Engaging Tenants in Reducing Plug Load Energy Use

Marta Schantz Waypoint Building Group
Rois Langner, National Renewable Energy Laboratory

ABSTRACT

Plug and Process Loads (PPLs) account for an increasingly large percentage of commercial building energy use in the U.S. due to the rising number of energy intensive plug-in devices. In addition, buildings are becoming more and more efficient and plug load energy use has become an increasingly pertinent component to achieving aggressive energy targets and net-zero energy status. For multi-tenant buildings, controlling plug loads in tenant spaces can be a significant challenge. Luckily, there are a number of PPL reduction strategies, best practices, and lessons learned from numerous commercial real estate and higher education leaders who have successfully engaged building occupants and tenants in reducing PPL energy use. This paper provides actionable PPL reduction strategies and best practices that building owners and managers can immediately apply to their own buildings.

Introduction

Plug and Process Loads (PPLs) account for an increasingly large percentage of commercial building energy use in the U.S. due to the rising number of energy intensive plug-in devices. Multiple studies show that plug loads consume approximately 30% of commercial building energy use (DOE 2010) (NREL 2013) (Stanford 2014) (GSA 2012). In simplest terms, PPLs are defined as anything that is plugged into an outlet, and they cover a wide variety of electronic, computer, refrigeration, and cooking devices, including equipment essential to information processing, medical treatment, and food service businesses. Each of these categories contains hundreds of types of devices (DOE 2016). As buildings become more and more efficient, plug load efficiency has become ever more pertinent to achieving aggressive energy targets and net-zero energy status. Figure 1 shows the breakdown of PPL energy use in the U.S.

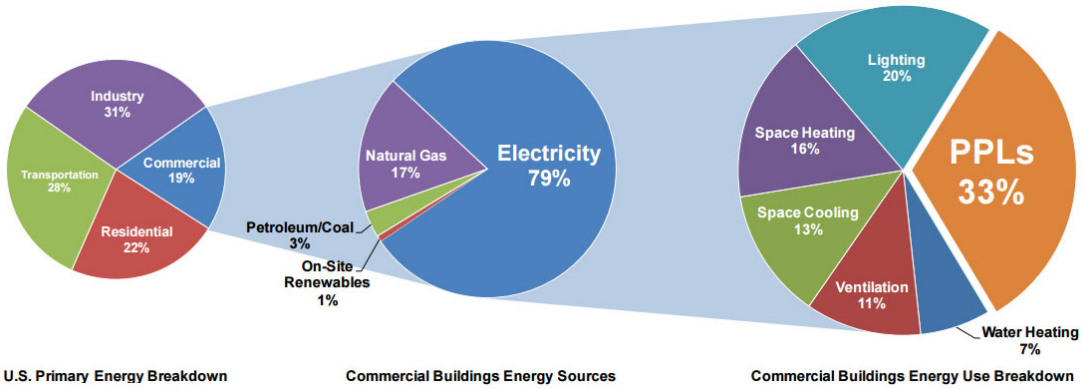

Figure 1. Breakdown of total PPL energy consumed by U.S. commercial buildings. *Source:* NREL 2013.

Often, a fraction of PPL energy is consumed by standby power, also known as parasitic, phantom, or vampire loads. Standby power is generally defined as the minimum electricity consumed by an appliance that is plugged into an alternating current (AC) outlet and switched off, doing nothing, or "not performing their primary" function (LBNL 2016). However, some appliances do not fully cut power off when in standby mode. The parasitic load is only switched off by either unplugging the device or controlling it with smart PPL controls such as advanced power strips (APSs). Occupant engagement campaigns to "turn it off" are another great way to encourage building occupants to reduce plug load energy at the parasitic load level.

Furthermore, there is a general assumption that PPLs require significant power capacities in commercial buildings. PPL power densities (that are often specified in commercial leases) have been requested as high as 16 W/sqft (CBEA 2012), when actual plug load usage has been found to average around 1 W/sqft. Table 1 shows a range of PPL measured and requested power densities in commercial buildings.

Table 1. PPL Power Densities Reported in Literature. *Source:* NREL 2014.

Reference	**Building Type**	**PPL Power Density (W/sqft)**
Wilkins and Hosni (2011)	Office	0.25 to 2.0 (min capacity)
ASHRAE* (2009)	Office	1 (minimum capacity)
Srinivasan et al. (2011)	K-12 education	0.22 to 1.06 (average density)
Metzger et al. (2011)	Office	0.9 (average density, cubicle only)
NRDC* (2011)	Office	7.5 (requested minimum capacity)
GSA* (2011), Haun (2013), GSA (2013)	Office	4 (requested minimum capacity)

*American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); Natural Resources Defense Council (NRDC); U.S. General Services Administration (GSA)

On a progressive note, increasingly stringent standards such as ASHRAE Standards 90.1-2010 and 2013 "Energy Standard for Buildings except Low-Rise Residential Buildings," requires automatic shutoff controls for 50% of power receptacles in specified spaces (ASHRAE 2013). As such, controlling plug loads is no longer an activity that can be ignored or deferred; engaging occupants and tenants in controlling plug loads can be critical for code compliance.

Scheduled shutoff controls can show significant savings for PPLs, especially because commercial buildings, on average, are only occupied one-third of the time. Turning PPLs off during unoccupied hours at night, on weekends, and during holidays presents a tremendous opportunity for energy savings. For example, the National Renewable Energy Laboratory's (NREL's) net-zero energy Research Support Facility (RSF) focuses an enormous effort on turning PPLs off during unoccupied hours in order to meet the building's net-zero energy goals. Table 2 shows annual plug load energy use intensity (EUI - kBtu/sqft) in the RSF that would result from occupied and unoccupied PPL power densities (W/sqft). The red circle shows the plug load EUI that NREL used in its old office space – about 25 kBtu/sqft. By turning equipment off by night, NREL reduced its EUI down to 10 kBtu/sqft in the RSF, as seen in the yellow circle. Furthermore, by using more efficient equipment such as laptops instead of desktops, and consolidating printers into central locations, NREL reduced its daytime PPL EUI to approximately 6 kBtu/sqft as shown in the green circle.

Table 2. PPL Power Density Reduction in NREL RSF. *Source:* NREL 2011.

Annual Plug Load Energy Use Intensity (kBtu/ft²)															
		Unoccupied Hours Power Density (W/ft²)													
		0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
Occupied Hours Power Density (W/ft²)	0.10	3.0	5.2	7.4	9.7	11.9	14.1	16.3	18.6	20.8	23.0	25.2	27.4	29.7	31.9	34.1
	0.20	3.8	6.0	8.2	10.4	12.7	14.9	17.1	19.3	21.5	23.8	26.0	28.2	30.4	32.7	34.9
	0.30	4.5	6.8	9.0	11.2	13.4	15.6	17.9	20.1	22.3	24.5	26.8	29.0	31.2	33.4	35.6
	0.40	5.3	7.5	9.7	12.0	14.2	16.4	18.6	20.9	23.1	25.3	27.5	29.7	32.0	34.2	36.4
	0.50	6.1	8.3	10.5	12.7	15.0	17.2	19.4	21.6	23.8	26.1	28.3	30.5	32.7	35.0	37.2
	0.60	6.8	9.1	11.3	13.5	15.7	17.9	20.2	22.4	24.6	26.8	29.1	31.3	33.5	35.7	38.0
	0.70	7.6	9.8	12.0	14.3	16.5	18.7	20.9	23.2	25.4	27.6	29.8	32.1	34.3	36.5	38.7
	0.80	8.4	10.6	12.8	15.0	17.3	19.5	21.7	23.9	26.2	28.4	30.6	32.8	35.0	37.3	39.5
	0.90	9.1	11.4	13.6	15.8	18.0	20.2	22.5	24.7	26.9	29.1	31.4	33.6	35.8	38.0	40.3
	1.00	9.9	12.1	14.4	16.6	18.8	21.0	23.2	25.5	27.7	29.9	32.1	34.4	36.6	38.8	41.0
	1.10	10.7	12.9	15.1	17.3	19.6	21.8	24.0	26.2	28.5	30.7	32.9	35.1	37.3	39.6	41.8
	1.20	11.4	13.7	15.9	18.1	20.3	22.6	24.8	27.0	29.2	31.4	33.7	35.9	38.1	40.3	42.6
	1.30	12.2	14.4	16.7	18.9	21.1	23.3	25.5	27.8	30.0	32.2	34.4	36.7	38.9	41.1	43.3
	1.40	13.0	15.2	17.4	19.6	21.9	24.1	26.3	28.5	30.8	33.0	35.2	37.4	39.7	41.9	44.1
	1.50	13.7	16.0	18.2	20.4	22.6	24.9	27.1	29.3	31.5	33.8	36.0	38.2	40.4	42.6	44.9

Getting to such low EUIs does require various levels of occupant engagement and controls, as PPLs are one of the few internal building system loads that have direct interface with tenants and occupants. Because of this, plug load efficiency measures require action from building owners and managers to support tenant education, and tenant buy-in. The following sections of this paper discuss the challenges of engaging tenants and solutions to overcome those challenges.

Challenges

There are many challenges that arise when engaging tenants in reducing plug load energy use. The first of those challenges is educating building owners, property managers, and occupants on the significance of PPL energy use in relation to whole-building energy consumption, and the opportunity that exists in saving energy by controlling PPLs. On average, PPLs consume approximately one-third of whole-building energy use. In providing this awareness, building owners, property managers, and occupants will have the background knowledge and impetus to take part in PPL energy reduction efforts.

Even if stakeholders understand the importance of reducing PPL energy use, the next challenge is to encourage building occupants to take action in controlling PPLs. There are a number of behavioral and technology options on the market ranging from simple messaging campaigns, to APSs, to networked circuit controls. Commercial building decision-makers need to be aware of these options to make more informed decisions about PPL controls, and to understand the benefits and costs of each reduction opportunity.

One of the biggest challenges, even after the business case for PPL efficiency measures has been made and savings have been justified, is the continual need to encourage tenants to reduce PPL energy use. This is especially true in multi-tenant and institutional buildings. Repeated efforts from building owners, managers, and upper management is required to encourage tenants and employees to turn plug loads off, reduce the number of plug-in devices, and overall, reduce their PPL energy impact. Creative messaging and incentive programs can also be an impactful way to encourage tenants and employees to take action.

Solutions

Building owners and managers can overcome the challenges that arise when engaging tenants and building occupants in reducing plug load energy use by leveraging a number of solutions. These solutions include education opportunities, tenant engagement campaigns, and technical solutions; each provides a significant opportunity to impact commercial building plug load energy use.

A wealth of educational resources have been developed that outline these solutions. Table 3 provides information on a few of the organizations and institutions that offer PPL-specific technical guidance, case studies, business case analyses, best practices, and lessons learned from peers and scientific research in the commercial buildings market.

Table 3. Market Resources for PPL Education & Information.

Organization	Description	Plug Load Specifics
Department of Energy's (DOE's) Better Buildings Alliance (BBA)	A platform for commercial building owners, corporate sustainability directors, facilities managers, and engineers to collaborate with technical experts, and together work to accelerate adoption of innovative energy efficiency solutions nationwide.	The BBA's PPL Technical Team shares best practices, deploys current PPL energy reduction information, and introduces new/upcoming PPL energy reduction technologies to commercial building owners/managers. (DOE 2016)
GSA's Green Proving Ground (GPG)	The GPG program leverages GSA's real estate portfolio to evaluate innovative sustainable building technologies.	GPG conducted an Advanced Power Strips pilot study in 2012 with results and details available for interested parties. (GSA 2012)
Regional Energy Efficiency Organizations (REEOs)	REEOs work to accelerate energy efficiency in the building sector through public policy, program strategies and education.	Various REEOs have implemented a number of plug load-focused activities across the U.S. For example, the Northeast Energy Efficiency Partnership convened an APS working group to study energy reduction associated with APSs in residential and commercial buildings. (NEEP 2016)

The educational resources developed by these organizations offer a range of opportunities to reduce plug load energy across all commercial building types. From basic plug load metering to the complex integration of plug load controls with energy management systems and other building systems, these resources offer solutions to address various levels of complexity, effort, cost, and tenant engagement for a particular building. A number of these solutions are described below.

Sub-Metering

To best manage plug loads, it is useful and important to understand baseline PPL energy use and operation. The often-used adage "if you can't measure it, you can't manage it" holds true for many electronic devices, where data collection and analysis can highlight opportunities for savings. While it is possible to get granular energy use data for PPLs, it may be infeasible for all

building owners or managers to collect high-resolution data due to cost or time investments. However, other opportunities exist, including simple data loggers on individual pieces of building equipment, over-the-outlet meters at each plug load outlet, circuit level metering at the plug load-specific panel itself, or a different metering option in between. While metering systems do not directly improve energy efficiency, metering systems enable focused, energy efficient actions to reduce PPL energy consumption.

To illustrate this, the commercial real estate company, Tower Companies, conducted a plug-load energy reduction pilot in one of their multi-tenant office buildings. Before implementing plug load reduction strategies, Tower Companies installed floor-by-floor submeters to first understand the baseline energy consumption associated with PPLs. They then used the submeters to trend PPL energy use after implementing PPL reduction strategies, and quantify the energy savings against the baseline (DCSEU 2016).

Messaging Campaigns

Tenant messaging campaigns and competitions offer more simple options to encourage PPL energy reduction. Tenant messaging campaigns often include training, informational letters or internal newsletters, emails, signage, videos, periodic reminders and updates, and incentive programs. Going a step further, submetering at the tenant or space level can help measure progress over time and feed into competitions, tenant messaging via newsletters, regular meetings, emails, or other announcements.

For example, the real estate organization, Shorenstein, implemented a “Flip the Switch” campaign in 2011 to promote occupant awareness of PPL energy use and encourage occupants to turn equipment off when not in use. The company used educational workshops to help tenants find and capitalize on energy savings opportunities in their own office space. The campaign achieved enough initial success for Shorenstein to expand by rolling out an “I Will if You Will,” tenant energy challenge that provides real-time feedback on energy use, easy strategies for improvement, and incentives to encourage participation (Shorenstein 2016). The “I Will if You Will” challenge participation included over 30 tenants representing 1 million square feet of office space across Shorenstein’s national portfolio. These participants achieved an average of 27% reduction in PPL energy use. Qualitatively, “Flip the Switch” has helped Shorenstein develop long-lasting relationships with its tenants. Focusing on energy efficiency and sustainability at large, the program has led to more active and environmentally conscious tenants. Shorenstein has leveraged the program as a gateway program for new tenant engagement initiatives, and as such the firm continues to enhance and expand its tenant engagement programming. The lessons learned from prior “Flip the Switch” initiatives are informing the next iterations of tenant-facing sustainability programming at Shorenstein (BBC 2015).

Advanced Power Strips

Another opportunity to reduce plug load energy use in tenant spaces is to install APSs at workstations and in common areas (BBA 2015). APSs are similar to conventional power strips that are often used for plugging multiple electronic devices into a wall outlet; however, APSs have built-in technology to reduce PPL runtimes and save energy when the devices are not in use. Contrary to popular belief, APSs can be used across building types and across equipment types; this concept is illustrated in Figure 2 below.

Figure 2. APS Applications across Building Types and Spaces. *Source;* BBA 2015.

The majority of APSs do require a certain level of tenant engagement and buy-in to achieve full savings potential in electronic devices. To ensure that occupants use APSs appropriately, building managers/owners can provide instructional information on how an APS works (NREL 2015) or work with tenants individually via in-person educational sessions.

There are five main types of APS controls that can be used for plug-in equipment, depending on the type of equipment and user preference. These five APS control types are described in Table 4 below: master-controlled, timer, activity monitor, remote switch, and masterless.

Table 4. The Five Common APS Control Strategies. *Source:* BBA 2015.

APS Type	Description	Usage Examples
Master-Controlled	Turn peripheral devices off when a primary device is turned off by the user.	• Office Desk Area/Computer Lab: Desktop/laptop computers connected to a control/master outlet. Monitors/lamps/phone chargers connected to "switched" outlets. • Hotel Room Entertainment Centers: TVs connected to a master outlet. DVD players, speakers, etc., connected to switched outlets. Exceptions include cable boxes or other always-on devices. • Multifamily Room Entertainment Centers: TVs connected to a master outlet. DVD players, game consoles, speakers, lamps, etc. connected to switched outlets. Exceptions include cable boxes or other always-on devices.
Timer	Automatically turn off outlets based on a pre-set schedule.	• Conference Rooms: Projectors, monitors, speakers, etc. Optional motion sensors can be used to turn equipment on or off if meetings end early or if unplanned meetings occur. • Break Rooms: Toasters, microwaves, coffee makers, or any other powered kitchen device. • Printer Rooms: Printers, copiers, fax machines, laminators, pencil sharpeners, hole punchers, etc. • Electronic Display Area: TV displays, computer/cellphone tryout stations, cosmetic lights/mirror stations, jewelry light stations, etc. • Cashier Aisles: Cash registers, conveyor belts, aisle lights, etc. • Gyms in Hotel or Multifamily Spaces: Workout equipment such as treadmills and elliptical machines, TVs, sound systems, etc. • Multifamily Game Room/Party Room: TVs, speakers, other plug-in equipment.
Activity Monitor	Turn equipment on or off in response to motion detected in a room.	• Office Desk – Commercial office, medical office, higher education research office, multifamily leasing office • Conference Rooms: Projectors, monitors, speakers, etc. • Break Rooms: Non-critical appliances • Hotel Business Centers: Computer monitors, printers, etc. • Game Room/ Party Room Multifamily: TVs, speakers, other plug-in equipment.
Remote Switch	Enable users to easily turn off a power strip via a remote switch.	• Office Desk Areas: Computers, monitors, task lamps, printers, miscellaneous plug-in office equipment. • Computer Lab: Computers, monitors, task lamps, printers. • Hotel Room Entertainment Centers: TVs, speakers, other plug-in equipment. • Electronic Display Area: TV displays, computer/cellphone try-out stations, cosmetic lights/ mirror stations, jewelry light stations, etc. • Cashier Aisles: Cash registers, conveyor belts, aisle lights, etc. • Game Room/ Party Room Multifamily: TVs, speakers, other plug-in equipment.
Masterless	Turn off power to outlets completely when the controlled devices are turned off, eliminating vampire loads.	• Office Desk Area: Computers, monitors, task lamps, printers, miscellaneous plug-in office equipment. • Electronic Display Area: TV displays, computer/ cellphone try-out stations, cosmetic lights/ mirror stations, jewelry light stations. • Cashier Aisles: Cash registers, conveyor belts, aisle lights. • Conference Rooms: Projectors, monitors, speakers, etc.

In 2012, GSA GPG coordinated with NREL to test the effectiveness of three plug load reduction strategies in eight federal office buildings throughout GSA's Mid-Atlantic Region. The tested strategies included 1) schedule-based control, 2) load-sensing, and 3) a combination of the two. Schedule-based control was found to be most effective. The program estimated savings from its APS plug load efficiency measures of 26% energy reduction at workstations with advanced computer management already in place, 50% energy reduction in kitchens and printer rooms, and a 2-year payback (GSA 2012).

Equipment Upgrades

When the time comes to upgrade plug-in equipment, low-energy or ENERGY STAR rated products (DOE EERE 2016) should be considered at a minimum. ENERGY STAR is a U.S. Environmental Protection Agency voluntary program that has helped businesses and individuals save money through superior energy efficiency over the past two decades (EPA 2016). Significant energy savings can be achieved by replacing old, inefficient equipment with low-energy or ENERGY STAR-certified equipment. Working with commercial building tenants during tenant improvement fit-outs to encourage the procurement and installation of high-efficiency equipment can result in significant PPL energy savings.

Utilizing Built-In Low Power States

Often, plug load devices and equipment have built-in low power states that, when activated, result in plug load energy savings. Built-in automatic low-power state functionality, such as standby and sleep modes, should be activated in as many devices and equipment as possible. When activated, internal processes monitor idle time and devices enter a low-power state when they have been idle for a given period of time. Automatic low-power states provide limited control, but when configured correctly, are often the most accessible, inexpensive, and effective energy-saving strategy. A prime example of this type of control is a computer entering "sleep" mode. One challenge with low-power state control is ensuring that information services departments enable appropriate settings and use newly available updating techniques (such as wake-on local area network) to update software and maintain effective business operations.

Space Optimization and Design Strategies

When it comes to new construction and major renovation projects, design teams have the opportunity to consolidate and optimize the layout of PPLs in a space. A designated "plug load champion" is recommended to work with the design team to ensure that PPLs are considered in the design, and that standard specifications, operations, and design standards that limit energy-saving opportunities are questioned. The design team also plays a key role in maximizing space efficiency, which increases the ratio of occupants per building area to specific pieces of equipment. Space efficiency can drastically reduce PPL energy use and can be achieved by consolidating break rooms, providing common print areas, and cafeterias. Consolidated equipment is used more efficiently than distributed equipment at each workstation, and thus the number of PPLs and PPL energy use is lowered.

Integrated Control Strategies and Energy Displays

Integrating PPL controls into other building systems is a more technical, detailed, and costly approach, but can offer significant PPL energy savings. For example, PPL controls can be integrated into a building's electrical system to control outlets at workstations and in common areas when a space is unoccupied. This strategy can be as simple as installing switches, vacancy sensors, or timed disconnects on outlets, or as sophisticated as controlling outlets through the building management system. These integrated control strategies typically apply to new construction, whole-building retrofits, large tenant improvement fit-outs, and staged retrofit projects.

Additionally, more for new construction or major renovation projects, aggregating PPLs onto dedicated electrical panels can enable long term, deep PPL savings opportunities. With dedicated PPL panels, circuits can be integrated with occupancy sensors through a building energy management system to turn off PPLs during nonbusiness or unoccupied hours. These panels also allow for easy energy submetering, which can be used to develop a building PPL energy-use display system that can provide feedback to the occupants. Dashboards and computer systems with real-time data feedback provide opportunities for tenant engagement and education in novel and interesting formats.

PNC Bank conducted a study to test the impact of energy dashboards on office occupants. Each workstation had access to an energy dashboard that provided feedback to the occupant (self-monitoring of personal computers, advice to reduce energy, and comparison of occupant energy to others), allowed remote control of workstation equipment, and automated controls based on individual occupant schedules. Workstations equipped with all four features achieved average energy savings of 35.4% (SpringerLink 2013).

Costs and Expected Energy Savings

The cost of implementing plug load control strategies varies. The Department of Energy (2015) recently published a set of decision guides that provides a range of costs (low, medium, or high), potential energy savings, implementation complexity and technical ease for several PPL control strategies. Each guide is tailored to show how the control strategies apply to specific building end uses, offering solutions for several building types. The resource also characterizes the control strategies by project type, providing users with insight into the appropriateness of the strategies for difference stages of building renovation or construction projects.

Additionally, when considering the full project cost of PPL energy reduction strategies, commercial building teams should make sure to take advantage of local utility incentives (DOE 2016) to bring down project implementation costs. Incentive programs are available for purchasing APSs in commercial properties across many utilities and efficiency organizations nationally.

Estimating savings from PPL efficiency measures can be a subjective process if a building does not have sufficient baseline energy use data or pilot test information on hand. To help estimate PPL energy savings in an office setting, NREL has published a free savings calculation worksheet (NREL 2013) to provide direction and clarity on calculating the savings potential of individual PPL devices and equipment. This is a hands-on exercise; the worksheet instructs users to conduct a walkthrough audit to inventory plug load equipment and calculate the estimated energy savings for recommended PPL strategies in each space.

It is important that each project estimate PPL energy savings, as these numbers can vary. Variations depend on variables such as the specific energy savings strategies chosen to implement, tenant buy-in, baseline energy usage, and available financial incentives.

Lessons Learned and Best Practices for Tenant Engagement

One of the easiest ways to understand appropriate tenant engagement PPL reduction strategies is to pull lessons learned and best practices from similar case studies. Table 5 highlights tenant engagement efforts from various commercial building owners that were used to encourage tenants to reduce PPL energy use.

Table 5. Tenant Engagement Strategies for PPL Energy Reduction

Strategy	Description	Examples
Messaging Campaigns	Emails, posters, slogans, lunch & learns, and building-wide events to promote specific PPL reduction efforts to building occupants/tenants	• Shorenstein "I Will if You Will" Campaign (BBC 2015) • Tower Companies messaging campaign and APS education pilot with DC Sustainable Energy Utility (DCSEU 2016)
Competitions	Peg offices, floors, or staff against each other or against others in a multi-tenant building to encourage more plug load efficiencies	• Interactive educational messaging: Energy Chickens, software dashboard, reward or incentive programs (Penn State 2013) (Researchgate 2013)
Tenant Incentives	Provide a monetary or prize incentive to tenants that meet specific plug load efficiency targets	• GSA's Wayne Aspinall Net Zero Courthouse (DOE 2014) • Stanford "Space heater Swap" fleece for space heater (Stanford 2015)
Data Transparency	Use dashboards and public screens to show efficiency and plug load energy consumption among tenants	• PNC Bank dashboard and engagement strategy for occupants (SpringerLink 2014)
Green Leases	Encourage tenant plug load efficiency by writing requirements into new leases	• Green Lease Library (GLL 2016)

Each of these occupant engagement strategies has been implemented in commercial buildings to varied success. The following results are presented to illustrate success of the strategies listed in Table 5:

- Messaging Campaigns: The Shorenstein real estate organization saw a 16.2% reduction in portfolio-wide energy use since 2008, a portion of which is attributed to their "Flip the Switch" comprehensive tenant engagement program (BBC 2015). Similarly, Tower Companies worked with tenant energy champions to pilot the use of APSs in combination with tenant educational material and in-person APS installation (DCSEU 2016).
- Competitions: A team at Penn State University developed the PPL behavioral change game, Energy Chickens that monitors energy use data collected by plug-in devices. The game provides graphical information about energy use accompanied by recommended ways to reduce energy use of specific appliances. Pilot deployment of the dashboard showed a 30% reduction in plug-load energy consumption (Penn State 2013) (Researchgate 2013).
- Tenant Incentives: GSA's Wayne Aspinall Net Zero Courthouse leveraged a number of PPL control strategies including sub-metering, energy use displays, and APS controls. To ensure PPL energy savings in tenant spaces, GSA incentivized their tenants by rewarding a portion

of the rentable square footage fee back to the agency if they met their PPL energy target (DOE 2014). In a different example, Stanford University conducted a campus-wide PPL inventory and recorded 955 space heaters, consuming 517,634 kWh/yr. Stanford incentivized students to swap their space heaters for a Sustainable Stanford fleece jacket (Stanford 2015).

- Data Transparency: PNC Bank rolled out an intelligent dashboard for occupants that provided feedback on energy use, remote control of equipment, and automated equipment controls. Resulting energy savings was 35.4% at each workstation (SpringerLink 2014).
- Green Leases: Green leases align financial and energy incentives of building owners and tenants so they can work together to save money, conserve resources, and ensure efficient building operations. Because plug loads are heavily tenant-facing, green leases provide a strong opportunity for achieving savings through tenant engagement (GLL 2016).

Conclusion

PPLs consume approximately 30% of commercial building energy use. Attributing to such a high portion of whole-building energy consumption, controlling PPLs and reducing their energy use is critical in achieving aggressive energy targets and net-zero energy status. Engaging tenants in reducing plug load energy consumption is a key factor in meeting these energy targets, even if it may not be an easy task for commercial building owners to implement. Numerous tenant engagement solutions exist, whether through more hands-off options such as APSs, or through more high-touch activities such as tenant competitions and prizes. These solutions have proven results and can be adopted by commercial building owners to achieve significant PPL energy savings.

Most successful tenant engagement strategies have included a combination of tenant education on PPL energy reduction efforts, messaging, incentives to encourage continued action, and cost-effective controls such as APSs. Newer innovations are also entering the commercial building market, which can be especially beneficial for new construction or major renovation projects. These strategies include integrated controls and building connectivity, networked controls and panels, and big data integration – all providing behind the scenes opportunities to save PPL energy without interrupting tenant day-to-day activities.

Together, these opportunities provide a number of technical solutions and tenant engagement activities for commercial building owners to investigate and implement immediately in their buildings. Obtaining tenant buy-in for PPL efficiency via messaging campaigns, competitions, incentives, or dashboards will jumpstart energy efficient activities throughout the building, and consistent outreach and engagement with tenants will support long-term persistent savings building-wide.

References

ASHRAE. (2013). “Standard 90.1-2013 (I-P Edition) -- Energy Standard for Buildings except Low-Rise Residential Buildings” http://www.techstreet.com/ashrae/products/1865966?utm_source=promotion&utm_medium=landingpage&utm_campaign=86273&utm_term=86273&utm_content=86273&ashrae_auth_token=

Better Buildings Alliance. (2015). “Leveraging the Advanced Power Strip (APS) Technical Specification for Commercial Buildings.” https://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/BBA-PPL-APS-Tech-Spec-Webinar-July-2015-508.pdf

Better Buildings Challenge. (2015). “Implementation Model: ‘Flip the Switch’ Tenant Engagement Program” http://betterbuildingssolutioncenter.energy.gov/implementation-models/%E2%80%9Cflip-switch%E2%80%9D-tenant-engagement-program

CBEA 2012 - CBEA [Commercial Buildings Energy Alliance]. 2012. CBEA Efficiency Forum Report. Accessed September 20, 2013: http://www1.eere.energy.gov/buildings/alliances/pdfs/cbea_efficiency_forum_report.pdf

DC Sustainable Energy Utility and Institute for Market Transformation. (2016). “Increasing Tenant Engagement through Plug Load Management”

Department of Energy. (2010). Buildings Energy Data Book. Washington, DC: Office of Energy Efficiency and Renewable Energy. http://buildingsdatabook.eren.doe.gov/

Department of Energy. (2014) “Aspinall Courthouse: GSA’s Historic Reservation and Net-Zero Renovation” http://www.nrel.gov/docs/fy15osti/62360.pdf

Department of Energy. (2015). “Decision Guides for Plug and Process Load Controls” http://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Decision_Guides_for_PPL_Controls_0.pdf

Department of Energy Better Buildings Alliance Plug and Process Loads Technical Team Website. (2016). https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/plug-process-loads

Department of Energy Office of Energy Efficiency & Renewable Energy. (2016). “Energy- and Water-Efficient Products.” http://energy.gov/eere/femp/energy-and-water-efficient-products

Environmental Protection Agency. (2016). ENERGY STAR website. https://www.energystar.gov/

General Services Administration APS Study. (2012). http://www.gsa.gov/portal/content/164611

Green Lease Leaders Website. (2016). http://greenleaselibrary.com/

Lawrence Berkeley National Laboratory (2016). “Standby Power” http://standby.lbl.gov/standby.html

NEEP. (2016). “Regional Energy Efficiency Organizations Network” http://www.neep.org/network/regional-energy-efficiency-organizations-network

NREL. (2015). “How to use APS in an Office Setting.” http://www.nrel.gov/docs/gen/fy15/63800.pdf

NREL. (2014) “Plug and Process Loads Capacity and Power Requirements Analysis.” http://www.nrel.gov/docs/fy14osti/60266.pdf

NREL. (2013) “Assessing and Reducing Plug and Process Loads in Office Buildings” http://www.nrel.gov/docs/fy13osti/54175.pdf

NREL. (2011). “Reducing Plug and Process Loads for a Large Scale, Low Energy Office Building: NREL’s Research Support Facility.” http://www.nrel.gov/docs/fy11osti/49002.pdf

Shorenstein. (2016). Flip the Switch Campaign website. http://greenshorenstein.info/main.cfm?sid=ftswitch&pid=iwiywill

SpringerLink. (2014) “The Design and Evaluation of Intelligent Energy Dashboard for Sustainability in the Workplace” http://link.springer.com/chapter/10.1007/978-3-319-07635-5_58

Stanford University. (2014) “Plug Load Inventory White Paper” http://sustainable.stanford.edu/resources/library/plug-load-inventory-white-paper

Stanford University. (2015). “Space Heater Swap” http://sustainable.stanford.edu/cardinal-green/cardinal-green-buildings

Penn State University Studio Lab. (2013) “Energy Behavior Change” http://studiolab.psu.edu/projects/energy-behavior-change

ResearchGate. (2013). “Energy Chickens and Dashboard Players: Giving Occupants the Power to Save Energy.” https://www.researchgate.net/publication/264000852_Energy_Chickens_and_Dashboard_Players_Giving_Occupants_the_Power_to_Save_Energy