Beyond Power Efficiency - The Path to True Datacenter Sustainability

Nicolas Dubé, HP

The last decade saw the emergence of the widely known PUE metric. But now that datacenter operators are arguing over PUEs under 1.1, are we really driving the right behaviour in a broader eco-responsible sense? Are power and energy efficiency necessarily equivalent? Although evaporative cooling works superbly compared to compressor-based chillers, can we consume water that freely? Could the carbon footprint of electricity drive site selection of datacenters? Ultimately, what would be the vision for a true net-zero datacenter...

Datacenter Philosophy 101

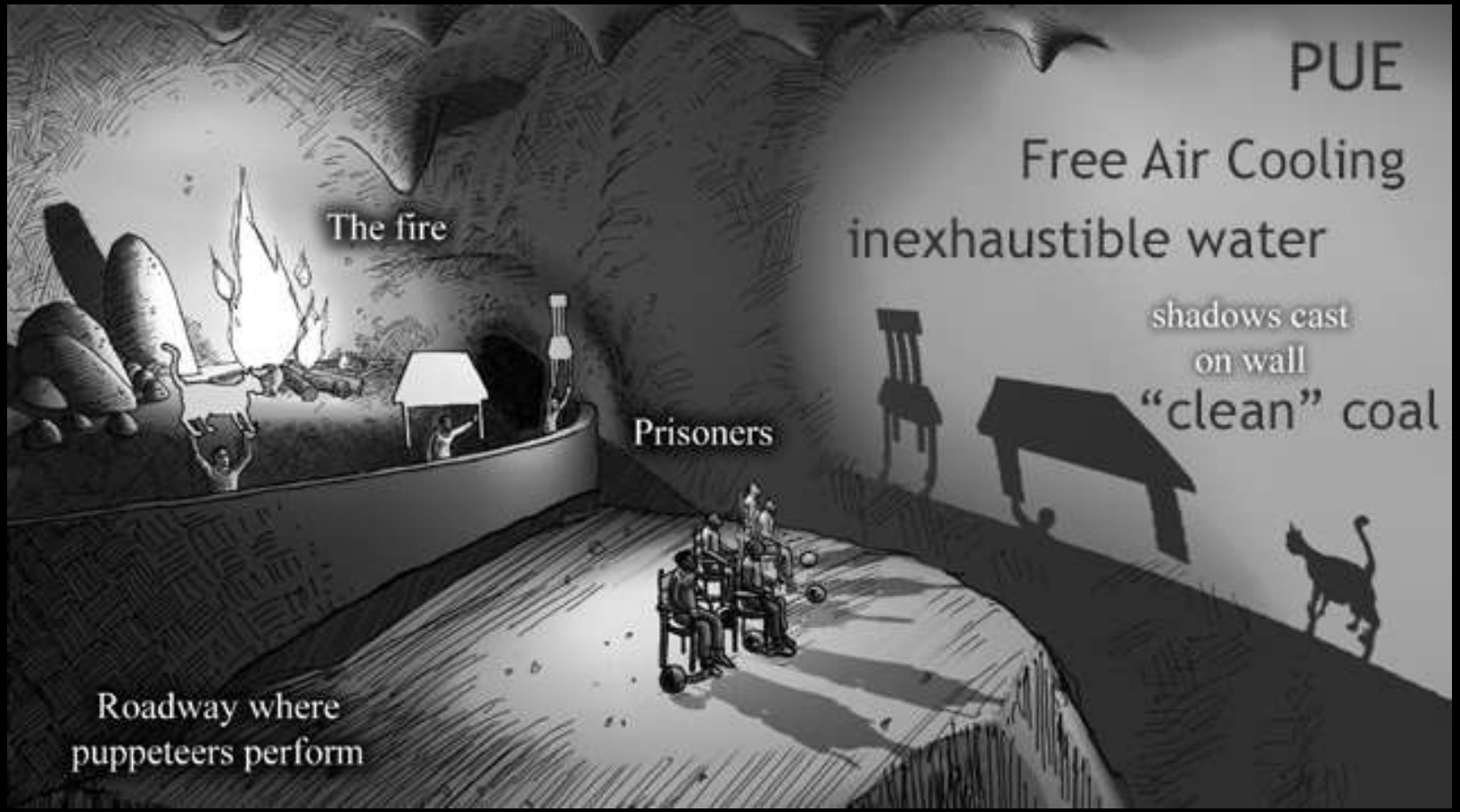
But can you “handle the truth”?

Nicolas Dubé, Ph.D.

HyperScale Business Unit, HP

Holger Gelinek

Server Presales, HP Germany


PUE
Free Air Cooling
inexhaustible water
shadows cast
on wall
"clean" coal
The fire
Prisoners
Roadway where
puppeteers perform

Proportion of renewable energy grew from 1.12% to 2.3% worldwide from 1990 to 2010.

Fact.

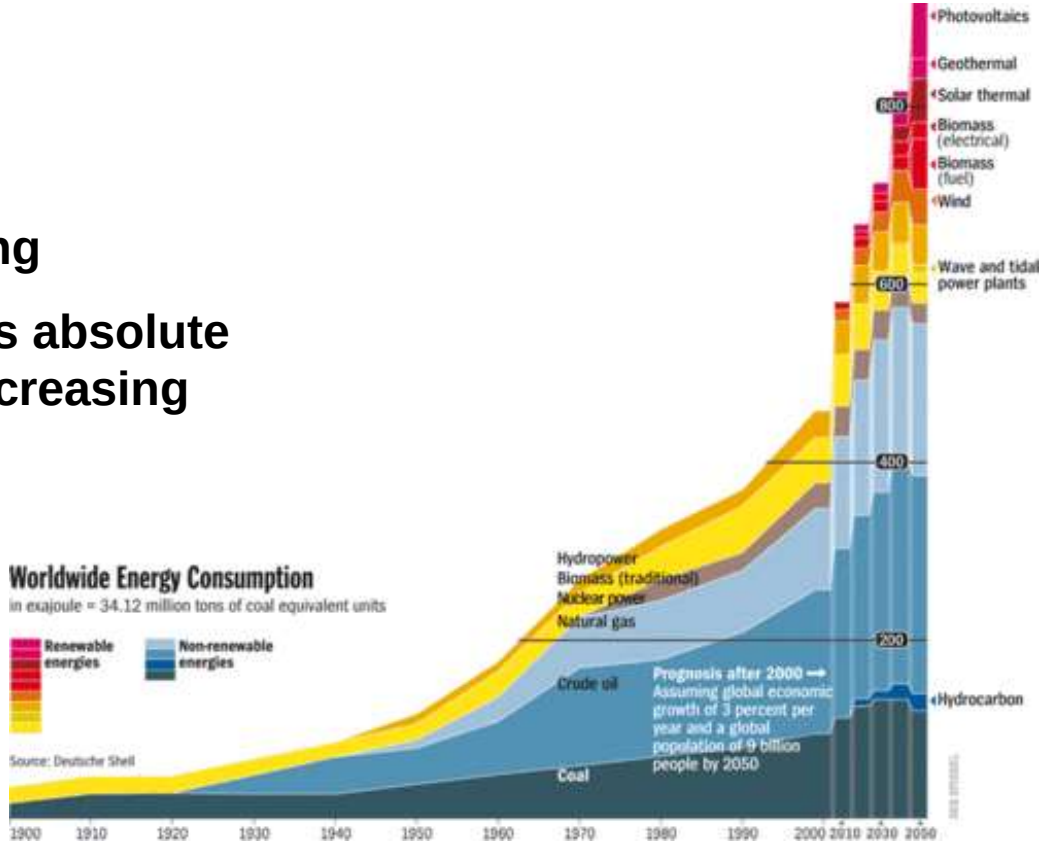
=> Therefore the world is more environmentally friendly

?

Not quite.

Worldwide Energy Situation

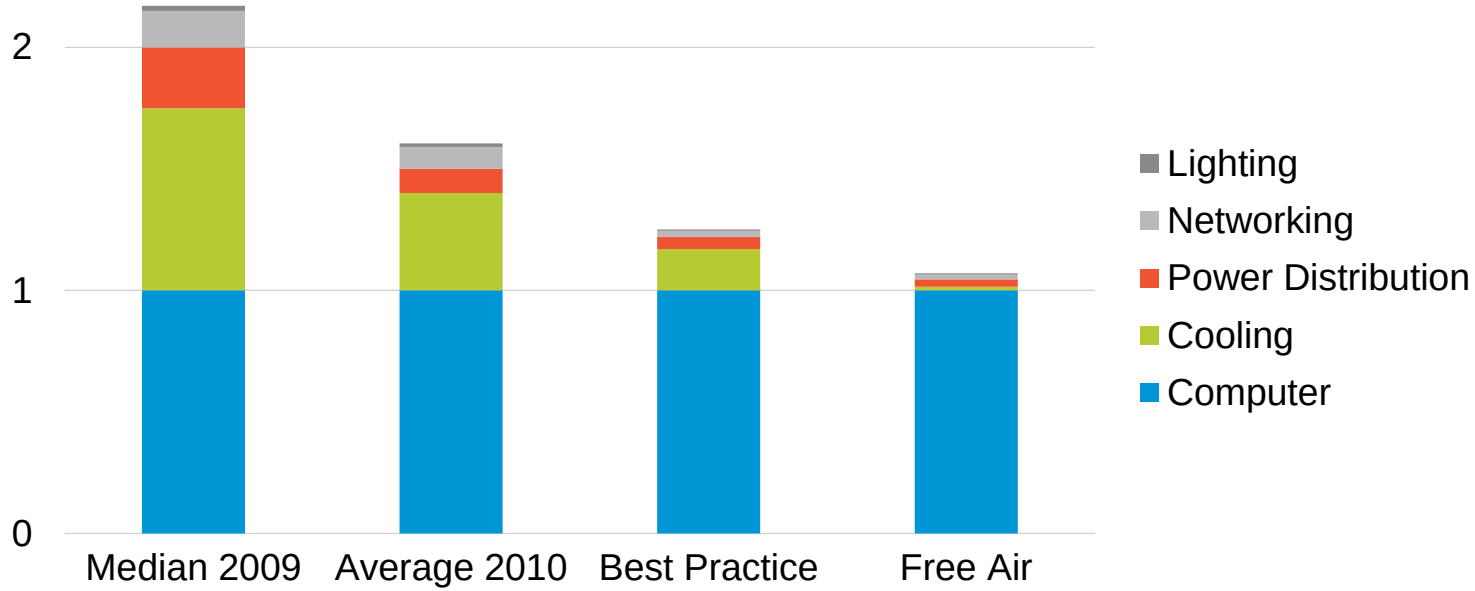
- **The Bad Side of Ratios:**
  - **Renewables % growing**
  - **But overall fossil fuels absolute dependency is still increasing**



Cave “truth” #1: Power Usage Effectiveness (PUE)

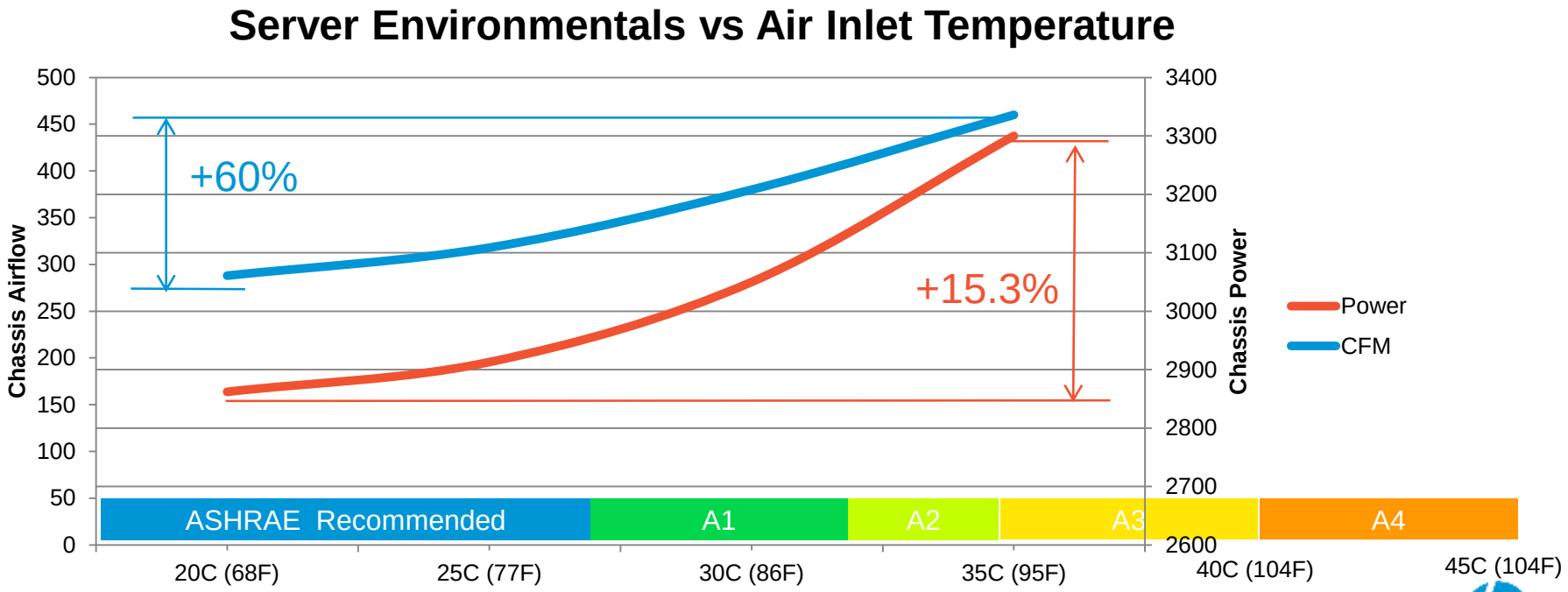
The “holy grail” of corporate IT?

$$PUE = \frac{\text{Total Energy}}{\text{IT Energy}}$$



PUE: “the untold story”

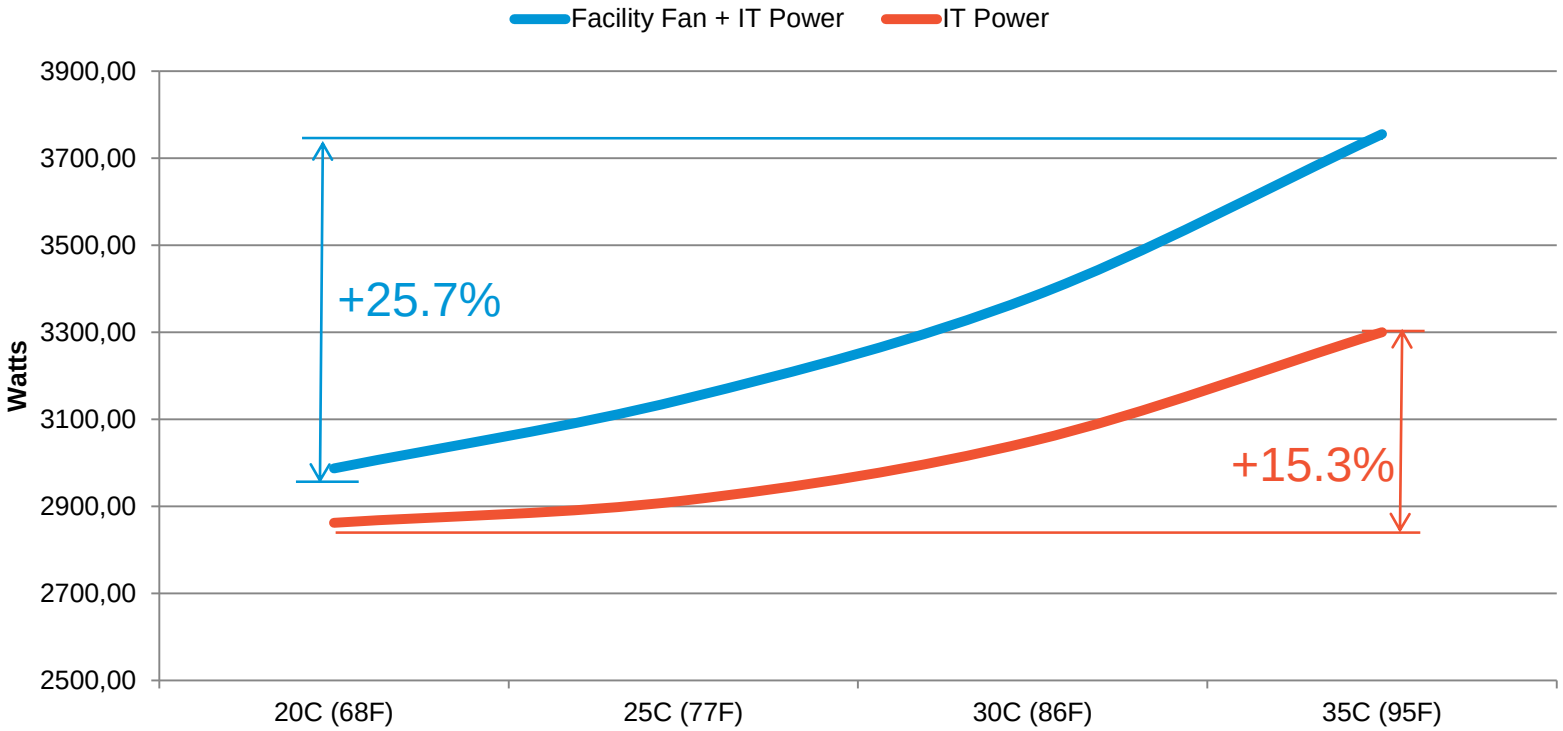
When you CAN’T afford Free Air Cooling



8x SL230 w/ E5-2670, 16x8GB, 4xSFF, Linpack

Free Air Cooling's "dirty little secret"

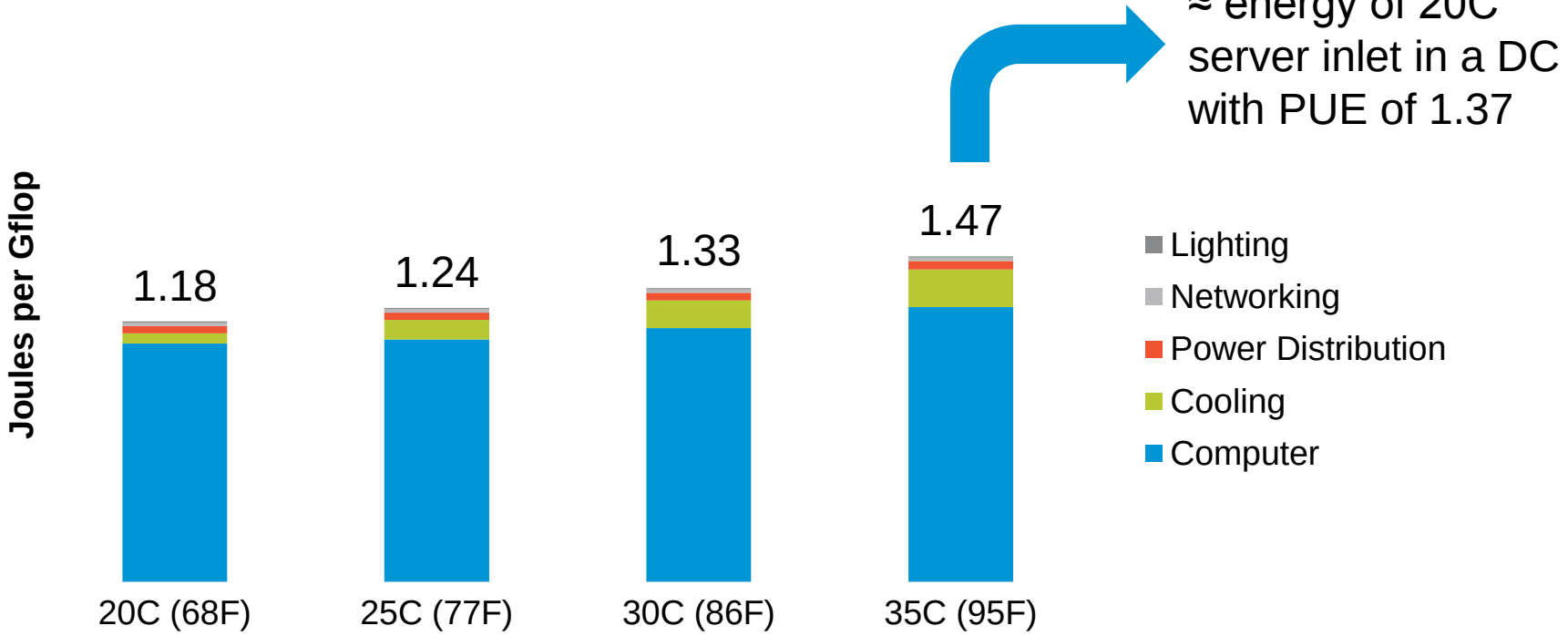
Fan power α (fan speed)^3



Baseline: 8% facility fan power @ 25C

What a ratio like PUE does not show

Looking at Energy per Compute Operation (free air cooling)



Why target “1”?

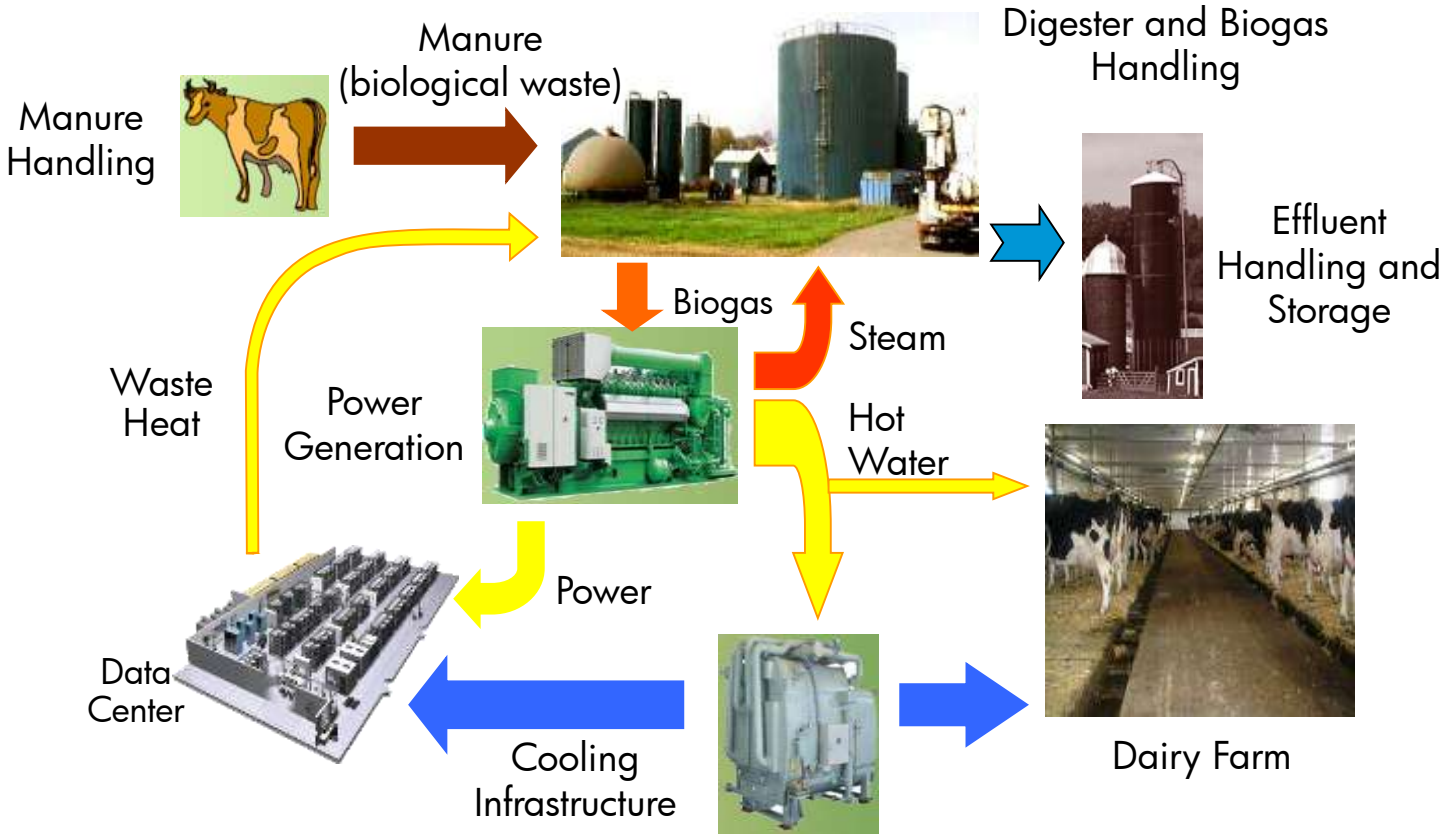
Shouldn’t the function objective be “0”?

$$PUE = \frac{\text{Total Energy}}{\text{IT Energy}}$$

$$ERE = \frac{\text{Total Energy - Reuse Energy}}{\text{IT Energy}}$$

$$NZE = \frac{\text{Total Energy - Reuse Energy - Site Production}}{\text{DC IT Energy}}$$

Datacenter ecosystem



Source: Martin Arlitt HP Labs, ASME 4th International Conference on Energy Sustainability, May 17–22, 2010 Phoenix, Arizona

From Cow Manure to kWh

- **Cow daily production**
  54.7 kg / day
  = 20 metric tons / year
- **Anaerobic digester:**
  1 cow = 15kWh /day
- **2 000 cows dairy**
  => 30 000 kWh / day
- **30MWh / 24h = 1.25MW**
- **Enough power for a 1MW datacenter with PUE 1.25**

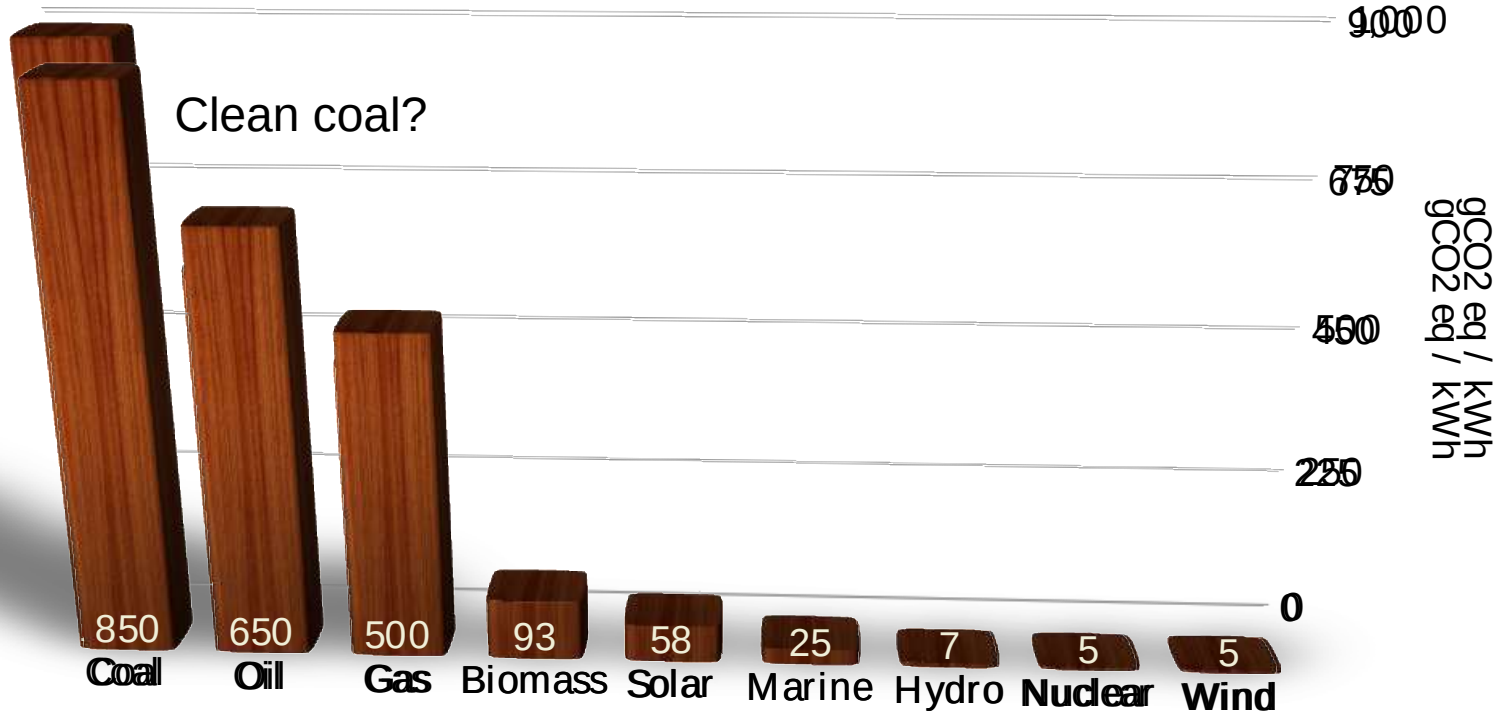
Cave “truth” #2: “Clean” coal

When the Cloud turns into Smog

Comparison of significant cloud data centres		Sq Footage	Estimated number of servers	Estimated power usage effectiveness	% of Dirty Energy Generation of local grid	% of Renewable Electricity of local grid
Google	Lenoir, NC	476,000	-	1.21	50.5% Coal 38.7% Nuclear	3.8%
	Dalles, OR	206,000	-	1.2 -	34.4% Coal 3.3% Nuclear	50.9%
	Apple, NC	500,000	-		50.5% Coal 38.7% Nuclear	3.8%
Microsoft	Chicago, IL	700,000	473,000	1.22	72.8% Coal 22.3% Nuclear	1.1%
	San Antonio, TX	470,000	-	1.2	37.1% Coal	11%
YAHOO!	Lockport, NY	190,000	-	1.16	21.0% Coal 27.0% Nuclear	27.7%
	La Vista, NE	350,000	100,000	-	73.5% Coal 14.6% Nuclear	7%

Source: Make IT Green, Cloud Computing and it’s contribution to climate change, GreenPeace, March 30, 2010

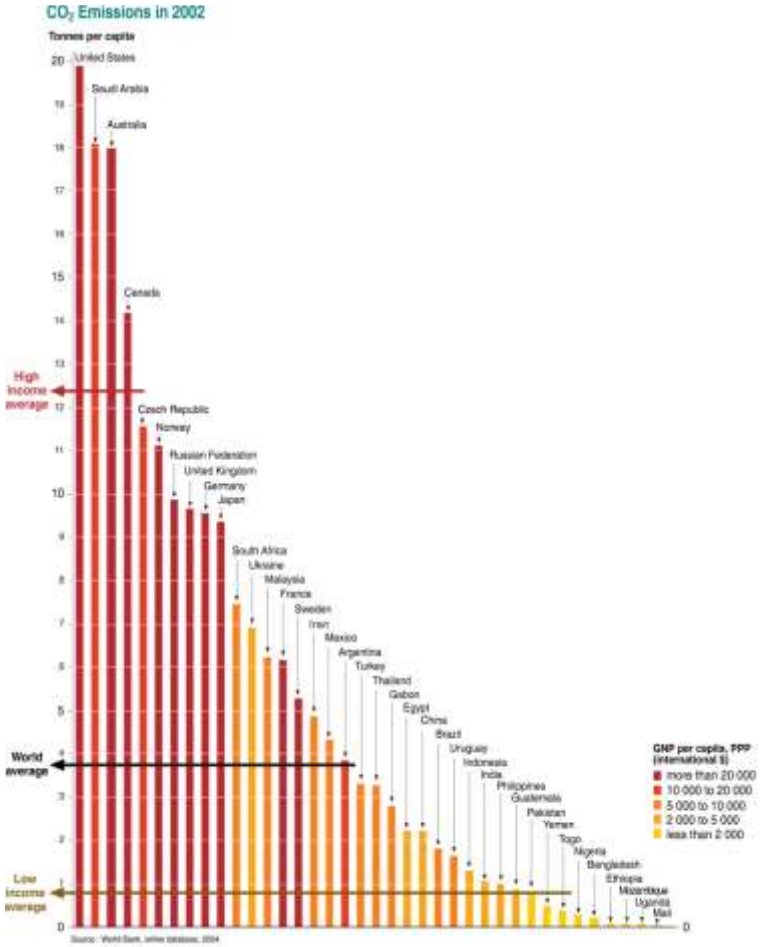
Energy Sources CO_2 footprint



Source: Carbon Footprint of Electricity Generation, UK Parliament Post, Oct 2006, www.parliament.uk/documents/post/postpn268.pdf

IT Carbon Footprint

- **A 20MW data center running on coal emits 175 200 Tons of CO_2 eq /year**
- **The equivalent annual carbon footprint of 43 800 people**
- **Same data center on Hydro power: 876 Tons, or 219 people**



Datacenter as a Carbon offsetting tool

Replacing a gas furnace by “compute” Btus

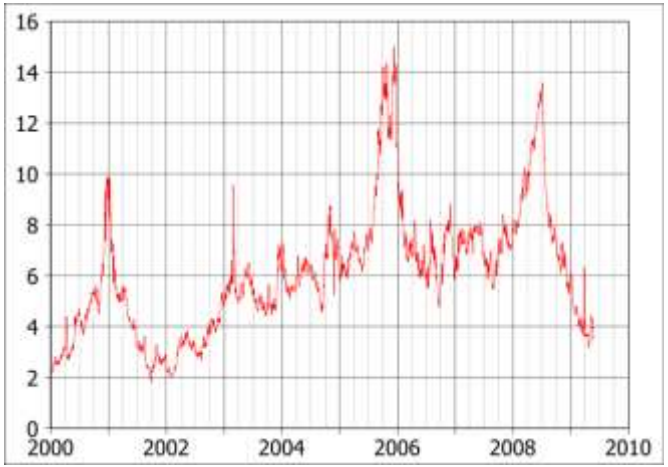
- **Datacenter power: 10 MW, 298 904 Mbtus (/year)**
- **Hydro kWh cost: 5 cents, 4 380 000 $**
- **Natural gas Mbtu cost (commercial): ~10$, 2 989 040$**

Net electrical cost: 1.6 cents !

Carbon Offset:

Natural Gas (not burnt): 6 695 tons -
Hydro-Electrical (lifecycle): 438 tons
= 6 257 tons !! (or about 1500 people)

Natural Gas Prices (Henry Hub)



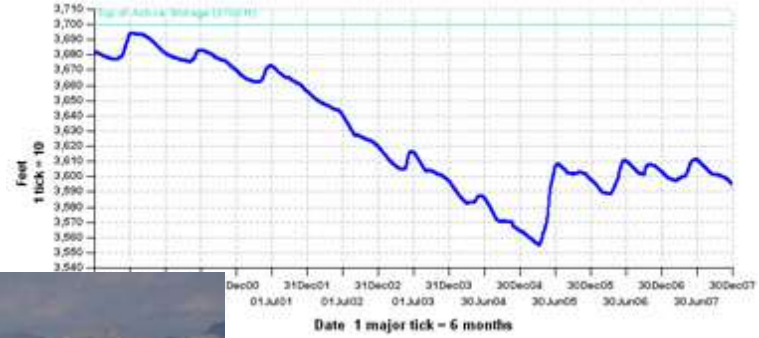
Water

Lake Mead reservoir

Cave “truth” #3: water is free and available

- **Colorado Basin situation:**
  50% chance dry up by 2021

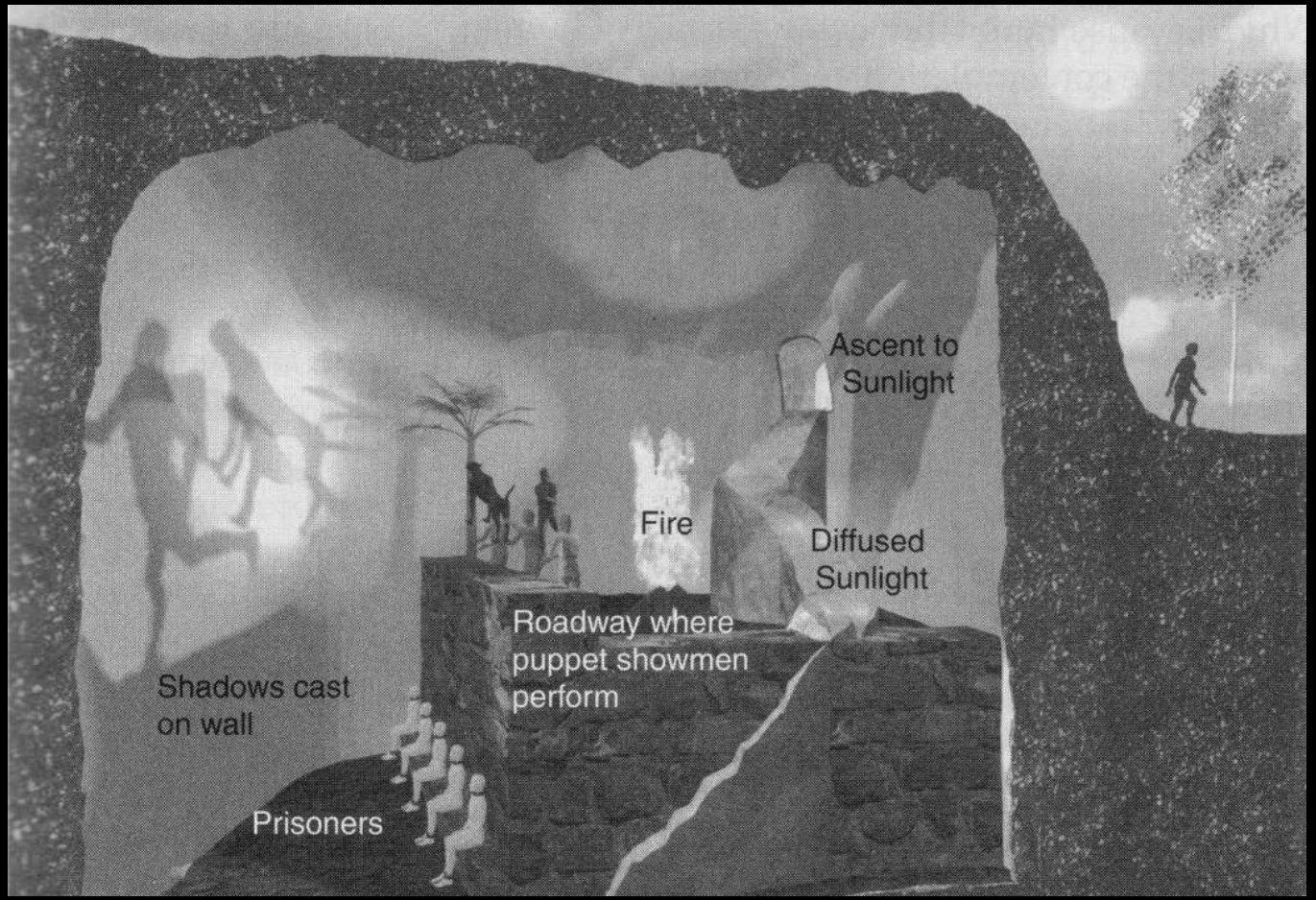
Lake Powell



Lake Mead reservoir

Heating up the Baltic Sea

- XX MW capacity
- Pumping sea water on primary
- Impact on ecosystems?


Ascent to
Sunlight
Fire
Diffused
Sunlight
Roadway where
puppet showmen
perform
Shadows cast
on wall
Prisoners

Path to Wisdom: Zero is the target, not “1”

1. Drive towards Net-Zero Energy Consumption

- Stop metering on watts, Energy is the real thing
- The lower the PUE, the better (of course)
- But PUE is not enough, and can be quite misleading
- Time to consider auto-production / net metering for datacenters

2. Shoot for ZERO carbon emissions

- Electricity source is critically important vs embedded
- Carbon taxes are emerging, kWh are not all made equal

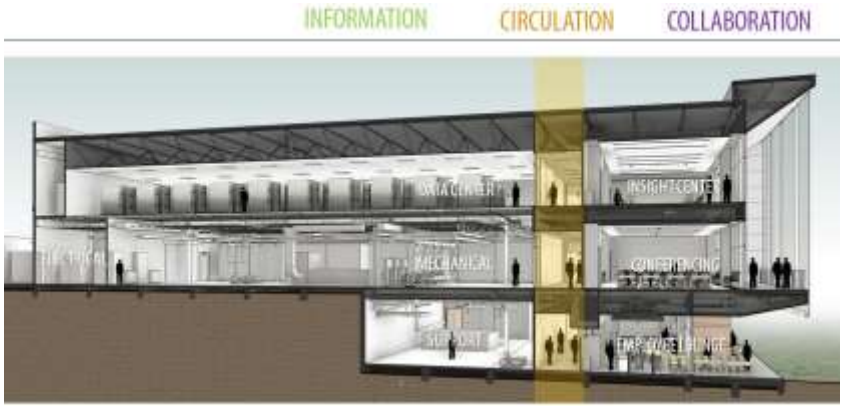
3. Use no water

- No more evaporative chillers, nor boiling up the ocean

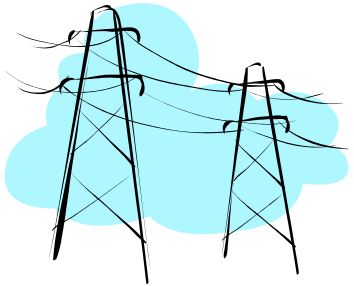
NREL – Energy Systems Integration Facility

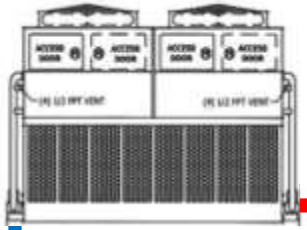
National Renewable Energy Labs – Golden, CO

- 1.06 PUE target
- ERE << 1
- Computer used as a furnace in winter: building heating and snow melting
- “warm water cooling”
- HV-AC power distribution
- Datacenter built like the “visible man”



Chiller less Data Centers



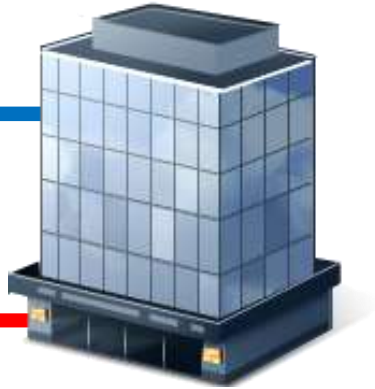


Evaporative
Cooling Tower

Warm Water
Cooled Servers

Energy
Reuse
Loop

Snow melting

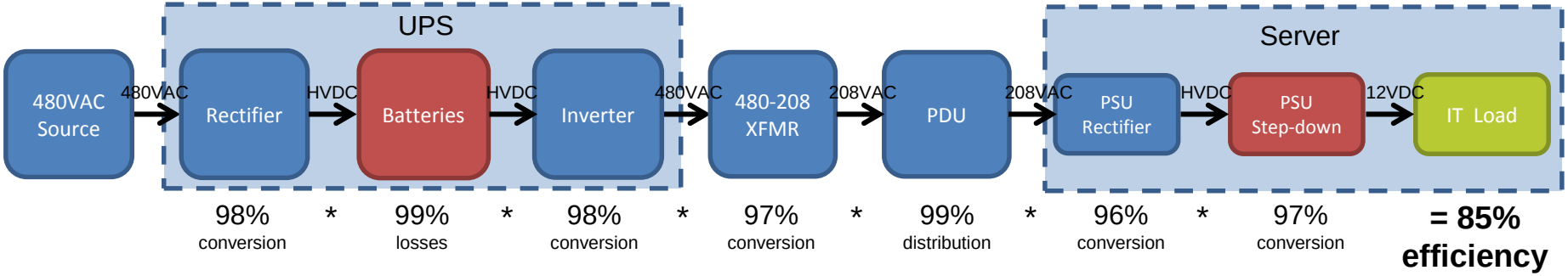


Building Heating

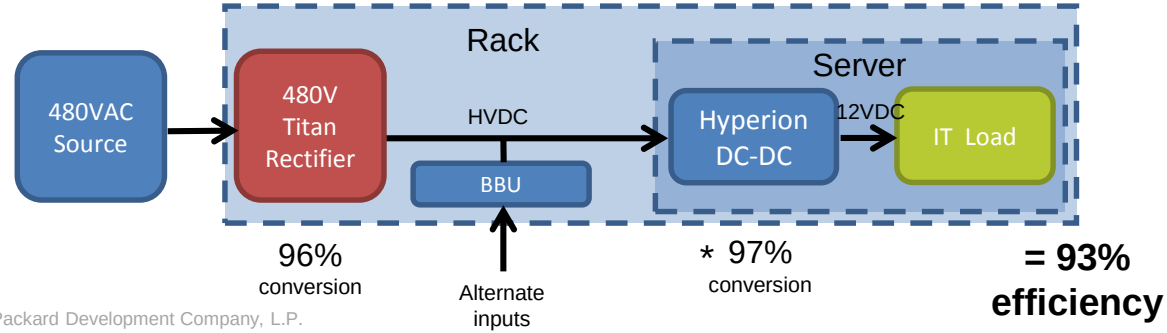
Power Distribution Efficiency

High-Voltage AC to the Rack: Limiting conversion steps

Typical



New Apollo



Apollo 8000 System Technologies

Advancing the science of supercomputing

Intelligent Cooling Distribution Unit

- 320 KW power capacity
- Integrated controls with active-active failover

Dry-disconnect servers

- 100% water cooled components
- Designed for serviceability

Open door view of 4 compute & redundant CDU racks

Management infrastructure

- HP iLO4, IPMI 2.0 and DCMI 1.0
- Rack-level Advanced Power Manager

Warm water

- Closed secondary loop in CDU
- Isolated and open facility loop

Power infrastructure

- Up to 80kW per rack
- Four 30A 3-phase 380-480VAC

Differentiated: Dry-disconnect servers

New patented technology making a liquid-cooled system as easy to service as air-cooled

- Enables maintenance of servers without breaking a water connection
- Inside the server tray, heat is transferred from components via vapor in sealed heat pipes
- Thermal bus bars on the side of the compute tray transfer heat to the water wall in the rack
- Water flows through thermal bus bar in the rack from supply-and-return pipes
- Fluid fully contained under vacuum

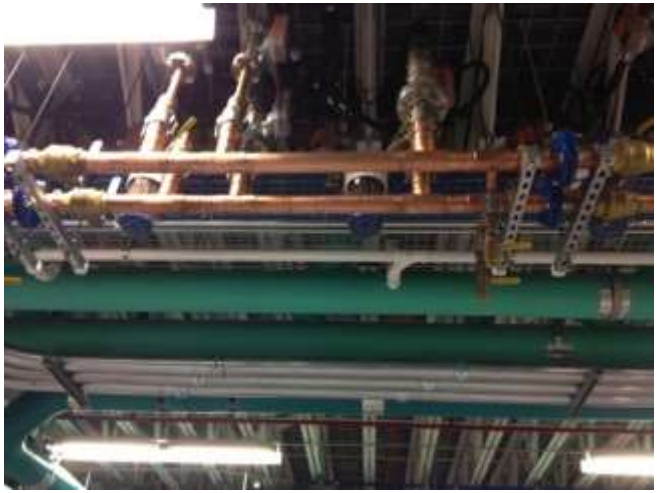
http://youtu.be/9Ih3R84Corg

Cooling Distribution Unit

Improved modularity and serviceability

Plumbing units

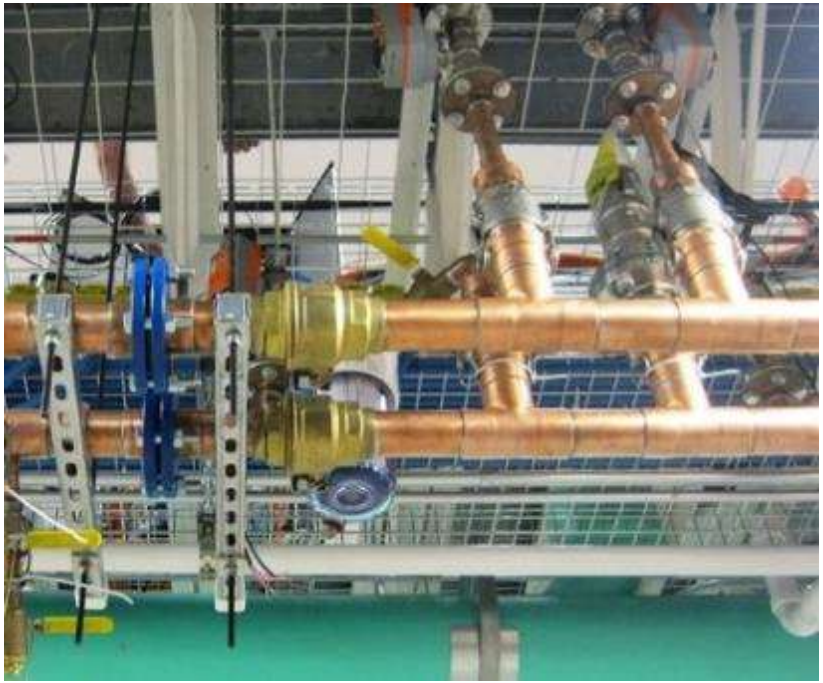
Redefining the deployment model



Failure is not an option

Efficient liquid cooling without the risk

- **Dry-disconnect servers**
  sealed heat pipes cool components
- **Facility water isolated from IT loop**
  Takes ASHRAE spec water
- Secondary IT loop **vacuum** keeps water in place
- Intelligent Cooling Distribution Unit designed to minimize and **isolate** issues
- Comprehensive **system insight** and management built on Advanced Power Management and smart sensors



University of Tromsø in Norway

Forget cooling! Use the server room to heat the campus

International research hub focuses on global environmental issues, up close

- Increasing research demands, # of advanced calculations
- Energy consumption/sq. meter increased dramatically, 2 megawatts with plans for more
- Building new 400 sq. meter data center
- Expect to reduce 80% of energy costs for computer operation, saving 1.5M krone in operating budget/year

"... the idea is to reduce electricity costs by sharing them with the rest of the university or other stakeholders heating."
-Svenn A. Hanssen, Head of IT department at the University of Tromsø

Thanks

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http://sites.google.com/a/lbl.gov/eehpcwg/home
http://thegreengrid.org
http://www.hp.com/go/apollo