



**Better Buildings Alliance
Plug and Process Loads (PPLs) Team Webinar**

Technical Lead: Kim Trenbath, NREL

March 17, 2021

Plug and Process Loads (PPLs) Technology Research Team



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Agenda

BBA PPL Team Update

Integrated Lighting Campaign – Felipe Leon, PNNL

Technical Presentation – Dr. Joy Pixley, CalPlug
Beyond Energy Efficiency: How Your Device Energy Usage Patterns Affect Energy Consumption

Member Updates

Q&A

PPL Resources for Building Owners

<https://betterbuildingsolutioncenter.energy.gov/alliance/technology-solution/plug-process-loads>

- Recorded webinars
- *NEW* Utility incentives
- Fact sheets (i.e. plug load disaggregation)
- Case studies
- *NEW* Guides for assessing and reducing plug loads



Assessing and Reducing Plug and Process Loads in Retail Buildings

Introduction

Plug and process loads (PPLs) account for 4% of U.S. commercial building energy consumption (EIA 2020) (see Figure 1). Minimizing these loads is a significant challenge for energy-efficient building design and operation.

Langner and Trembath (2019) define PPLs as all plug-in and hardwired loads in a building that are not associated with heating, ventilating, and air conditioning (HVAC), lighting, water heating, or other major equipment needed for basic building operation. This includes all plug-in equipment and appliances, as well as processes for cooking, computing, and internal transportation. The percentage of total building energy use from PPLs is increasing; by 2029, the percentage of PPL energy consumption is anticipated to increase to 51% (EIA 2020). The commercial sector is making strides increasing energy efficiency in other end uses, such as HVAC and lighting, but to continue the trend of reducing whole-building energy consumption, PPLs must be targeted as well.

Retail PPLs present a unique challenge because they can directly generate revenue (e.g., vending machines) or be items for sale (e.g., televisions on display). Figure 2 shows the measured PPL energy use for a large retail building and the potential energy cost savings associated with a 30% PPL reduction (in this example, \$40,000 annually).

U.S. PRIMARY ENERGY BREAKDOWN

Category	Percentage
Industrial	22%
Residential	21%
Commercial	18%
Transportation	28%
Water Heating	4%
Space Heating	14%
PPLs	47%

COMMERCIAL BUILDINGS ENERGY CONSUMPTION BREAKDOWN

Category	Percentage
Lighting	9%
Refrigeration	9%
High-rise	10%
PPLs	47%

Figure 2. A 30% saving in PPL energy use would save \$40,000 annually.

Category	Annual Energy Cost (\$/year)
Before	130,000
After	90,000

Automatic Receptacle Controls

Automatic receptacle controls are outlets installed in the building that can be controlled to shut off power to appliances based on schedule or occupancy. This may be done wirelessly, using sensors, or using buttons on the device. This strategy is effective for automatically controlling devices and for meeting the most recent ASHRAE standards (ASHRAE 2019) on PPL controls. To determine what method of control (schedule, occupancy) is most relevant for each device, see Table 2-2 in Lobato et al. (2012).



Figure 5. Automatic controlled receptacle. Photo from Japovst

Integrated Controls

Integrated controls are an emerging area that offers potential for connecting lighting, HVAC, and PPL systems to monitor and control them together. They are not widely available yet but will soon be relevant in the market. This strategy is effective for automatically controlling devices and understanding full building and device-specific energy usage and behavior. Using various sensors (such as occupancy and photosensors), they can connect multiple systems for centralized control and monitoring and further interoperability. The sensor data is logged and can be analyzed to better understand energy savings and the building operation.



Photo, NREL 40314 4031

Assessing and Reducing Plug and Process Loads in Retail Buildings

Assessing and Reducing Plug and Process Loads in Retail & Office Buildings



Designate a PPL champion

Choose someone who understands PPL systems and can work with all teams to implement system controls.



Institutionalize PPL reduction practices

Formalize and incorporate PPL energy-saving tactics into building policies (see guide for examples).



Establish the business case for PPL reduction

Utilize available resources to demonstrate the potential energy and financial savings from PPL reduction.



Educate employees on the benefits

Educate employees on the benefits of PPL reduction to realize improvements and prevent misuse.

Access the Retail Guide at:

<https://www.nrel.gov/docs/fy20osti/76998.pdf>

Access the Office Guide at:

<https://www.nrel.gov/docs/fy20osti/76994.pdf>

Better Buildings Beat Blog Post



The screenshot shows the Better Buildings website header with the logo, a search bar, and navigation menus. The main content area features a blog post with a title, author information, and two paragraphs of text. An image of a power strip with a green plug is also visible.

Better Buildings
U.S. DEPARTMENT OF ENERGY

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STRATEGIES FOR REDUCING PLUG AND PROCESS LOAD ENERGY USE IN THE RETAIL SECTOR

By Better Buildings Beat Team on Aug 24, 2020

Plug and Process Loads (PPLs) are building electrical loads used by plug-in equipment and appliances as well as processes for cooking, computing, and internal transportation. PPLs consume more than 45% of commercial building energy use, and this number is **expected to increase to more than 50% by 2029** as buildings become more efficient and occupants plug in additional electronic devices. Furthermore, during unoccupied times, PPLs can use substantial energy, a challenge that has impacted many retail partners as commercial buildings sat empty or adjusted operating hours in 2020. In response to increased interest, the [Plug and Process Load Technology Research Team](#), part of [DOE's Better Buildings Initiative](#), updated the [Assessing and Reducing Plug and Process Loads in Retail Buildings](#) guide for retailers to curtail energy use from PPLs in their buildings.



DOE's guide was recently updated to reflect the current state of commercial energy usage and the PPL control market, as well as to detail necessary steps for planning and executing an effective PPL control strategy. It includes guidance based on research and findings from plug load management field studies, and features current plug load management technologies such as wireless meter and control devices like smart outlets, automatically controlled receptacles, and advanced power strips.

The [Plug Load Efficiency Utility Incentives](#) database has also been updated. This companion resource to the Retail Guide identifies over 300

Access the Blog Post at:

<https://betterbuildingsolutioncenter.energy.gov/beat-blog/strategies-reducing-plug-and-process-load-energy-use-retail-sector>

Plug Load Management System Emerging Technologies

- PPL team's paper, [Emerging Technologies for Improved Plug Load Management Systems: Learning Behavior Algorithms and Automatic and Dynamic Load Detection](#), was published in the [ACEEE 2020 Summer Study](#) conference proceedings.
- One-page fact sheet, [Emerging Plug Load Management Technologies that Save Energy and Time](#), summarizes findings from Trenbath et al. (2020), ACEEE conference paper

Emerging Technologies for Improved Plug Load Management Systems: Learning Behavior Algorithms and Automatic and Dynamic Load Detection
*Kim Trenbath, Bennett Doherty, National Renewable Energy Laboratory
Katie Vrabel, Carly Burke, Waypoint Energy*

ABSTRACT

Plug loads are responsible for commercial buildings, yet their distribution and control are challenging building end users to manage. Smart plugs to meter and control devices in part because of the significant behavior algorithms and automatic could accelerate the adoption of plug and providing additional energy efficiency algorithms learn occupant behavior allowing for the automatic creation detection allows a plug load management building and keeps the system up to date. We present our findings on this existing research and patents as well as plug load space. We found that no current technologies, and more work is needed findings related to the technology of these technologies moving forward.

Introduction

Plug and process loads (PPL) commercial buildings and this period (2020). PPLs are challenging to manage building and can consist of numerous PPL reductions, building standards International Energy Conservation Code that require a portion of the outlets to be turned on and off automatically via power consumption when not in use. 30% savings on PPL energy consumption. Currently, there are solution capabilities down to the socket level technologies collect power consumption off by controlling the flow of electrical hardware located between the outlet into the outlet itself. These smart plug

©2020 Summer Study on Energy Efficiency in

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Fact Sheet: Emerging Plug Load Management Technologies that Save Energy and Time
BETTER BUILDINGS ALLIANCE

Introduction

This fact sheet introduces two emerging technologies that could streamline plug load management (PLM) for increased energy savings for building owners. Plug loads are responsible for 47% of the energy consumed in commercial buildings¹, yet their distributed and ever-changing nature makes them challenging to manage. PLM systems exist today that use smart plugs to meter and control devices at the outlet level, but their uptake has been relatively slow in part because of the significant labor required for installation and maintenance.

Two emerging technology areas may address these challenges and provide additional energy efficiency and nonenergy benefits:

Learning behavior algorithms (LBA) learn occupant behavior and adjust plug load controls accordingly, allowing for the automatic creation of optimized control schedules.

Automatic and dynamic load detection (ADLD) allows a PLM system to identify devices as they are plugged in to a building and keeps the system up to date as devices are moved throughout a building.

This fact sheet summarizes the findings from a 2020 conference paper.²

What is the current state of LBA & ADLD technologies in PLM systems?

- ▶ **Learning Behavior Algorithms**
Behavior-based machine learning algorithms have been applied to HVAC and lighting end uses more frequently than plug loads. Still, some companies are actively investigating LBA for plug load applications. There are at least 5 companies developing or offering products with behavior-based machine learning technologies.
- ▶ **Automatic and Dynamic Load Detection**
At the time of this writing, there is no well-vetted technology through which a building management system can automatically identify the type and location of a device plugged in to an outlet. There are several ADLD-related patents and completed research projects supporting the R&D of this technology. Three of the 7 companies interviewed for this paper have explored ADLD plug load applications. Depending on market demand, this technology is expected to become available to consumers within 3-5 years.

Conclusions

As PLM evolves, expect to see the integration of LBA and ADLD into product offerings, with LBA arriving to market earlier. Both will allow for streamlined plug load control, saving building owners time and money in their pursuit of energy savings.

KEY TAKEAWAYS

- ▶ LBA reduce human impact in a PLM system and can predict anomalies, flagging possible issues in device performance and health. Additionally, LBA could encourage integration of plug load data with data from other sources. Researchers are working to expand the technology beyond simple cases and single building types, and to provide a low-cost product to meet market demand. There are at least 5 companies developing or already offering products with LBA technologies.
- ▶ ADLD offers a plug-and-play system and easy installation that saves time. Researchers are working to reduce development costs and fully automate the technology. ADLD is expected to become available to consumers within 3-5 years.
- ▶ Some areas of R&D for both technologies are scaling for large commercial building applications, achieving economies of scale, and addressing data privacy and cybersecurity.

¹ EIA (U.S. Energy Information Administration). 2020. Annual Energy Outlook 2020. <https://www.eia.gov/outlooks/aeo/>.

² K. Trenbath, et al. (2020). Emerging Technologies for Improved Plug Load Management Systems: Learning Behavior Algorithms and Automatic and Dynamic Load Detection. ACEEE Summer Study Energy Efficiency Building, 409.

Learn more at betterbuildingsolutioncenter.energy.gov

ENERGY

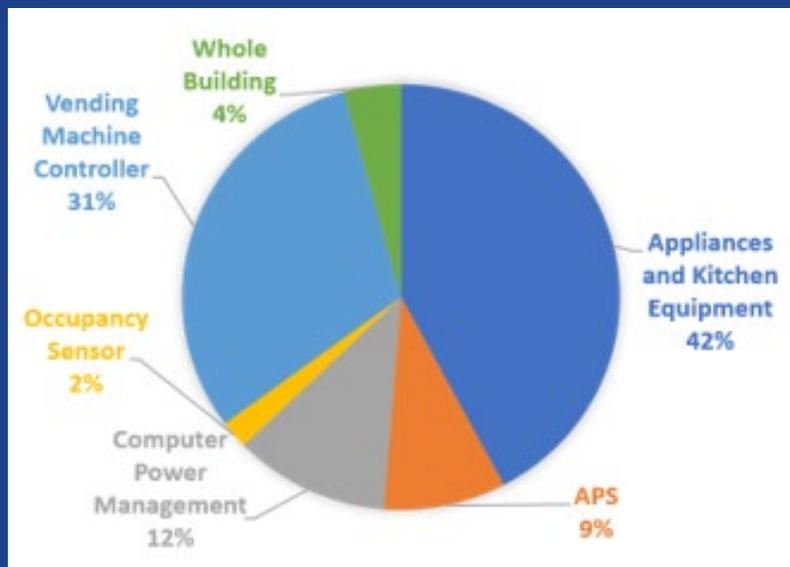
Recently updated! PPL Utility Incentives List

Incentive Sponsor	State	Rebate/Incentive	Applica	Type of Incentive	PPL Strategy	URL	Details
Empire Arkansas	AR	\$90/unit	Commerci	Prescriptive Reb	Vending Machine Control	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	\$90/unit	Commerci	Prescriptive Reb	Vending Machine Control	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	\$40/unit	Commerci	Prescriptive Reb	Vending Machine Control	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	\$145/unit	Commerci	Prescriptive Reb	Vending Machine Control	http://empirearkansas.programprocessing.com/content/prescri	Evaporat
Entergy Arkansas	AR	\$0.10/kWh	Commerci	Custom Rebate	Computer Power Manager	http://www.energy-arkansas.com/your_business/save_money/	Up to 100
Arizona Public Service Company (APS)	AZ	Varies	Commerci	Prescriptive Reb	Whole Building	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	Contact p
Arizona Public Service Company (APS)	AZ	\$8/computer	Commerci	Prescriptive Reb	Computer Power Manager	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	CPM Sof
Arizona Public Service Company (APS)	AZ	\$100/unit	Commerci	Prescriptive Reb	Vending Machine Control	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	Beverage
Arizona Public Service Company (APS)	AZ	\$50/unit	Commerci	Prescriptive Reb	Vending Machine Control	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	Snack ma
SRP	AZ	\$100/controller	Commerci	Prescriptive Reb	Vending Machine Control	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Reach-in
SRP	AZ	\$100/controller	Commerci	Prescriptive Reb	Vending Machine Control	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Beverage
SRP	AZ	\$40/controller	Commerci	Prescriptive Reb	Vending Machine Control	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Snack ma
SRP	AZ	\$8/PC	Commerci	Prescriptive Reb	Computer Power Manager	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Network

Use the List to Sort by:

- Incentive sponsor
- State
- Type of incentive

Access the [PPL Incentive List](#) under the Featured Solutions on our webpage



Better Buildings Beat Blog Post coming soon!

Coming Soon... Smart Outlet Fact Sheet

- Smart Outlets: Wireless Meter and Control Systems for Plug and Process Loads
- Access at:
<https://www.nrel.gov/docs/fy21osti/77971.pdf>



Smart Outlets: Wireless Meter and Control Systems for Plug and Process Loads

What are smart outlets?

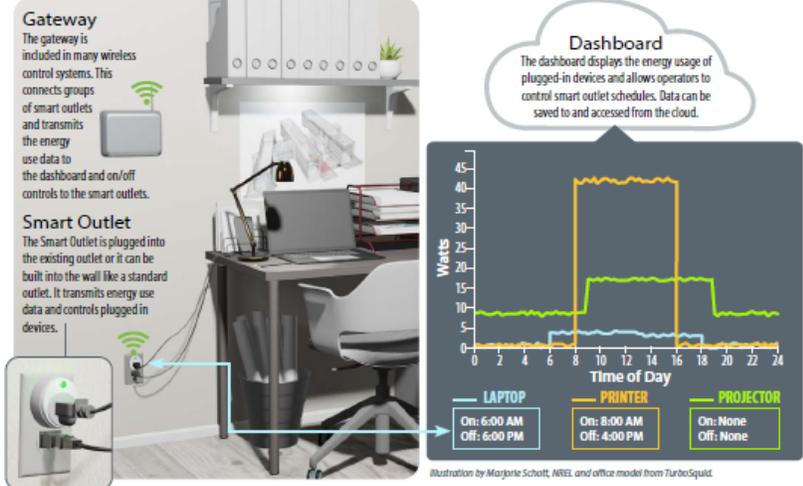
Smart outlets control the flow of power to devices plugged into them and measure their energy use. These outlets collect control and energy data, which are then sent wirelessly, often via an intermediate gateway, to a cloud database or the building's energy management system (EMS). Often, data can be accessed via an online dashboard or smartphone application, allowing the user to turn power to plug-in devices on or off based on a schedule established in the dashboard or application. Additionally, some smart outlet systems use machine learning algorithms that can predict schedules, while others can apply controls based on occupancy sensor data. There are buttons built directly into smart outlets that allow the in-room user to instantaneously override the control and turn on power delivery through the outlet.

Smart outlet systems can also be connected to lighting and heating, ventilating, and air-conditioning systems through an energy management information system (EMIS) platform or advanced lighting controls. This interoperability allows building system energy use to be optimized by leveraging sensor data and building schedules, improving overall operation and efficiency.

Gateway
The gateway is included in many wireless control systems. This connects groups of smart outlets and transmits the energy use data to the dashboard and on/off controls to the smart outlets.

Smart Outlet
The Smart Outlet is plugged into the existing outlet or it can be built into the wall like a standard outlet. It transmits energy use data and controls plugged in devices.

Dashboard
The dashboard displays the energy usage of plugged-in devices and allows operators to control smart outlet schedules. Data can be saved to and accessed from the cloud.



Device	On	Off
LAPTOP	6:00 AM	6:00 PM
PRINTER	8:00 AM	4:00 PM
PROJECTOR	None	None

Illustration by Margerie Schott, NREL, and office model from TurboSquid.



Check Out Our PPL Recorded Webinars!

Access PPL webinars from -

- PPL Website at: <https://betterbuildingsolutioncenter.energy.gov/alliance/technology-solution/plug-process-loads>
- On-Demand Better Buildings Webinars [webpage](#).

The image shows two screenshots of the Better Buildings website. The top screenshot displays the 'PLUG & PROCESS LOADS' section, featuring a green power cord plugged into a white outlet. The bottom screenshot shows the 'ON-DEMAND BETTER BUILDINGS WEBINARS' page, which includes a 'Watch Now' button circled in green. Below the main content, there is a section titled 'EXPLORE WEBINARS BY TOPIC' with three columns: 'TECHNOLOGY', 'SECTOR-SPECIFIC', and 'BEYOND ENERGY'. The 'Plug & Process Loads' link under 'TECHNOLOGY' is also circled in green.

TECHNOLOGY

- Building Envelope
- Energy Data Management
- Lighting
- Plug & Process Loads
- Refrigeration
- Renewables Integration
- Resilience
- Space Conditioning
- Zero Energy Buildings

SECTOR-SPECIFIC

- Data Centers
- Industrial
- K-12 Schools
- Multifamily
- Smart Labs

BEYOND ENERGY

- Communications & Engagement
- Financing
- Green Leasing
- Health & Wellness
- Treasure Hunts
- Waste Reduction
- Water & Wastewater
- Workforce Development
- Working with National Labs

Upcoming PPL Webinar

- **Title:** Getting to Net Zero Energy Through Strategic Building Operations and Plug Load Management
- **Date/Time:** May 25, 2021; 1:00pm ET / 11:00am MT
- **Description:** Properly managing plug loads were key in the Houston Advanced Research Center (HARC) transitioning its headquarters from a LEED Platinum office building to becoming the first Net Zero Energy certified office building in Texas in early 2020. Learn more about the technologies used and strategies adopted to manage and reduce plug loads and overall building energy consumption.
- **Registration link:** <https://attendee.gotowebinar.com/register/1684985489526186253>



[Register today](#) for the **free** Better Buildings Summit on May 17-20, 2021

A promotional banner for the Better Buildings Summit. The background is a blue geometric pattern on the left and a photograph of a city skyline (likely San Francisco) on the right. The text is overlaid on the blue pattern.

MAY
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2021

Better Buildings, Better Plants

SUMMIT

A LEADERSHIP SYMPOSIUM



Felipe Leon

Pacific Northwest National Laboratory (PNNL)



Integrated Lighting Campaign

Felipe Leon
Electrical Engineer

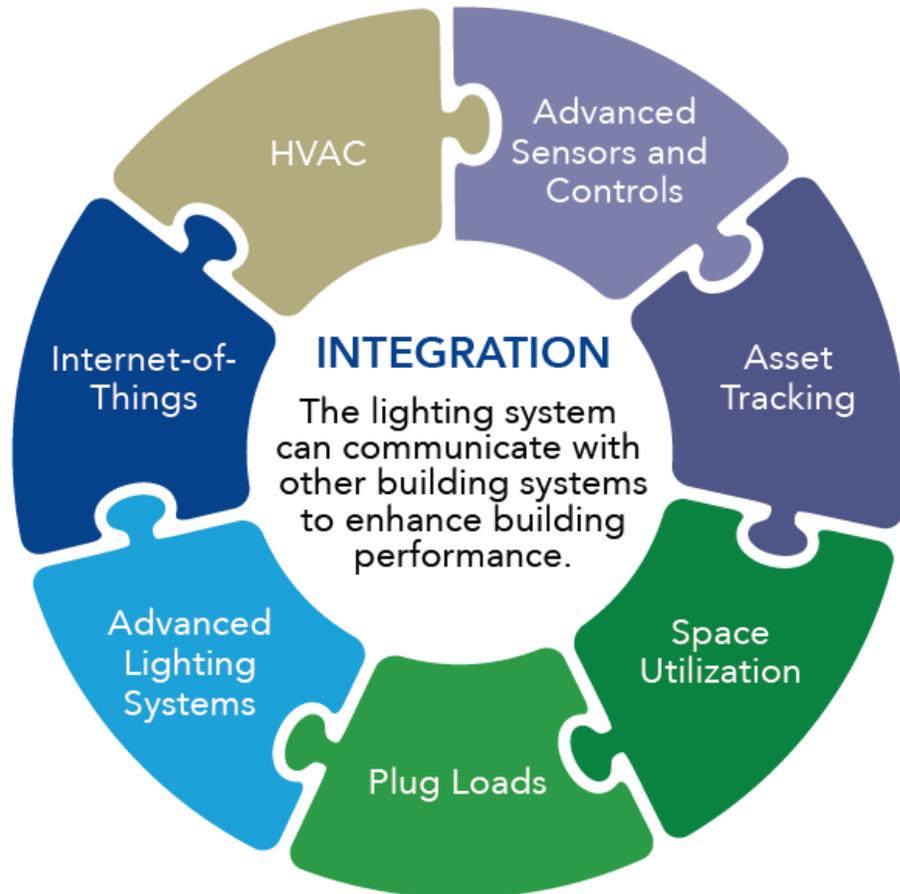


PNNL is operated by Battelle for the U.S. Department of Energy



Integrated Lighting Campaign

Designed to help building managers take advantage of energy savings and other benefits of advanced lighting controls, and the integration of lighting systems with other building and business systems.



Provide relevant resources to inform projects



Promote use of innovative lighting sensors



Encourage integration with other building systems such as HVAC and plug loads



Document and recognize integration and innovation

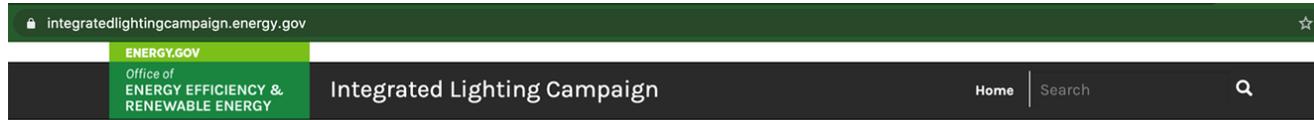
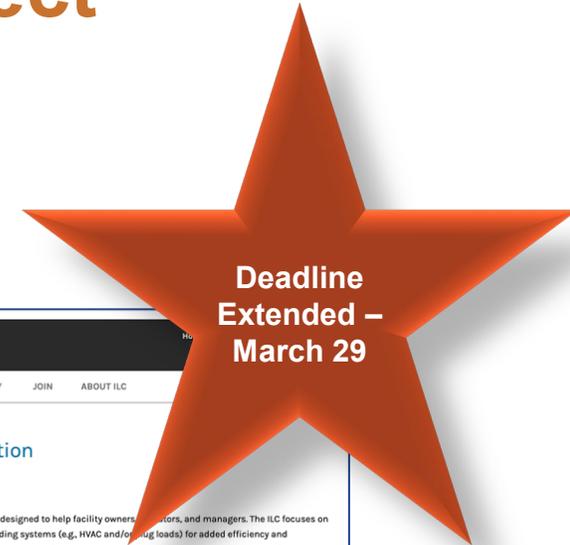
Tinker Air Force Base Lighting + Plug + HVAC

(Dept. of Defense / ESTCP project)

Lighting	+ Plug Loads Controls	+ HVAC Integration
 <p>FL to LED</p>		
69% Savings	38% Savings	26% Savings
<ul style="list-style-type: none"> ✓ Integral Lighting Controls w/ combined daylight and occupancy sensors ✓ Sensor data also available to HVAC and plug load 	<ul style="list-style-type: none"> ✓ Limited evaluation – 14 outlets ✓ Majority (55%) of plug load energy use occurred during off hours – huge potential ✓ Proactive device management might have achieved greater savings 	<ul style="list-style-type: none"> ✓ Impressive incremental savings for HVAC ✓ Active coordination between contractors was critical to success

Case study available at: https://integratedlightingcampaign.energy.gov/sites/default/files/2021-02/EED_1063_BROCH_ESTCPbrand.pdf

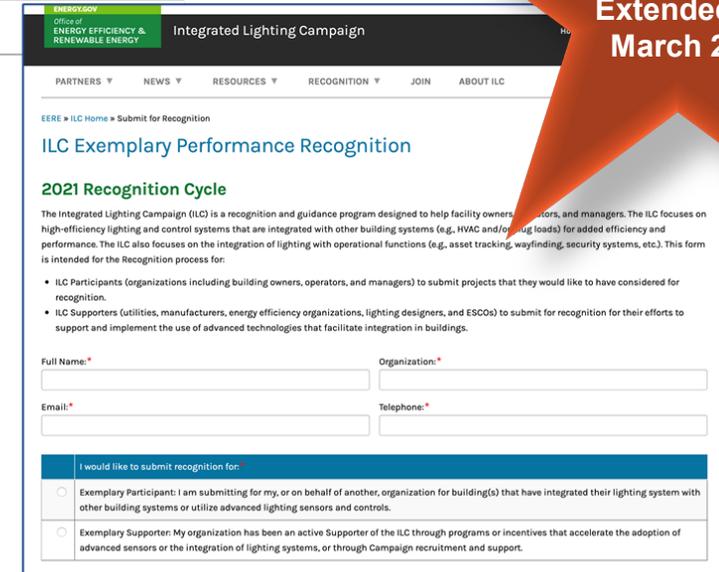
How to Submit Your Project



Submit for Recognition Now!

Each year the Integrated Lighting Campaign will confer recognition for exemplary projects submitted by Participants, and for programs, incentives, and/or support to the ILC by

[READ MORE](#)



Partners

Participants

Organizations—including building owners, operators, and managers—have access to resources and technical assistance.

[Learn More](#)

Supporters

Supporting partners include utilities, manufacturers, energy-efficiency organizations, lighting designers, and energy service companies (ESCOs).

[Learn More](#)



Recognition Opportunities for Participants

Lighting Sensors/Controls Categories

Advanced Use of Sensors and Controls for Lighting:

The Campaign is interested in how sensors and controls are enabling deeper energy savings in lighting applications, improving building operations, and creating enhanced user/occupant experiences. This category seeks to recognize uses of sensors and controls that go beyond basic occupancy, daylighting, dimming, and scheduling approaches.

Integrated Categories

Integrated Controls for Plug Loads and Lighting Systems:

This category seeks to recognize integration of lighting and plug load meter and control systems, with a focus on energy savings. For example, lighting control signals can often be used to control plug load devices that are plugged into controlled outlets or panels. Similarly, energy signals from plug load devices could help inform lighting controls.

Integrated Controls for HVAC and Lighting Systems:

This category seeks to recognize innovative approaches the integration of HVAC and lighting systems. For example, lighting controls that are integrated with HVAC systems can indicate when a space is vacant to modify air flow or temperature set points during periods when spaces are un-occupied.

Other Integrated Systems:

This category recognizes new, novel uses of integrating the lighting to provide features other than simply lighting a space. Some examples include; grid services, external shading systems integrating with electric lighting, using sensors in the lighting to provide data about space utilization or asset tracking, or other unique features.



Recognition Opportunities for Participants

Lighting Sensors/Controls Categories

Advanced Use of Sensors and Controls for Lighting:

The Campaign is interested in how sensors and controls are enabling deeper energy savings in lighting applications, improving building operations, and creating enhanced user/occupant experiences. This category seeks to recognize uses of sensors and controls that go beyond basic occupancy, daylighting, dimming, and scheduling approaches.

Project Description (narrative):

Provide a written narrative about how your lighting system sensors and controls are going beyond the norm; the novel capabilities they provide, and the resulting outcomes (e.g., incremental savings, improved business operations, occupant satisfaction, etc.). Sites will be evaluated on the novelty of the approaches and the benefits/outcomes. Please note any building automation system or energy management information system platform used to integrate controls and include additional information deemed informative, including summary data quantifying energy benefits, business operation benefits, or occupant satisfaction (e.g., from formal or informal surveys).

This project uses advanced sensors that with occupancy, photo-sensing, temperature sensor, kW logging, and Bluetooth. Every luminaire was hardwired to the retrofit kit from the previous lighting upgrade which reduced installation costs by not requiring access above the dropped ceiling. With the increased number of sensors the time-delay for turning luminaires off was decreased, which prevented false-offs while occupants are present. Luminaire-dedicated sensors also facilitate individual controllability of the luminaires, which allowed each user to select light levels comfortable for them. The average set-point based on occupant preference was 40% of full light output.

Measured/Perceived Benefits (narrative):

Our conservative estimated kWh savings were calculated at 556,000 kWh, or 34% of the baseline annual lighting and fan energy consumption. This approach also saved 2,985,918 kBtu, or 27% of the heating and cooling energy use.

An informal survey of building occupants showed that people love the light levels, because they have control of it.



Recognition Opportunities for Supporters

Utility Programs

- Incentives given for products/systems aligned with ILC
- Aggregate data provided on energy saved from incentivized projects

Exemplary Recruiting Efforts (Utility/ESCO/EE Org)

- ILC joins due to promotion/encouragement of ILC
- Providing Participant(s) support to submit projects

Stay Up-To-Date – Join Today



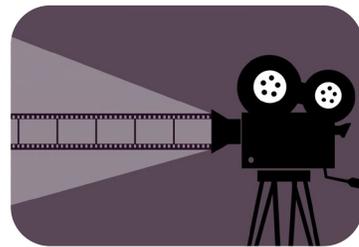
Reports /
Case Studies



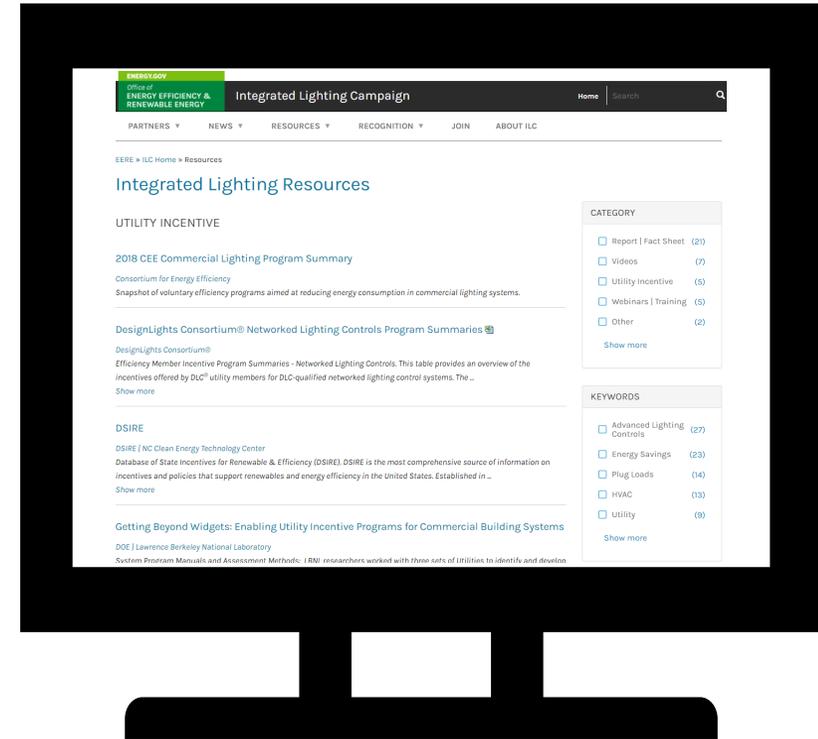
Utility
Incentives



Webinars /
Training



Videos



JOIN, SUBMIT FOR RECOGNITION, FIND RESOURCES, AND MORE!
[INTEGRATEDLIGHTINGCAMPAIGN.ENERGY.GOV](https://integratedlightingcampaign.energy.gov)



Questions?



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Dr. Joy Pixley

California Plug Load Research Center

Beyond Energy Efficiency: Adjusting How You Use A Device Can Lower Energy Consumption

Joy E. Pixley

Research Director, California Plug Load Research Center (CalPlug)

University of California, Irvine

March 17, 2021

The plug load challenge

Increasingly large number of relatively small problems

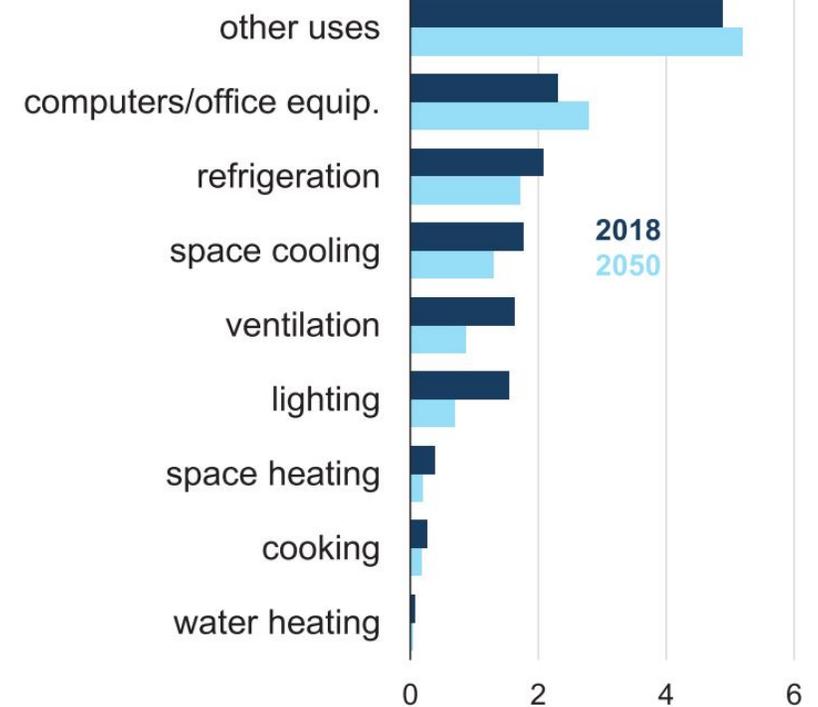
Many products are rated for efficiency

But that's only step one



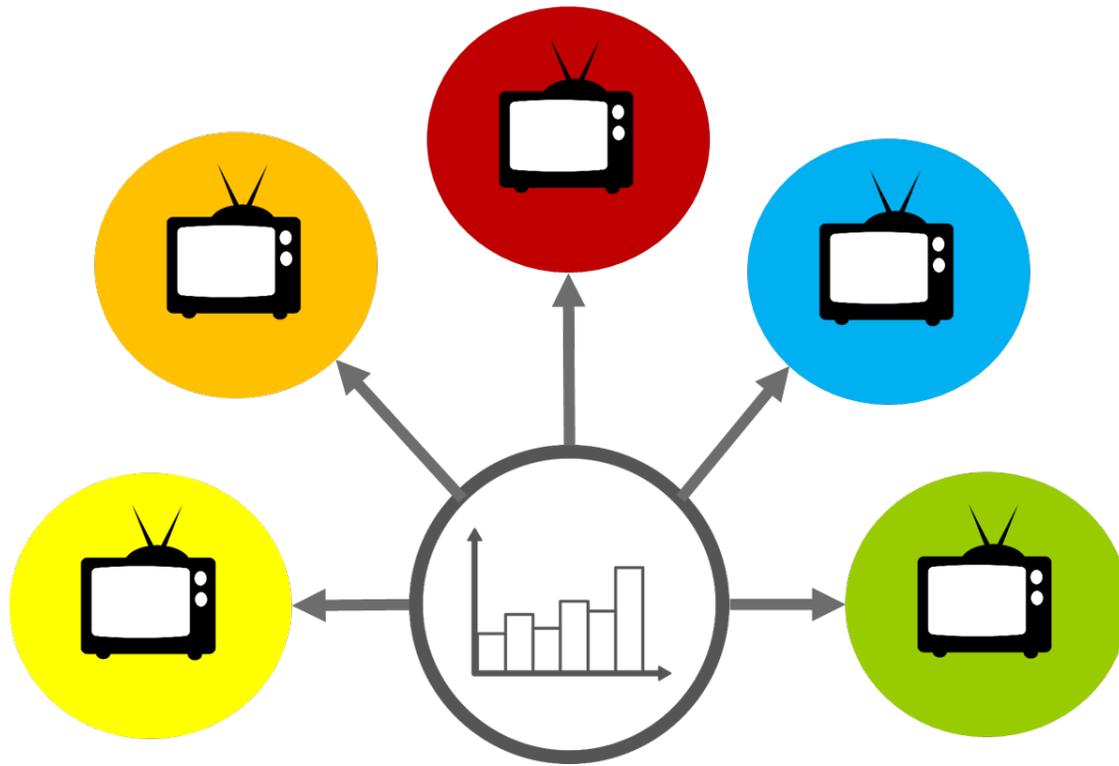
Purchased electricity consumption intensity (Reference case)

kilowatthours per square foot

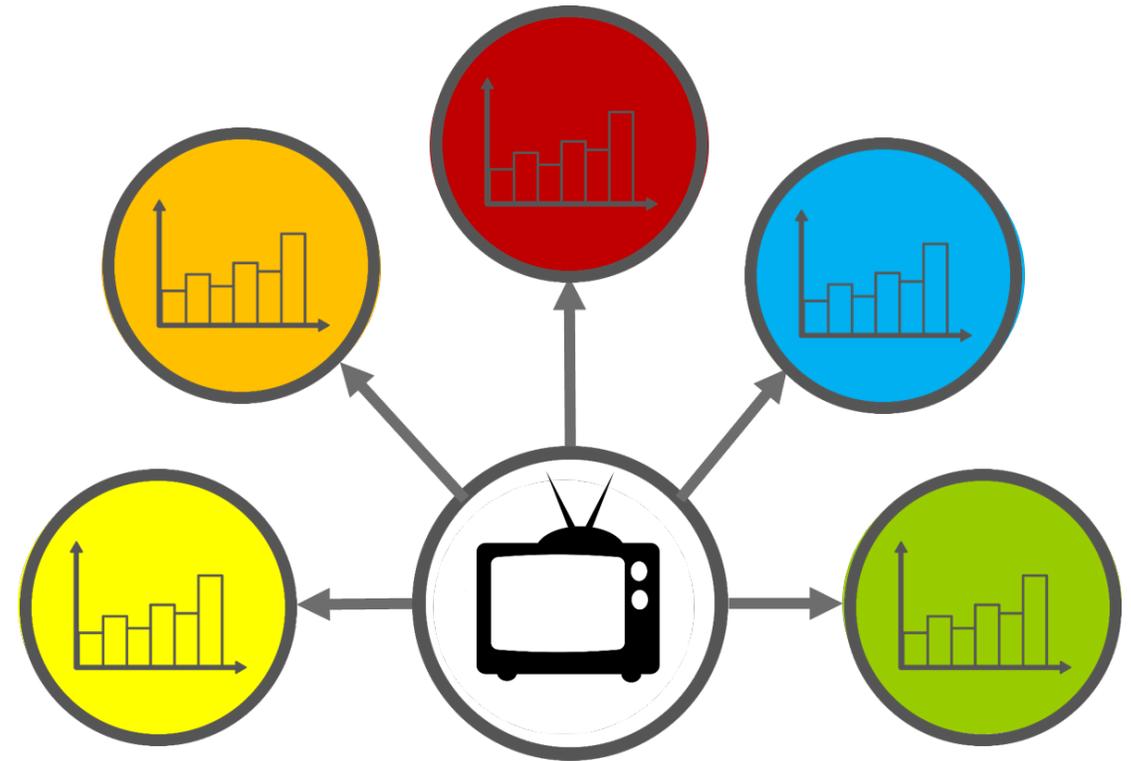


Source: U.S Energy Information Administration (EIA) 2019

Standard energy estimates vs. device use profile estimates



One use profile across many devices



One device across many use profiles

Research question: How does energy consumption vary by device usage?

❖ Characterize three aspects

- ❖ Active use time
- ❖ Pattern of use
- ❖ Power management

❖ Construct device usage profiles

- ❖ “Standard” versus other combinations

❖ Testing, energy modeling

- ❖ Device states and transitions

❖ Analyze

- ❖ Range: How much more (or less) energy v. standard profile?
- ❖ Reason: How much variation is due to each aspect?

Standard

Aspects			
Profile #	Active	Pattern	PM
1	Low	Low	Low
2	Low	Low	Mod
3	Low	Low	High
4	Low	Mod	Low
5	Low	Mod	Mod
6	Low	Mod	High
7	Low	High	Low
8	Low	High	Mod
9	Low	High	High
10	Mod	Low	Low
11	Mod	Low	Mod
12	Mod	Low	High
13	Mod	Mod	Low
14	Mod	Mod	Mod
15	Mod	Mod	High
16	Mod	High	Low
17	Mod	High	Mod
18	Mod	High	High
19	High	Low	Low
20	High	Low	Mod
21	High	Low	High
22	High	Mod	Low
23	High	Mod	Mod
24	High	Mod	High
25	High	High	Low
26	High	High	Mod
27	High	High	High

Devices studied

- ❖ Televisions: HD and 4K
- ❖ Sound bar
- ❖ Set-top box
- ❖ Streaming device
- ❖ Video game console



- ❖ Desktop computer
- ❖ Laptop computer

- ❖ Pod coffee makers
- ❖ Rice cooker



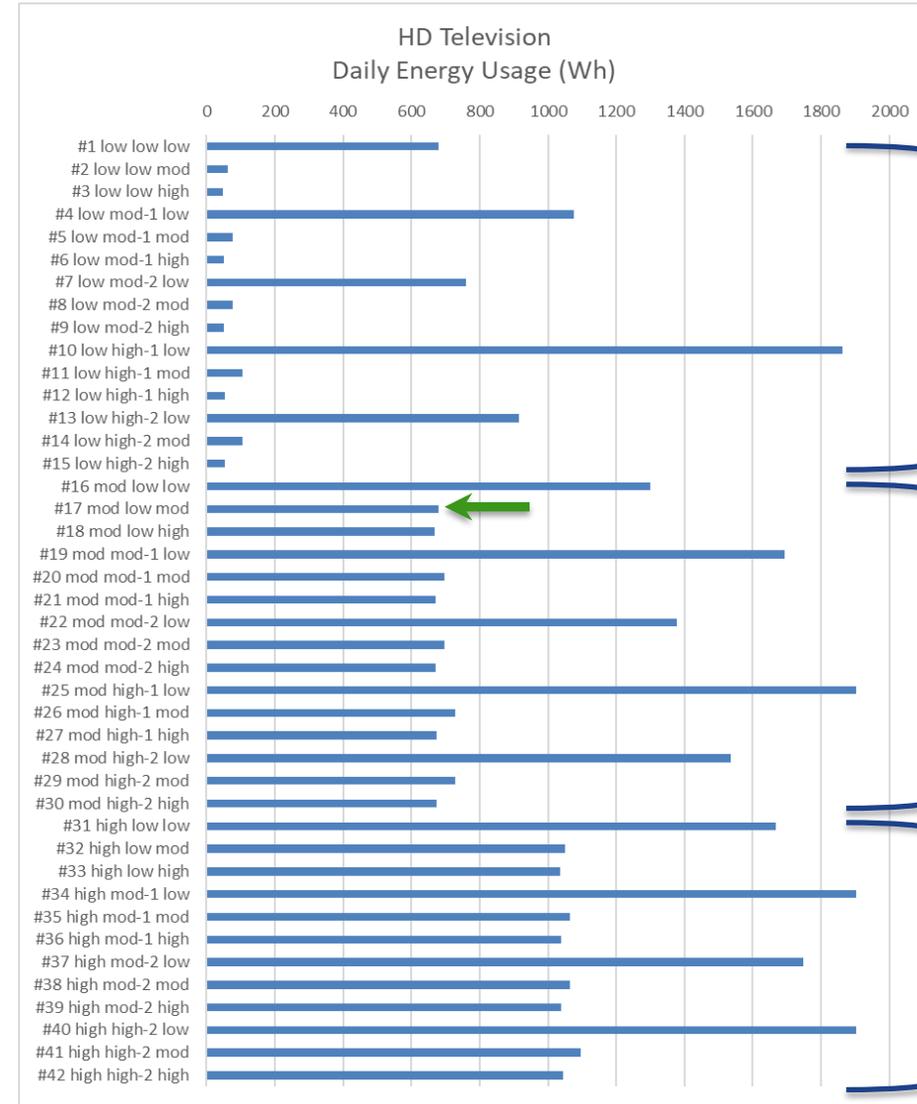
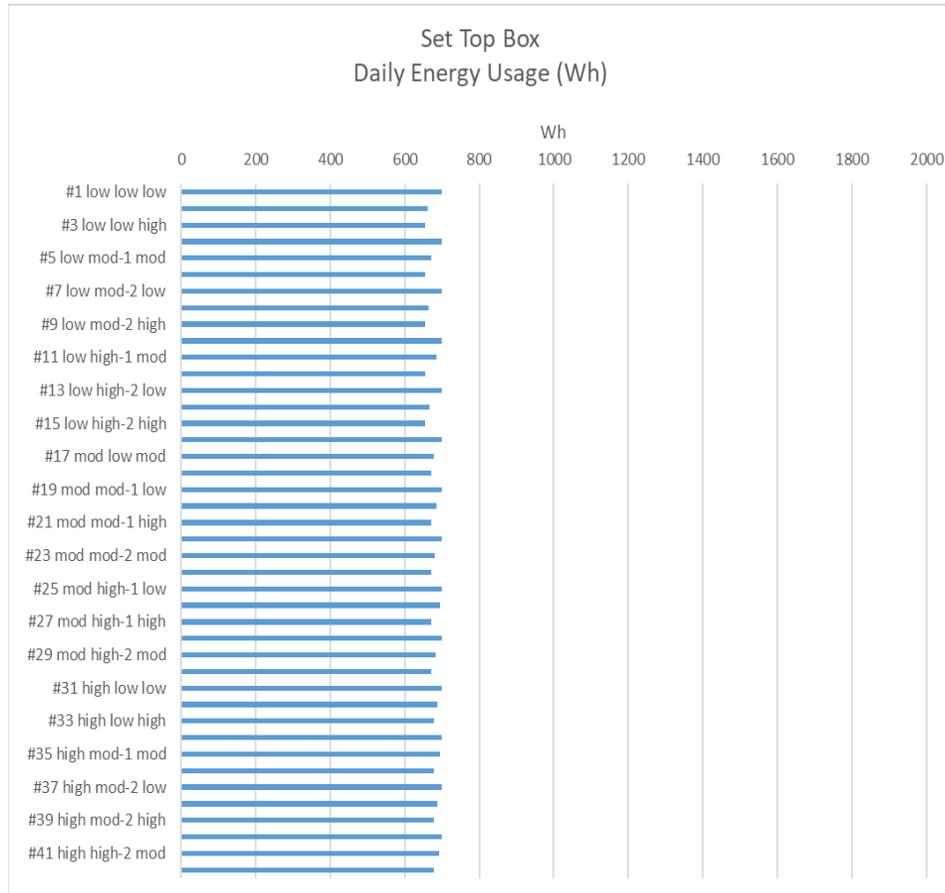
Other commercial devices

- ❖ Think about how your building's devices differ on:
 - ❖ Active use
 - ❖ Pattern of use
 - ❖ Power management



Calculate daily energy consumption for each device use profile

Some devices showed more variation across profiles than others



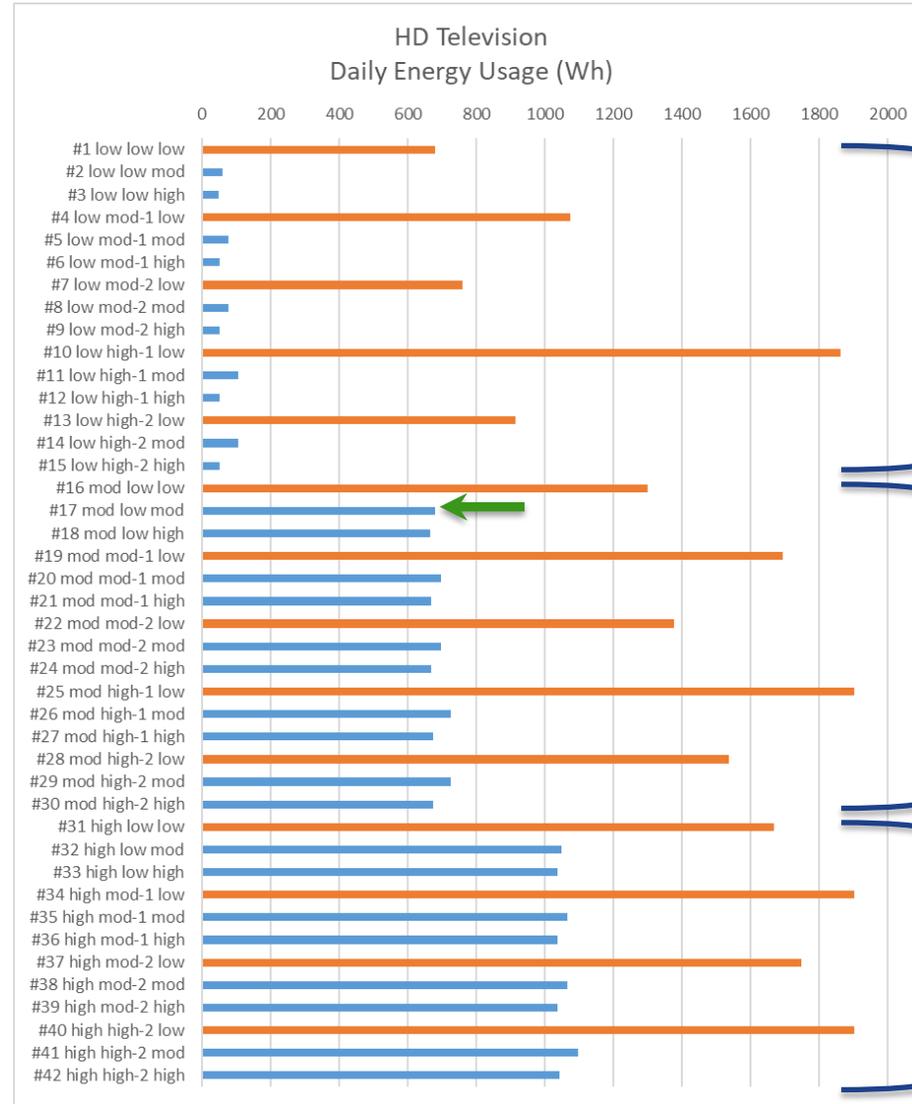
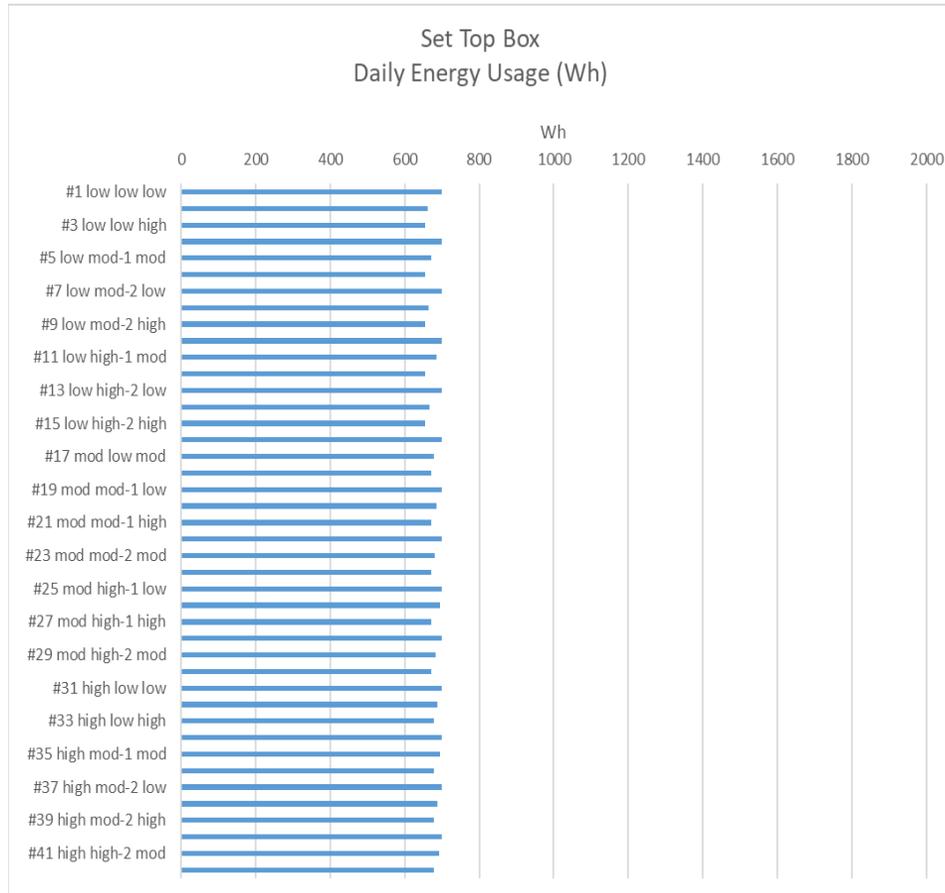
Active low

Active mod

Active high

Calculate daily energy consumption for each device use profile

Some devices showed more variation across profiles than others



PM low

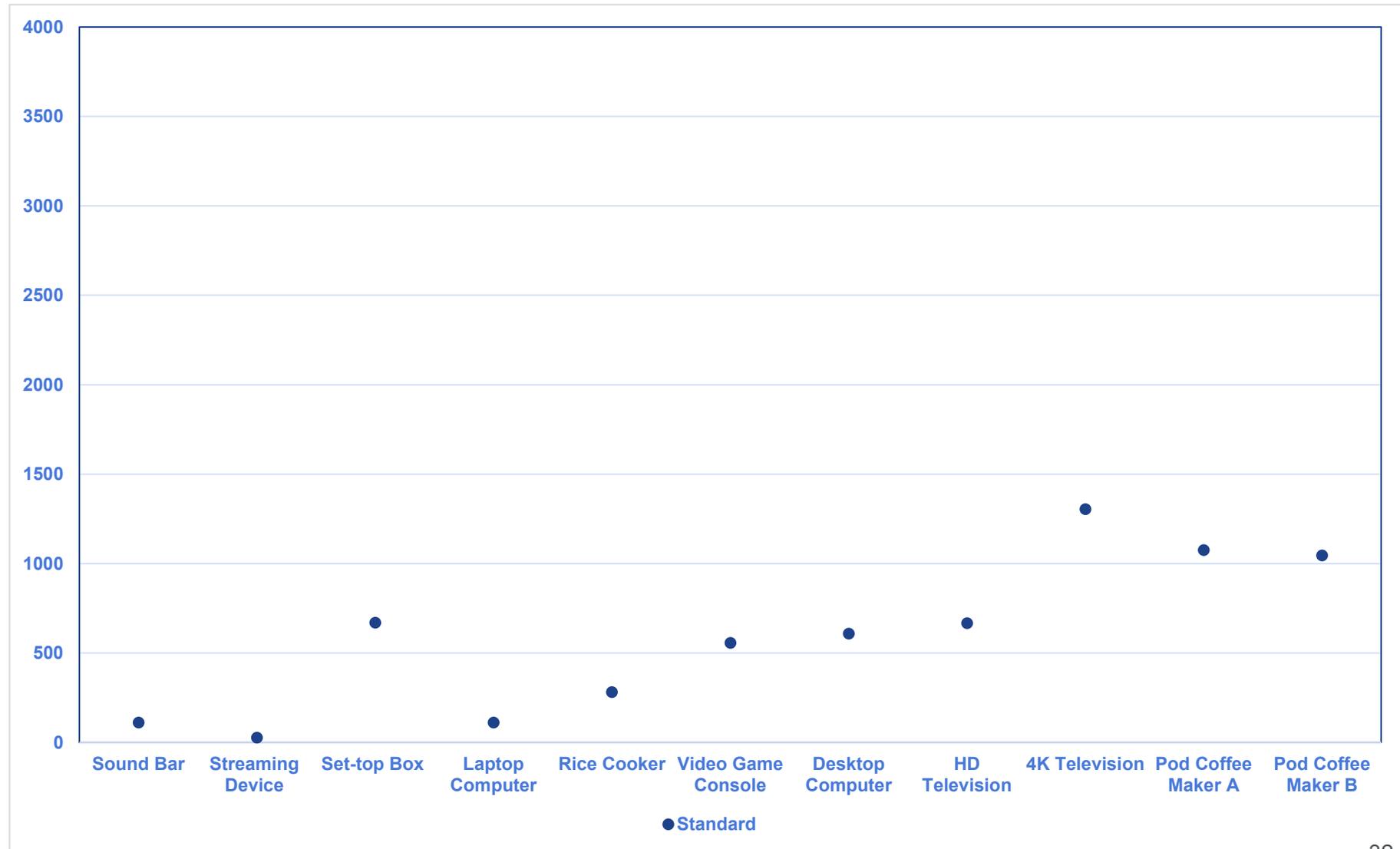
Active low

Active mod

Active high

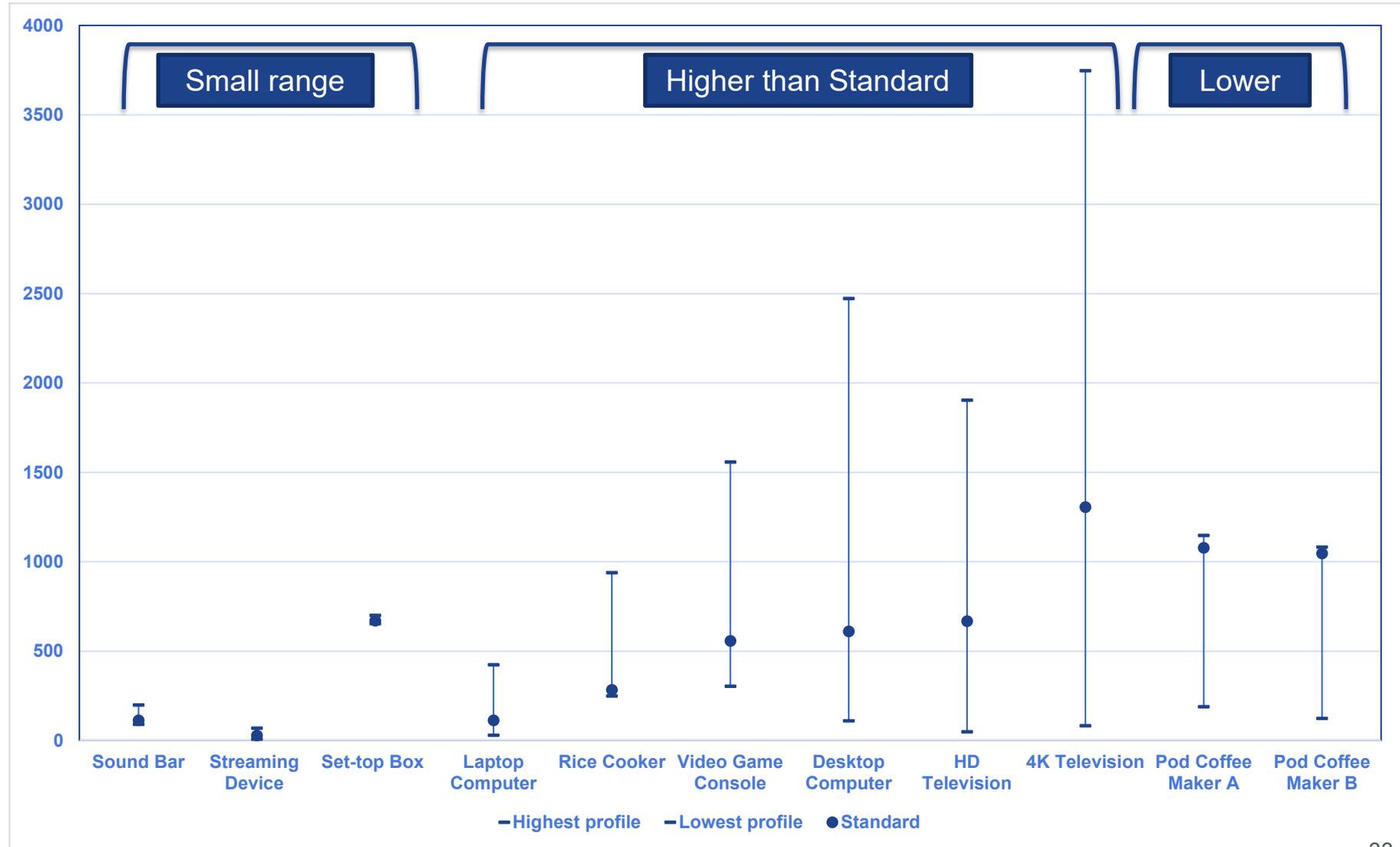
Energy use for standard profiles

Based on standard usage profile, some devices would be expected to use more than others



Energy use for highest and lowest profiles compared to standard profile

But the ranges can be quite large

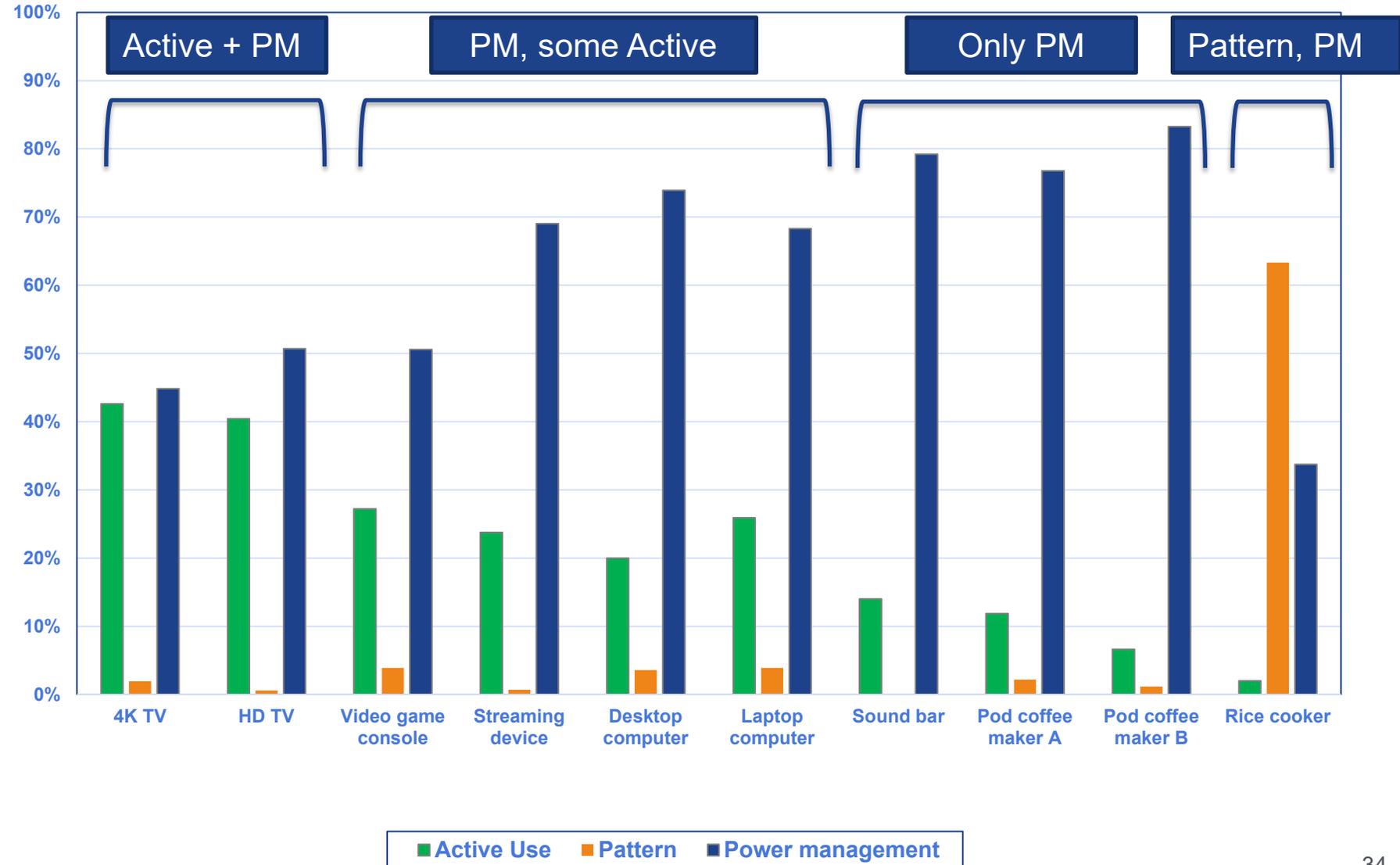


Which aspect of device use drives the variation in energy use?

Power management is a major factor for all devices

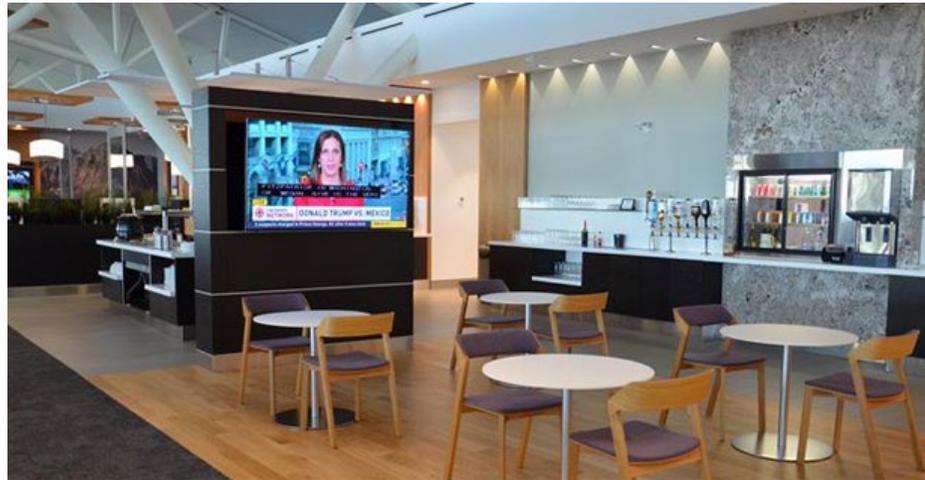
Active use varies in *relative* importance

Pattern is only significant for rice cooker



What to do about it

- ❖ Identify device usage problems
 - ❖ Use versus waste
- ❖ Choose solutions
- ❖ Get users onboard

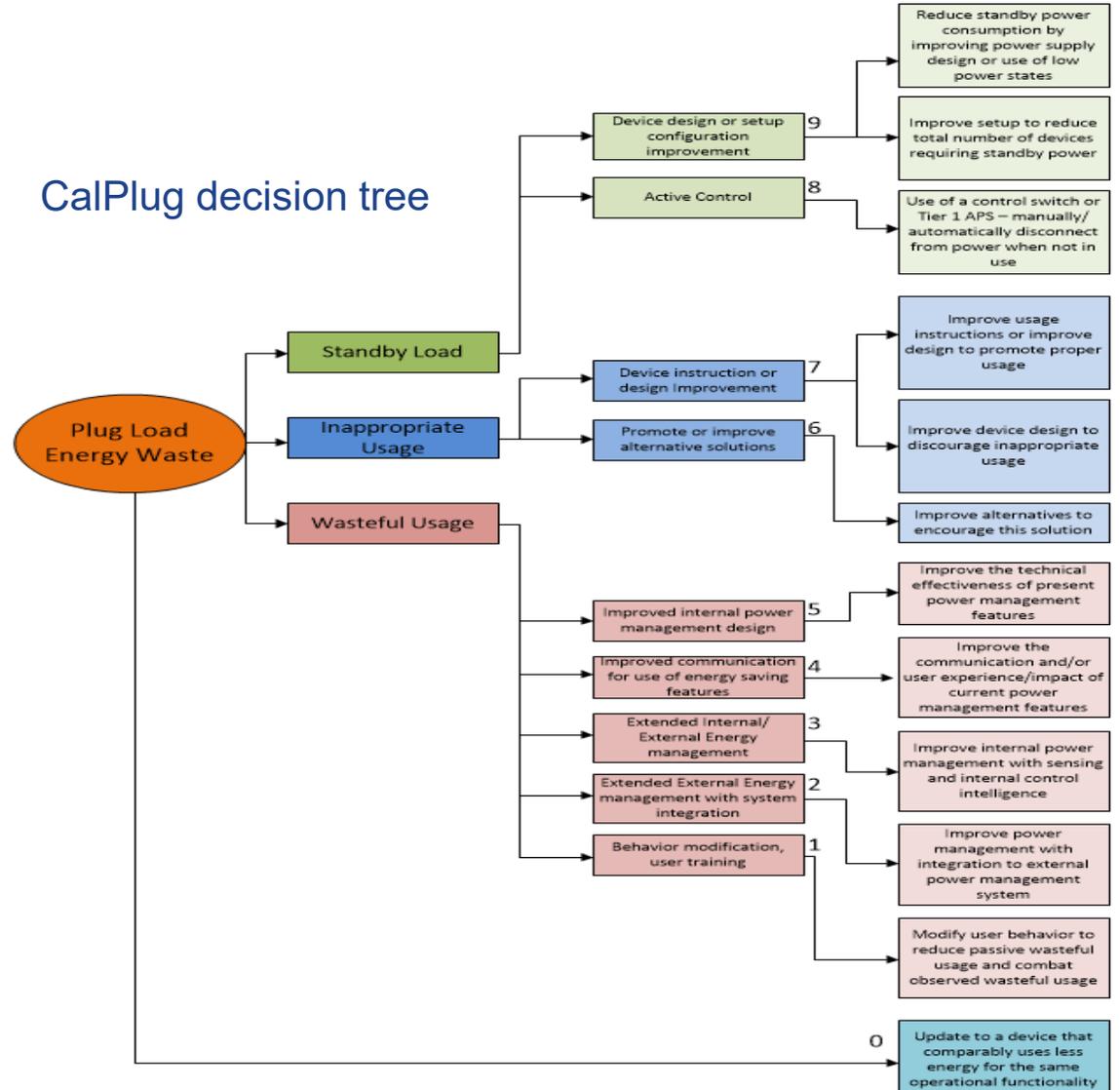


Identifying device usage problems

Space	Device	Number of Users per Device	Quantity of Devices	Average Power During Business Hours (W)	Average Power During Nonbusiness Hours (W)	Number of Business Hours per Week	Annual Energy Use (kWh)	Is this device in the ENERGY STAR or EPEAT database?			Does this device turn off during nonbusiness hours?		
								YES	NO	NA	YES	NO	NA
								<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Break Rooms and Kitchens	Full-Size Refrigerators							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Mini-Refrigerators							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Coffee Makers							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Toasters							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Microwaves							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Refrigerated Vending Machines							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Nonrefrigerated Vending							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Water Coolers							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Drinking Fountains							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Water Heaters							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Water Filters							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Dishwashers							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Ovens/Stoves/Ranges							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
									<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
								<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Recommended Plug Loads Energy Reduction Strategies for Office Buildings						
For each strategy listed here, answer the question "Is my building doing this?" If your response is "NO" for any strategy, fill out the adjacent cells to the right to determine the approximate savings the given strategy could yield in your building. Strategies that are listed without savings numbers are highly variable depending on the office building being assessed.						
Enter the number of business days per year at your building		250				
Enter the number of business hours per day at your building		10				
Enter your utility rate (\$/kWh) at your building		\$0.10				
Is your building doing this?			If you answered "NO," enter the quantity for each piece of equipment below to determine the approximate savings in your building.			
Strategies	YES	NO	N/A	Potential Energy Savings per Piece of Equipment	Quantity in Your Building	Potential Annual Savings for your Building (kWh)
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			
Break Rooms and Kitchens						
Remove underused refrigerators	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	400 kWh/year for every underused refrigerator that is removed	X ____	= 0
Replace aging, inefficient refrigerators with one of the most efficient, full-size ENERGY STAR® refrigerators for every 60 people	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	400 kWh/year for every inefficient refrigerator that is replaced	X ____	= 0
Consolidate personal mini-refrigerators into a full-size shared refrigerator	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	350 kWh/year for every mini-refrigerator that is removed	X ____	= 0

CalPlug decision tree



NREL facility assessment checklist

Identifying device usage problems

- ❖ Aspects of device usage
 - ❖ Active usage
 - ❖ High consumption for type
 - ❖ Power management
 - ❖ Idle/unused periods
 - ❖ Pattern
 - ❖ Delay periods to low-power mode
 - ❖ Warm-up periods
 - ❖ Load capacity
- ❖ Beyond individual devices
 - ❖ Redundancy



Technology solutions: device level

- ❖ Better devices
 - ❖ Factor in energy savings

Energy labels

U.S. Government Federal law prohibits removal of this label before consumer purchase.

ENERGYGUIDE

Clothes Washer Capacity Class: Standard XYZ Corporation Models G39, X88, Z33 Capacity (tub volume): 2.5 cubic feet

Compare **ONLY** to other labels with yellow numbers. Labels with yellow numbers are based on the same test procedures.

Estimated Yearly Energy Cost (when used with an electric water heater) **\$43**

Cost range not available

358 kWh Estimated Yearly Electricity Use

\$16 Estimated Yearly Energy Cost (when used with a natural gas water heater)

• Your cost will depend on your utility rates and use.
 • Cost range based only on standard capacity models.
 • Estimated operating cost based on six wash loads a week and a national average electricity cost of 12 cents per kWh and natural gas cost of \$1.09 per therm.

ftc.gov/energy

Online comparisons

HP 24UH

- Monitor Type: LED
- Screen Size: 24
- Response Time: 5 milliseconds

\$117
[Get price drop alerts!](#)

92

- Ideal efficiency with an **Enevee Score** of 92
- **CLEARCOST** of \$148 with a lifetime energy usage of \$31

\$\$\$\$

- Lower price compared to similar monitors
- No price change since last week

★ 4.6

- 4.6 star rating
- With 432 reviews from 2 retailers

(shown: Enevee)

Utility energy efficiency programs

ComEd powering lives

Outage | Pay Bill | Moving | Español | Contact Us Search... Sign In

My Account Outages **Ways to Save** Smart Energy Safety & Community Marketplace

Home > Ways to Save: For Your Home > Rebates & Discounts

Rebates & Discounts

Appliance Rebates: Choose ENERGY STAR® home appliances and save.

Lighting Discounts: Get instant in-store discounts on select ENERGY STAR® certified LEDs.

Smart Thermostat Rebates: Manage your heating and cooling costs with an ENERGY STAR® smart thermostat.

Home Products Discounts: Find instant discounts on energy-efficient home products.

Pool Pump Rebates: Install an ENERGY STAR® pool pump and start saving now.

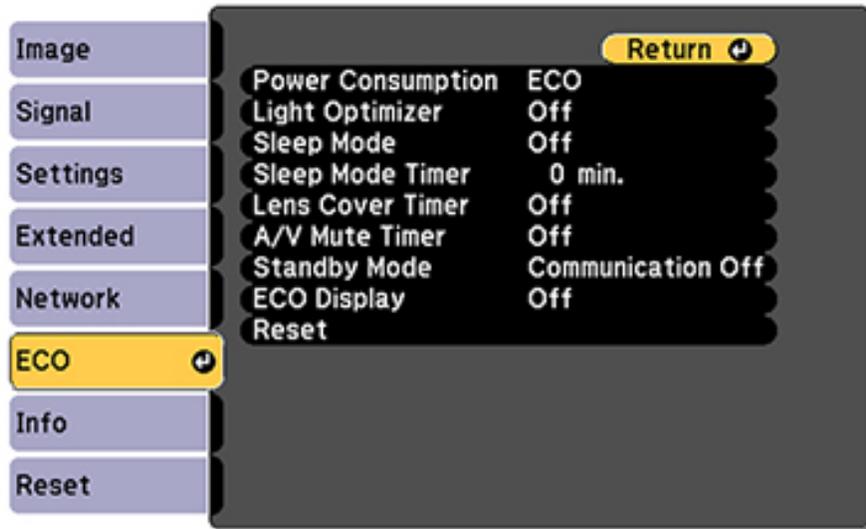
Heating & Cooling Rebates: Upgrade your heating/cooling and boost your energy efficiency.

Marketplace: Get instant rebates on energy-saving products. Explore Marketplace.

Service Providers: Help homeowners implement energy efficiency improvements. Learn More.

Technology solutions: settings level

- ❖ Better automatic settings
 - ❖ Check with off-hours walk-through
 - ❖ Check with energy assessments
 - ❖ Check each device



Projector “eco” mode – default disabled

Power & sleep

Screen

On battery power, turn off after

3 minutes

When plugged in, turn off after

15 minutes

Sleep

On battery power, PC goes to sleep after

30 minutes

When plugged in, PC goes to sleep after

3 hours

Laptop

Can be complicated....

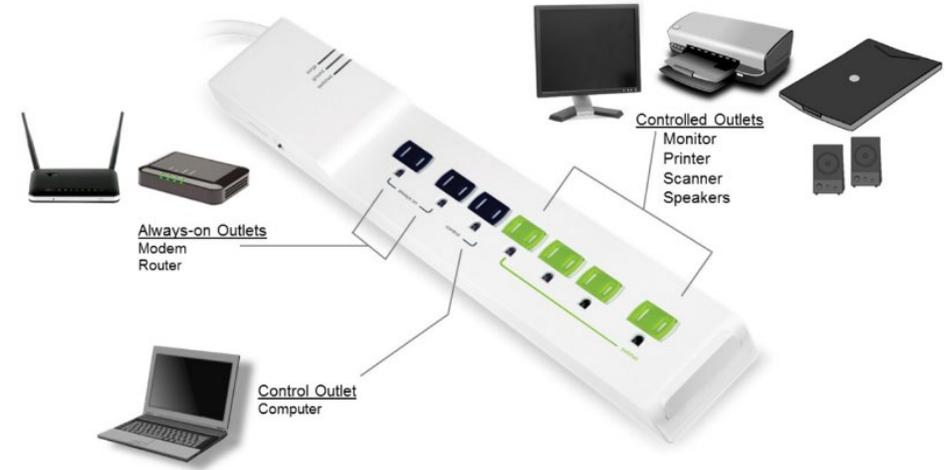


...and may still allow vampire load

Technology solutions: control level

- ❖ Better controls
 - ❖ Individual control devices
 - ❖ Control device systems
 - ❖ Whole building management

Individual control devices

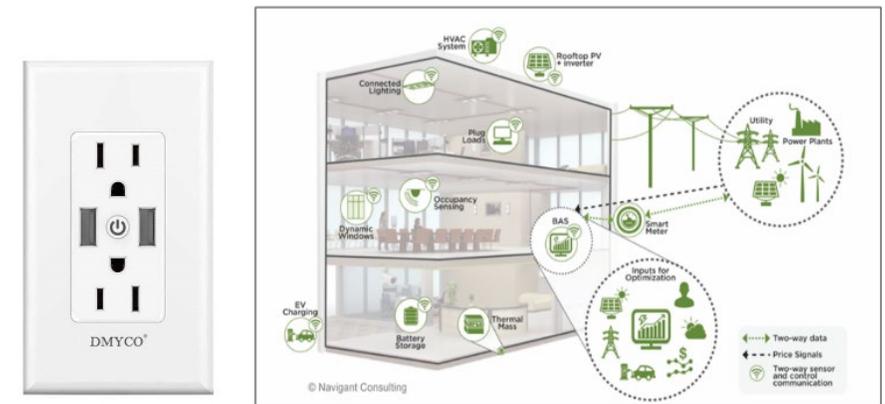


Control device system



(shown: Sapien)

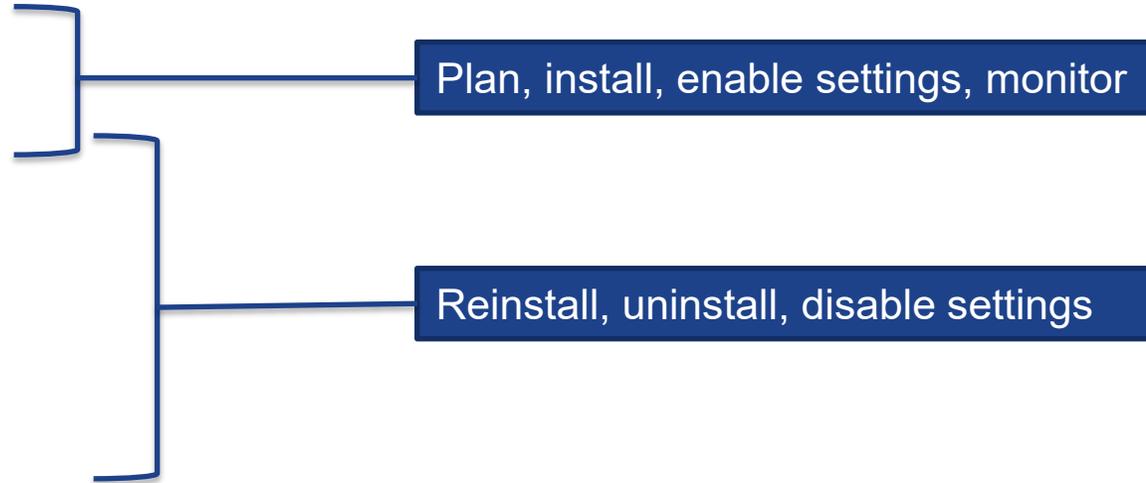
Controlled outlets and BAS / BEMS / GEBs



Getting users onboard is key to persistence

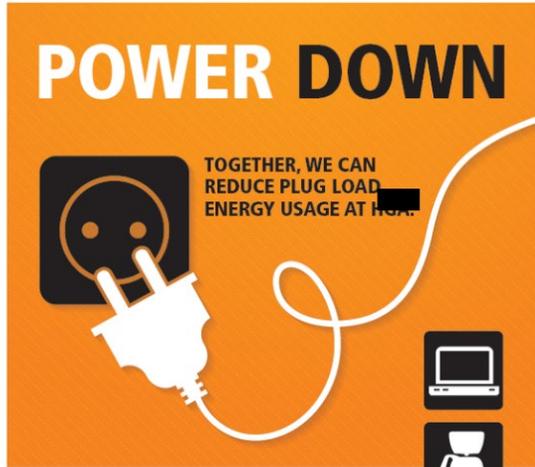
❖ Engage stakeholders at every level

- ❖ Owners
- ❖ Facility managers
- ❖ Management
- ❖ Workers
- ❖ Maintenance



Strategies for informing and engaging

Prompts, reminders



POWER DOWN

TOGETHER, WE CAN REDUCE PLUG LOAD ENERGY USAGE AT WORK.

- Turn off lights, printers, copiers, computers and monitors when not in use.
- Enable power management settings on computers, printers and copiers so they power down when not in use.
- Use a smart power strip to manage plug loads and turn off unused equipment.

HAS... 321 COMPUTERS, 477 MONITORS, 40 PRINTERS, 9 SCANNERS, 265 TASK LIGHTS, 21 TELEVISIONS, 10 PROJECTORS... IT ALL ADDS UP!

(Numbers are for Minneapolis office, extrapolated from a partial field inventory.)

Hackel et al (2016)

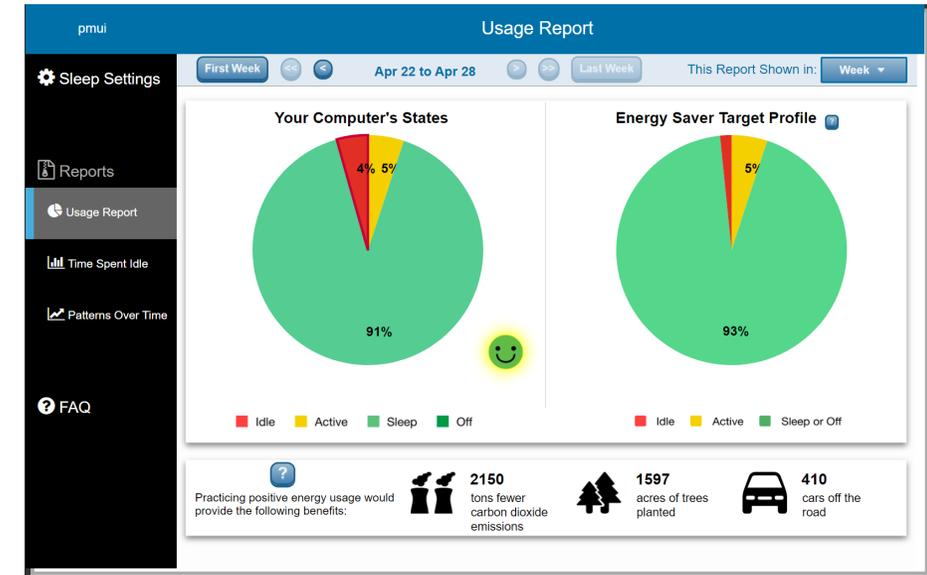
Gamification

Level -2	Level -1	Baseline 0	Level +1	Level +2
				



CoolChoices.com

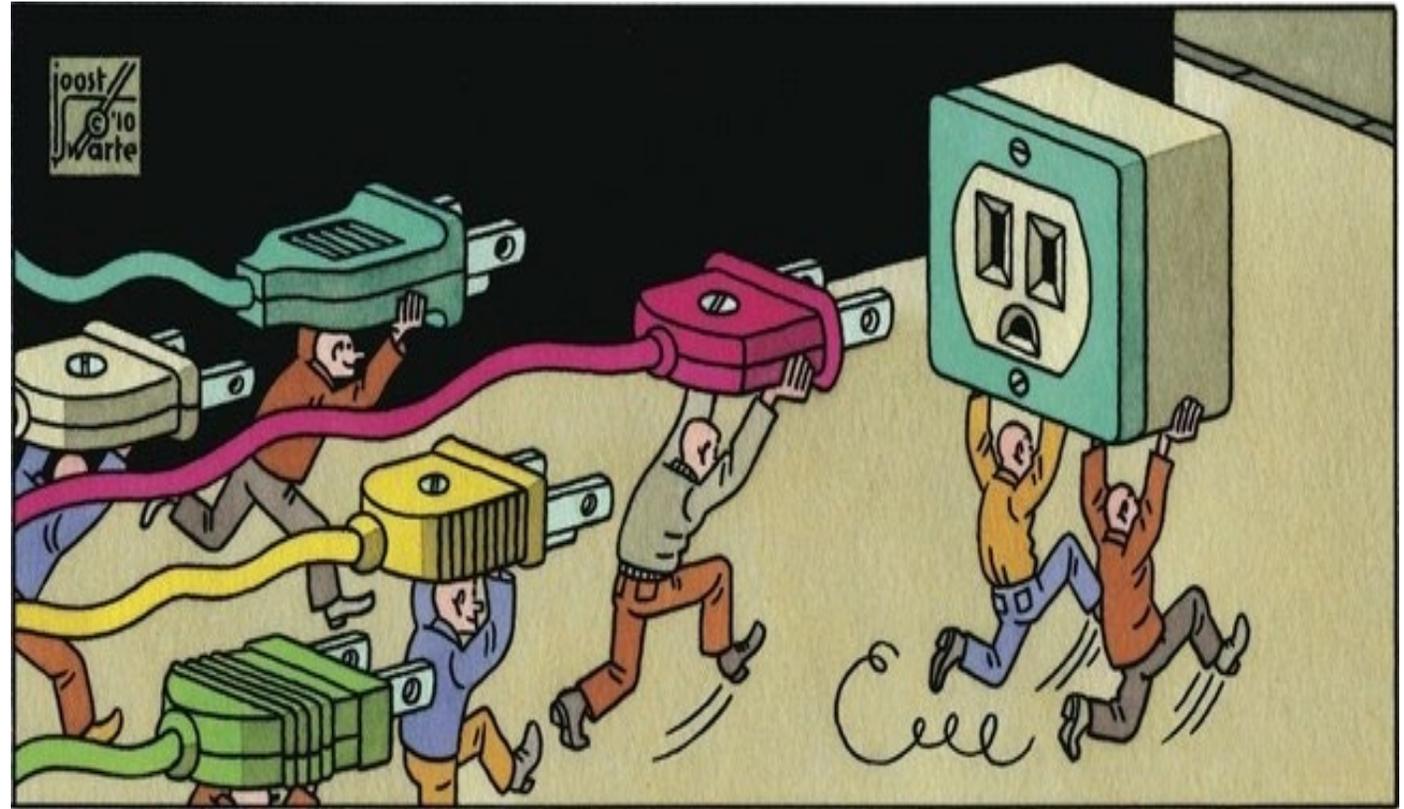
User feedback



Power Management User Interface (UCI)

Take away

Buying energy efficient devices is only the first step. Adjust how they are being used—and engage users—to maximize your savings.



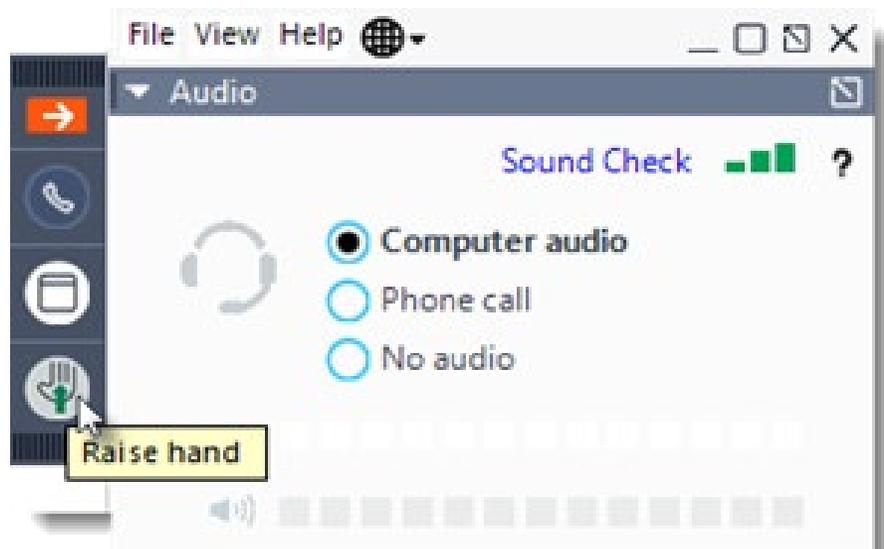
Questions?

Joy E. Pixley
Research Director, CalPlug, UC Irvine
jpixley@uci.edu

Would you like to share an update?

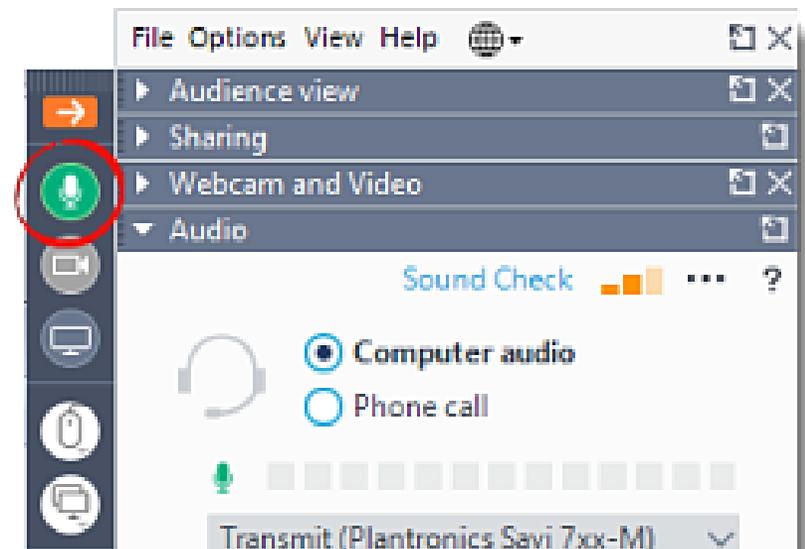
1. Raise Your Hand

- Click the Hand icon in the Control Panel. The Hand icon will turn green  when you raise it.



2. Unmute Yourself

- Click the Mic icon at the top of the Control Panel. The icon will turn green  when you have successfully unmuted.



We would love to hear from you!

- Are you thinking about PPL strategies?
 - What are your successes?
 - What are your challenges?
- What resources or support would help you?

Please email us:

PPL@NREL.gov

Visit our BBA website:

<https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/plug-process-loads>