E3T Energy Efficiency Emerging Technologies

Washington State University Extension Energy Program

Information Technology and Data Centers (Webinar 1)

Emerging Technologies Showcase

IT Equipment & Power Management

November 20, 2013

Welcome. Today's webinar is being recorded and will be posted at:

- www.E3Tnw.org
- www.ConduitNW.org

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Energy Services Western Area Power Administration

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Information Technology and Data Centers (Webinar 1)

Mike Bailey – Ecova

Server Virtualization

High-Efficiency UPS Equipment

Power Management for IT Equipment

Brian Fortenbery & Micah Sweeney – EPRI

Solid State Drives (Flash Memory)

John Seger – CABLExpress

Storage Area Network (SAN) & Network Core Consolidation

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Server Virtualization

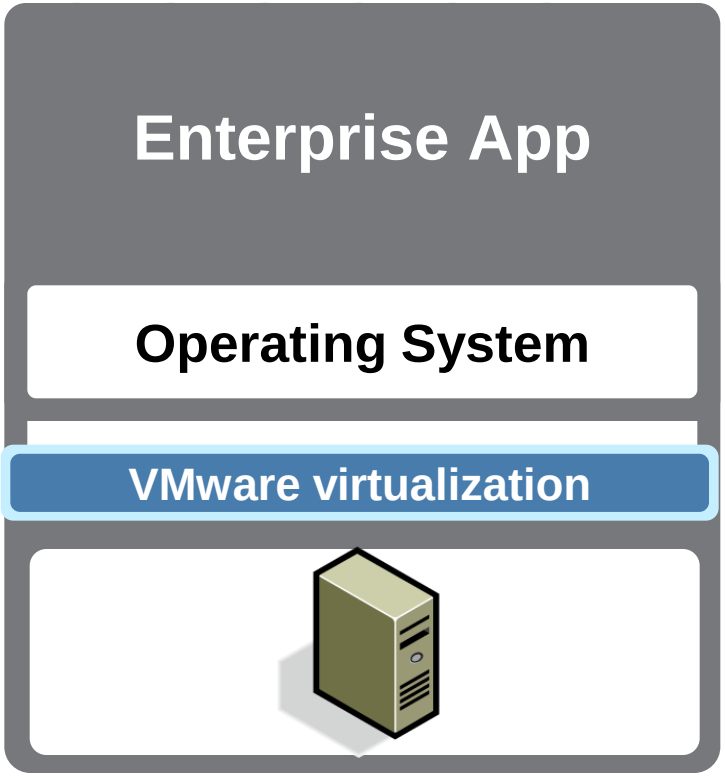
Mike Bailey – Director, Facility Engineering

November 20, 2013

Virtualization

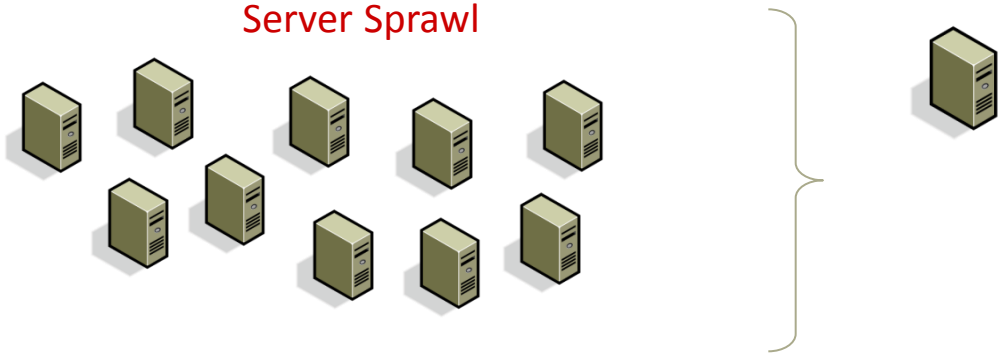
Virtualization Overview

- VMware decouples software from hardware :

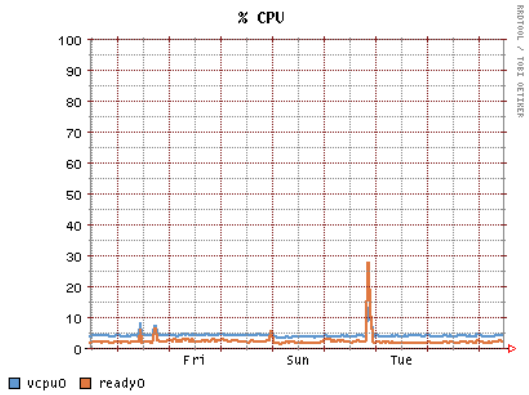


Source: VMware Overview Presentation to PG&E

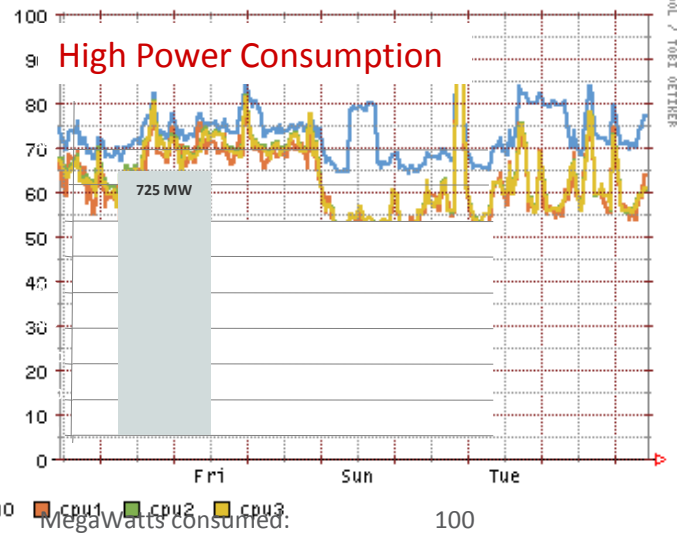
Challenge: Server Proliferation



- Consolidate se
- Increase utiliza
- Reduce hardwa cooling



Avg. utilization rate/server

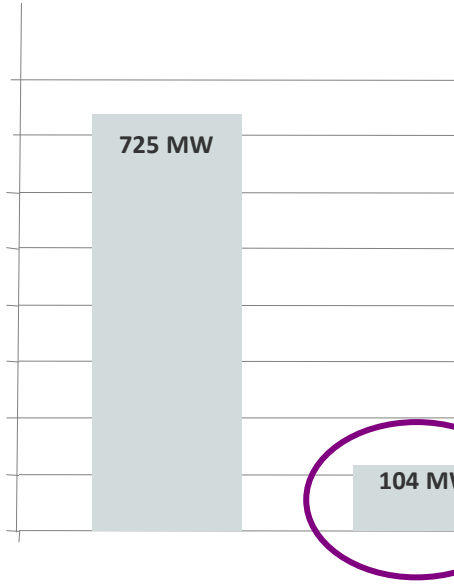


MegaWatts consumed:

server high use

100

Higher Utilization

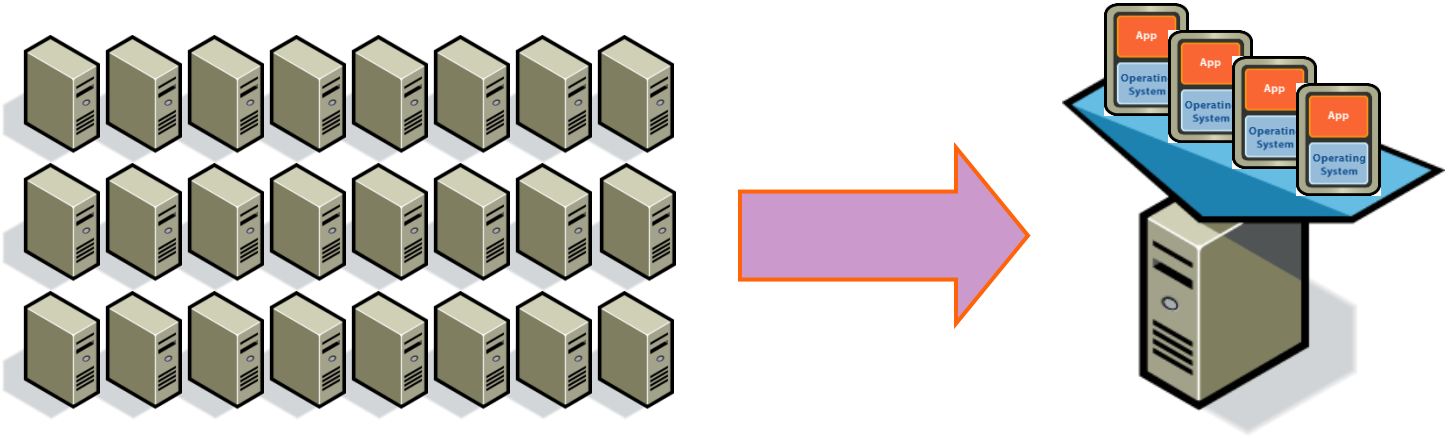


Lower Consumpti

Source:VMware Overview Presentation to PG&E

Server, Storage and Network Consolidation

	BEFORE VMware	AFTER VMware
Servers	1,000	**80**
Storage	Direct attach	**Tiered SAN and NAS**
Network	3000 cables/ports	**300 cables/ports**
Facilities	200 racks	**10 racks**
	400 power whips	**20 power whips**



Source: VMware Overview Presentation to PG&E March 2008

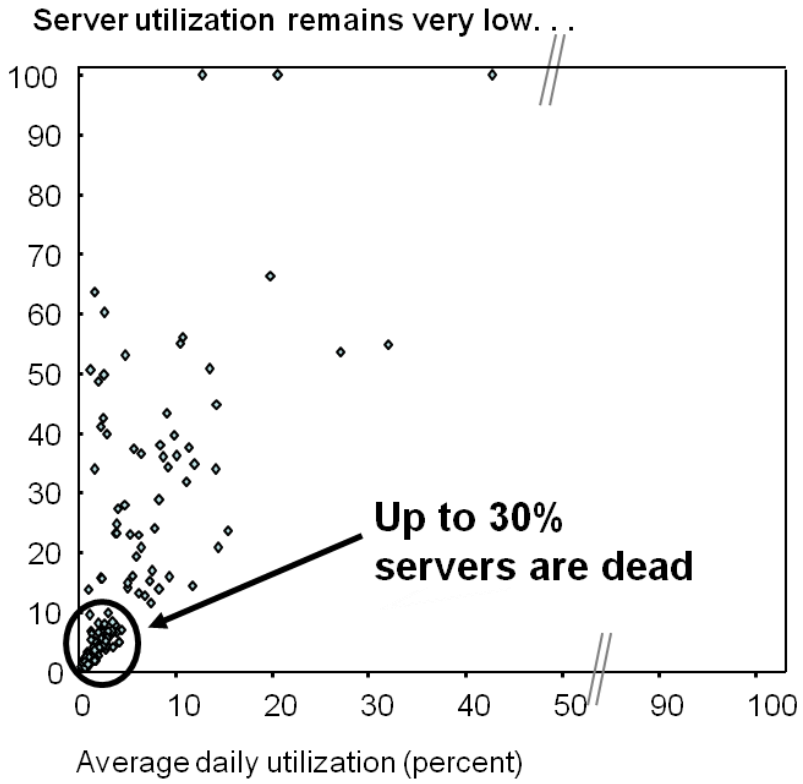
Power Savings from Consolidation

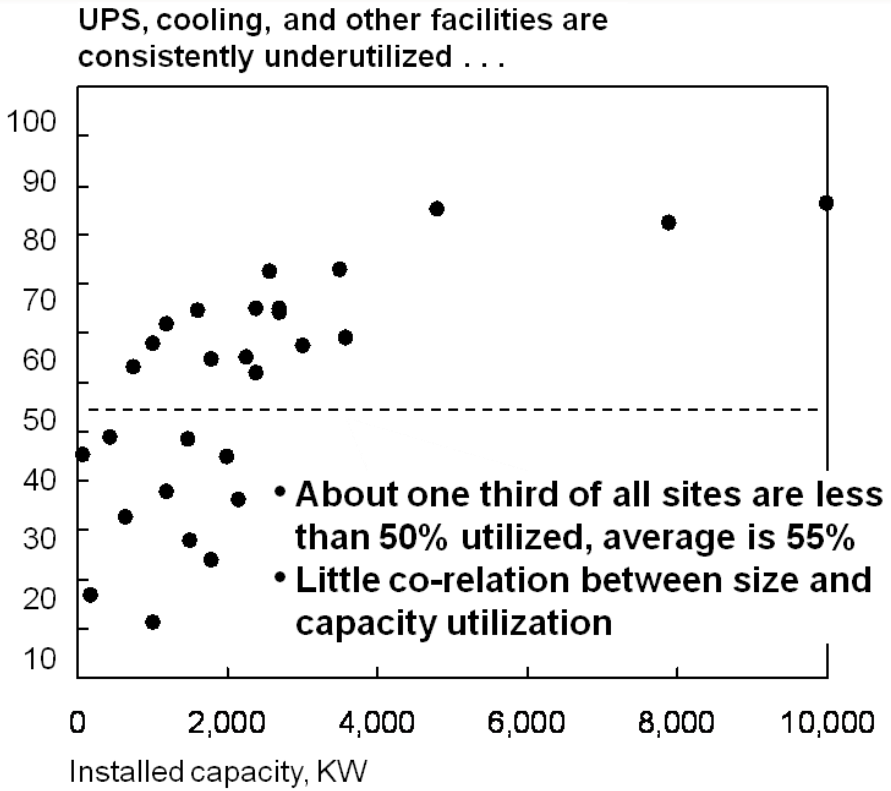
	BEFORE			AFTER		
Max Power Capacity Rating	1 CPU	300	475 W	1 CPU	--	594 W
	2 CPU	500	550 W	2 CPU	38	688 W
	4 CPU	200	950 W	4 CPU	38	1188 W
	8 CPU	--	1600 W	8 CPU	4	2000 W
% of Max	x 67%			x 67%		
kW / Yr	407 kW/hr x 24 x 365			53 kW/hr x 24 x 365		
Cost / kWh	x $0.10			x $0.10		
Cost / Yr	=		Power: $356,554	=		Power: $46,513
	=		Cooling: $445,693	=		Cooling: $58,141
Savings / Year				**= Savings: $697,593 (86%)**		

Rule of thumb: ~$700 and 7,000 kWh saved per year per workload virtualized

Source:VMware Overview Presentation to PG&E

Data Centers are often under utilized





* Sample size – 45 data centres

Source: Uptime Institute, McKinsey Data Center Report

- Savings from removing "dead" or decommissioned servers often included in virtualization benefits – but can be done without virtualization

Replace Old Servers (Refresh!)

	2005	2009	2013
Product	Intel Xeon Single Core (3.8GHz w/ 2M cache)	Intel Xeon 5680 (6 cores, 3.33GHz)	Intel Xeon E5-4650 (4-socket, 8 cores)
Performance per Server	50,970bops SPECjbb2005	765,000bops SPECjbb2005	**2,818,988** SPECjbb2005
KWh per server per day	6.704 (382 W active / 228 W idle)	4.936 (383 W active / 117 W idle)	3.216 (402 W active / 98 W idle)
Desired Performance	9.4 million business operations per second	9.4 million business operations per second	9.4 million business operations per second
Servers Needed	315 in 15 racks	21 in 1 rack	**6 Servers**
Estimated Annual Energy Cost (2.0 PUE)	**$154,581**	**99% REDUCTION**	**$1,410**

- Savings from server refresh often included in virtualization benefits – but can be done without virtualization

Source:: Intel Xeon 5600 Refresh Brief, Xeon Performance

High Efficiency UPS Equipment

Mike Bailey – Director, Facility Engineering

November 20, 2013

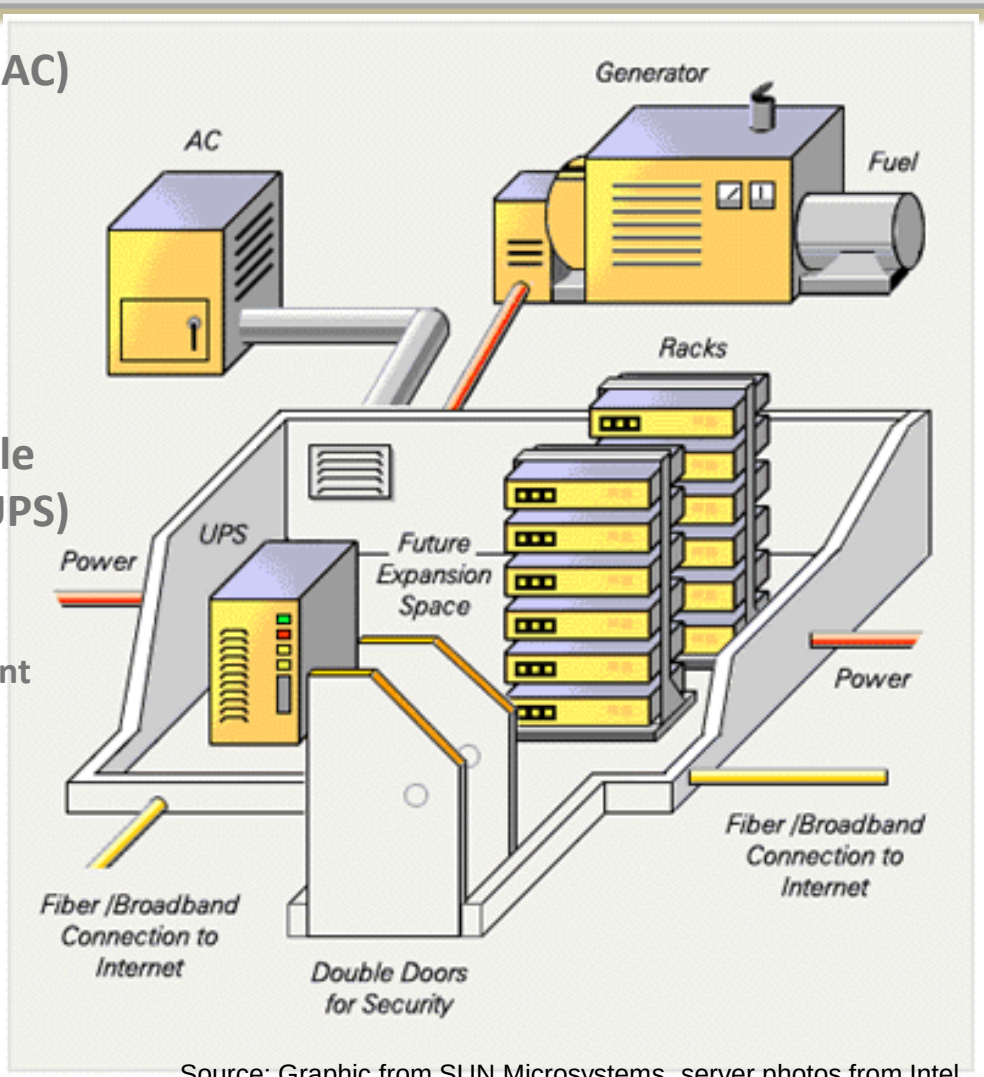
Components of a data center

Air Conditioning (AC)

HVAC, Chillers
ACU, CRAC

Uninterruptable Power Supply (UPS) - batteries

AC – Alternating Current
DC - Direct Current

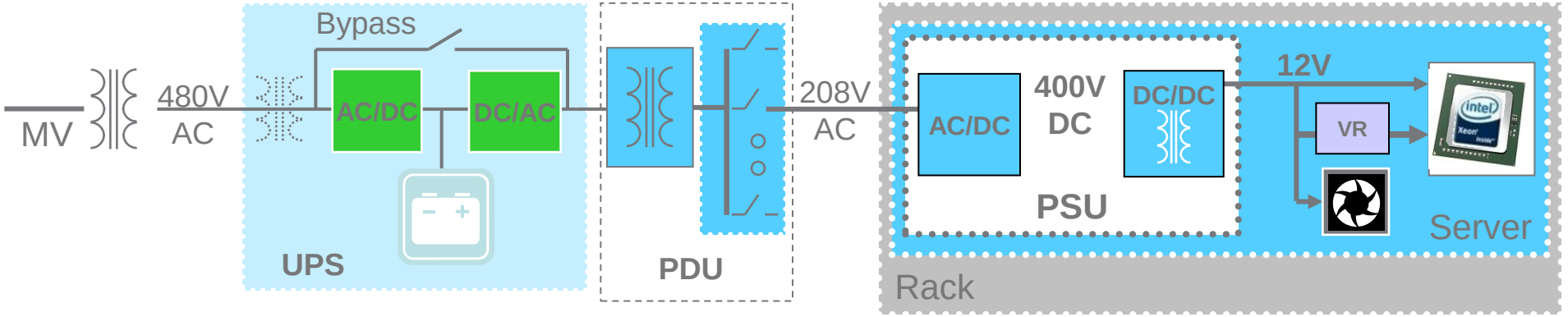


Emergency Generator "Gen-set"

Computer (Server) Racks

Source: Graphic from SUN Microsystems, server photos from Intel

Increase Component Efficiency



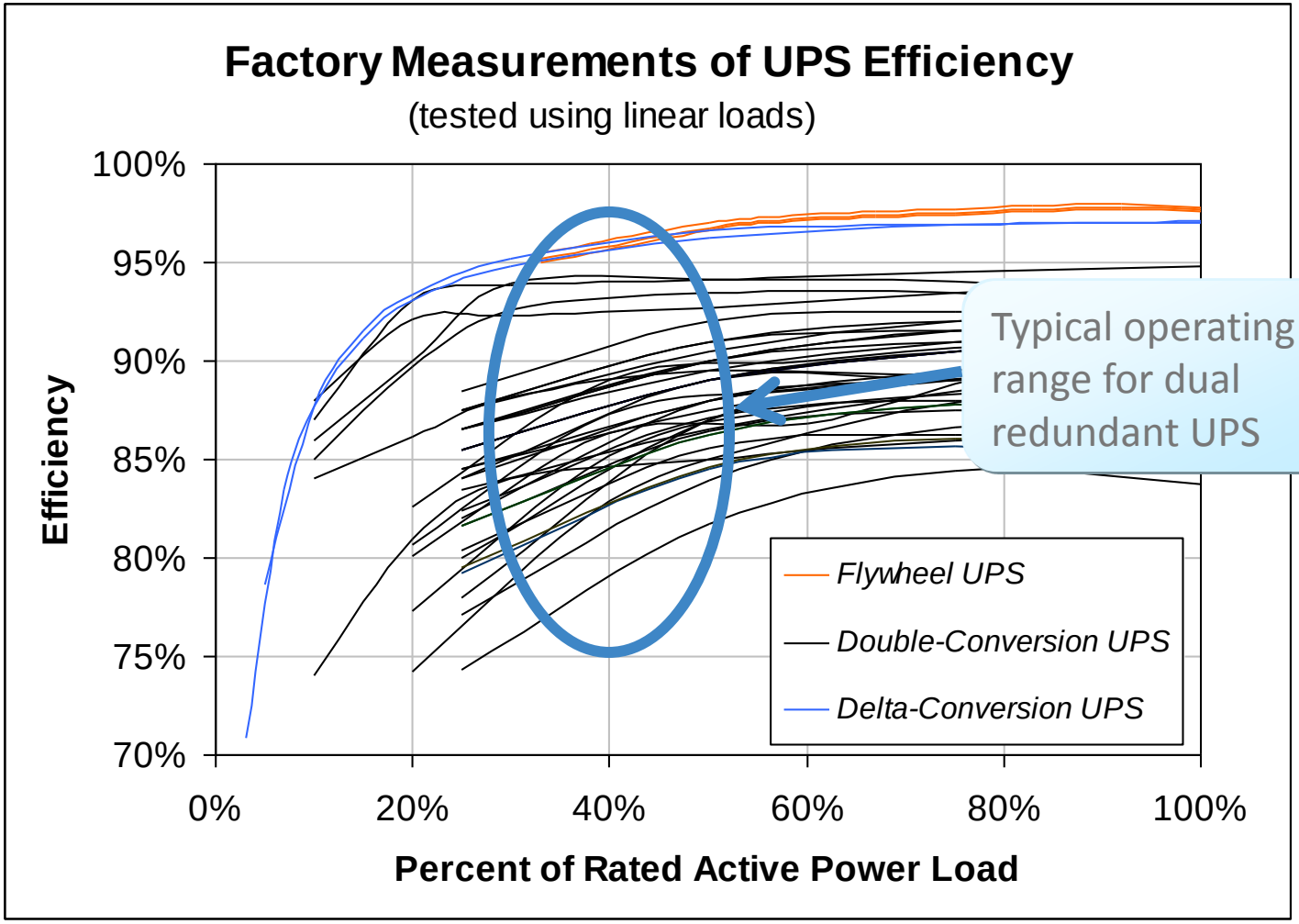
Source: Intel Public Presentation on benefits of DC Data Centers

Typical	**89%**	**x**	**93%**	**x**	**75%**	**x**	**81%**	**=**	**52%**
Better	**94%**	**x**	**94%**	**x**	**88%**	**x**	**87%**	**=**	**68%**
Best?	**96%**	**x**	**95%**	**x**	**94%**	**x**	**91%**	**=**	**78%**

- Assume rack mount Dual Processor server and centralized UPS
- PDU includes cable losses
- Heavy load efficiencies

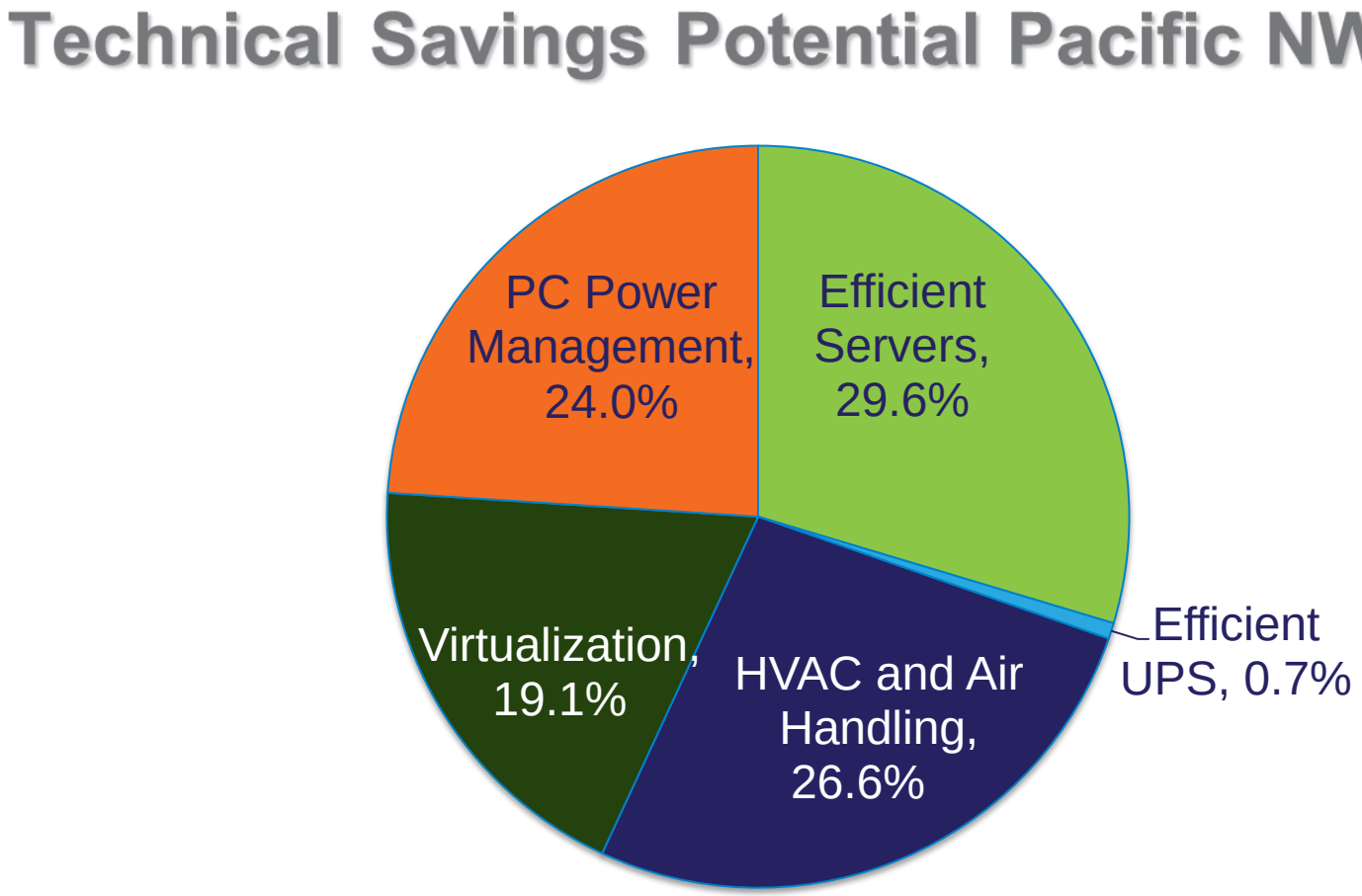
- **High efficiency components: reduce input power by 30%**
  - For PSU, can recoup higher cost of high efficiency unit in < 1 year

Purchase High Efficiency Power Equipment



Source: US Department of Energy

Where is the Savings?



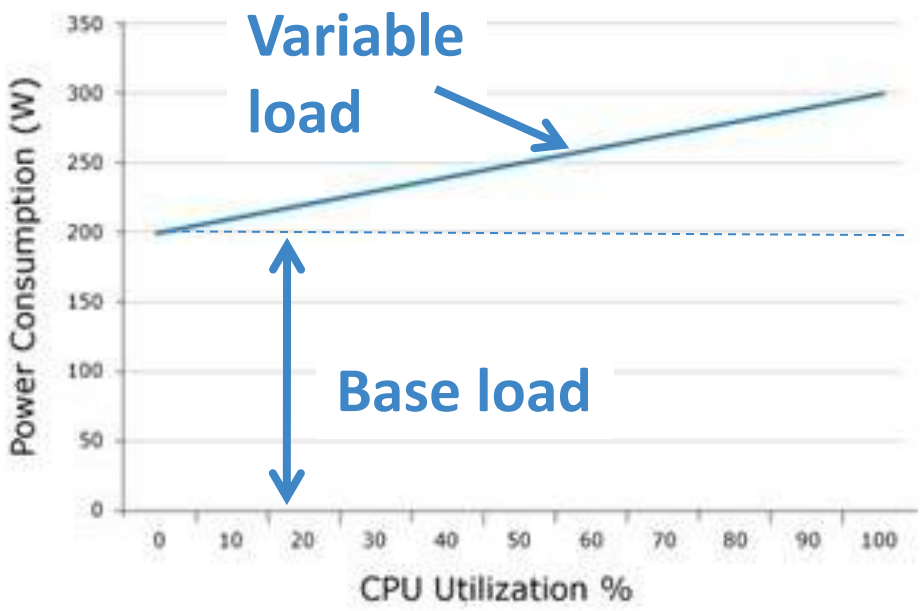
Source: Integrated Data Centers Opportunity Assessment – Final Report , 2013, PECI report to NEEA

Power Management for IT Equipment

Mike Bailey – Director, Facility Engineering

November 20, 2013

Server Power Demand vs. Utilization



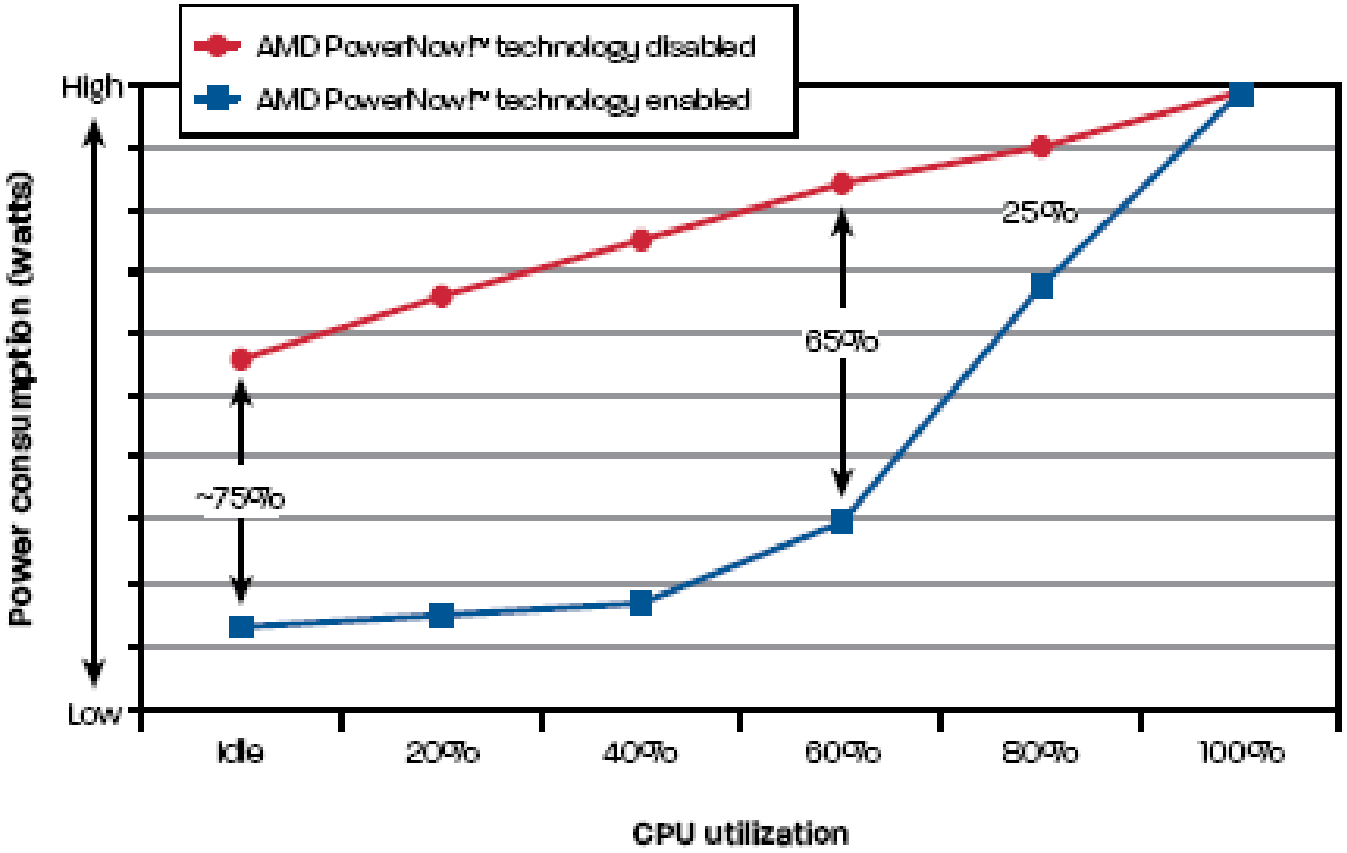
Source: US DOE Energy Matters

CPU power use varies with utilization

Memory, Disk Drives, Cooling Fans, & I/O are fairly constant

- Idle or Low Utilized Servers & PC still use 60-70% of power of servers at fully capacity

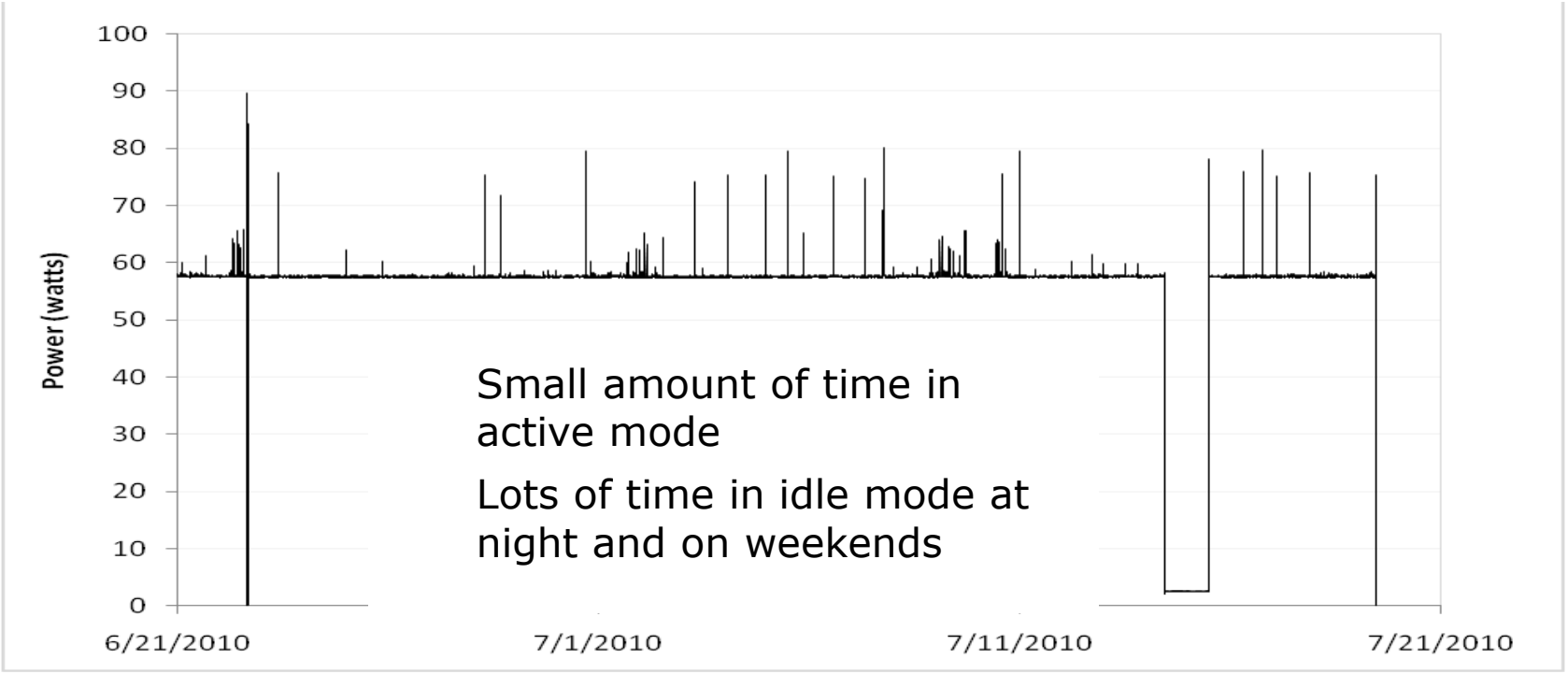
Enable CPU Power Management



Source: AMD Whitepaper: Power and Cooling in the Data Center

Computers left on overnight & Weekend

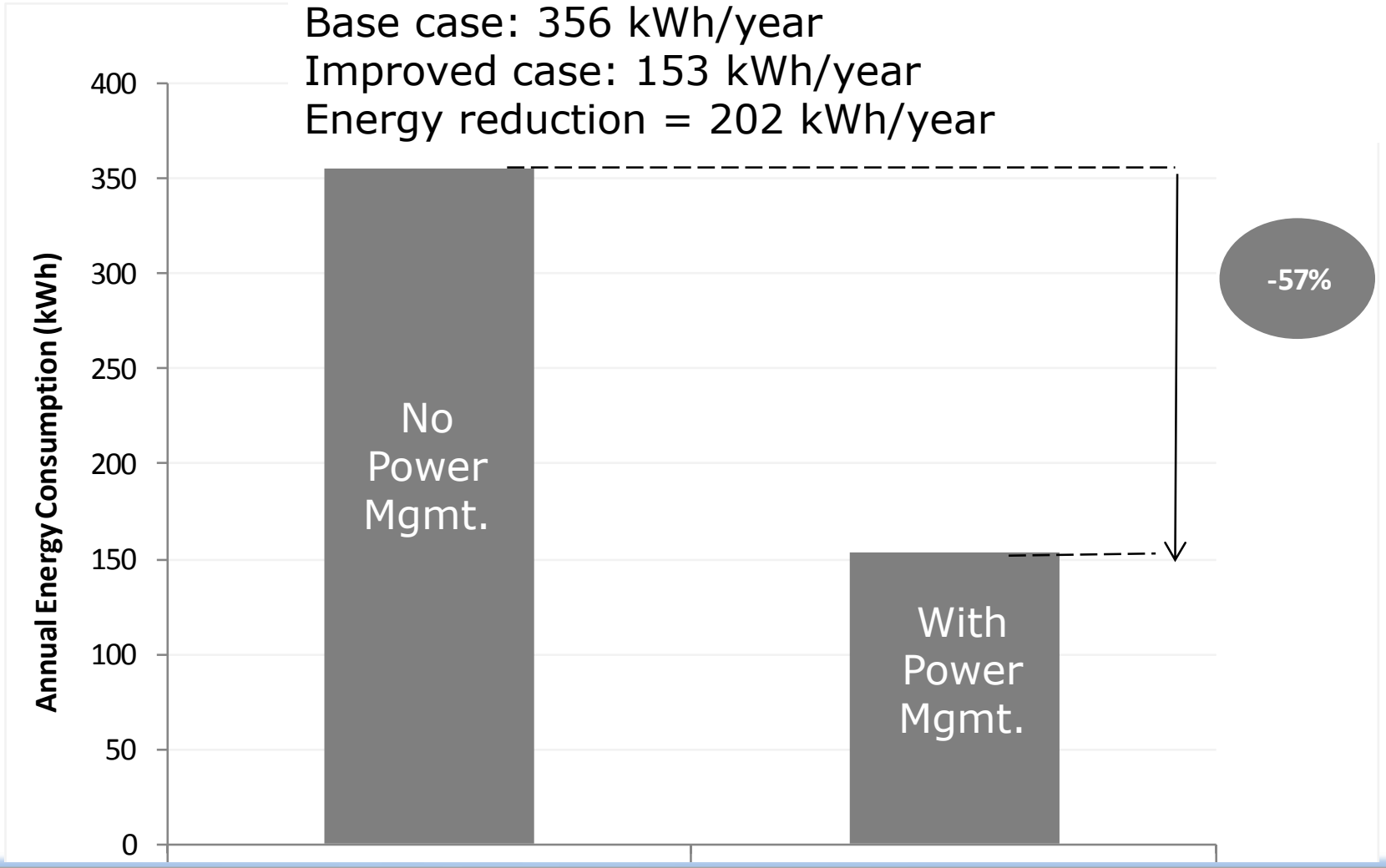
Power meter data of a desktop computer at the small office



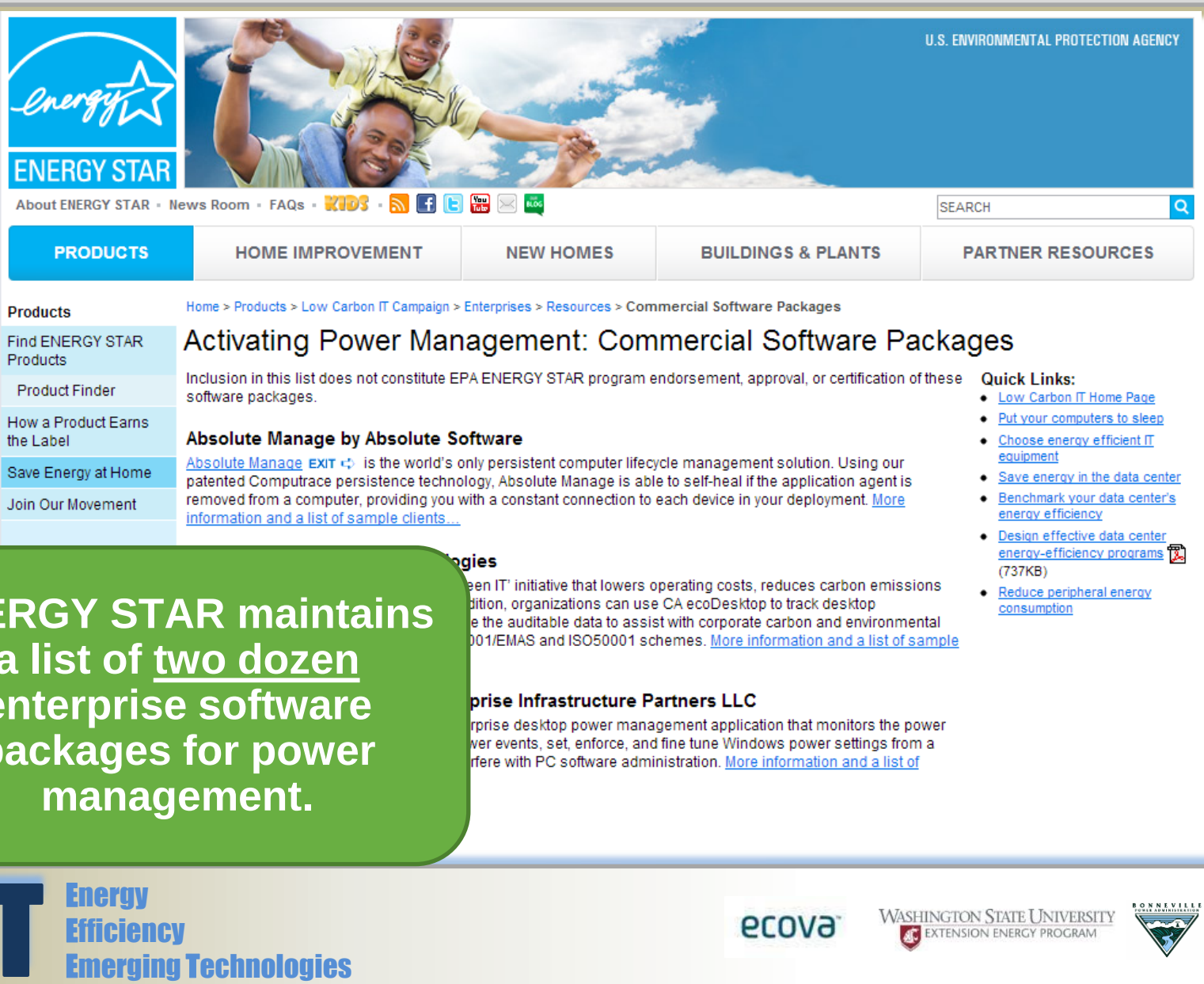
62% of desktop computers at the small office and 40% of staff (non-public) computers at the library were often left operating in active or idle mode overnight and on weekends.

Source: Ecova PEIR Plug Load Study

Power Management: Desktop Computer



Enterprise Power Management Solutions



ENERGY STAR maintains a list of two dozen enterprise software packages for power management.

E3T Energy Efficiency Emerging Technologies

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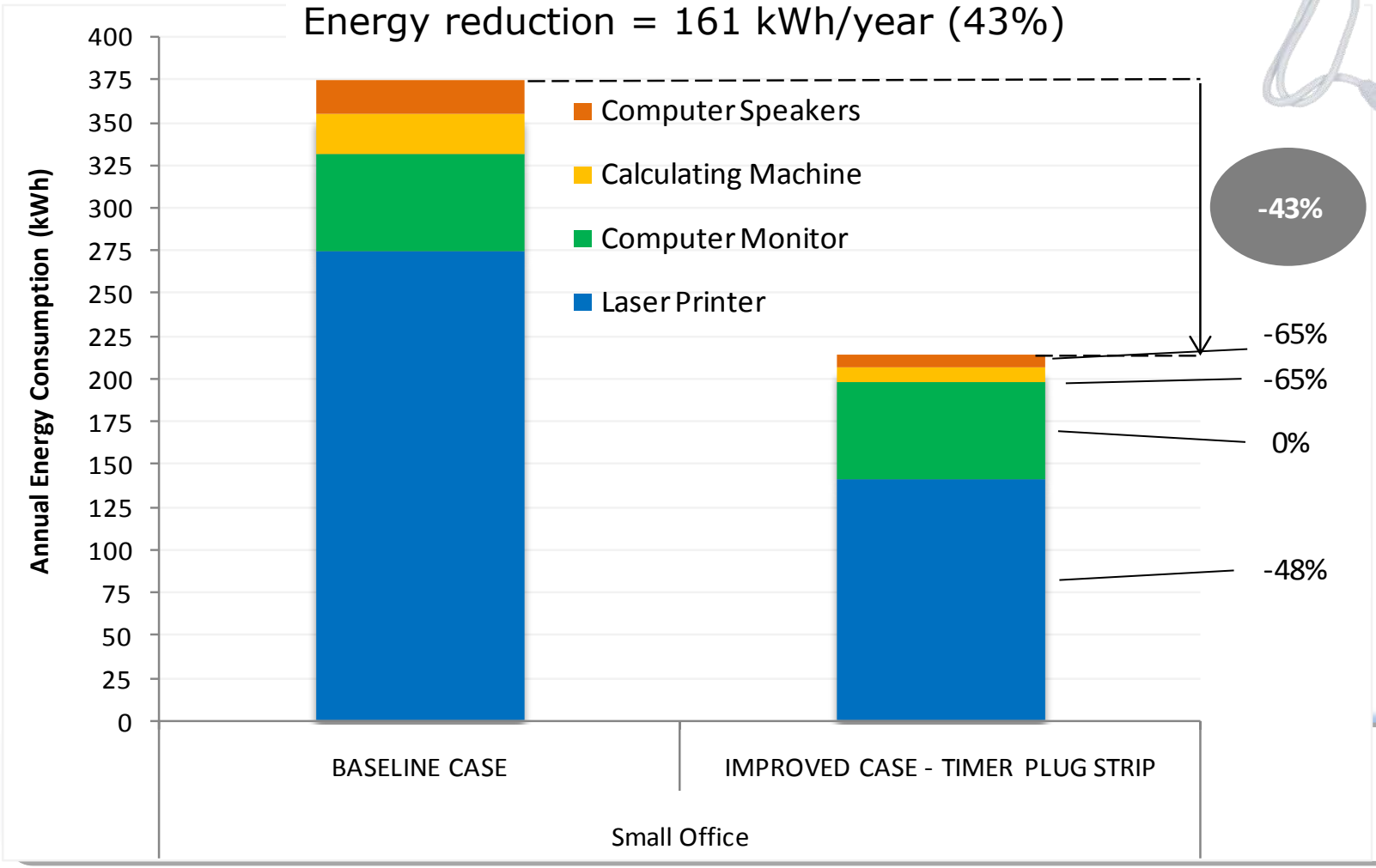
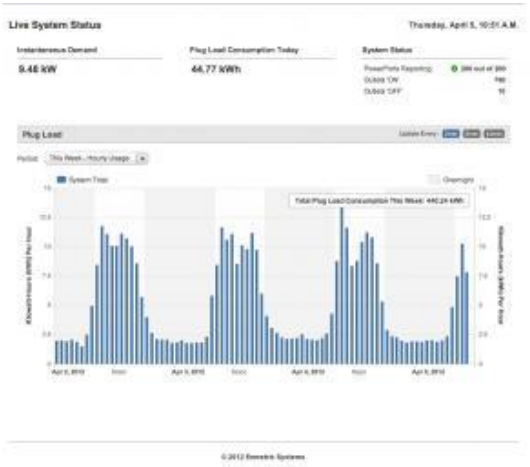
Timer Plug Strip: Workstation at the Small Office

Base case: 375 kWh/year
Improved case: 214 kWh/year
Energy reduction = 161 kWh/year (43%)



Smart Plug Strips 2.0



Wirelessly networked

Centrally managed

Dashboards

BEMS integration

BUT…

Pricey

What's the right form factor?

Is this overkill?

Solid State Drives (SSDs)

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

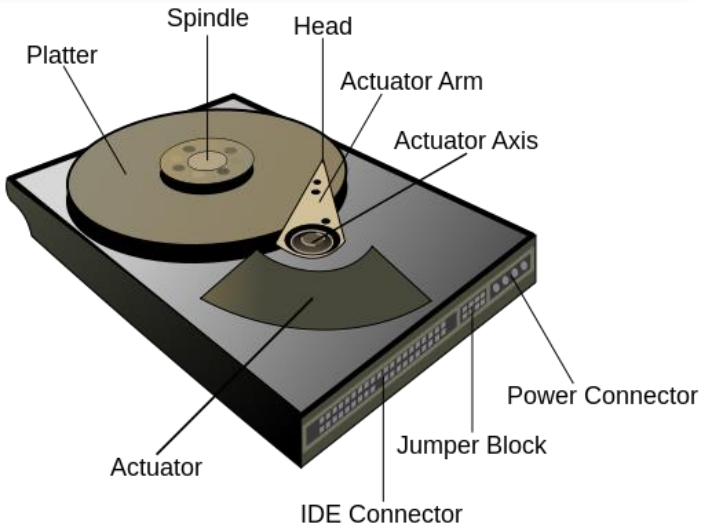
Brian Fortenbery – Program Manager

Micah Sweeney – Project Engineer/Scientist

November 20, 2013

Conventional Hard Disk Drives (HDDs)

- Invented in 1956
- Data stored magnetically on solid disk
- Disk spinning
- Latency of moving arm
- Prone to random mechanical failure
- Typically 12-15 W for servers
- Common speeds: 5400, 7200, 10k, 15k rpm



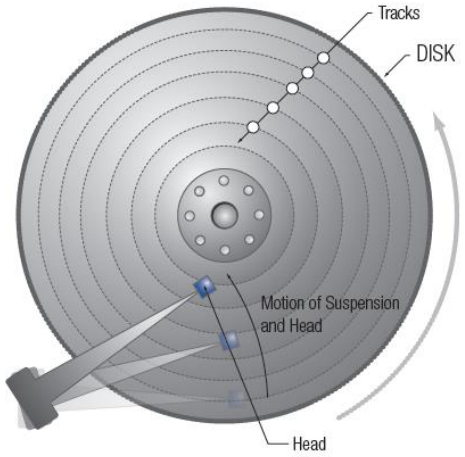
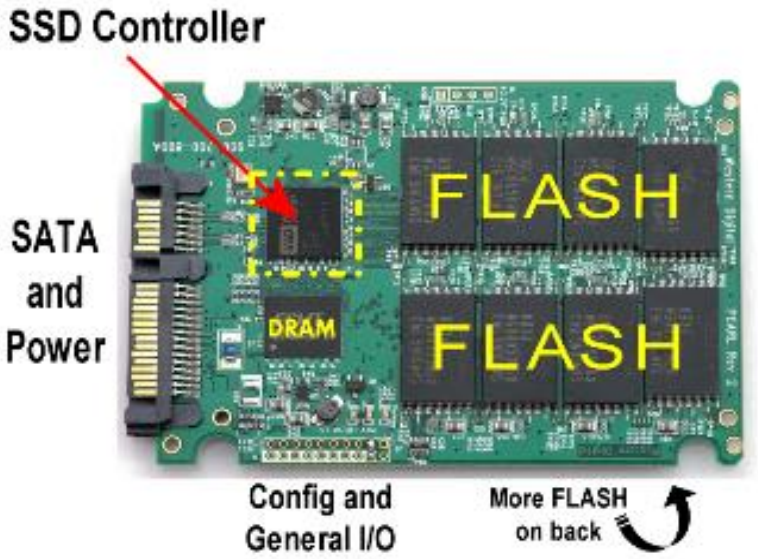


Figure 1. HDD Mechanical Characteristics

Solid State Drives (SSDs)

- Flash-based data storage
- No moving parts
- Faster Response (low access latency)
- Low power
- High cost / GB
- Little impact to shock, vibration
- Lifetime based on write-endurance



10x faster at 50% power of 15k rpm HDDs

SSD vs. HDD

	HDD (15k)	Enterprise SSD
Rated Power	8-15 W	1-4 W
Response time (latency)	4-7 ms	<0.1 ms
Bandwidth (sequential)	100-150 MB/s	100-150 MB/s
Throughput (random)	200-500 IOPS	3,000-60,000 IOPS
Capacity	HUGE!	Price coming down…

- IOPS – input / output operations per second
- About half the power of HDD per drive

SSD Technology Merits

	GB/$	MB/s/$	IOPS/$	GB/W	MB/s/W	IOPS/W
HDD						
SSD						

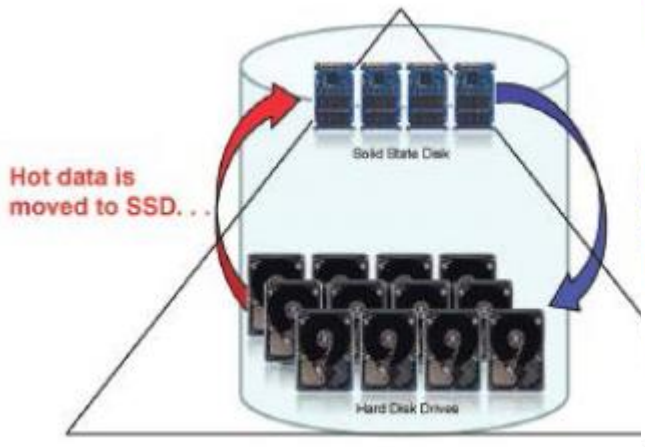
- Worst
- Average
- Better
- Best

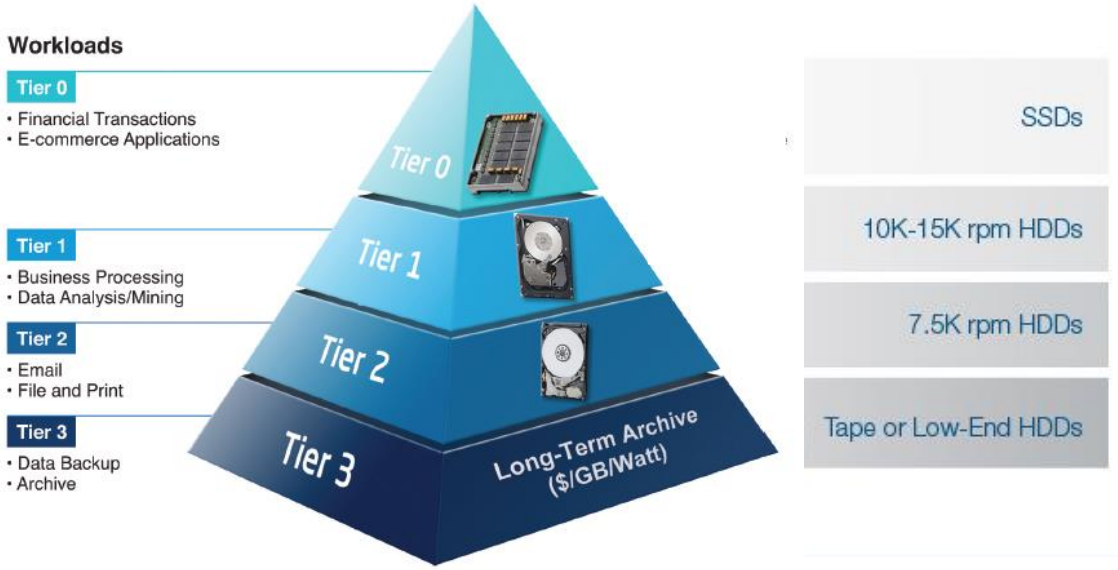
IOPS – Random read/write
MB/s – Sequential read/write
GB – Capacity

- Comparable capacity per watt
- Superior performance per watt
- Up to 100x IOPS/W over HDD

Tiered Storage

- Virtualization of storage
- Storage Area Network (SAN) or storage array
- Utilize SSD for high I/O applications
- Tier 0 – between memory (RAM) and storage (drives)





Tiered Storage

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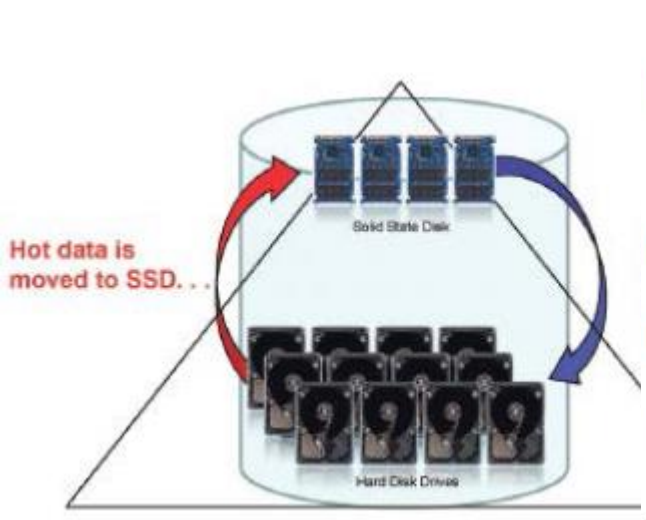
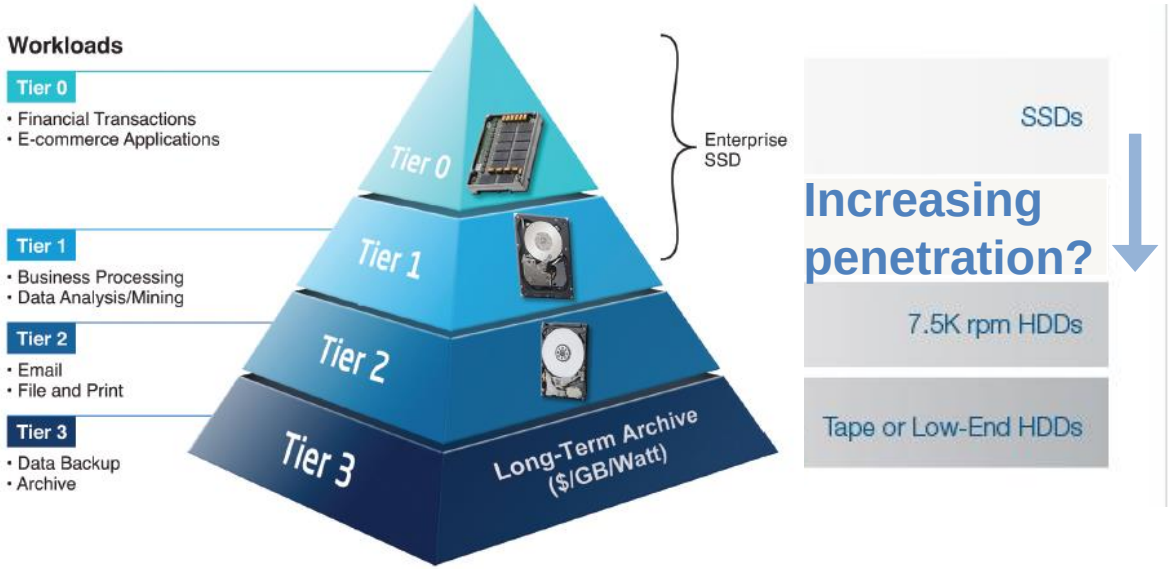




Killer App: Short-Stroked HDDs

- High-performance application demanding 100k IOPS
- Baseline: 200 “short-stroked” HDDs
- Replaced with 2 SSDs
- 100:1 reduction
- 50% energy savings per drive
- ***99.5% energy savings***
- Lower cost
- 100x lower latency

Short-Stroked Savings Potential

- Storage accounts for about 24% of IT power (9% of total data center)[1]
- Short-stroked HDDs account for 5% of market – iSuppli 2009
- 99.5% savings through 100:1 drive reduction
- **Roughly 300-400 GWh savings annually**

[1]Source: J Koomey. *Growth in data center electricity use 2005 to 2010.* (2011)

SAN/IP Convergence

Impacts to network design and power consumption

John Seger – Data Center Infrastructure Architect

November 20, 2013

Acronym Breakdown

- SAN – Storage Area Network
- FC – Fibre Channel
- IP – Internet Protocol – Ethernet – “Network”
- FCoE – Fibre Channel over Ethernet
- NIC – Network Interface Card (IP)
- HBA – Host Bus Adapter (FC)
- CNA – Converged Network Adapter

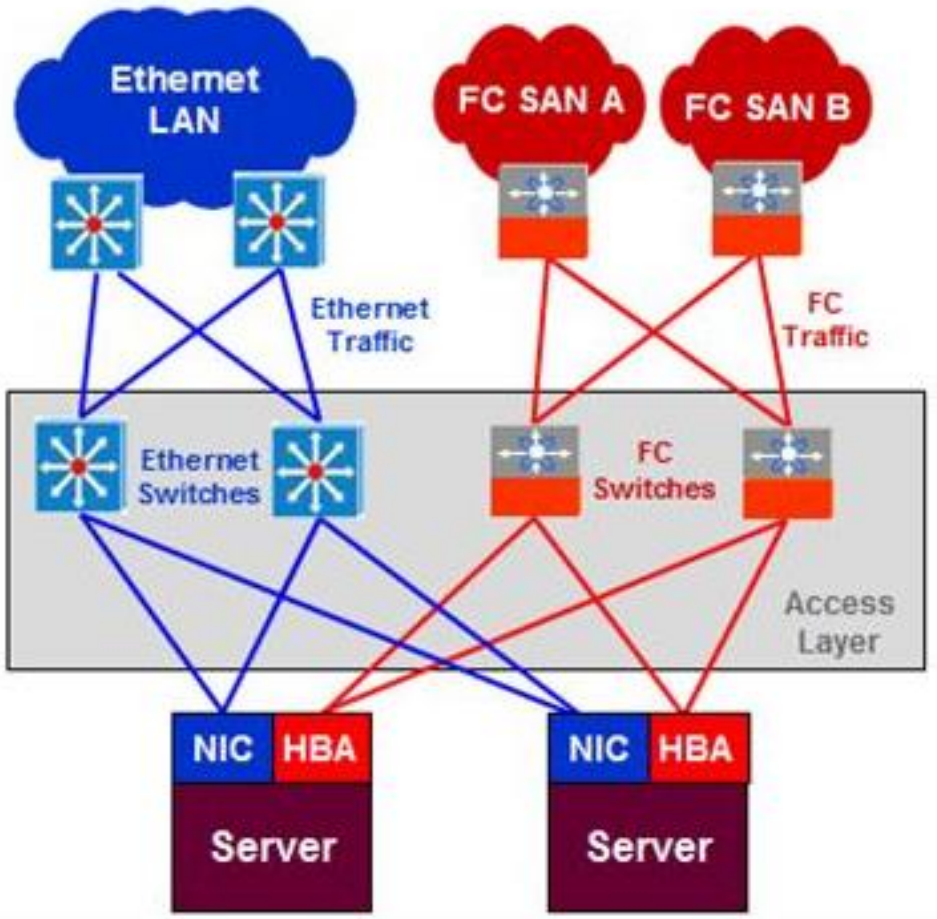
  – All links lead to Wikipedia entries

Background

- Typical DC Network designs included two distinct and separate systems – SAN and Network (IP)
- SAN – Storage Area Network: Low Latency access from servers to block storage equipment that appears to be internal to the server operating system. FC dominates
- IP – Ubiquitous across all networks, but has design characteristics that limit scalability in a SAN arrangement

Typical Topography

- IP Network (Enet LAN) and SAN connectivity to each server
- Top level units are large chassis based core or director class switches
- SAN typically fiber optic while LAN typically copper at access layer with a copper or fiber core
- “Access Layer” switches are smaller in-row or Top Of Rack



Typical Connectivity

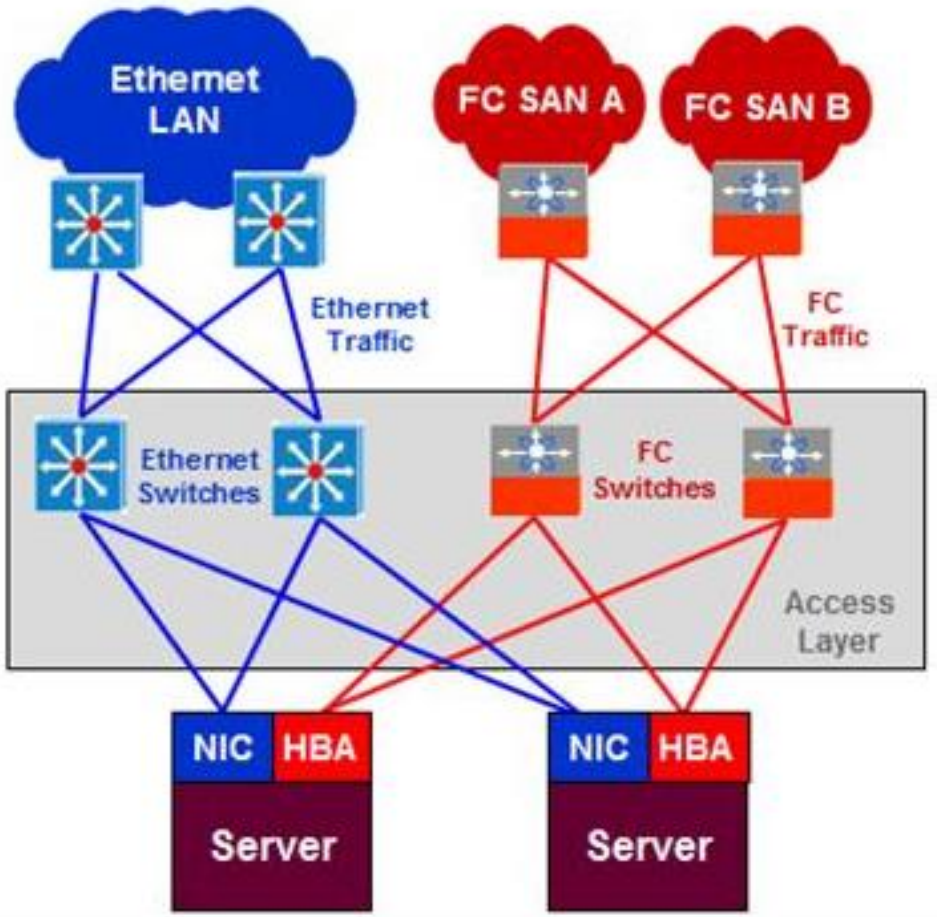
- IP connections in small to mid-tier DC's are largely copper – 1Gbps moving to 10Gbps quickly
  - Approx. 1W at 1G and 2 to 4W+ at 10G up to 100Meters
- SAN connections are fiber based – 2 to 4Gbps (FC) moving to 8Gbps now.
  - Less than 1W at any speed, .7W typical

Model Power Consumption at 10G

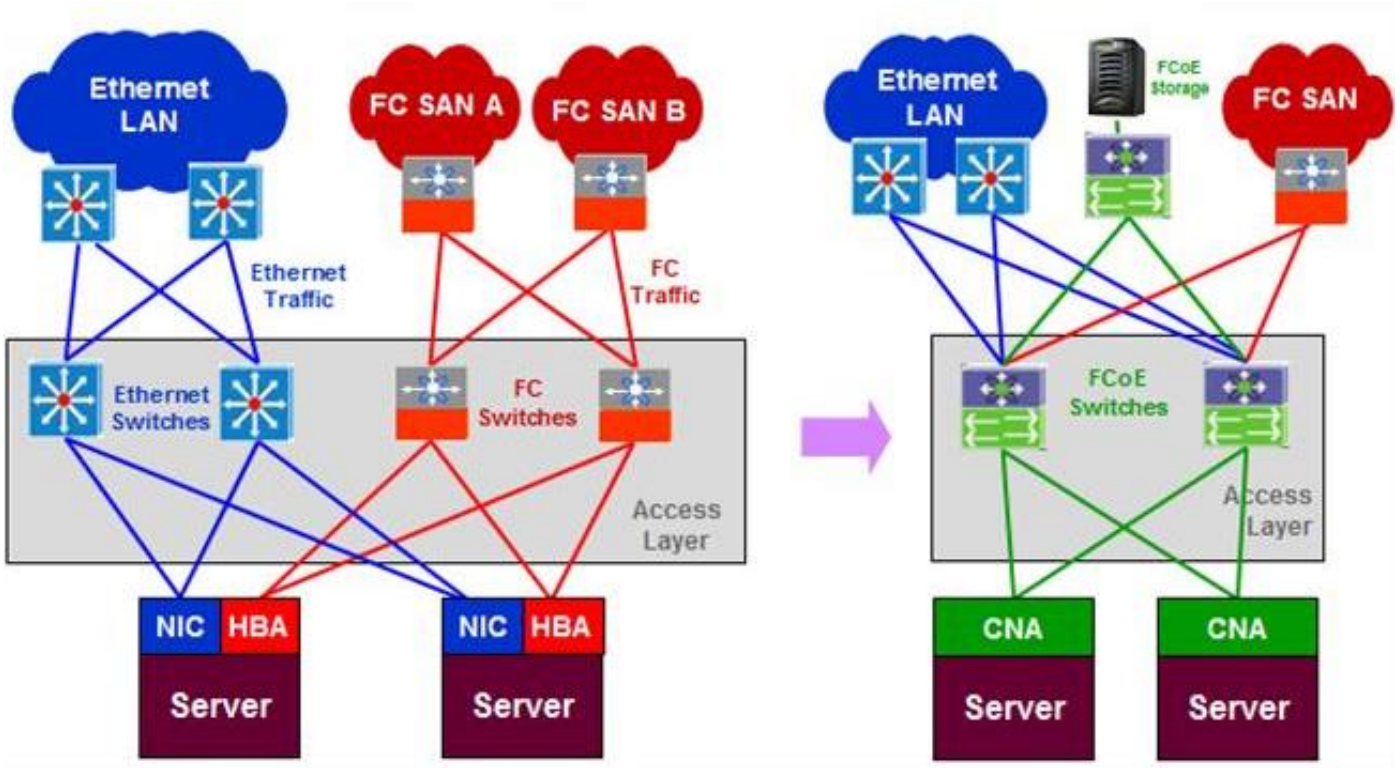
- Enet LAN fiber = 8 ports – 8W
- Enet LAN Copper = 8 ports – 24W (3Wpp)

- SAN = 16P – 16W

- **Total power (Ports only) – 48W**



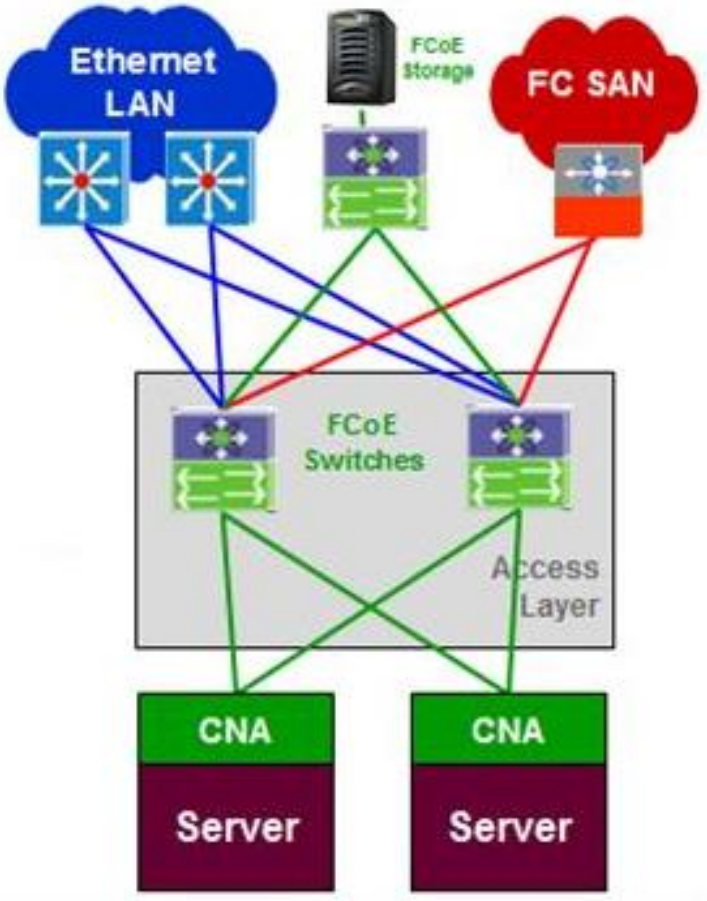
Converged Network



Model Power Consumption

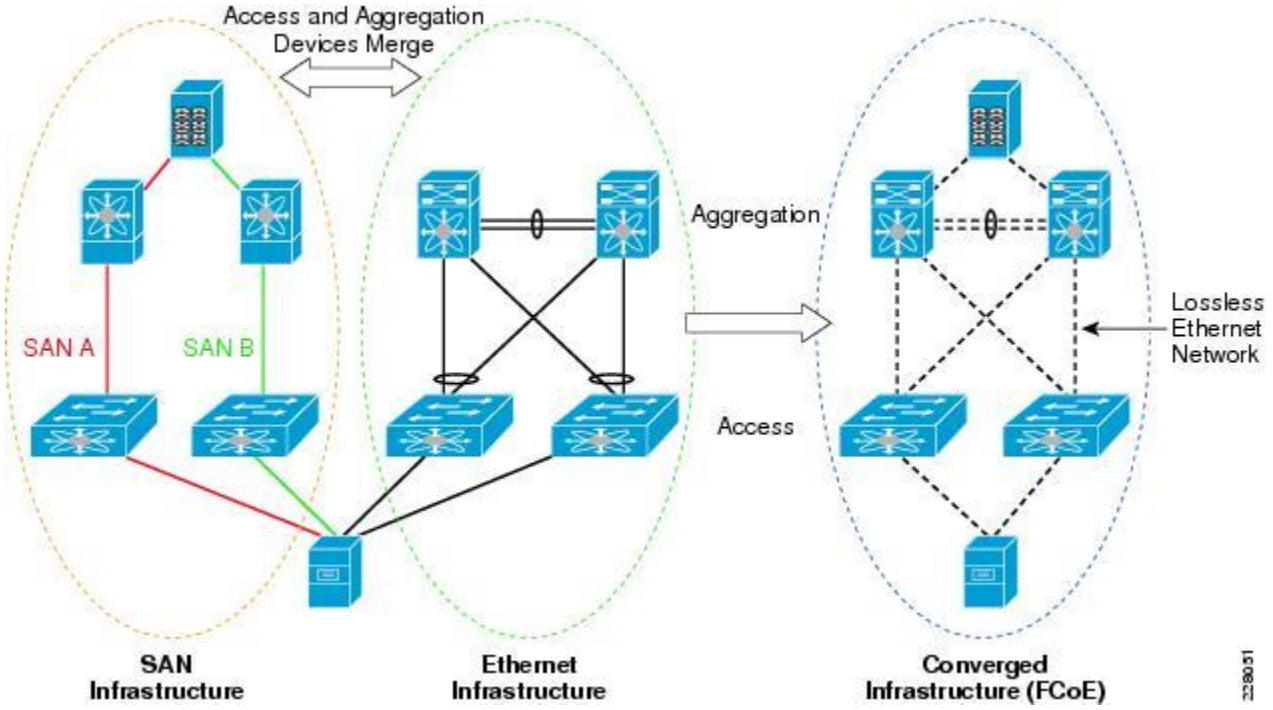
- Enet LAN fiber = 8 ports – 8W
- FCoE = 4 ports – 4W
- SAN = 4P – 4W
- CNA = 8 ports – 8W

- **Total power (Ports only) – 24W**



Equipment reduction

- Many options and paths to network convergence exist
- Simplified view of end goal results in a reduction in deployed switch equipment
- Reduced footprint, power and cost



Cisco

Questions?

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Next Webinar

Tuesday, November 26, 2013 at noon PST

IT Emerging Technologies – focus on HVAC

Register at www.e3tnw.org/webinars

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E3T Program: www.bpa.gov/energy/n/emerging_technology/

Conduit: www.ConduitNW.org