Eco Computing
Improving Data Center Energy Efficiency

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Save earth it's the only planet with chocolate.

The Eco Challenge

Demand and Capacity Are Colliding...

...and your data center is right in the MIDDLE!

Demand

_ Users
_ Services
_ Access

Watts per Square Foot

- 2003: 40
- 2005: 120
- Next Generation: 800
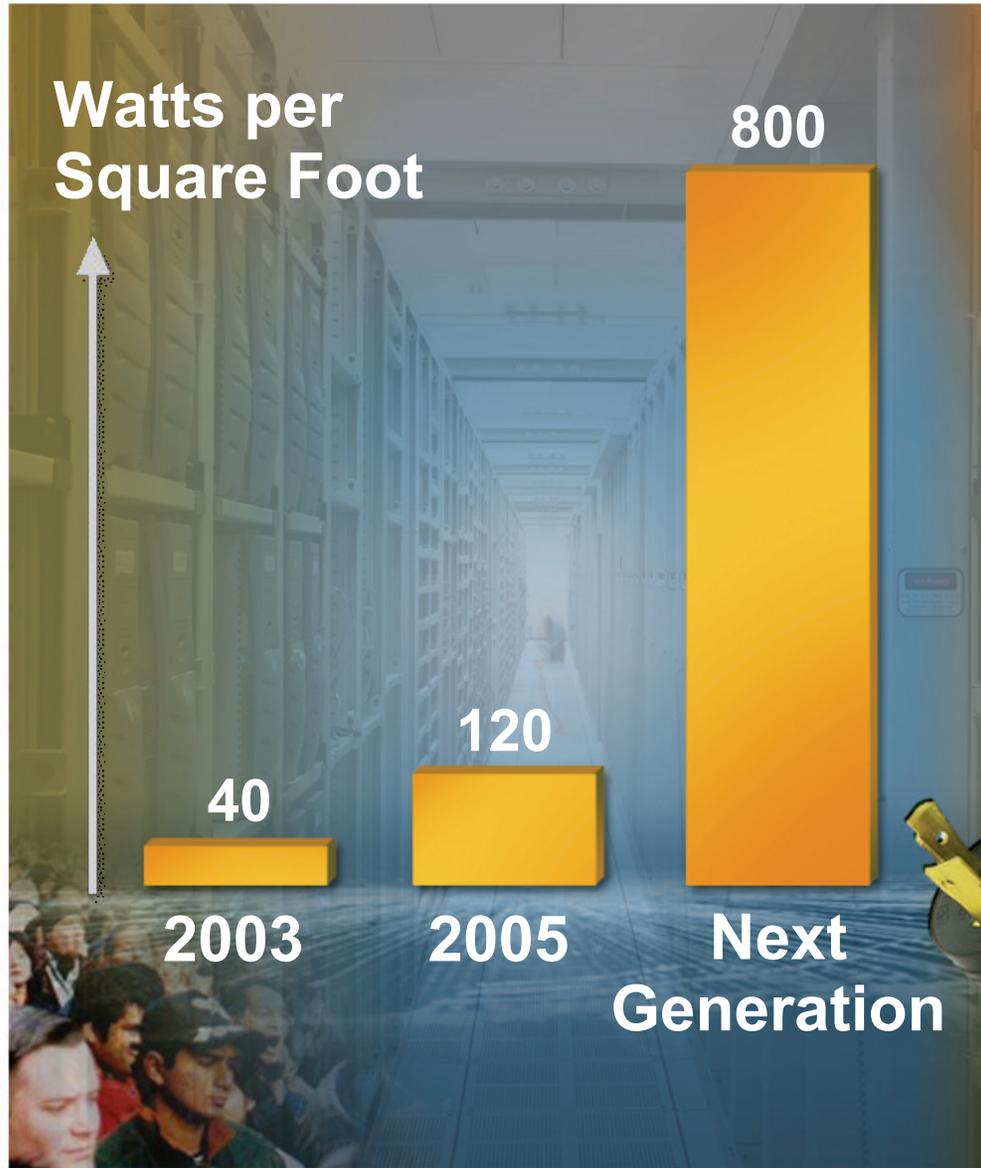
Power

_ Costs
_ Space
_ Heat

Economic Impact

$/yr

IT Equipment Cost

2010-2015

IT Energy Cost

Time
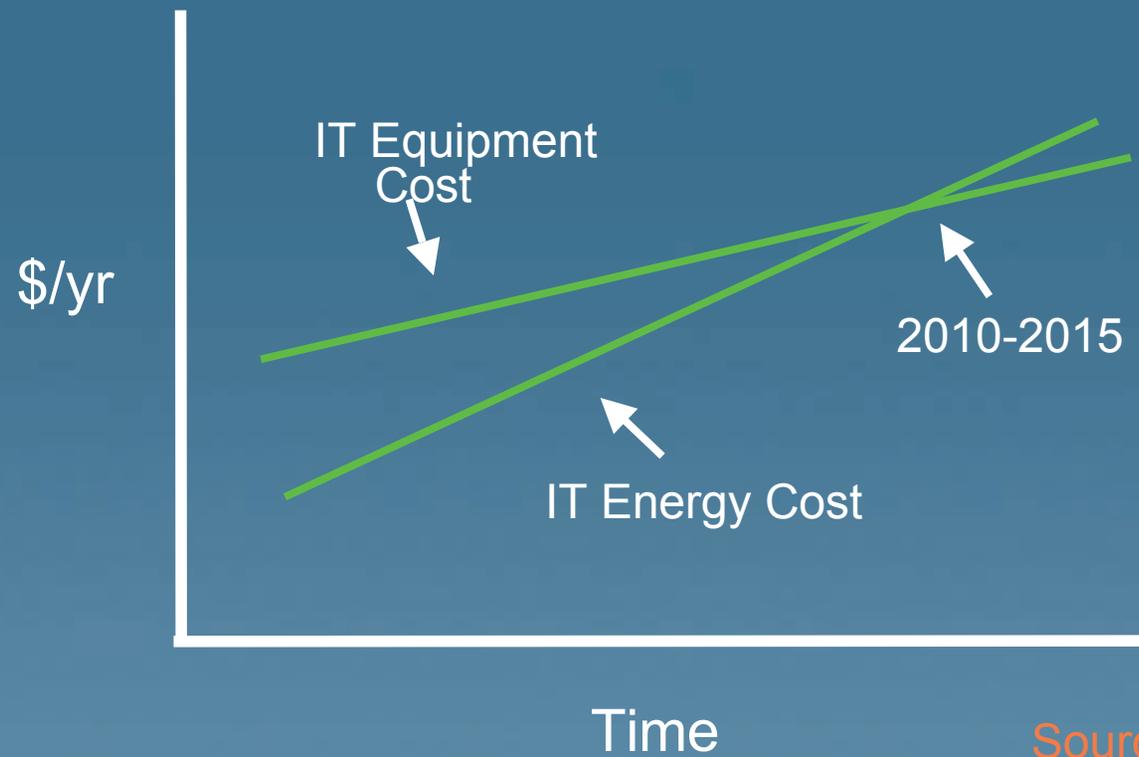
Increasing power density is shifting the balance of cost

Greenhouse Gas Emission Trends

- GHG emissions increased 70% from 1970 to 2004
- Energy supply sector rose the sharpest (145%)

Source: http://www.ipcc.ch/SPM040507.pdf

# The Drive for Energy Efficiency: Prepare for Legislation

- US House of Representatives
  - > H.R. 5646: To study and promote the use of energy efficient computer servers in the United States

- EU Commission
  - > Energy Efficiency Action Plan to reduce energy consumption ¤100B by 2020

Datacenter Power Densities

What is your current maximum power density per rack?

Power density	Percentage
< 2 kW	2%
>2 - 4	13%
>4 - 8	31%
>8 - 12	18%
>12 -16	18%
>20 - 24	13%
>24 KW	6%
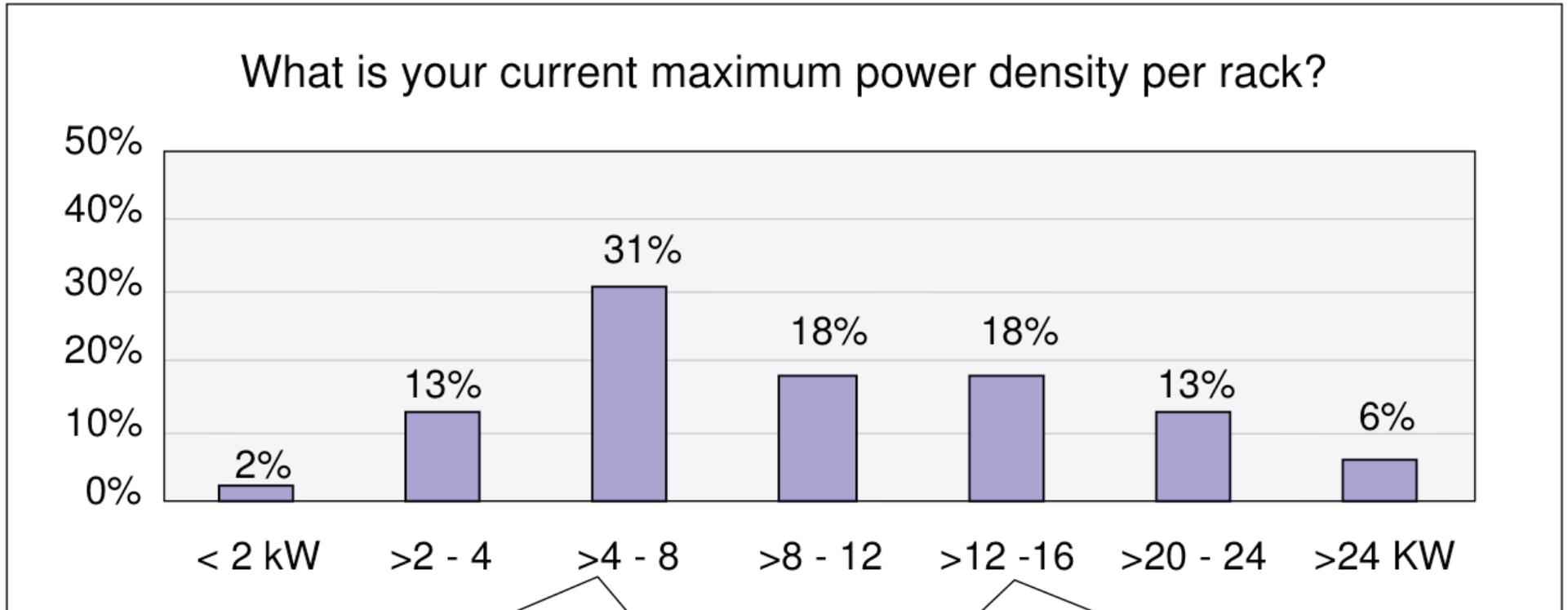
Most data centers are already well past the cooling capacity of good raised floors (~4-6kW per rack)

Racks above 12kW are probably Blade based, and will require supplemental cooling
E.g. - 12kW/200W = 60 Sockets

Not enough Cooling for High Loads

CRAC
Air Supply
Rack Rack Rack Rack

Recommended
< 68   72.5   77   81.5   > 86

*Source: Uptime Institute
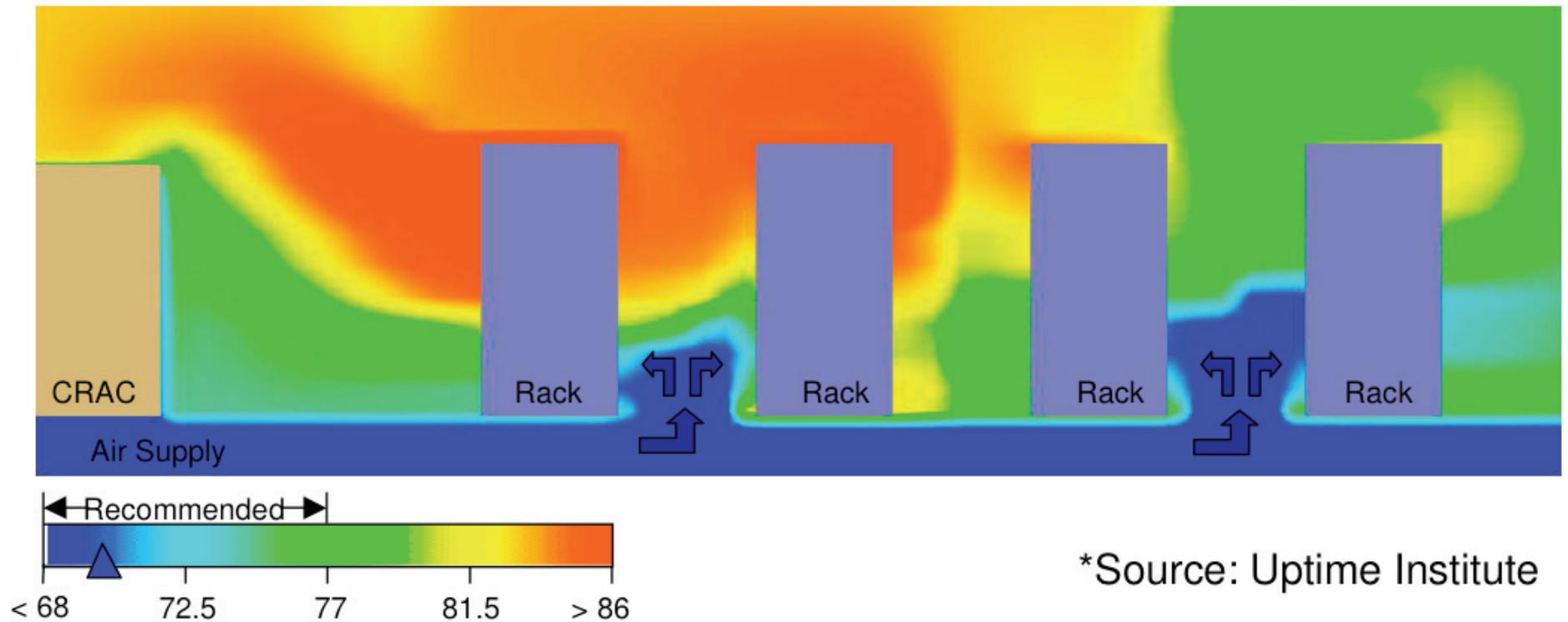
Where Does Data Center Energy Go?

Electrical Power IN →

- Chiller 33%
- Humidifier 3%
- CRAC 9%
- IT Equipment 30%
- PDU 5%
- UPS 18%
- Switchgear / Generator 1%
- Lighting 1%

INDOOR DATA CENTER HEAT → Waste Heat OUT
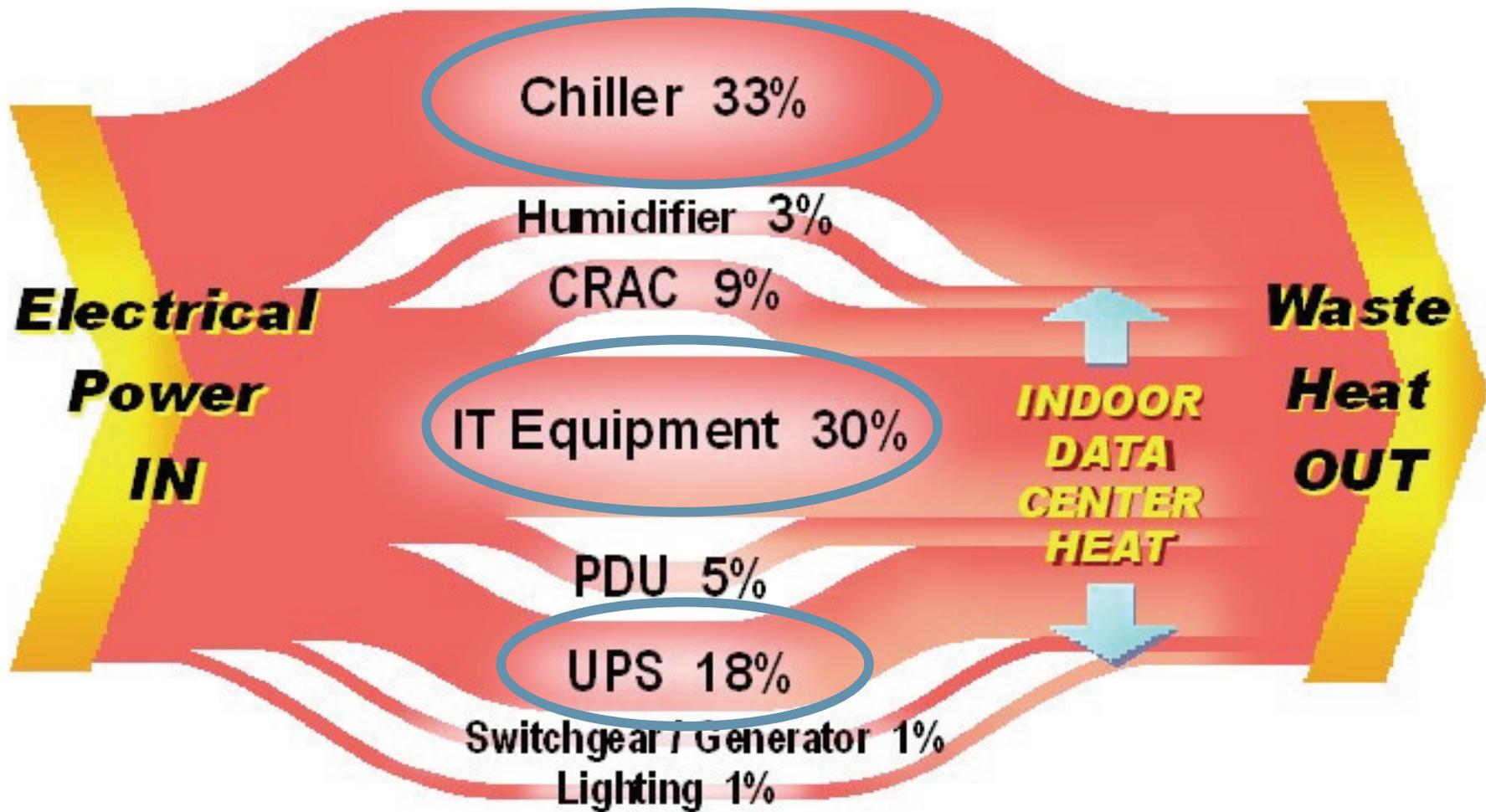
source: APC Corp.

IT Equipment Power Consumption

Percent of BRM Data Center Energy Consumption

27.46%

3.97%

68.05%

Legend:
- Computers
- Network Gear
- Storage Devices
- Unknown
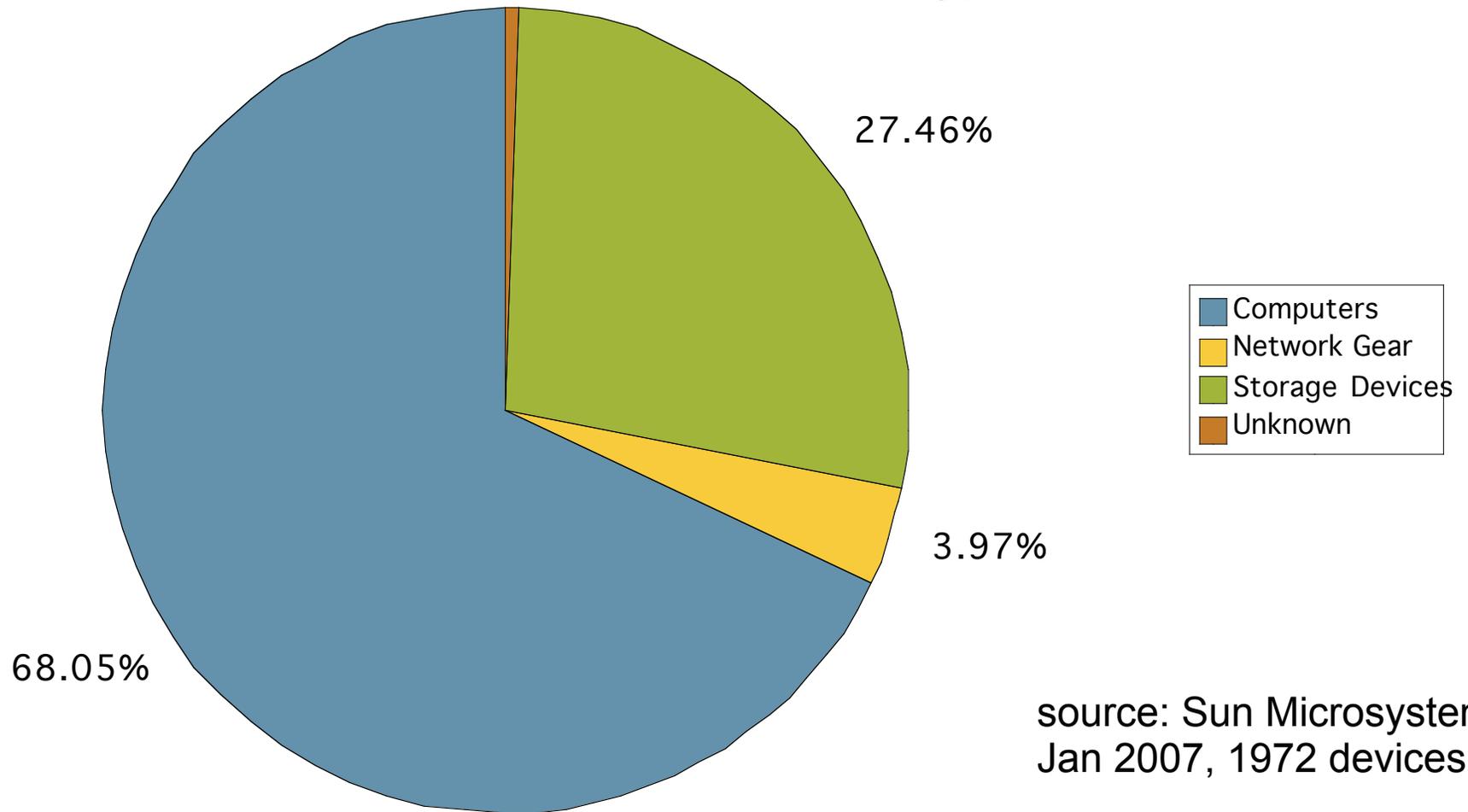
source: Sun Microsystems
Jan 2007, 1972 devices

Short Term Data Center Energy Solutions

- Reduce Computer Equipment Consumption
  - EOL Unused Systems
  - Consolidation and Virtualization
  - Technology Refresh

- Cooling Technologies

- Local Power Generation

- Organizational Changes

Reduce Computer Consumption

- Why?
  - 2:1 (or more) payoff
  - Each watt saved on IT floor = 2 watts not drawn from utility
  - No need to condition, distribute, cool unused watts

- Strategies
  - Eliminate Unused Systems
  - Consolidation
  - Virtualization
  - Technology Refresh

Eliminate Unused Systems

- Studies at Sun and another major computer manufacturer
- Aged servers with no use still in data centers
- 8%-10% of servers studied had no identifiable function
  - 150 of 1800 in one study
  - 354 of 3500 in another study

- At Sun, systems were turned off, kept in place 90 days
- If no complaints after crossing quarter boundary, removed

90 days or less to implement

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stopglobalwarming.org

- Join the 880,106 supporters of the Stop Global Warming Virtual March on Washington DC, and become part of the movement to demand our leaders freeze and reduce carbon dioxide emissions now!

Solaris Containers for Virtualization
Less Servers = Reduced Energy Use

Strong isolation between App and System Administrators

OS Virtualization built into the kernel

Very light weight and scales with any Solaris system

Calendar Server	Database	Web Server	Application
solaris™			OS
			Server
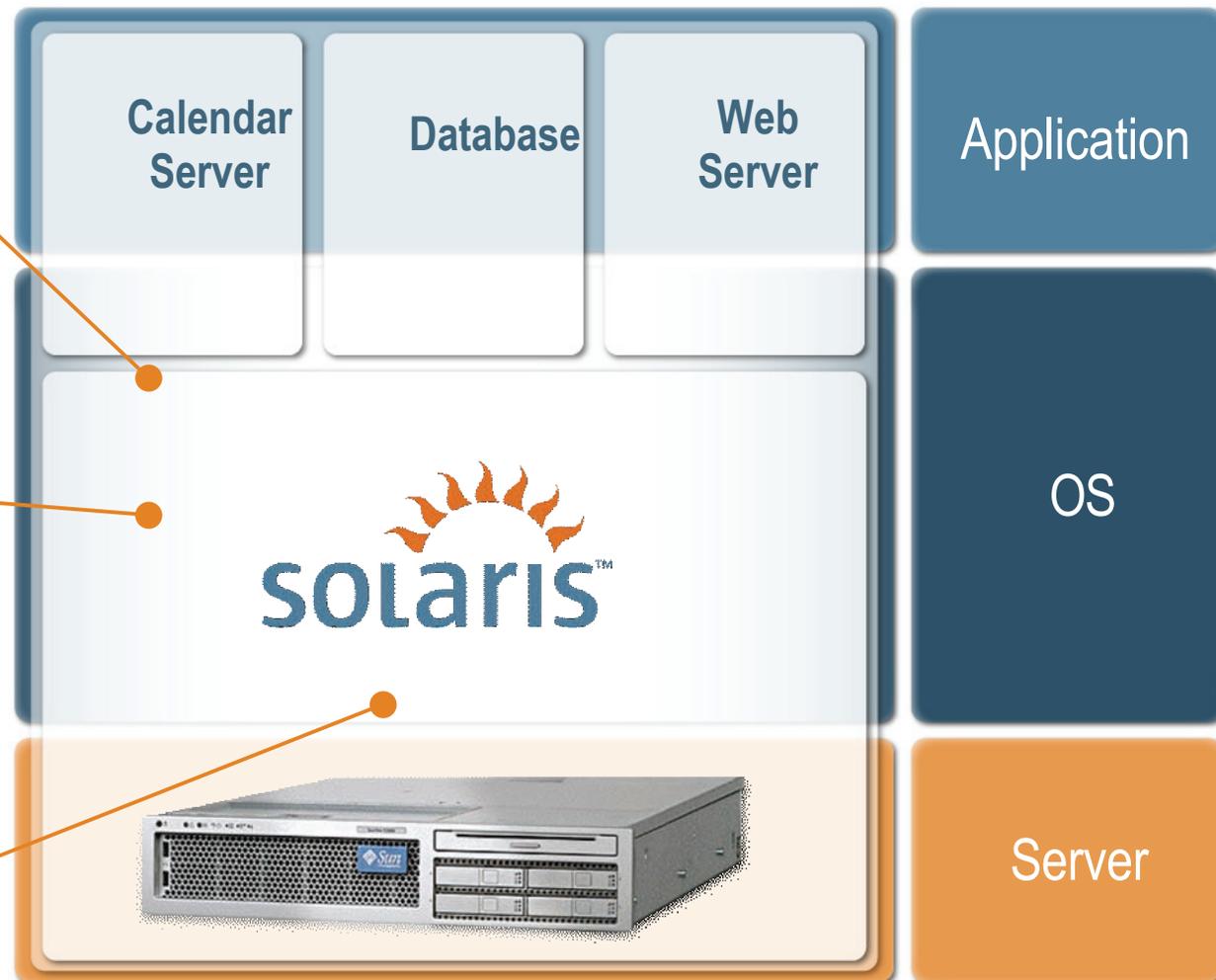
Industry Leading Server Virtualization

Hard Partitions	Virtual Machines	OS Virtualization	Resource Management

| App Server | Database | Identity Server | | File Server | Web Server | Mail Server | | Calendar Server | Database | Web Server | | SunRay Server | Database | App Server | App |

HYPERVISOR

Multiple OSs ← → **Single OS**

Trend to flexibility → ← **Trend to isolation**

Dynamic System Domains

Logical Domains

Xen

VMware

Microsoft Virtual Server

Solaris Containers (Zones + SRM)

Solaris Trusted Extensions

Solaris Containers for Linux Applications

Solaris Resource Manager (SRM)

Not All Applications Are Candidates

BRM Average Sun Ray Use

Legend:
- avg-stderr
- Average Total Users
- 7x24 avg
- avg+stderr

X-axis: Hour-segment (00:00, 08:00, 12:00, 18:00)
Y-axis: -10.00% to 90.00%
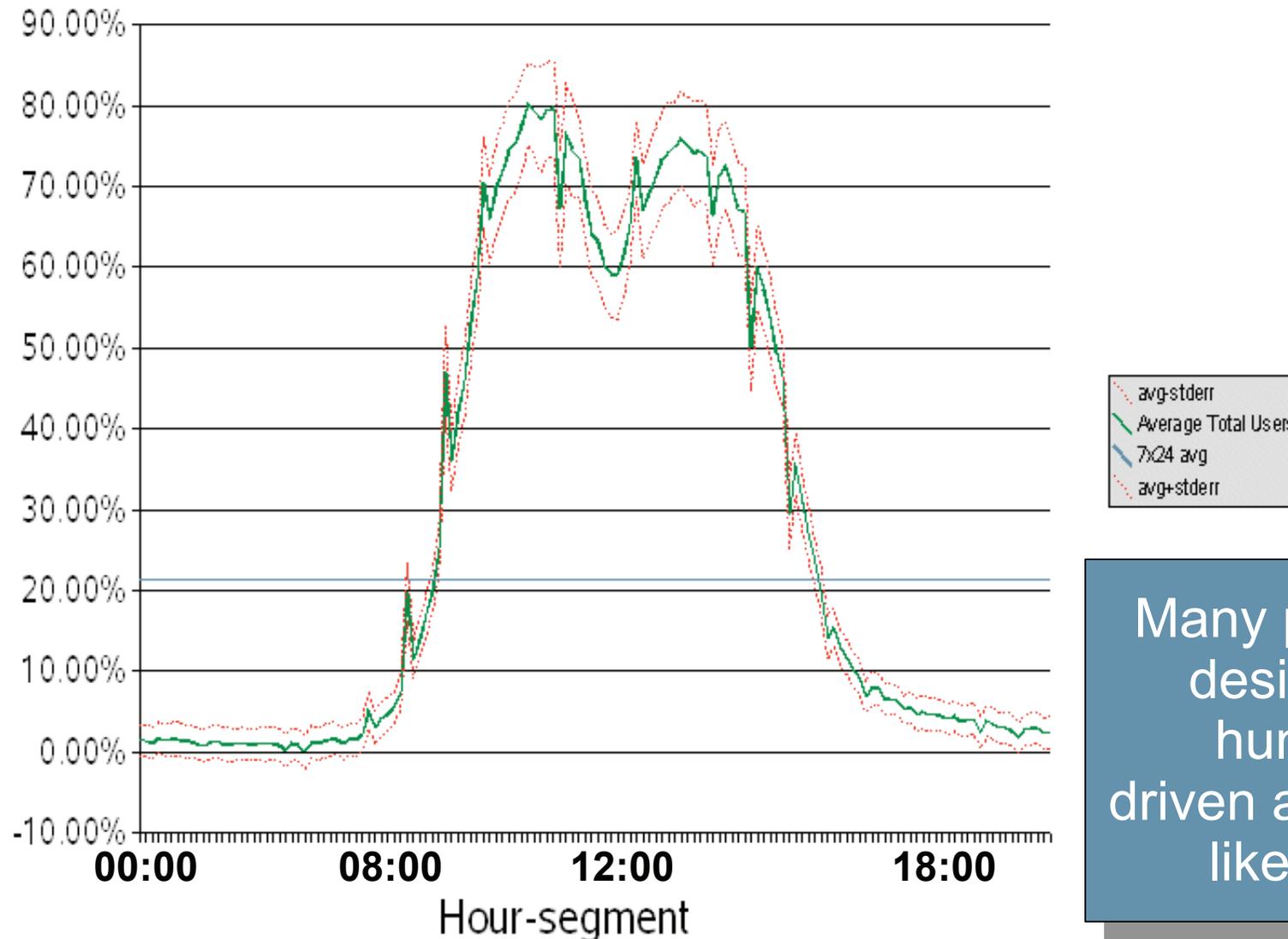
Many properly designed, human-driven apps look like this.

But Even Tough Apps Can Be Done

Typical User-Driven Application Usage Profile

9 virtualized servers account for 116 server-hours, a 46% savings over non-virtualized servers (9 x 24 = 216 server-hours)

4 virtualized servers account for 57 server-hours, a 41% savings over non-virtualized servers (4 x 24 = 96 server-hours)

Each block equals 1 server-hour
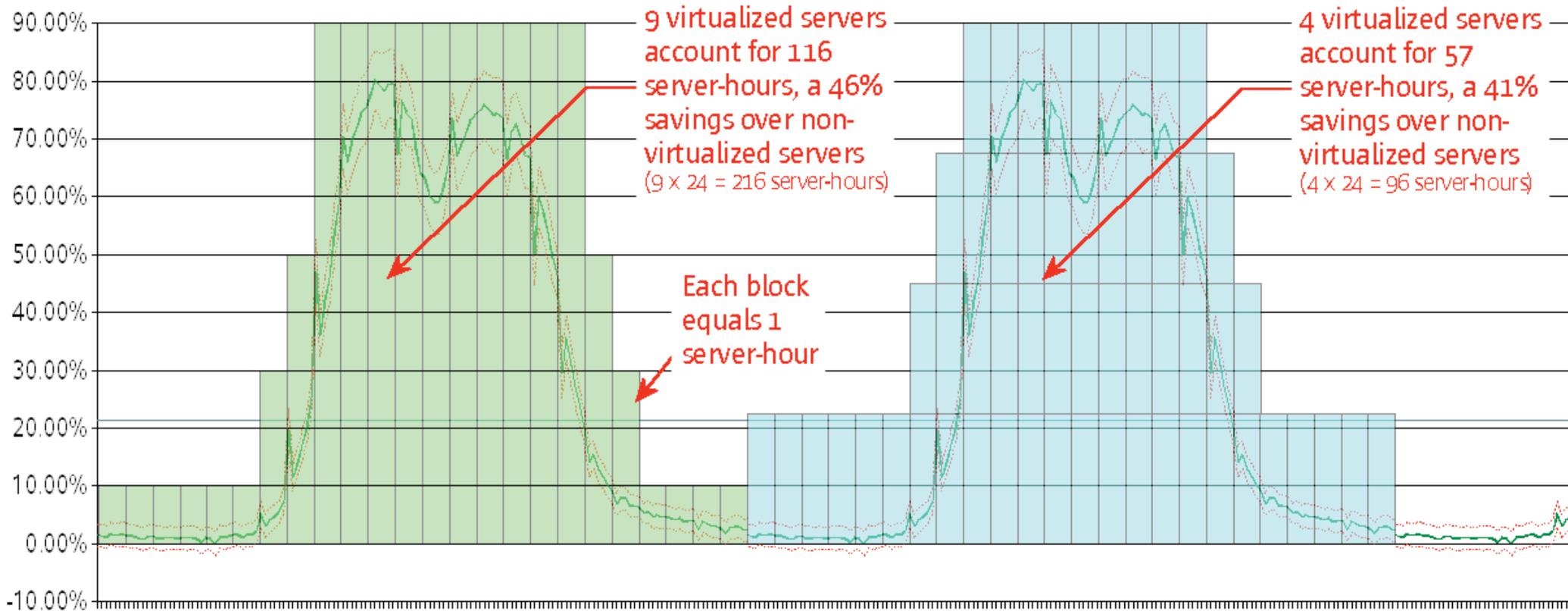
Must turn off load balanced servers to realize any power savings
Still have peak power problems

Consolidation/Virtualization Can Be Hard

- Anecdote from CIO of Bay Area Small-Medium Business

- "Virtualized my whole environment"

- Saved $1500 per application instance (no HW purchase)

- Upon asking for details:
  - > Approx. 300 servers was "whole environment"
  - > Virtualized ~30 servers per month for 12 months
 - > 3-5 people working full time on project

New Virtualization foundation

Virtualization

Benefits

- ROI - $1.8m (Over 4 year period)
- ROI model based upon 452 servers reduced to 69 (260 in final scope)
- Cost Savings - $5.4m
- One time Costs - ($1.6m)
- On-going Support – ($2.0m)
- Payback – 10th Qtr
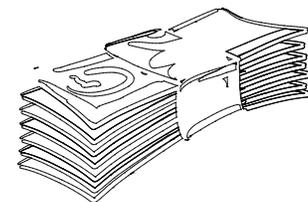
Energy savings spread across 6 data centers
in 3 geographic regions
Estimated

Proposed Timeline

Phase 1

	March	April	May	June	July	Aug	Sept	Oct	Nov

- **Project Resourcing**
- **PLC Concept Review**
- **CAP Plan**
- **Criteria Development**
- **PLC Plan Review**
- **S10 Pre-Work** — Critical Path Item
- **Perf Data Collection**
- **Profiling**
- **Test Env Upgraded S10**
- **Zones Proof of Concept**
- **Support Model**
- **Dev Consolid Plan, Migr Plan, & Update ROI** — Critical Path Item
- **PLC Dev & int Review**

Phase 2

- **PLC Systems Test Review**
- **PLC Cust. Accept & Deploy Review**
- **Execute Plan**

Phase 1 Resource Requirements

(hc numbers = headcount equivalents)

- Dev Teams
  - Profiling: 7 hc for 30 days (CSSIT– 4, DCSIT – 1.75, EFIT – 1.25)
  - Existing Test to S10: 4.7 hc for 90 days (CSSIT-2.6, DCSIT-1.2, EFIT-.9)
  - Proof of concept consolidation .50 hc for 30 days
  - ITAS Project planning: 15% for 90 days
- ITOPS
  - S10 pre-work: 2 hc for 60 days
  - Existing Test to S10: 1 hc for 90 days
  - WWDCO Project planning: .15 hc for 90 days
  - WWTS Project planning .15hc for 90 days
  - DBA planning: .15 hc for 90 days
  - Project Coordination: 1 hc for 5 months
  - Stack Design: 1.5 hc for 60 days
  - Environmental Design: 1.5 hc for 60 days
  - Profiling & Performance Data Collection: 3 hc for 60 days
- ITSM
  - Program management: 1 hc for for 5 months
  - Standards Dev & Zones work: 1 hc for 90 days
- ITSTAR
  - Architecture & Sun on Sun support: .50 hc for 90 days
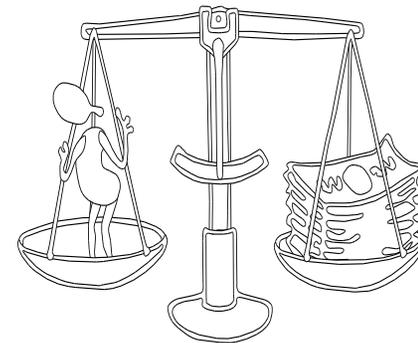
How Much Can Virtualization Save?

- Sun IT data: 10-25% of 1000+ applications are candidates

- Sun IT manages 3500+ production servers globally

- 350-875 servers to be virtualized

- 1-3 years to complete project

- Final configurations consume one-third to one-half of original energy

> 8-18% of IT equipment load
> 16%-36% of total load
> 18-36 months to implement

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Technology Refresh @ Sun

- Colorado campus Sun Ray server upgrade

Servers	Qty	Racks	Power KWh/yr
v880	22	11	617,000
T2000	11	1	39,000
Savings	2x	10x	16x

- $40K/yr savings in power *at the computer*
    $80K-$100K including cooling load, power losses

Can You Guess What This Is?

Newark, CA Consolidation

- 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
- $10M construction costs avoided
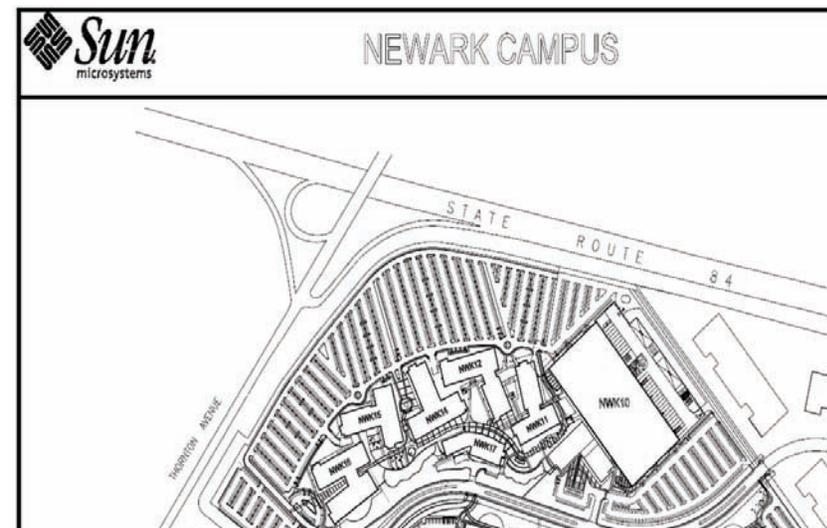
NEWARK CAMPUS

Shared Lab Services
Hardware Replacement Program

09/30/2006
This picture shows 20% of the hardware that was replaced from the SLS hardware replacement program initiated for phase I of the Newark, CA campus closure . For more information contact: dean.nelson@sun.com

Technology Refresh Savings

- Newer, faster servers allow consolidation

- Minimum two old machines for each new one

- Can be as high as 75% space/energy/cooling savings

- Faster payback because of 2:1 cooling savings

- Build virtualization in from the start

- Use Project Blackbox for energy saving and space

Project Blackbox Helps Refresh

- Sun IT planning to use Project Blackbox as "Flexspace"

- Incent application developers to deploy in standard HW config
  - Custom HW in 3-6 mo
  - Flexspace available in 1-2 weeks

- Also provides high efficiency cooling
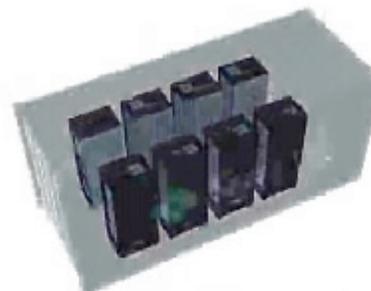
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Size Of The Cooling Opportunity?
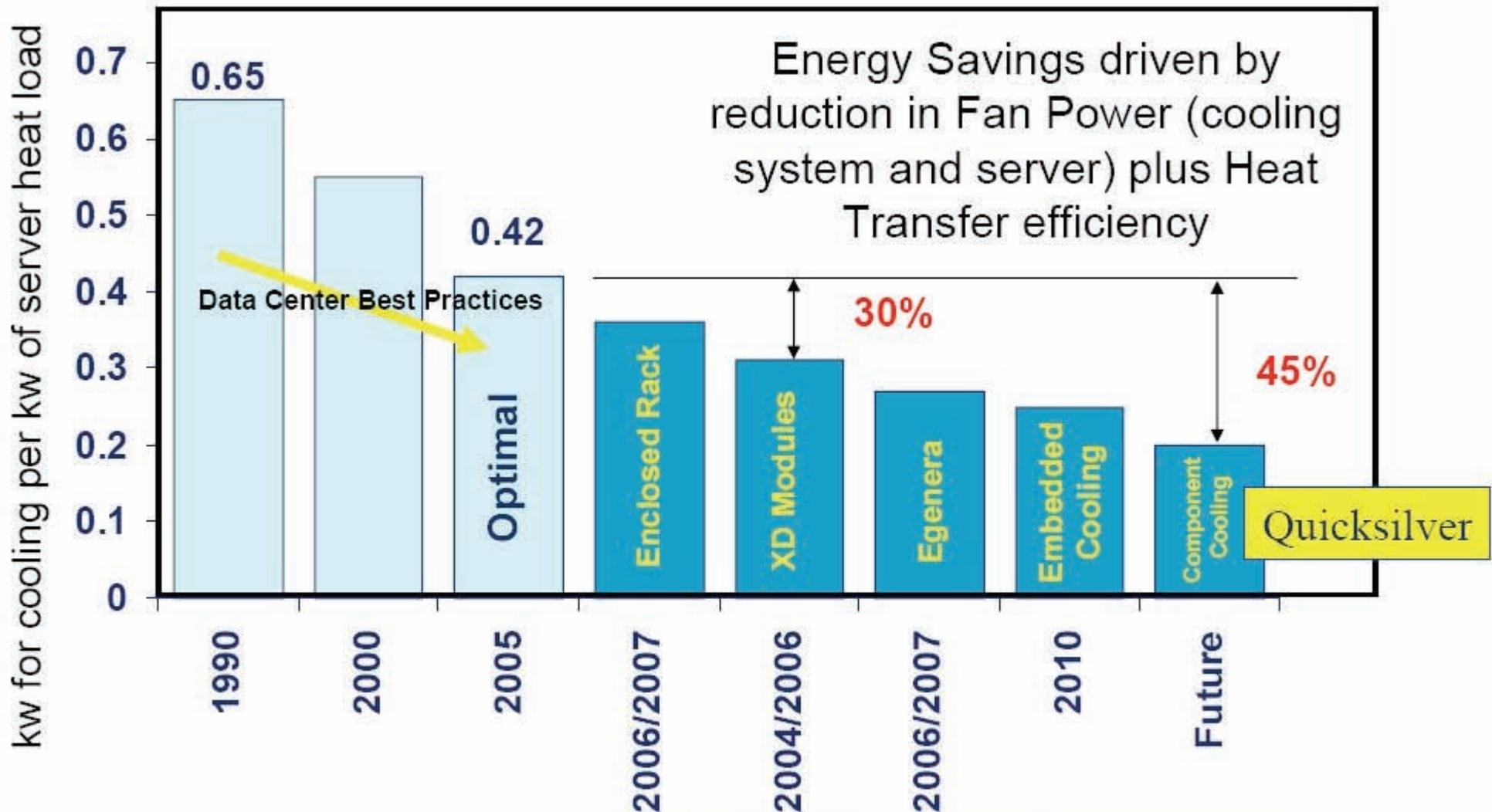
Short Term Solutions

- Data Center Commissioning
  - Sun's Managed Environmental Services
  - Detailed inspection and measurement of data center
  - Identifies operational problems
  - Studies show average 15% building energy savings*

- Clogging holes and correct placement of vented tiles
  - Can account for as much as 20% of cooling load
  - Can be implemented in a matter of weeks

- Check data center A/C setpoints
  - 4% energy for each degree F

* - Lawrence Berkeley Labs/DOE study of 150 building commissioning projects

Medium Term Solutions - Refit

- Rework sections of existing data center for higher density

- Sun examples:
  - > IBIS production: Sun's new ERP systems
  - > 1500 sq ft
  - > 8 x 12 KW racks with in-row liquid cooling modules
  - > Total project cost $600K
  - > 10 weeks from approval to commissioned

Broomfield, CO

# Trondheim, Norway

Menlo Park, CA

APC High Density InfraStruXure (tm) with four NetworkAir In-Row Computer Room Air Conditioners cooling ten Netshelter IT Enclosures running at 16 Kwatt each plus four cabinets running at 4 Kwatt.. All power outlets are remotely controlled and the complete system is IP monitored.

Contact
Dean.Nelson@Sun.COM

Project Blackbox Cooling

- Air flows in circular path with fans and heat exchanger per rack

- Up to a 60-ton chiller for full 200kW load

- 20% more efficient than conventional space
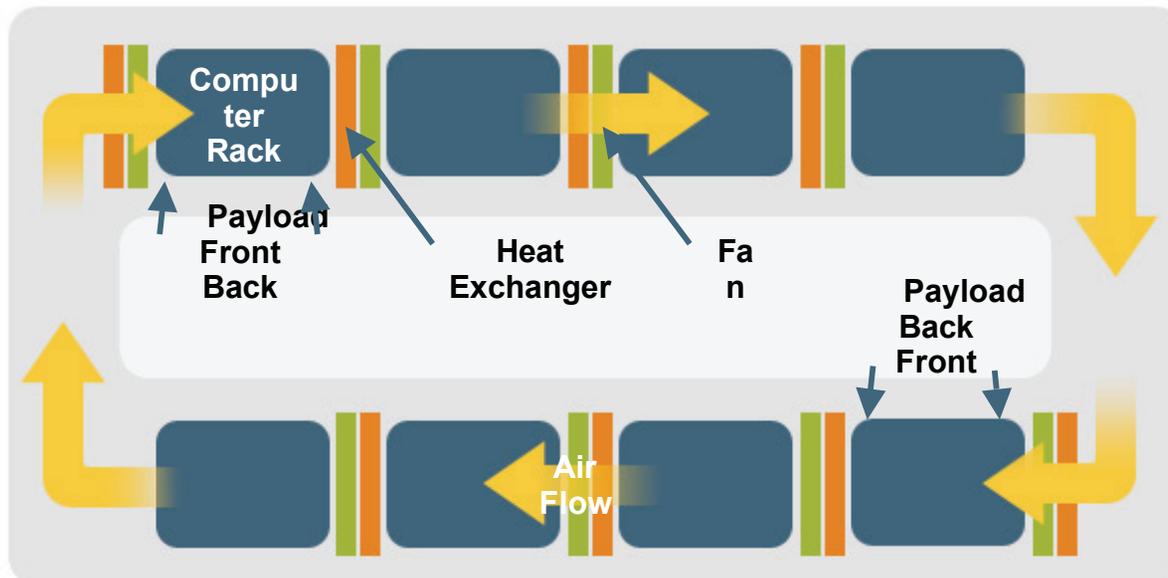
Computer Rack

Payload Front Back

Heat Exchanger

Fan

Payload Back Front

Air Flow

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EPA Server And Data Center Energy

Report to Congress on Server and Data Center Energy Efficiency
Public Law 109-431

U.S. Environmental Protection Agency
ENERGY STAR Program

Public Review Draft

23 April 2007

Table 6-1: Energy Cost Savings Comparison for DG/CHP in Data Centers

CHP System	Molten Carbonate Fuel Cell/ Chiller	Phosphoric Acid Fuel Cell /Chiller	Microturbine/ Chiller Package	Gas Turbine/ Chiller
Capacity, kW	1,000	200	200	3,364
Heat Rate, Btu/kWh	8,060	9,480	14,300	13,930
Electric Efficiency, %	42.3%	32.6%	23.9%	24.5%
Heat Available for Cooling, MMBtu/hr	1.4	0.37	1.28	19.6
Temperature, F	650	250	588	838
Cooling, COP	1.2	0.7	1.2	1.2
Cooling Provided, Tons	140	22	128	1,960
Avoided AC kW/CHP kW	0.14	0.14	0.83	0.58
Total Power Generated plus Avoided AC, kW	1,140	228	366	5,324
CHP Efficiency, %	59.7%	75.0%	68.6%	66.3%
Gas Cost, $/MMBtu	$7.50	$7.50	$7.50	$7.50
Average Electric Cost, $/kWh	$0.130	$0.130	$0.130	$0.130
Unit Capital Cost, $/kW	$7,238	$7,805	$4,088	$2,312
O&M Rate, $/kWh	$0.032	$0.029	$0.022	$0.022
Annual Gas Cost	($503,065)	($118,339)	($178,507)	($2,924,767)
Annual O&M Cost	($266,304)	($48,268)	($36,617)	($615,895)
Annual Avoided Electricity Savings	$1,103,497	$220,756	$354,668	$5,153,526
Annual Savings, $	$334,128	$54,149	$139,544	$1,612,864
Annual Savings, $/kW	$334.13	$270.75	$697.72	$479.45
Total Capital Cost	$7,238,000	$1,560,900	$817,600	$7,778,200
California SGIP	($2,500,000)	($500,000)	($160,000)	($800,000)
MT/FC Energy Tax Credit	($1,000,000)	($200,000)	($40,000)	
Net Capital Cost	$3,738,000	$860,900	$617,600	$6,978,200
Net Unit Capital Cost, $/kW	$3,738	$4,305	$3,088	$2,074
Payback, years Payback without Incentives	21.7	28.8	5.9	4.8
Net Payback with Incentives	11.2	15.9	4.4	4.3

Data Center News:

Solar powered data center wins fans, financial benefit

By Matt Stansberry, News Editor
13 Dec 2005 | SearchDataCenter.com

RSS FEEDS: IT infrastructure news

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A Romoland, Calif.-based hosting data center is now completely "green." Phil Nail, the company's data center manager and co-founder switched over to solar power in 2001 and has been tweaking his facility ever since. The investment has paid off in low energy costs and an eco-friendly marketing angle.

The 2,000-square-foot building from Affordable Internet Services Online Inc. (AISO), is powered by 120 photovoltaic panels generating electricity on ground-mounted platforms beside the data center. The power harvested from the solar panels is DC and is stored in a battery bank. After it leaves the battery bank, the power is converted to AC through Sunny Boy inverters from Grass Valley Calif.-based SMA America Inc.

According to Nail, these panels supply the power to run the data center and offices, including the air conditioners. In case of an emergency, AISO can get power from its emergency generator or the utility grid.

For more

Instead of diesel generators, AISO

Courtesy of International Fu
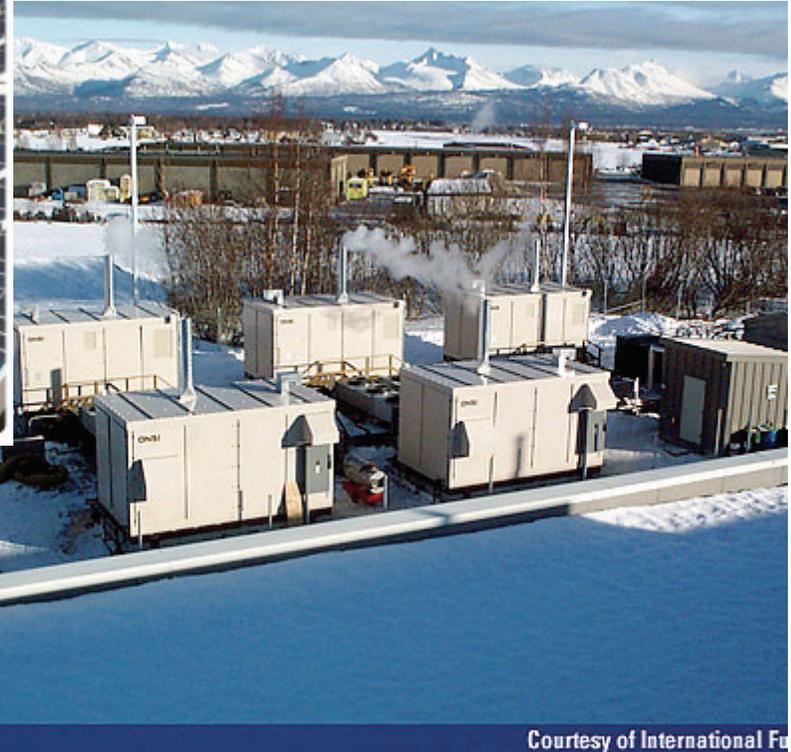
Getting to Green

Do you have teenagers?

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Split Incentives - Consumers/Suppliers

- Many organizations disconnect electric consumption from energy budget
  - CIO one of largest consumers of energy
  - VP of Facilities pays bill

- Align spending with budget responsibility
  - Give CIO electric budget
  - Give Facilities IT capital
  - Sun's NWK consolidation done with Facilities money

Recycle

Developing Countries - Dumping Grounds

- Monitors 8 pounds of lead

- Plastics- flame retardants and cadmium

- 500 containers enter Lagos, Nigeria a month
  - > 800 computers per container
    - >400,000 systems per month
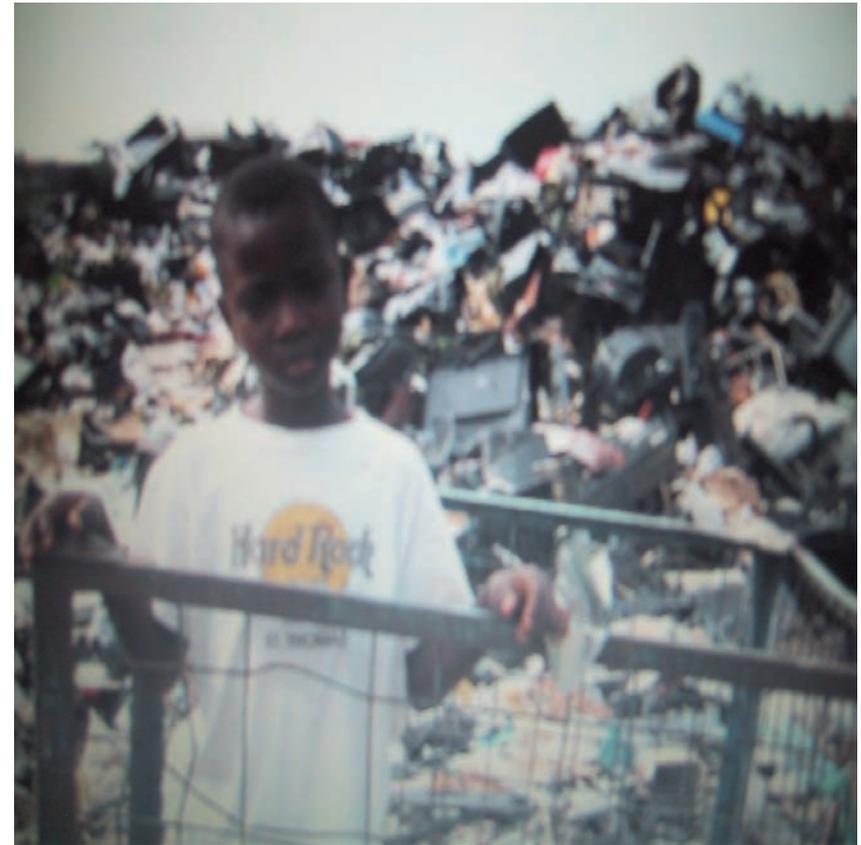
The Basel Action Network

Sun eWaste and HazMat Leadership

- > 50% enters re-manufacturing

- All metal and plastic recovered

- Less than 5% enters waste stream

- Fully RoHS compliant

- Ready for next regs

European WEEE Directive
sets target that 65% of IT equipment must be recycled*

*(EC Directive on Waste Electrical and Electronic Equipment (WEEE) and EC Directive on the restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)

Thank You

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