Formerly known as

COMMERCIAL OFFICE PLUG LOAD SAVINGS AND ASSESSMENT: EXECUTIVE SUMMARY

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December 2011

This work is supported through the California Energy Commission's Public Interest Energy Research Program
The CEC is in the process of completing the final review of this report

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Acknowledgments

The authors would like to thank the following people for their contributions to this research:

Cathy Turner, New Buildings Institute

Cathy Higgins, New Buildings Institute

Dan Harris, New Buildings Institute

Lia Webster, Portland Energy Conservation, Inc.

Erin Rowe, Portland Energy Conservation, Inc.

Eric Greensfelder, Portland Energy Conservation, Inc.

Mark Effinger, Portland Energy Conservation, Inc.

Craig Billingsley, Ecova

Chris Calwell, Ecova

David Weightman, California Energy Commission

The support of the California Energy Commission's Public Interest Energy Research program is also gratefully acknowledged.

Executive Summary

Plug loads (devices that plug into wall outlets) account for 23% of total electricity consumption in California's commercial office buildings. Office equipment alone accounts for 74% of this plug load energy, which is as much as 17% of electricity consumption in California's small office buildings (Itron Inc., 2006). While voluntary programs and mandatory regulations have had an important role in improving the energy efficiency of commercial plug loads, significant energy savings opportunities remain.

This study characterizes electricity consumption of plug load devices in two recently LEED-certified buildings in California and explores opportunities for plug load energy savings in these buildings. In this report, plugs loads include primarily user-interface office electronics such as computers, monitors and printers; white goods and server closets were *not* part of this study's scope (Figure 1). As part of a PIER-funded study on high performance buildings led by New Buildings Institute (NBI), the plug load research team (led by Ecos and supported by Portland Energy Conservation, Inc. [PECI] and NBI) inventoried and metered plug loads in a 95,000 ft^2 public library and a 14,000 ft^2 small office in California. The team first inventoried all plug load devices at the library and the small office (n=924), with the exception of servers and their dedicated air conditioning units. The team then chose 100 of these devices to meter at one-minute intervals for one month, placing the highest priority on computers, computer monitors, imaging equipment and computer peripherals, the most numerous devices at the two sites and which use significant amounts of energy (Moorefield et al., 2011, revised 2nd Edition) (Figure 1).

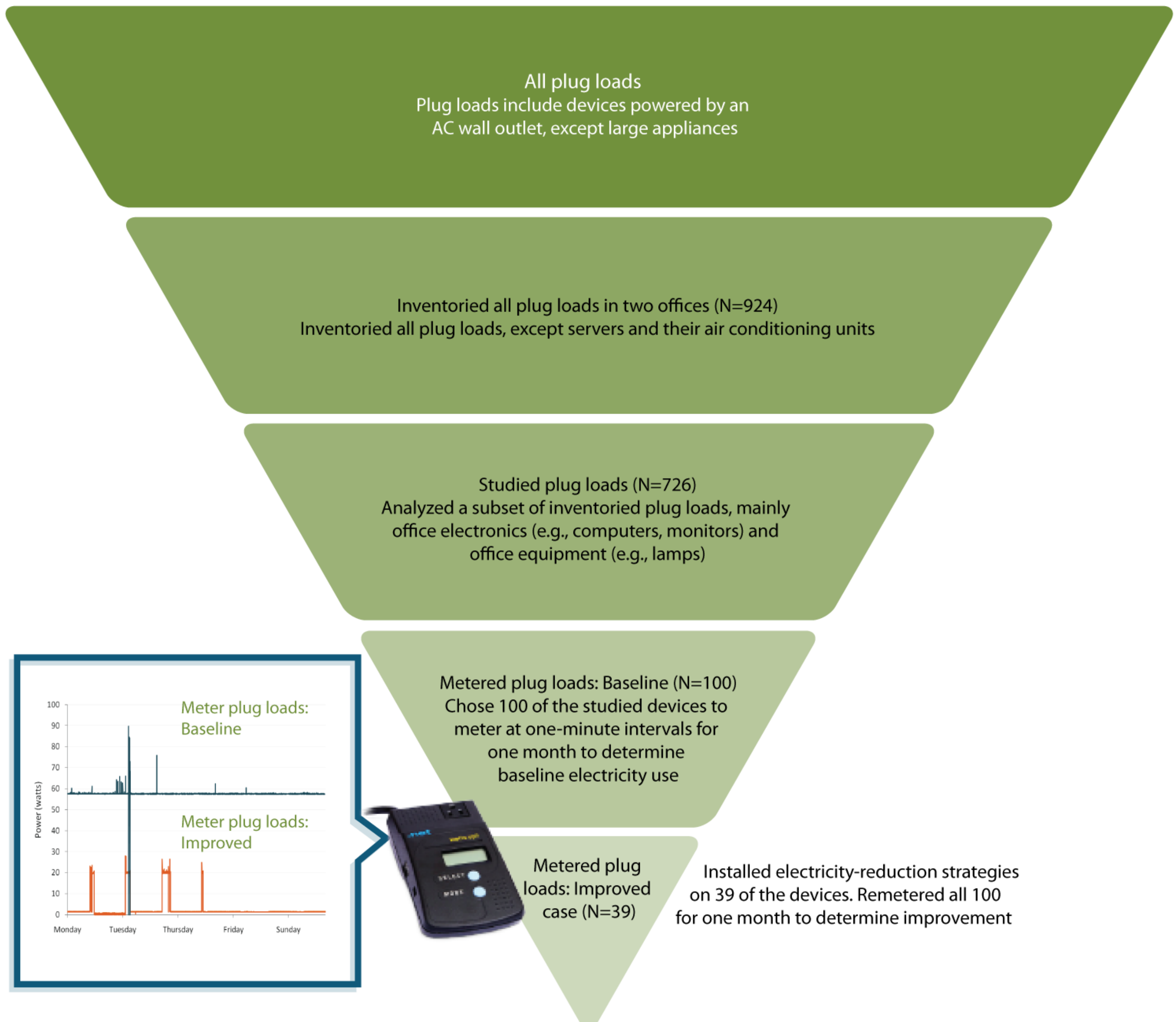


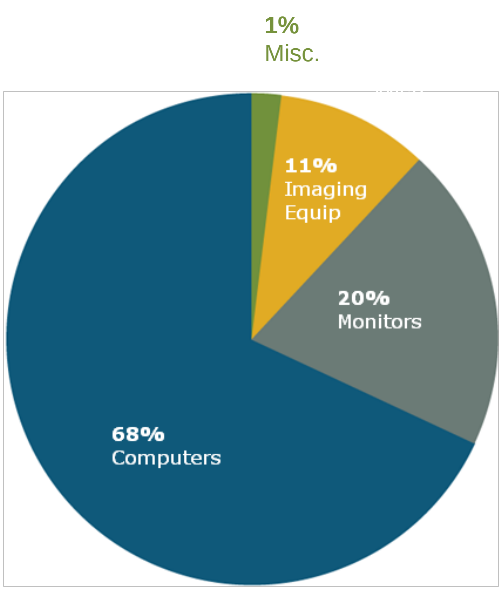
Figure 1: Overview of Methodology and Scope

Energy Use. From device inventories at each site and energy use recorded on the 100 metered devices, we estimated the plug loads studied used 66,300 kWh or 0.7 kWh/ft^2 per year at the public library and 13,100 kWh or 0.94 kWh/ ft^2 per year at the small office. For each site, studied plug loads used about 6% of the building's total annual energy (electricity plus natural gas). These kWh/ft^2 plug load estimates are significantly lower than findings by the most recent California Energy Use Survey (CEUS) report — 2.19 kWh/ft^2 per year in small offices (Itron Inc., 2006). [1] Logical reasons for this difference could include two factors. The first is that the CEUS

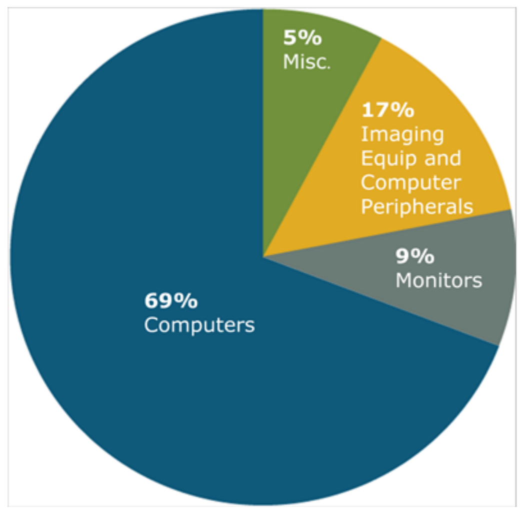
[1] Note that libraries are not a separate category in the CEUS analysis; we compared results for the library to the most similar category, small office.

office equipment category includes servers, a category excluded from the current study due to liability issues. In addition, both the library and small office had lower-than-average densities of office equipment (about 2 PCs/1000 ft^2 at each site) and were occupied by users who purchased more efficient office equipment than average.

A reasonability check of Ecos' studied plug load estimate was done by NBI based on direct panel-level metering at the small office as a part of NBI's development of key performance indicators for this PIER research. NBI's top-down estimation of plug loads without servers orserver closet A/C was 1.3 kWh/ ft^2/yr, roughly comparable, given the level of estimation involved, to this study's bottom up total of 0.94 kWh/ft^2/yr.



Public Library plug load electricity use breakdown
Total = 66,300 kWh (0.7 kWh/ft^2) per year



Small Office plug load electricity use breakdown
Total=13,100 kWh (0.94 kWh /ft^2) per year

Figure 2. Results: Savings Opportunities and Strategies

Savings Opportunities and Strategies. Desktop computers were the largest plug load electricity users studied at both sites (Figure 2). We estimate their energy consumption to be 68% of studied plug load energy use at the library and 69% at the small office. LCD computer monitors were the second largest plug load energy users at the library and the third largest at the small office, accounting for 20% and 9% of total studied plug load energy use, respectively (Figure 2). Based on our findings during the first metering period, we identified four key opportunities for energy savings:

1. Desktop computers, LCD monitors and imaging equipment typically consumed more active power than the most efficient models available today.

2. Many desktop computers were left running in active or idle modes at night and on weekends.

3. Most imaging equipment and computer peripherals such as computer speakers were used rarely but drew power continuously when not in use.

4. Some imaging equipment and miscellaneous plug loads such as projectors were not very numerous, but each device consumed a significant amount of energy and did not appear to scale power consumption effectively to usage.

We evaluated three different approaches to assess energy savings opportunities:

1. **Software** — Set aggressive power management settings on all equipment or use power management software controlled by the IT departments.

2. **Hardware** — Purchase and install advanced power strips, timers and more efficient office equipment.

3. **Occupant behavior** — Encourage users to flip the switch on power strips and turn off devices when not in use, and increase awareness of efficiency settings.

We installed low- and no-cost energy reduction strategies on 39 of the 100 metered devices, then re-metered all 100 devices for an additional month. Because of budget constraints, it was not feasible to install some of the identified energy savings measures. In these cases, we quantified the impact of the measures by applying savings estimates from previous commercial studies to our baseline energy consumption meter data or by comparing the average energy use of metered devices to the reported qualified products data from the EPA ENERGY STAR website. Key results are described below and summarized in Table 1.

1. **Software Power Management Settings** — Enabling and properly programming existing power management settings of computers and imaging equipment provides the largest energy savings opportunity. If adequate software is already installed on the system, this solution can be implemented at no cost. There are barriers to be addressed if energy savings are to be achieved, such as a lack of user information and education, users requesting remote access to their desktop computers and conflicting practices with existing IT management policies. Alternatively, low-cost, network-based power-management software that allows IT managers to centrally control power to devices during nights and weekends may be purchased. Although we did not test this strategy, it has been proven very cost effective in various locations in the country.

2. **Hardware Control Strategies (Timers and Advanced Plug Strips)** — Several control strategies can be employed to turn off devices when not in use and significantly reduce energy consumption, but this benefit must be weighed against the cost of purchasing and installing these control strategies.

i. **Timers and Timer Plug Strips**. Timers and timer plug strips were unobtrusive to the participants and reduced electricity use significantly, making them good options to control devices with regular schedules. For example, at one workstation with a laser printer, computer monitor, calculator and computer speakers, we reduced electricity use by 43%.

ii. **Load-sensors Plug Strips.** Load-sensor plug strips automatically turn off power to devices when the current drops below a certain threshold. Although the associated savings ranged widely and were dependent on user behavior, these devices are easy, low-cost ways to eliminate the energy used by often-forgotten computer peripherals.

3. **Occupant Behavior Measures** — Even the easiest and least expensive behavioral measures, such as sending an Outlook calendar reminder encouraging employees to turn off equipment at night and on weekends, reduced desktop computer electricity use by 6% on average in the two case studies. Our findings show that providing simple, easy to understand real-time feedback to users on their energy consumption can affect behavior and reduce energy consumption. Using an energy use feedback monitoring device saved 51% of electricity use per workstation or 200 kWh per year at the library. Most savings were associated with shutting off the computer when not in the office (Figure 3). In the timeframe of this study it was not possible to prove that these savings would persist over time, given their sole reliance on continued user behavior.

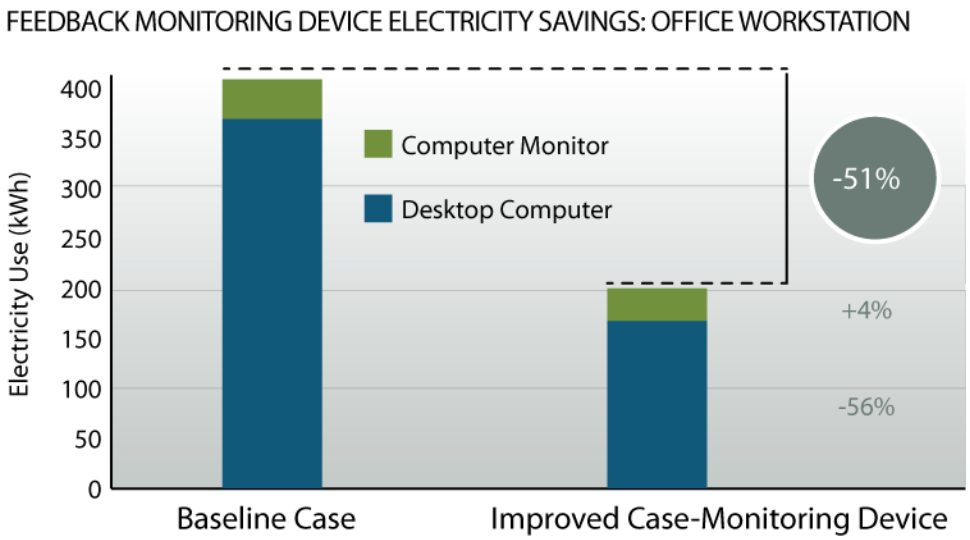


Figure 3. Feedback Monitoring Device Electricity Savings: Office Workstation

4. **Hardware Equipment Replacement** — Because the absolute cost of purchasing new office equipment is large relative to the dollar value of the annual energy savings, we typically recommend that users procure better equipment at the time they are normally purchasing rather than discard currently functioning equipment in favor of something more efficient. Our review of cost data on standard and efficient office equipment showed little to no cost difference between a highly energy efficient model and one that is less efficient. Replacing older equipment before it is worn out can be a strategy worth pursuing, but it will be a higher cost approach than if the equipment were replaced when it was no longer functional. In some cases, we achieved significant energy savings by replacing inefficient equipment and sizing the replacement equipment appropriately. For example, we reduced the electricity use of an occasionally used, inefficient desktop computer by 95% by replacing it with a micro-sized desktop with basic functionality, ultra-low power use and power management settings enabled (Figure 4).

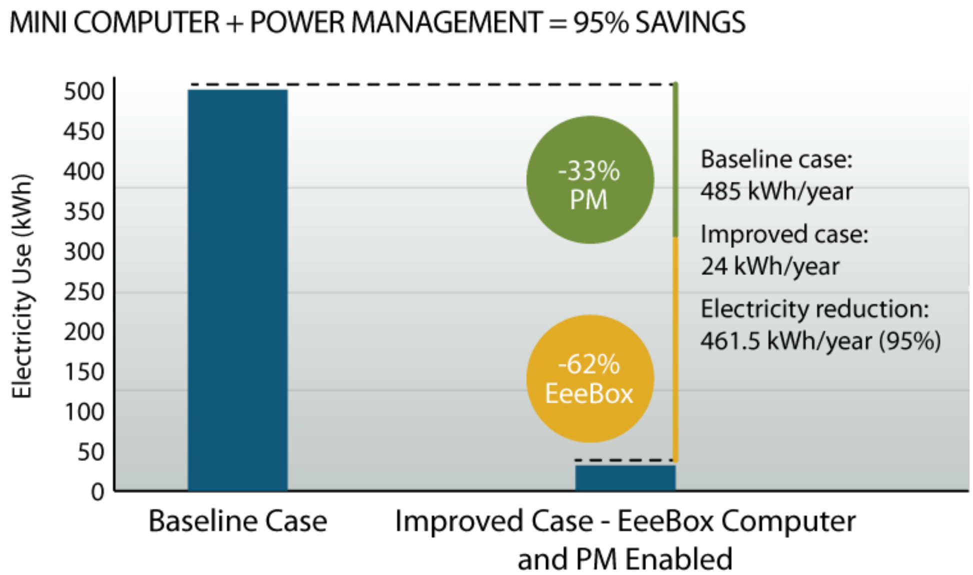


Figure 4. Mini Computer + Power Management = 95% Savings

Summary of Savings Opportunities per Site. By installing upgrades on 39 devices (15 at the library and 24 at the small office), we reduced the energy consumption of affected plug loads by 17% at the library and 46% at the office. Extrapolating these findings to estimate potential energy savings for a realistic scenario at each site, we found that *low*- and *no-cost* energy savings strategies could save about 12,270 kWh per year at the library (19% of studied plug load energy use) and about 5,180 kWh at the small office (40% of studied plug load energy use) (Figures 5 and 6). These savings represent 1% and 3% of the total building energy use at the library and the small office, respectively. Because the library already automatically powers down desktop computers in the public area, there were more energy savings opportunities per square foot at the small office. Also, we found that because of the size and the public nature of the library, capturing energy savings opportunities there presented more challenges in terms of time and effort.

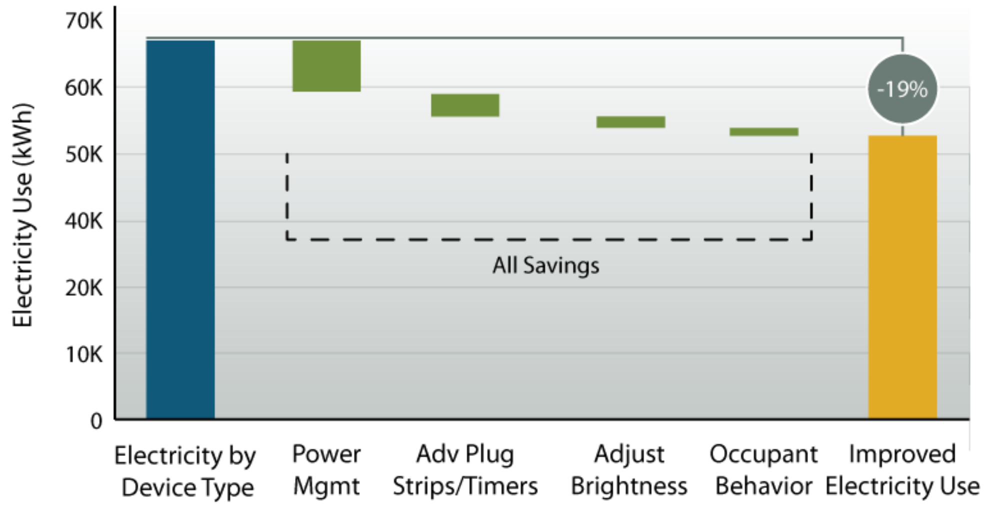


Figure 5. Public Library - About 12,270 kWh per Year (19% of Studied Plug Load Energy Use)

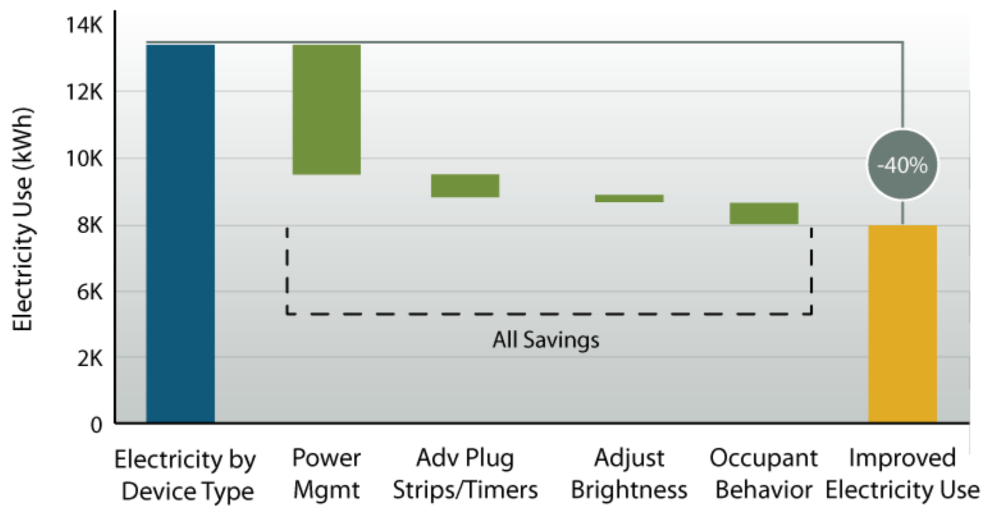


Figure 6. Small Office - About 5,180 kWh per Year (40% of Studied Plug Load Energy Use)

When these buildings are ready to upgrade equipment, additional savings could be achieved by replacing those desktop computers that do not require large memories or processor speeds with micro-sized desktops and by replacing other desktop computers, monitors and imaging equipment with the most efficient models.

Table 1. Electricity Reduction Strategies

Electricity Reduction Strategy	Applications	Savings Potential	Barriers
Power Management Settings Network-wide and local	Computers and imaging equipment	Mid-High Largest electricity savings opportunity	• Lack of user information and education • Requests for remote access to desktop computer • Conflicts with IT management policies
Timers/Timer plug strips	Legacy devices with regular schedules	Low-Mid Very effective at reducing standby power (>20W) in older imaging equipment	• Lack of user information and education • Benefits must be weighed against cost of control strategies
Load sensor plug strips Automatically turn off power at a certain thresh-old	Workstations	Depends on user behavior Easy, low-cost way to eliminate electricity used by peripherals	• Lack of user information and education • Savings depends on user behavior • Benefits must be weighed against cost of control strategies
Occupant behavior measures Feedback monitoring displays and Outlook® reminders	Workstations	Depends on user behavior • An Outlook reminder reduced computer electricity use by 6% on average • Feedback monitoring saved 51% of electricity use at one workstation	• Savings depends on user behavior • Ongoing savings could not be proven
New equipment Replacing inefficient equipment and sizing replacements appropriately	All equipment	High Best-class equipment with power management enabled	• Savings must be weighed against cost of new equipment • Typically cost-effective at procurement cycle

Although the range of savings potential may vary widely by office, a low- to no-cost approach can be the first energy savings action to reduce office plug loads by 19%-40%, even at buildings already employing green and energy efficient strategies. Because these efficient buildings have generally low overall plug load energy use compared to the CEUS average, the absolute savings would be significantly more at office buildings with less efficient equipment or higher densities.

Because of the small size of the study, we cannot make sweeping conclusions from our findings. Rather, findings from this field research can be used to suggest savings opportunities and consumer acceptance of various strategies and can help streamline future plug load energy reduction research.

As California marches toward broader requirements for zero net energy commercial buildings, policy makers and utility companies will need to exploit every cost-effective opportunity for office plug load energy reduction. These energy reduction opportunities include:

- Power management of existing equipment
- Advanced plug strips and timers to control legacy equipment
- Power scaling in energy efficiency specifications
- Title 20 for office electronics
- Plug load peak power density requirement in Title 24
- Targeted procurement of highly efficient products
- Aggressive education and awareness campaigns for staff about efficient behaviors and usage patterns

The findings of this study also highlighted the following future research needs:

- Energy use of and savings opportunities for servers and server closets
- Savings potential from behavioral changes
- Incremental cost of measures
- Plug load demand impacts
- Equipment and technology improvements
- Continuous outreach and education efforts

Finally, researchers should leverage the methodology developed during this study. A follow-on study scaled up to a larger sample size and longer duration could build upon the findings and lessons learned from this study, meter devices that haven't been the focus of extended field metering studies such as servers and televisions, and address other gaps we identify in this analysis.