Who needs skeletons? We've got servers in the closets

Mark Monroe, Chief Technology Officer and VP at DLB Associates
Kendra Tupper P.E., Principal at Rocky Mountain Institute
Josh Whitney, Senior Project Director, WSP Environment + Energy

Energy Manager's Roundtable

E Source

Presentation Outline

Introduction/Overview (25 min)

- **Energy consumption**
- **Metrics for data center/server room efficiency**
- **Unique challenges for small server rooms/closets**

Best Practices for Server Rooms/Closets (25 min)

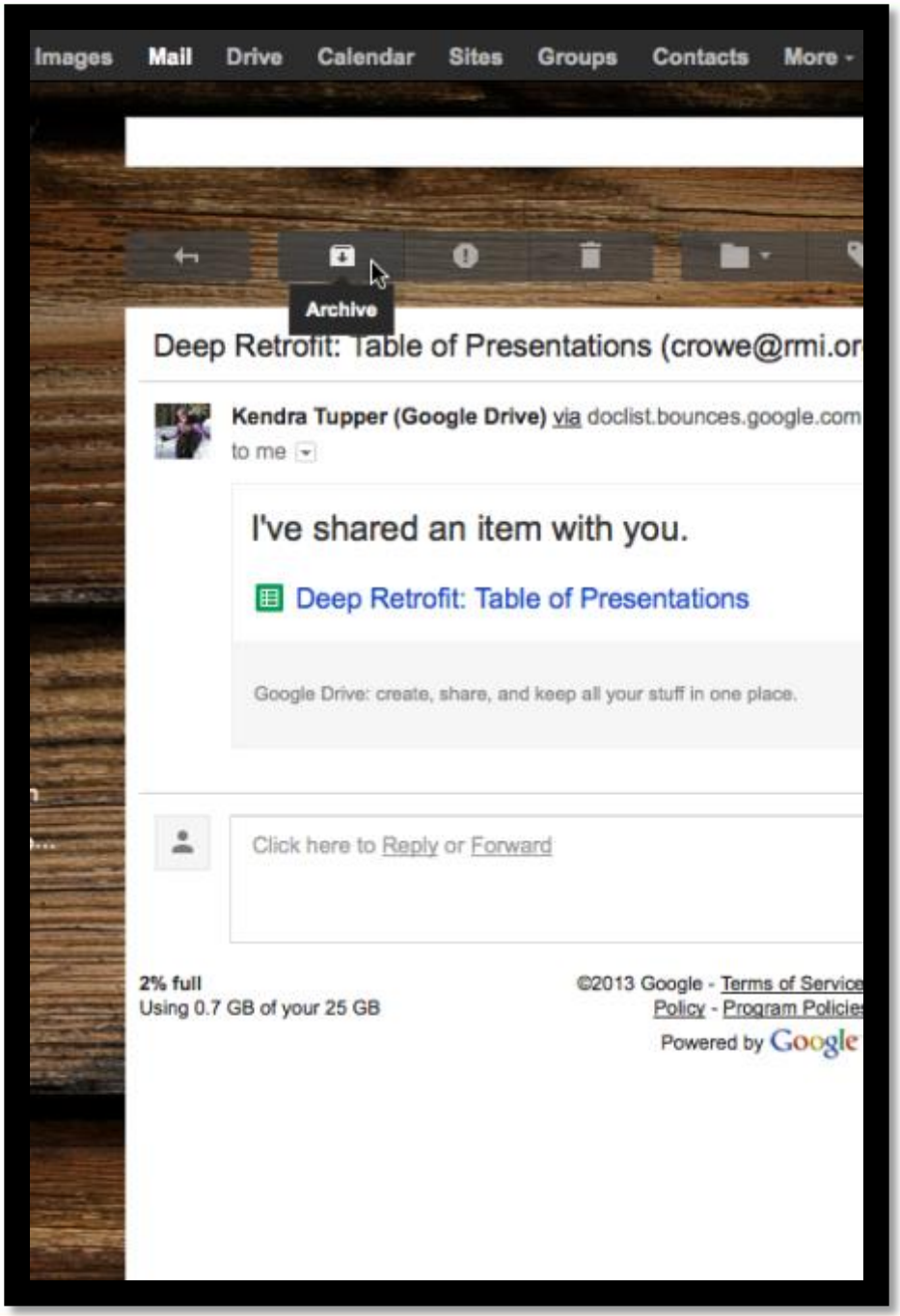
Portfolio Planning (5 min)

Making the Business Case (15 min)

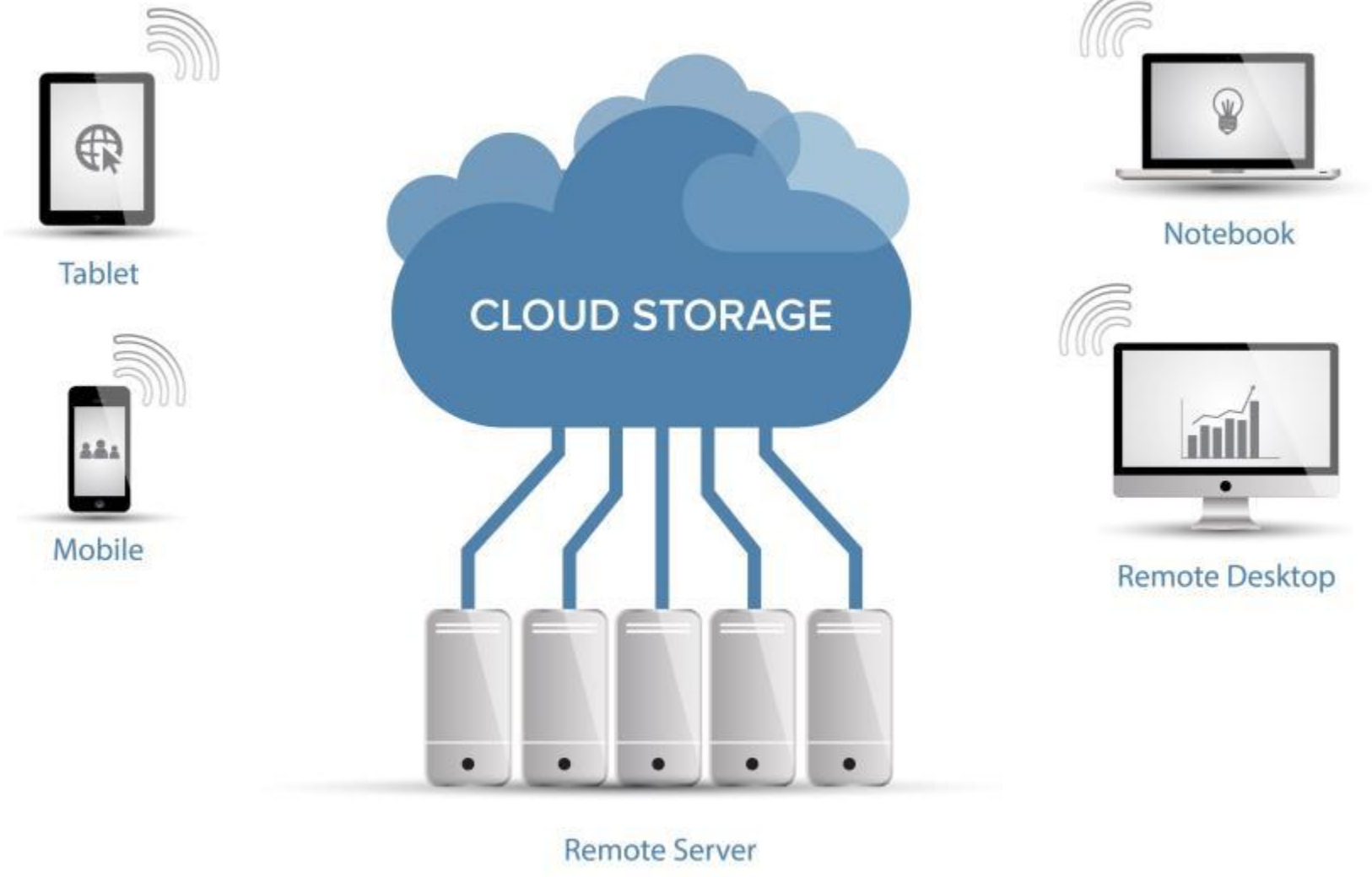
Q&A (20 min)

INTRODUCTION


COMPACT

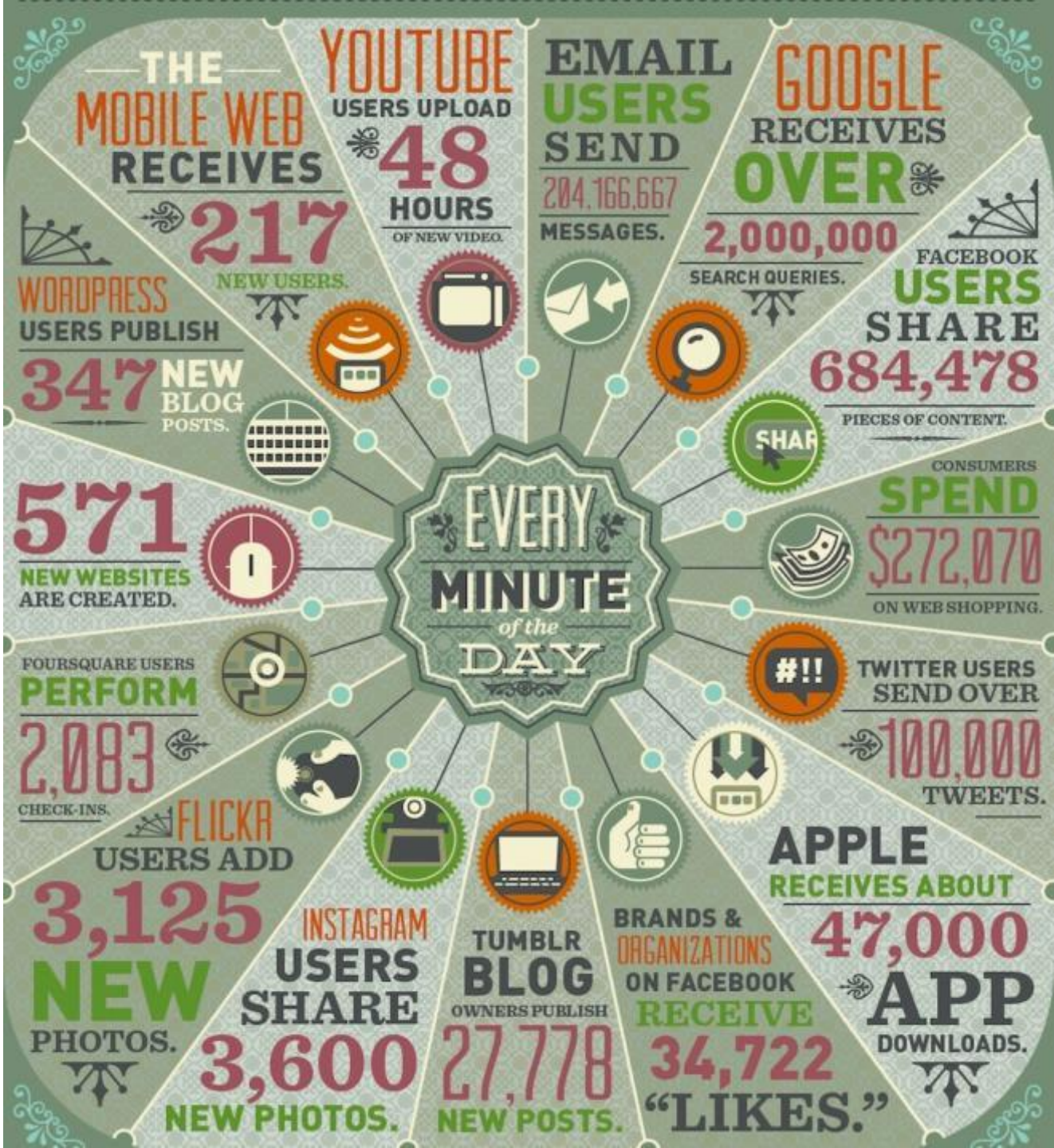

Images
Mail
Drive
Calendar
Sites
Groups
Contacts
More
Archive
Deep Retrofit: Table of Presentations (crowe@rmi.or
Kendra Tupper (Google Drive) via doclist.bounces.google.com
to me
I've shared an item with you.
Deep Retrofit: Table of Presentations
Google Drive: create, share, and keep all your stuff in one place.
Click here to Reply or Forward
2% full
Using 0.7 GB of your 25 GB
©2013 Google - Terms of Service
Policy - Program Policies
Powered by Google


Tablet
Mobile
CLOUD STORAGE
Notebook
Remote Desktop



Data centers consume 75 billion kWh/yr in the U.S.

In the last minute…..



PUE: Power Usage Effectiveness

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

- Measures infrastructure efficiency (cooling, lighting, UPS, etc.)
- Useful for tracking efficiency over time or comparing between similar facilities
- Related metric - DCiE: Data Center infrastructure Effectiveness

$$DCiE = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}}$$

CUE: Carbon Usage Effectiveness

$$CUE = \frac{\text{Total CO2 emissions caused by the Total Data Center Energy}}{\text{IT Equipment Energy}}$$

OR

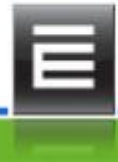
CUE = Carbon Emission Factor (CEF) X PUE

- Expressed as: $kgCO_2eq$ per kWh
- Right now, limited to Scope 1 and Scope 2 emissions

RUE: Rack Unit Effectiveness

$$RUE = \frac{\text{Maximum RU count at capacity}}{\text{Installed RU count x Utilization}}$$

- Developed by David Cappuccio (Gartner)
- Addresses resource efficiency in IT equipment
- Based on the most common resource in most data centers – Rack Unit
- Takes into account installed capacity and utilization
  - Extremely variable (5-70%) and hard to measure
  - Consolidation and virtualization increases the utilization

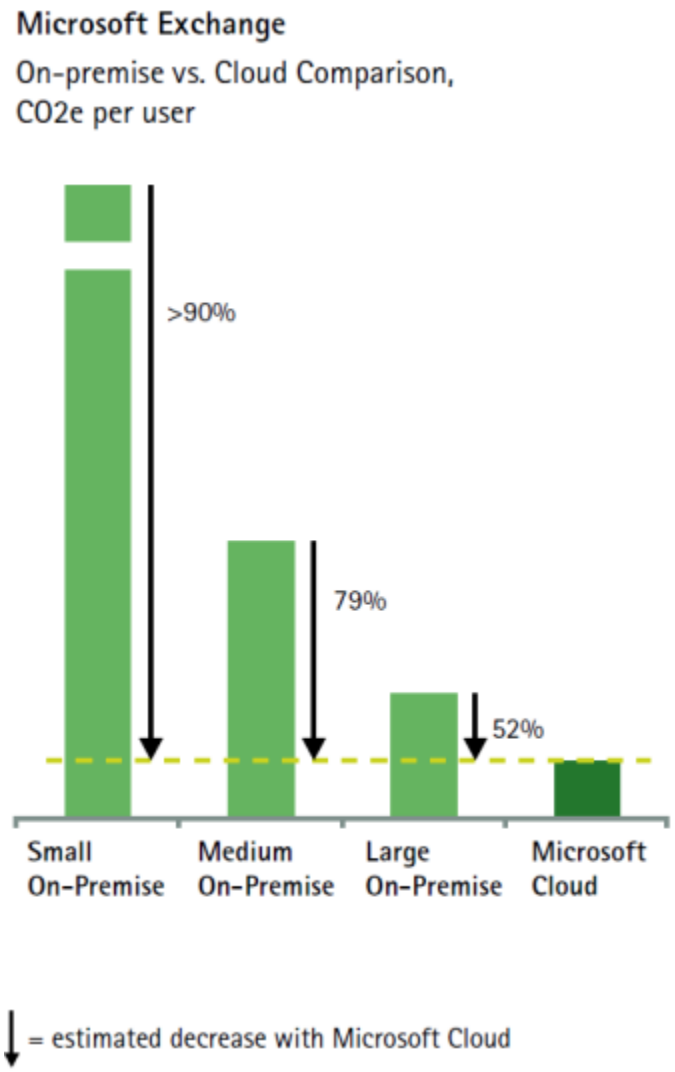


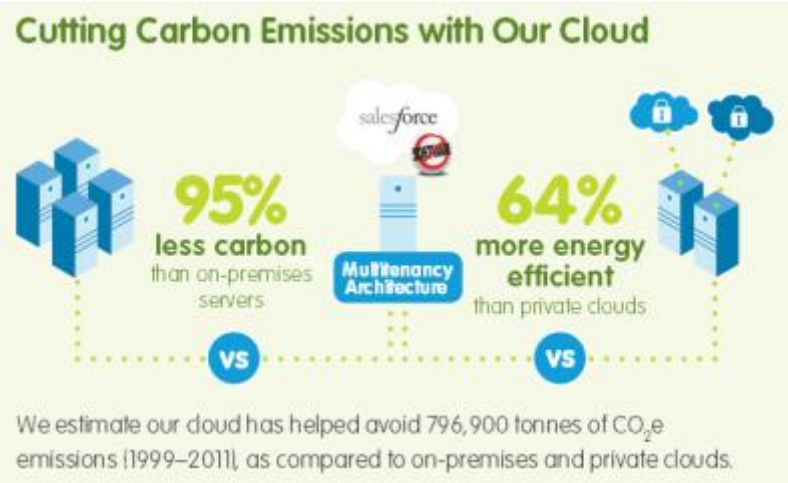
DCeP: Data Center Energy Productivity

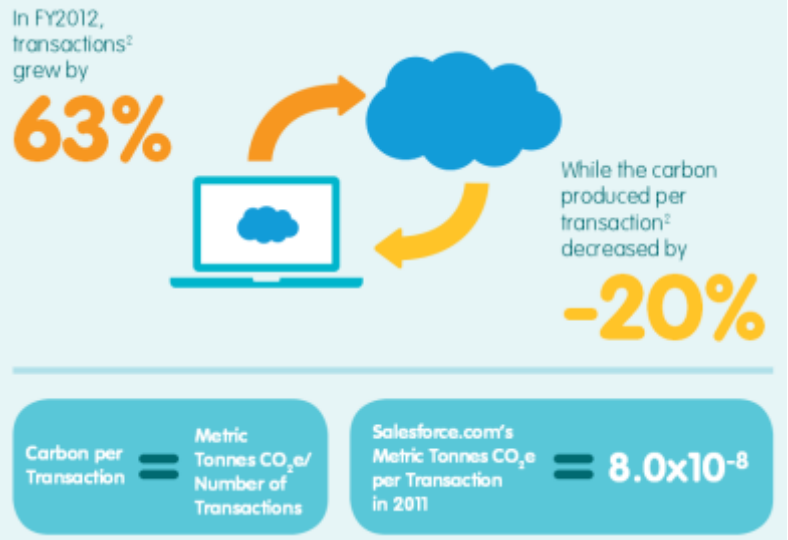
$$DCeP = \frac{\text{Useful Work Produced}}{\text{Total Data Center Energy Consumed}}$$

- Quantifies the useful work that is produced based on the amount of energy consumed
- Requires quantification of useful work

Microsoft & Salesforce.com measure the cloud







eBay launches Digital Service Efficiency Dashboard

Metrics Comparison

	PUE	CUE	RUE	DCeP
Cooling and lighting energy	X	X		X
Carbon emissions		X		
On-site renewables		X		
Utilization			X	X
Useful work				X
IT equipment energy	X	X		X

Metrics “Game”

3 Different Data Centers in Various States:
All 9,000 sf with a max capacity of 300 Racks (42 U size)

Washington	Colorado	North Carolina
180 racks	280 Racks	220 Racks
Low efficiency infrastructure	Mid efficiency infrastructure	High efficiency infrastructure
50,000 transactions/yr	35,000 transactions/yr	75,000 transactions/yr
10% Utilization	60% Utilization	3% Utilization

*Infrastructure = HVAC, lighting, and UPS

Metrics "Game"

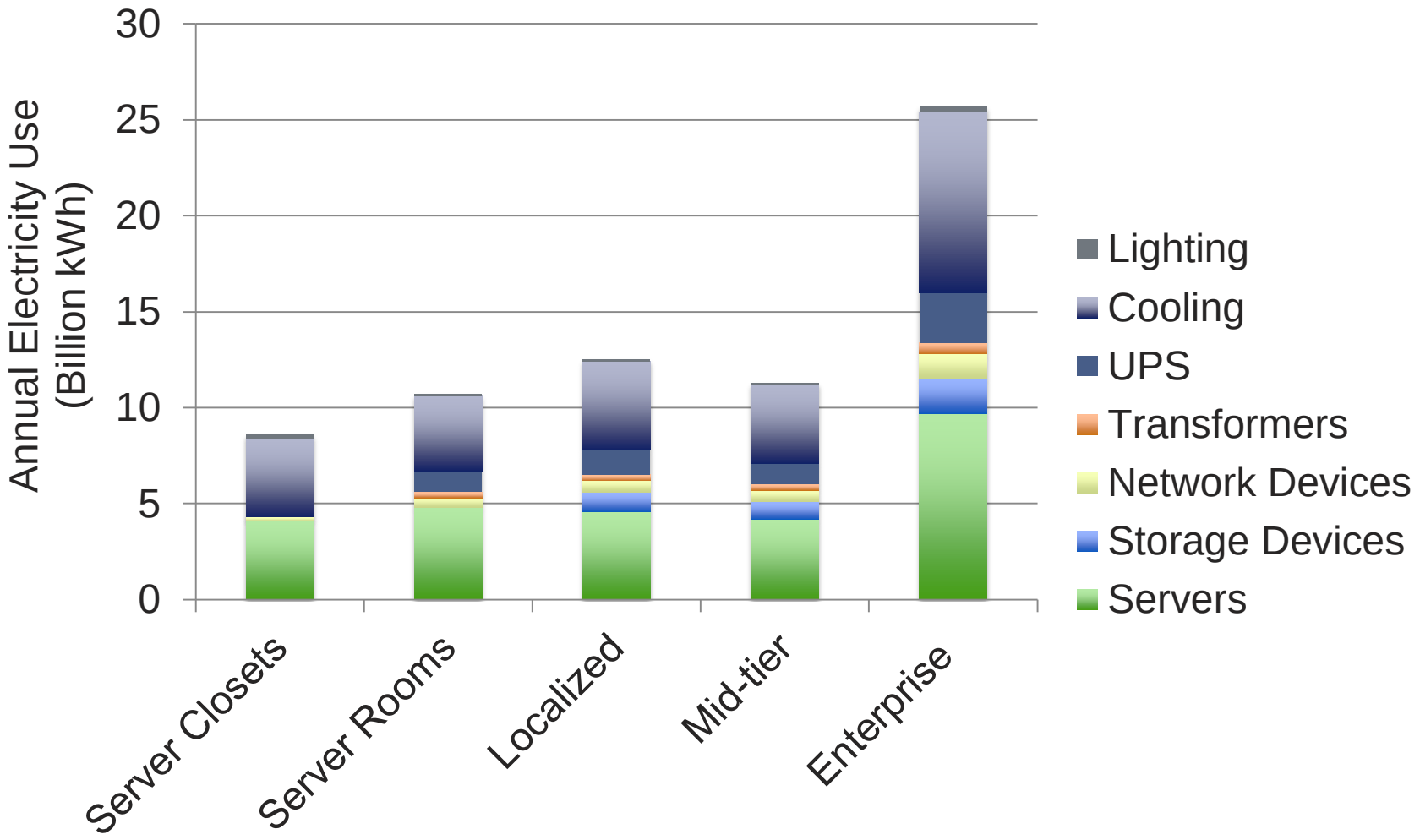
3 Different Data Centers in Various States: All 9,000 sf with a max capacity of 300 Racks (42 U size)

	Washington	Colorado	North Carolina
PUE (Total kW/IT kW)	2.4	3.5	1.6
CUE (CEF x PUE)	0.6	1.6	1.3
RUE	16.7	1.8	45.5
Transactions per IT kWh	0.05	0.07	0.06

Types of Data Centers

Space type	Typical size (sf)	Typical IT device characteristics	Notes/ Examples
Server closet	<200	1-2 servers No external storage	Managed in-house in small-medium organizations
Server room	<500	Few dozens of servers No External Storage	Managed in-house in small-medium organizations
Localized data center	<1,000	Dozens to hundreds of servers Moderate external storage	Typical of large organizations or a university, often managed in-house
Mid-tier data center	<5,000	Hundreds of servers Extensive external storage	Smaller colocation facilities and private cloud data centers
Enterprise-class data center	5,000+	Hundreds to thousands of servers Extensive external storage	Largest colocation facilities and public cloud data centers

U.S. Data Center Energy Use



Source: Masanet et al. 2011

Server rooms/closets represent a huge opportunity for savings in commercial building

23% of annual energy costs (typical office bldg, including plug loads)

40-50% of annual energy costs (high performance office bldg, including plug loads)

Byron Rogers Federal Office Building (Denver, CO)

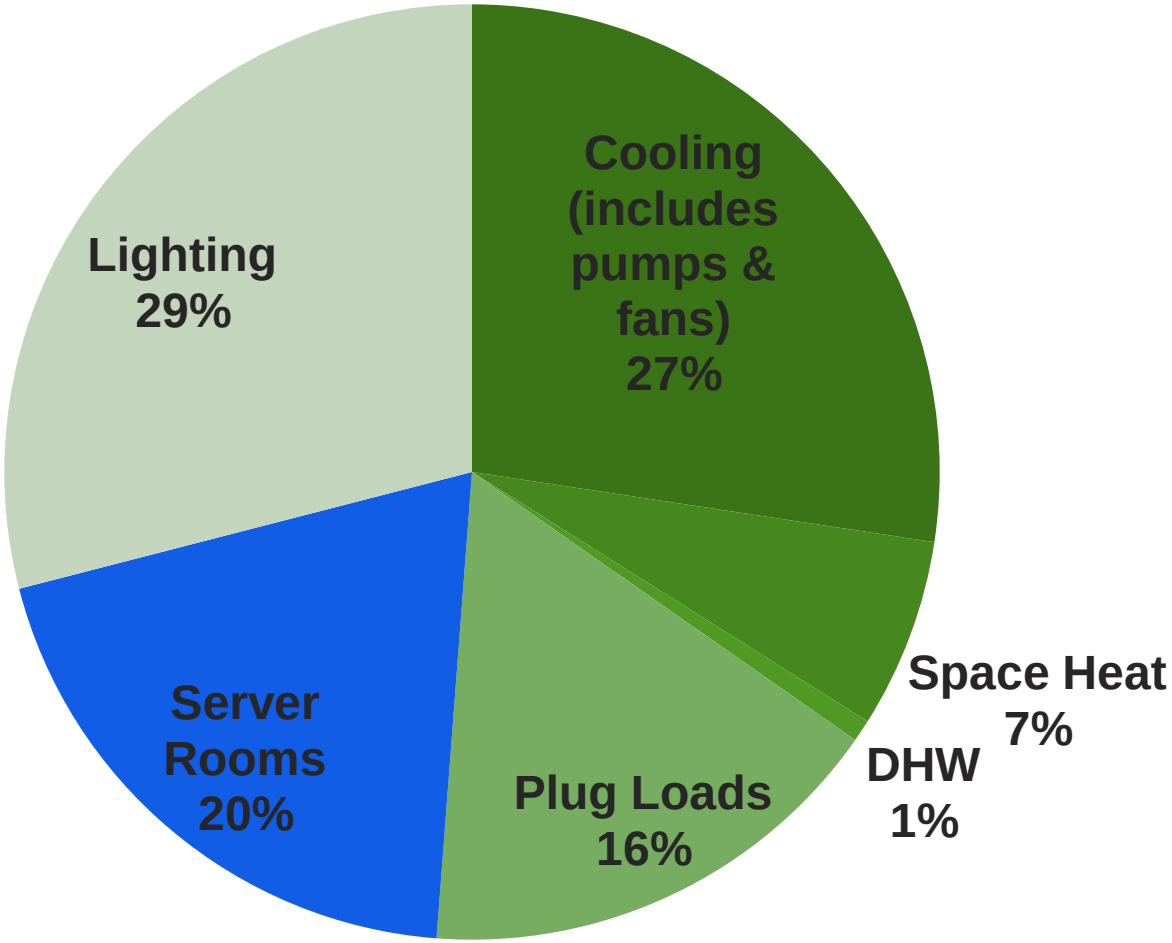
Predicted Post Retrofit Performance

- 28-38 kBtu/ft^2-yr
- 60-70% reduction from 2009 use

- **LED Ltg**
- **Chilled beams**
- **Super-insulated envelope**
- **High perf. glazing**
- **Heat recovery & thermal storage**
- **DOAS**
- **Solar thermal**
- **EnergyStar office equipment**

Byron Rogers Federal Office Building (Denver, CO)

Breakdown of annual energy costs



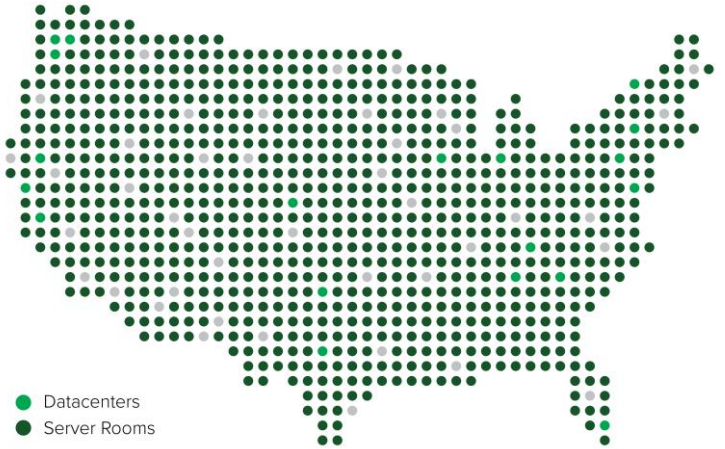
Server Rooms/Closets: Unique Challenges

- No economies of scale
- Split Incentives
  - Tenant/Owner
  - IT Manager/Energy Manager
- Data center energy use is not core to business model
- Space constraints
- Widely distributed (and sometimes hidden)

Widely distributed, Tough to manage

- **43% of Servers are in 0.6% of Datacenters (Enterprise & Mid-tier)**
  - Concentrated & easy to find
  - 16,800 data centers

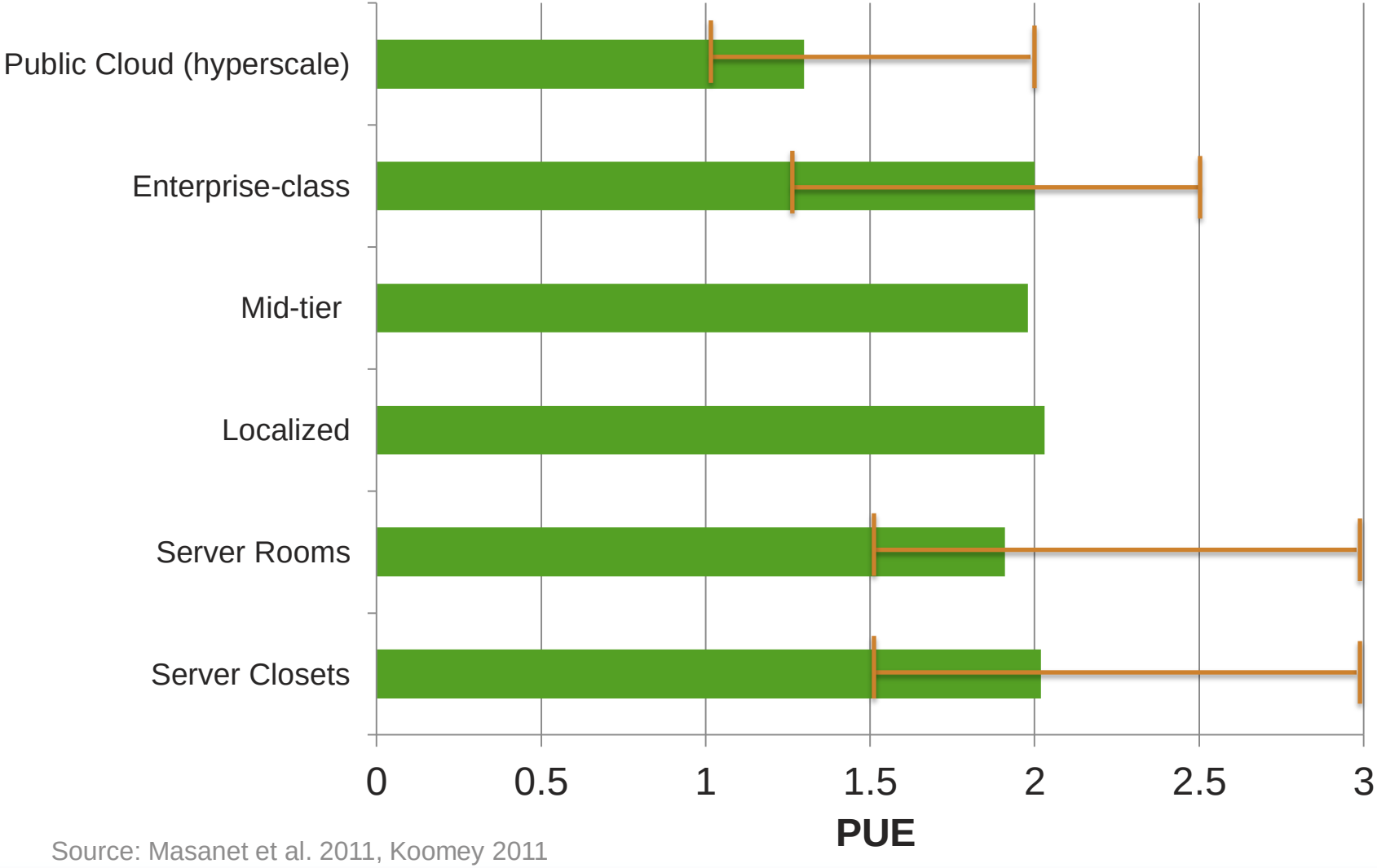
- **41% of Servers are in 97% of rooms**
  - > 2.5 million ‘Server Rooms’
  - Hospitals/ Hotels/ Universities/ Utilities/ Banks/ City Halls/ Chain Stores/ Office Buildings



Source: EPRI Analysis of IDC Special Study, Data Center of the Future

Comparison of PUE

National average Power Usage Effectiveness (PUE) = 1.91



Source: Masanet et al. 2011, Koomey 2011

Utilization is much higher for the internet hyperscale clouds…

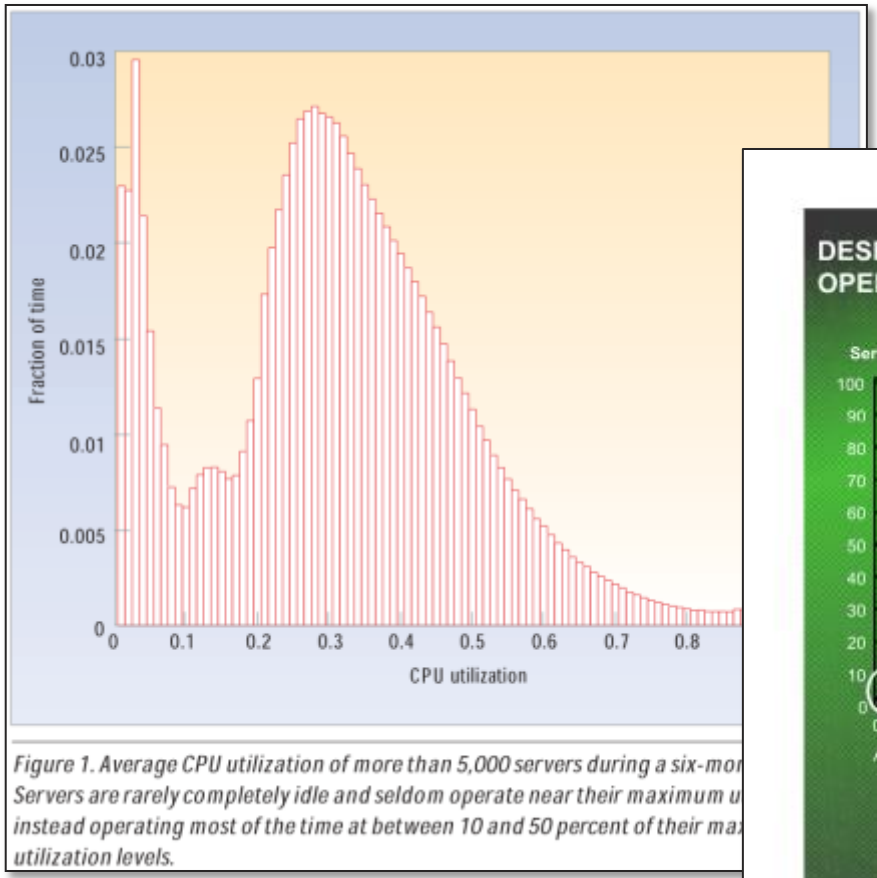
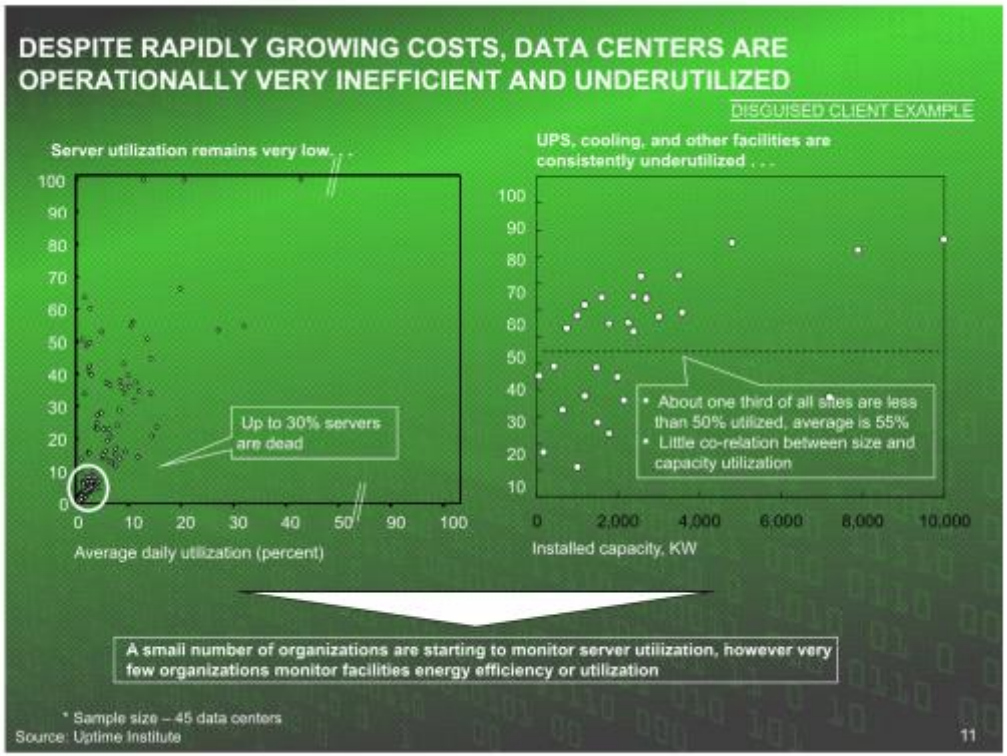


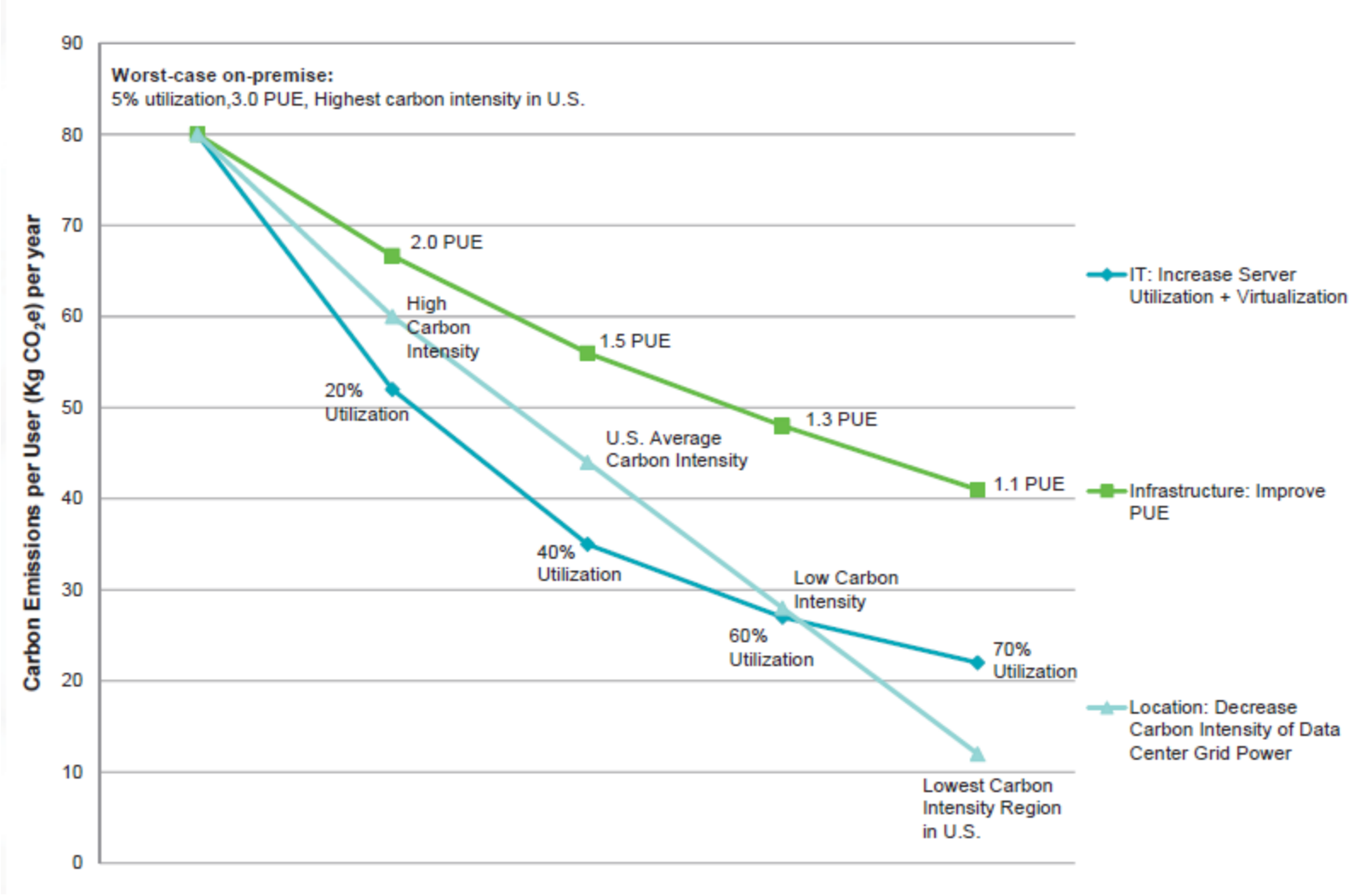
Figure 1. Average CPU utilization of more than 5,000 servers during a six-mo
Servers are rarely completely idle and seldom operate near their maximum u
instead operating most of the time at between 10 and 50 percent of their ma
utilization levels.

Source: Google, Barroso & Hölzle,
http://impact.asu.edu/cse591sp11/Barroso07_EnergyProp-clean.pdf



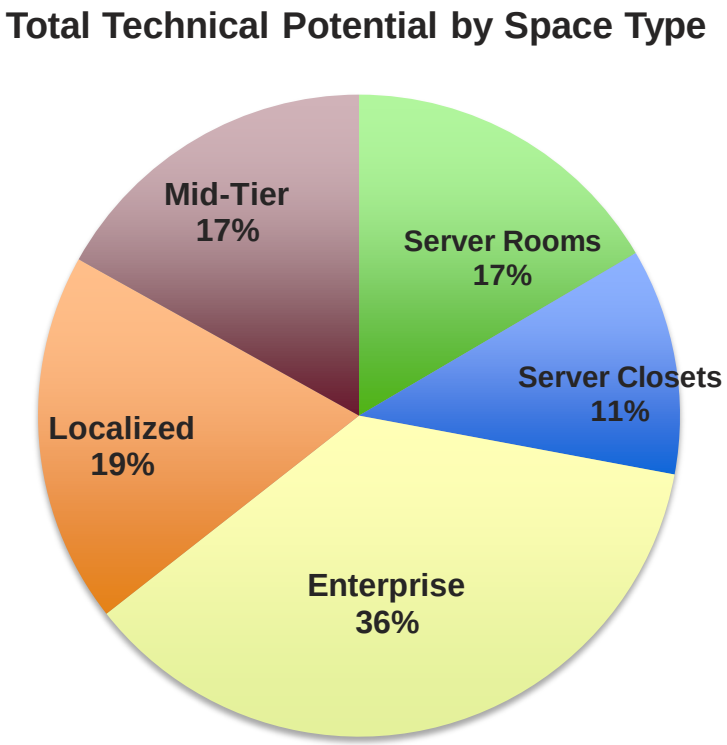
source: presentation, "Revolutionizing Data Center Efficiency,"
UPTIME INSTITUTE SYMPOSIUM, 2009. McKinsey & Company

Improving utilization is just as important as improving PUE



Source: The Carbon Emissions of Server Computing for Small to Medium Sized Organizations, NRDC and WSP, October 2012

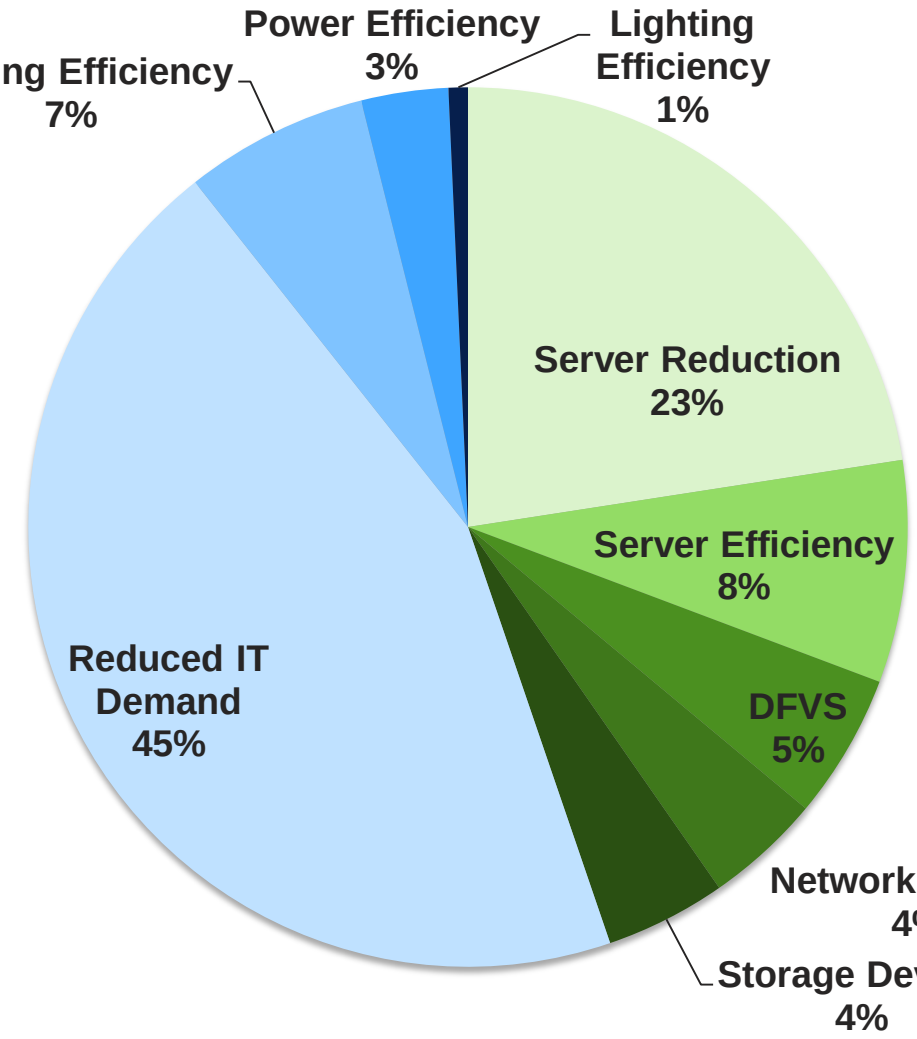
Technical Efficiency Potential



- 70-80% Estimated Savings (~56 Billion kWh)
- Reduced annual electricity costs from from $5.9 billion to $1.1 billion

Source: Masanet et al. 2011, EPA 2007, RMI Analysis

Technical Efficiency Potential



Infrastructure Savings: 55% of Total

IT Equipment Savings: 45% of Total

Source: Masanet et al. 2011, EPA 2007, RMI Analysis

BEST PRACTICES

The Data Center Industry Ecosystem around Energy & Carbon Efficiency

Federal Gov't

US Office of Management & Budget

LBNL

DOE/ EERE

EPA/ EnergyStar

Industry Associations & Standards

Silicon Valley Leadership Group

7x24 Exchange

The Green Grid

Sustainable Roundtable

ASHRAE 90.4

Standard Performance Evaluation Corp

NGO's

Carbon Disclosure Project

Carbon Trust

WBCSD/ WRI

Greenpeace

NRDC

GESI

Research, Media & Consulting

Jonathan Koomey

Uptime Institute/ 451 Research

BCG, Accenture, Pwc, CapGemini

Gartner, Forrester

DLB Associates

Rocky Mountain Institute

WSP Environmental

And hundreds of providers

Disjointed Progress in the Data Center

"Facilities is from Mars, IT is from Venus"

What Facilities is Doing

- MEASURE
- Hot/cold containment
- Raise Temperature
- Variable frequency drives
- Economizers
- Evaporative Cooling

What IT is Doing

- MEASURE
- Server refresh
- Consolidation
- Virtualization
- Utilization Management

Infrastructure Efficiency Makes A Difference

Typical Datacenter

PUE 2.00

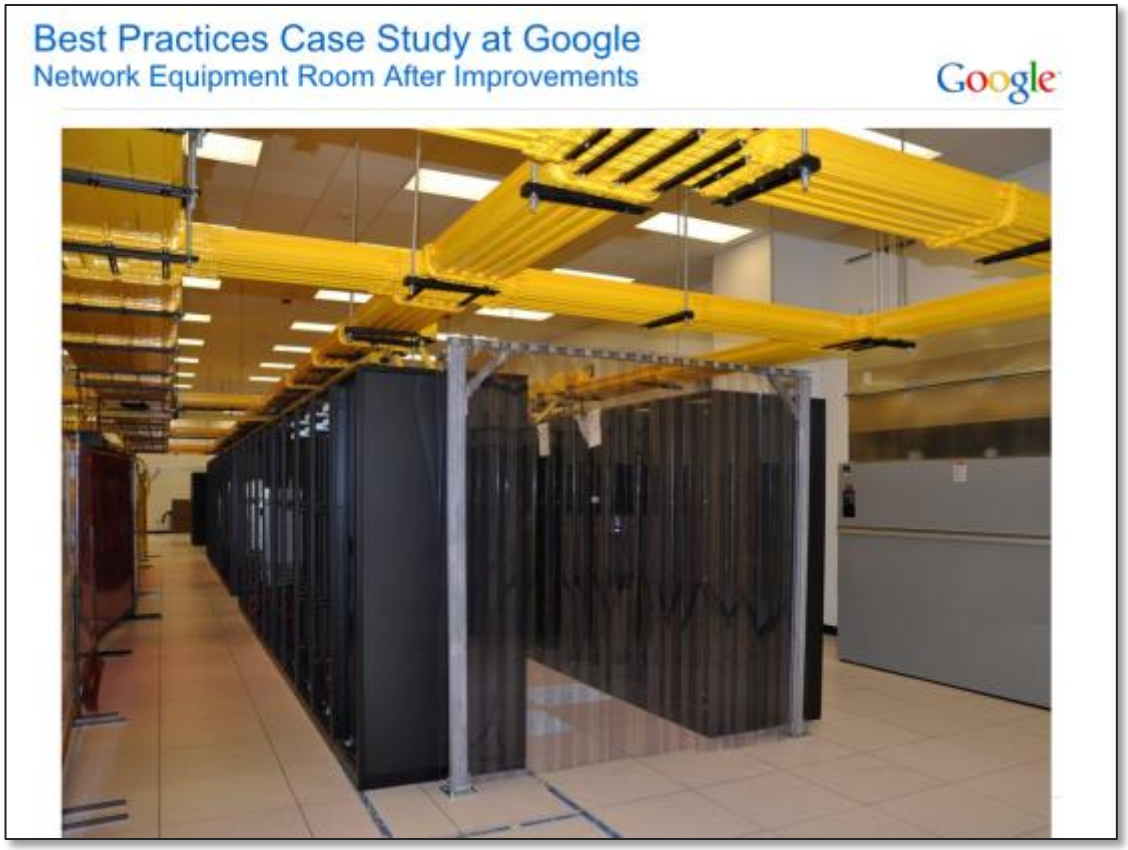
Efficient Data Center

PUE 1.28

0.1 improvement in PUE
for 1MW IT load
at $0.10/kWh
equals $100,000/yr
savings

* Industry average & target from uptime institute:
http://www.datacenterknowledge.com/archives/2008/Jan/22/case_study_ups_green_data_center.html

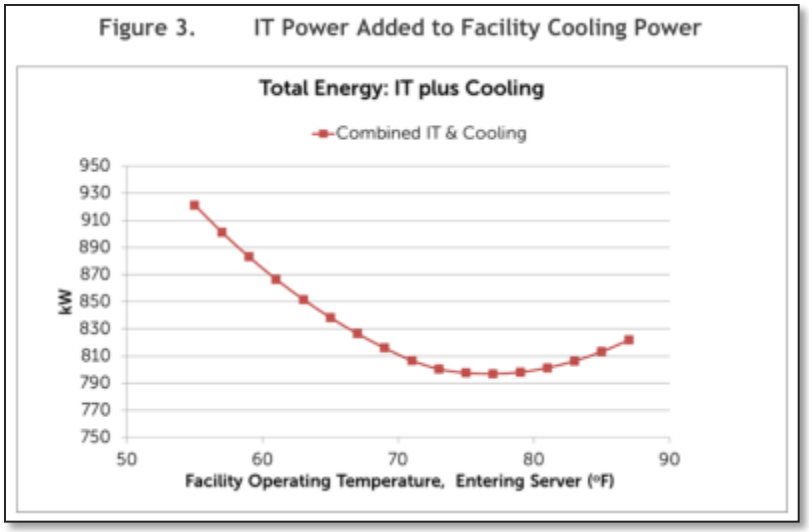
Hot/Cold Containment



Before: 2.5 PUE

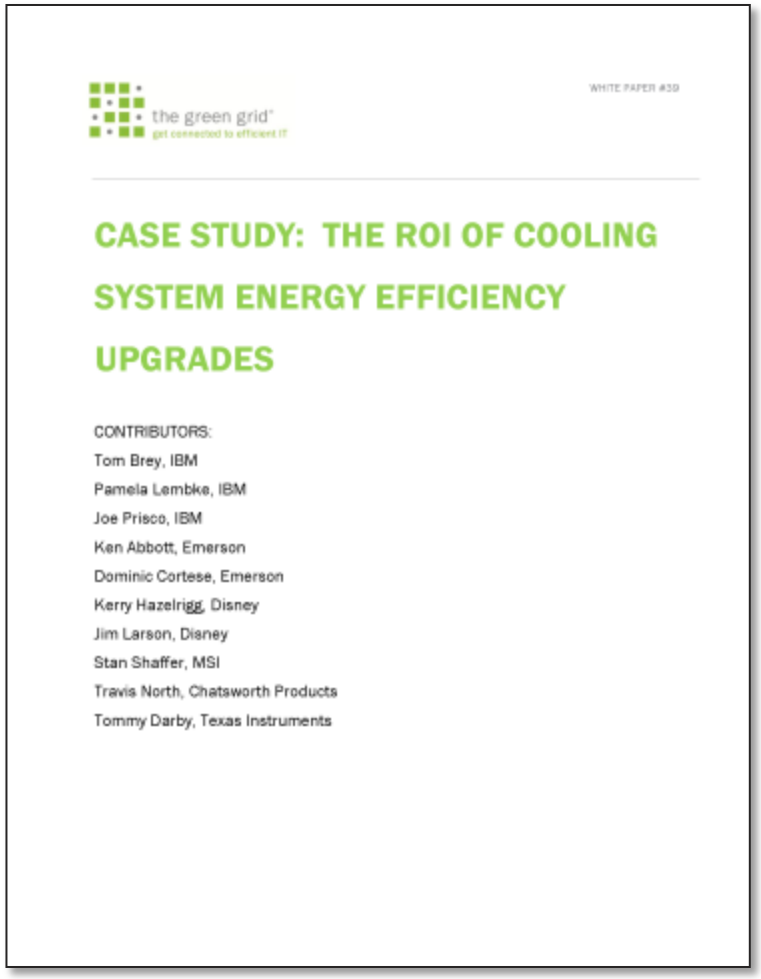
After: 1.6 PUE

Raise Set Point Temperature in Data Centers



Source: Moss, David L., "Data Center Operating Temperature: The Sweet Spot," Dell Technical White Paper, June 2011

- Demonstrated net savings from reduced HVAC outweighs increase in IT energy
- "Sweet Spot" 78°F in this case
- Zero cost, instant payback



- Showed 3% savings per degree F
- $300K/yr by increasing 3°F

Source: The Green Grid, 2011, http://goo.gl/xpQx8

IT Equipment Refresh/Consolidation
Case Study

- 202,000 sq-ft reduced to 80,000 sq-ft
- 2,200 servers -> 1,000 servers
- 738 storage devices -> 225 storage devices
- 2,200 KW power requirement -> 560 KW
- Compute capacity increased 273%
- Storage capacity increased 373%
- $7.2M capital equipment costs
- $11M construction costs avoided

Facilities buys new IT equipment

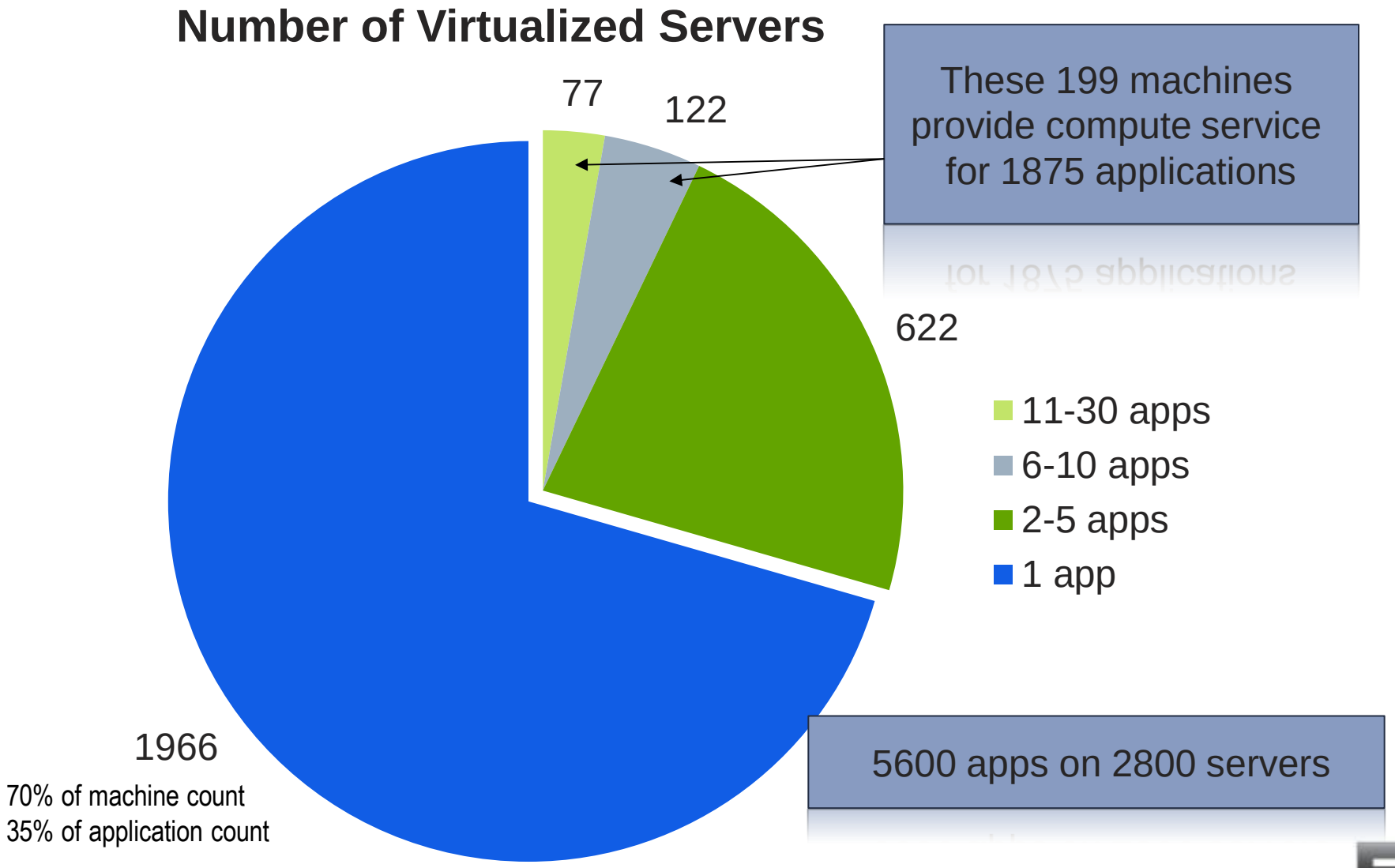
Facilities benefits from reduced costs

BOYD: Santa Clara, CA

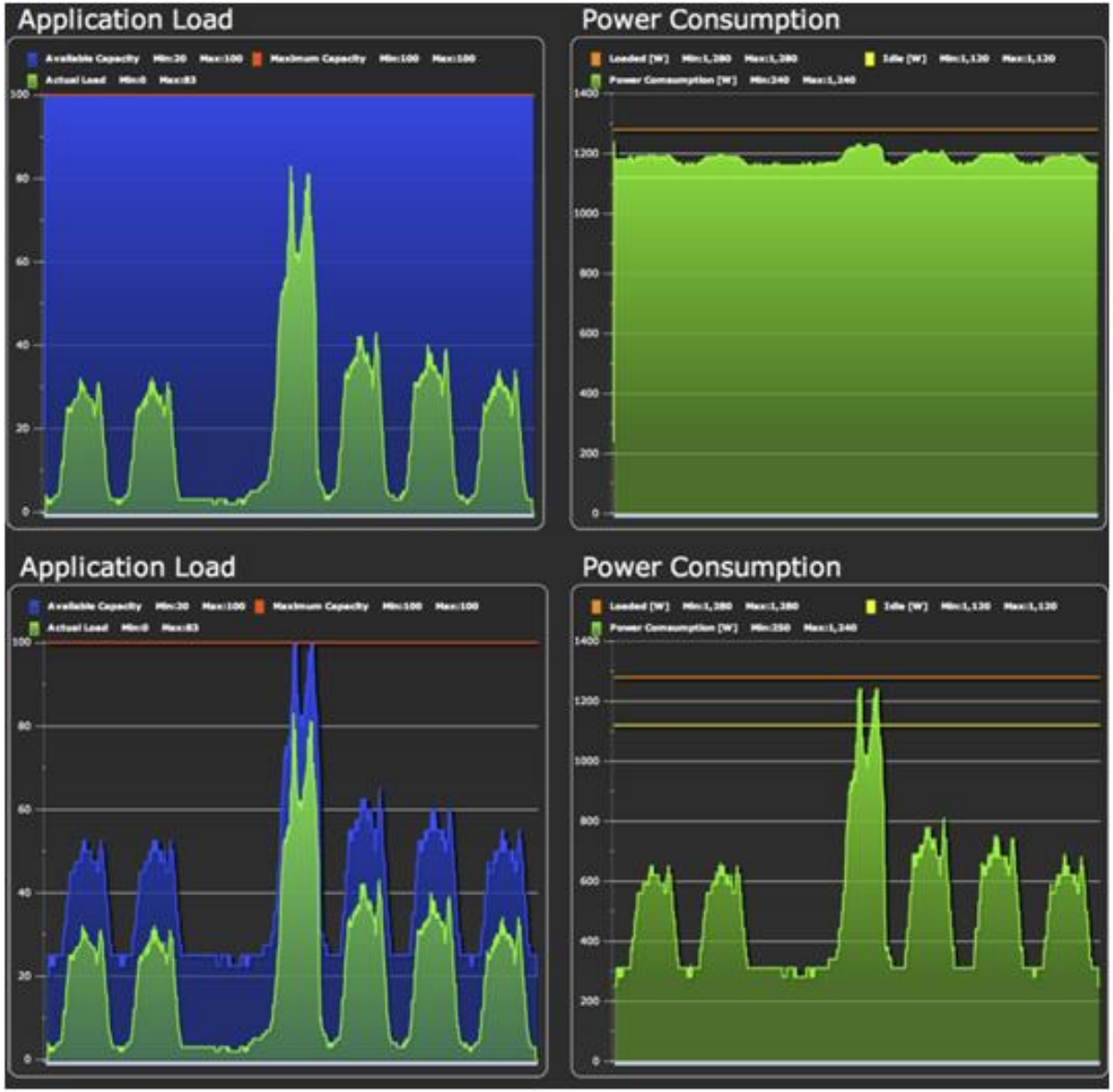
- Hardware “amnesty” program funded by facilities

- $9M cost avoidance
- 2.2MW to 500KW
- 450% compute increase
- 550 racks to 65
- 3,227 tons CO2 reduced
- Completed in 3 months
- 2:1 Server, 3:1 Storage
- 2,915 devices replaced

Virtualization Case Study



Power Off Unused Servers



- Match capacity to load automatically
- 57% energy savings, no impact on users

source: Power Assure

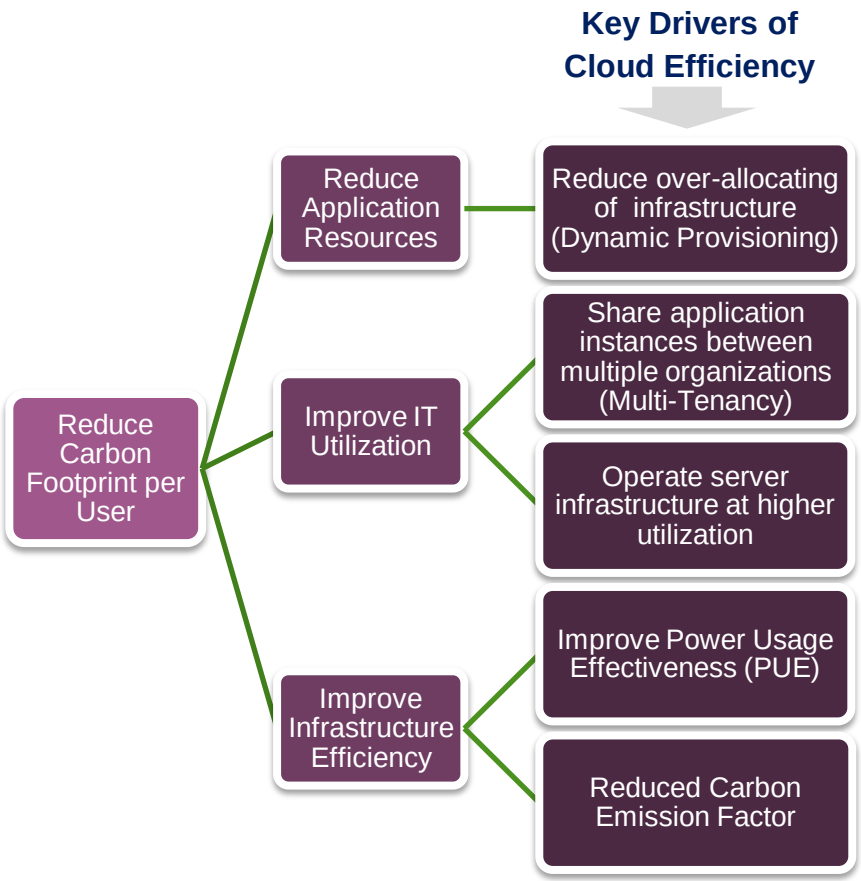
Age of “Warehouse Scale” Machines

Google’s data center on the Columbia river, Oregon

Thousands and Thousands of Commodity Parts Built into a System to Essentially Serve a Single Application

Power and Cooling Major Drivers of Cost

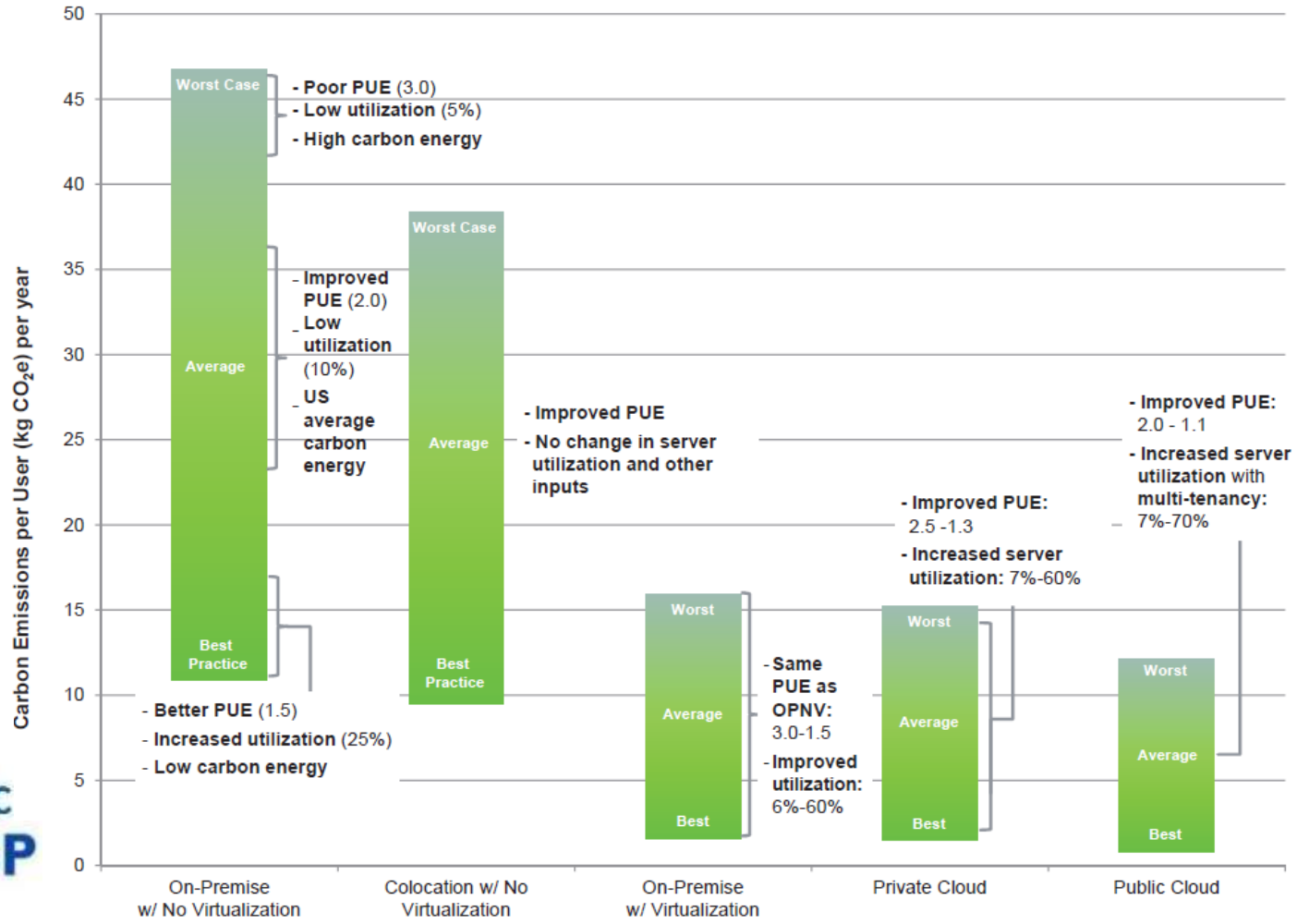
The key drivers of cloud efficiency



Cloud Benefits
Forecasting and ongoing adjustment of allocated capacity avoids unnecessary over-allocation of resources and sizing close to actual usage.
Sharing application instances between client organizations (tenants) flatten peak loads and reduce overhead for tenant on-boarding and management.
Large deployments of virtualized server infrastructure serving multiple tenants can balance compute and storage loads across physical servers and thus be operated at higher utilization rates.
Industrialized data center design at scale and optimized for power efficiency reduces power waste for cooling, UPS etc. and allows running servers at optimal utilization and temperature.
Locating data centers near low-carbon power sources (e.g. hydropower) or sourcing less carbon-intensive electricity can reduce carbon emissions.

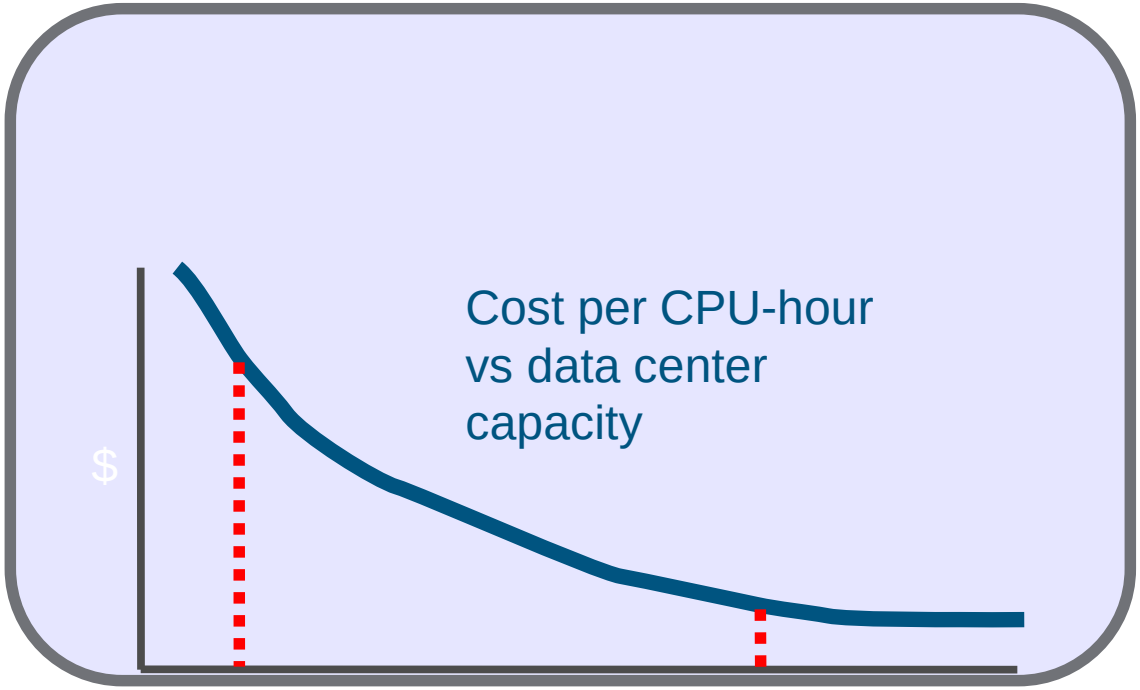
Is the cloud always greener?

Exploring the most energy and carbon efficient IT solutions for small- and medium-sized organizations (SMOs)



http://www.wspenvironmental.com/newsroom/news-2/view/wsp-conducts-research-with-nrdc-which-indicates-cloud-computing-may-not-always-be-greener-than-on-premise-server-rooms-383

Taking Advantage of Cloud Scale



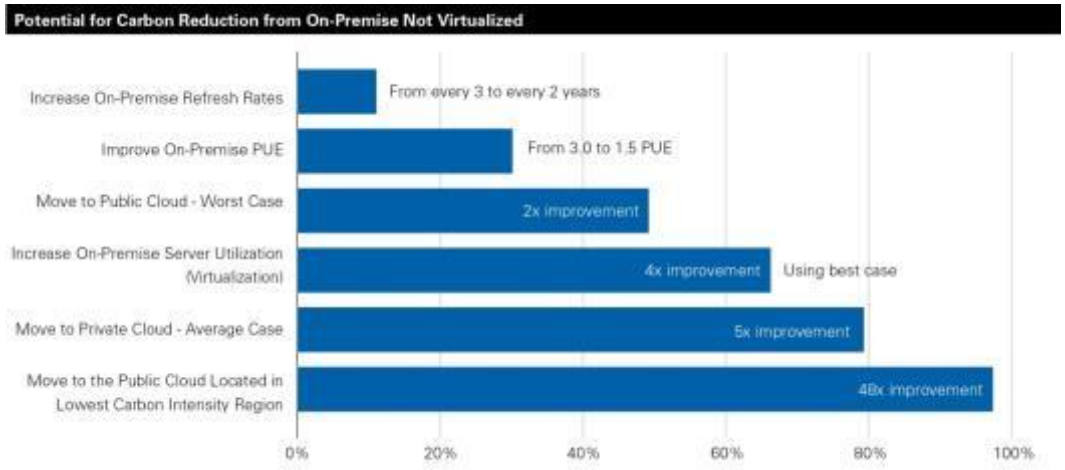
Typical
Enterprise IT
Volume/Cost
(1000s of cores)

Typical
Cloud Provider
Volume/Cost
(100K-1M cores)

IT strategies: On-premise versus the Cloud

- To uncover the major factors determining how on-premise server rooms and cloud computing compare in carbon emissions and energy savings, WSP examined five different scenarios with the goal of making it easier for companies to compare options and consider sustainability in their decision-making.
- The analysis identifies how best practice, average, and worst-case scenarios impact environmental performance when modeled across a variety of application and deployment types (from a simple on-premise server with no virtualization, to a server room with virtualization, through to private and public cloud deployments).

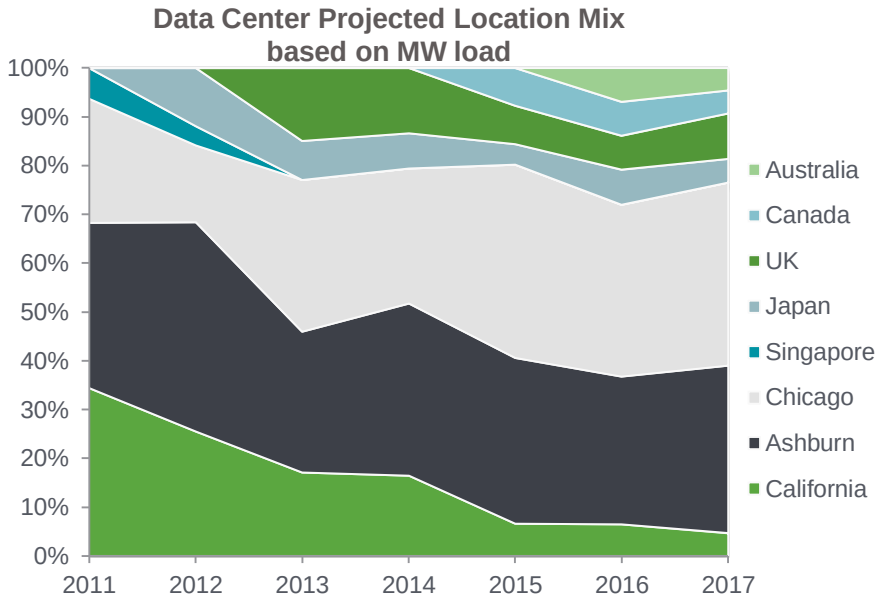
- The carbon footprint of business computing is highly dependent on a number of important variables:
  - the type of electricity powering the data center,
  - the amount of server processing capacity being effectively utilized, and
  - the efficiency of the facility's cooling.
- Not all clouds are created equal; there are "green" clouds and "brown" clouds.
- "Virtualization" -- Running more than one application on a server or having more than one customer share a server as in the case of cloud computing, can increase server utilization to 50 percent or higher.



	Baseline: On-Premise Not Virtualized	Variable Scenario
Increase On-Premise Refresh Rate	Average Case On-Premise	Best Case On-Premise
Improve On-Premise PUE	Average Case On-Premise	Best Case On-Premise
Move to Public Cloud – Worst Case	Average Case On-Premise	Worst Case Public Cloud
Increase On-Premise Server Utilization (Virtualization)	Average Case On-Premise	Best Case On-Premise with Virtualization
Move to Private Cloud	Average Case On-Premise	Average Case Private Cloud
Move to the Public Cloud – Best Case Low Carbon	U.S. Average	Best Case Low Carbon (Public Cloud)

PORTFOLIO PLANNING

Data Centers Portfolio Planning

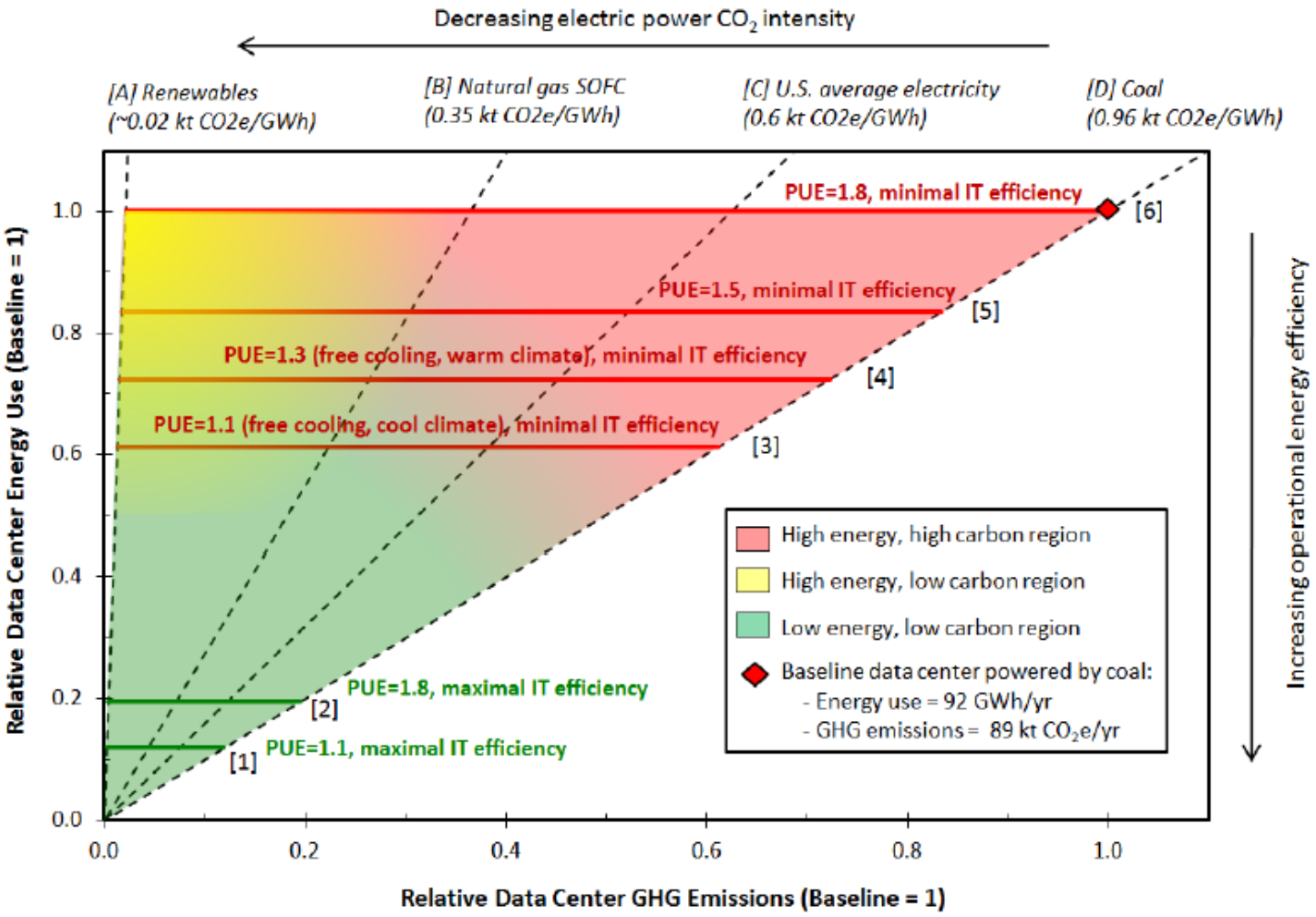


Data Center Highlights over BAU	
% of Total Growth from Today	48%
PUE natural improvement per year	1%
IT watt per transaction natural improvement per year	8%

Potential Trends to Consider

- 65% YoY growth in transactions drives significant emissions
- Network density, proximity and power availability are key factors for data center location, have not yet considered carbon emissions grid factor of utility
- Colocation vs. Build-to-own strategy is currently being considered
- ~1 yr hardware refresh rate means watt per transaction efficiency improvements are limited to market trend
- Colo's may not enable better HVAC mgmt opportunities
- Current growth plan increases the average carbon intensity of data centers by placing 72% of all SqFt in 'dirty' grid locations (Virginia and Chicago)
- Core business strategies will constrain how aggressively we can pursue emission reduction opportunities:
  - Lease vs. Own
  - Commodity Hardware vs. Customize

Data Centers Portfolio Planning



Data Centers Portfolio Planning

Site Selection Scorecard

			COLORADO	OREGON	UTAH	WASHINGTON
Sustainability	25%	25	2	4	4	5
		Score	10	20	20	25
Network	30%	30	4	2.9	2.9	2.4
		Score	24	17	17	14
Cost	30%	30	1	4	3	4
		Score	6	24	18	24
Work Force	7.5%	7.5	5	5	5	1
		Score	8	8	8	2
Accessibility	7.5%	7.5	4.2	4.0	4.6	1.0
		Score	6.3	6	7	2
RESULTS	100%	100	53.8	74.8	70	66.4
		RANK	4	1	2	3

MAKING THE BUSINESS CASE

In a Nutshell

Economy ≥ Ecology

Why Think About Green IT?

The Economist Intelligence Unit's "Doing Good: Business And The Sustainability Challenge" report:

> "Companies that rated their green efforts most highly over the past three years saw **annual profit** increases of **16%** and **share price** growth of **45%**, whereas those that ranked themselves worst reported growth of 7% and 12% respectively."

- based on a global survey of 1,254 senior business executives, including more than 300 CEOs.

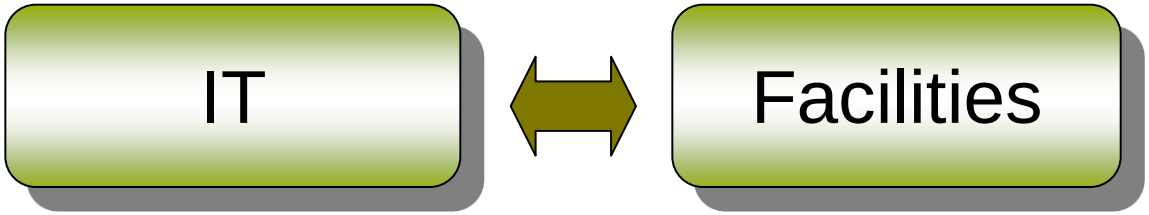
Split Incentives

- Organizational boundaries cause bad behavior

Get the Money In One Place

- Re-connect consumption to energy budget
  - CIO is usually one of largest consumers of energy
  - ...but the VP of Facilities pays bill

- Align spending with budget responsibility. Options:
  - Give CIO electric budget
  - Give Facilities IT capital
  - Account for savings where they happen



Collecting Raindrops

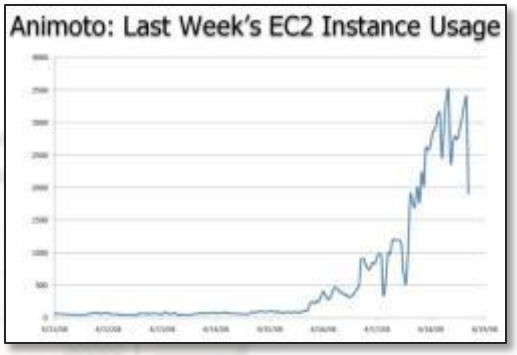
Satellite Server Rooms – Summary Table

	Closet	Growing High Density	Lights Out Cinderblock	Mini Datacenter	High Density
Cooling	Fan Coil + House System	Liebert Water Cooled Racks	DX	Raised Floor & CRAH Units	APC Hot-Aisle Containment
IT Load	10 kW	41 kW	44 kW	59 kW	223 kW
IT Watts/Sq Ft	83	34	30	50	278
Operating PUE	2.36	2.00	1.70	3.14	1.27
Target Norm PUE	1.65	1.99	1.54	2.63	1.38
% of Building	0.2%	12%	100%	15%	2.7%
% of Building Energy	7%	14%	100%	22%	41%
Annual Utility Cost to Run	$19,029	$62,875	$71,995	$141,918	$261,387
Average Daily Utility Cost/ kW IT Load	$5.11	$4.19	$4.44	$6.55	$3.21

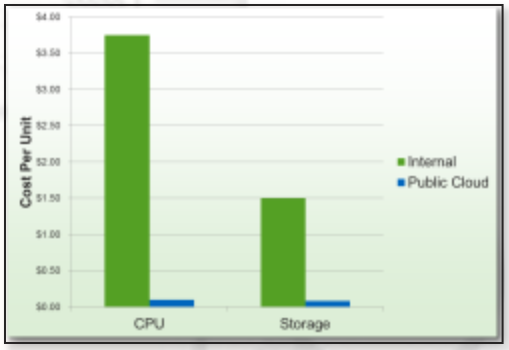
Source: Dickerson, Joyce, "Satellite Server Rooms… do they really need to be eliminated?," Presentation. Silicon Valley Leadership Group Data Center Efficiency Summit, 10 Oct 2010

Compelling Reasons To Move To Cloud

- Speed to deploy/ decommision

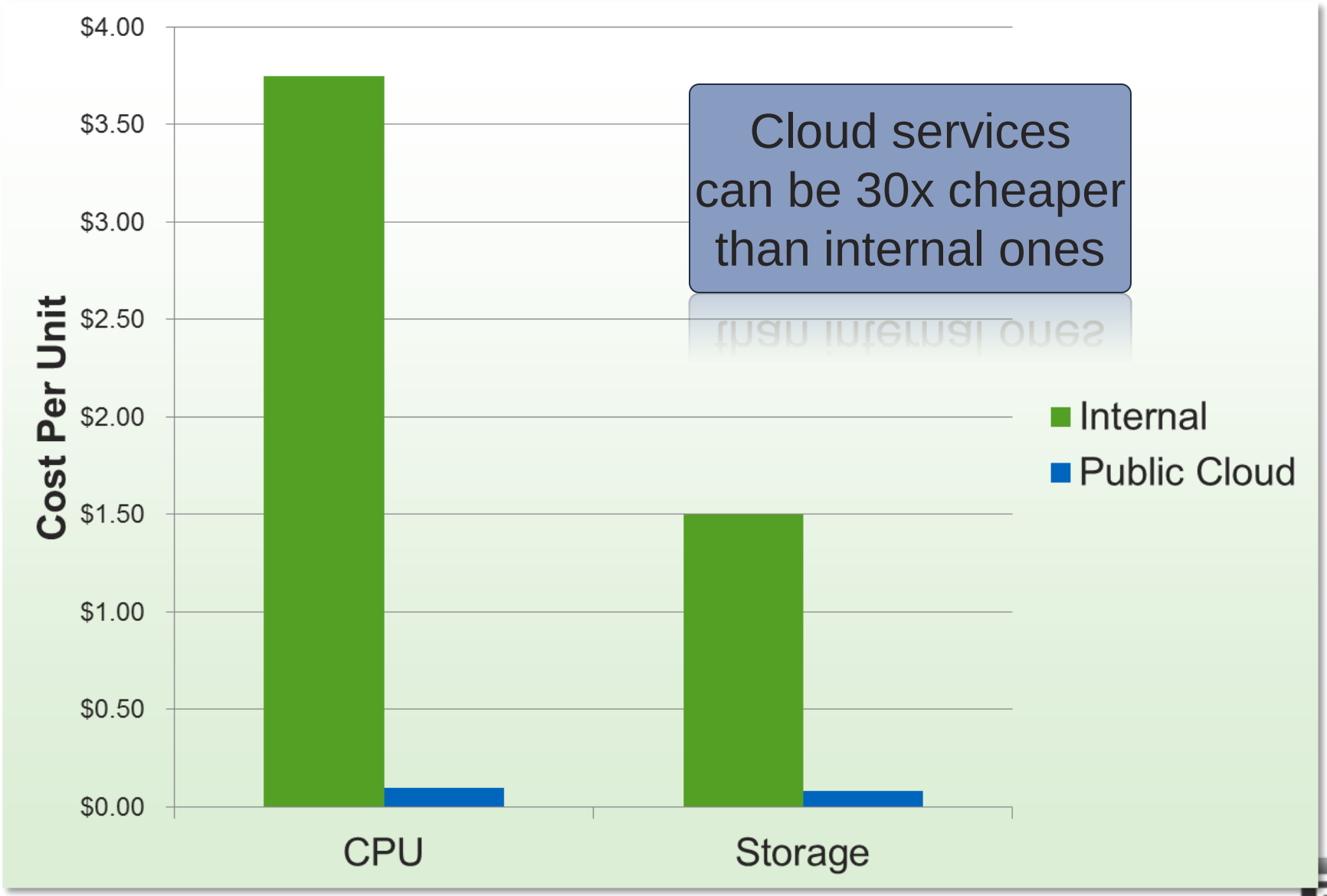


- Cost



Compelling Reasons

Compelling Reasons



Q&A