlänge.:	mm
Wickeldaten:					
Rotor:					
Rotornummer:		Rotorschnitt:		Rotorwerkstoff:	
Wärmeb. Rotor:	/	Rotornutschräge:		Rotornutzahl:	
Laufrad:					
Laufradherst.:		Laufradwerkst.:		Laufradnummer:	
Laufrad Ø:	mm	Laufradbreite:	mm	Schaufelzahl:	
Einlassring:		Wandring:		Austrittsbreite:	mm
Maß C:	mm	Ausblasquersch.:	m²	Dichte Luft:	1,15 kg/m³
Kanal:	C				
Luftdruck:	987,3 mBar	Luftfeuchtigkeit:	45,99 %	Raumtemperatur:	23,5 °C

Bemerkung:
Widerstandskennlinie des Serverschranks
Durchblasen von Rückseite durch Tauscher zur Vorderseite hin

Nr	D	U~ [V]	I~ [A]	P1 [W]	COS [Phi]	n 1/min	Pfe [Pa]	Pfe12 [Pa]	Pt [Pa]	Volstr [m³/h]	ηges [%]
1	4	0	0	0	0	0	0	0		0	
2	4	0	0	0	0	0	2,5	2,8		749,5	
3	4	0	0	0	0	0	5,599	5,93		1506	
4	4	0	0	0	0	0	10	10,4		2252	
5	4	0	0	0	0	0	15,6	16,2		2995	
6	4	0	0	0	0	0	22,5	23,4		3753	
7	4	0	0	0	0	0	30,1	31,3		4516	
8	5	0	0	0	0	0	39,6	41,2		5067	
9	5	0	0	0	0	0	49,2	51,2		5996	
10	5	0	0	0	0	0	60,4	62,9		6755	
11	5	0	0	0	0	0	72,9	75,9		7544	
12	5	0	0	0	0	0	81	84,3		8004	

U~ =Versorgungsspannung (Effektivspannung)
P1 =Leistungsaufnahme (Wirkleistung)
P2 =Abgegebenleistung des Ventilators (P2=Volstr·Pt)
Rho =Luftdichte (Dichte der Fördermediums)
Pt =Totaldruckerhöhung des Ventilators Pt=Pfe+Pd
Pfe =Druckerhöhung frei ausblasender Ventilator
n =Motordrehzahl

Cos$_{phi}$ =Leistungsfaktor (Cos$_{phi}$=P1/(U·I))
I~ =Stromaufnahme (Effektivstrom)
η$_{ges}$ =Gesamtwirkungsgrad des Ventilators (η$_{ges}$=P2/P1)
D =mittlere Ausblasgeschwindigkeit (D=Volstr/Ausblasquersch.)
Pd =dynamischer Druck (Pd=Rho·D²/2)
Pfe12 =Druckerhöhung frei ausblasender Ventilator für Rho=1,2kg/m³
Volstr =Volumenstrom

Wirkleistung: $P = \frac{1}{T}\int_0^T u(t)\cdot i(t)\,dt$

Effektivstrom: $I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt}$

Effektivspannung: $U_{eff} = \sqrt{\frac{1}{T}\int_0^T u^2(t)\,dt}$







Knürr DCD – Server fan power consumption

15 kW IT load

15K delta T_{air}

Air flow rate

app. 3100 m³/h

= 0.86 m³/s

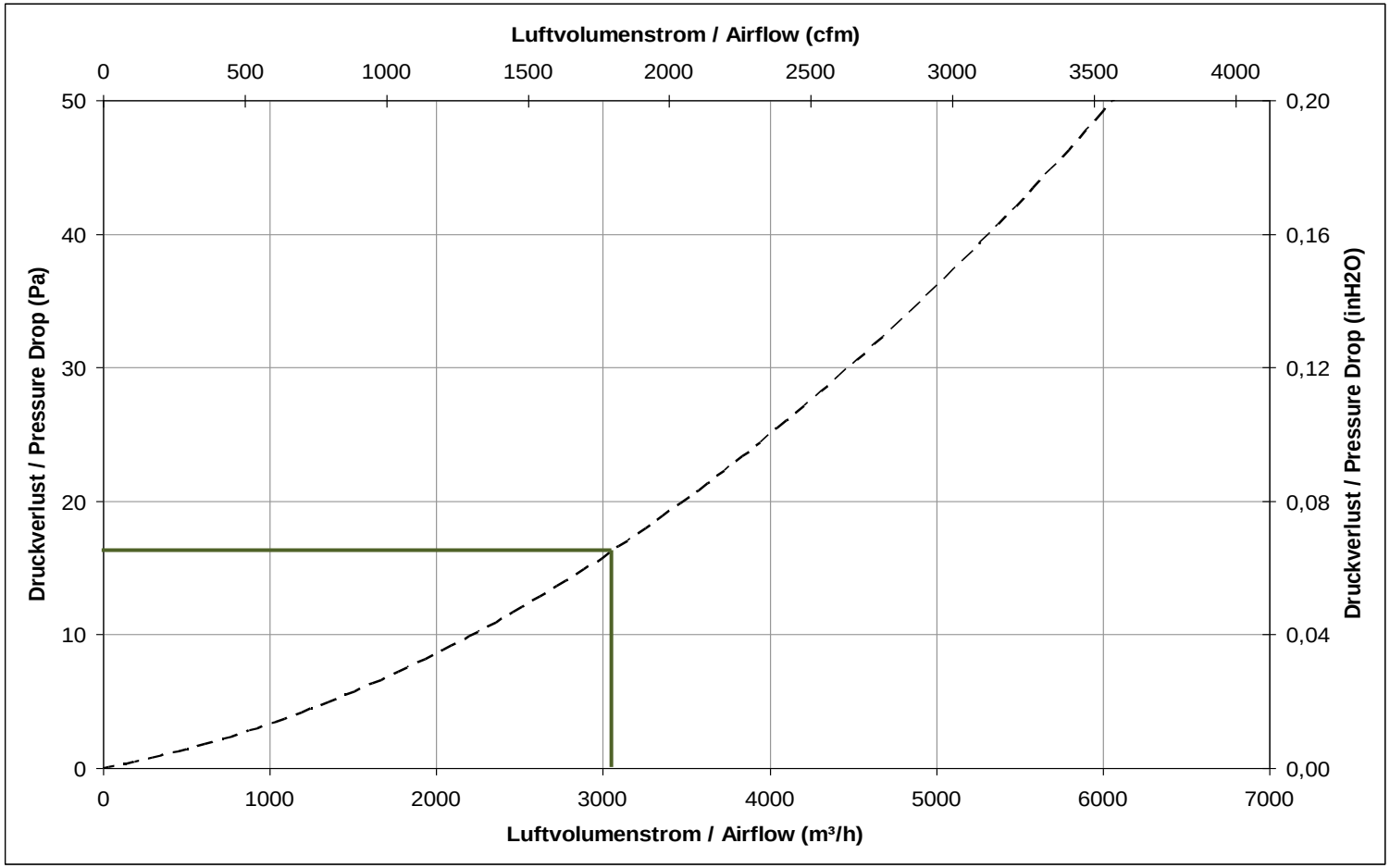
Delta p = 17 Pa

$$P_{el}=\frac{\Delta p \times \dot{V}}{\eta}$$

$$P_{el}=\frac{17Pa \times 0.86\frac{m}{s}}{0.3}$$

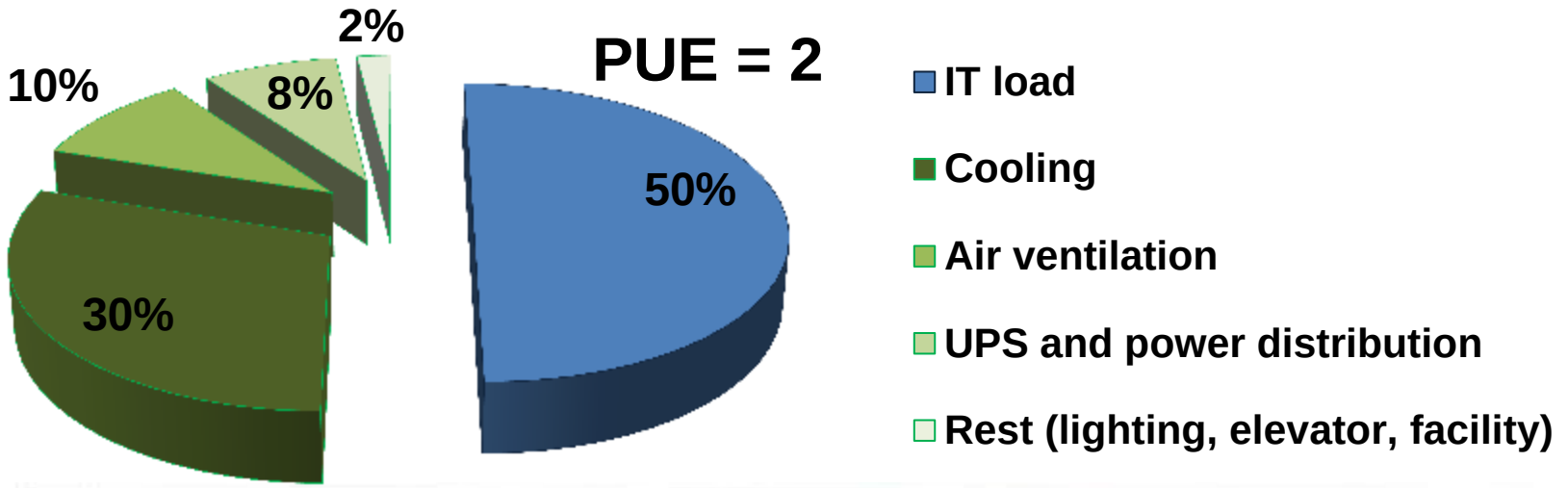
$$P_{el}=\sim 50W$$

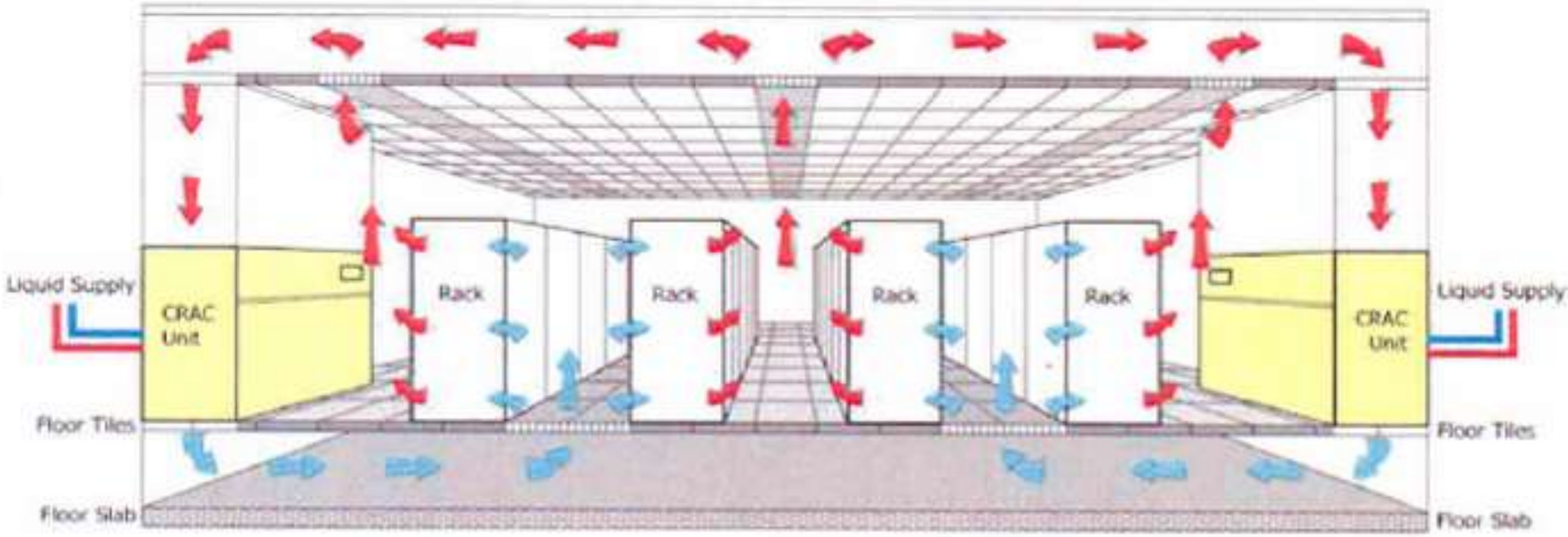
Back Pressure Air



Additional fan power consumption: negligible

Knürr DCD – PUE Calculation



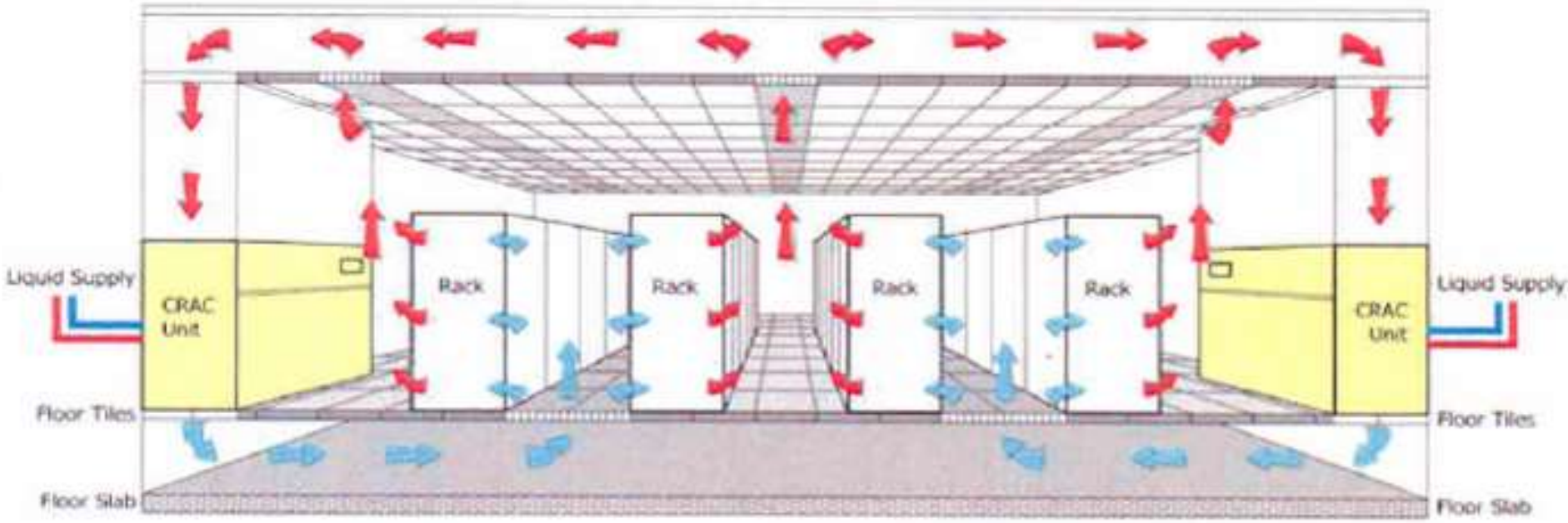


Source: ASHRAE 2005

Knürr DCD – Air flow

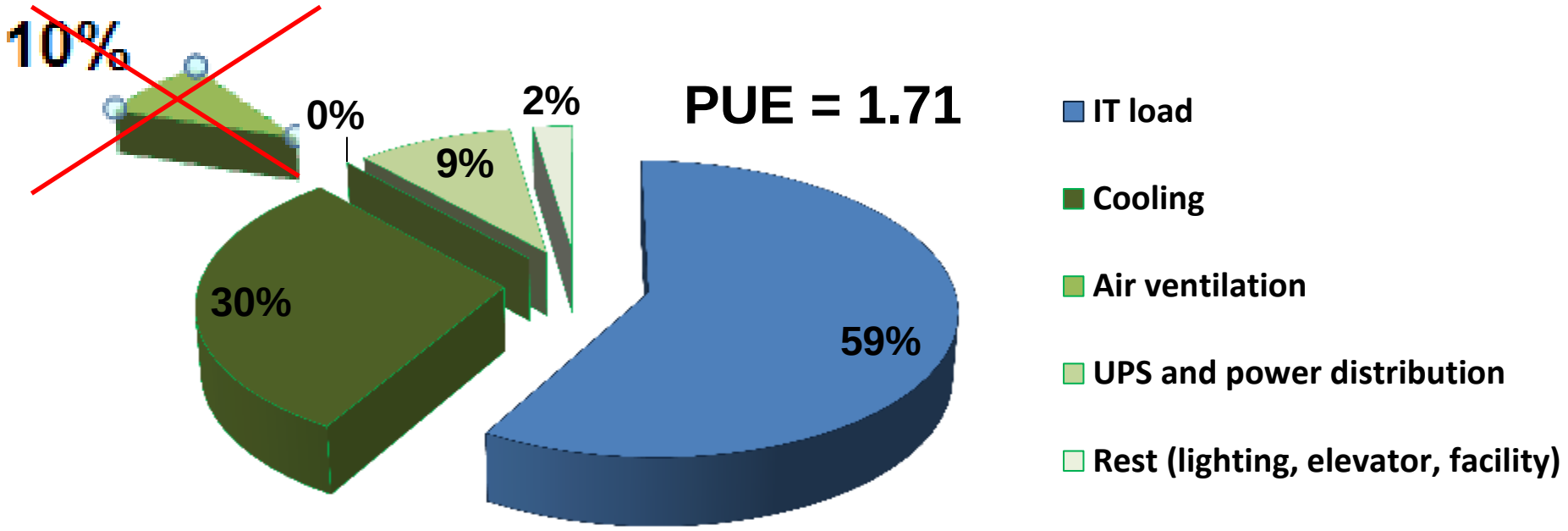
- Short air path
- No air ducts
- No dampers





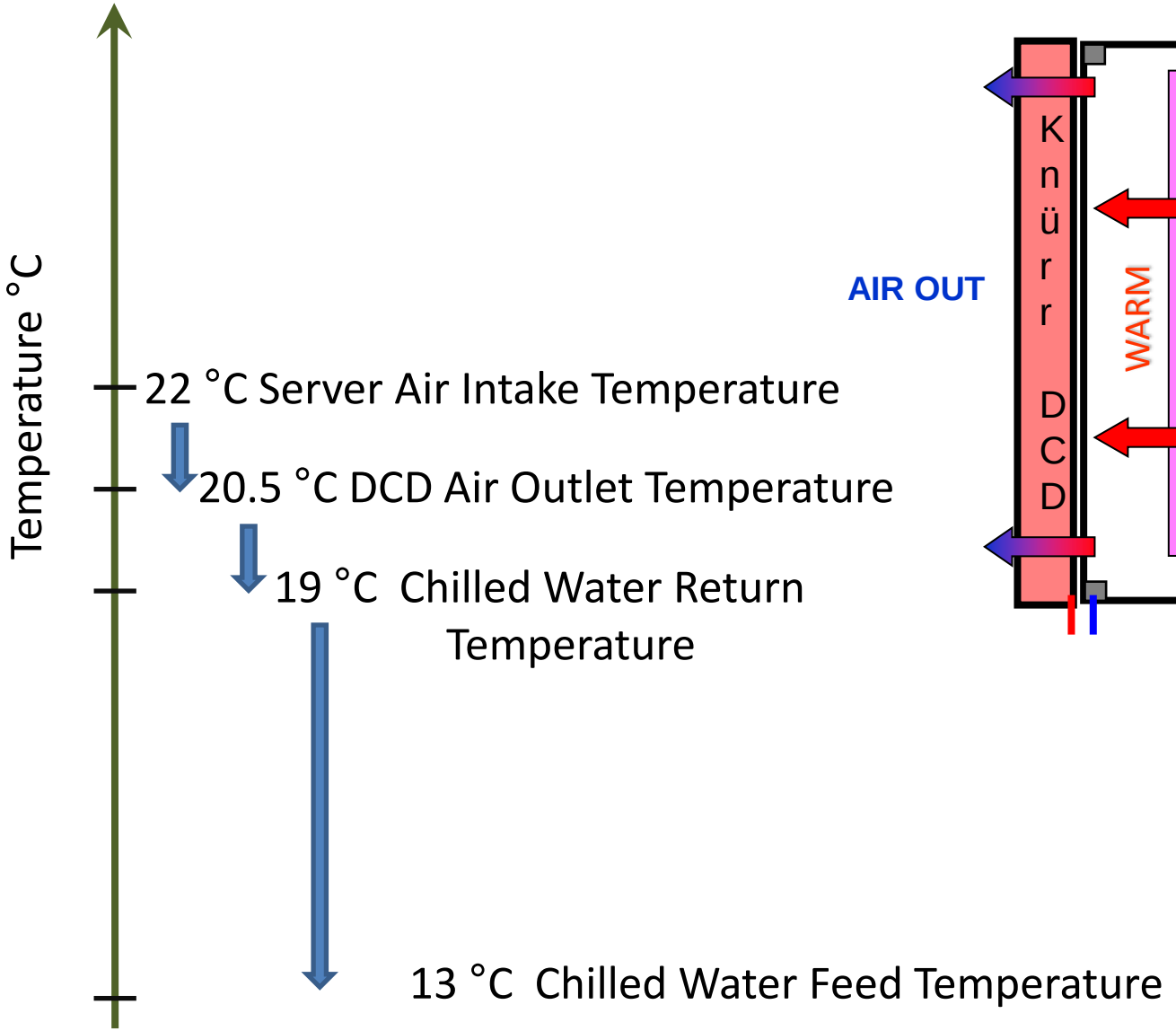
Source: ASHRAE 2005

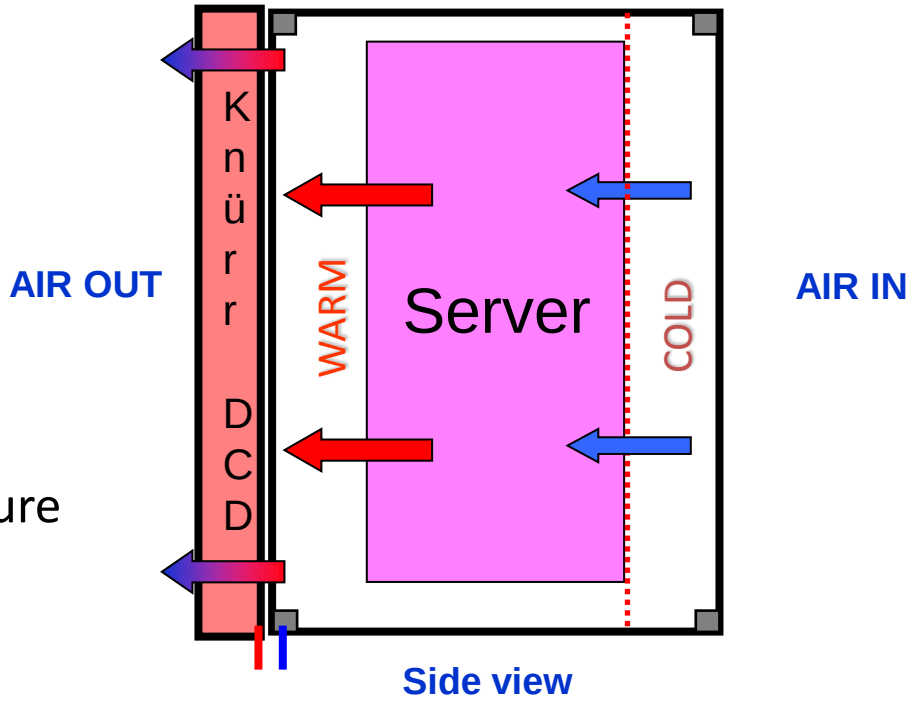
Knürr DCD – PUE Calculation



PUE	2	1,71
IT load	1000 kW	1000 kW
Cooling	**600** kW	**514** kW
Air ventilation	200 kW	**0** kW
UPS and power distribution	160 kW	160 kW
Rest (lighting, elevator, facility)	40 kW	40 kW
Total Power	**2000 kW**	**1714 kW**

Knürr DCD – Temperatures





Knürr DCD – Server Inlet Temperatures

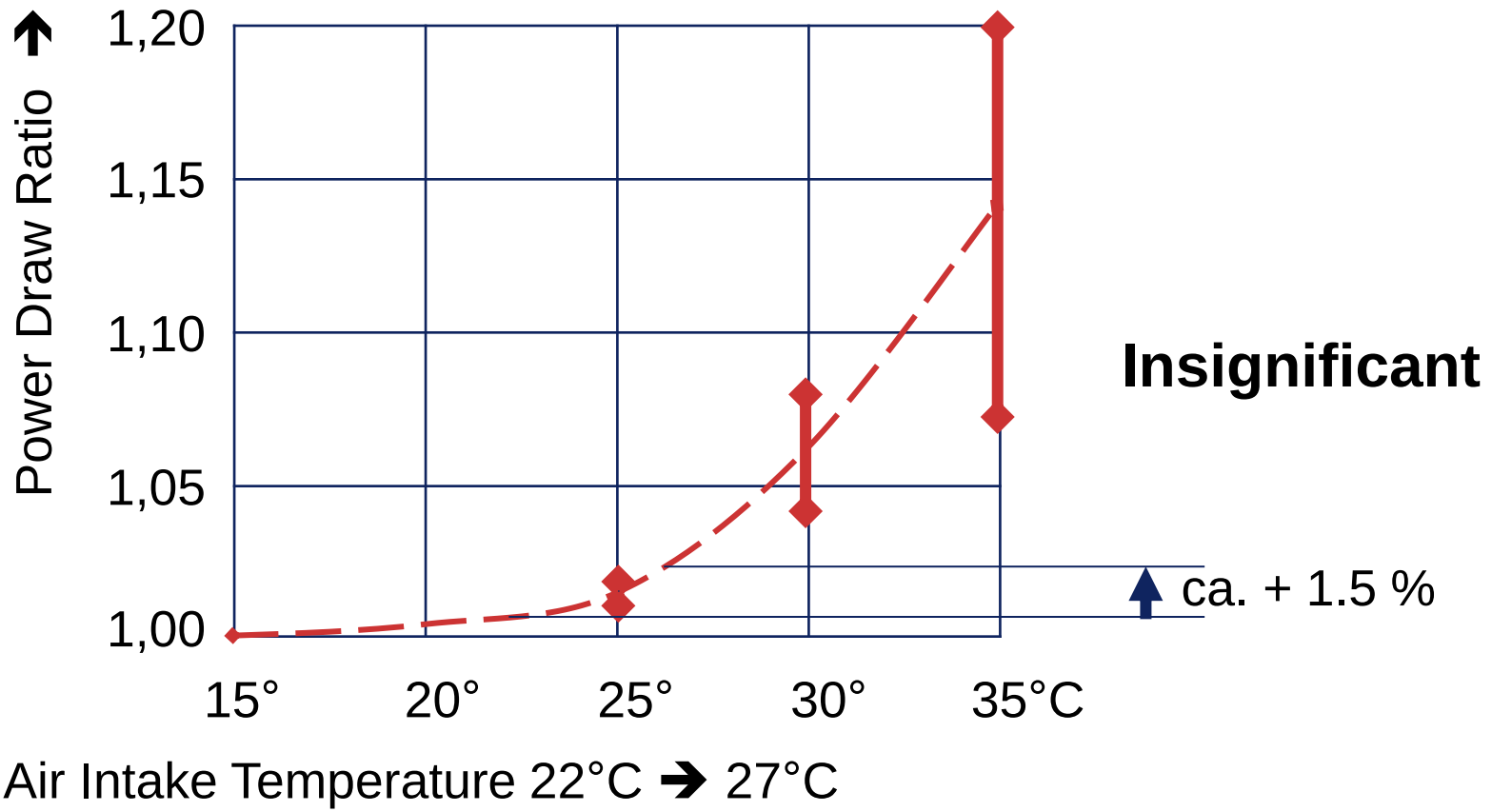
Discuss with server vendor:

✓ Define as warm as possible? "**optimum"**

Too warm server air intake temperatures causes

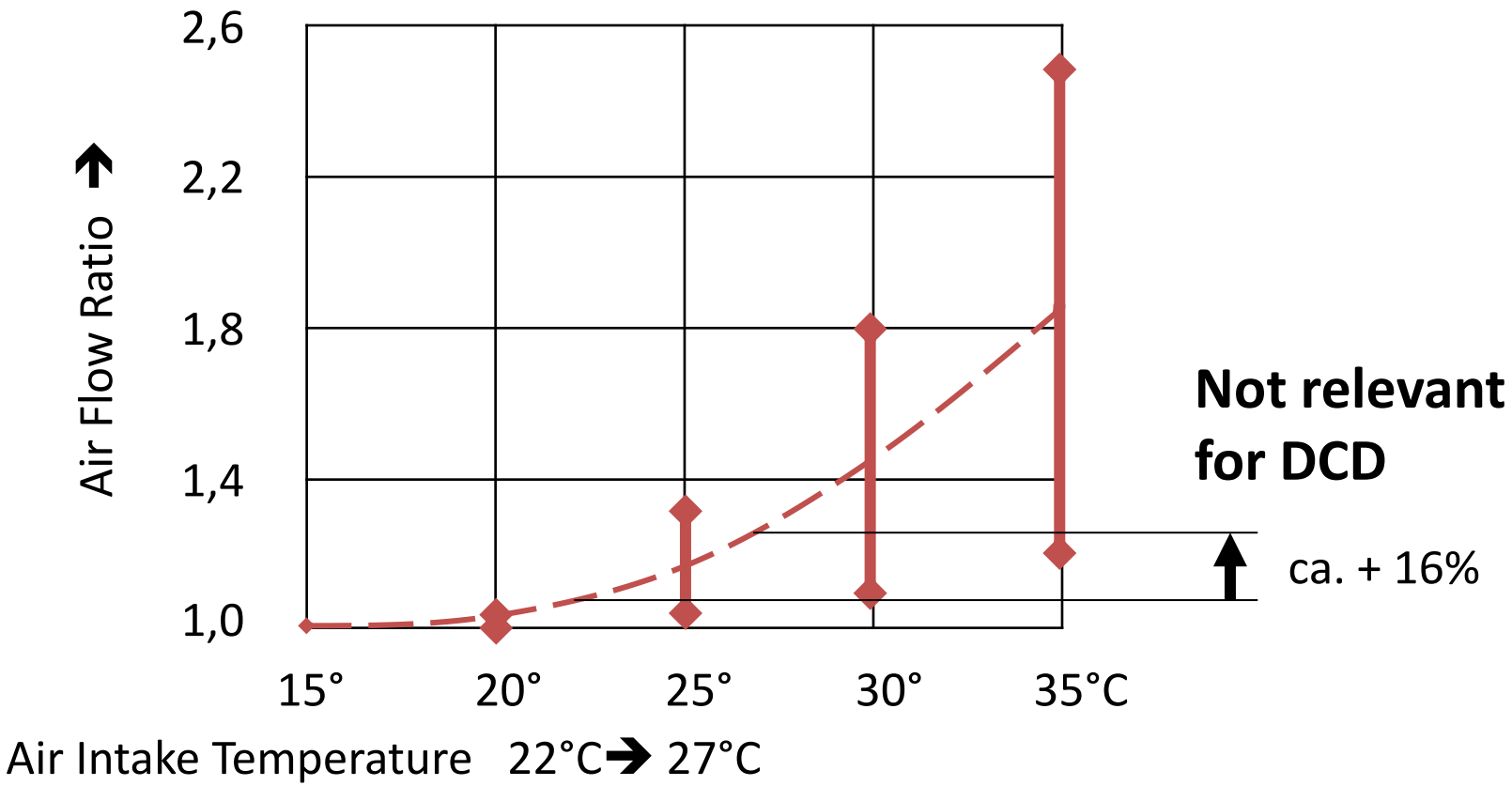
- Increase of cooling air flow
- Increase of power consumption
- Negative effect for lifespan
  However sometimes a new server counts

Server Power Draw vs. Intake Temperature



Source: 2011 Thermal Guidelines for Data Center Processing Environments - Expanded Data Center Classes and Usage Guidance (ASHRAE Whitepaper)

Server Air Draw vs. Intake Temperature



Source: 2011 Thermal Guidelines for Data Center Processing Environments - Expanded Data Center Classes and Usage Guidance (ASHRAE Whitepaper)

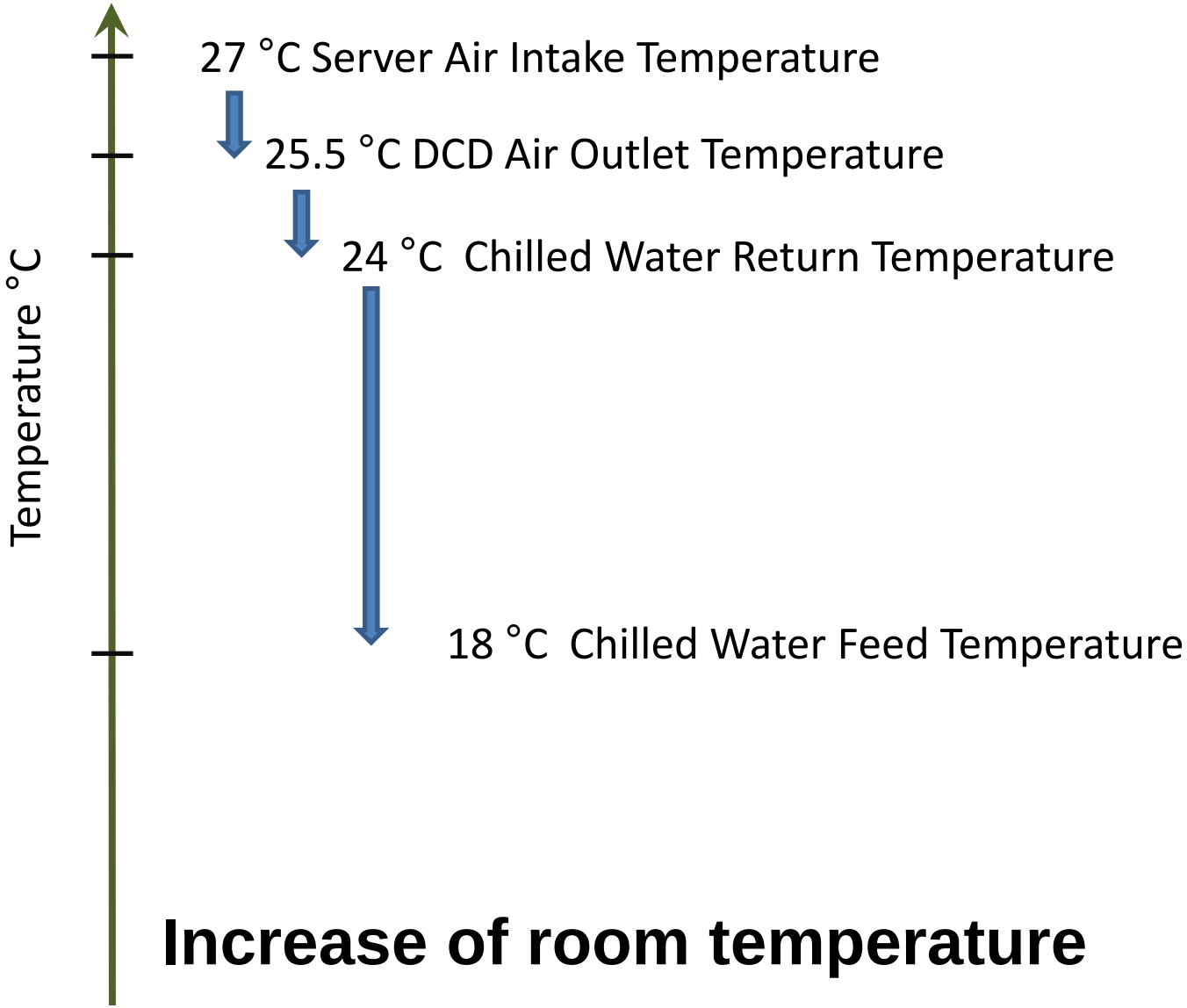
Knürr DCD – Testing

Check for

- Cooling capacity
- Air leakages
- Cooling air temperatures
- Increase of power draw
- Possible increase of chilled water temperatures
- Water flow rate optimisation

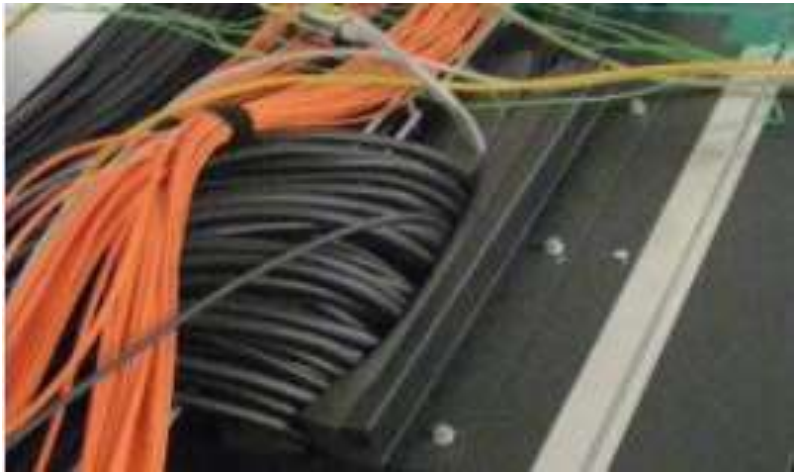


Knürr DCD – Temperatures



Knürr DCD – Air Tight Installation



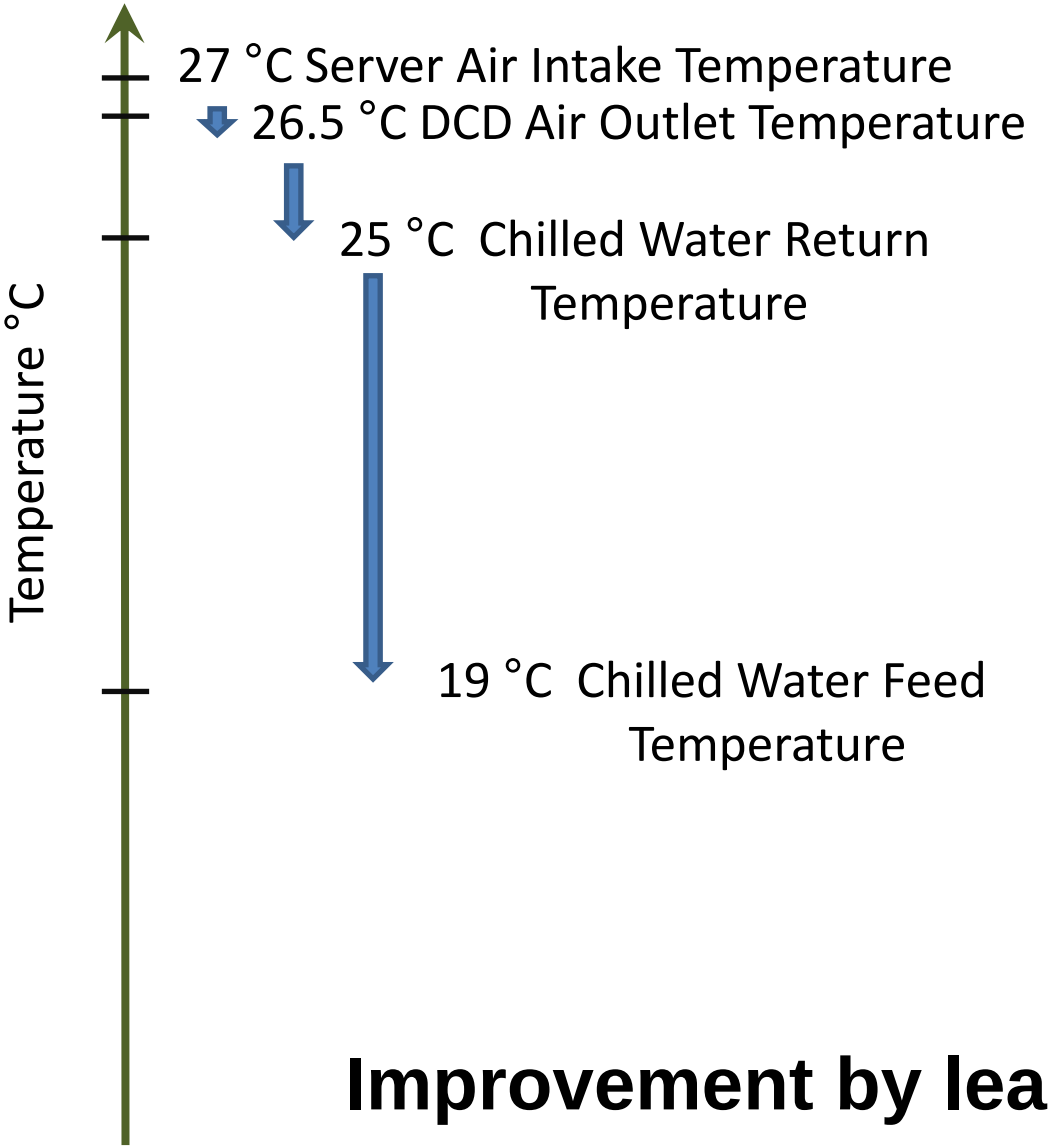


Pay attention to:

- Internal re-circulations
- Air flow direction
  cold aisle / warm aisle
- Cable inlets



Knürr DCD – Temperatures





Improvement by leakage reduction

Knürr DCD – Temperatures

Temperature °C

27 °C Server Air Intake Temperature

26.5 °C DCD Air Outlet Temperature

25 °C Chilled Water Return Temperature

22 °C Chilled Water Feed Temperature

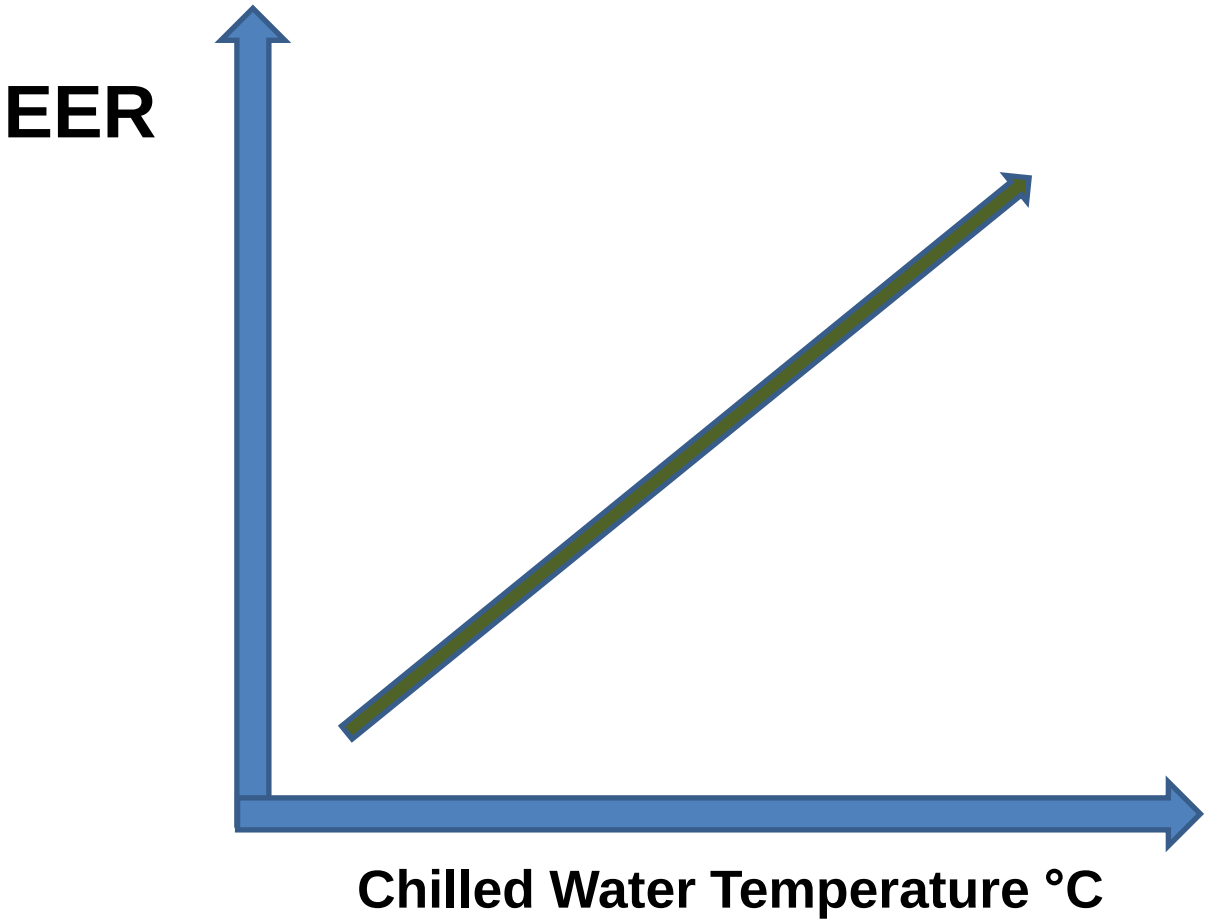


Dynamic chilled water flow rate control

Reduction of chilled water temperature spread

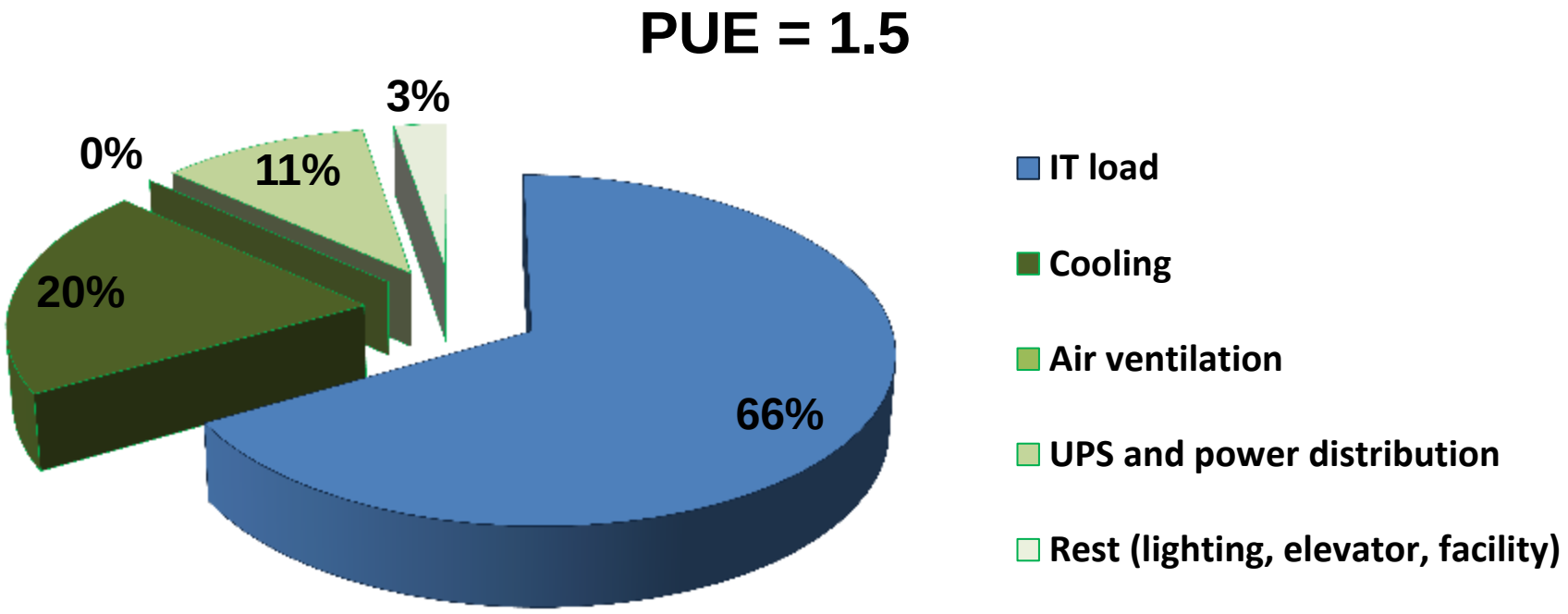
Increase of pipe cost and pump power consumption

Knürr DCD – Positive Chiller EER effect



Increase of Chiller EER lowers the PUE

Knürr DCD – PUE Calculation



PUE	2	1,5
IT load	1000 kW	1000 kW
Cooling	**600** kW	**300** kW
Air ventilation	200 kW	0 kW
UPS and power distribution	160 kW	160 kW
Rest (lighting, elevator, facility)	40 kW	40 kW
Total Power	**2000 kW**	**1500 kW**

Knürr DCD – Room cooling requirements

Knürr DCD operation:

Includes

- ✓ Massive sensible cooling
- ✓ Cooling for other minor heat loads

Not includes

- ! Air filtration
- ! Humidity control
- ! Fresh air supply

GSI GreenCube

Knürr DCD - Best Practice Example - Germany



GSI GreenCube

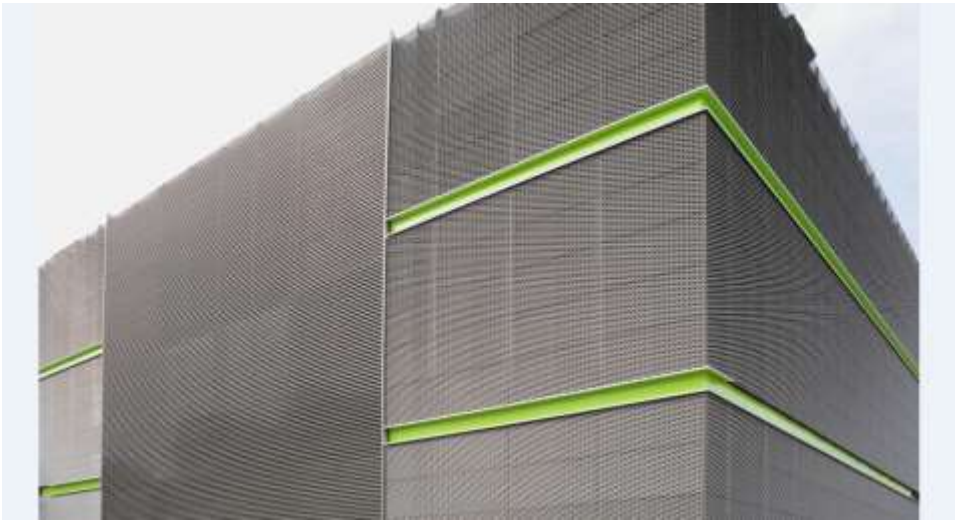
Knürr DCD - Best Practice Example - Germany

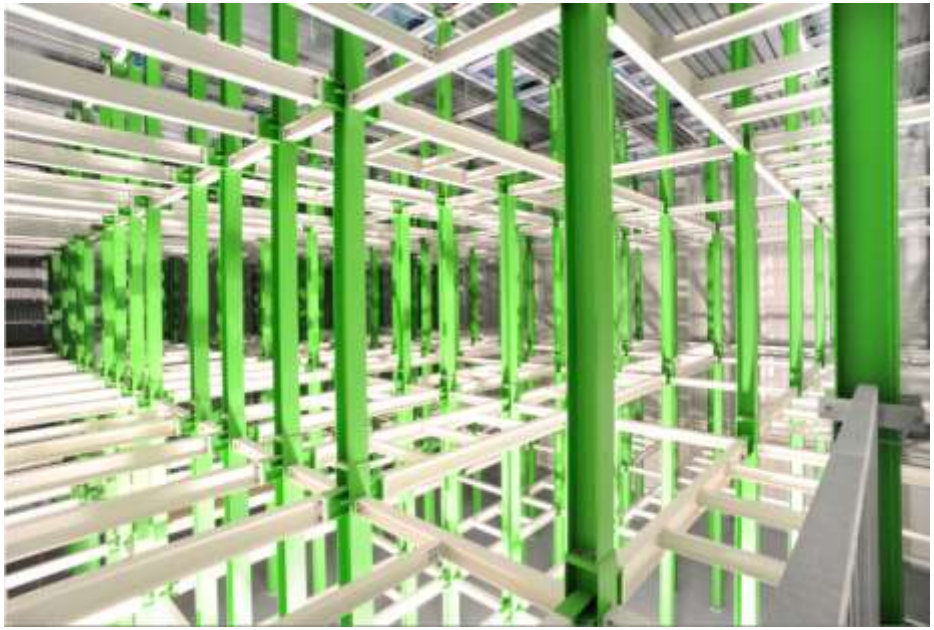
Item	Customer requirements
Type	Primary Data Centre
Location	Germany, Darmstadt
Number of Racks	768 on 6 levels
Average IT Load per rack	16 kW (range 1-35kW)
Total IT Load	12,000 kW
TIER –Level	> II (N+1 in cooling; 2N power supply; no UPS)
PUE	< 1,1on yearly average
External dimensions	27 m x 27 m x 27 m

GSI GreenCube

Knürr DCD - Best Practice Example - Germany

- 6 level internal steel frame
- 3 levels of chilled water supply
- Floor made of steel panels
- Lowest construction cost
- **Cold room concept**







GSI GreenCube

Knürr DCD - Best Practice Example - Germany

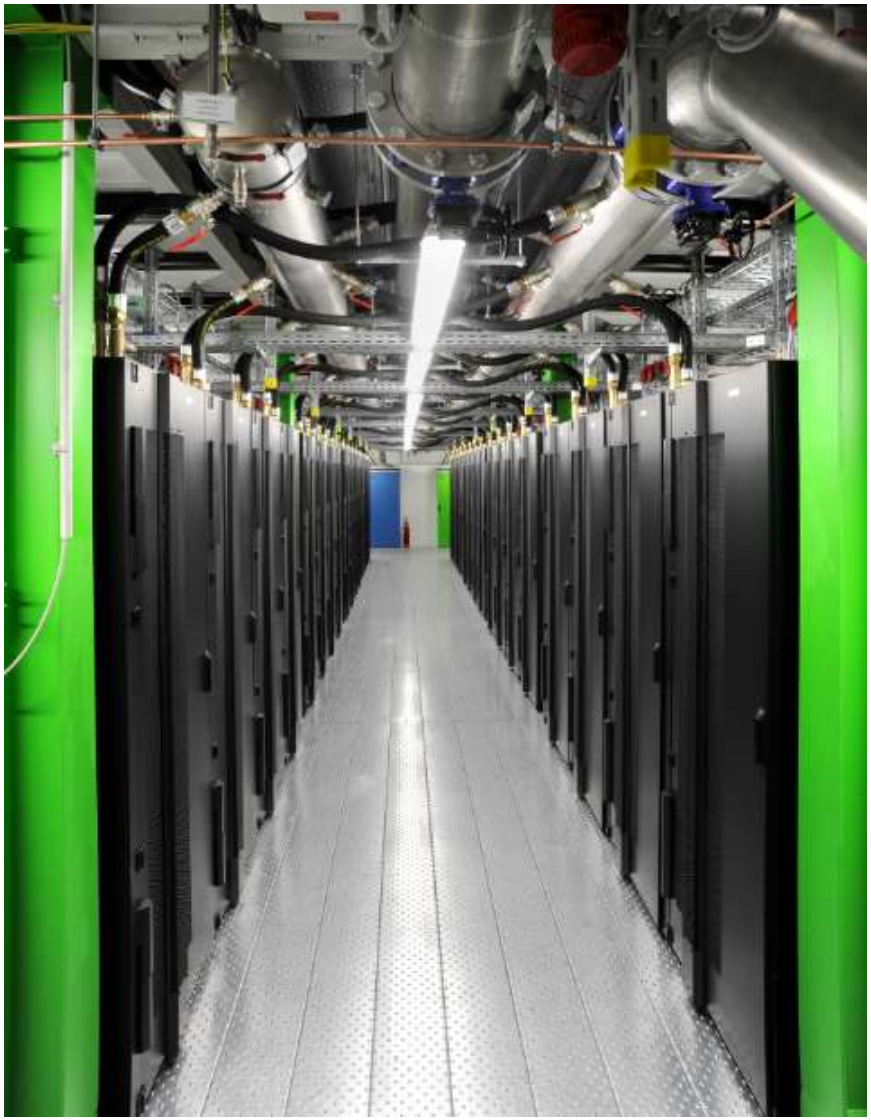
- Slightly oversize pipe dimension for back pressure minimisation
- “Tichelmann” pipe arrangement (common return pipe – easy for hydraulic balance)





GSI GreenCube

Knürr DCD - Best Practice Example - Germany





GSI GreenCube

Cooling with adiabatic cooling towers
Example for Germany



Partial PUE for cooling 1,04 on yearly average

Knürr DCL – Lateral Cabinet Cooling Unit

Modular Rack Cooling from 6 to 60 kW





Knürr DCL – Lateral Cabinet Cooling Unit

DCL Product Features



- Modularity
  - Up to four Knürr DCM racks per Knürr DCL
  - Two room-neutral rack cooling concepts
- Reliability
  - Multi-level “fail-safe” controller
  - N + 1 fan redundancy
  - Comprehensive alarm and monitoring functions
  - Automatic door opening
- Energy Efficiency
  - Controlled EC fans ➔ minimized power consumption
  - Generously proportioned heat exchanger ➔ long free cooling time
  - Dynamic fan speed control ➔balanced air flow

Knürr DCL – Lateral Cabinet cooling unit

- Compact design
  ➔ Best floor space utilization
- Short cooling air path
  ➔ Cooling close to heat source
- Noise reduction



Knürr DCL









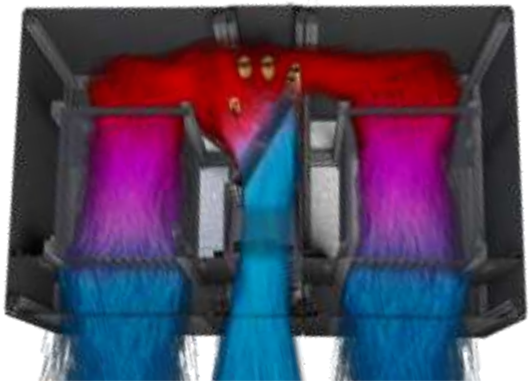
Modularity

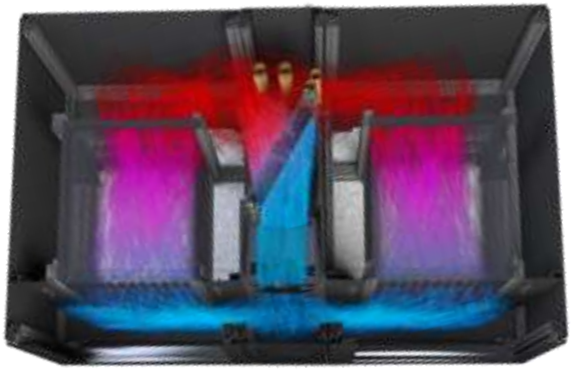
- Up to 4 server racks per cooling unit
- Numerous combinations of Knürr DCM and Knürr DCL
- Rack cooling from 6 to 60kW



Knürr DCL – Two Types of Room Cooling

- **No heat load to the room**
- **Contain the hot air**





DCL-H

- "Hybrid" configuration

Warm air flow is separated from the room
Cabinet are **open** at the **front**
and **closed** at the **rear**

- The better alternative to

hot aisle containment

- Cold air reserve from the room

DCL-L

- Rack cooling
- Front and rear door closed
- No air flow to/from the room

Knürr DCL – Heat Exchanger

- High performance heat-exchanger with great efficiency - Generous sizing

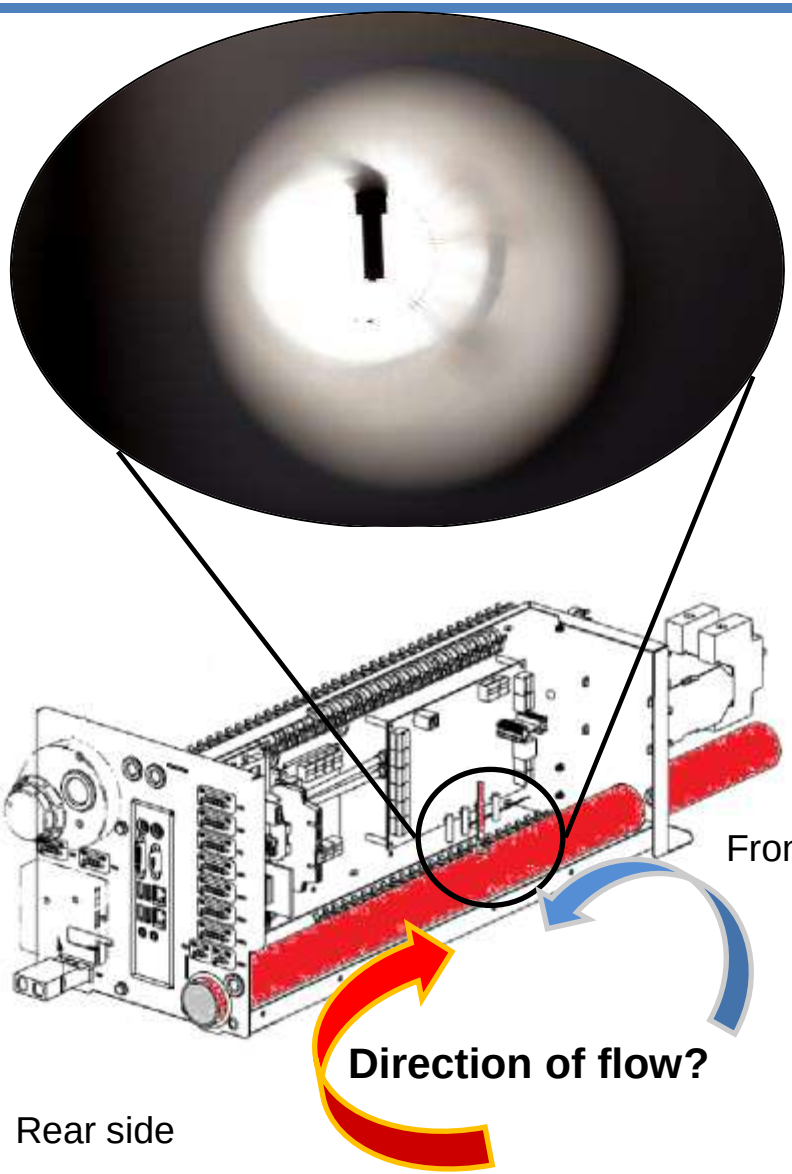
  Supply air temperature 0.5 to 3 K higher than the chilled water return temperature

- **Sweet spot: 10 to 20 kW cooling capacity**

- Low pressure drop app.50 Pa (air) and app 50kPa (water) for improved energy efficiency
- Hydrophilic coating and vertical fin orientation improves condensate drainage
- No need for droplet separator
- Low air velocity across the heat exchanger



Knürr DCL – Fan Speed Control



Indirect pressure different measurement

- Precise and reliable way of measuring pressure difference
- Temperature sensor in the bypass line
- Temperature of the air in the bypass indicates the direction of the air flow



Knürr DCL – "Fail-safe" System

In the event of a controller failure:

- CW valve goes to "fully open" to maximize water flow through the coil
- Fans go to full speed to maximize airflow

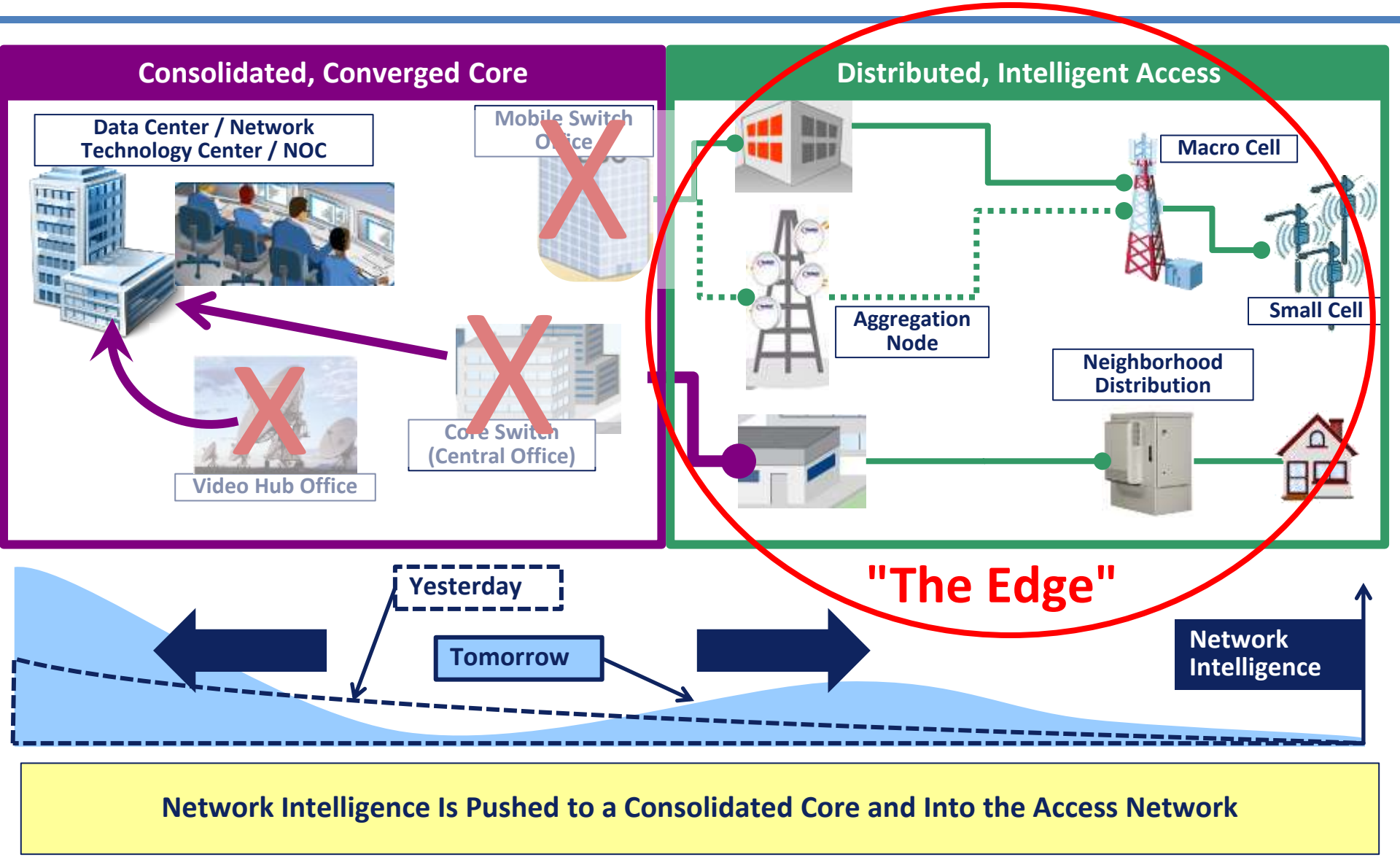
In the event of cooling failure:

- Automatic door openers (optional) will open the doors of the racks to utilize room cooling



Knürr DCL – Cooling solution for Edge Computing

Edge Landscape



Network Intelligence Is Pushed to a Consolidated Core and Into the Access Network

Edge Landscape

Applications

- Banks / Branch Offices
- Retail Stores
- Warehouse logistics
- Video streaming, gaming
- Internet switching centers
- Industry 4.0
- Sensor Networks
- Internet of Things
- HPC (Supercomputing)

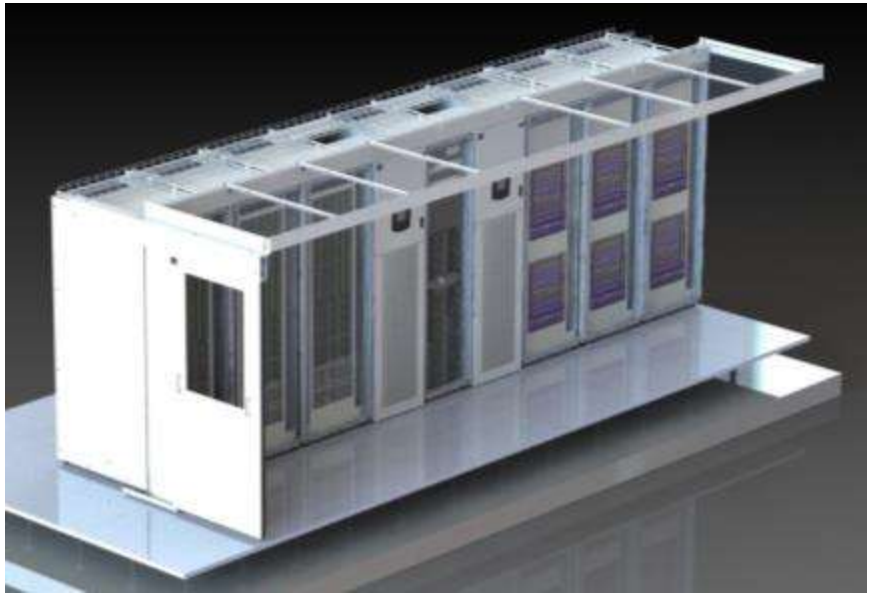
Drivers

- Data security
- Legislation
- Bandwidth
- Real-time applications
- Latency
- Internet independency
- Autonomous operation
- Isolated Networks
- Need for
  - ⇨ Local computing
  - ⇨ Local storage

Requirements

- Capacity on demand
- Selectable redundancy
- Rapid deployment
- … into office rooms
- Physical protection
- Standard modules
- Central administration
- Remote management
- Remote maintenance
- Automated operation

SmartRow with DCL – Example for Cooling of Edge Computing



- Global design
- "Edge Computing" for hundreds of branch locations around the globe
- “Boxed” very small data center
- Racks + PDUs + UPS + Row Cooling + Fire Prevention

⇨ Cooling with DCL-H, cold room concept, no heat load to the room

⇨ Cold air distribution by using a containment

⇨ Includes all relevant data center infrastructure

SmartAisle™

Aisle Containment

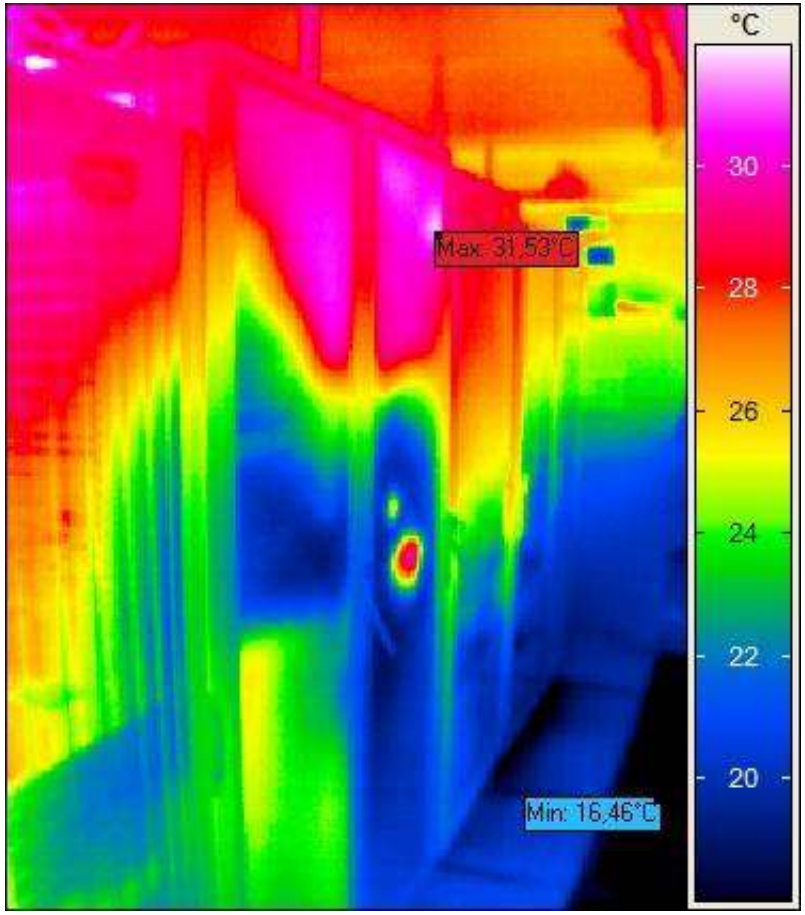


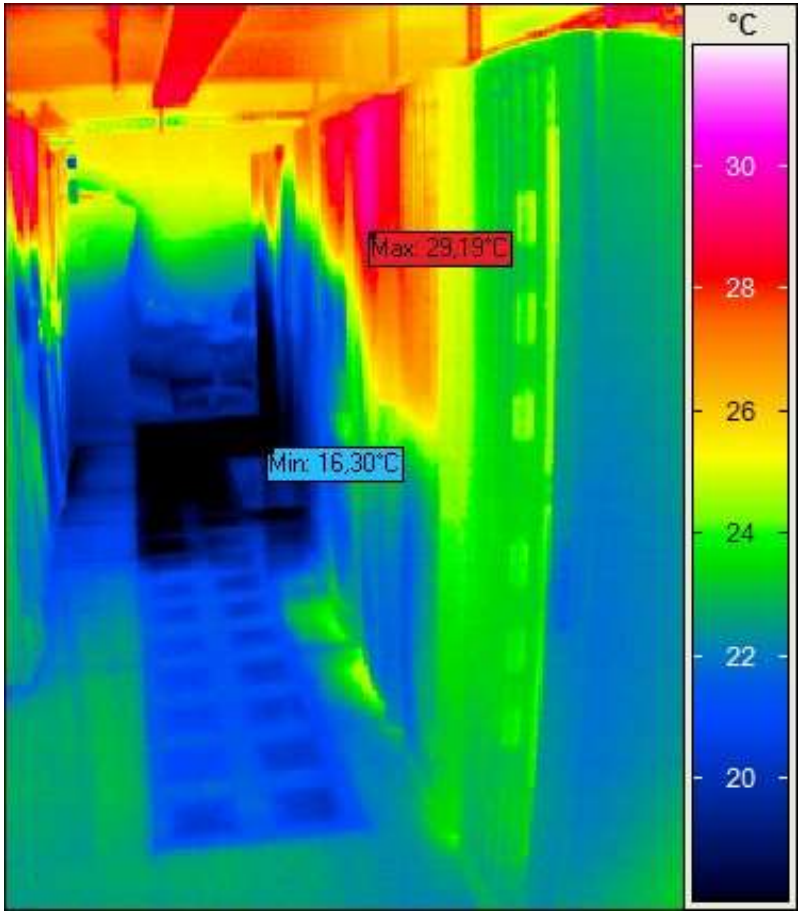
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Aisle Containment



The separation of warm and cold cooling air is the mother of rack cooling

Temperature profiles without containment

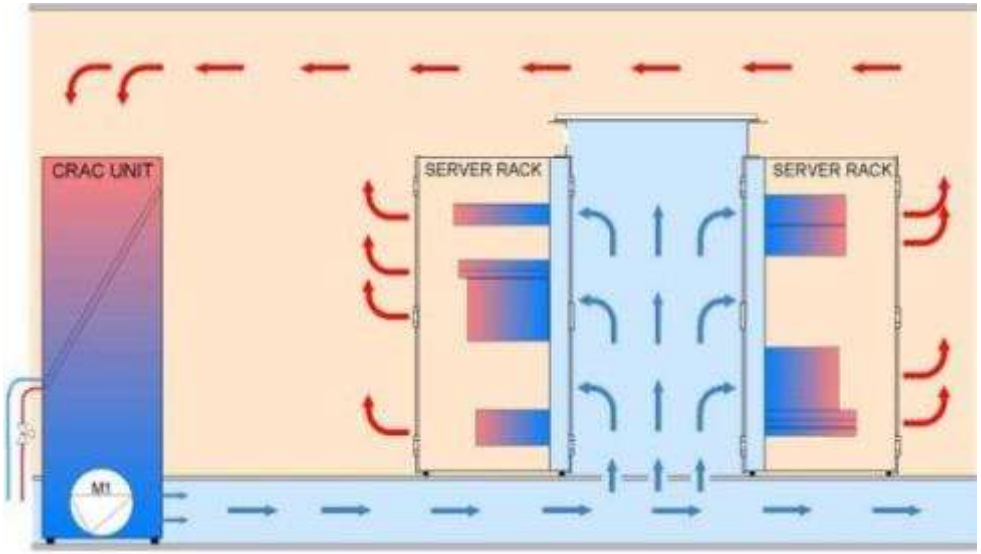




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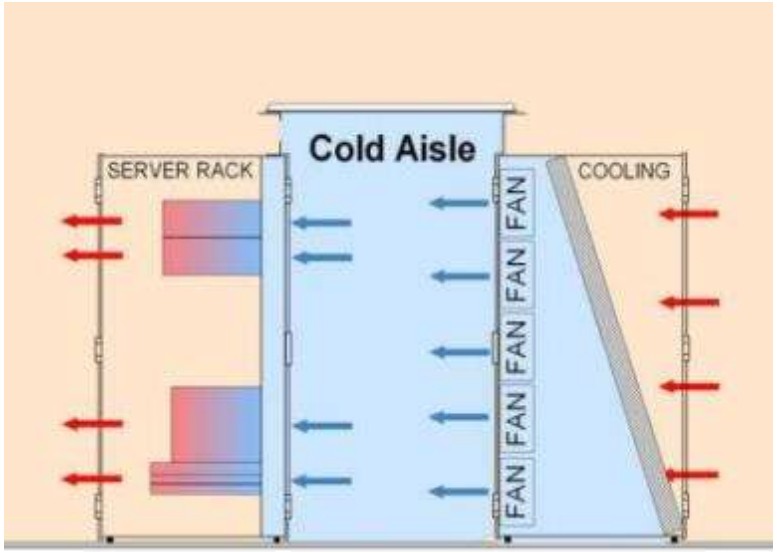
Two principles of air circulation

ROOM COOLING



→ main application in the market
→ for mid-sized to large DC
→ usually with raised floor

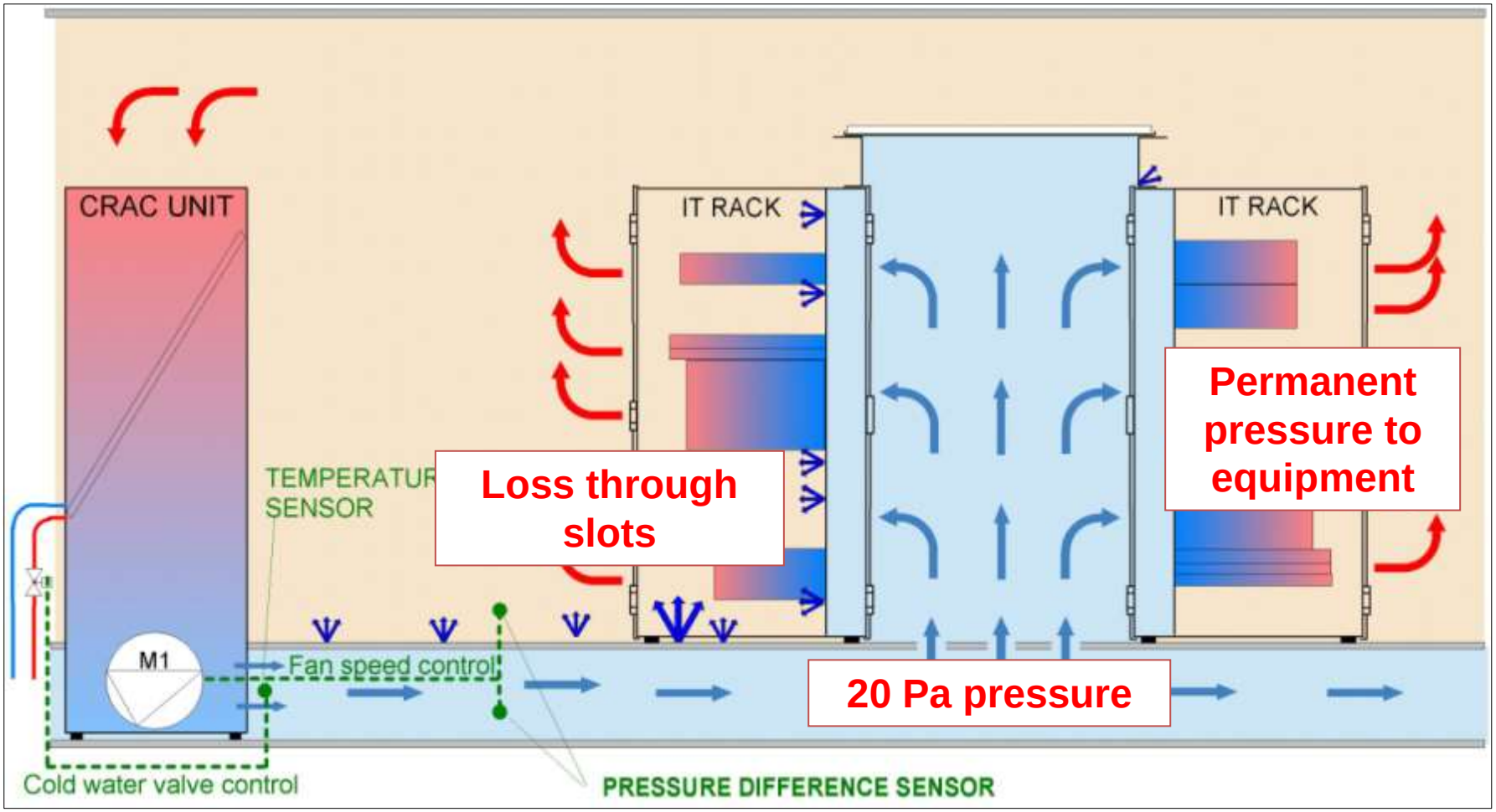
ROW COOLING



→ for small to mid-sized DC
→ raised floor not necessary

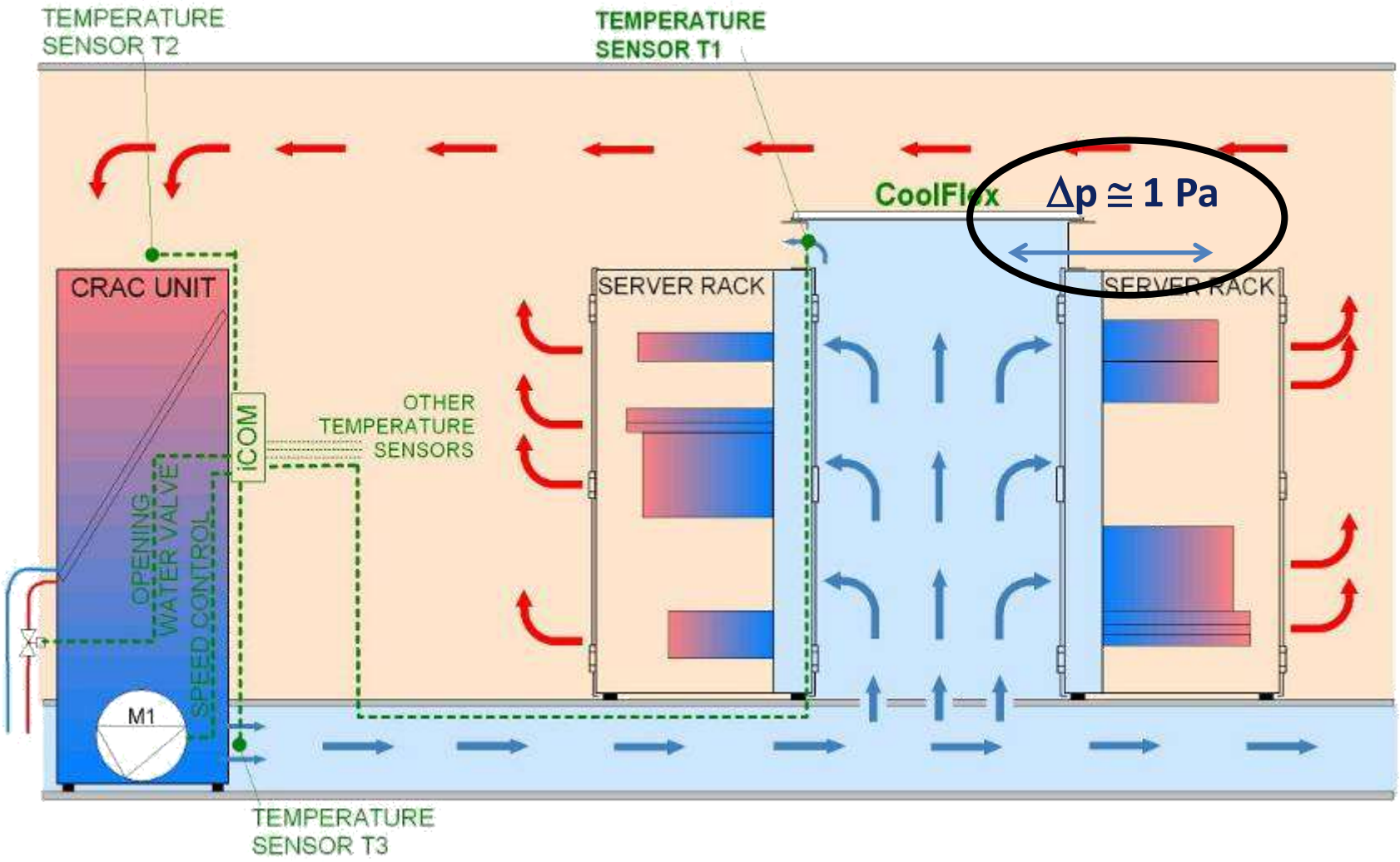
SmartAisle™
Aisle Containment

Common air flow control principle



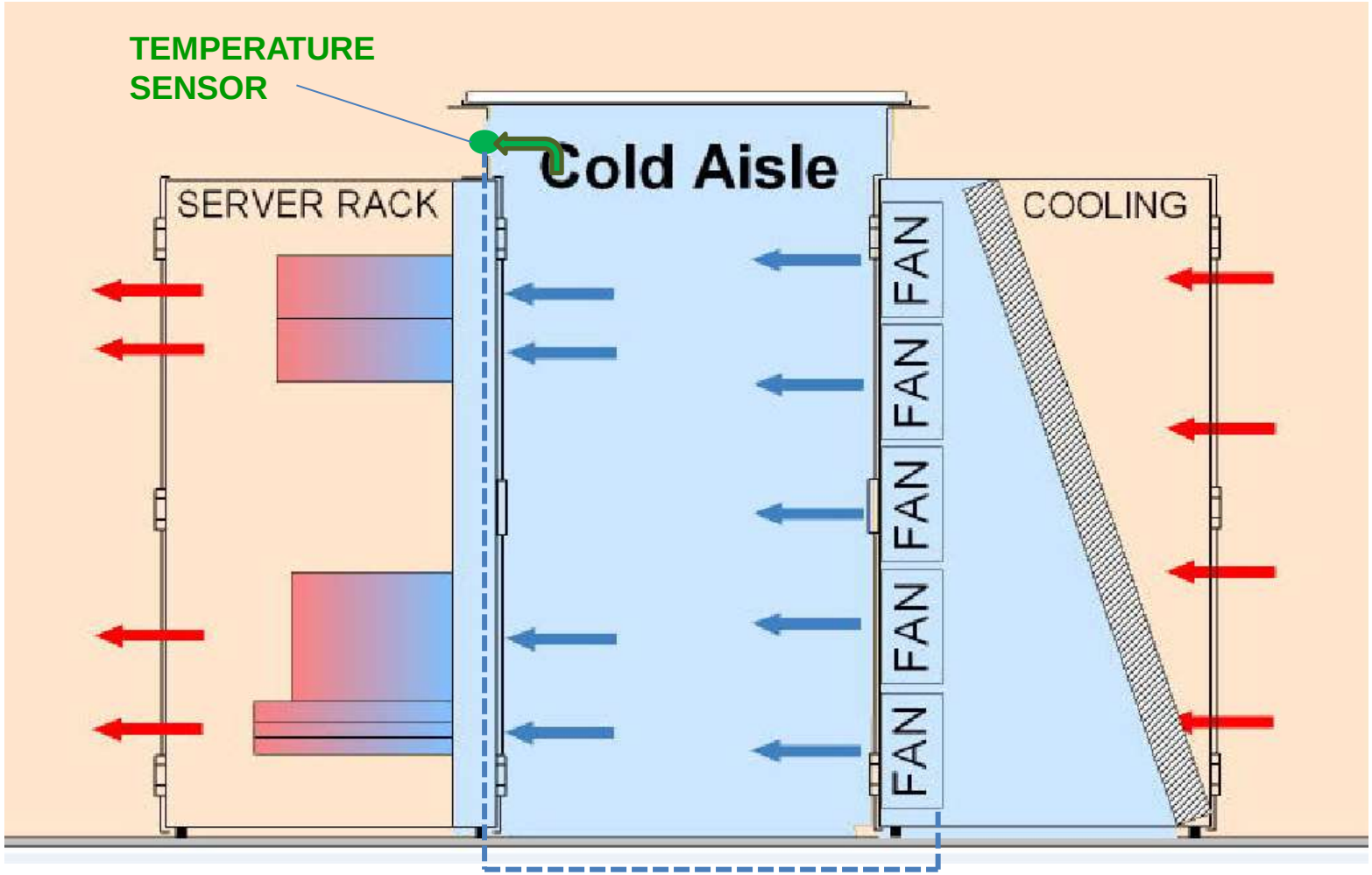
SmartAisle:

The State of the Art air flow control principle



SmartAisle™

Dynamic Control for row cooling



SmartAisle:
The State of the Art air flow control principle

Objectives for Smart Aisle Control:

- Elimination of air re-circulation
- Evenly cooling air distribution
- No “waste” of cooling air ➔ Minimization of leakage air
- Reduction of fan power consumption ➔ PUE optimisation

Conclusions and Recommendations

1. Stay below the nominal cooling capacity
2. Increase the room temperature to an optimum
3. Use dynamic control for chilled water flow rate and temperature
4. Lower the warm/cold zone pressure difference by dynamic fan speed control
5. Detect the demand of cooling air



Thank you

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BCA-IDA GREEN MARK

