OCP Harmonization

Jessica Gullbrand & Rolf Brink
Cold Plate & Immersion Work Stream Leads
Advanced Cooling Solutions

Liquid Cooling Terminology

Liquid Cooling Terminology

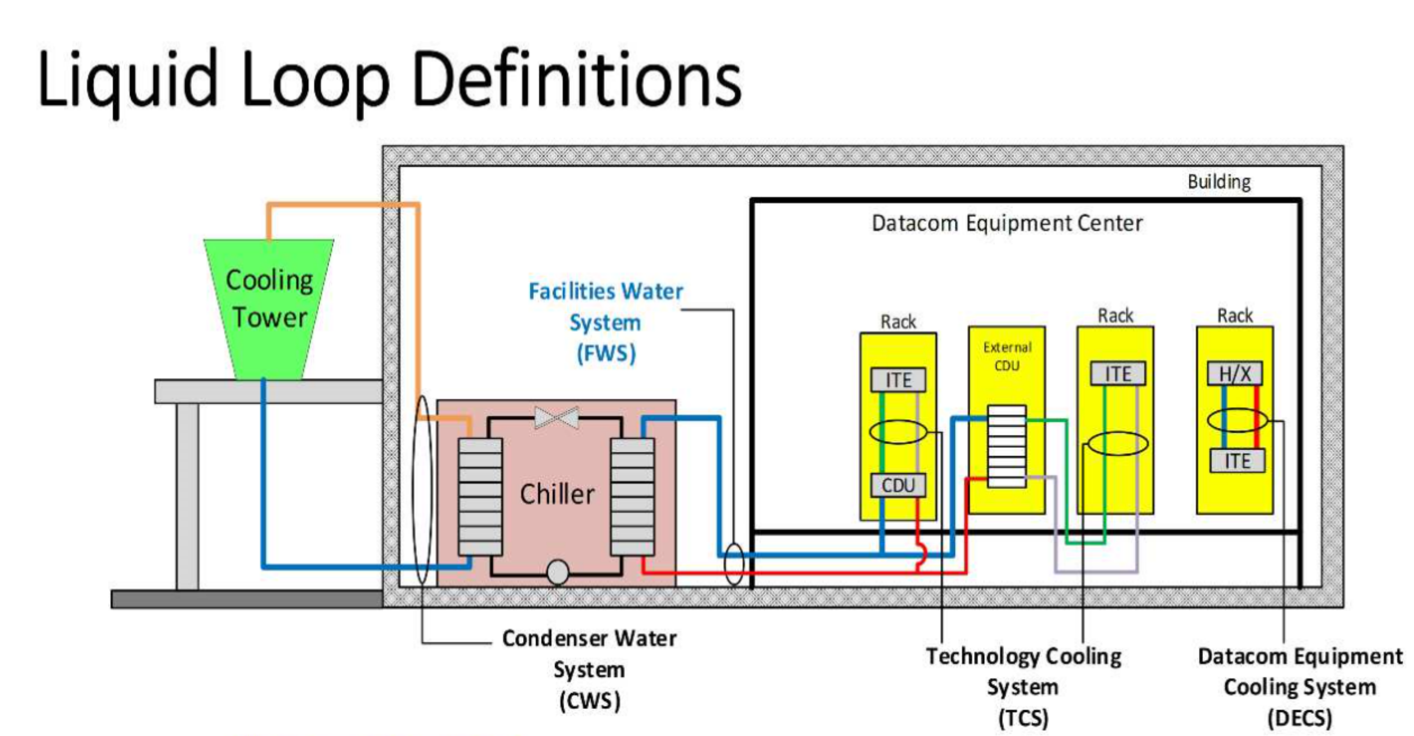
Develop OCP specific or use existing? F.ex. ASHRAE

ASHRAE terminology:

- **Condenser Water System (CWS)**
- **Facility Water System (FWS)**
- **Technology Cooling System (TCS)**
- **Datacom Equipment Cooling System (DECS)**

Liquid Cooling Terminology

Worked with ASHRAE representatives to clarify the definitions



- ASHRAE's recommendation: eliminate DECS and use TCS

Figure from ASHRAE 2014. Liquid Cooling Guidelines for Datacom Equipment Centers, Book 4

Liquid Cooling Terminology

Cold Plate & Immersion Work Streams

- ASHRAE's FWS extended to also include other cooling liquids than water
- TCS used and DECS not used

Cooling Liquid Quality

Cooling Liquid Quality

Something for OCP to developliquid quality requirements?

References:
ASHRAE 2014, Liquid cooling guidelines for datacom equipment centers, second edition, Atlanta ASHRAE

EEHPCWG 2019, Open specification for a liquid cooled server rack, draft version
https://docs.google.com/document/d/14OkMv_q28Aw9KBlRkFIMSLuQmeT-2p2Gy81zoT706XI/edit

ASHRAE 2019, Water-Cooled servers common designs, components, and processes, White Paper, Atlanta ASHRAE

Note: ASHRAE only considering water with additives cooling liquids!

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Baseline water comparison for Cooling loop April 2019
Prepared for **EEHPCWG by Nigel Gore**

This document compares water quality guidelines issued by industry bodies for the Technology Cooling System (TCS)

Parameter	Maximum Limit or Range				Notes
	EEHPCWG	ASHRAE TCS	ASHRAE FWS	IBM DECS	
TSS	1 ppm	<3 ppm	-----		
pH	7.6-10.3	7 to 9***	7 to 9	6.5 to 8	Metallurgy dependent
Alkalinity	------	------	------		
Calcium	50 ppm	<20 ppm**	<200 ppm	<1.0 ppm	* or 100 ppm total hardness
Magnesium	50 ppm	--------	--------	<1.0 ppm	* or 100 ppm total hardness
Silica	-----	-----	------	<1.0 ppm	
Chloride	25 ppm	<5 ppm	<50 ppm	<0.50 ppm	
Sulfate	25 ppm	<10 ppm	<100 ppm	<0.50 ppm	
Iron	1.0 ppm	------	--------	See note	IBM states that all metals to be less than 0.10 ppm
Copper	0.5 ppm	------	--------	See note	IBM states that all metals to be less than 0.10 ppm

/*2014 Ashrae Datacom series 4 Liquid Cooling Guidelines for Datacom equipment discrepancy with 2019 Water-cooled Servers whitepaper
pH on TCS 8.0 to 9.5 (7 to 9)
Calcium on TCS <0 ppm (<20 ppm)

Baseline water comparison for Cooling loop April 2019
Prepared for **EEHPCWG by Nigel Gore**

In addition to Baseline water specifications stated the following parameters are mentioned as areas of best practice and consideration.

Parameter	Maximum Limit or Range OSHWG	ASHRAE TCS	ASHRAE FWS	IBM DECS	Notes
Turpidity		<20 NTU	<20 NTU	<1 NTU	The measure of particles in a fluid that affect the clarity of water. Quantitative determination of Turbidity defined by ISO 7027-1:2016
Conductivity					According to Ashrae is a measurement of Mineral content in the water, high conductivity is an indicator of bacterial degradation of the nitrite.
Filtration	<50 µm	<50 µm			Filtration considerations for the TCS loop, with maintenance schedules, up to 50 µm dependent on particulate size and cold plate fin width design.
Strainers					To purge sediment from a TCS loop, design considerations to consider strainer or side stream filters.
Commission of system					Water treatment with chemical flush of the TCS loop.
Bacteria	<1000 CFU/mL	<100 CFU/mL	<1000 CFU/mL	<100 CFU/ml	Maintain systems to limit bacteria count below 1000 CFU/mL
Chlorine, Chlorine dioxide, bromine,	Avoid	Avoid			Materials to avoid within TCS loop

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FWS Parameters

FWS Parameters

To add to current OCP ready list:				
Rack grounding point location				
Additional items for ACS				
Cooling				
Liquid interfaces per solution	1x feed+return	2x feed+return		
Pipe sizes	1" BSP	1,25“ BSP	1,5" BSP	2" BSP
FWS liquid heat capacity	{Specify}			
FWS liquid viscosity	{Specify}			
FWS circulation method	Pressure drive	Flowrate	Other (specify)	
FWS default flowrates	{Specify}			
FWS Supply temperature	{Specify}			
FWS desired return temperature	{Specify}			
FWS pressure (gauge)	50-100 kPa	100-400 kPa	400-800 kPa	
FWS Quality management	?	?	?	?

Leakage Detection & Mitigation

Leakage Detection & Mitigation

How important is it?

- Is it a significant concern?
- What are the concerns?
- Documentation or information about potential leaks?
- What type of detection is preferred?
- What type of mitigation is preferred?

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Performance Metric

Performance Metric

PUE versus TUE for liquid cooling

PUE = Power usage effectiveness

TUE = Total PUE, “PUE” type metric

ITUE = PUE for the IT equipment

Performance Metric

PUE

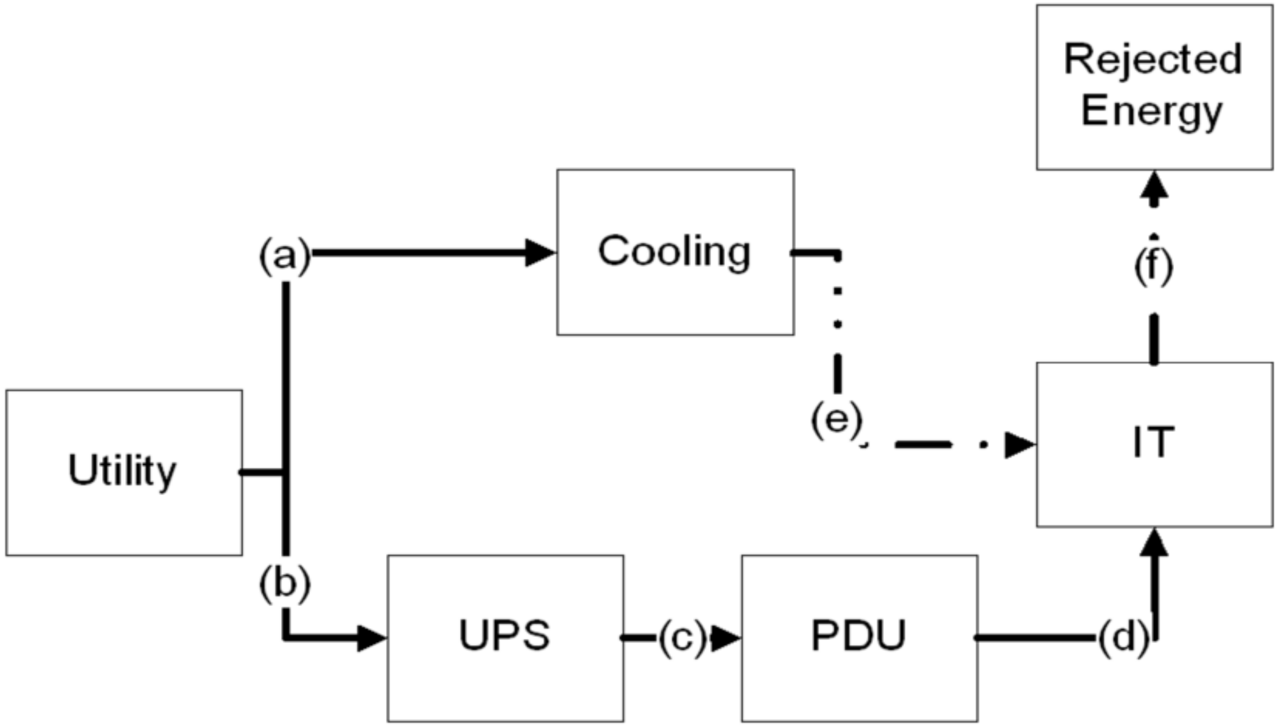
$$PUE = \frac{Total\ Data\ Center\ Annual\ Energy}{Total\ IT\ Annual\ Energy}$$

- Introduced in 2006 by Malone and Belady
- Developed and agreed to by EU Code of Conduct, DOE, EPA, Green Grid, ASHRAE, etc…

https://eehpcwg.llnl.gov/assets/as_tue_a_new_look_at_pue.pdf

Performance Metric

PUE Definition

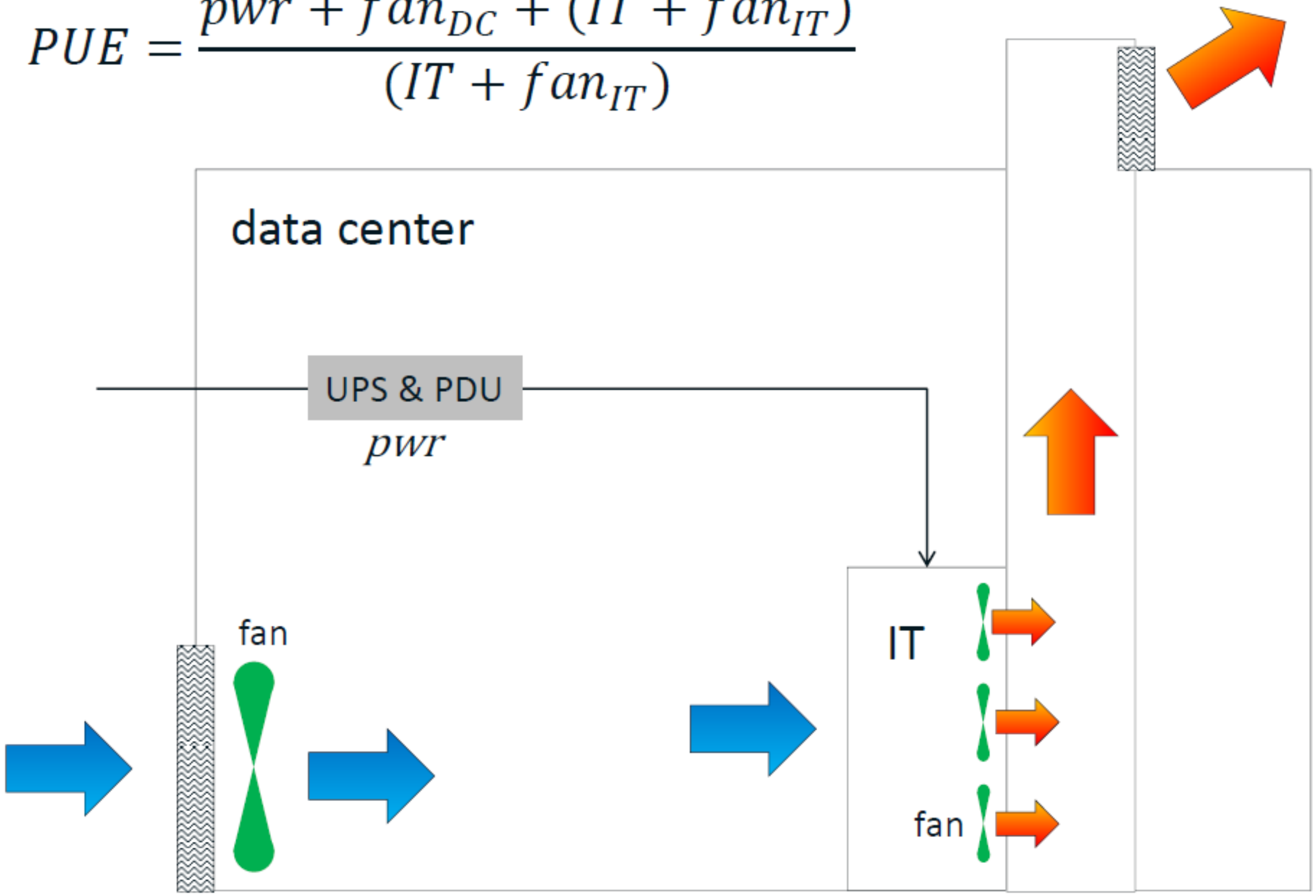


$$PUE = \frac{Total\ Energy}{IT\ Energy} = \frac{Cooling + PowerDistribution + Misc + IT}{IT} = \frac{a+b}{d}$$

Performance Metric

but PUE isn't perfect, consider…..

$$PUE = \frac{pwr + fan_{DC} + (IT + fan_{IT})}{(IT + fan_{IT})}$$



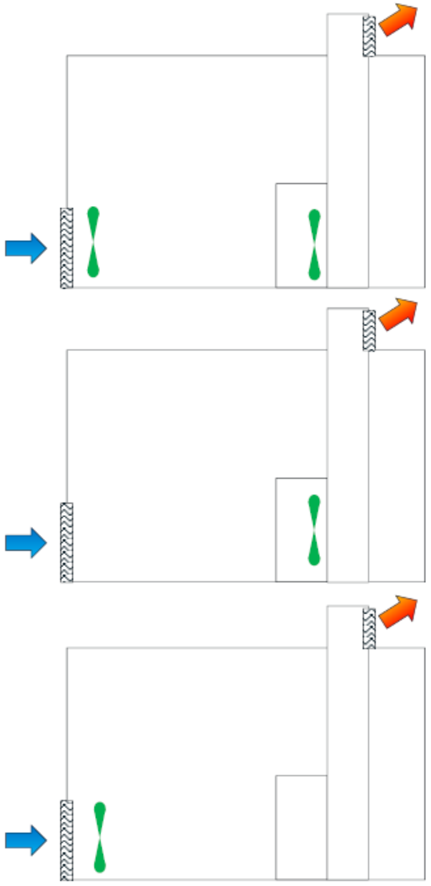
Performance Metric

Three variations…

a) both fans

b) IT fans only

c) bldg fan only



$$PUE_a = \frac{pwr + fan_{DC} + (IT + fan_{IT})}{(IT + fan_{IT})}$$

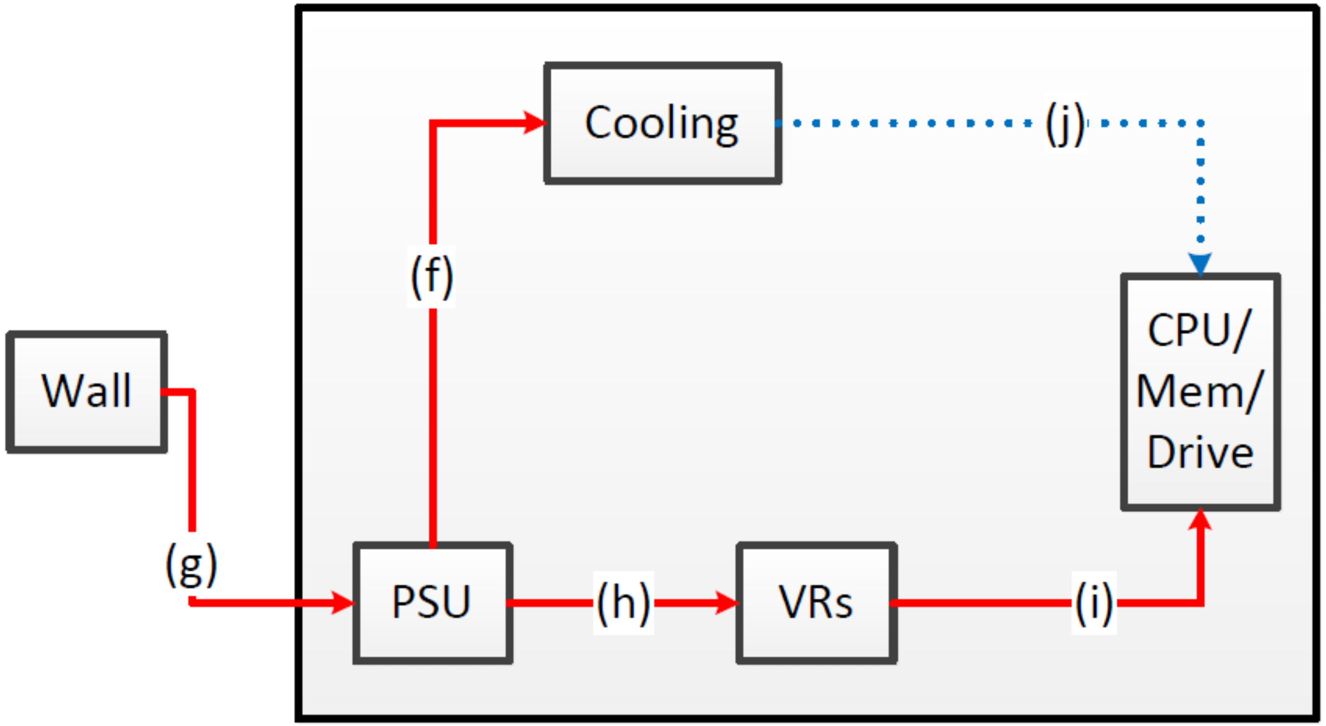
$$PUE_b = \frac{pwr + (IT + fan_{IT})}{(IT + fan_{IT})}$$

$$PUE_c = \frac{pwr + fan_{DC} + IT}{IT}$$

$PUE_b < PUE_a < PUE_c$ but is (b) best?
We don't know….

Performance Metric

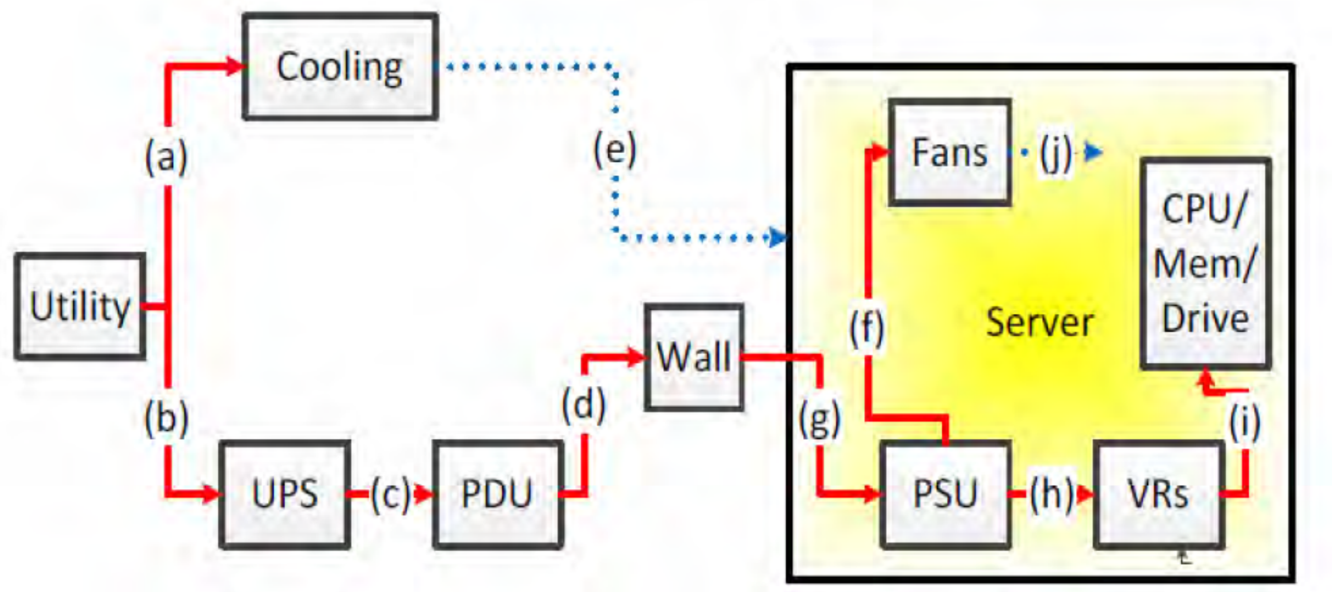
ITUE



$$ITUE = \frac{total\ energy\ into\ the\ IT\ equipment}{total\ energy\ into\ the\ compute\ components} = \frac{g}{i}$$

Performance Metric

TUE



$$PUE = \frac{Total\ Energy}{IT\ Energy} = \frac{a+b}{d}$$

$$ITUE = \frac{Total\ Energy}{Compute\ Energy} = \frac{g}{i}$$

$$TUE = ITUE \times PUE = \frac{a+b}{i}$$

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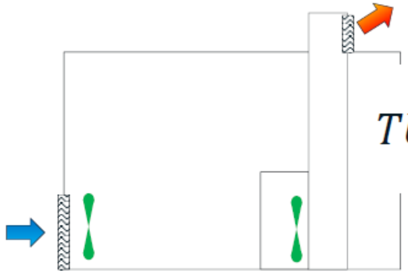
Performance Metric

Does it work?

a) both fans

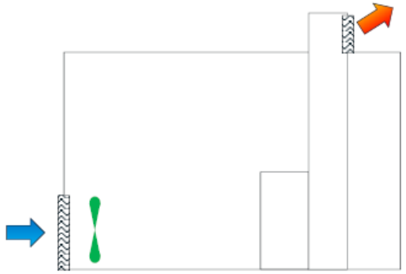


$$TUE_a = \frac{pwr + fan_{DC} + fan_{IT} + compute}{compute}$$

b) IT fans only

$$TUE_b = \frac{pwr + fan_{IT} + compute}{compute}$$

c) bldg fan only



$$TUE_c = \frac{pwr + fan_{DC} + compute}{compute}$$

The lowest TUE yields the lowest energy use. *Yes, it works!*

Heat Reuse

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Datacentre energy is "HOT"

THE STACK

DATA CENTRE

No time to waste: warmin
using heat from data cent

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Cooling the High-Performanc Computing Center of Atlanta' Tech Square

BY VOICES OF THE INDUSTRY - JULY 8, 2019 — LEAVE A COMMENT

An illustration of the DataBank ATL-1 data center, part of the Coda mixed-use development in Atlanta's Technology Square. (Image: DataBank)

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at from data centres to be

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10 okt 17

ndse datacenters kunnen 2 woningen verwarmen'

te van Nederlandse datacenters kunnen in 2030 zo'n
gen worden verwarmd. Dat betoogt technisch
nica. Het bedrijf ziet voor zichzelf niet alleen een rol

warm

eal with ris

local community

At Facebook, we aim to minimize our energy, emissions and water impact, while embracing the responsibility and opportunity to impact the world beyond our operations.

The opportunity

When we announced the construction of our Odense Data Center in 2017, we were determined to build one of the most advanced, energy-efficient data centers in the world. The new facility will feature our latest hyper-efficient hardware, cooled using outdoor air through indirect evaporative cooling technology and powered by clean and renewable wind energy.

This facility will also be unique because of infrastructure to capture and

2 million

metric tons of CO2 emissions avoided between 2011 and 2017

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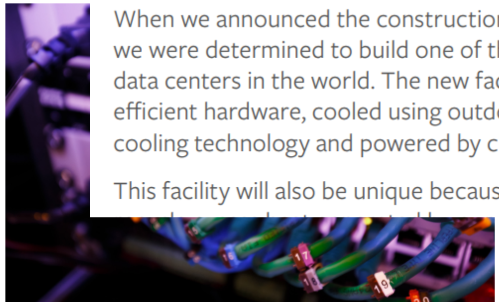

plaatsvond op de Dag van de Duurzaamheid in Amsterdam, met op het programma o.a. Diederik Samsom, voorzitter van de Klimaattafel Gebouwde

(source: Asperitas “Datacentre of the Future” https://www.asperitas.com/_whitepapers)

Temperature chaining

- Serial implementation of the infrastructure

17°C → CRAC Parallel → Any ACS solution → Any ACS solution → CP or Immersion → 2x CP or Immersion → Facility output

CRAC Parallel:
- +5°C
- Output 22°C
- ΔT 5°C

Any ACS solution:
- +6°C
- Output 28°C

Any ACS solution:
- +8°C
- Output 36°C

CP or Immersion:
- +8°C
- Output 44°C

2x CP or Immersion:
- + 2x8°C
- Output 60°C

Facility output: **60°C**

Usable
Valuable
heat

- Low volume displacement: 500% dT=20%flowrate
  - high Δp : Small, more powerful pumps
  - Small pipes
- 3-stage cooling for low water volume
  - Down to 40 °C, Free-air
  - Between 32-40 °C, Free-air/Adiabatic
  - Between 28-32 °C, Chiller

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Reuse value

- Main goal: fixed temperature determines value
  - Absolute temperature determines value
  - 40-50°C heating households, swimming pools etc.
  - 50-70°C Local distribution district heating (Gen4 heat grids roll-out in Europe)
  - 70-100°C Longer distance distribution
- Secondary goal: Volume determines reuse propensity
  - Heat is expressed in Joules (GJ)
  - 1 MW=1 MJ/s, 1MWh=3.6GJ
  - In Europe, 1 GJ= € 18.1 ($ 20.3)
  - 100 MW facility heat potential: €571K/year ($ 640K)

(source: european-district-heating-price-series-energiforskrapport-2016-316)

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Backup

Liquid Cooling Terminology

Worked with ASHRAE to clarify their definitions

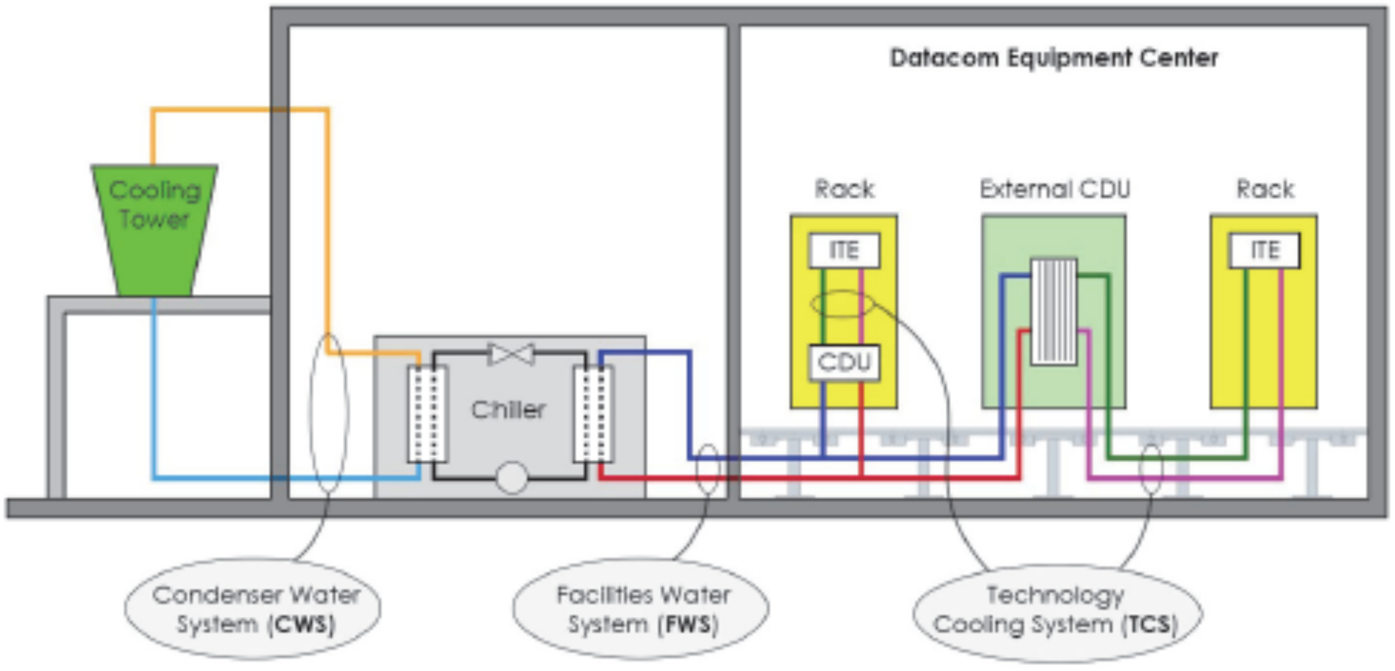

Figure 6 CDU liquid cooling system within a data center.

Figure from ASHRAE 2019. Water-Cooled servers common designs, components, and processes, White Paper

Liquid Cooling Terminology

Worked with ASHRAE to clarify their definitions

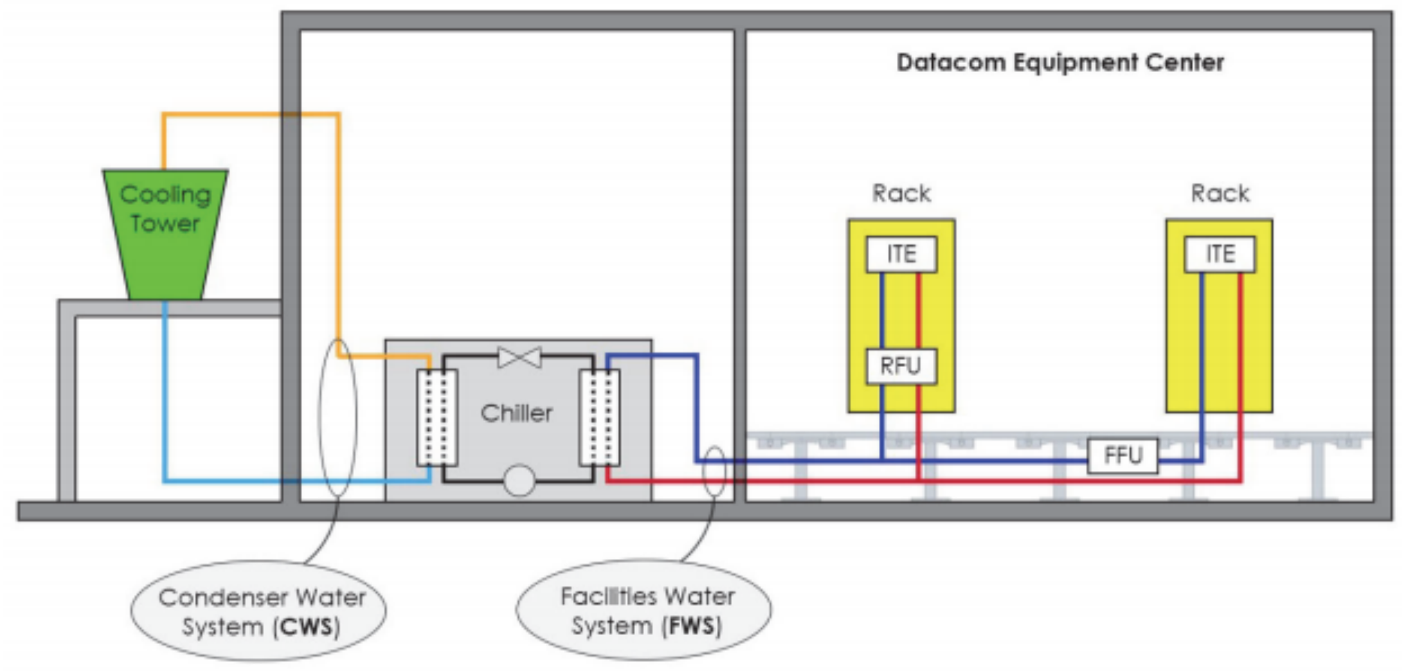

Figure 7 Non-CDU liquid cooling system within a data center.

RFU = rack filtration unit
FFU = facility filtration unit

Figure from ASHRAE 2019. Water-Cooled servers common designs, components, and processes, White Paper

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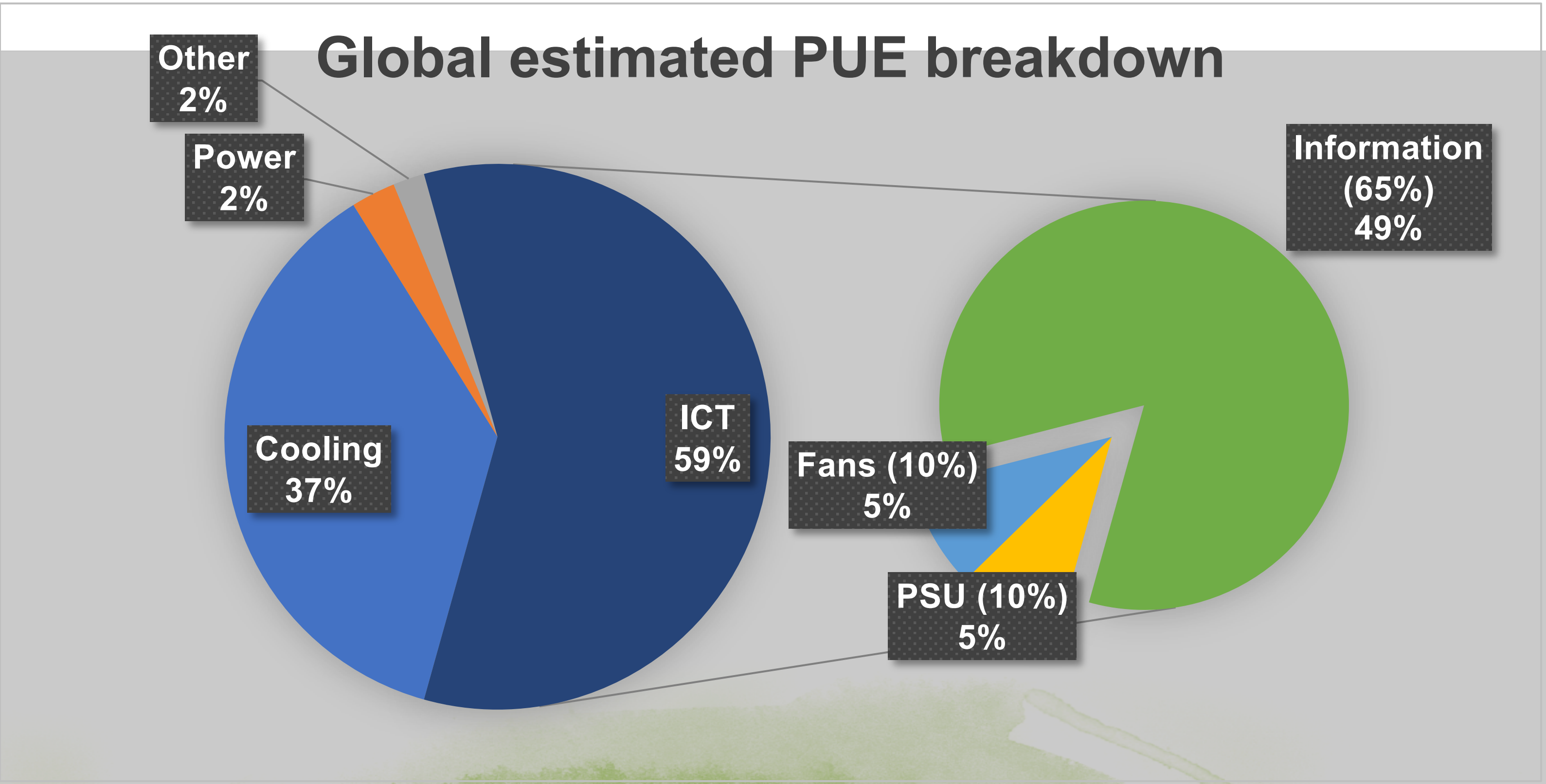
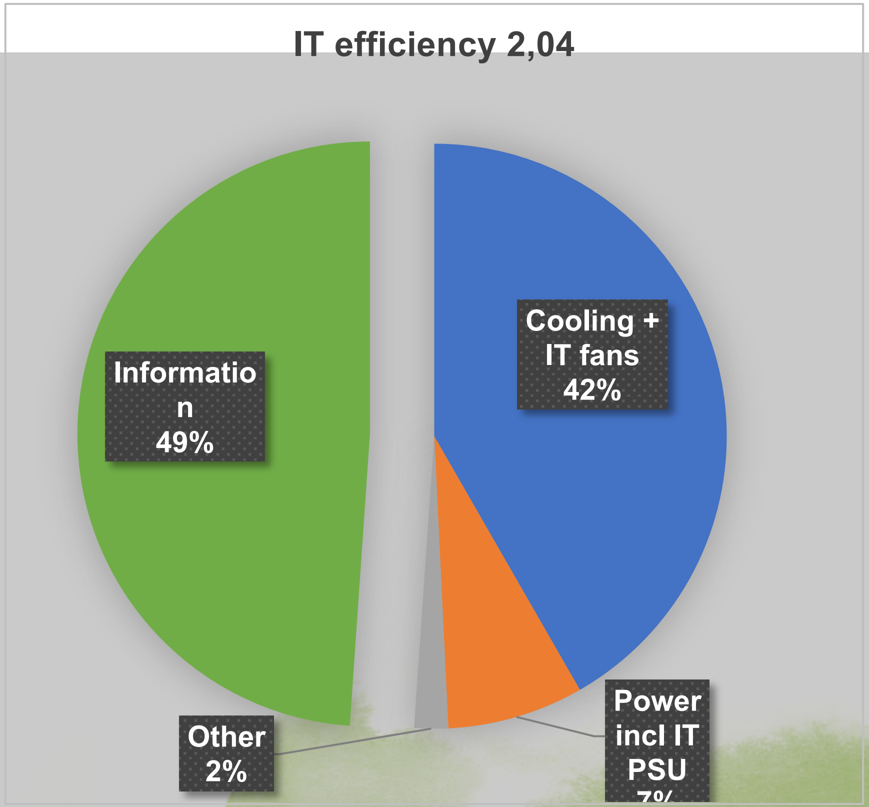
Global average PUE: 1.70





Efficient PUE: 1.12