Sustainable IT – a Year in Review
Stanford University

Joyce Dickerson, Director, Sustainable IT
Stanford University

Educause, November 5, 2009

Copyright Joyce Dickerson, 2009. This work is the intellectual property of the author. Permission is granted for this material to be shared for non-commercial, educational purposes, provided that this copyright statement appears on the reproduced materials and notice is given that the copying is by permission of the author. To disseminate otherwise or to republish requires written permission from the author.
8,200 acres, 49 miles of roads, 670 major buildings (13.1 million square feet)

6,800 undergraduate and 8,300 graduate students across seven schools (Business, Earth Sciences, Education, Engineering, Humanities and Sciences, Law, Medicine), representing every US state and 88 other countries

1,900 professorial faculty

11,000 administrative staff

Reference: Stanford Budget Plan FY09-10
Average PC wastes \( \frac{1}{2} \) the energy delivered to it

**US, with 5% world population, uses 30% of world’s paper**

- Energy prices expected to rise 6% per year
- Typical office disposes 350 lbs waste paper/employee/year
- 50 million tons of e-waste produced yearly worldwide
- Office equipment is 26% of the energy used in office buildings
- IT Industry’s CO2 footprint is equivalent to that of the Aviation Industry
- Datacenters use 3% of the total energy used in the US, and office computing is another 1%

As many as 60% don’t turn computer off at night
Opportunities for Sustainability Initiatives

Sustainable IT at Stanford

Three main initiatives of Sustainable IT:

1. PCs / Office Equipment
2. Datacenters / Server Rooms
3. High Performance Computing
Goal: Enabling Energy Savings and Carbon Reduction

**Industry:** IT energy usage expected to rise 15% annually

**Goal:** Keep energy usage flat, while meeting increasing demand on IT infrastructure
Goal: Enabling Energy Savings and Carbon Reduction

Stanford: IT energy usage depends on application

Challenge: Finding a solution for Research Computing
Initiatives and Results

1. Personal Computers / Office Equipment

2. Data Centers / Server Rooms

3. High Performance Computing
Myths and Facts about Sustainable Personal Computing

**Myth:** Turning off your computer harms it
**Fact:** PCs are built to withstand 40,000 power cycles

**Myth:** It takes more energy to boot a computer than it does to keep it awake overnight
**Fact:** The surge of power needed to turn on a computer is much smaller than the energy used to keep it on

**Myth:** Screensavers save energy
**Fact:** Screensavers use more energy (42-114 watts); it’s better to turn it off
Energy Saving Personal Computing - Projects

**PC Power Management**
- Monitors off after 15 minutes, going to standby (central management installed on 23,000 computers)

**‘Phantom’ Power Reduction**
- Smart Strips
  - (peripherals waste up to 75% lifetime energy use)

**Sustainable Maintenance**
- Move from nighttime backup and patches
- Computers to sleep or off at night

**Lifecycle Management**
- Buying Smart
- Disposing Correctly
PC Power Management - Results

- **10,000 participating PC’s**
  - 23,000 SW installed
  - 83% turn off monitor after 15 minutes
  - 9% go to standby after 60
  - Per-unit annual savings: $10 (monitor) to $20 (standby)

- **Market Stats:**
  - Market Share: 25%
  - Cost to implement: $0: 100% of incremental licenses rebated by utility
    - No additional SW or HW
  - Annual Savings: >$100,000/year

- **Next Steps:**
  - Upgrade to production code
  - Negotiate for university-wide policy

- **Goals:**
  - Market Share: 80%
  - Cost to implement: $0: utility rebates
  - Incremental Annual Savings: >$300,000/year
## Phantom Power Reduction - Results

### 700 SmartStrips installed
- Student housing, School of Medicine, LBRE, IT services...
- Available through Staples
- Local printer or > peripherals
- Eligible systems: 25%
- Per-unit annual savings: $25

### Market Stats:
- Market Share: 2%
- Annual Energy Saving: $17,500
- Cost to implement:
  - <$30/unit, Utility Rebates
- Annual Savings: ~$25/year/unit

### Next Steps:
- Setup $10 Campus Rebates
- Coordinate program with Desktop Consulting
- Coordinate with Procurement

### Goals:
- Market Share: 25% (100% of available market)
- Cost to implement:
  - $93,000 rebates
  - $186,000 departments
- Incremental Annual Savings: $232,500
Sustainable Maintenance - Results

- **Nighttime Backups**
  - Two backup options with backup on idle
  - Retiring ‘nighttime only’ backup solution
  - Power Management software offers wake-on-LAN

- **Market Stats**
  - 9+% of computers in sleep

- **Next Steps:**
  - Coordinate program with Desktop Consulting
  - Identify pockets of ‘night-time’ backup
  - Overcome remote access issues

- **Goals:**
  - No excuses
  - Make it easy
  - >50% computers in sleep
Lifecycle Management – Beginning of Life - Results

**Project Goals**
Adopt policy and procedure to ensure sustainable computers are purchased
- Coordinate Purchasing and Central IT
- Use EPEAT and Energy Star 5.0
- Adopt Climate Savers Computing Initiative

**Project Status**
- Hardware bundles are 100% EPEAT Gold
- RFP sustainability requirements
- SmartStrips easily available: SmartMart, Student Sustainability Store, bookstore
- ‘Sustainable IT Favorites’ in SmartMart

**Next Step**
- Reporting: Procurement & Vendors
- Bookstore ‘Sustainable IT’ section
Lifecycle Management – End of Life - Results

Project Goal
Ensure ewaste is reused or recycled. No landfill.

Still viable:
- Reuse: [reuse.stanford.edu](http://reuse.stanford.edu)
- Resell: Property Management Office

Not working:
- E-waste bins in almost every building
- Third party recycler. No landfill.

Next Step:
- Reporting: EH&S
Initiatives and Results

1. Personal Computers / Office Equipment

2. Data Centers / Server Rooms

3. High Performance Computing

Credit: IStock IPhoto; used with permission
Datacenter Opportunities

Main Datacenter
- Forsythe – 20,000 square feet
- Some hot/cold aisles, no containment

Satellite Server Rooms
- Independent server rooms managed by departments/schools/researchers
- Identified by facilities on main campus
- Definitely more undiscovered

Research Computing
- High Performance Computing
- Fastest growing sector
Datacenter Efficiency Metric

- Power Usage Effectiveness (PUE)
- Data Center Infrastructure Efficiency (DCiE = 1/PUE)

\[
PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}} = \frac{\text{IT Equipment Power + Facility Operations}}{\text{IT Equipment Power}}
\]

IT Equipment Power = Total IT load
- Servers, Storage, Telco Equipment, etc

Facility Operations = Power + Cooling
- Power = Switchgear, UPS, Racks, Battery Backup, etc.
- Cooling = Chillers, CRAH/CS, etc

2.0+ = Typical
1.5 = Exceptional
1.2 = Google & Others
1.0 = Theoretical Target
Main Datacenter Project

Project goal:
Understand current efficiency of datacenter. Chart path forward to reduce PUE
- PUE Calculated at 1.8
- Install VFDs, temp sensors, connect to bldg management system and outside air economizers

Current Status
- Adjusting airflow, increasing temperature, target 77° cold aisle
  (Most vendors approved at 90°)

Learnings
- This took a lot longer than expected
- Installing sensors was the easy part

Project Financials:
- Initial PUE Calculation – funded by Utility
- Work recommendations – funded by Utility
- VFDs, Sensors, Software, power monitors – prepaid, 50-100% paid for by Utility and Campus Rebates
- Estimated Payback: <1 year

Next Steps:
- Explore Isolated hot/cold aisle
- Explore high-efficiency UPS
- Explore Passive Cooling
- Get energy efficiency engineers involved in design stage of planned expansion
Satellite Server Rooms

~70 distributed satellite server rooms

5 primary cooling methods

- In-row cooling, Water-cooled racks, CRAH units, DX, Fan coil + House system

Goals:

- Determine energy efficiency by cooling method
- Identify room efficiency projects
- Create Facility Design Guides

Partners:

- SynapSense Wireless monitoring
- Jacobs Engineering
The Closet

- 120 Square Feet
- Fan Coil, but outgrew it so turned to house air
- 2 Racks
- 2.8 Ton Cooling Capacity
- 10 kW IT Load
- 11 kW Cooling Load
- Average Top Temp: 76.7 F
- Administrative Servers

PUE = 2.14
Satellite Server Rooms: About the Rooms

The Growing High Density Computing Room
- 1200 Square Feet
- Water cooled racks
- 18 Racks

- 99.2 Ton Cooling Capacity
- 41 kW IT Load
- 29 kW Cooling Load
- Average Top Temp: 66.5 F
- Research Servers

PUE = 1.78
Satellite Server Rooms: About the Rooms

The Raised-Floor mini-datacenter

- 1180 Square Feet
- CRAH units
- 42 Racks
- 68.7 Ton Cooling Capacity
- 59 kW IT Load
- 107 kW Cooling Load
- Average Top Temp: 69.4 F
- Research & Administrative Servers

PUE = 2.94
Satellite Server Rooms: About the Rooms

The Lights-Out Cinderblock

- 1450 Square Feet
- DX units
- 13 Racks
- 47.8 Ton Cooling Capacity
- 44 kW IT Load
- 22 kW Cooling Load
- Average Top Temp: 75.2 F
- Telecom & Administrative Servers

PUE = 1.70
The High Density Computing Room

- 800 Square Feet
- In-row cooling with contained hot aisle
- 16 Racks
- 72.8 Ton Cooling Capacity
- 223 kW IT Load
- 37 kW Cooling Load
- Average Top Temp: 71.5 F
- Research Servers

PUE = 1.27
### Satellite Server Rooms: ‘Normalizing’ for IT Power Distribution

<table>
<thead>
<tr>
<th></th>
<th>Closet</th>
<th>Growing High Density</th>
<th>Mini Datacenter</th>
<th>Lights Out Cinderbloc</th>
<th>High Density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PUE</strong></td>
<td>2.14</td>
<td>1.78</td>
<td>2.94</td>
<td>1.70</td>
<td>1.27</td>
</tr>
<tr>
<td><strong>UPS/PDU</strong></td>
<td>No / No</td>
<td>No / No</td>
<td>12% / 12%</td>
<td>Redundant</td>
<td>30% / 70%</td>
</tr>
<tr>
<td><strong>Normalized PUE</strong></td>
<td>2.36</td>
<td>2.00</td>
<td>3.14</td>
<td>1.70</td>
<td>1.42</td>
</tr>
</tbody>
</table>
### Satellite Server Rooms: ‘Optimizing’ the Rooms ...

<table>
<thead>
<tr>
<th></th>
<th>Closet</th>
<th>Growing High Density</th>
<th>Mini Datacenter</th>
<th>Lights Out Cinderbloc</th>
<th>High Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normalized PUE</td>
<td>2.36</td>
<td>2.00</td>
<td>3.14</td>
<td>1.70</td>
<td>1.42</td>
</tr>
<tr>
<td>Efficiency Measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Blanking Plates</td>
<td></td>
<td>VFDs on 2 Pumps: run in parallel</td>
<td>- Blanking Plates</td>
<td>- VFD on CRAC</td>
<td></td>
</tr>
<tr>
<td>- Replace Fan Coil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Turn off House System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg Temp Increase (F)</td>
<td>5.8</td>
<td>8.4</td>
<td>11.0</td>
<td>3.2</td>
<td>8.1</td>
</tr>
<tr>
<td>Air Flow Reduction</td>
<td>63% (house system)</td>
<td>0%</td>
<td>63%</td>
<td>45%</td>
<td>28%</td>
</tr>
<tr>
<td>Target Norm PUE</td>
<td>1.65</td>
<td>1.99</td>
<td>2.63</td>
<td>1.54</td>
<td>1.38</td>
</tr>
</tbody>
</table>
# Satellite Server Rooms: Room Efficiency Summary Table

<table>
<thead>
<tr>
<th></th>
<th>Closet</th>
<th>Growing High Density</th>
<th>Mini Datacenter</th>
<th>Lights Out Cinderblock</th>
<th>High Density</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starting PUE</strong></td>
<td>2.36</td>
<td>2.00</td>
<td>3.14</td>
<td>1.70</td>
<td>1.27</td>
</tr>
<tr>
<td><strong>Target PUE</strong></td>
<td>1.43</td>
<td>1.77</td>
<td>2.43</td>
<td>1.54</td>
<td>1.23</td>
</tr>
<tr>
<td><strong>Normalized PUE</strong></td>
<td>2.36</td>
<td>2.00</td>
<td>3.14</td>
<td>1.79</td>
<td>1.42</td>
</tr>
<tr>
<td><strong>Target Normalized</strong></td>
<td>1.65</td>
<td>1.99</td>
<td>2.63</td>
<td>1.54</td>
<td>1.38</td>
</tr>
<tr>
<td><strong>% of Building</strong></td>
<td>0.2%</td>
<td>12%</td>
<td>15%</td>
<td>100%</td>
<td>2.7%</td>
</tr>
<tr>
<td><strong>% of Building Energy</strong></td>
<td>7%</td>
<td>14%</td>
<td>22%</td>
<td>100%</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Annual Cost to run</strong></td>
<td>$19,029</td>
<td>$62,875</td>
<td>$141,918</td>
<td>$71,995</td>
<td>$261,387</td>
</tr>
<tr>
<td><strong>Average daily cost/IT kWLoad</strong></td>
<td>$5.11</td>
<td>$4.19</td>
<td>$6.55</td>
<td>$4.44</td>
<td>$3.21</td>
</tr>
</tbody>
</table>
Satellite Server Rooms: Next Steps

Integrate construction and maintenance costs
  ▪ Lifecycle Total Cost of Ownership (TCO)

Implement savings & report actuals
  ▪ Utility rebates

Rank order remaining 65 rooms and find efficiencies

Develop 2-3 recommended designs depending on compute needs

Create formal guidelines for Facilities
  ▪ Remodel
  ▪ New Construction
  ▪ IT components: racks, UPS, virtualization opportunities, and so on
Satellite Server Rooms: Lessons Learned

Lots of server rooms exist in spaces not designed for IT equipment

- Conference rooms, closets, classrooms, lab space ...
- Extremely inefficient if tied to house system

Rooms are small, yet consume significant % of building energy

- <1-3% of floor space
- 7-40% of building energy usage

Match cooling technology with IT needs

- Isolate from house system
- VFDs make a meaningful difference
  - most rooms had too much airflow
- High density cooling only if high density racks (15+ kW)
- Overbuilding for growth is wasteful – go modular
Tightly managed cooling flow yields better the PUE

- Least efficient are traditional datacenter designs
  - Cool air blowing into room
- Bring cooling closer to heat source
  - In-row cooling, water chilled racks
    - PUE ~ 1.4 to 1.5
  - Hot/cold aisles

Small legacy raised-floor data center with best practices is still worst performer

- PUE = 3.14 non-optimized, best at 2.43/2.63

Visibility is Critical

- Easy to let them slip: PUE → 1.6 – 3.2
- Can’t improve what you don’t measure
- Most rooms don’t have sub-meters
Datacenter Initiatives

**Successes for the year:**

- **Metrics:** Created awareness of datacenter energy efficiency & metrics
  - PUE
  - Access to already-in-place energy metering data
  - Awareness that simple things can make a difference

- **Visibility:** Significant impact from measuring

- **Rebates:** Awareness of Utility Rebates

- **Local Rebates:** Expanded campus utility energy efficiency rebates to include IT-related projects: server virtualization, datacenter efficiency. Modeled after Utility rebate program

- **Partnerships:** Strong partnership between Facilities, Central IT, Distributed IT groups, Utility, local organizations

**Next Steps**

- Partner with Facilities & Utility to evaluate next batch of Satellite Server Rooms
Initiatives and Results

1. Personal Computers / Office Equipment

2. Data Centers / Server Rooms

3. High Performance Computing
High Performance/Research Computing

Fastest growing IT Need
- Affects Central Datacenter as well as Satellite Server Rooms
- CRAYs to Server Farms to Clouds

Scientific Research Computing Facility (SRCF)
- Proposed facility for high density research computing
- Reduces energy usage by 60%

Innovative Design – Cooled by outside air
Modular Design Approach

Image Courtesy IDC Architects
Summer Air Flow

Image Courtesy IDC Architects
Winter Air Flow

Winter Air Flow Analysis

Pressure

Temperature

Image Courtesy IDC Architects
High Performance Computing – The Future

Still sorting it out, and likely a blend...

- Scientific Research Computing Facility
- Local Clusters
- Local Cloud
- Outsourced Cloud
- New IT Strategies
  - Graphical Processing Units (GPUs), Energy efficient storage, etc.
Sustainable IT Challenge

Opportunities are plentiful
- Create a framework
- Start where you’ve got support

Use budget reductions to your favor
- Paybacks frequently < 1 year
- Take advantage of rebates

You can’t do it alone: build a cross-functional team
- Inside: IT, facilities, utilities, researchers
- Outside: Utility Rep, local policy groups, local companies, other campuses
- Fully utilize your campus Utility rep
Conclusion

Every request for more energy is a challenge to be more GREEN
Questions and Answers