Fan, PSU, & Idle Power in Air-/Direct-Liquid-Cooled Servers

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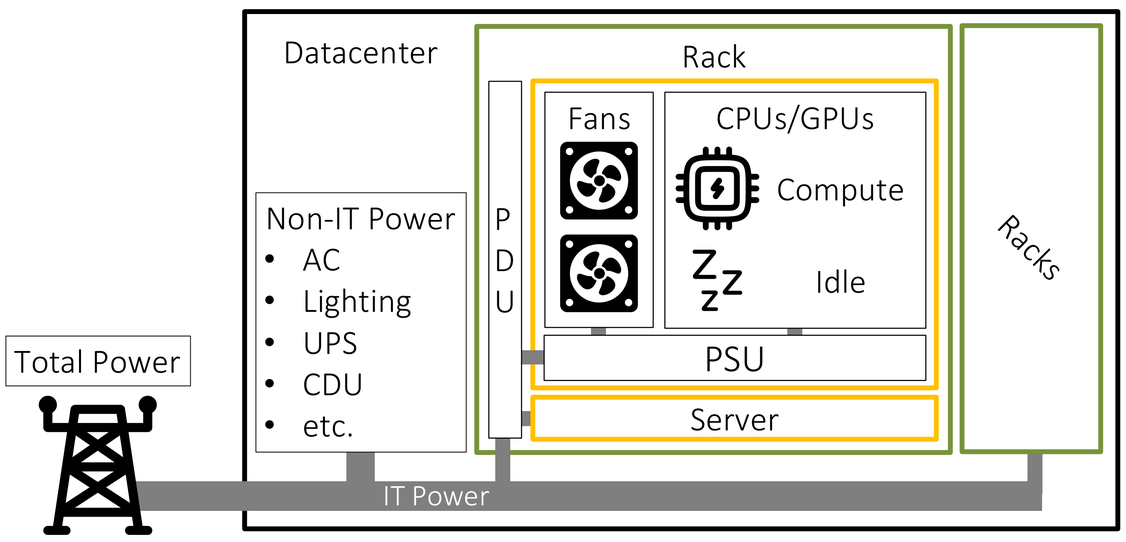
Datacenter Power, PUE, and IUE



Power Usage Effectiveness (PUE) = E_{Total} / E_{IT}

$E_{IT} = E_{PSU} + E_{Fans} + E_{Idle} + E_{Compute}$

Infrastructure Usage Efficiency (IUE) = $E_{Compute} / E_{IT}$

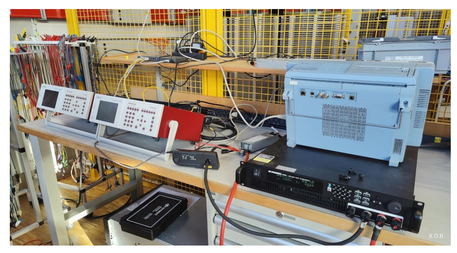
Experimental Setup

Break down and characterize server power

Experiments done at EPFL EcoCloud

Server	HPE ProLiant DL380 Gen11
CPUs	Dual Socket Intel Sapphire Rapids
	Dual Socket AMD Zen 4
RAM	256 GB
Fans	High Performance Fan Kit (6x fans)
DLC CDU*	CoolIT CHx200
PSU	2x HPE Artesyn PSU
PDU	RNX RN3517

*Direct liquid cooling is CPU only



EcoCloud servers and PSU measurement setup

Server Power Breakdown

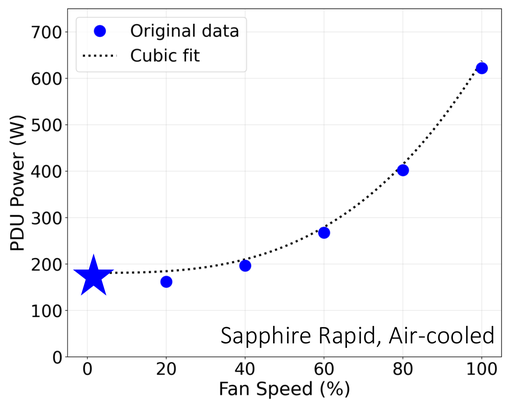
PSU Loss

PSU yield varies by load

Load PSU	Power PDU	Power PSU_{in}	Power PSU_{out}	Yield PSU
160W (10%)	179	179	158	0.886
320W (20%)	346	345	319	0.924
480W (30%)	514	513	482	0.936
640W (40%)	686	685	645	0.941
800W (50%)	861	860	808	0.940
960W (60%)	1040	1039	973	0.936
1120W (70%)	1224	1223	1139	0.931
1280W (80%)	1413	1410	1306	0.926
1440W (90%)	1608	1604	1473	0.918
1500W (limit)	1686	1682	1536	0.913

Fan Power

Fan power ∝ (fan speed)^3



Fan Speed	20%	40%	60%	80%	100%
Fan Power	3W	28W	93W	221W	432W

Idle Power

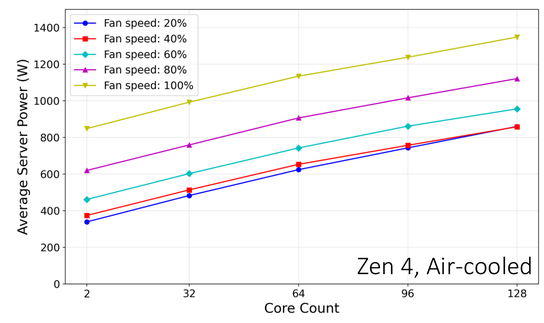
Idle power = server power with no compute load and no fan load

IPMI limits min. fan speed
↓
Sweep fan speed and extrapolate no-fan-load PDU power
↓
Subtract PSU yield loss

	Sapphire Rapids Air-Cooled	Sapphire Rapids DLC	Zen 4 Air-Cooled
PDU	180W	190W	210W
Idle Power	155W	165W	182W

Compute Power

Increase CPU load with stress-ng benchmarks

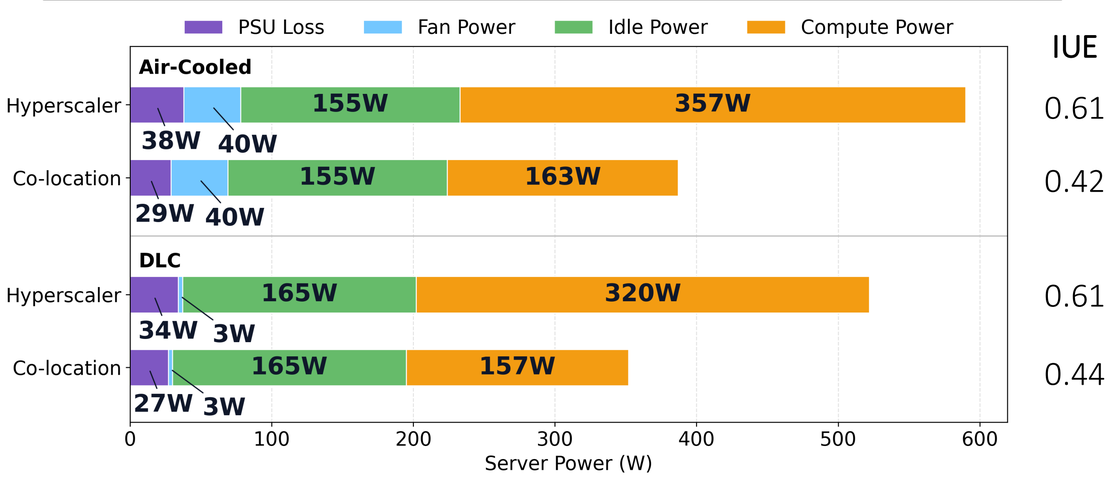


Use Case	PUE* (24°C)	Server Util.	DLC Fan Speed	DLC CDU Power†
Hyperscaler	1.1	60%	20%	20W
Co-location	1.3	15%	20%	20W

*Assuming identical racks and cooling solutions throughout the datacenter, negligible PDU loss
†Assuming 200W CDU pump power for a 20kW rack with 10 servers

Ambient Temperature Study

DC operators are interested in increasing ambient temps (32°C)



Estimated Server Power Breakdown @ 32°C

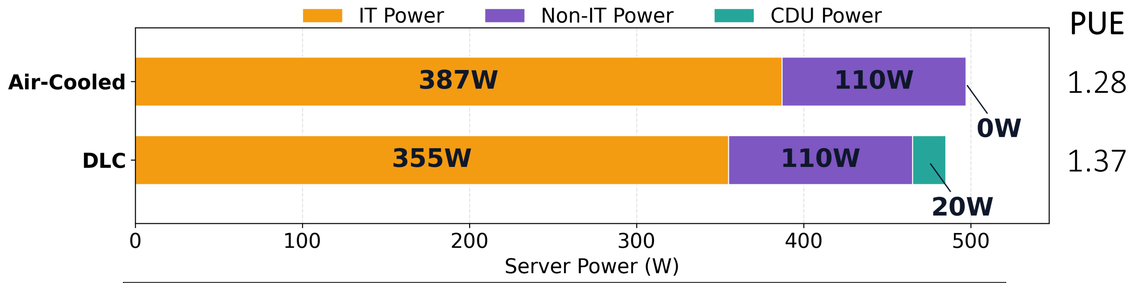
Fan power becomes > 10% of total server power for co-location servers when operating at high ambient temps

Increasing fans from 20% to 45% → 10× fan power

Idle power ranges 26% to 46% of total server power

Fan-Adjusted PUE

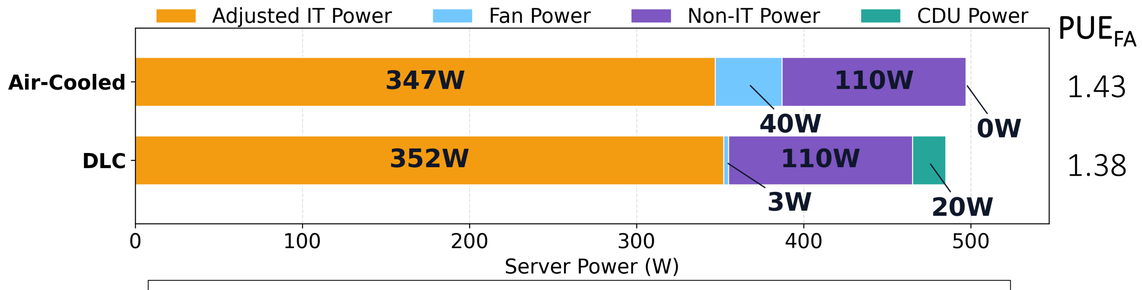
$PUE = (E_{IT} + E_{non\text{-}IT}) / E_{IT}$



At higher ambient temps, increased fan power decreases PUE

DLC has higher PUE despite using less overall power!

$PUE_{FA} = (E_{IT} + E_{non\text{-}IT}) / (E_{IT} - E_{fans})$



Server fans are used for cooling and should be non-IT power