ADVANCING THE LAST FRONTIER:

Reduction of building plug loads

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Seventhwave (Research Partner)

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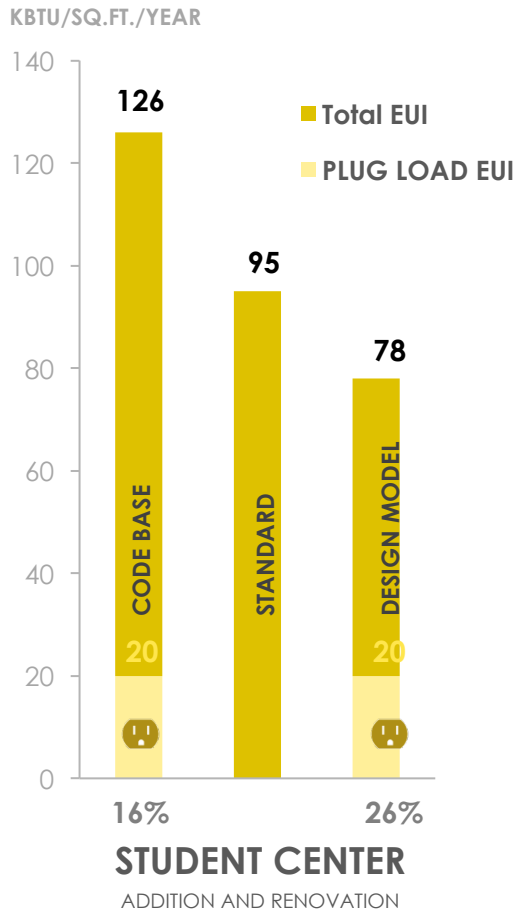
seventhwave

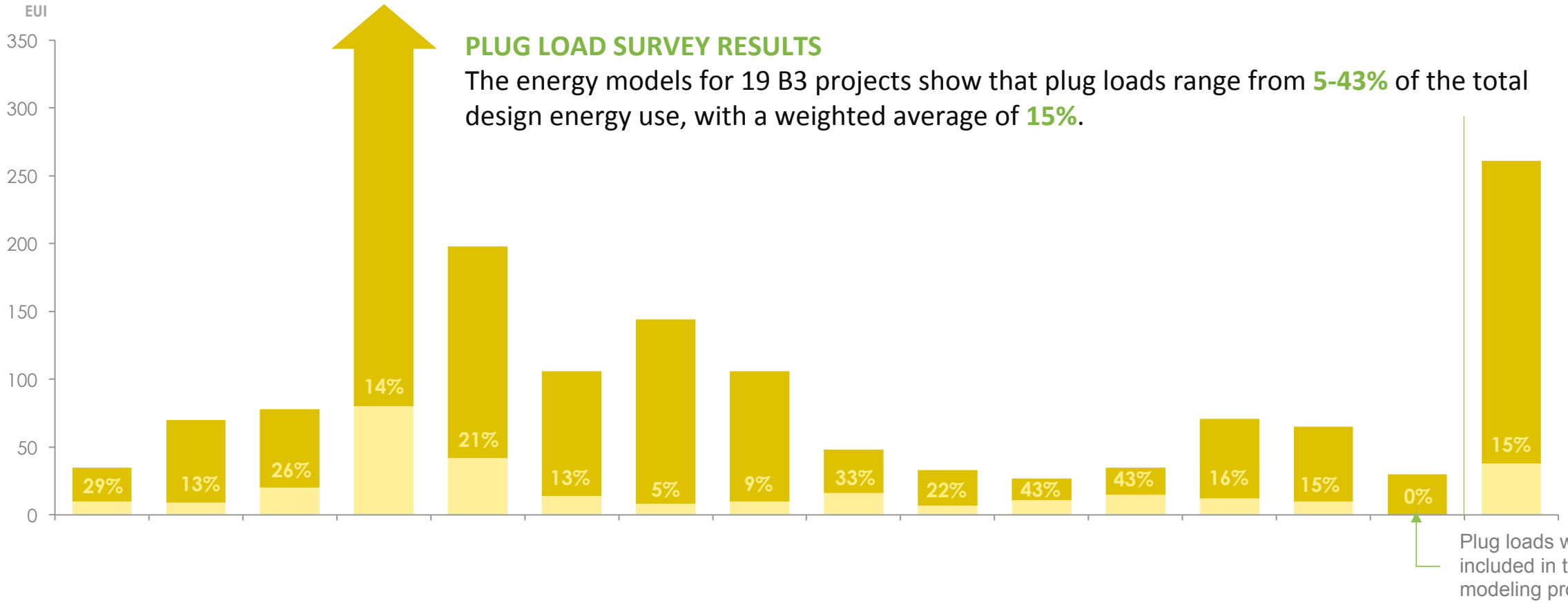
LHB PERFORMANCE DRIVEN DESIGN.

WHAT IS A PLUG LOAD?



All energy consumed by appliances, office equipment, and anything else that is not a part of the facility's primary HVAC, lighting, water heating or conveyance (elevators, escalators, etc.) systems. This includes just about anything that is actually plugged into an outlet.

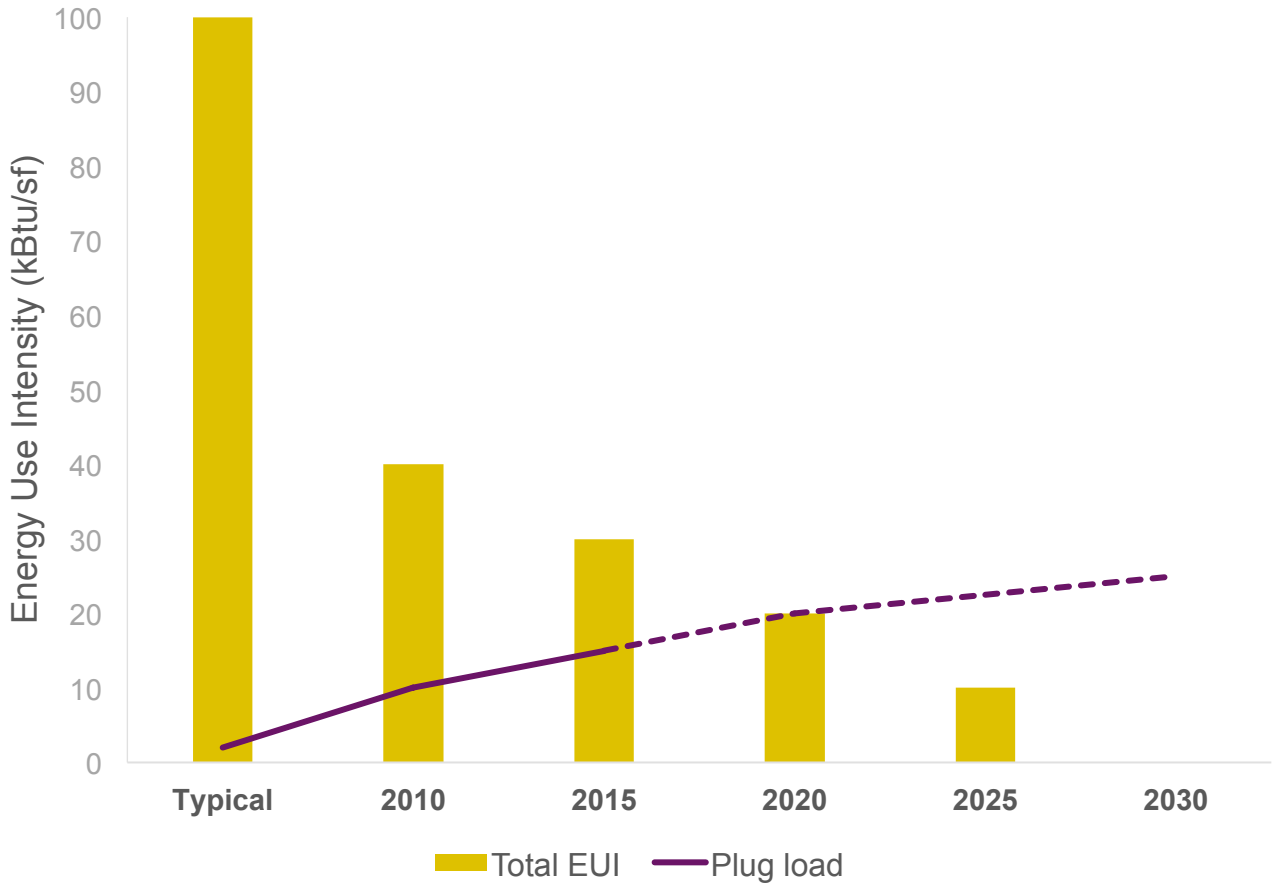
ENERGY USE ATTRIBUTED TO PLUG LOADS



PLUG LOAD SURVEY RESULTS

The energy models for 19 B3 projects show that plug loads range from **5-43%** of the total design energy use, with a weighted average of **15%**.

WHAT'S THE PROBLEM?

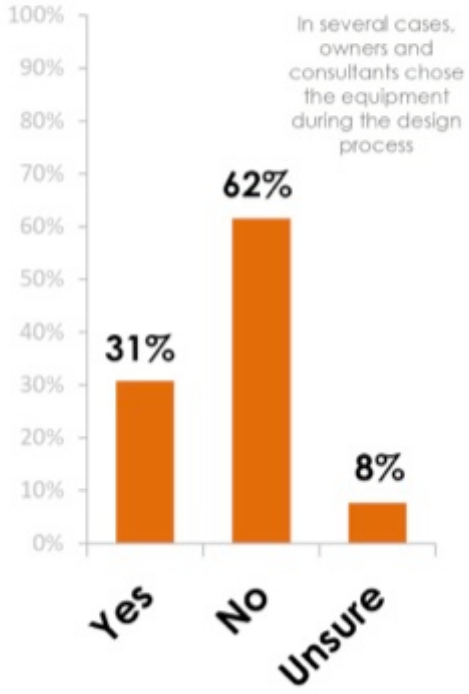


While plug loads are increasing, overall energy use intensity needs to decrease.

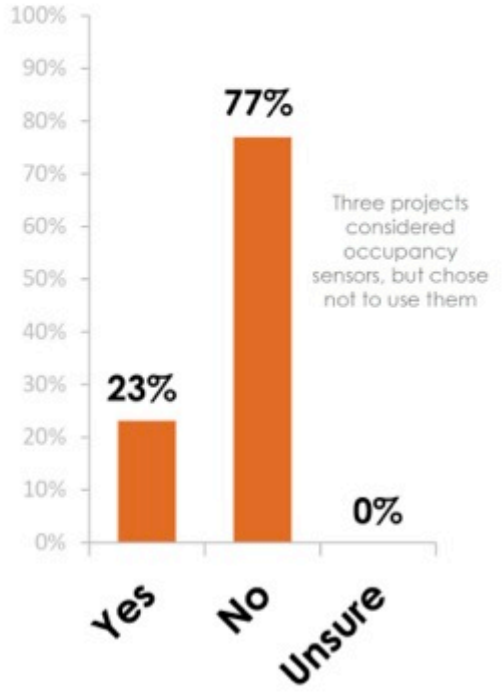
Currently Plug Loads = 11% of total electric load

HISTORIC APPROACH TO PLUG LOADS

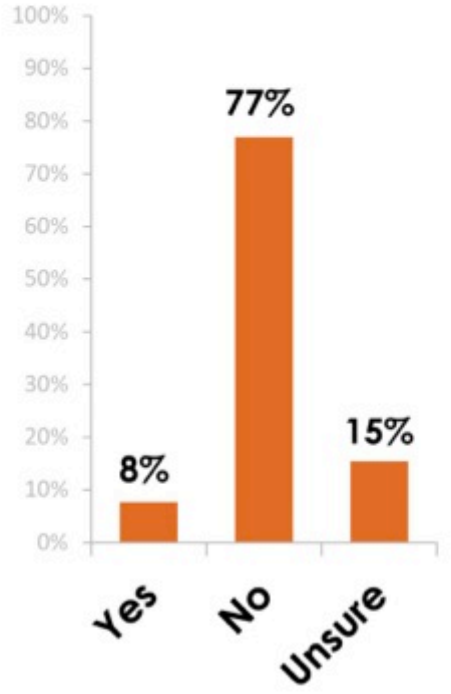
Are purchasers of equipment involved in the design and modeling process?



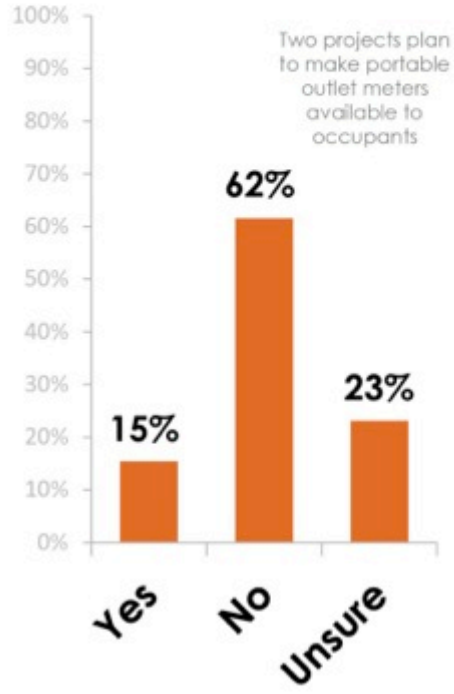
Are plug load reductions used as strategies in the energy modeling process?



Will plug loads be metered separately from other energy use in the completed building?



Is there a plan to provide plug load information to the building's occupants?



B3/SB 2030 PLUG LOAD REQUIREMENTS

E.1B:

For all New Buildings and Major Renovations, document predicted and actual energy use by type in the B3 Guidelines Tracking Tool, including recording modeled plug loads and sub-metered actual plug loads separately from other electrical loads in the built project.

MINNESOTA ENERGY CODE

ASHRAE 90.1-2010 Prescriptive Path requires 50% of electrical outlets in offices and computer classrooms must be on automatic control so they can be switched off when the room is unoccupied

RESEARCH STUDIES

- Electricity Savings Opportunities for Home Electronics and Other Plug-In Devices in Minnesota Homes | May 2010
- **Office Plug Load Reduction Strategies | October 2016**
- Small Embedded Data Center Program Pilot | June 2017
- Using Network Switches to Operate and Control Lighting and Plug Loads in Commercial Building | October 2020

OFFICE PLUG LOAD REDUCTION STRATEGIES

ACKNOWLEDGEMENTS

This project was supported in part by:

Minnesota Conservation Applied Research and Development (CARD) Grant Program

Minnesota Department of Commerce
Division of Energy Resources

OVERVIEW

Background

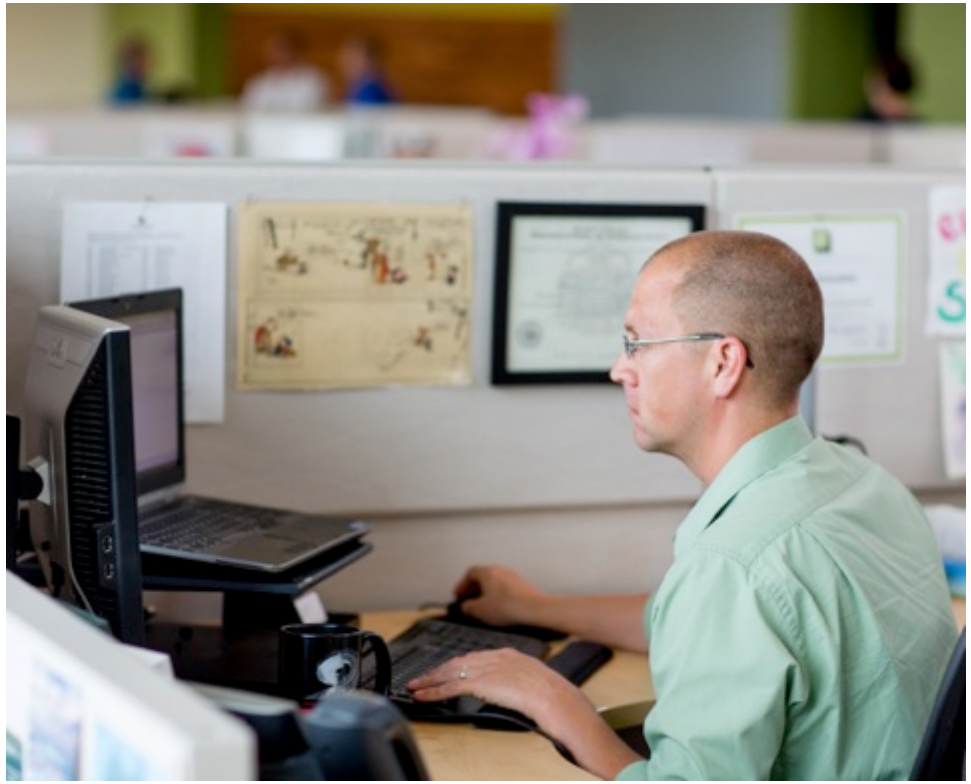
Plug load energy in a typical office

Saving energy

Economics

Impact of behavior

Context



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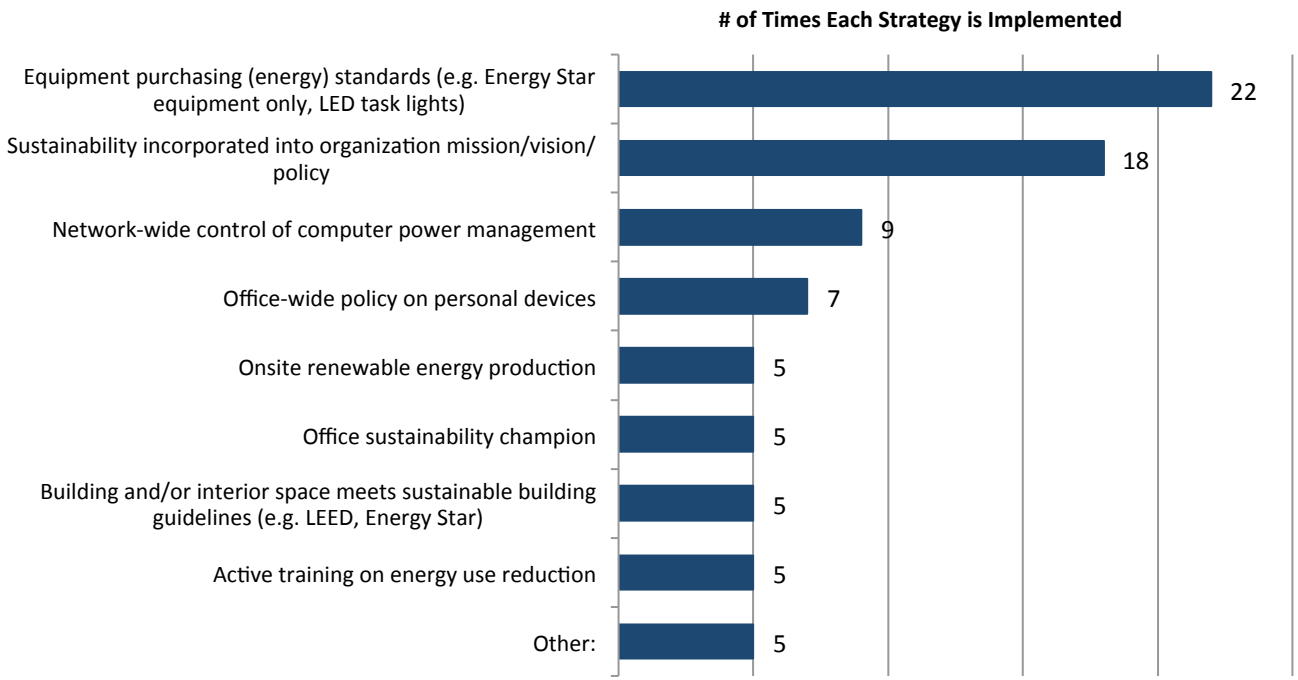
CREDIT: Samsung

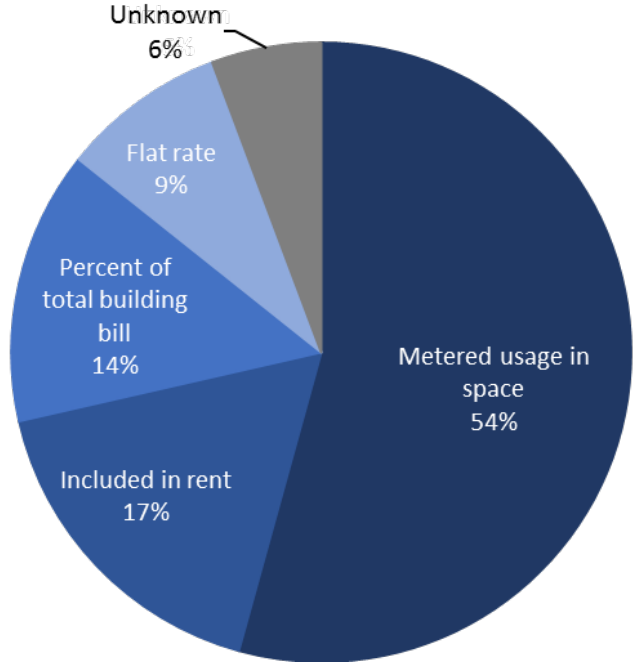
BACKGROUND AND METHOD

DISCOVERY

Most surveyed offices…



had at least one sustainability strategy…



are billed by actual use…

PLUG LOAD INVENTORIES

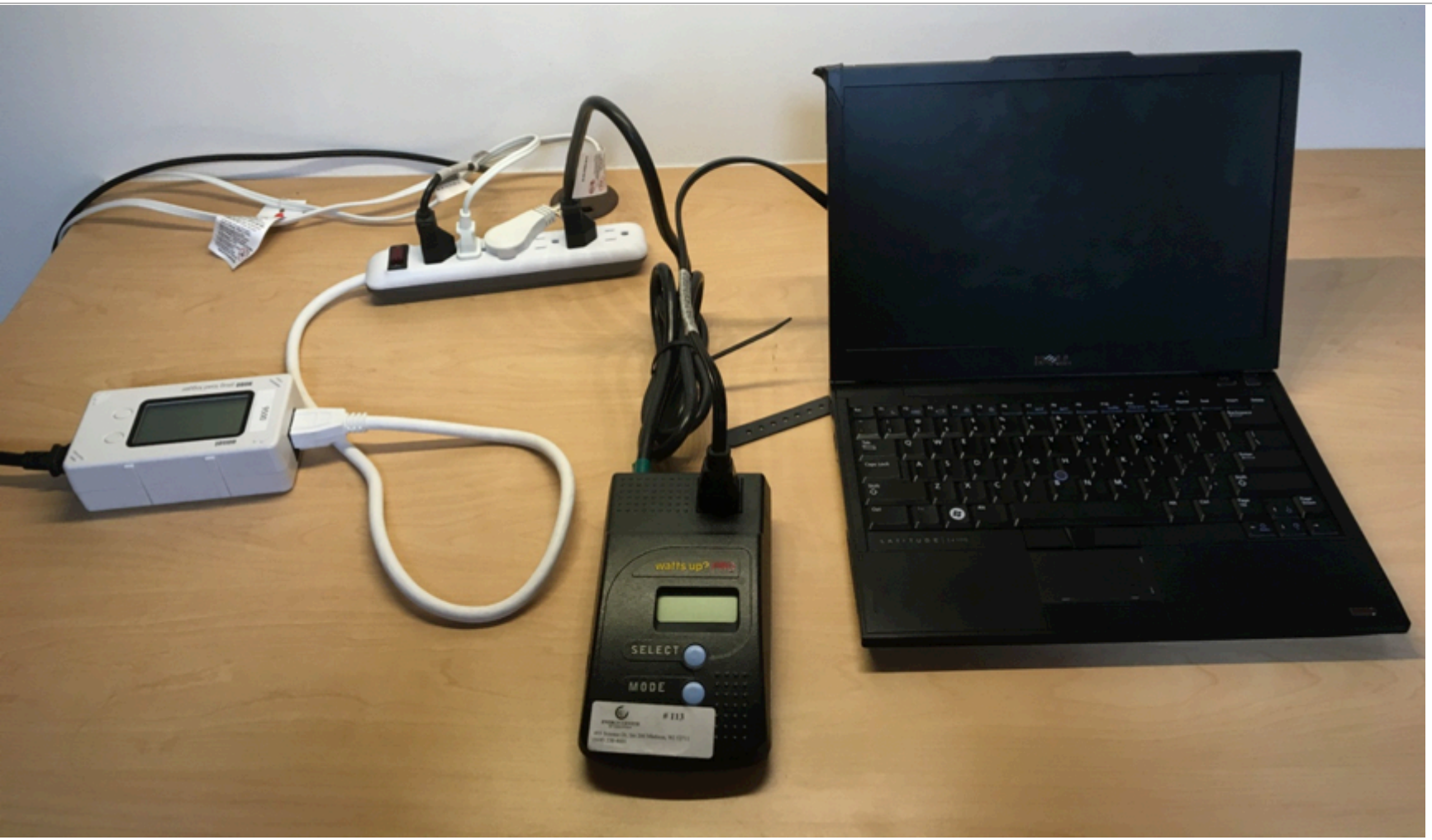
	Self-reported (N=34 offices)	
	Average	Range
Area per person (ft^2)	280	170 - 600
Desktop/workstation	0.65	0 - 1.4
Laptop/workstation	0.43	0 - 1
Monitor/workstation	1.32	0.2 - 2.4
Task Light/workstation	0.80	0 - 2.6
All other	1.40	0 - 4.8
Total Plug Devices	**4.6**	**1-10.4**
Phone/workstation	1.00	0.6 - 1.8

DATA COLLECTION

First divided by treatment vs control

- First Visit: Inventory and monitoring
- Second Visit: Install plug load control measures
  - Repeated up to 2 more times
- Third visit: Remove equipment and download data

MONITORING



Monitored total workstation electric AND computer only

ENERGY SAVING STRATEGIES

Advanced power strips:

- APS – Occupancy sensor
- APS – Foot pedal

Computer power management

Behavior campaign + APS

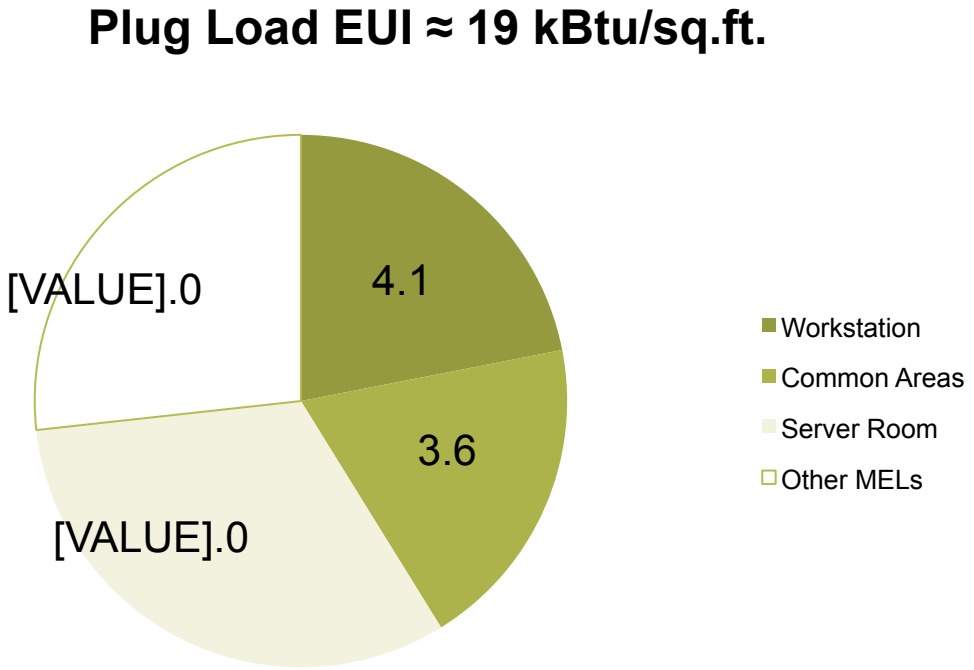
Common area equipment: Basic timer

CREDIT: Tricklestar

PLUG LOAD ENERGY IN A TYPICAL OFFICE

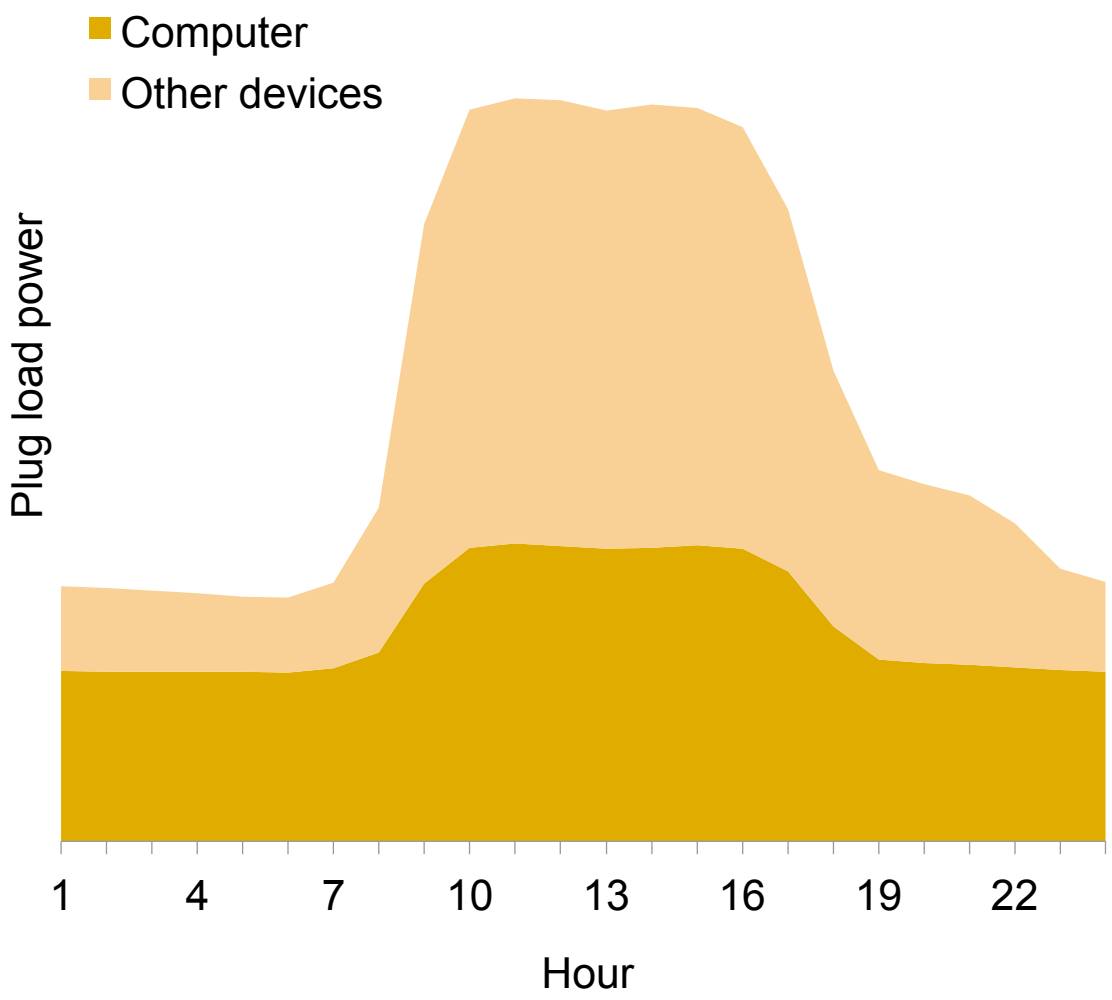
CONTROLLABLE PLUG LOADS

- Over 40% of typical office plug load is controllable
- Workstations make up 53% of controllable load
- Common area is the rest
  - Office equipment 30%
  - Break room 16%

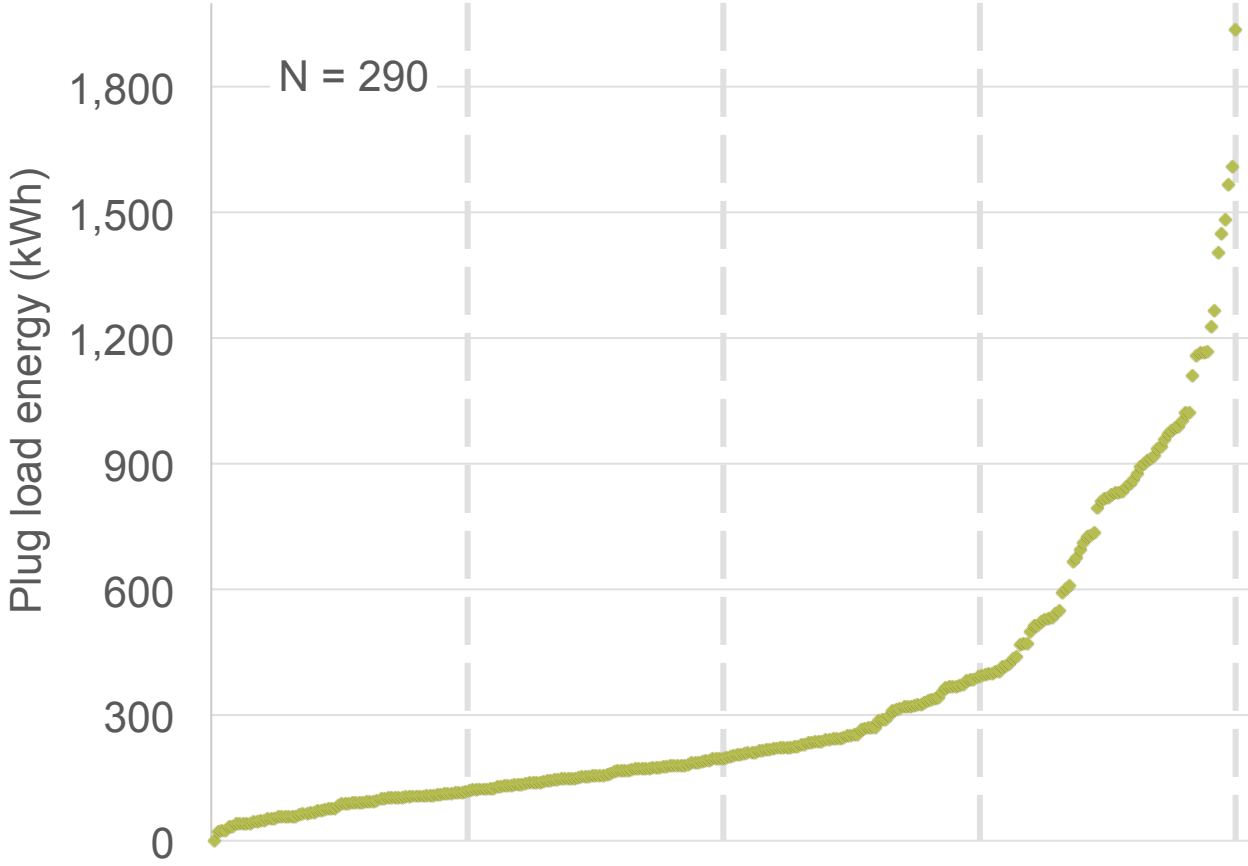


TYPICAL LOADS

By day…

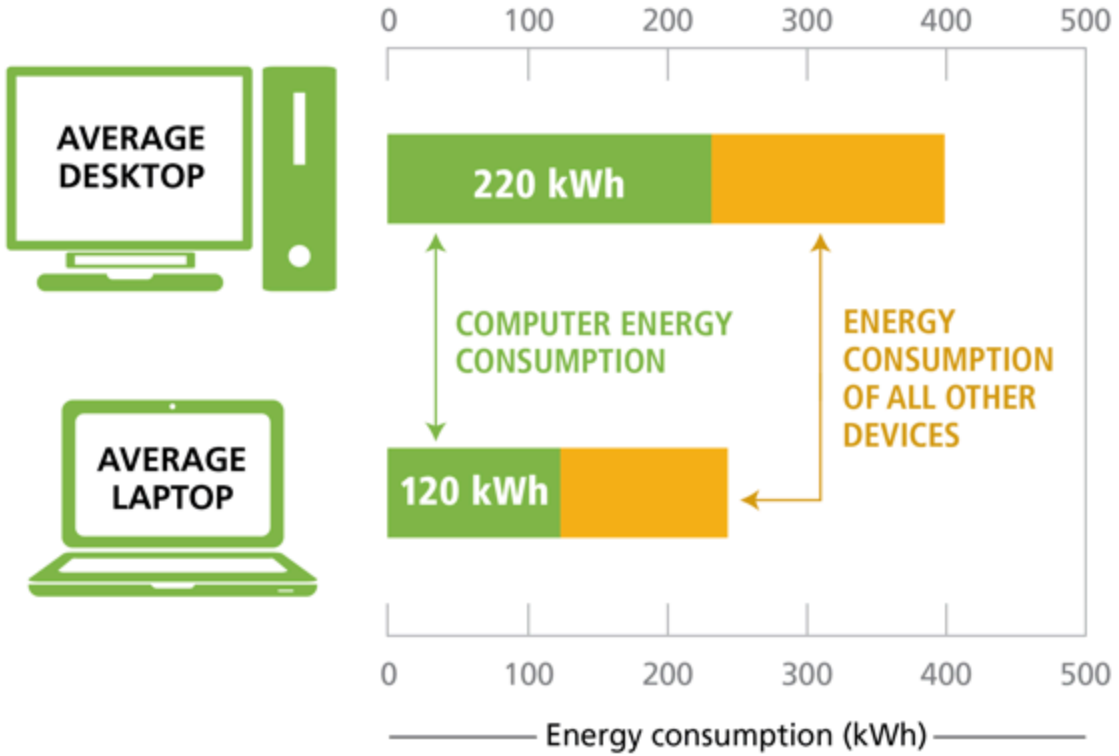


…and for the year.



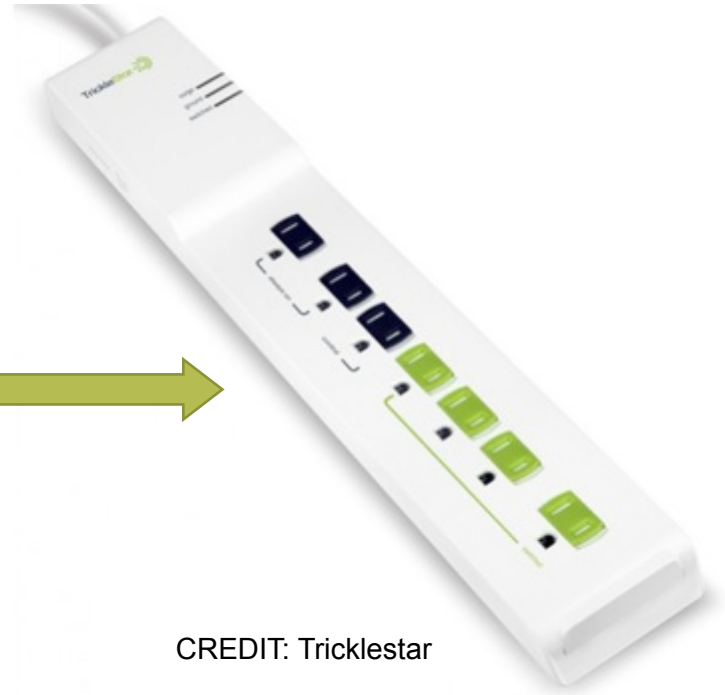
TYPICAL LOADS - TRENDS

Increasing use of laptops saves energy



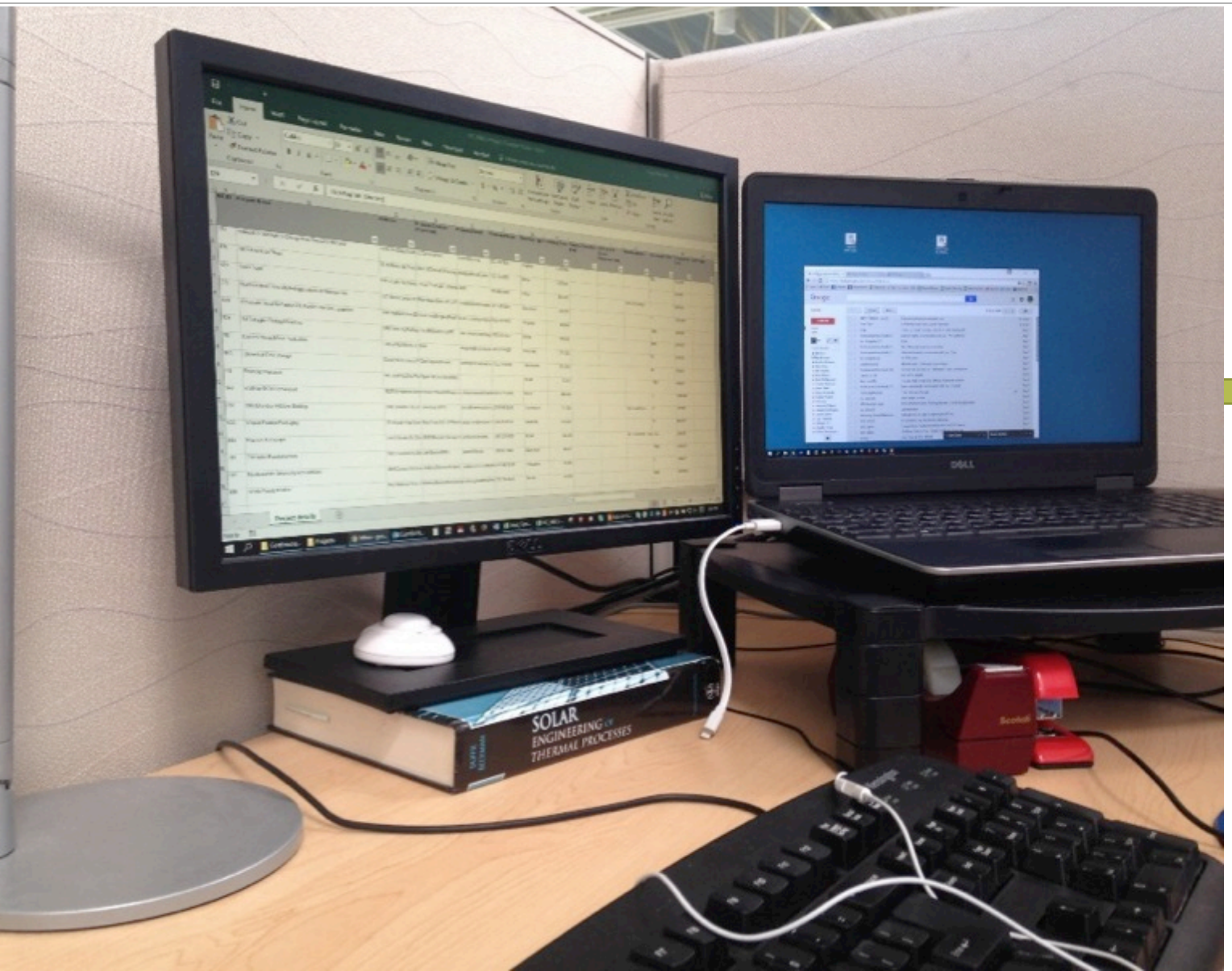
SAVING ENERGY IN WORKSTATIONS

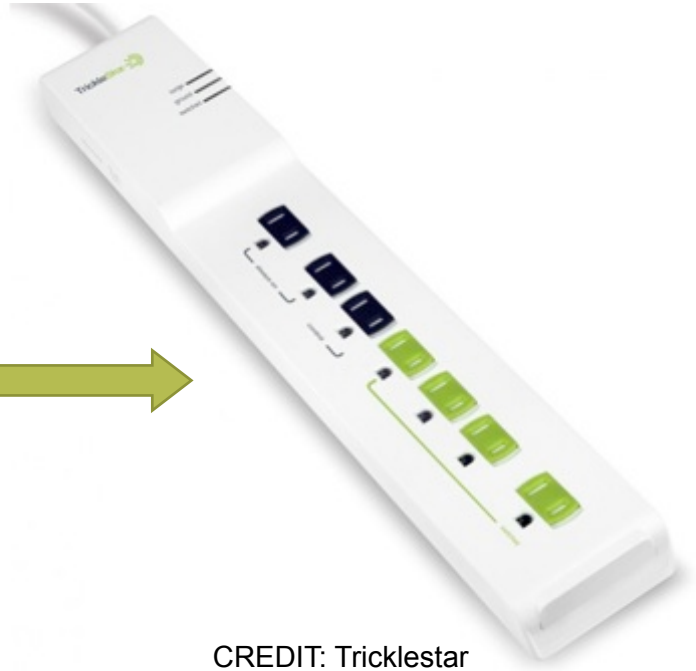
APS – OCCUPANCY SENSOR



CREDIT: Tricklestar

APS – FOOT PEDAL





CREDIT: Tricklestar

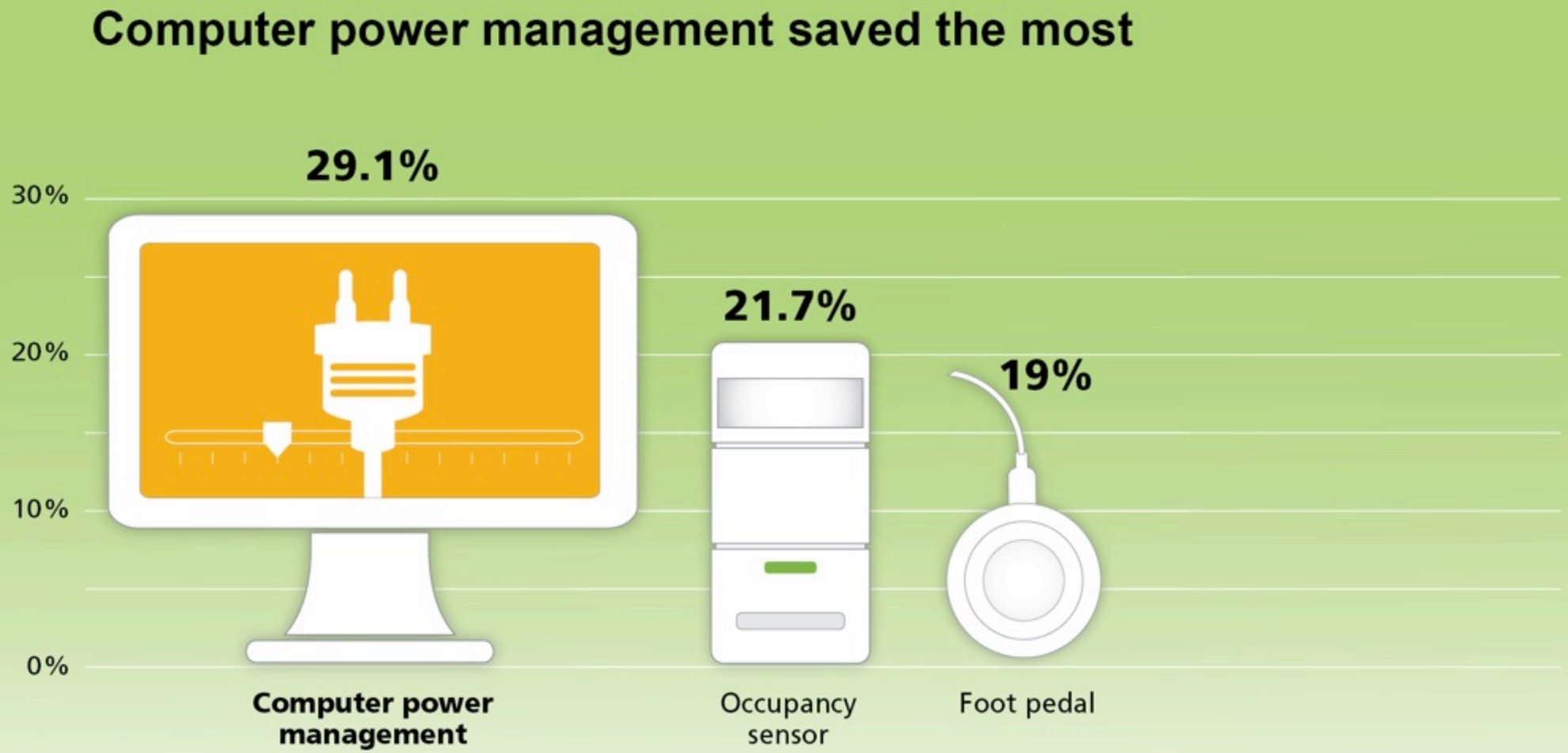
COMPUTER POWER MANAGEMENT

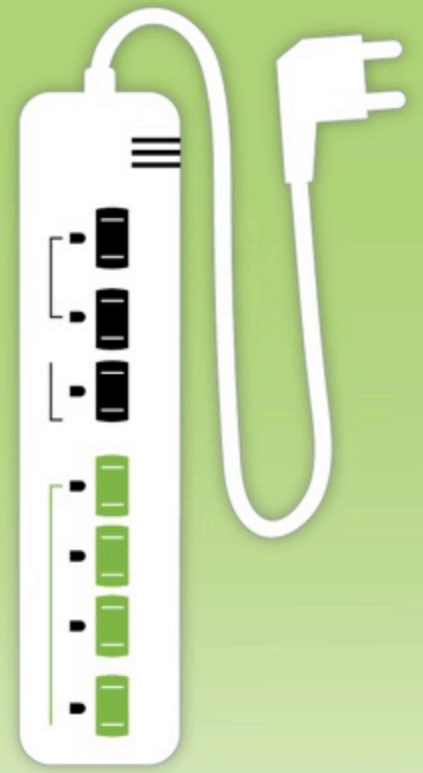
Consistent with ENERGY STAR recommendations

15 MINUTES
- Monitor off
- Hard disk off

30 MINUTES
- Desktops sleep
- Laptops sleep

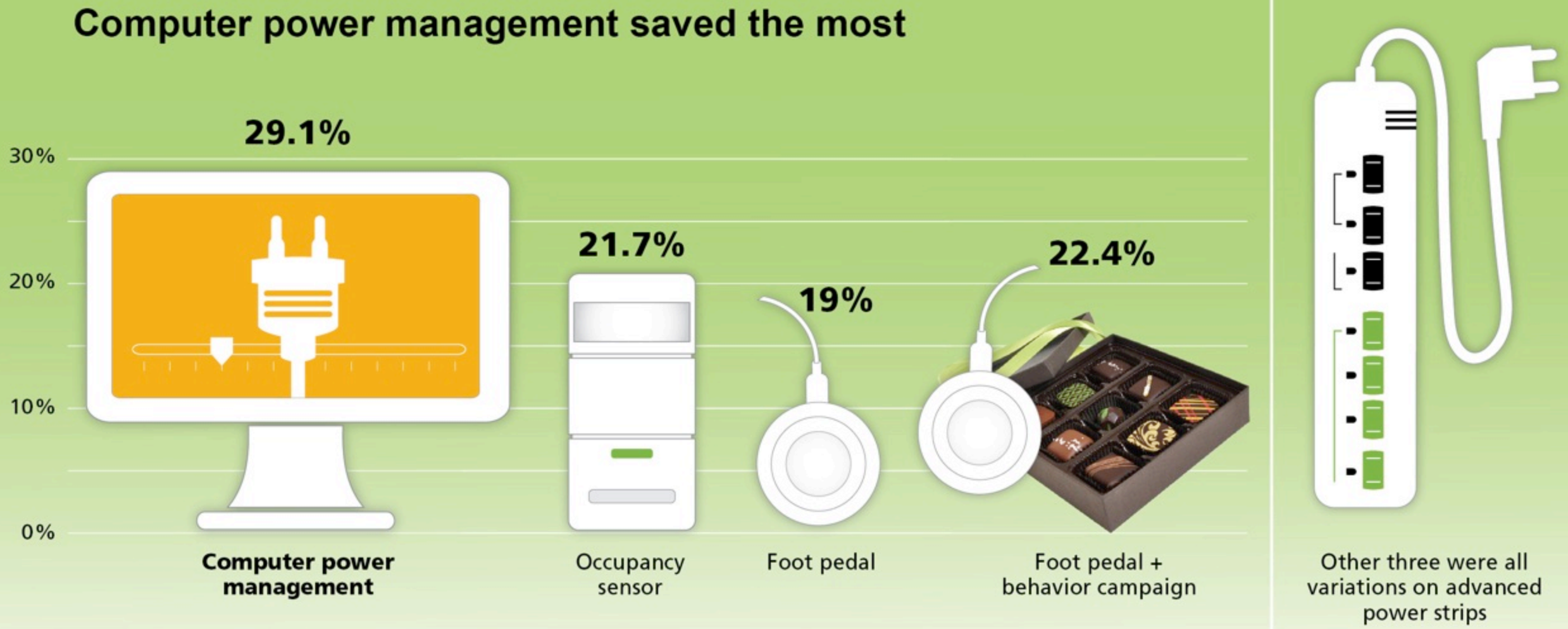
WORKSTATION SAVINGS





Other three were all variations on advanced power strips

WORKSTATION SAVINGS



WORKSTATION SAVINGS

	ENERGY SAVINGS			
	kWh per station	% (with 95% conf. int.)		N
Occupancy sensor	67	21.7%	± 14%	95
Computer power management	106	29.1%	± 18%	116
Foot pedal	42	19.0%	± 13%	74
Foot pedal + behavior campaign	70	22.4%	± 13%	48

WORKSTATION SAVINGS

These strategies are effective

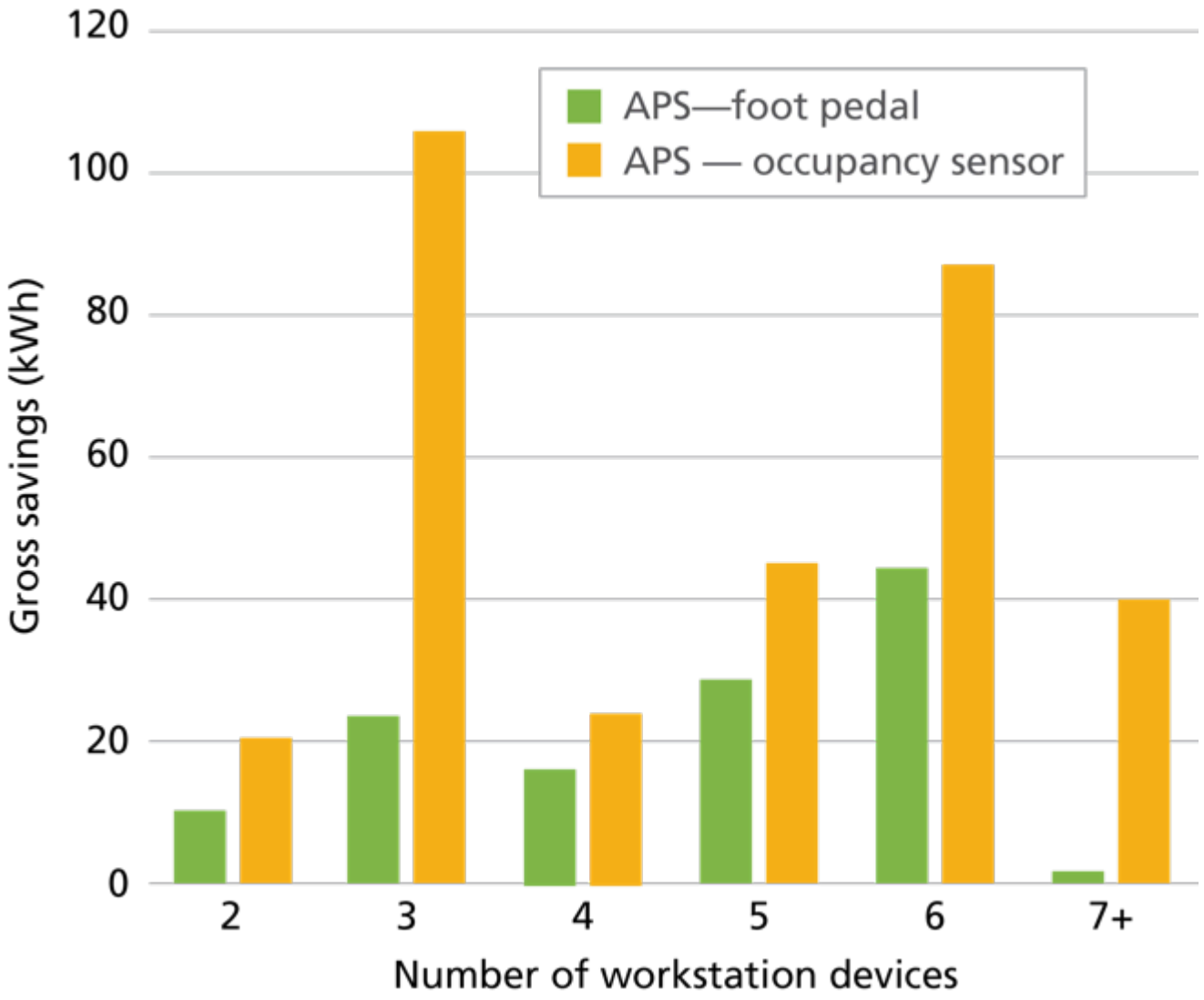
- As fraction of night + weekend energy: 53–69%

Reducing plug loads saves cooling energy too:

- CPM: add 4–7% savings
- APS: add 0–3% savings

CREDIT: Thomas Kelsey

TARGETING WORKSTATIONS?



Difficult to target based on device count alone

Look instead for:

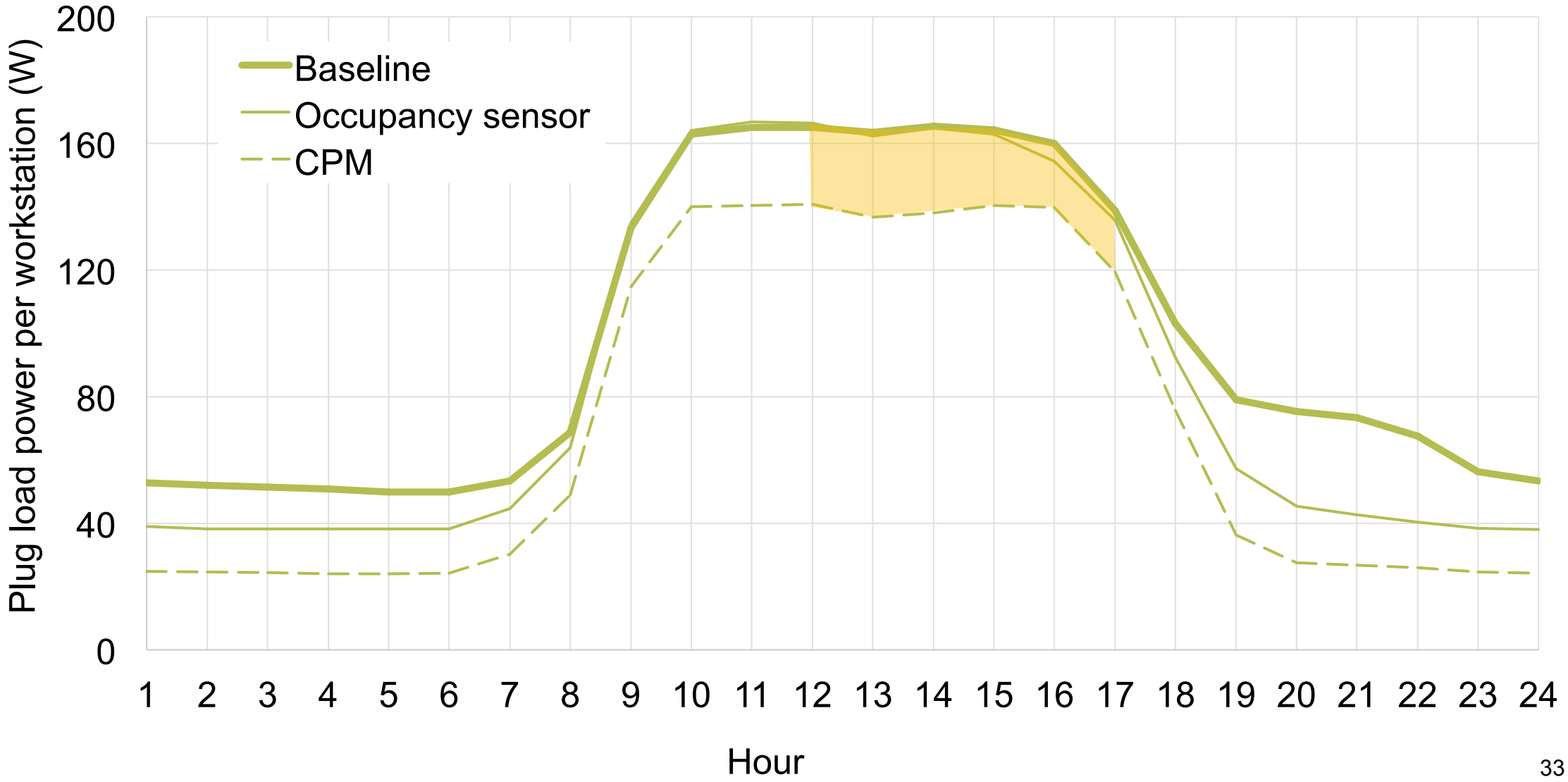
- ✓ Printers
- ✓ Very large monitors
- ✓ Desktop PCs
- ✓ Those without CPM

HOW DOES THIS COMPARE TO RESIDENTIAL?

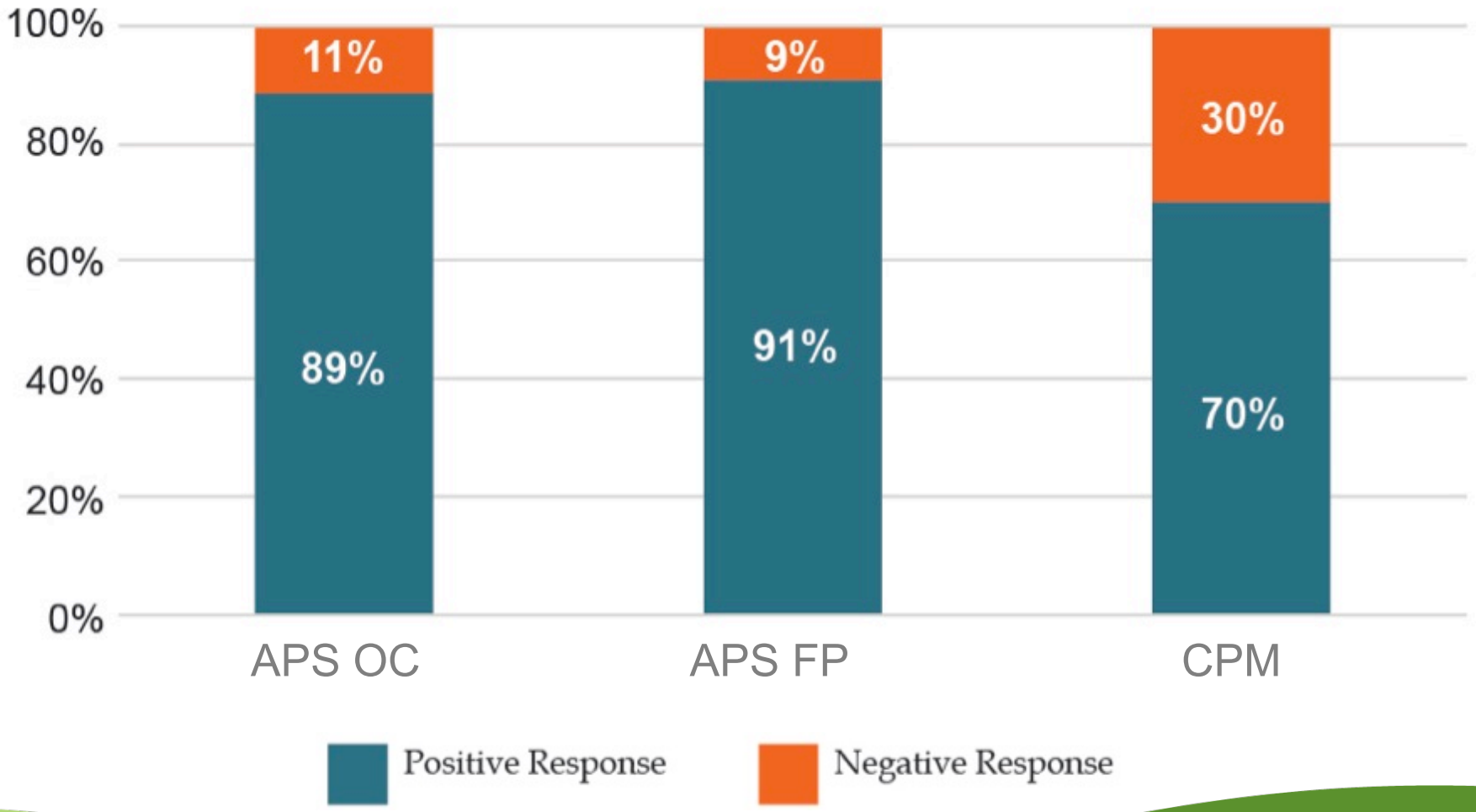
Everything from televisions to toasters, 15-30% of electric use

End Use	Percent of electric use	Percent of savings potential
TV and audio related	36%	22% - manually unplug 10% - turn off/timer 5% - power strip
Computer related	21%	40% - computer power management 5% - manually unplug 6% - power strip
HVAC related	25%	3% - turn off
Appliances (coffeemakers, toasters, microwaves, cordless phone)	8%	6% - unplug/timer
Other (clocks, chargers, hand tools, etc.)	10%	3% - timer/unplug

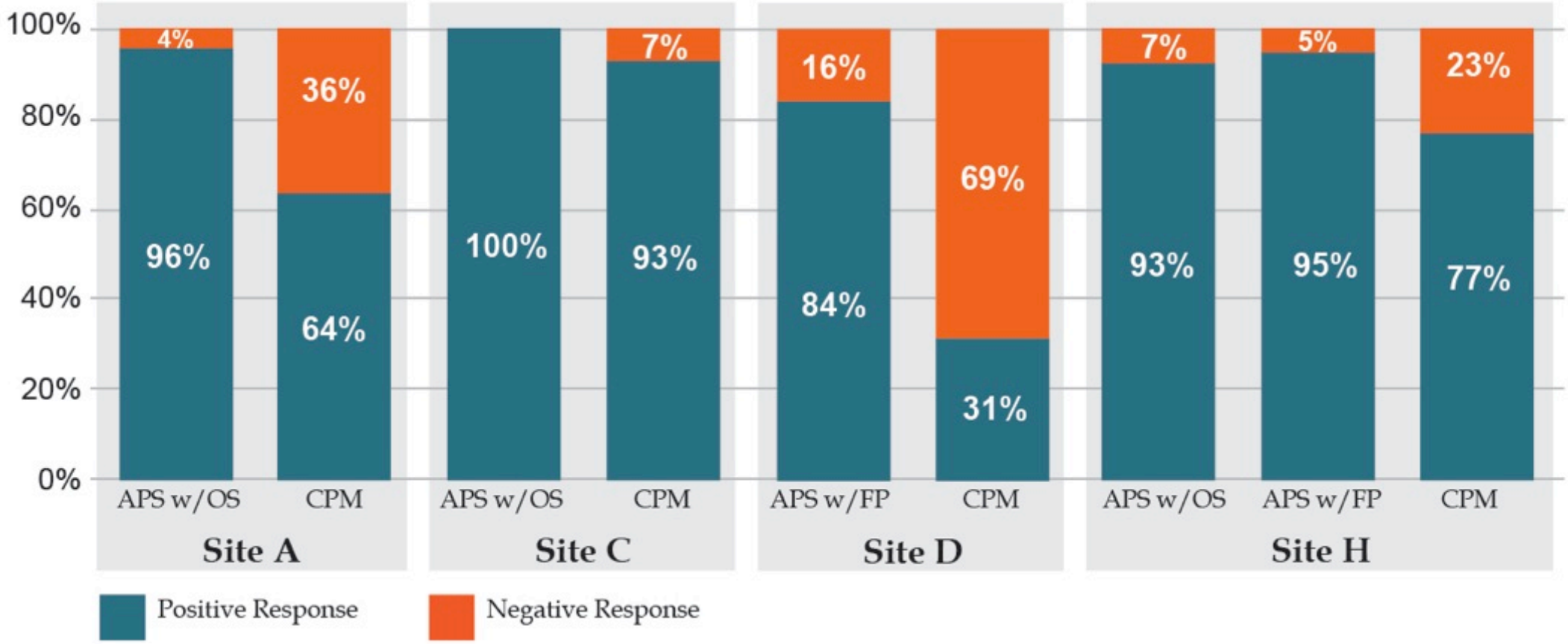
PEAK DEMAND IMPACT



PARTICIPANT FEEDBACK



PARTICIPANT FEEDBACK



IMPLEMENTING CPM

	CPM as found	Concerns / barriers posed	Improved	Network policy used	
Architecture	None	Large	X	X	Nearly all concerns overcome
City public works	User-controlled	None			
Engineering	None	Moderate			
City office	None	Small	X	X	Remote desktop was only barrier
Real estate	User-controlled	None	X		Fully outsourced IT
Product development	Weak settings	Small	X	X	
County office	None	Large			IT: Computers must run 24/7
Energy nonprofit	User-controlled	Small	X	X	

Problems with solutions: Remote access | Pushing updates | Problem software | Other IT priorities

CONCLUSIONS FOR WORKSTATIONS

Computer power management

- Not widely implemented
- Effective with existing software
- IT concerns have solutions

Advanced power strips

- Simple controls can save

Cooperation: IT + Sustainability staff

SAVING ENERGY IN COMMON AREAS

COMMON AREA EQUIPMENT

Evaluate needs!

	Annual energy usage
	kWh
Desktop printers	170
Medium-sized MFDs	352
Coffeemakers	548
Televisions	67
Water coolers	386

PHOTO CREDIT: Wikimedia commons

COMMON AREA TIMER SAVINGS

	Energy savings		Idle power	
	kWh	%	W	N
Projectors	0	0	0	6
Televisions	43	42%	12	3
Desktop printers	47	27%	16	6
Medium-sized MFDs	51	17%	19	7
Water coolers	104	21%	—	4
Coffeemakers	110	18%	30	5

COMMON AREA EQUIPMENT - OTHER

- TV backlight settings
- Choice of coffee service

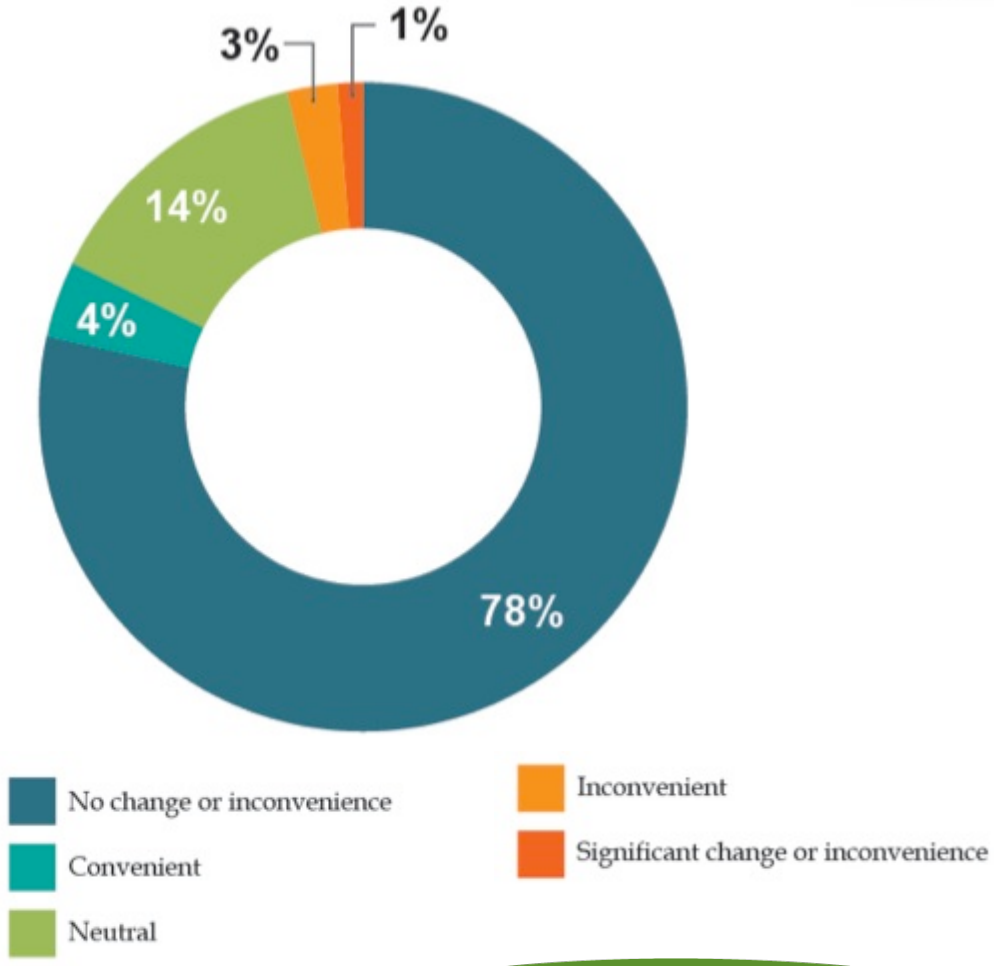
CREDIT: Adam Dachis

PARTICIPANT FEEDBACK

Common area equipment timers:

96% of respondents indicated that they did not notice any change/ inconvenience

Most issues were related to equipment that is not designed for hard shutdown (MFDs, video conferencing equipment, etc.)



ECONOMICS

COSTS

- APS $55
- APS—for new workstation. $35
- Common area timers $36
- CPM $17

COSTS + BENEFITS

	APS	APS	CPM	Timer	Timer
	new workstation	existing workstation		beverage	MFD / printer
Simple payback	5.8 years	8.4 years	1.6 years	3.3 years	6.6 years

IMPACT OF BEHAVIOR

BEHAVIOR CAMPAIGN PLANNING

Stakeholder interviews revealed the following design needs:

- Allow user to easily and conveniently turn off the devices.
- Remind user that the devices have been left on.
- Help create social norms to help others perform the action.
- Allow others like co-workers or facilities/custodial personnel to help the action be performed.

Solution:

- APSs with foot switches
- LED status lights

BEHAVIOR CAMPAIGN + APS

POWER DOWN

TOGETHER, WE CAN REDUCE PLUG LOAD ENERGY USAGE IN THE 1902 BUILDING.

AS A CITY, we have made great strides in reducing our environmental footprint–but we can do more– especially in the area of plug load energy.

As part of this effort to improve, you'll notice we've tried some technological strategies (and are measuring those as part of a research project) to reduce plug loads at some of the workstations in the 1902 Building. **But now it's time to get EVERYONE involved in trying to save energy through individual actions.** As part of this effort, you'll notice some workstations have received blue, microwatt LEDs to remind occupants to turn off their equipment. We hope these will also serve to remind us ALL to turn equipment and lights off.

To help inspire everyone, **your efforts will be rewarded by treats** (in addition to that warm, fuzzy feeling) if we catch you in the act of saving energy!

TO GET STARTED, SOME ACTIONS YOU CAN TAKE INCLUDE

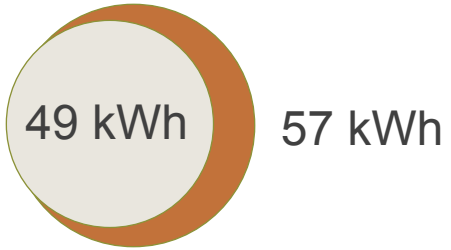
- "Hit the switch" to turn off unneeded plug loads whenever leaving your desk
- Unplug any electronics that are only rarely used (printers, radios, chargers)
- At the end of the day, shut down or hibernate your computer (when you won't need remote access)
- Brag about your energy-saving actions to co-workers and get them saving too!

IMPACT OF BEHAVIOR

City public works

APS savings alone:

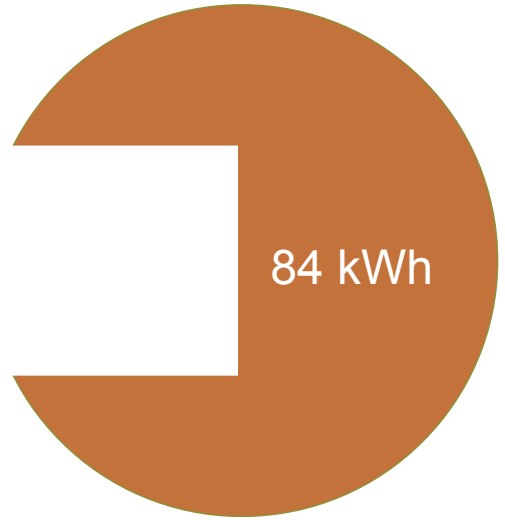
… with behavior campaign:



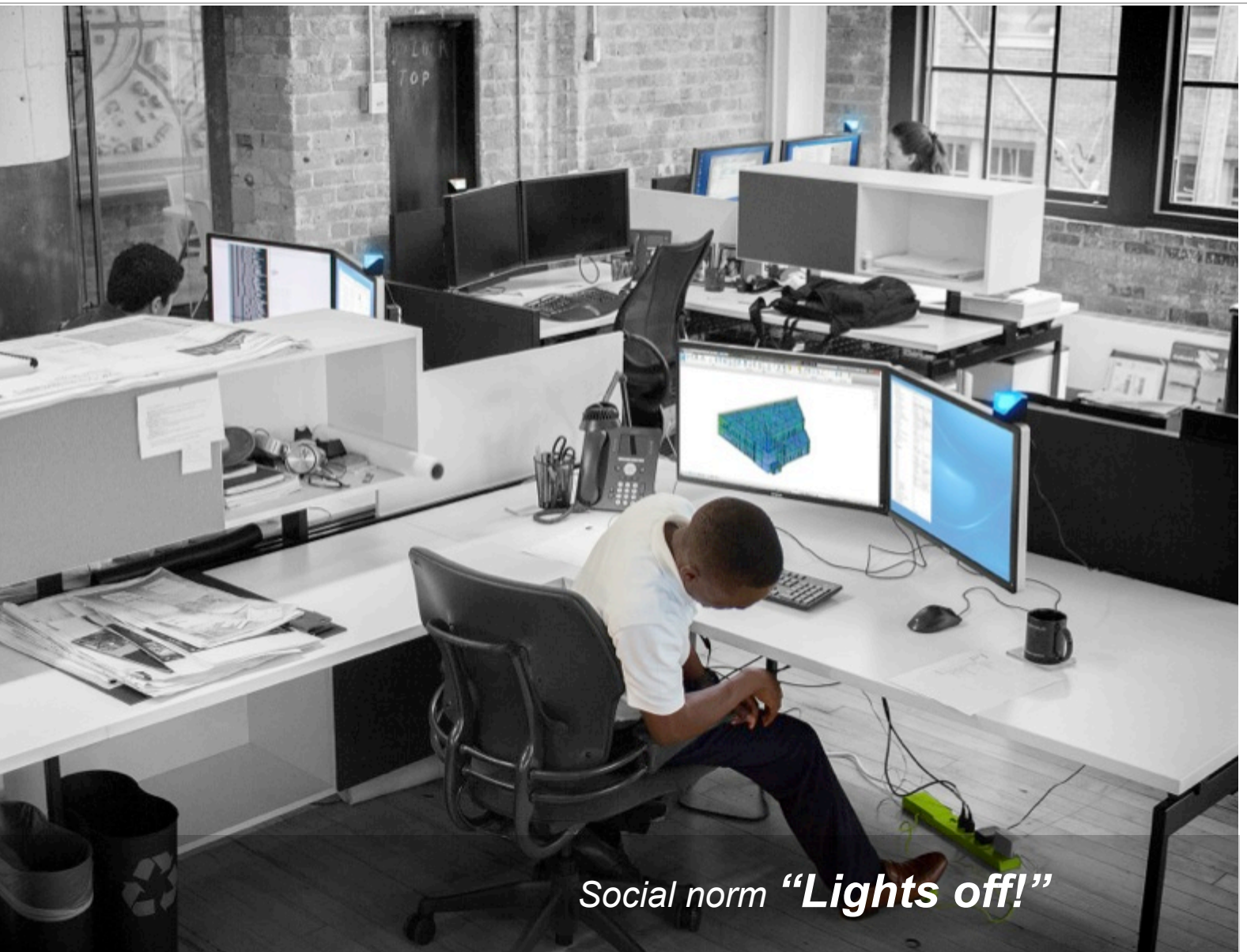
Engineering

APS savings alone:

… with behavior campaign:



BEHAVIOR CHANGE CAMPAIGN



"What the lights are good for is providing awareness of the energy state of my cubicle."

"The blue indicator lights were often called 'the blue light of shame.'"

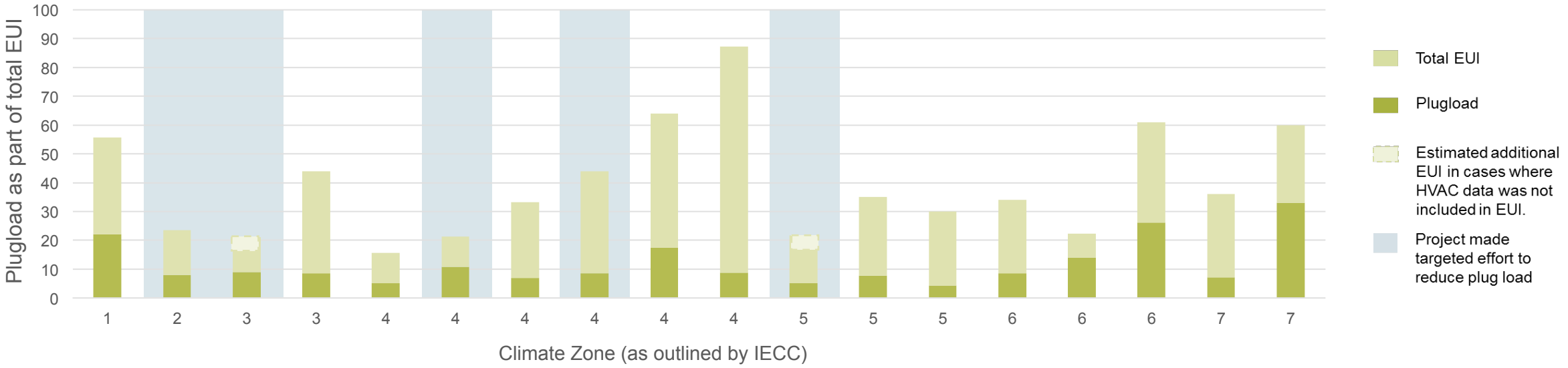
CONTEXT, CONCLUSIONS

CHECK THE CLOSET

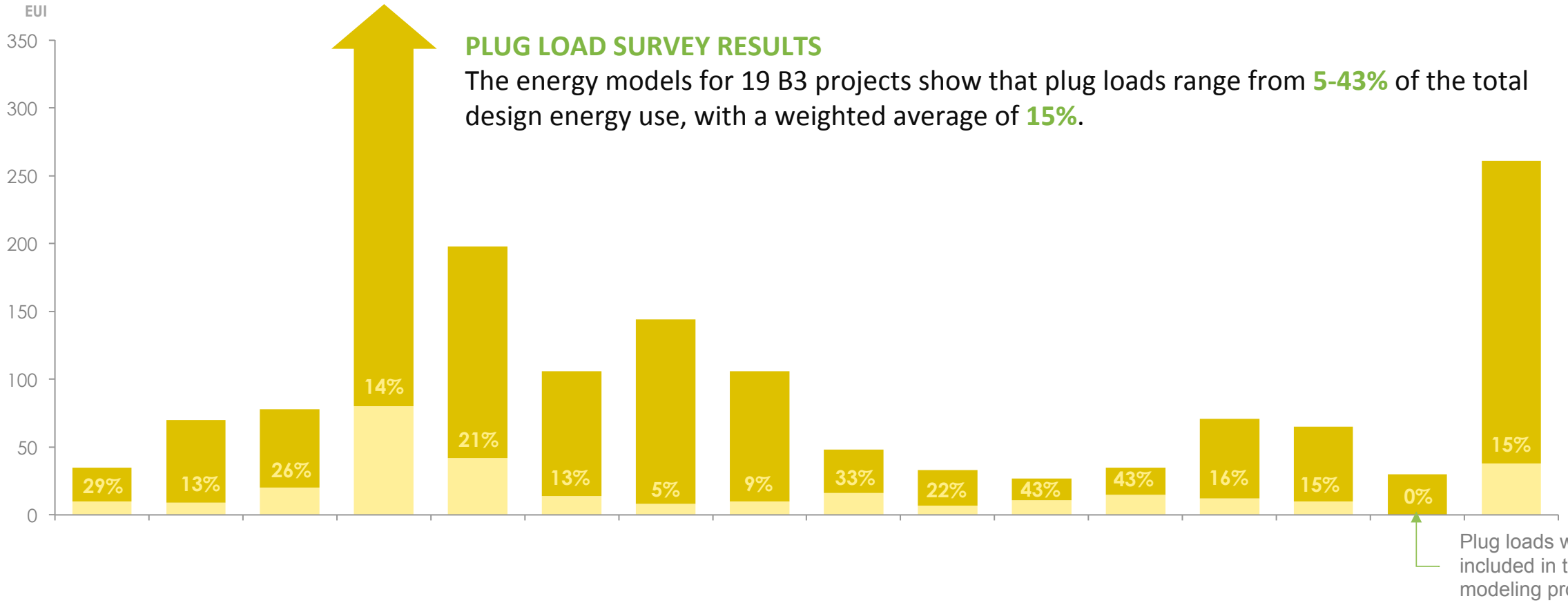
PHOTO CREDIT: Samsung

BROADER CONTEXT

Targeting plug load during design is an effective strategy….



ENERGY USE ATTRIBUTED TO PLUG LOADS



PLUG LOAD SURVEY RESULTS

The energy models for 19 B3 projects show that plug loads range from **5-43%** of the total design energy use, with a weighted average of **15%**.

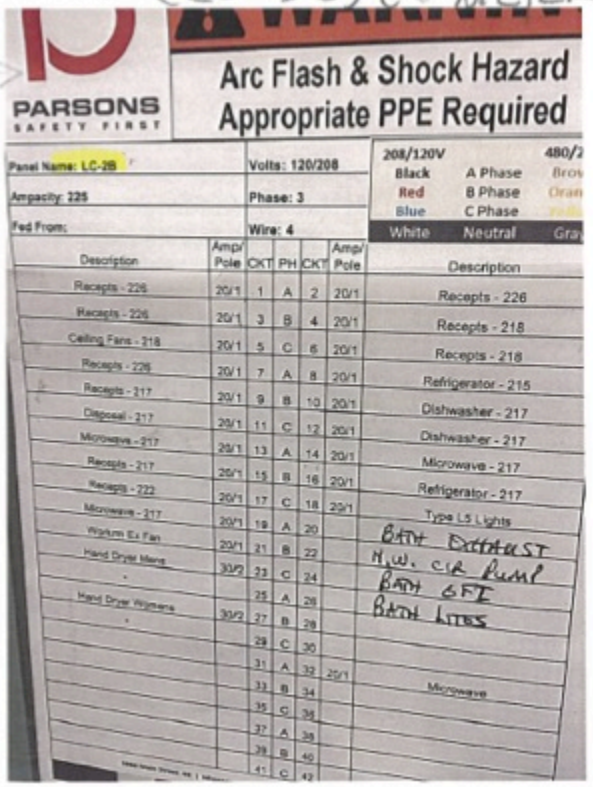
PLUG LOAD CASE STUDY
LHB OFFICE

PROCESS

- Create an Energy Management Team
- Submeter plug loads to create a baseline
- Set goals
- Take action and record as “Events” in B3 Benchmarking
- Track results

SUBMETERS

(LC-2A) FURNITURE PLUG LOADS (LC-2B) (SHARE METER)

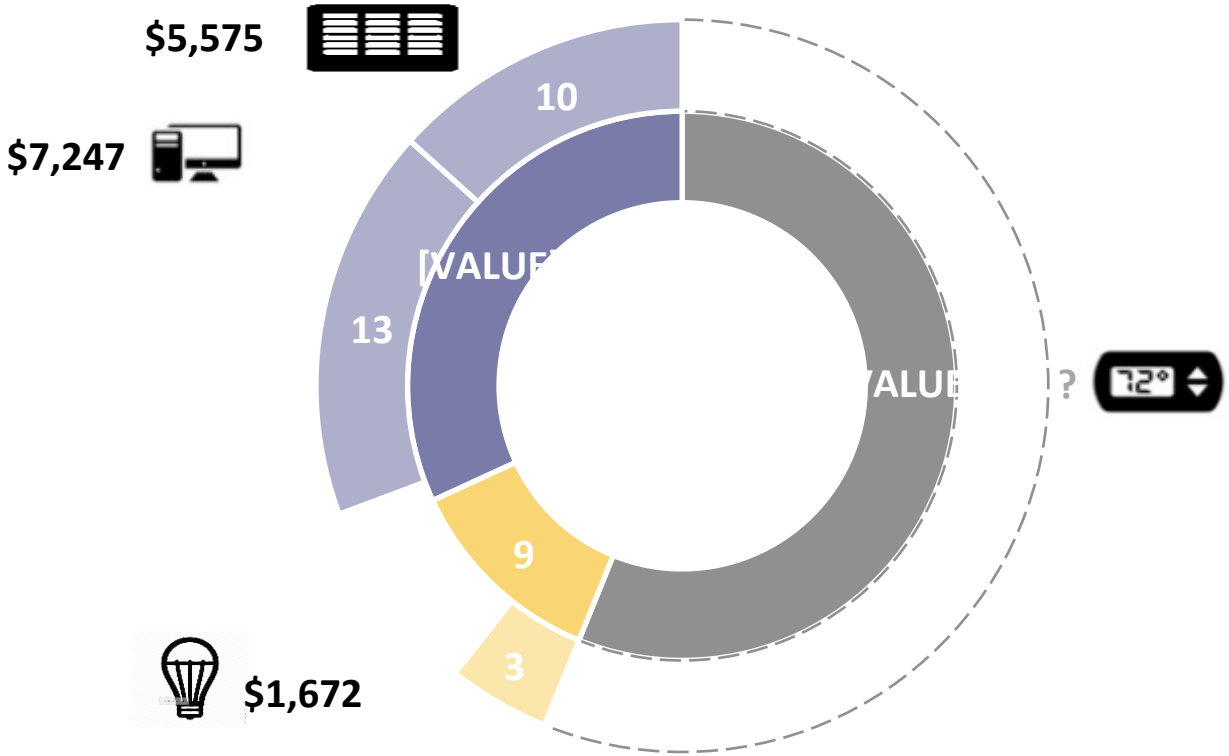


SUBMETERS + INTERVAL METERS

Meter Name	Status	Type	Utility
LHB 1: LE-2A (IT Panel A/C Plug Loads) & LE-2 (Furniture Plug Loads)	✔	Electric Interval Meter	Energy Resource Products (ERP)
LHB 1: Submeter LE-2A (IT Panel A/C Plug Loads)	✔	Electric Interval Submeter	Energy Resource Products (ERP)
LHB 2: Panels H2-A (Lighting)	✔	Electric Interval Meter	Energy Resource Products (ERP)
LHB 3: EM-1 (Emergency Lighting)	✔	Electric Interval Meter	Energy Resource Products (ERP)
LHB 4: Panel LC-2A & 2B (Furniture Plug Loads)	✔	Electric Interval Meter	Energy Resource Products (ERP)
Utility Invoice: EM-1 (Emergency Lighting)	✔	Electric Meter	Xcel Energy
Utility Invoice: H2-A (Lighting Panel)	✔	Electric Meter	Xcel Energy
Utility Invoice: LC-2A & 2B (Furniture Plug Loads)	✔	Electric Meter	Xcel Energy
Utility Invoice: LE-2A (IT Panel A/C Plug Loads) & LE-2 (Furniture Plug Loads)	✔	Electric Meter	Xcel Energy

BASELINE

ANNUAL DISTRIBUTION & COST OF OFFICE ENERGY USE
(kBtu/SF-Year)



NATIONAL AVERAGE

77 EUI

AVERAGE OFFICE (CBECS 2012)
ELECTRIC EUI 33

LHB-MSP OFFICE (2016)
ELECTRIC EUI 27

LHB-MSP Energy Update - January 2017

CHECK THE CLOSET

PHOTO CREDIT: Samsung

GOALS

Data Center:

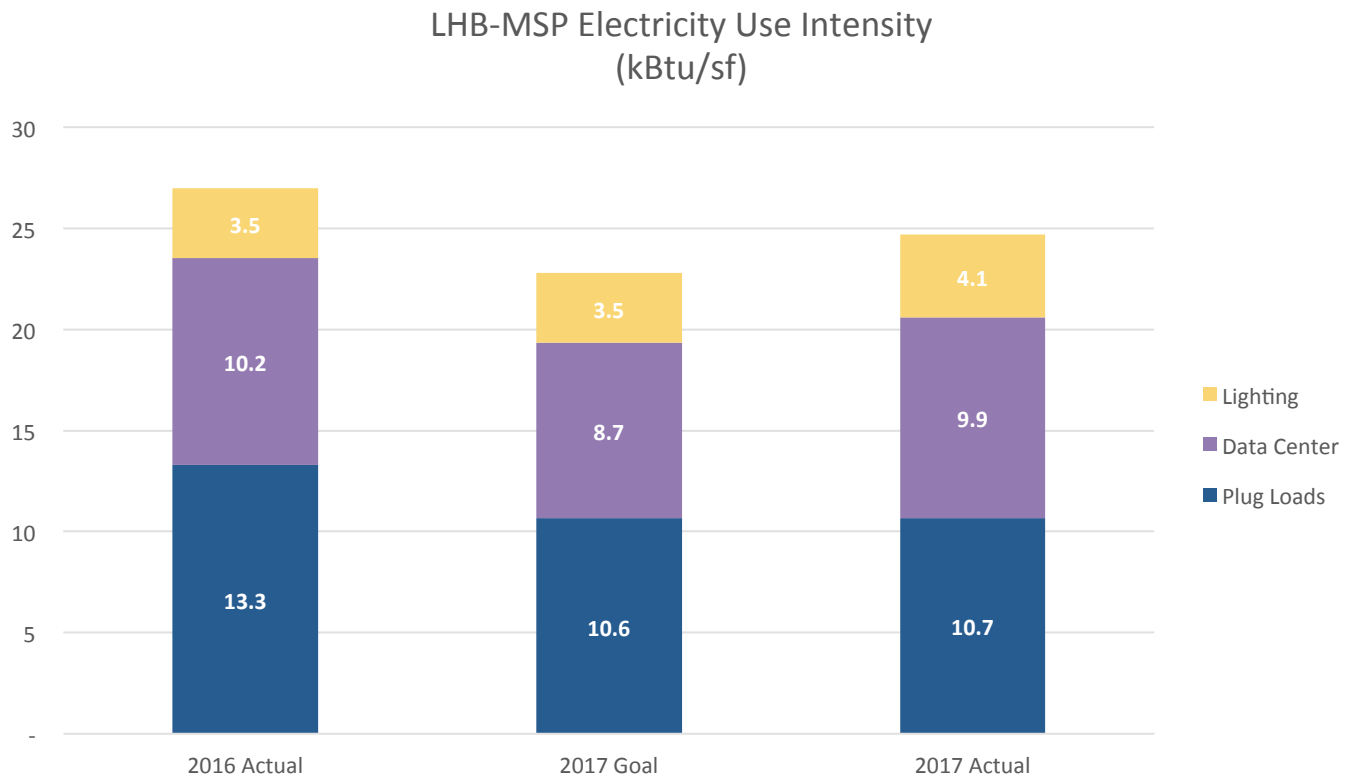
15% reduction

Plug loads:

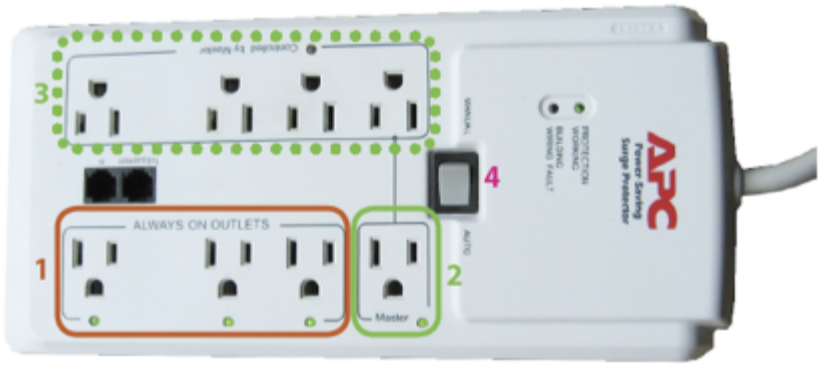
20% reduction

Total Electricity:

16% reduction



ACTIONS



1. ALWAYS ON OUTLETS
Plug anything that must remain on at all times into these outlets
(Optional: CPU if you use remote desktop, headsets)

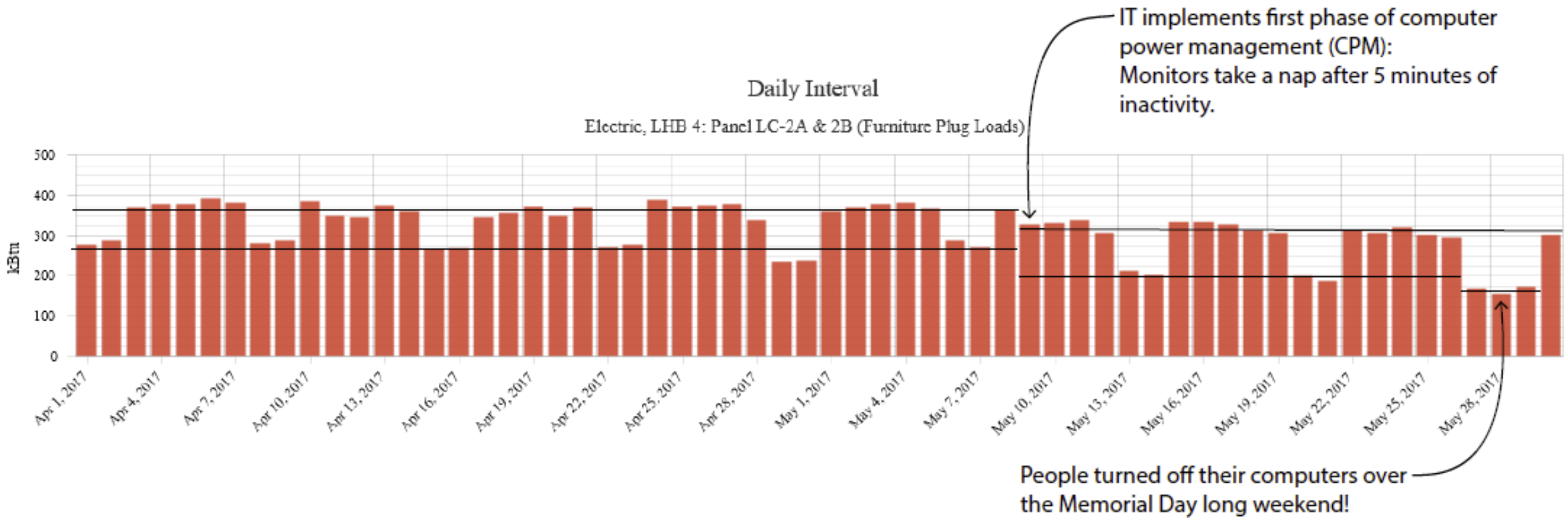
2. MASTER
Select one device at your desk to be a control. Plug this control device into the "Master" outlet. When you turn this device off, power to the "Controlled" outlets will be turned off.
(If you use your computer when you do a "shut down" at the end of the day everything else will turn off. This device could also be your primary monitor)

3. CONTROLLED BY MASTER
Plug anything that can be powered down in the "Controlled" outlets. When you shut down your control, or "Master" device, power to these outlets will be cut off. Think of it as "hitting the switch" on a typical power strip.
(phone chargers, computer monitors, etc.)
NOTE: DO NOT PLUG YOUR COMPUTER TOWER INTO THE CONTROLLED OUTLETS

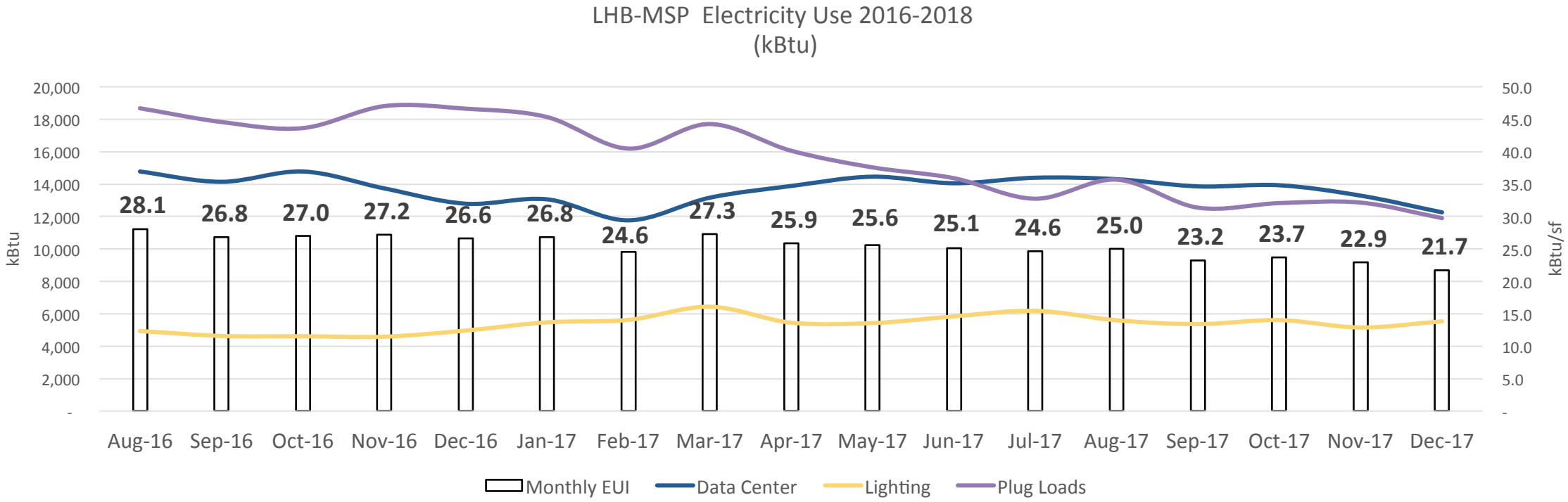
4. SWITCH
Flip the switch to "Auto" to enable the advanced power control in your smart power strip.

- Computer power management
- Advanced power strips
- Behavior campaign
  - Updates at staff meeting
  - Education on use of advanced power strips
  - Feedback meters
  - Outreach prior to holiday weekends

RESULTS


IT implements first phase of computer power management (CPM):
Monitors take a nap after 5 minutes of inactivity.
Daily Interval
Electric, LHB 4: Panel LC-2A & 2B (Furniture Plug Loads)
kBtu
500
400
300
200
100
0
Apr 1, 2017
Apr 4, 2017
Apr 7, 2017
Apr 10, 2017
Apr 13, 2017
Apr 16, 2017
Apr 19, 2017
Apr 22, 2017
Apr 25, 2017
Apr 28, 2017
May 1, 2017
May 4, 2017
May 7, 2017
May 10, 2017
May 13, 2017
May 16, 2017
May 19, 2017
May 22, 2017
May 25, 2017
May 28, 2017
People turned off their computers over the Memorial Day long weekend!

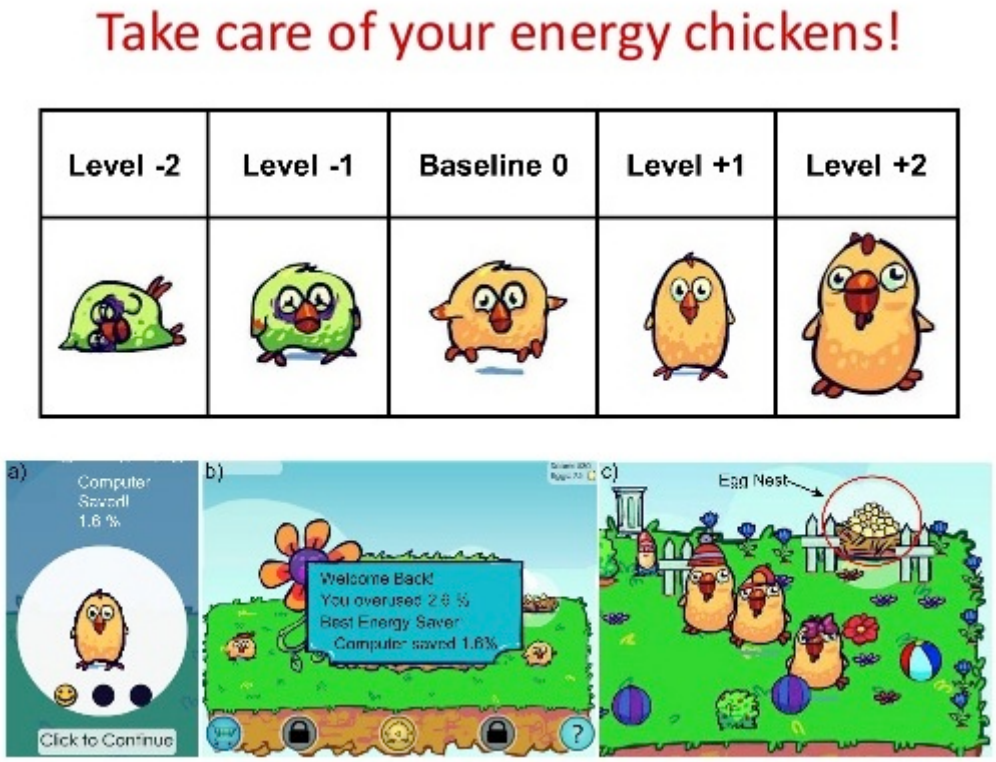
RESULTS



19.8% reduction in plug loads

NEXT STEPS

- Behavior campaign
  - Implement monitor brightness adjustments
  - Evaluate opportunities for remote desktop users
  - Plug load competition
- Efficient equipment purchasing policy + standard for new workstations
- Timer controls for common area equipment



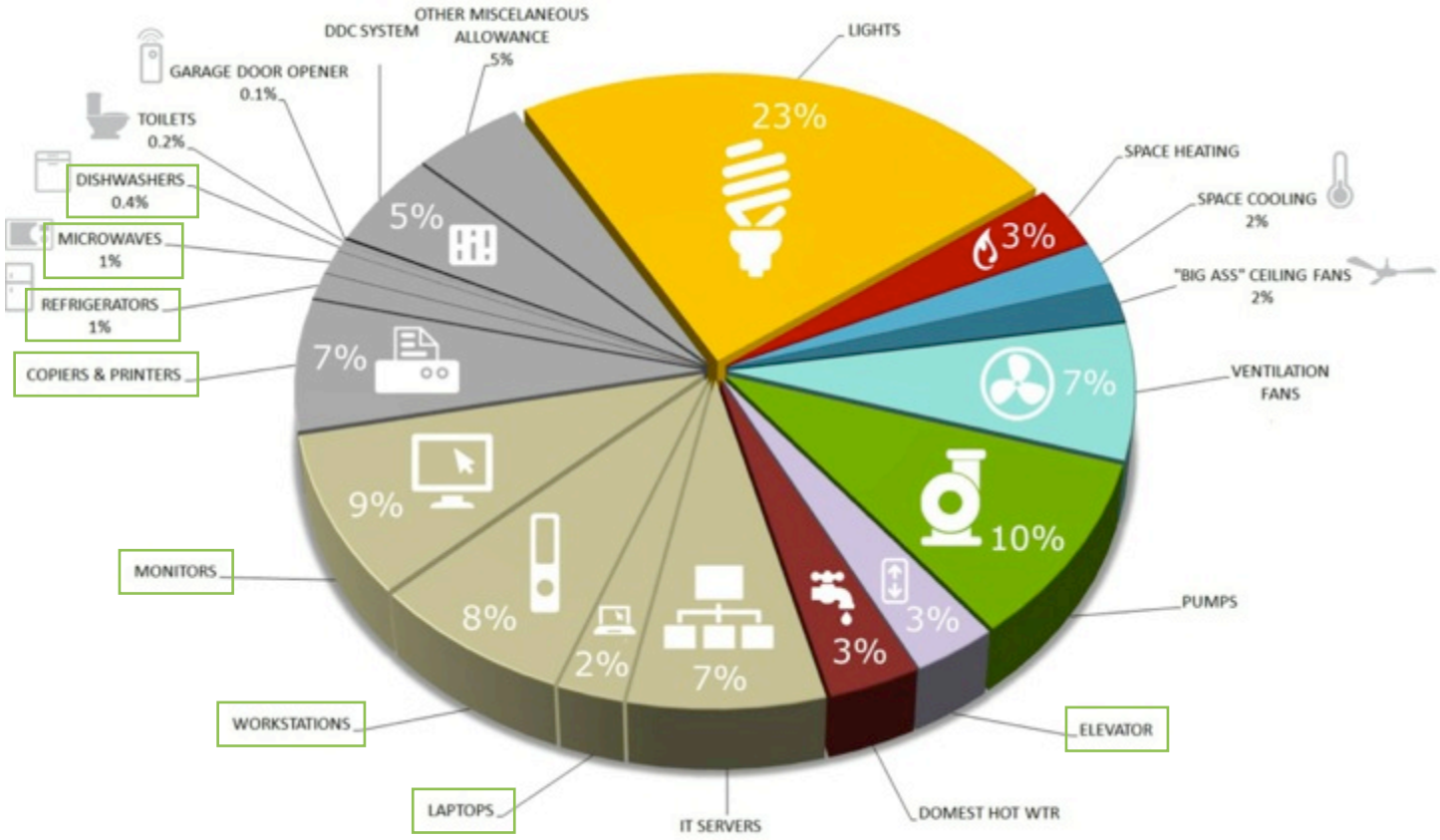
BULLITT CENTER CASE STUDY

http://www.bullittcenter.dreamhosters.com/building/building-features/

92 EUI = Typical Office Building

16 EUI = Bullitt Center

31.4% of EUI = Plug Load



**PAE Consulting Engineers, Inc.

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TAKES ADVANTAGE OF THE SUN

- 82% of interior is naturally daylit (reduces task lighting)
- 14,303 sq.ft. solar array (230,000 kWh/year)

ACTIVE DESIGN

- Irresistible stair design encourages use
- Hidden elevator

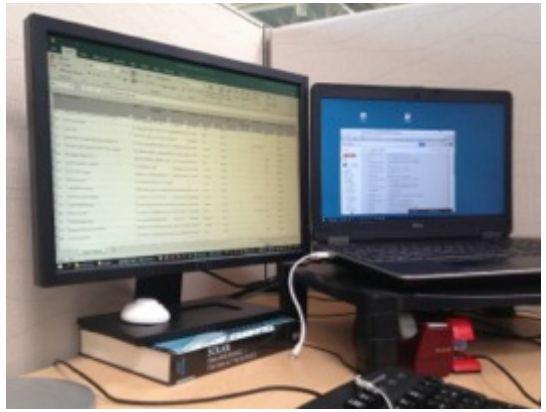
SMART TECHNOLOGICAL CHOICES

- Regenerative elevator designed by KONE converts potential energy from braking into useable electricity which saves 60% of its energy
- Energy Efficient Computers
- Computerized systems to help manage building systems

MEASUREMENT & FEEDBACK LOOP

- Dashboard shows real-time data about energy and water use
- Each tenant has agreed to an energy allowance as part of lease

DESIGN IMPLICATIONS



Target plug loads

- New codes/Energy Design Assistance
- Separate plug loads onto dedicated electrical panels

Tailor workspaces

- Equipment size
- Workstation types

Kitchenettes and common spaces

- Number, location, and efficiency of equipment

Lighting, thermal comfort

- Reduce need for personal task lights, heaters & fans

KEY TAKE-AWAYS

- Relatively simple solutions are available to save 30% or more
- There's value in discussing behavior
- IT can impact energy efficiency
- Though some loads are moving out of the workstation, significant savings remains

FOR MORE INFORMATION

Energy Star

https://www.energystar.gov/products/reduceitenergycosts

https://www.energystar.gov/campaign/home?s=mega

Better Buildings: Myth Busting Market Barriers to APS
https://betterbuildingssolutioncenter.energy.gov/myth-busting-market-barriers-advanced-power-strips

NBI: Plug Load Best Practices Guide

https://newbuildings.org/resource/plug-load-best-practices-guide/

Minnesota Power Rebates link

https://www.mnpower.com/ProgramsRebates

NEED MORE DETAIL?

Download the study

See a fact sheet and the full report: seventhwave.org/commercial-plug-load-study

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