Better Buildings®
U.S. DEPARTMENT OF ENERGY

Engaging Building Occupants: How to Reduce Plug Load Energy Use

Rois Langner, NREL
Technical Lead, Plug & Process Load Technical Solutions Team
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U.S. DEPARTMENT OF ENERGY

Engaging Building Occupants: How to Reduce Plug Load Energy Use

- Presentations:
  - Christine Wu, Sustainability Program Manager at the U.S. General Services Administration
  - Moira Hafer, Sustainability Specialist at Stanford University
- Discussion and Q & A

Join the Better Buildings Alliance!

Join the BBA PPL Tech Team

Featured Solutions

[Decision Guides for Plug and Process Load Controls](#) Guidance

The decision guides found in this resource were created to help building owners find the right c
their buildings.

[View Related Solutions](#)

[Technical Specifications for Advanced Power Strips (Version 1.](#)

This specification provides detailed selection criteria for five m
intended to help those who procure APSs select the most effe

[View Related Solutions](#)

[How To Use Advanced Power Strips in an Office Setting](#) Fact She

Each advanced power strip has three outlet types for equipment
the uses for each outlet type.

[View Related Solutions](#)

[Assessing and Reducing Plug and Process Loads in Office Buildin](#)

Using the process and strategies outlined in this brochure, the U.S
Laboratory (NREL) was able to drastically reduce its PPL energy use

[View Related Solutions](#)

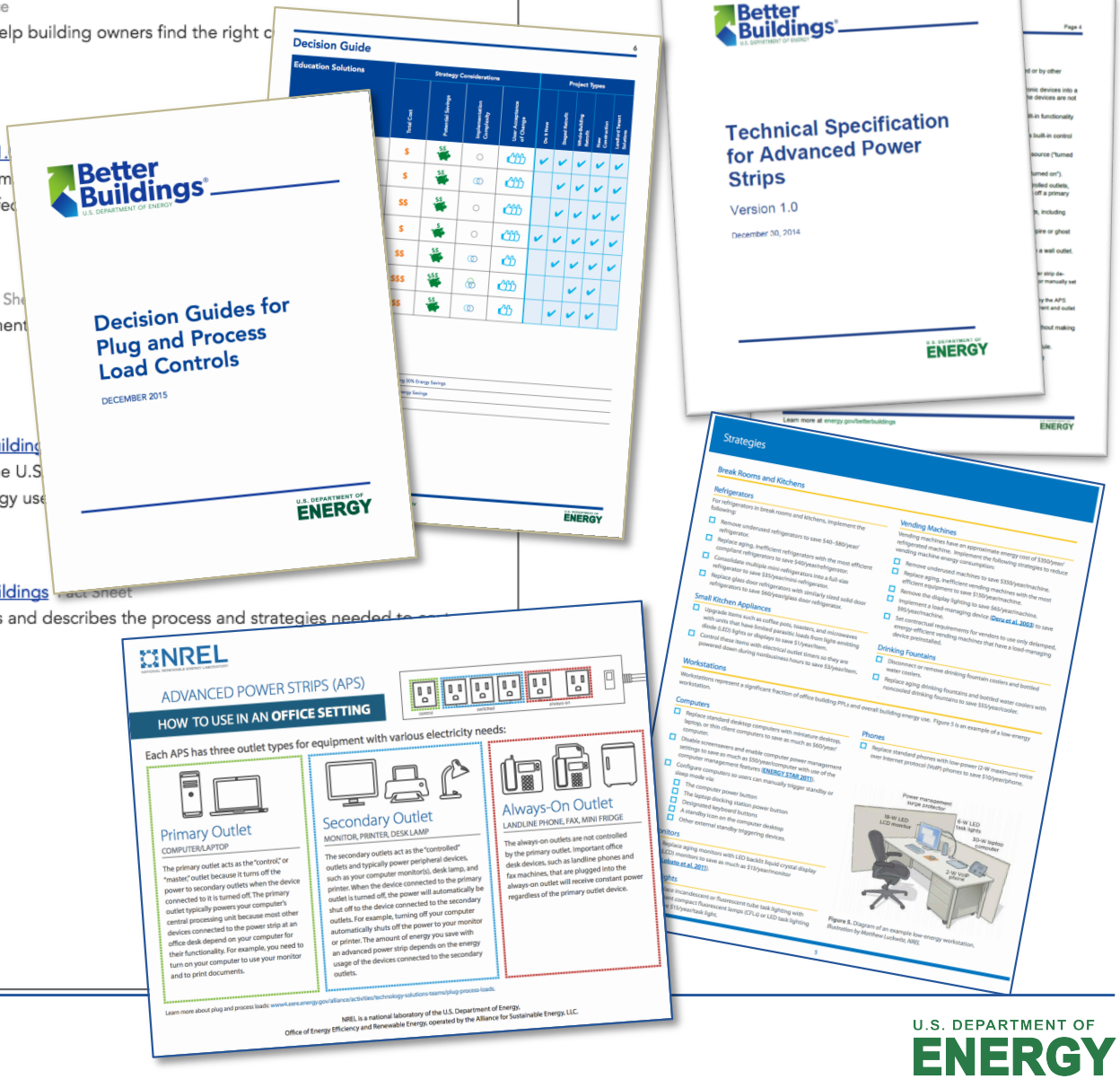
[Assessing and Reducing Plug and Process Loads in Retail Buildings](#) Fact Sheet

This brochure provides an overview of PPLs in retail buildings and describes the process and strategies needed to
effectively reduce their energy impact.

[View Related Solutions](#)

Other Resources

- Fact Sheet
- Guidance
- Report
- Additional Information



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Thank you!

Rois Langner
National Renewable Energy Laboratory
Rois.Langner@nrel.gov

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Plug Load Control: Real-World Testing and Application

Christine Wu, GSA

U.S. DEPARTMENT OF ENERGY

Plug Load Control:
Real-World Testing and Application

U.S. General Services Administration | Christine Wu, Green Proving Ground Program

GSA

GPG
Green Proving Ground Program

“THE GOVERNMENT’S LANDLORD”

8,792 assets

- Owned: 1,621 assets

374M square feet

- Owned: 183M square feet

1.1 million federal employees

$365M annual energy costs

FEDERAL MANDATES SET THE PACE

Energy Independence and Security Act, 2007

30 reduction in energy use intensity (EUI) by 2015 over 2003 levels

GSA Response:

-30.0 EUI reduction EOFY2015*

Executive Order 13693, 2015

2.5 annual reduction in EUI through 2025, over 2015 levels

GSA Response:

-2.4 EUI reduction as of FY2016 Q2*

GSA buildings are 33%* more efficient than typical U.S. office buildings.

* January 2016, GSA Average EUI = 52.2 kBTU/GSF/yr, as reported per legislative mandate;
Commercial office average EUI = 77.8 kBTU/SF/yr, 2012 CBECS, eia.gov


Green Proving Ground leverages GSA’s real estate portfolio to evaluate innovative sustainable building technologies.

HOW DOES GPG WORK?

Identify promising technologies at the edge of commercialization

Pilot technology installations within GSA's real estate portfolio

Partner with Department of Energy national laboratories to objectively evaluate real-world performance

Recommend technologies with broad deployment potential

Green Proving Ground, 2011-2015

ENERGY MANAGEMENT

12.15—Socially Driven HVAC *†
09.12—Advanced Power Strips *
03.12—Wireless Sensor Networks *
Passive Thermal Storage Platform
Predictive HVAC Optimization
Variable-Speed Chiller Plant Control
Circuit-Level Energy Monitoring

LIGHTING

08.15—LEDs with Integrated Controls *
05.15—Wireless Lighting Controls †
08.14—Integrated Daylighting Systems *
09.12—Occupant Responsive Lighting *
LED Replacement Lamp for CFLs
Networked Lighting
T-LED Retrofit for Fluorescent Luminaires

WATER

04.15—Wireless Moisture Sensing Irrigation System
03.15—Catalyst-Based Non-Chemical Water Treatment *
01.15—Weather Station for Irrigation Control *

BUILDING ENVELOPE

05.15—Electrochromic Windows for LPOEs *
01.15—Applied Solar Control Retrofit Films *
03.14—Chromogenic Windows
03.14—Vacuum Insulated Panels
10.13—High R-Value Window Panels *†
Electrochromic Windows with Dynamic Controls
Low-Emissivity Window Film
Daylight Redirecting Window Film

ON-SITE POWER & RENEWABLES

01.15—Photovoltaic-Thermal Hybrid System
06.14—Wood-Pellet-Fired Biomass Boilers
10.13—PV Guidance
12.12—Photovoltaic Systems
Honeycomb Solar Thermal Collector
Building Integrated PVs for Windows

HVAC

03.15—Wireless Pneumatic Thermostat *†
07.14—Condensing Boilers, Updated *†
03.14—Multistaged Indirect Evaporative Cooler
03.14—Synchronous and Cogged Fan Belts *
10.13—Variable Speed Maglev Chiller *†
12.12—Variable Refrigerant Flow
High Efficiency RTU
Variable Speed Screw Chiller
Continuous Combustion Control System
Intelligent Valves for Hydronic Systems
Smart Scrubbers for HVAC Load Reduction

*More information available at **gsa.gov/GPG***

M&V STATUS *(as of April 2016)*

(00.00) = Completed —25
Continuing Evaluation —17
Deployed/Pending Deployment—9

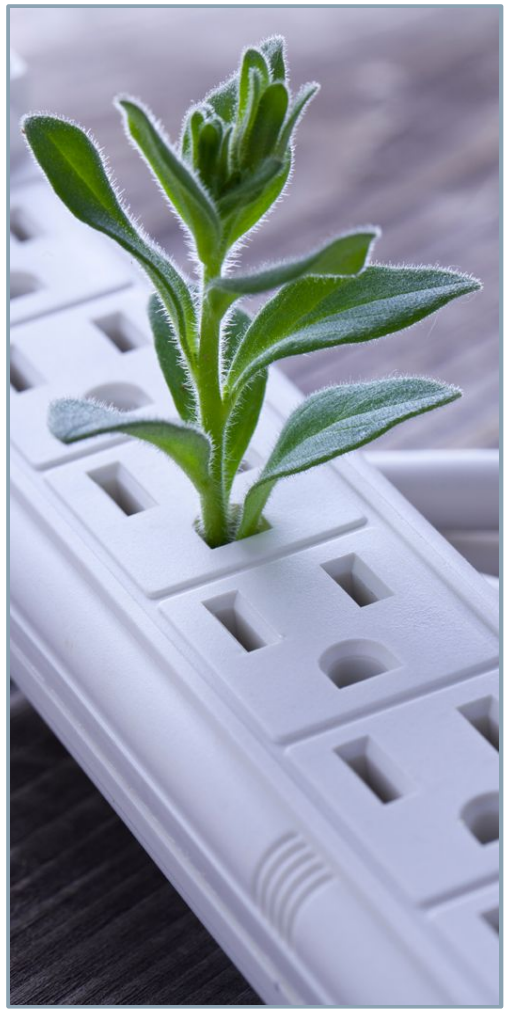
* Identified for Broad Deployment – 15
† Deployed through ESPC – 6

GPG PLUG LOAD CONTROL EVALUATION

- **Opportunity:** 20-25 of building electricity consumption goes to plug loads.

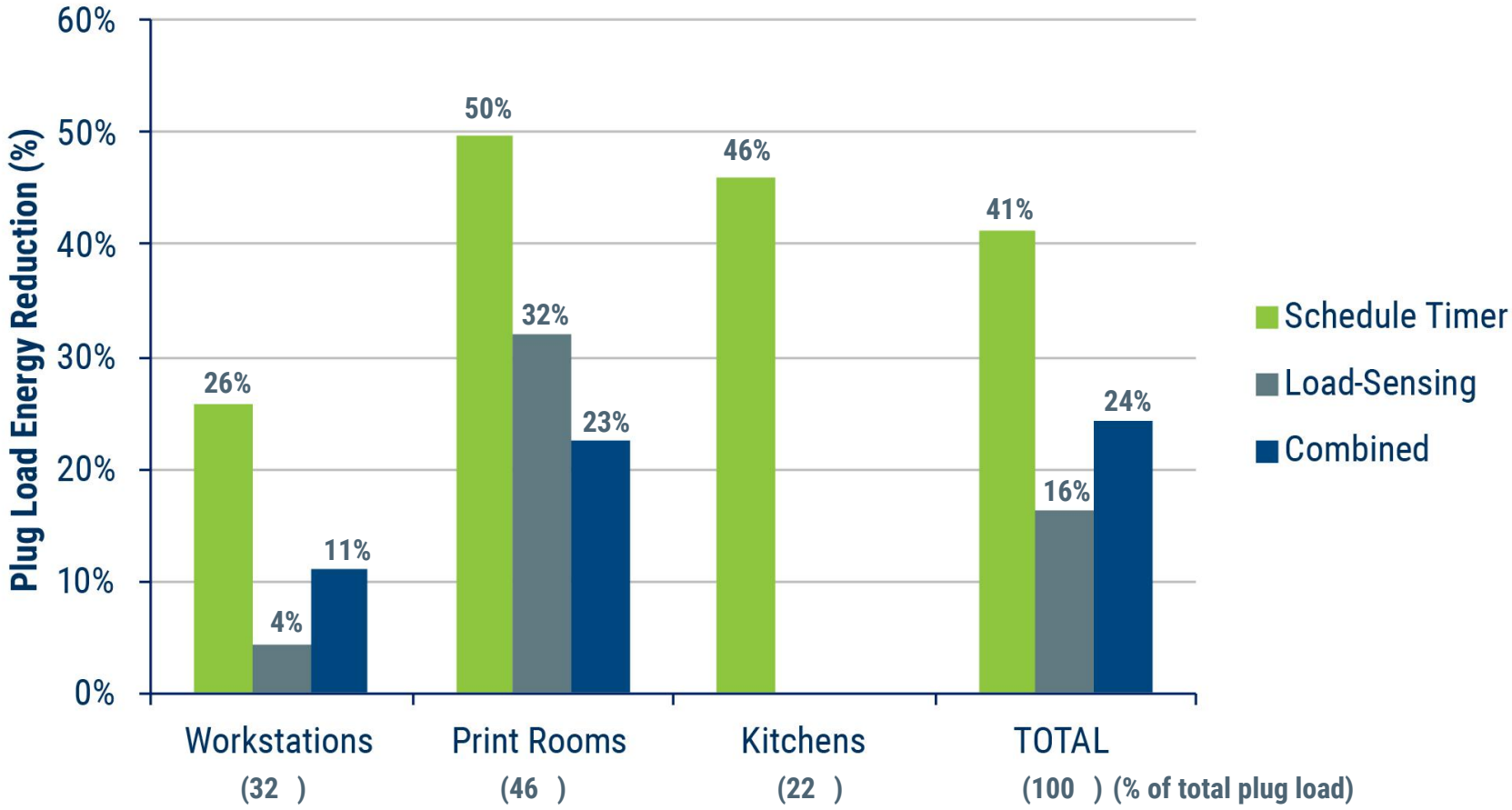
- **What We Did:** In 2012, NREL tested three plug load reduction strategies at workstations*, kitchens, and print rooms in eight federal office buildings throughout GSA's Mid-Atlantic Region.
  ** Baseline for workstations include IT policy to perform daily computer shutdown.*

- **Technology:** Tested strategies included:
  a. **schedule-based control** from 6a-6p
  b. **load-sensing** based on monitor draw
  c. **combined** schedule & load-sensing



GPG PLUG LOAD CONTROL EVALUATION

Energy Reduction for Tested Control Strategies



GPG PLUG LOAD CONTROL EVALUATION

Lessons Learned

Schedule-based

- Account for real-world variability in work schedules and habits. “Tight” scheduling may seem to save more energy, but may result in more dissatisfaction and higher rates of manual overrides or disabling of devices.
- Account for warm-up times (e.g., printers, kitchen equipment)

Load-sensing

- At workstations, account for sweep times (i.e., the amount of time required to sense a master load). If the device sweeps once per minute, is a one-minute lag in slave wake-up time acceptable?
- Meter master device draw states (e.g., “in-use,” “standby,” and “off” draws for monitors) prior to implementation in order to avoid sending faulty commands to slave devices.

GPG PLUG LOAD CONTROL EVALUATION

Lessons Learned

Tenant engagement

- Tenants must be knowledgeable of:
  - How the strategy will save energy
  - How individual actions may help to save energy
  - How to override, disable, and/or reset the plug strip
- Select a strategy that does not require tenants to prioritize energy savings over personal convenience.

General

- Minimize complexity for both installation and operations
- Employ strategies that minimize impact on tenants' daily operations

APS NATIONAL DEPLOYMENT

16,359 timer-based advanced power strips deployed in 98 federal buildings in 35 cities across the US.

One-Touch Desktop Button

Use the Desktop Button to turn your Timed Outlets on and off. These outlets automatically turn off after 11 hours to save power. The blinking LED status indicator notifies you when your outlets are about to be turned off. Press the button to keep outlets on for another 11 hours.

6 Auto-Off Timed Outlets

Timed outlets automatically turn off after 11 hours. Use these outlets for devices that don't require constant power (24/7), such as laptop computers*, monitors, phone chargers, printers, and desk lights.

2 Always-On Outlets

Use these outlets for devices that require power at all times, such as desktop computers, phones and clocks.

APS NATIONAL DEPLOYMENT

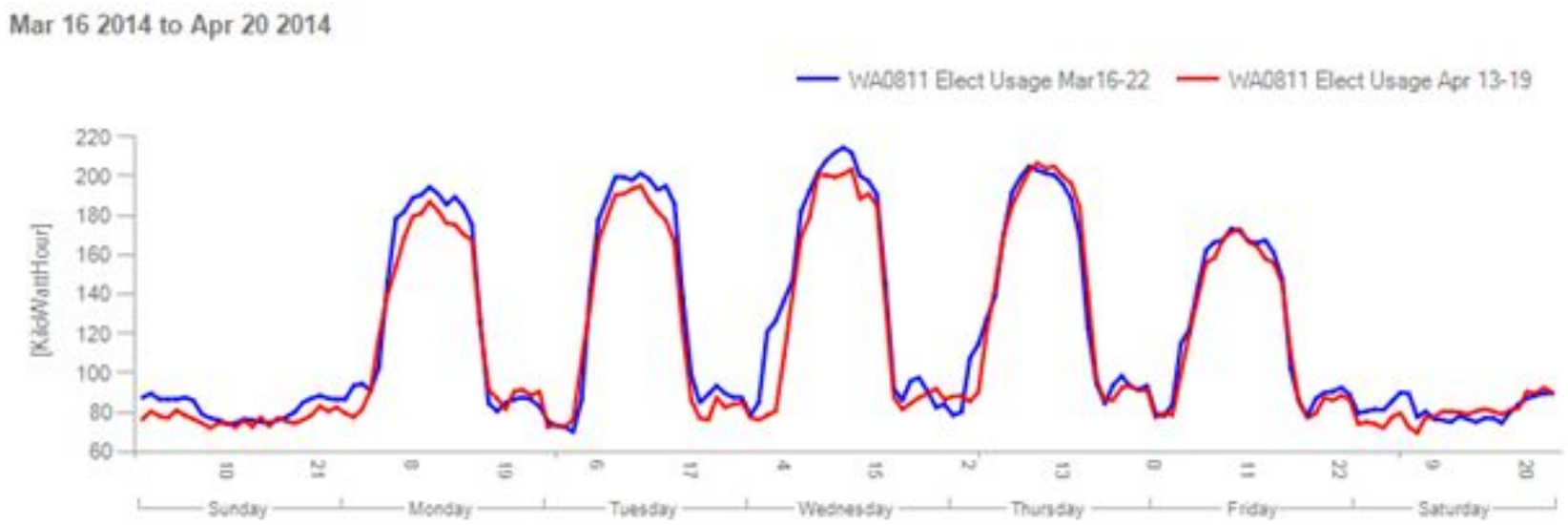
Why this device?

- Manual on / Auto off
- Immediate wake-up signal
- Unlikely to be permanently disabled
- 2-year payback
- Plug & Play: Easy installation, no commissioning
- No IT component

Lessons Learned

- Train installers on standard always on / auto off devices
- Issue tenant reminders to turn off APS when they leave their workstation

APS NATIONAL DEPLOYMENT



	Baseline (Before)	After	Energy Reduced kWh	% Change
Sunday	1960.00	1842.50	-117.50	-6%
Monday	3194.00	3075.00	-119.00	-4%
Tuesday	3225.50	3063.00	-162.50	-5%
Wednesday	3480.00	3224.50	-255.50	-8%
Thursday	3345.00	3342.50	-2.50	0%
Friday	2988.00	2911.00	-77.00	-3%
Saturday	1949.50	1916.00	-33.50	-2%
	20142.00	19374.50	-767.50	-4%

APS NATIONAL DEPLOYMENT

$1.6M lifecycle energy cost avoidance

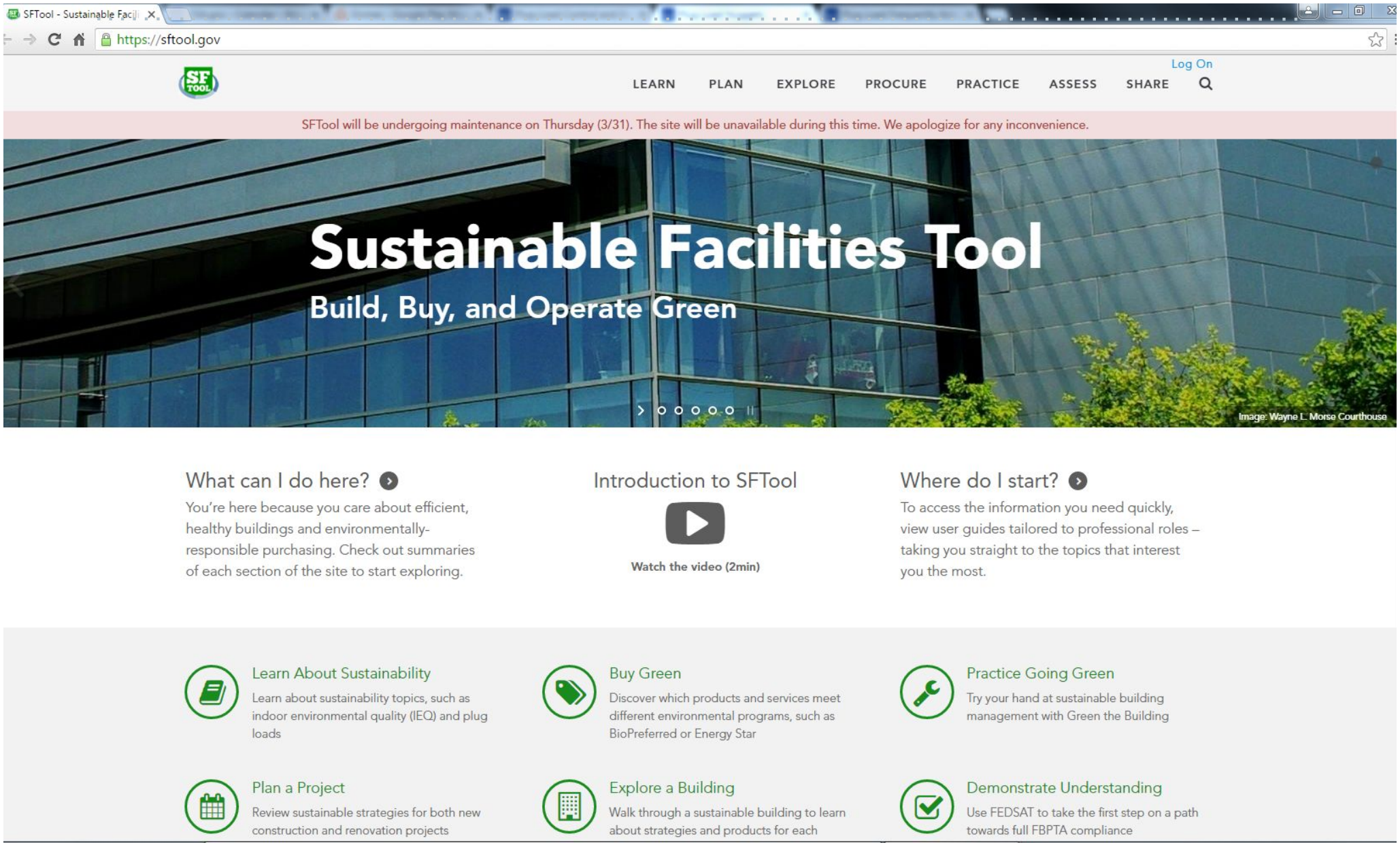
1,500 MWh annual energy savings

2-year payback

$0.17 - $0.23/sf saved for office buildings.

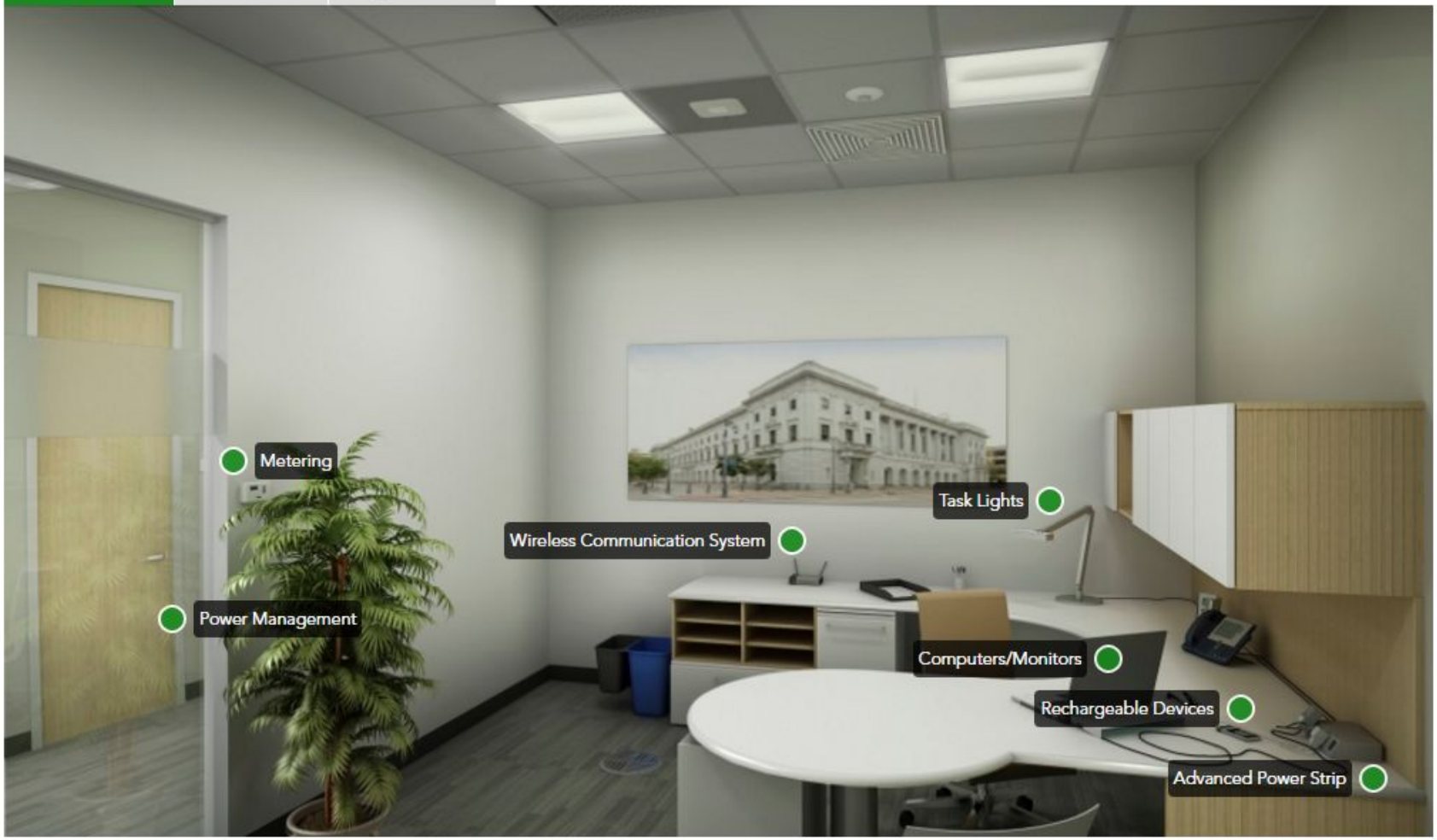
Potential impact: **$96M** avoided lifetime energy costs, if distributed for every employee in GSA buildings.

SFTool.gov


SFTool - Sustainable Facil
https://sftool.gov
Log On
LEARN
PLAN
EXPLORE
PROCURE
PRACTICE
ASSESS
SHARE
SFTool will be undergoing maintenance on Thursday (3/31). The site will be unavailable during this time. We apologize for any inconvenience.
Sustainable Facilities Tool
Build, Buy, and Operate Green
Image: Wayne L. Morse Courthouse
What can I do here?
You're here because you care about efficient, healthy buildings and environmentally-responsible purchasing. Check out summaries of each section of the site to start exploring.
Introduction to SFTool
Watch the video (2min)
Where do I start?
To access the information you need quickly, view user guides tailored to professional roles – taking you straight to the topics that interest you the most.
Learn About Sustainability
Learn about sustainability topics, such as indoor environmental quality (IEQ) and plug loads
Buy Green
Discover which products and services meet different environmental programs, such as BioPreferred or Energy Star
Practice Going Green
Try your hand at sustainable building management with Green the Building
Plan a Project
Review sustainable strategies for both new construction and renovation projects
Explore a Building
Walk through a sustainable building to learn about strategies and products for each
Demonstrate Understanding
Use FEDSAT to take the first step on a path towards full FBPTA compliance

Plug Loads Components

Private Office | Break Room | Support Area



Plug Load Management

Plug Load Nuggets	Best practices and key strategies in short form (250 words) covering seven plug load topics. Learn what you need to know, fast!
Plug Load FAQ	Find out the "what", "why", and "how" needed to effectively manage plug loads.
Plug Load Checklist	Utilize the checklist to assist your integrated team execute and monitor a plug load reduction program.
Plug Load Research Review Summary	For those really looking to learn more, get summaries of the forefront research findings that serve as the plug load knowledge foundation.

PLUG LOAD CHECKLIST

- ❑ Establish a plug load **champion**
- ❑ Develop a **business case** to address plug loads
- ❑ **Benchmark** the efficiency of current equipment and operations
- ❑ Identify occupants' true **needs**
- ❑ **Meet** needs efficiently
- ❑ Turn **unused** equipment off
- ❑ Institutionalize plug load measures through **procurement** decisions and **policy** programs
- ❑ Promote occupant **awareness**
- ❑ Address **unique** miscellaneous plug loads
- ❑ Address plug loads in building **design/retrofits**

Thank You!

Christine Wu
christine.wu@gsa.gov
gsa.gov/GPG

GPG
Green Proving Ground Program

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Stanford Equipment Inventory & Plug Load Reduction Project

Moira Hafer, Stanford University

U.S. DEPARTMENT OF ENERGY

Stanford Equipment Inventory & Plug Load Reduction Programs

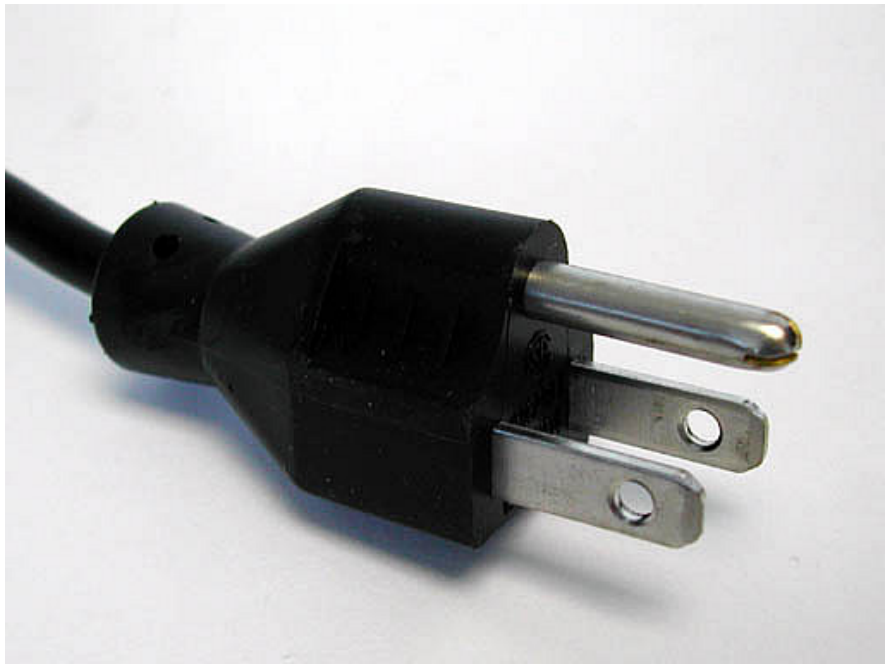
Moira Hafer, Sustainability Specialist
Office of Sustainability
Stanford University

Better Buildings Alliance Summit, May 10, 2016

Stanford Equipment Inventory Overview

- **Comprehensive 260-building equipment inventory**
- **Goals:**

1. Quantify campus plug load energy consumption and understand its composition
2. Identify viable plug load energy reduction opportunities
3. Collect data that supports Office of Sustainability's partners



Scope

- Types of equipment included:
  - Standard office equipment
  - Standard lab equipment
  - Common IT equipment
  - Kitchen & break room equipment
  - Gym equipment
  - Other
    - EH&S hazards
    - Water fixtures
    - Occupancy data
- Attributes collected for each type of equipment to provide necessary details for estimating energy consumption
- Inventory covers 93% of campus square footage

Collection Process by the Numbers

14
student interns

3,200
student work hours

55
types of equipment

263
buildings

10,278,972
square feet

19,909
rooms inventoried

129,774
pieces of equipment

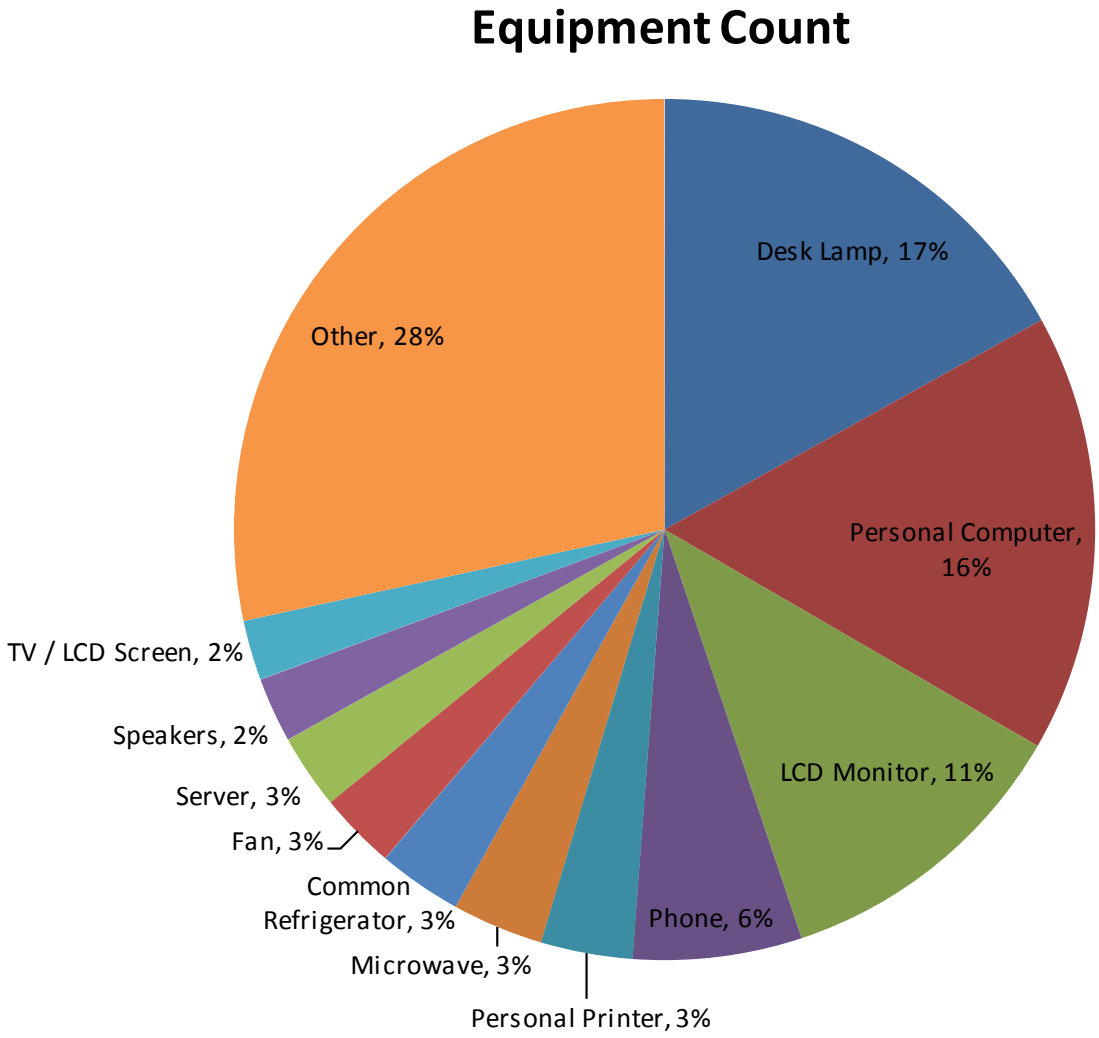
79,313,779 kWh
consumed per year

Data Collection Tool

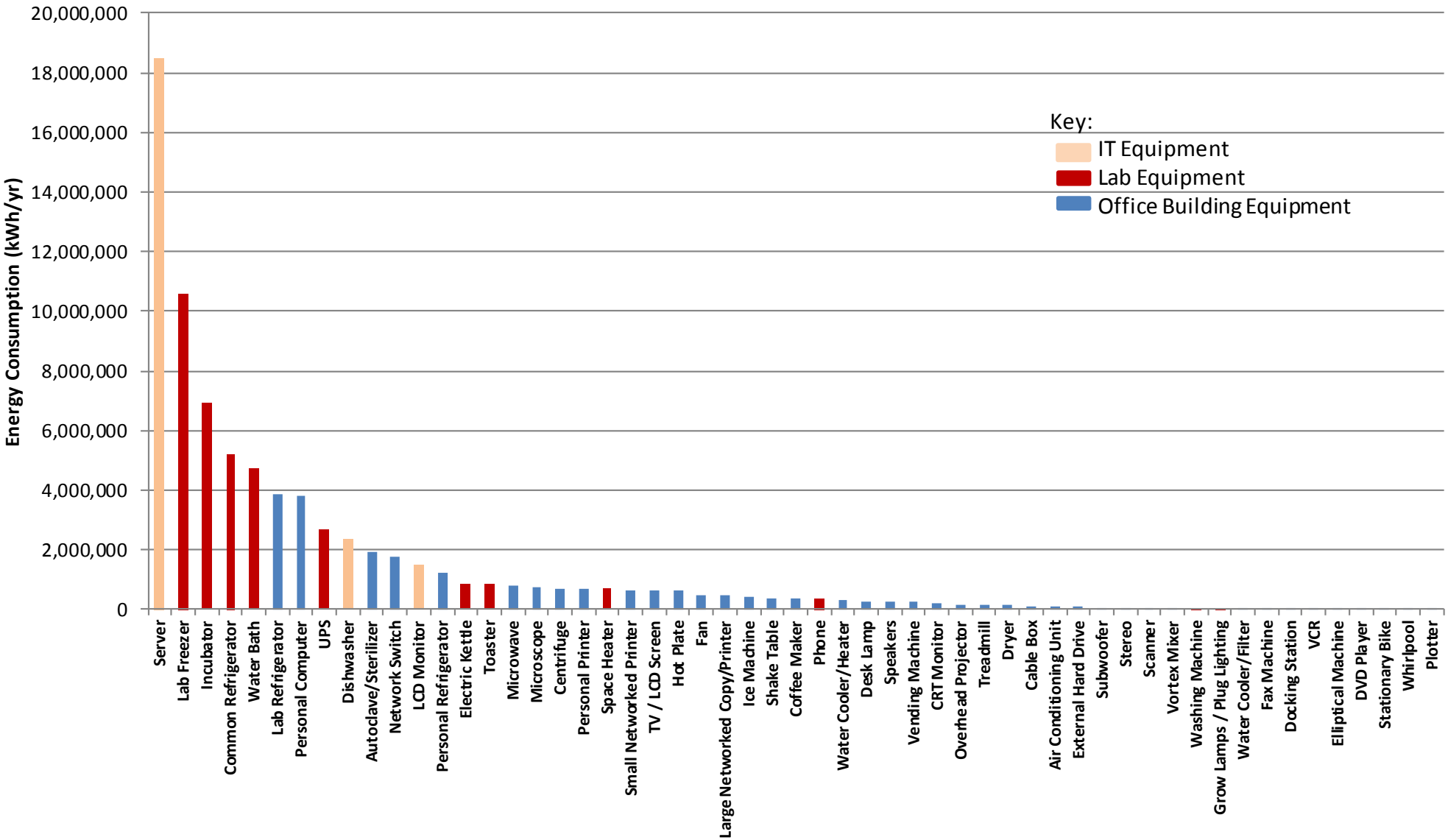
Interns used web application developed by LBRE IT to collect inventory data

Results (A) – Campus-Wide Context

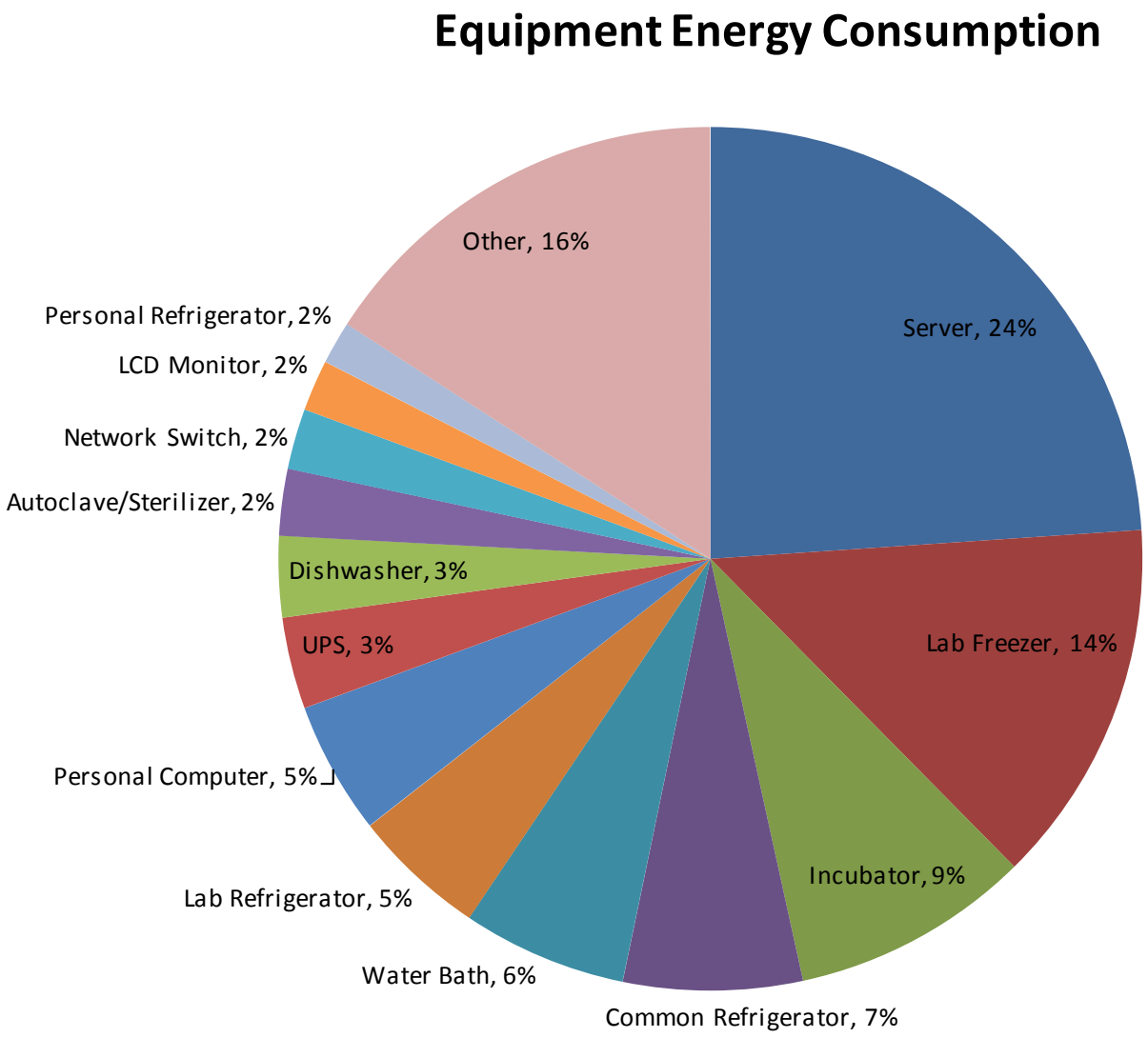
Total Equipment Count	**204,000**
Total Energy Consumption (kWh/yr)	**77.3 million**
Total annual cost	**$9 million**
Plug Load as % of Total Campus Electricity Use	**34%**



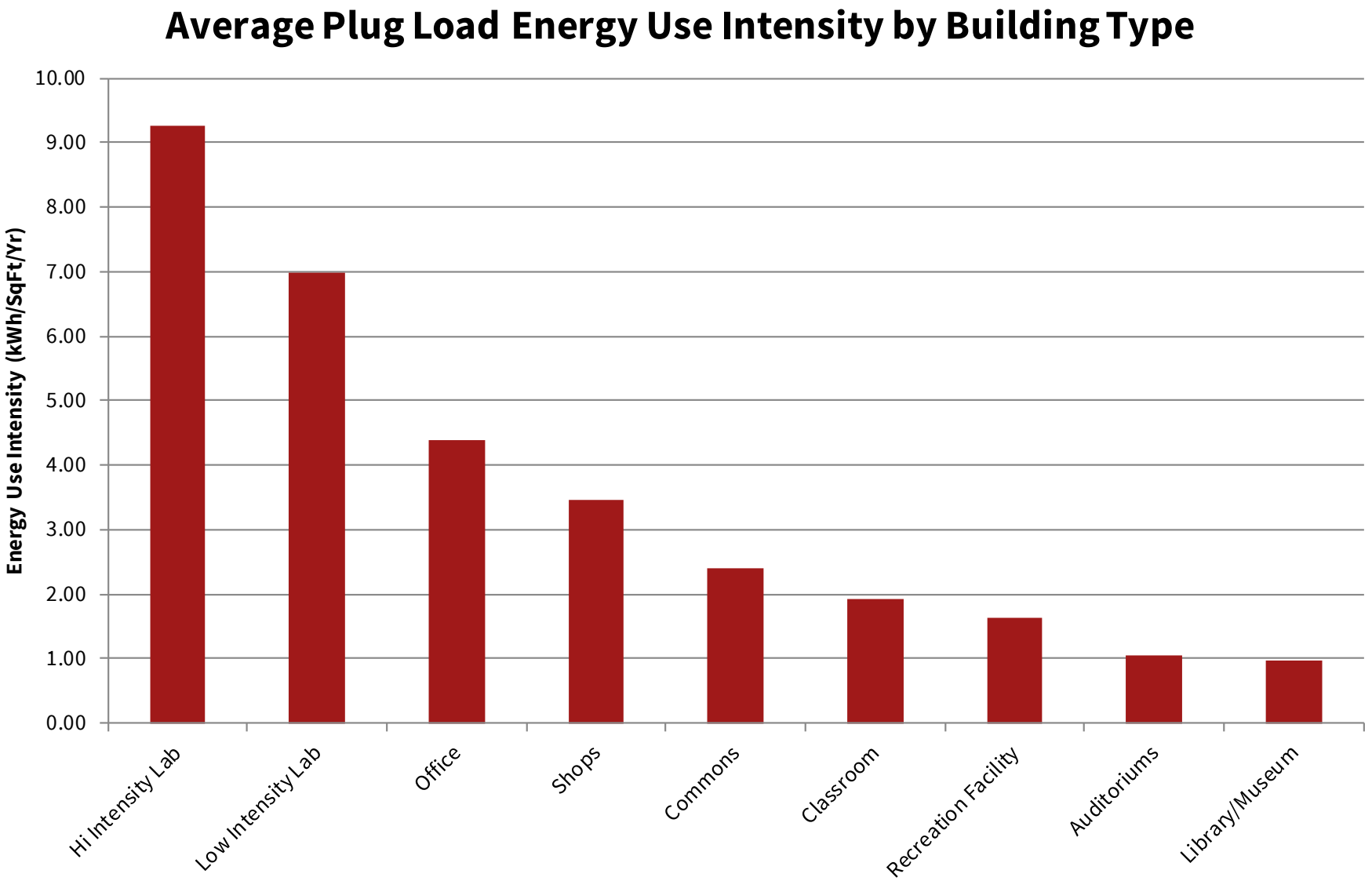
Results (B) - Energy Consumption by Equipment Type



Results (C) - Energy Consumption by Equipment Type, cont'd



Results (D) – Energy Consumption by Building Type

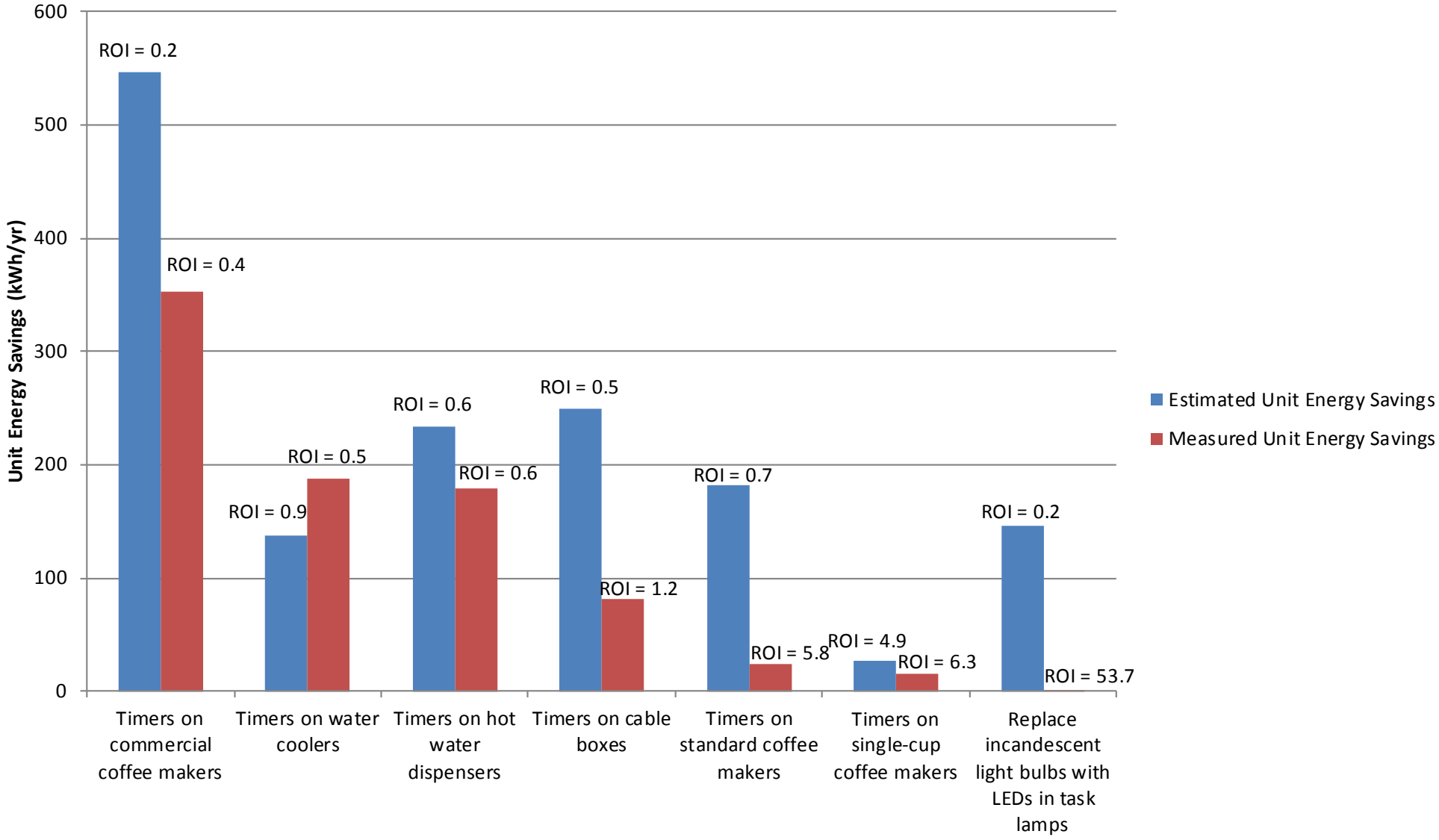


Plug Load Energy Savings Programs Summary

Potential Savings: $2.3 million

Program	Total Potential Savings	Average ROI (years)	% Plug Load Reduction	% Total Electricity Reduction
Equipment Retrofits	$183,000	0.5	2%	1%
Space Heating	$23,700	2.4	0.3%	0.1%
Sustainable IT	$682,000	2.5	8%	3%
Green Labs	$1,457,000	3.4	16%	5%
Total	**$2.3 M**	**2.2**	**26%**	**9%**

Field Test of Basic Energy Efficiency Measures



Direct Install Program for Timers

Program	Expected Annual Savings	Average ROI	% Plug Load Reduction
Equipment Retrofits	$183,000	0.5 years	1%

1. Data from pilots showed significant savings from installing programmable timers on:
   - Coffee makers
   - Water coolers & hot water dispensers
   - Cable boxes
2. Direct Install program developed for timers to complement existing ***voluntary*** Cardinal Green Office Program
3. Feedback positive from standard office occupants but challenging in 24/7 buildings
4. Persistence was a concern but follow-up checks showed only 5% of water cooler timers removed and no coffee maker timers removed
5. Considering similar program for advanced power strips, especially new technologies that connect to a mobile app (pilot will run June – August 2016)

Timer Program Materials

HOW TO...

RECEIVE FREE TIMERS THROUGH ERP EXPRESS

SUSTAINABILITY OPPORTUNITY

In spring and summer 2015, the Office of Sustainability (OOS) conducted studies on the potential energy savings from implementing several energy efficiency measures that were revealed through the Plug Load Equipment Inventory. The pilots definitively showed that campus-wide installation of timers on water coolers, commercial coffee makers, cable boxes, and hot water dispensers would lead to significant savings. In fact, this simple measure is expected to save the university $16,000 per year once timers are installed on all qualifying equipment across campus. To facilitate this process, timers are now available to be installed on these select equipment types for free through the ERP Express program and installed in your building by interns in the Office of Sustainability.

HERE'S HOW:

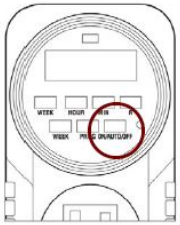
1. **Find out** when your building is scheduled to receive its timers. The Office of Sustainability will be in contact with each building manager to schedule an installation time.
2. **Share details** about the equipment identified to receive timers with the intern who is installing them. The Office of Sustainability has predetermined which equipment qualifies for timers, but we want to hear from YOU. Here are some things we encourage you to share during the installation visit:
   - How often the equipment is used
   - If you typically experience any problems with the equipment
   - If the equipment is ever used during non-working hours
   - At what times you prefer the equipment to be turned off at night and back on in the morning
3. **Learn how to use the timer**. The Office of Sustainability intern will show all interested occupants how to use the timer. The timer is approximately the size of a coffee mug and is

This Equipment is on a Timer

To save energy, this machine is automatically turned off between the hours of _____pm and _____am, as well as on weekends.

To override the timer control:

Hit the "ON/AUTO/OFF" button until "ON" is displayed. When you are finished with the equipment, hit the button again until "AUTO" is displayed



Questions? Feedback? Contact your Green Building Champion!

SUSTAINABLE STANFORD

Pledge to save energy in your building!

Your building is doing its part to save energy at Stanford by participating in the ERP Express Free Timer Installation Program. Show your support by adding your name to the list below, indicating that you're willing to keep this timer running optimally!

Details on timer functionality are below.
A building-wide event will be awarded to buildings with the most names below—help your building win!
Find out more at http://sustainable.stanford.edu.

Timer Instructions: Office of Sustainability interns have installed timers on water coolers, commercial coffee makers, cable boxes, and hot water dispensers in your building. All timers have been scheduled to turn equipment off at night and usually on weekends based on building hours and preferences. The timer's scheduled hours are recorded on the sign posted next to the timer.

If you **need to override** the timer at any point, please don't unplug the equipment from the timer! Instead, press the "ON/AUTO/OFF" button until the digital screen shows the word "OFF" in the lower right hand corner. When you're ready to turn the timer back on again, press the "ON/AUTO/OFF" button until the word "AUTO" appears at the bottom of the digital screen, which will make the timer follow the schedule that was previously set. If you **need to adjust the timer's schedule**, see the Sustainable Stanford How-To Guide that was sent to you by your building manager, which is also available at https://sustainable.stanford.edu/sites/default/files/How_to_Receive_Free_Timers_ERP_Express_10.15.pdf. For questions, contact Moira Hafer in the Office of Sustainability at mbhafer@stanford.edu.

Name	Name
Sample: Moira Hafer	Sample: Davianna Olert

More spots for names on reverse!

Space Heater Minimization

Program	Expected Annual Savings	Average ROI	% Plug Load Reduction
Space Heater Minimization	$23,700	2.4 years	0.1%

1. Follow-up study conducted in the 20 buildings with the highest number of space heaters to determine most effective energy-saving strategy
   - Results showed only 6% of people use space heaters excessively
   - 45 space heaters automatically removed
2. Space heater swap as part of fall energy savings campaign
   - 50 individuals volunteered to turn in space heaters, 25 actually did so (and were very excited!)
   - 1.5 year ROI to provide fleece jacket as incentive

Sustainable IT

Program	Expected Annual Savings	Average ROI	% Plug Load Reduction
Sustainable IT	$682,000	2.5	3%

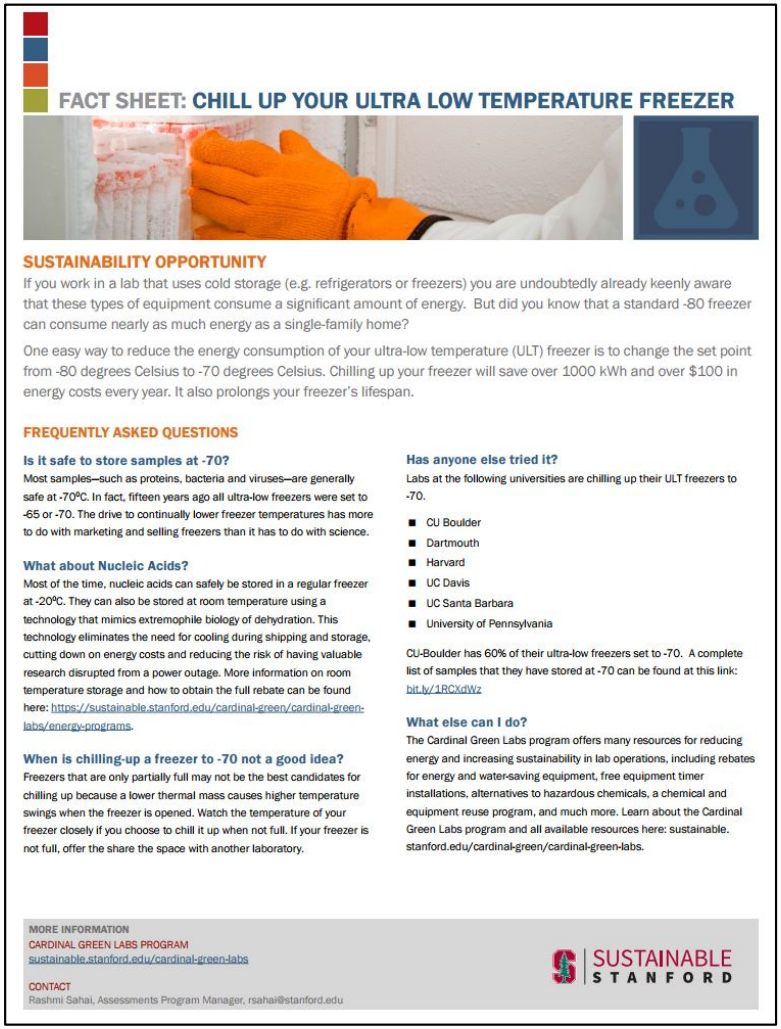
1. Power management:
   - Partnerships with department-level IT groups are critical, although it can be a difficult ask if IT groups are focused on other projects
     - Familiariarity with computers and unique use cases in their departments
     - Can set appropriate and consistent sleep schedules throughout the department
   - Occupants generally OK with pushing out new settings (similar to security, patches, etc.), unless they need remote access
2. Server virtualization and relocation – move servers out of closets!

Green Labs

Program	Expected Annual Savings (kWh)*	Average ROI	% Plug Load Reduction
Green Labs	1,457,000	3.4 years	5%

Incorporate plug load measures into existing Green Labs Program:

1. Equipment timers on heating blocks, water baths, etc.
2. Rebates for energy efficient ULT freezers
3. Free room-temperature storage sample kits
4. Chill-up ULT freezers - *part of fall energy savings campaign*
5. Outreach is biggest challenge!



FACT SHEET: CHILL UP YOUR ULTRA LOW TEMPERATURE FREEZER

SUSTAINABILITY OPPORTUNITY

If you work in a lab that uses cold storage (e.g. refrigerators or freezers) you are undoubtedly already keenly aware that these types of equipment consume a significant amount of energy. But did you know that a standard -80 freezer can consume nearly as much energy as a single-family home?

One easy way to reduce the energy consumption of your ultra-low temperature (ULT) freezer is to change the set point from -80 degrees Celsius to -70 degrees Celsius. Chilling up your freezer will save over 1000 kWh and over $100 in energy costs every year. It also prolongs your freezer's lifespan.

FREQUENTLY ASKED QUESTIONS

Is it safe to store samples at -70?
Most samples—such as proteins, bacteria and viruses—are generally safe at -70ºC. In fact, fifteen years ago all ultra-low freezers were set to -65 or -70. The drive to continually lower freezer temperatures has more to do with marketing and selling freezers than it has to do with science.

What about Nucleic Acids?
Most of the time, nucleic acids can safely be stored in a regular freezer at -20ºC. They can also be stored at room temperature using a technology that mimics extremophile biology of dehydration. This technology eliminates the need for cooling during shipping and storage, cutting down on energy costs and reducing the risk of having valuable research disrupted from a power outage. More information on room temperature storage and how to obtain the full rebate can be found here: https://sustainable.stanford.edu/cardinal-green/cardinal-green-labs/energy-programs.

When is chilling-up a freezer to -70 not a good idea?
Freezers that are only partially full may not be the best candidates for chilling up because a lower thermal mass causes higher temperature swings when the freezer is opened. Watch the temperature of your freezer closely if you choose to chill it up when not full. If your freezer is not full, offer the share the space with another laboratory.

Has anyone else tried it?
Labs at the following universities are chilling up their ULT freezers to -70.

- CU Boulder
- Dartmouth
- Harvard
- UC Davis
- UC Santa Barbara
- University of Pennsylvania

CU-Boulder has 60% of their ultra-low freezers set to -70. A complete list of samples that they have stored at -70 can be found at this link: bit.ly/1RCXdWz

What else can I do?
The Cardinal Green Labs program offers many resources for reducing energy and increasing sustainability in lab operations, including rebates for energy and water-saving equipment, free equipment timer installations, alternatives to hazardous chemicals, a chemical and equipment reuse program, and much more. Learn about the Cardinal Green Labs program and all available resources here: sustainable.stanford.edu/cardinal-green/cardinal-green-labs.

MORE INFORMATION
CARDINAL GREEN LABS PROGRAM
sustainable.stanford.edu/cardinal-green-labs

CONTACT
Rashmi Sahai, Assessments Program Manager, rsahai@stanford.edu

SUSTAINABLE STANFORD

Conclusion

- Summary:
  - Equipment inventory data helped narrowed focus by revealing biggest savings opportunities (i.e. labs and IT equipment, including computers)
  - “Low-hanging fruit” still valuable to go after
  - With 4 new programs developed, approximately $66,000 saved in electricity costs in one year
- Ongoing Challenges:
  - Outreach
  - Boots on the ground to get the work done
  - Persistence is still a concern, although it was not shown to be a problem with timers on select equipment
  - Occupants tend to receive programs well, except in unique environments/use cases
- Next Steps:
  - Widespread active monitoring and control technologies could have a big impact

Thank you!

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