Philosophy 301

But can you “handle the truth”?

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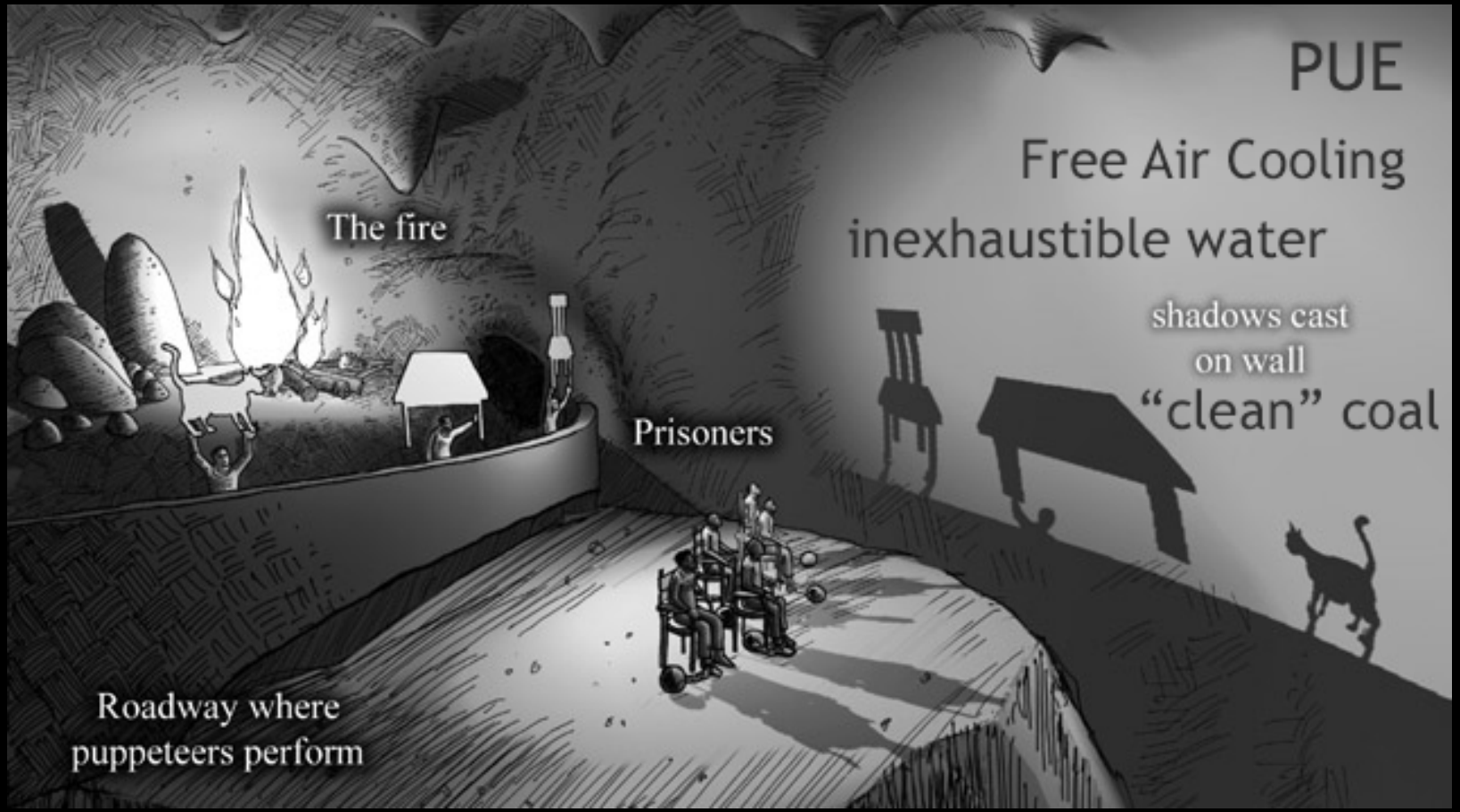

PUE
Free Air Cooling
inexhaustible water
shadows cast
on wall
“clean” coal
The fire
Prisoners
Roadway where
puppeteers perform

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

Fact.

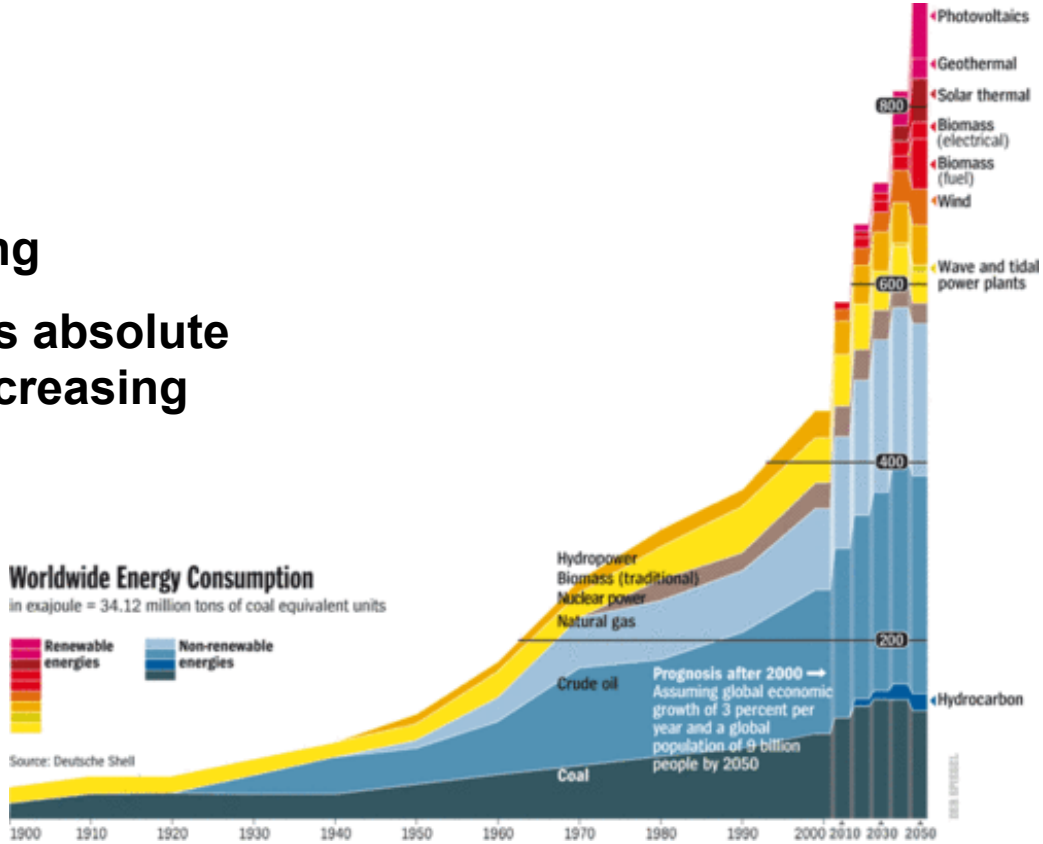
=> Therefore the world is more environmentally friendly

?

Not quite.

Worldwide Energy Situation

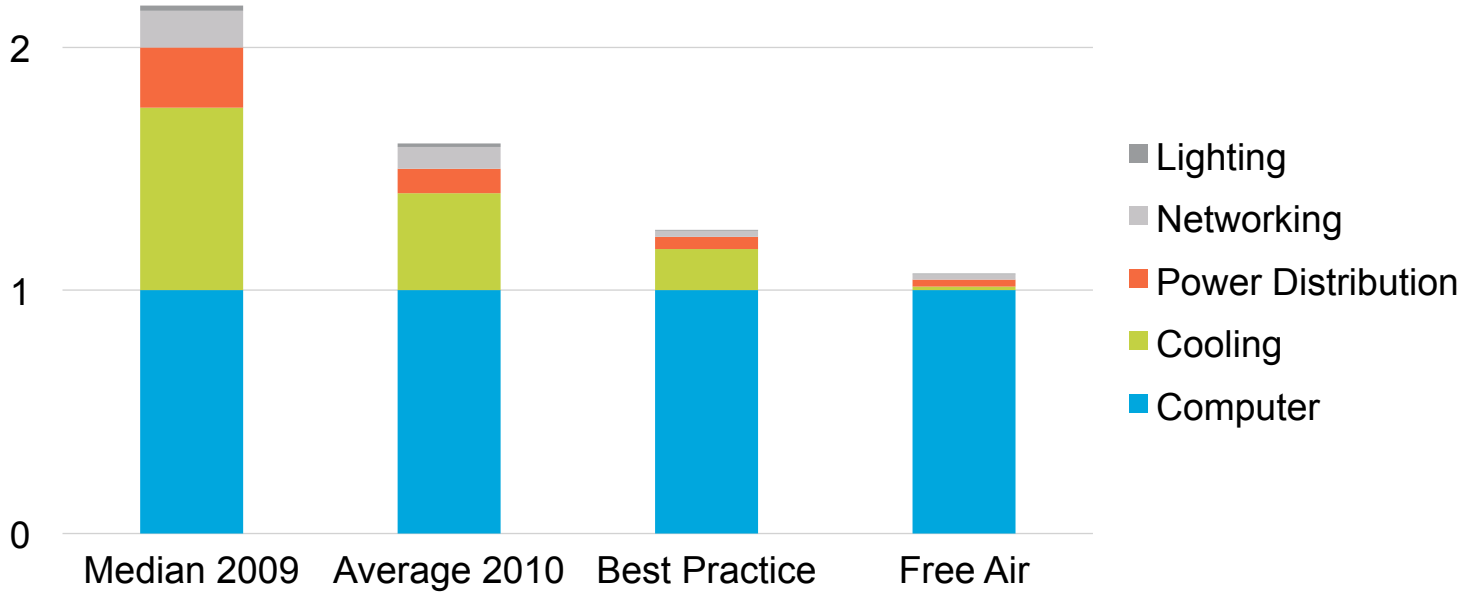
- **The Bad Side of Ratios:**
  - **Renewables % growing**
  - **But overall fossil fuels absolute dependency is still increasing**



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

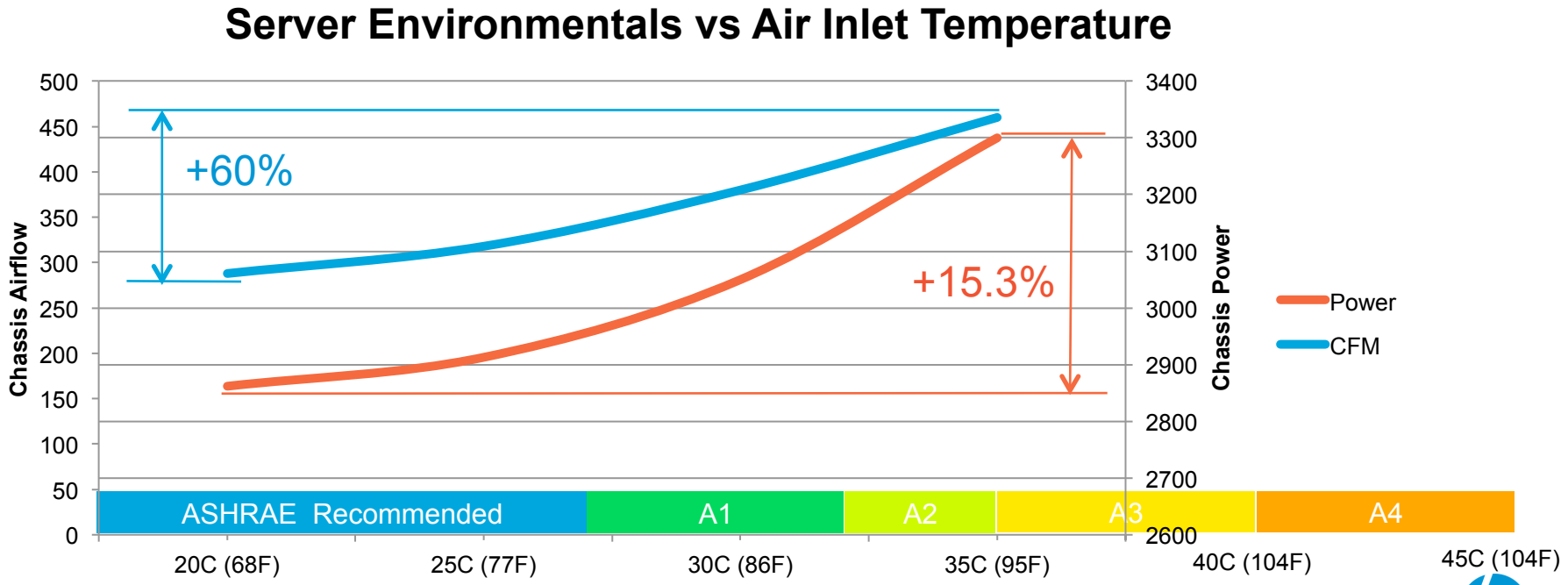
The “holy grail” of corporate IT?

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



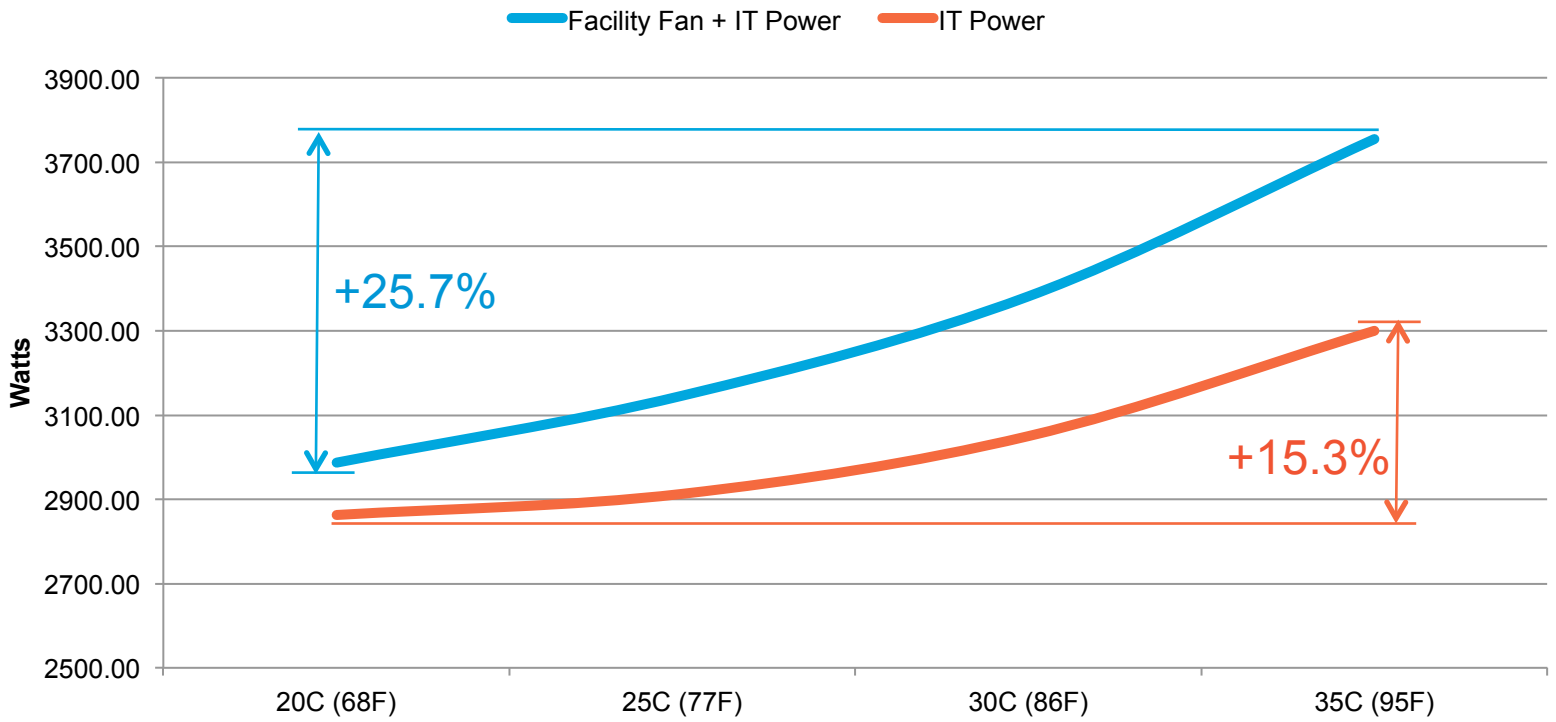
PUE: “the untold story”

When you CAN’T afford Free Air Cooling



Free Air Cooling's "dirty little secret"

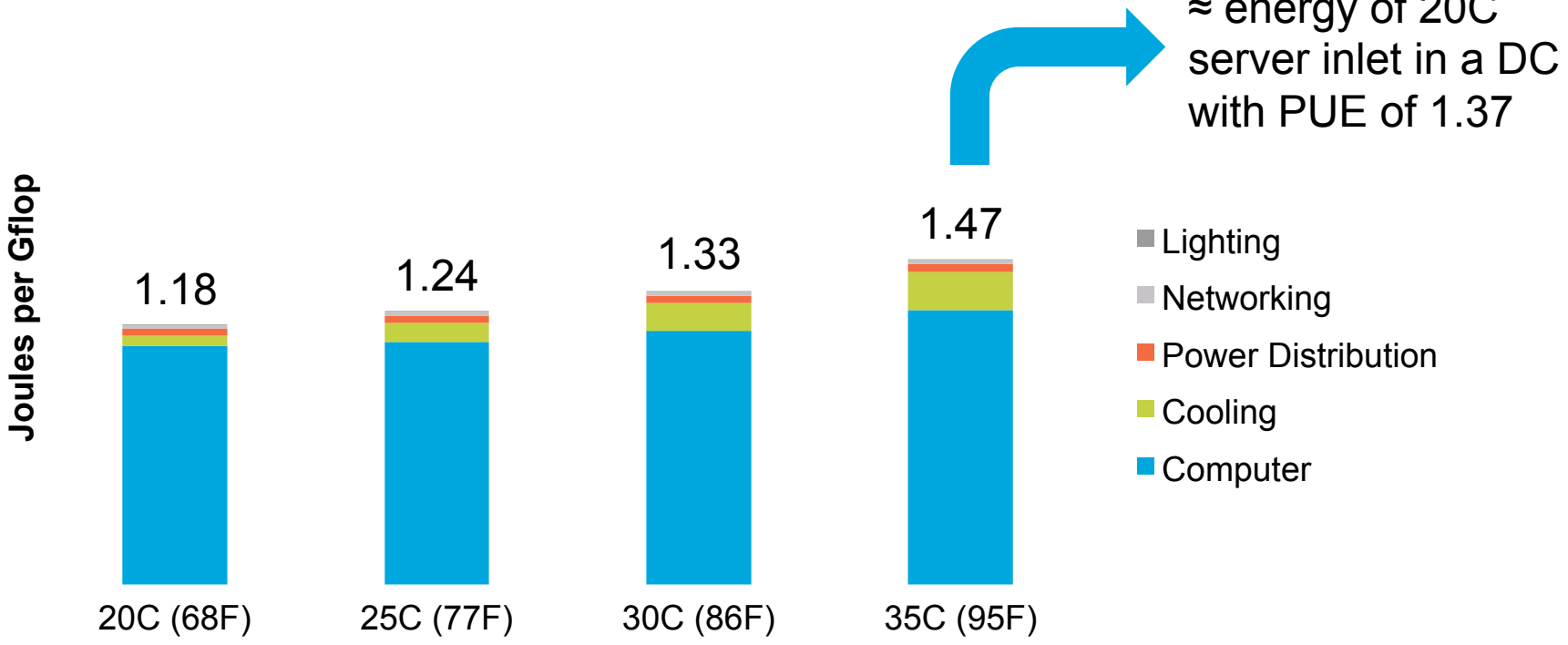
Fan power α (fan speed)^3



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”?

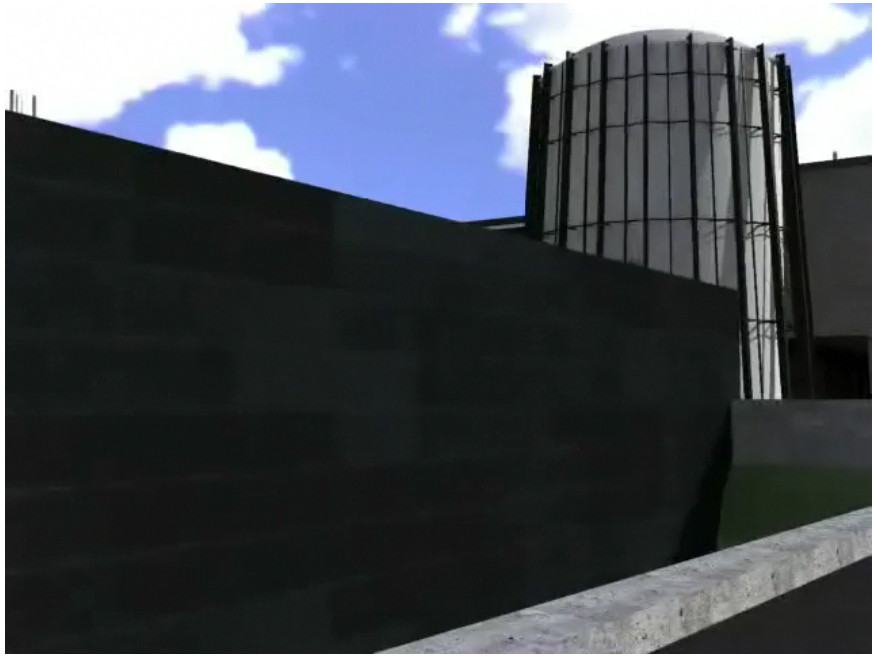
$$PUE = \frac{\text{Total Energy}}{\text{IT Energy}}$$

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

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

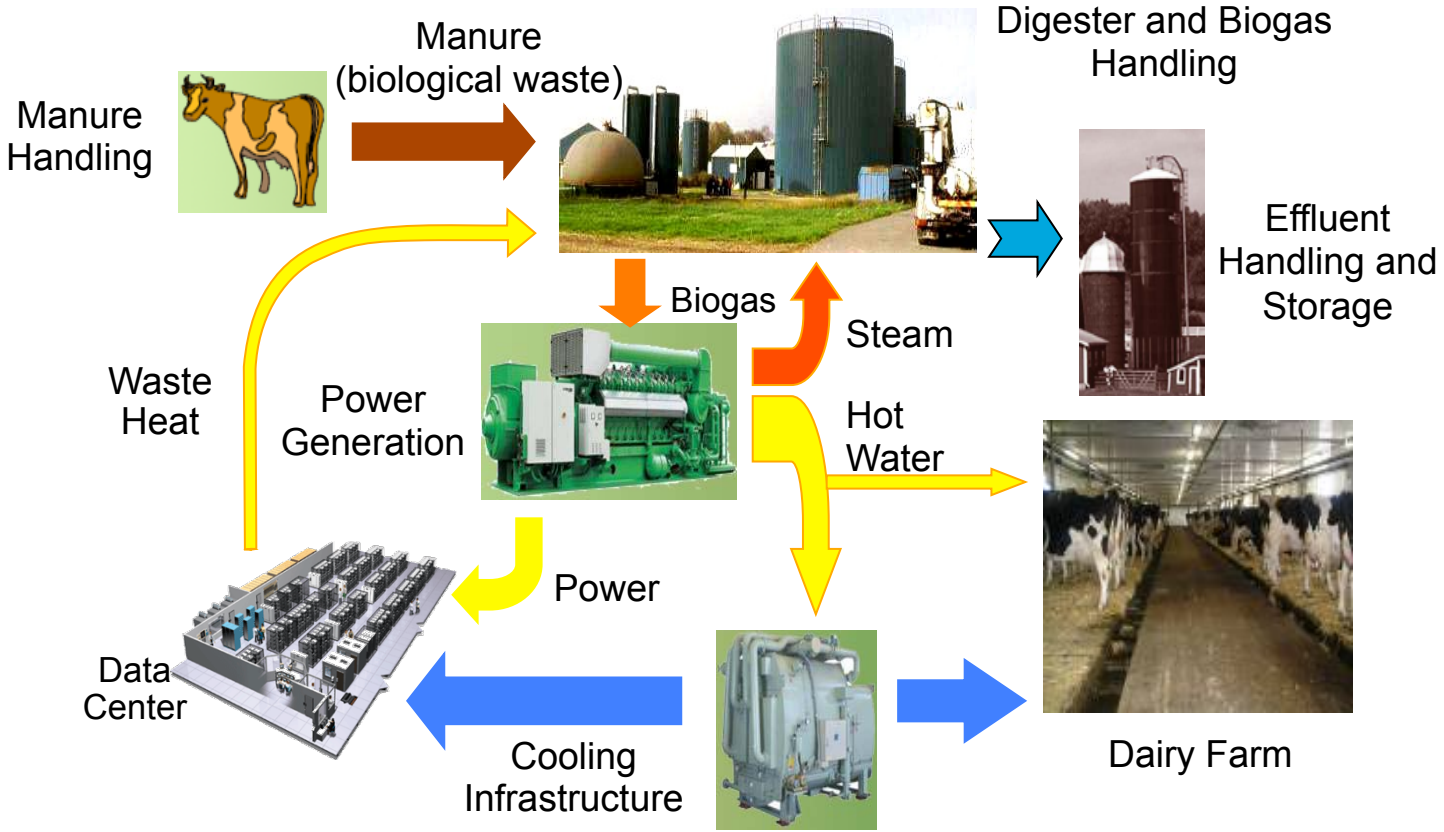
CLUMEQ Silo Datacenter

Quebec city, Canada



CLUMEQ Silo PUE Data						
Operating hours						8760
Chilled water hours						720
Free air cooling hours						3660
Free water cooling / re-use hours						4380
	kW	summer	free-air	free-water	hours	energy (kWh)
IT load	330.00	X	X	X	8760	2890800
Fans load	3.60	X	X	X	8760	31536
Chiller load	56.30	X			720	40536
Water tower	9.38	X			720	6756
Water pumps	3.75	X		X	5100	19142
Ultrasonic humidifying	1.75	X	X	X	240	420
Transformer loss	6.60	X	X	X	8760	57816
UPS loss (60 kVA)	7.20	X	X	X	8760	63072
Lighting (daily average)	1.50	X	X	X	8760	13140
Total	**420.09**					**3123218**
Energy re-use	**330.00**				**4380**	**1445400**
Net Energy consumption						**1677818**
Summer PUE						1.27
Free air-side PUE						1.06
Free water-side PUE (heat re-use)						1.07
PUE (year average)						**1.08**
rPUE / ERE (year average)						**0.58**

Datacenter ecosystem

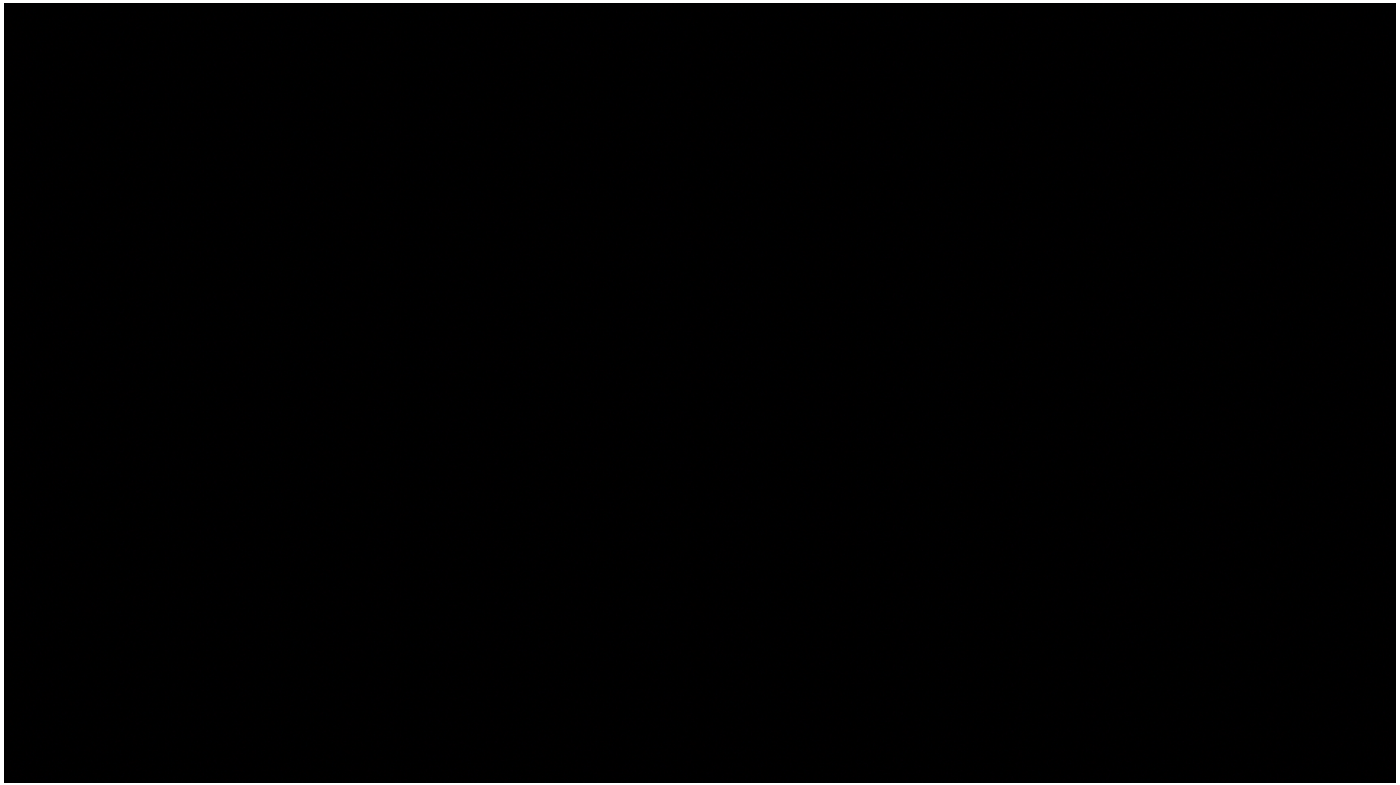


Source: Martin Arlitt HP Labs, ASME 4th International Conference on Energy Sustainability, May 17–22, 2010 Phoenix, Arizona

From Cow Manure to kWh

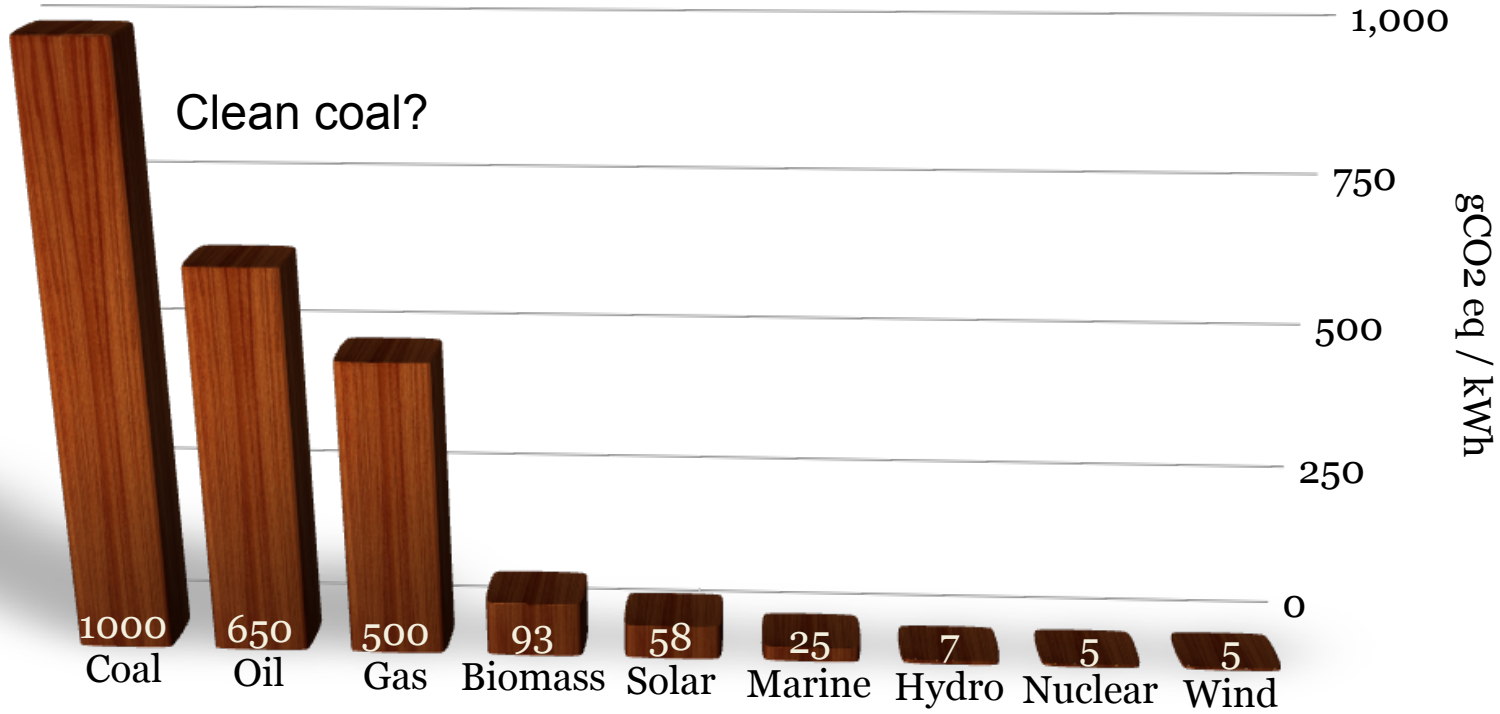
- **Cow daily production**
  54.7 kg / day
  = 20 metric tons / year
- **Anaerobic digester:**
  1 cow = 15kWh /day
- **2 000 cows dairy**
  => 30 000 kWh / day
- **30MWh / 24h = 1.25MW**
- **Enough power for a 1MW datacenter with PUE 1.25**

Cave “truth” #2: “Clean” coal



http://www.thisisreality.org
http://www.youtube.com/watch?v=W-_U1Z0vezw

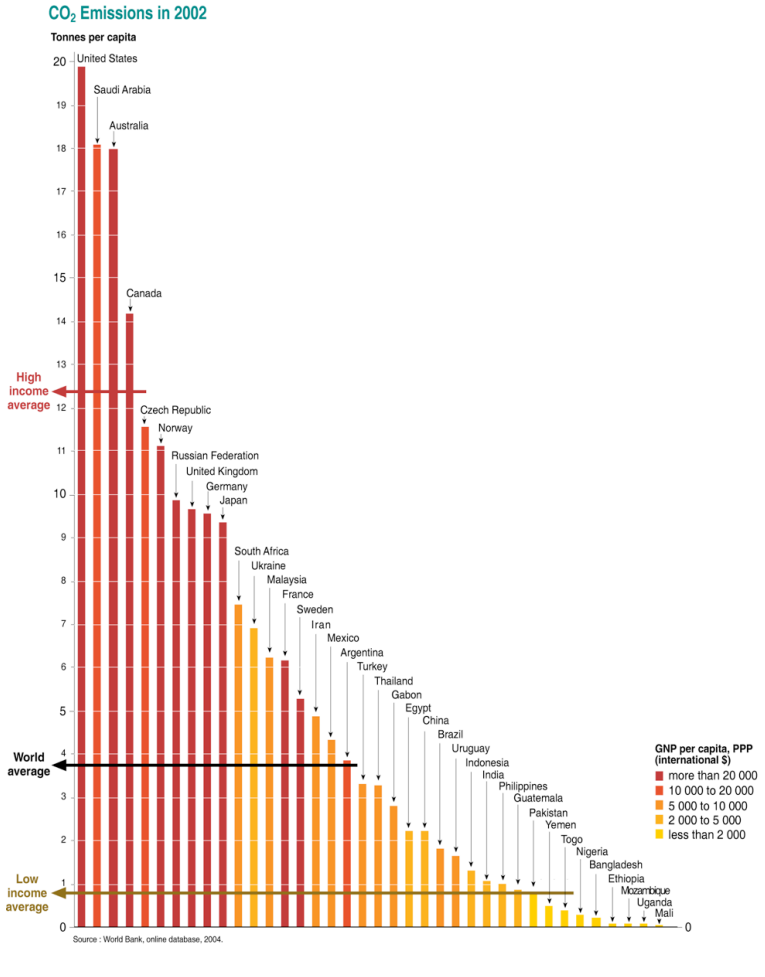
Energy Sources CO_2 footprint



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

IT Carbon Footprint

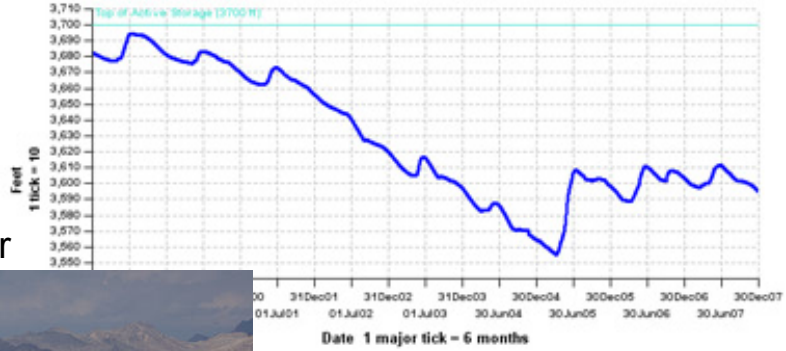
- **A 20MW data center running on coal emits 175 200 Tons of CO_2 eq /year**
- **The equivalent annual carbon footprint of 43 800 people**
- **Same data center on Hydro power: 876 Tons, or 219 people**



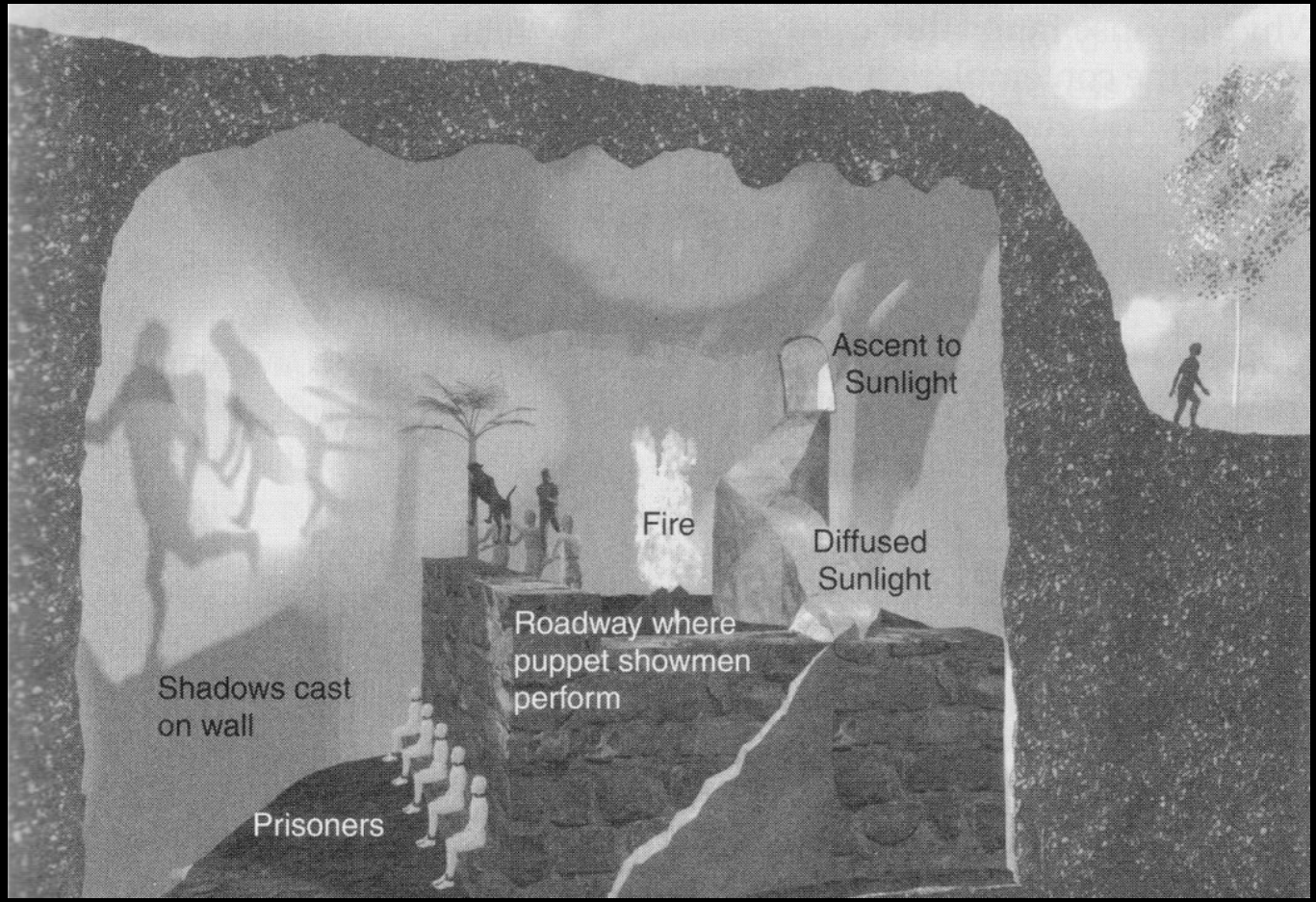
Cave “truth” #3: water is free and available

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

Lake Powell



Lake Mead reservoir


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

Think different.

Why use air, a commonly used “insulator”, as the default heat removal mechanism?

Water heat transport capacity is up to 100 times better than air.

$$h_{water} = 100 \times h_{air}$$

$$h = \frac{Q}{A * \Delta T}$$

h: heat transfer coefficient
Q: heat input (W)
A: heat transfer surface area (m^2)
ΔT: Delta-T (K)

Back to the Future

1985

2012

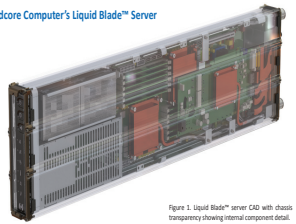
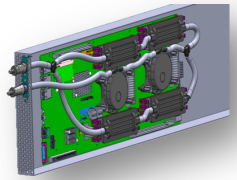


Figure 1. Liquid Blade™ server CAD with chassis transparency showing internal component detail.



HP's Liquid Cooling ~~Today~~ – well, quite soon

Democratizing component level liquid cooling

Warm water cooling
- Eliminate chillers
- Minimize evaporative
- Leverage dry cooling

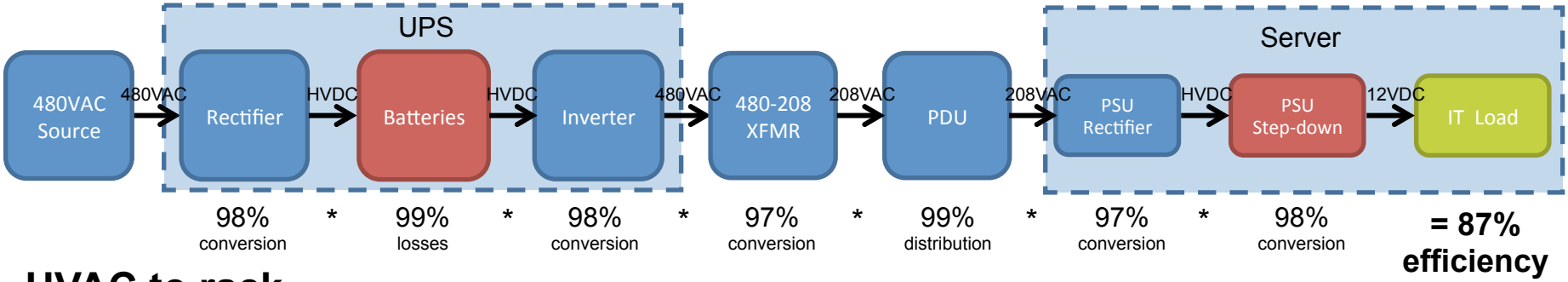
Maximize heat re-use
- Hot water outlet
- Optimized water flow rate

Component level cooling
- Improved silicon thermals
- Lower leakage currents
- Facilitated "turbo" modes

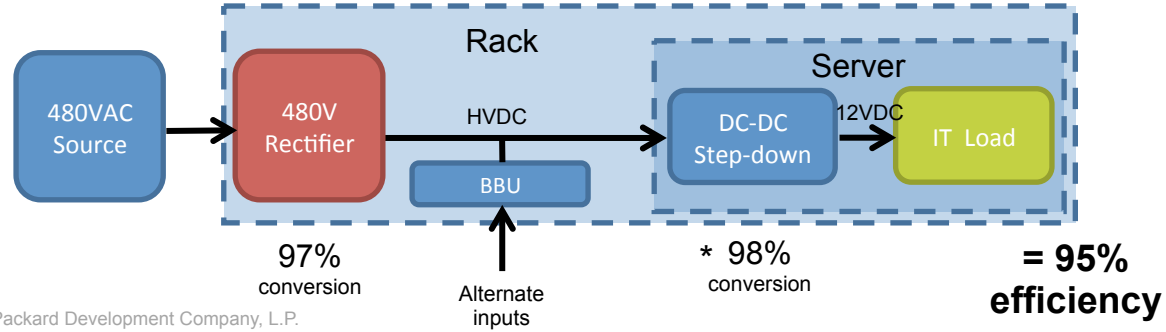
Power Distribution Efficiency

High-Voltage AC to the Rack: Limiting conversion steps

Typical



HVAC to rack



10 MW Datacenter Design Match-up

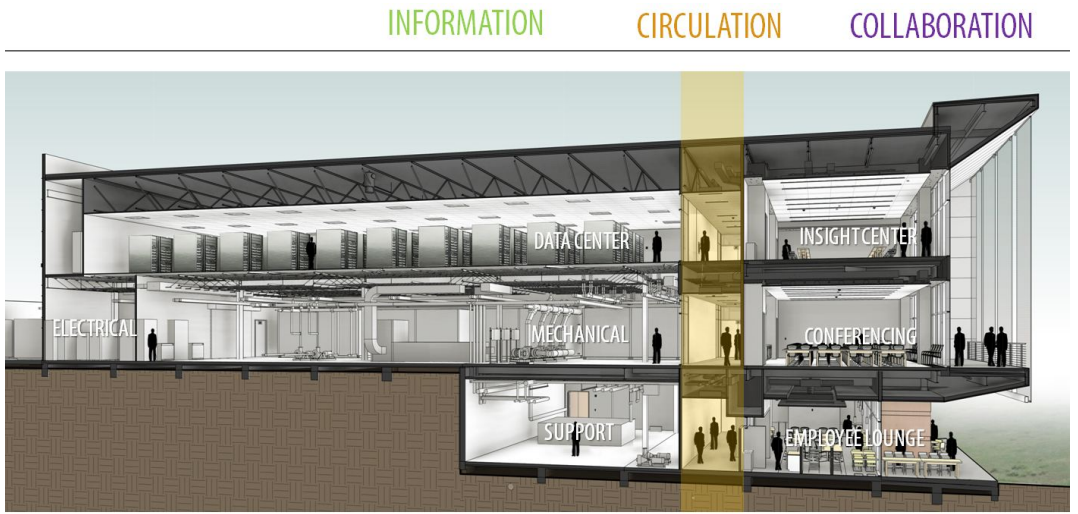
kWatts	Conventional	Free Air @ 20C	Free Air @ 35C	NREL + HP Rack
IT Load	10 000	10 000	11 530	10 000
DC Fan Load	400	400	1614	0
Chiller Load	1 706	0	0	0
Evap. Towers	0	0	0	284
Water Pumps	114	0	0	40
UPS Losses	500	0	0	0
Power Distribution Losses	900	900	1 038	400
Humidification/DeHum	100	200	231	0
Lighting	2	2	2	2
IT Load PUE	1.37	1.15	1.25	1.07
Total Power Consumption	13 722	11 502	14 415	10 726

2.6M$ annual energy savings! (@ 10 cents / kWh)

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
- Heat re-use aware scheduler



See you in @ SC13 in Denver next year!

Thank you

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