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://betterbuildingssolutioncenter.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

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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

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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://betterbuildingssolutioncenter.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

Introduction

Better Buildings U.S. DEPARTMENT OF ENERGY

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 buildings[1], 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 Effic. Build.*, 409.

Learn more at betterbuildingssolutioncenter.energy.gov

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Recently updated! PPL Utility Incentives List

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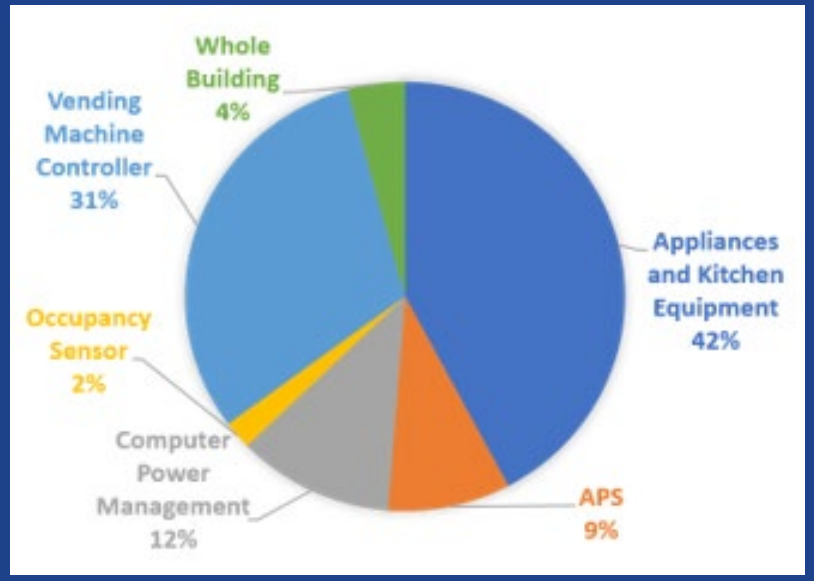
For Questions or Comments, contact ppl@nrel.gov

Updated Plug and Process Load Efficiency Utility Incentives List - as of 2/24/2021

PPL Strategy Definitions	
Appliances and Kitchen Equipment	*Procurement of plug load equipment, that is often ENERGY STAR certified, that reduces overall plug load energy usage in a space*
APS	*Unlike typical power strips, Advanced Power Strips (APSs) have increased functionality to combat PPLs. They have outlets that are designated as prima*
Computer Power Management	*Installation of software on PCs to enable a centralized, server-level control of power management settings*
Occupancy Sensor	*Occupancy sensors can be installed specifically for the purpose of managing and controlling plug load energy usage*
Vending Machine Controller	*Vending Machine control devices that use a motion sensor to automatically power down the vending machine when the area around it is unoccupied, and*
Whole Building	*These programs allow you to create your own plug load savings strategies and receive a custom incentive if it meets the utility's requirements*

Type of Incentive	
Custom Rebate	*Incentive is offered by the reduction of energy consumption due to new measures*
Prescriptive Rebate	*Incentive is based on the installation of a specific device or software*
Upstream Rebate	*Incentive is offered directly from the vendor/manufacturer*

Incentive Sponsor	State	Rebate/Incenti	Applica	Type of Ince	PPL Strategy	URL	Details
Empire Arkansas	AR	$90/unit	Commerci	Prescriptive Reb	Vending Machine Controll	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	$90/unit	Commerci	Prescriptive Reb	Vending Machine Controll	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	$40/unit	Commerci	Prescriptive Reb	Vending Machine Controll	http://empirearkansas.programprocessing.com/content/prescri	Occupan
Empire Arkansas	AR	$145/unit	Commerci	Prescriptive Reb	Vending Machine Controll	http://empirearkansas.programprocessing.com/content/prescri	Evaporati
Entergy Arkansas	AR	$0.10/kWh	Commerci	Custom Rebate	Computer Power Manager	http://www.entergy-arkansas.com/your_business/save_money/	Up to 10
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 Soft
Arizona Public Service Company (APS)	AZ	$100/unit	Commerci	Prescriptive Reb	Vending Machine Controll	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	Beverage
Arizona Public Service Company (APS)	AZ	$50/unit	Commerci	Prescriptive Reb	Vending Machine Controll	https://www.aps.com/-/media/APS/APSCOM-PDFs/Business/S	Snack ma
SRP	AZ	$100/controller	Commerci	Prescriptive Reb	Vending Machine Controll	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Reach-in
SRP	AZ	$100/controller	Commerci	Prescriptive Reb	Vending Machine Controll	http://www.savewithsrpbiz.com/rebates/standardrebate.aspx	Beverage
SRP	AZ	$40/controller	Commerci	Prescriptive Reb	Vending Machine Controll	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	Networke



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!

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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

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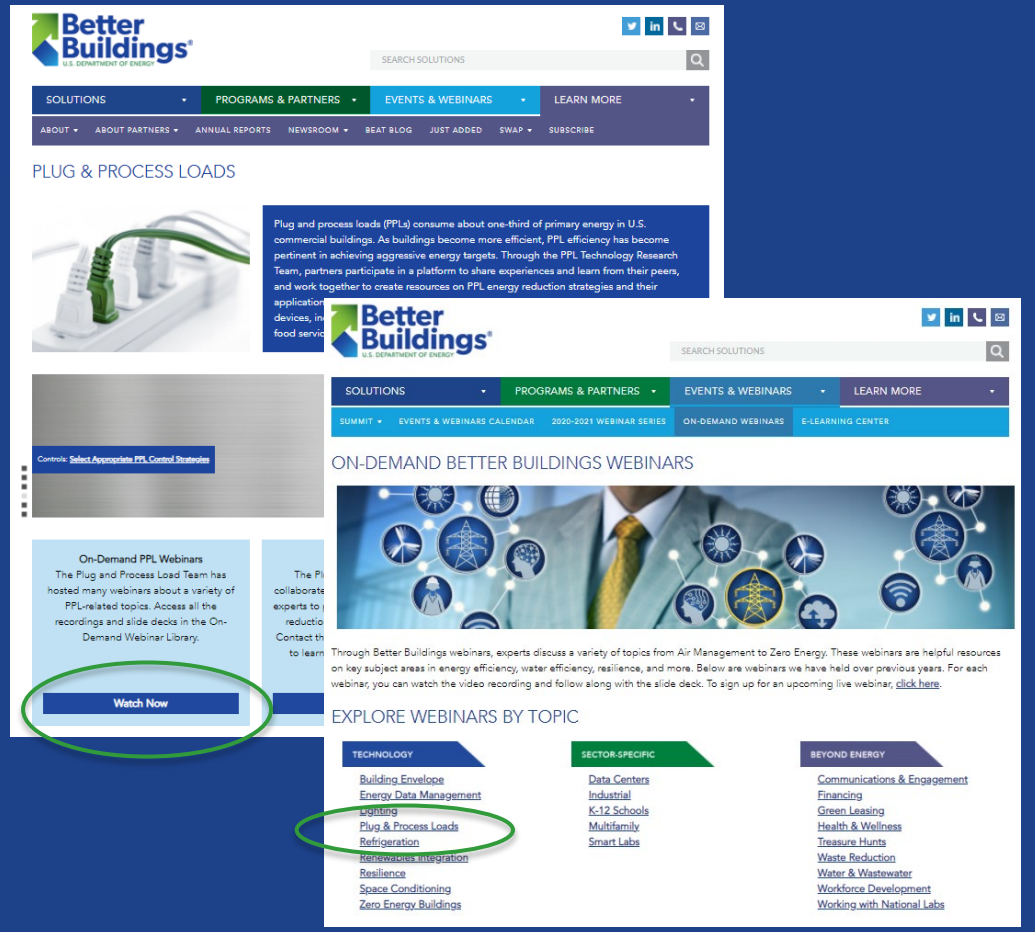
Check Out Our PPL Recorded Webinars!

Access PPL webinars from -

- PPL Website at: https://betterbuildingssolutioncenter.energy.gov/alliance/technology-solution/plug-process-loads

- On-Demand Better Buildings Webinars webpage.



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

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Felipe Leon

Pacific Norwest National Laboratory (PNNL)

Pacific Northwest
NATIONAL LABORATORY

Integrated Lighting Campaign

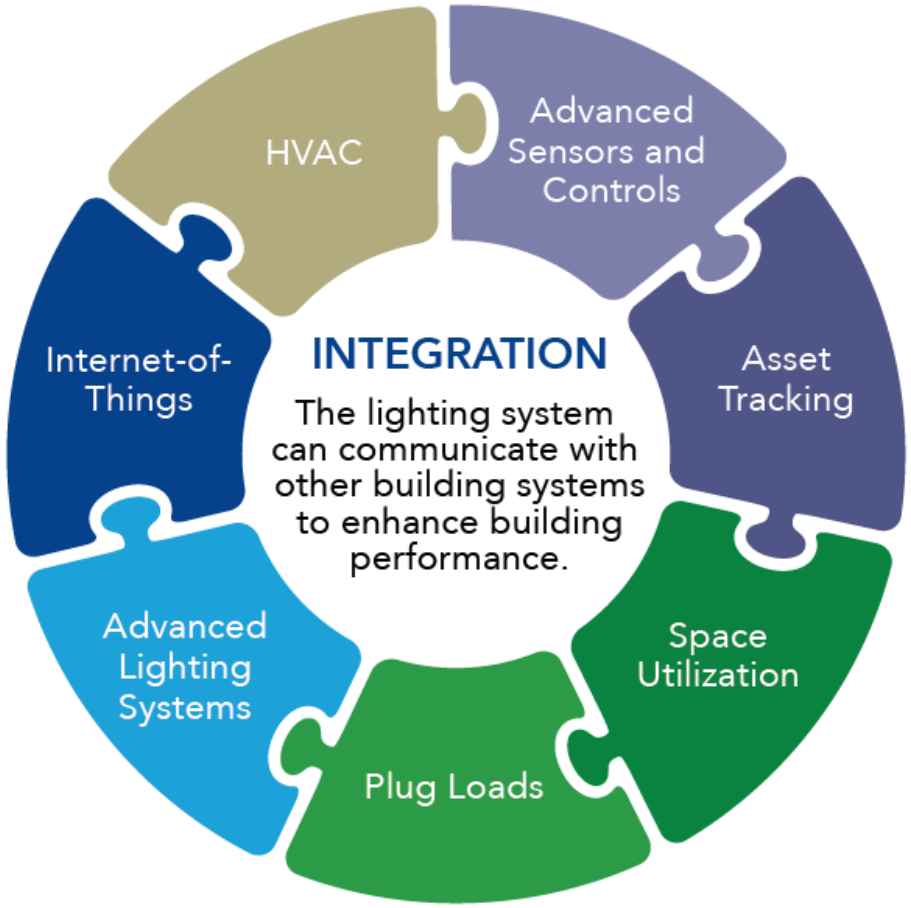
Felipe Leon
Electrical Engineer

U.S. DEPARTMENT OF ENERGY BATTELLE

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.



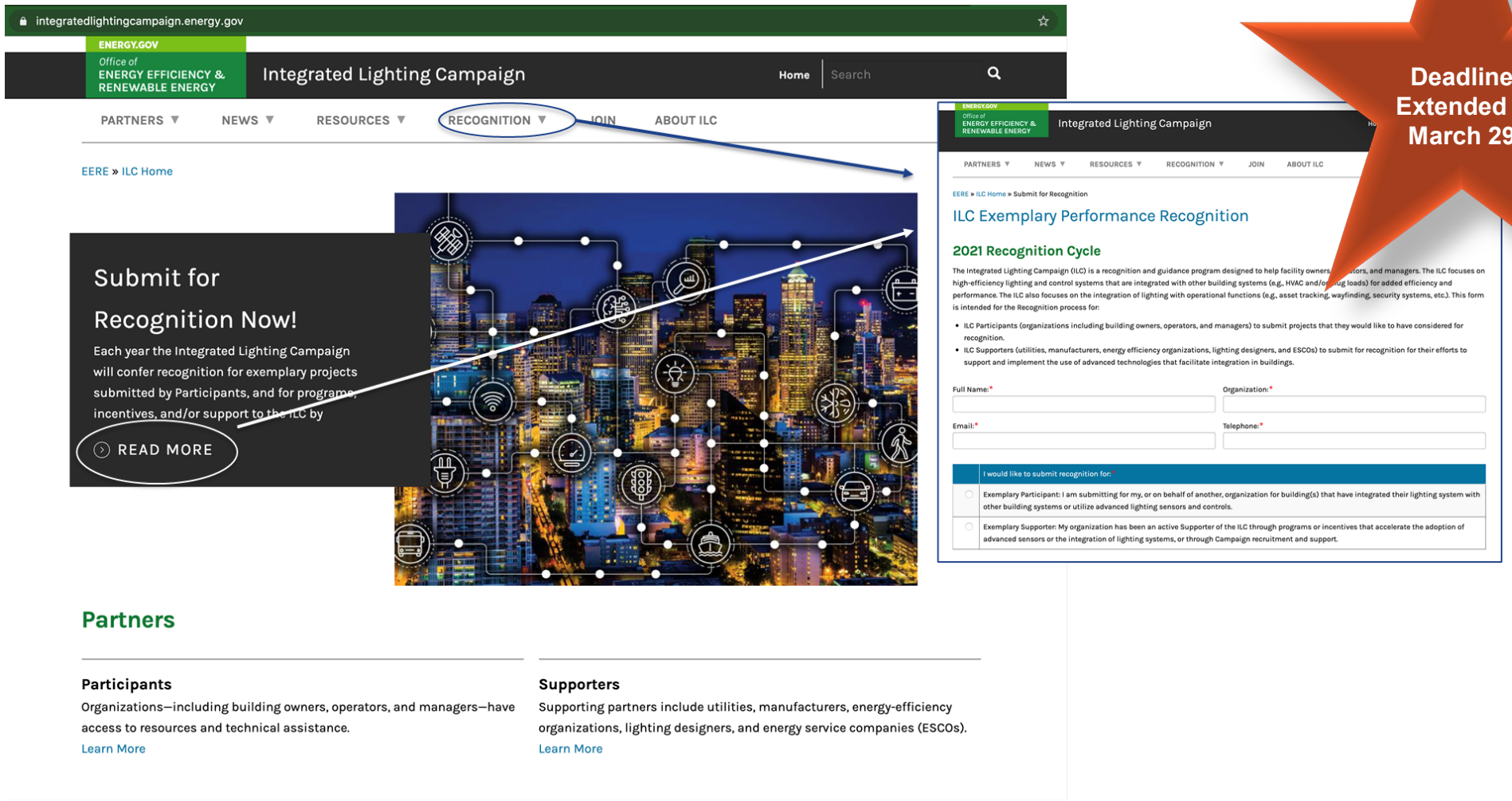
- Provide relevant resources to inform projects
- Promote use of innovative lighting sensors
- Encourage integration with other building systems such as HVAC and plug loads
- Document and recognize integration and innovation

Tinker Air Force Base Lighting + Plug + HVAC
(Dept. of Defense / ESTCP project)

Lighting	+ Plug Loads Controls	+ HVAC Integration
		
69% Savings	38% Savings	26% Savings
✓ Integral Lighting Controls w/ combined daylight and occupancy sensors ✓ Sensor data also available to HVAC and plug load	✓ 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	✓ 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



Deadline Extended – March 29

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

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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 are occupants 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)

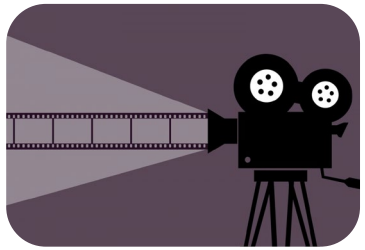
- ILC joins due to promotion/encouragement of ILC
- Providing Participant(s) support to submit projects

Stay Up-To-Date – Join Today

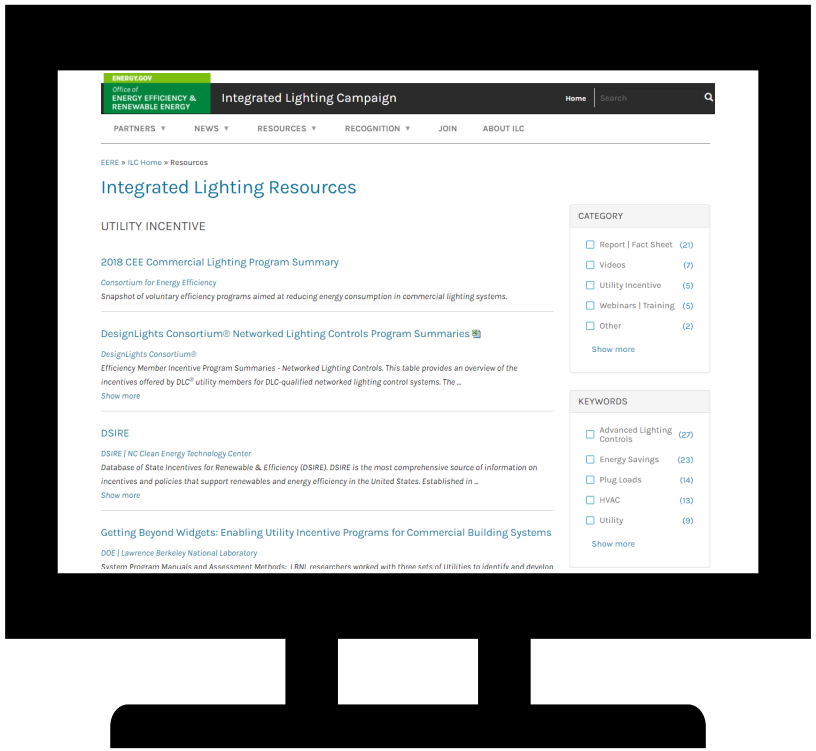
Reports / Case Studies

Utility Incentives

Webinars / Training



Videos



JOIN, SUBMIT FOR RECOGNITION, FIND RESOURCES, AND MORE!
INTEGRATEDLIGHTINGCAMPAIGN.ENERGY.GOV

Pacific Northwest
NATIONAL LABORATORY

Questions?

… or IntegratedLighting@PNNL.GOV

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

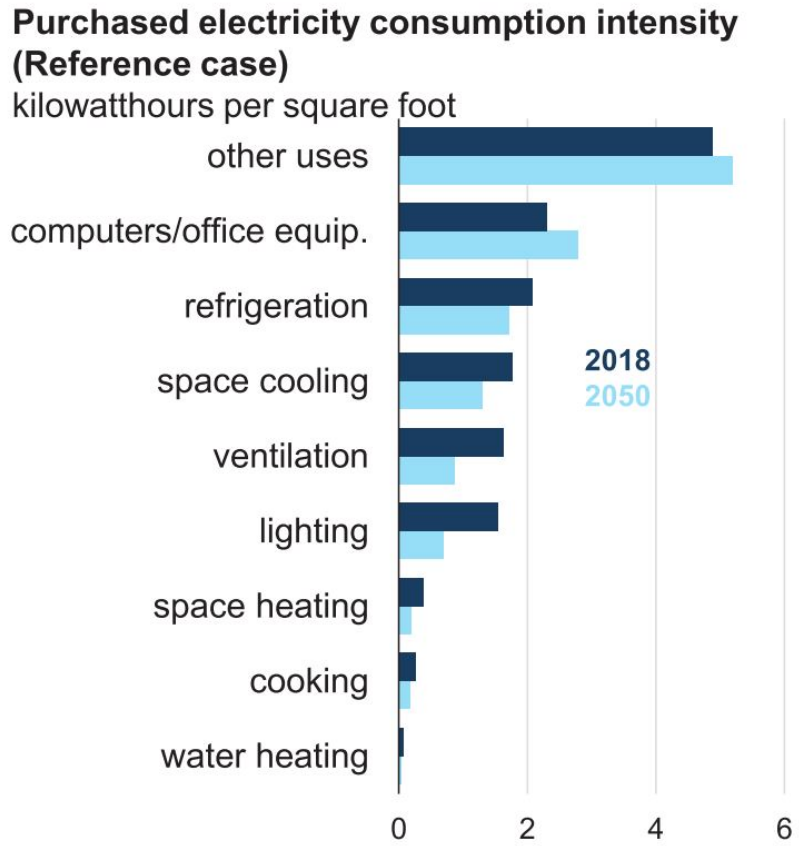
March 17, 2021

The plug load challenge

Increasingly large number of relatively small problems

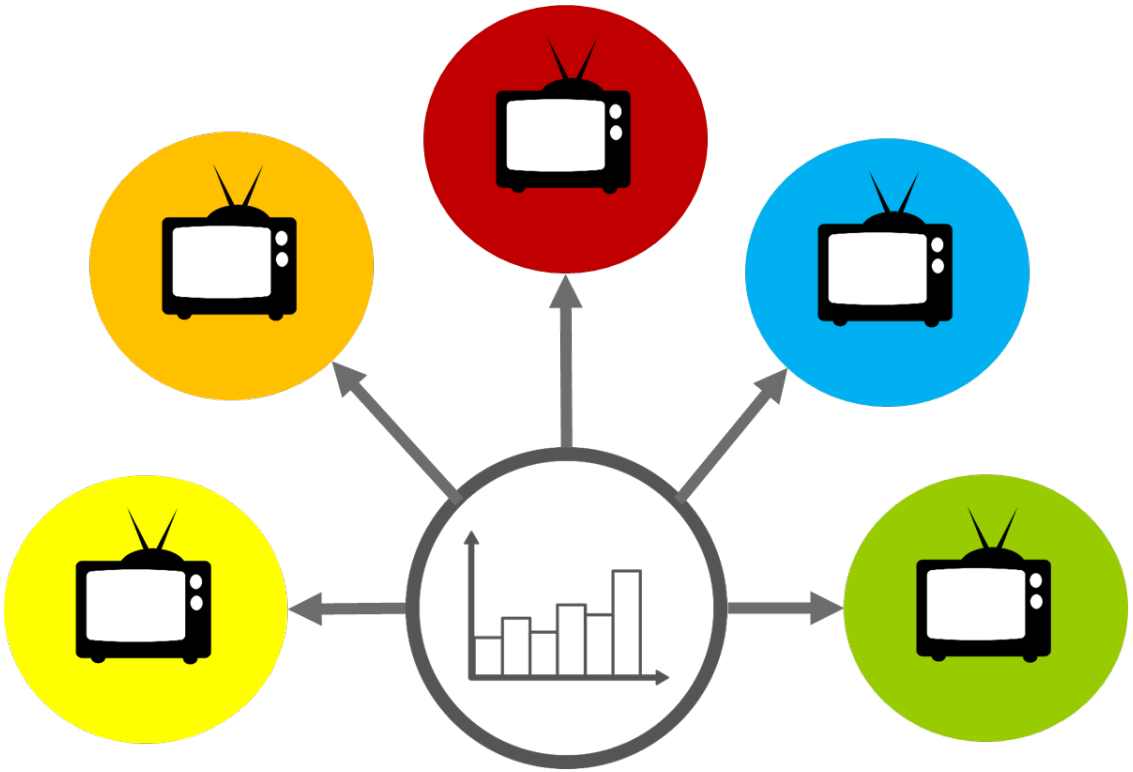
Many products are rated for efficiency

But that's only step one

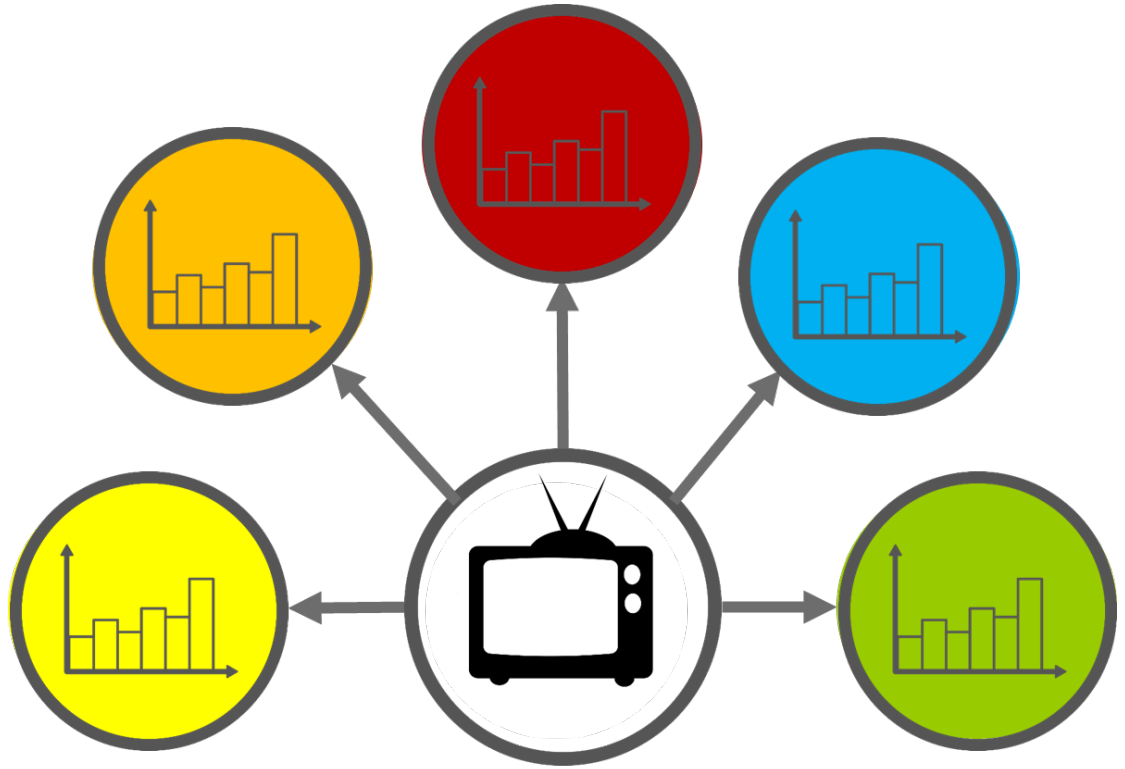


Source: U.S Energy Information Administration (EIA) 2019

Standard energy estimates vs. device use profile estimates



One use profile across many devices



One device across many use profiles

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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

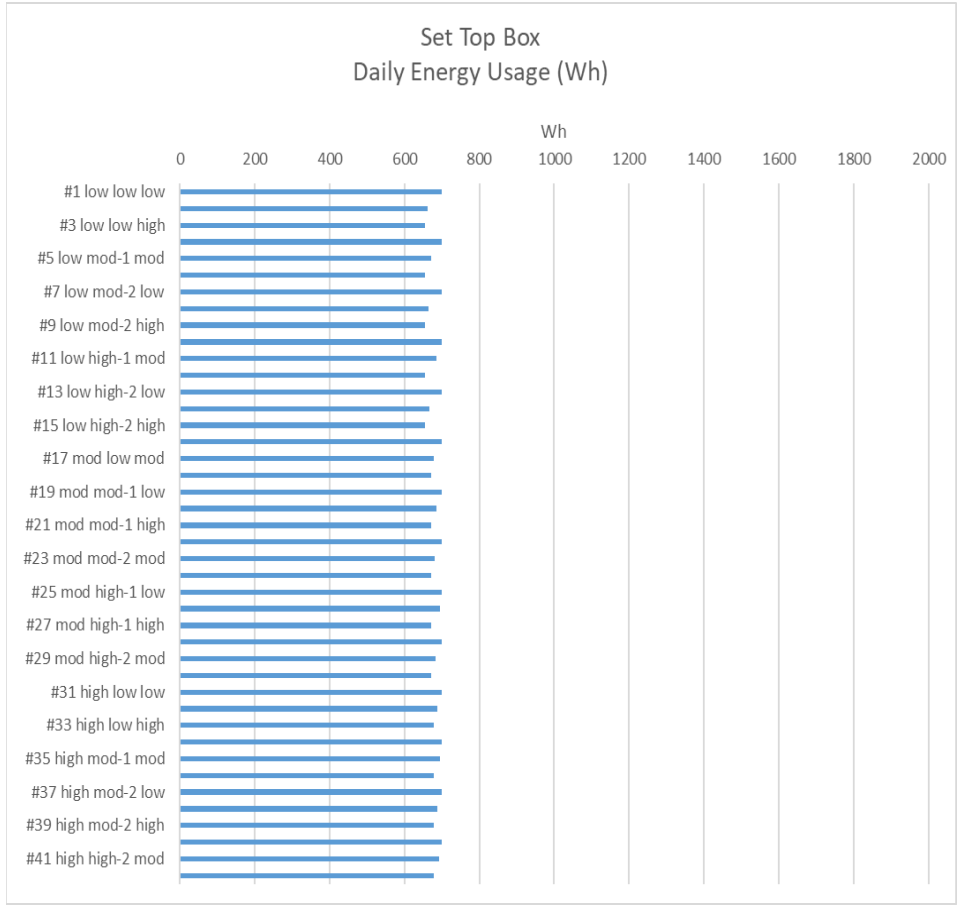
- Pod coffee makers
- Rice cooker

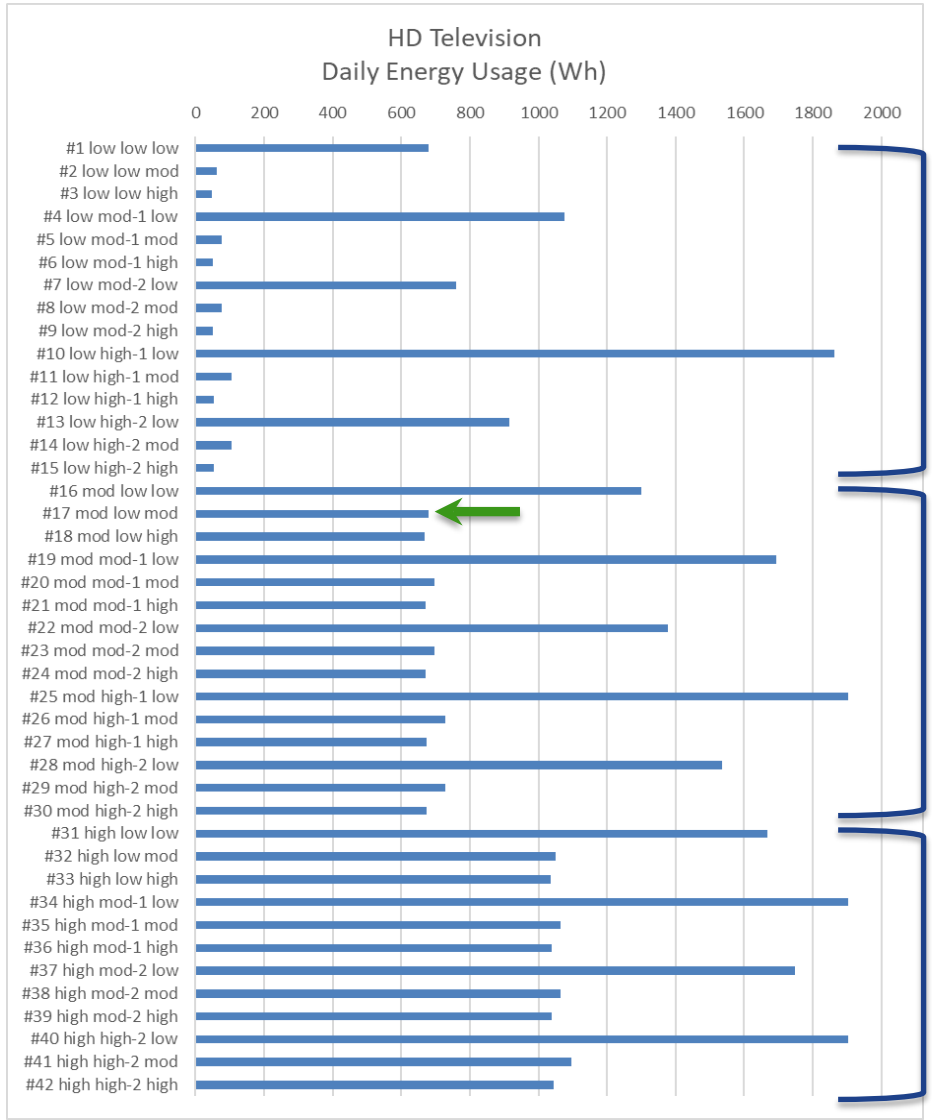
Other commercial devices

- 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





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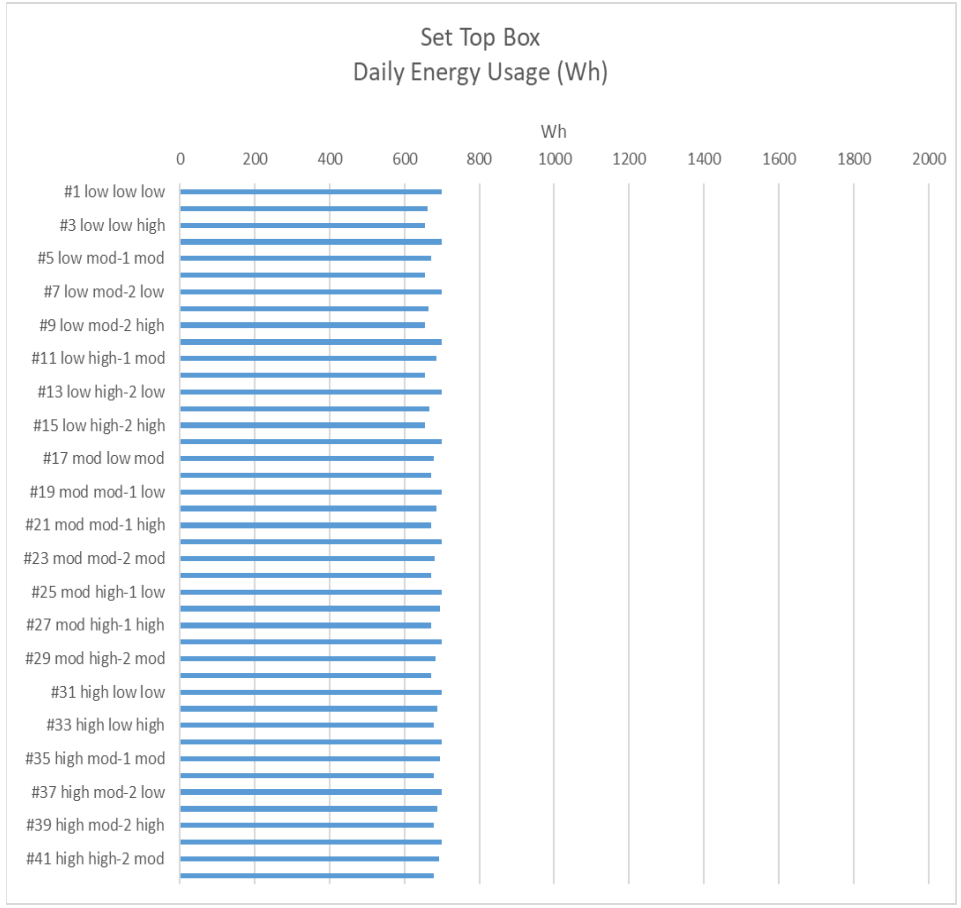
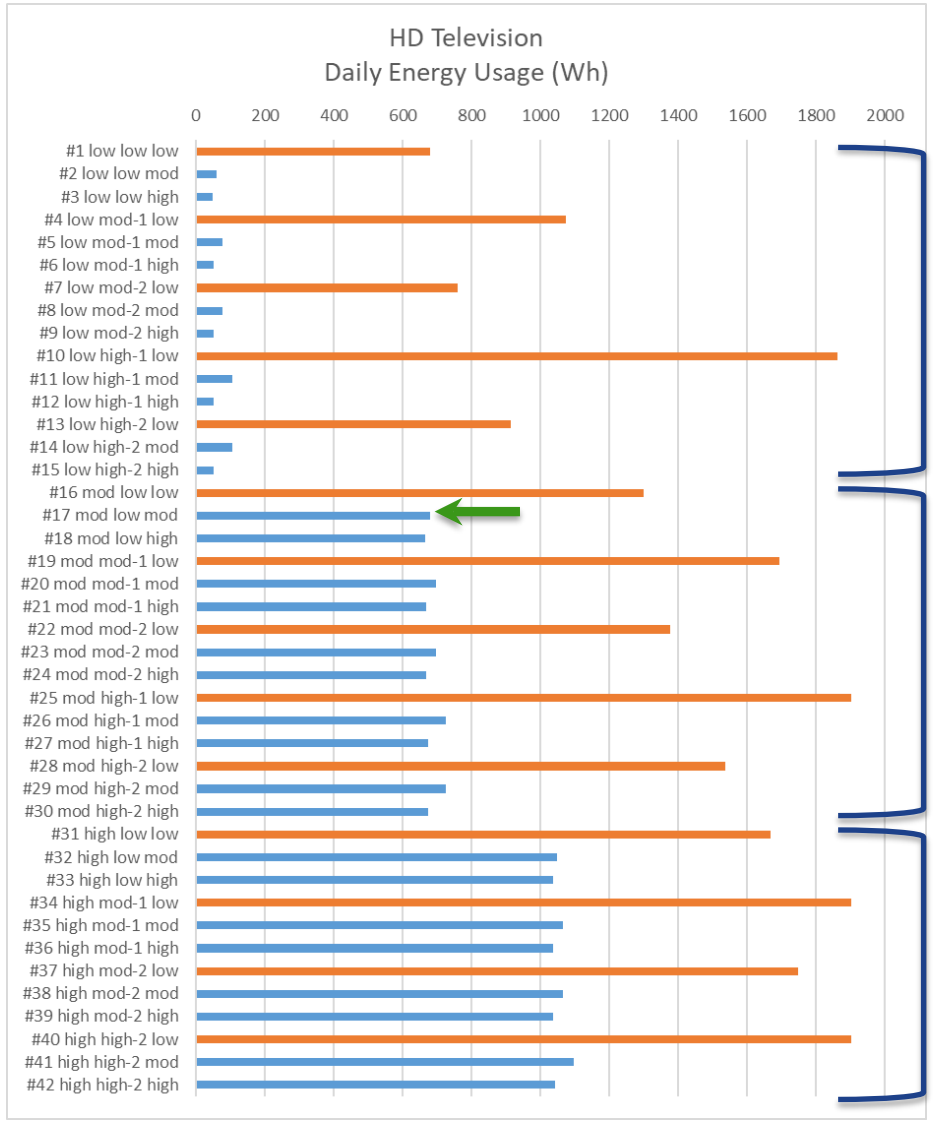




PM low

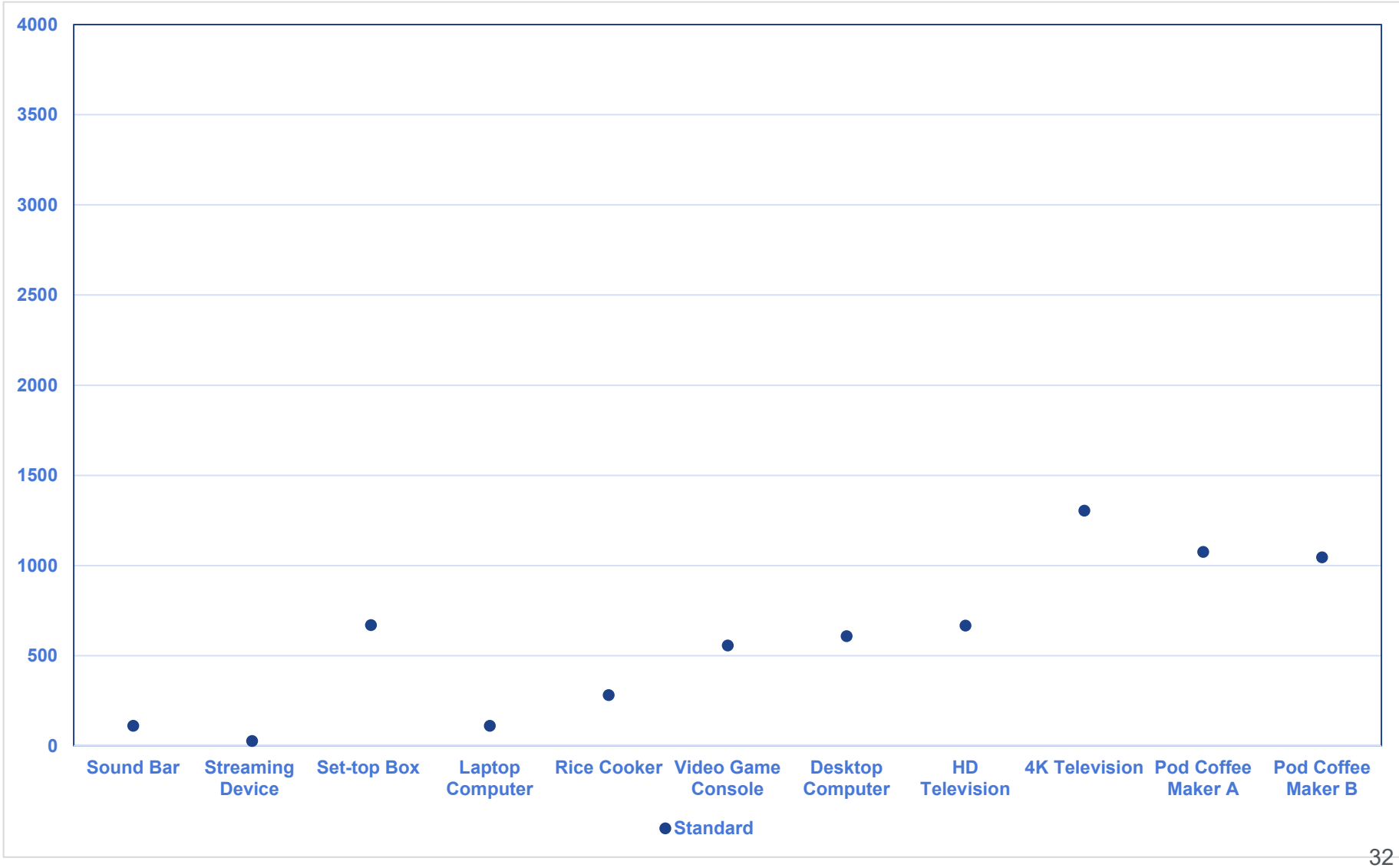
Active low

Active mod

Active high

Energy use for standard profiles

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



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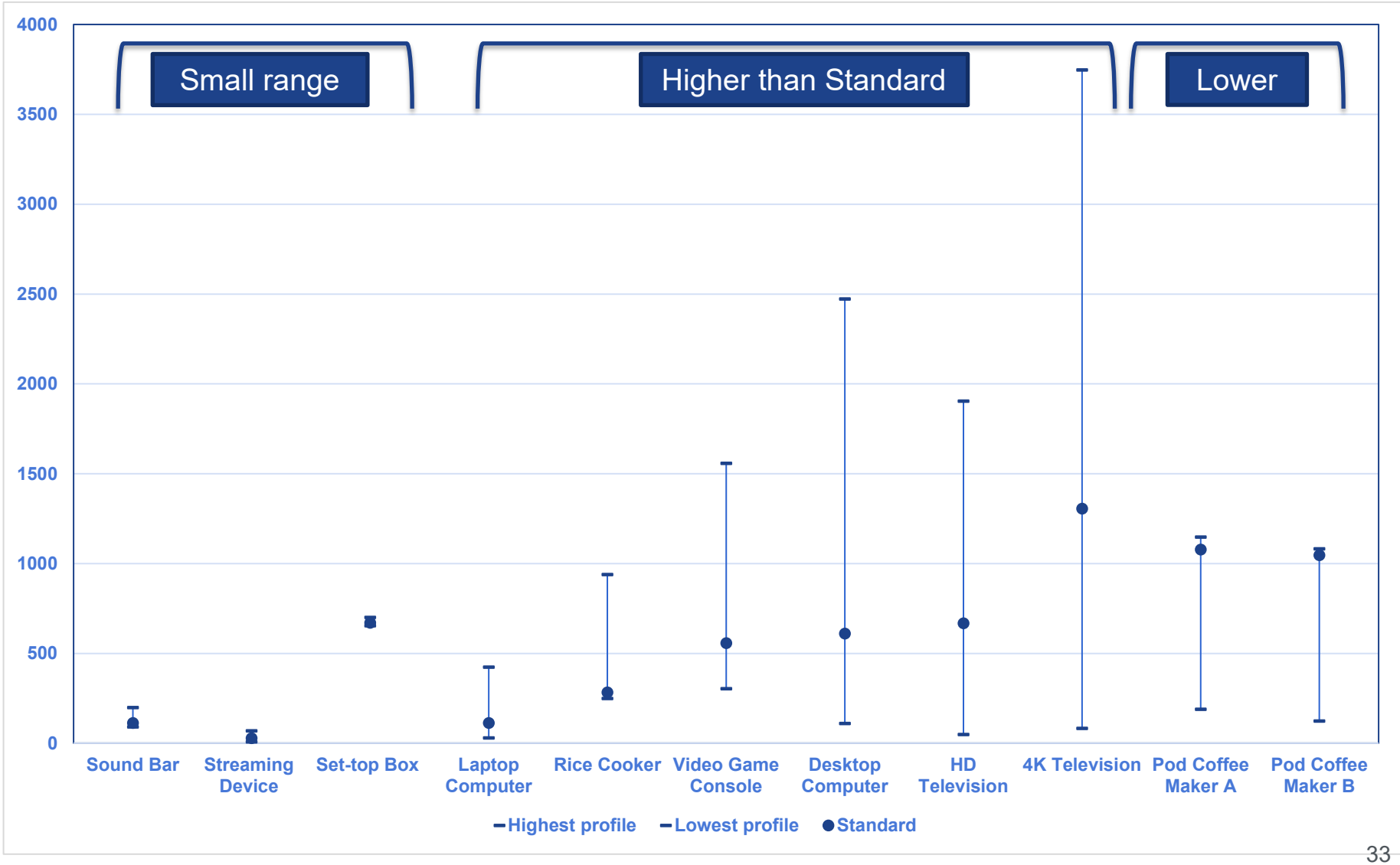
Energy use for highest and lowest profiles compared to standard profile

But the ranges can be quite large



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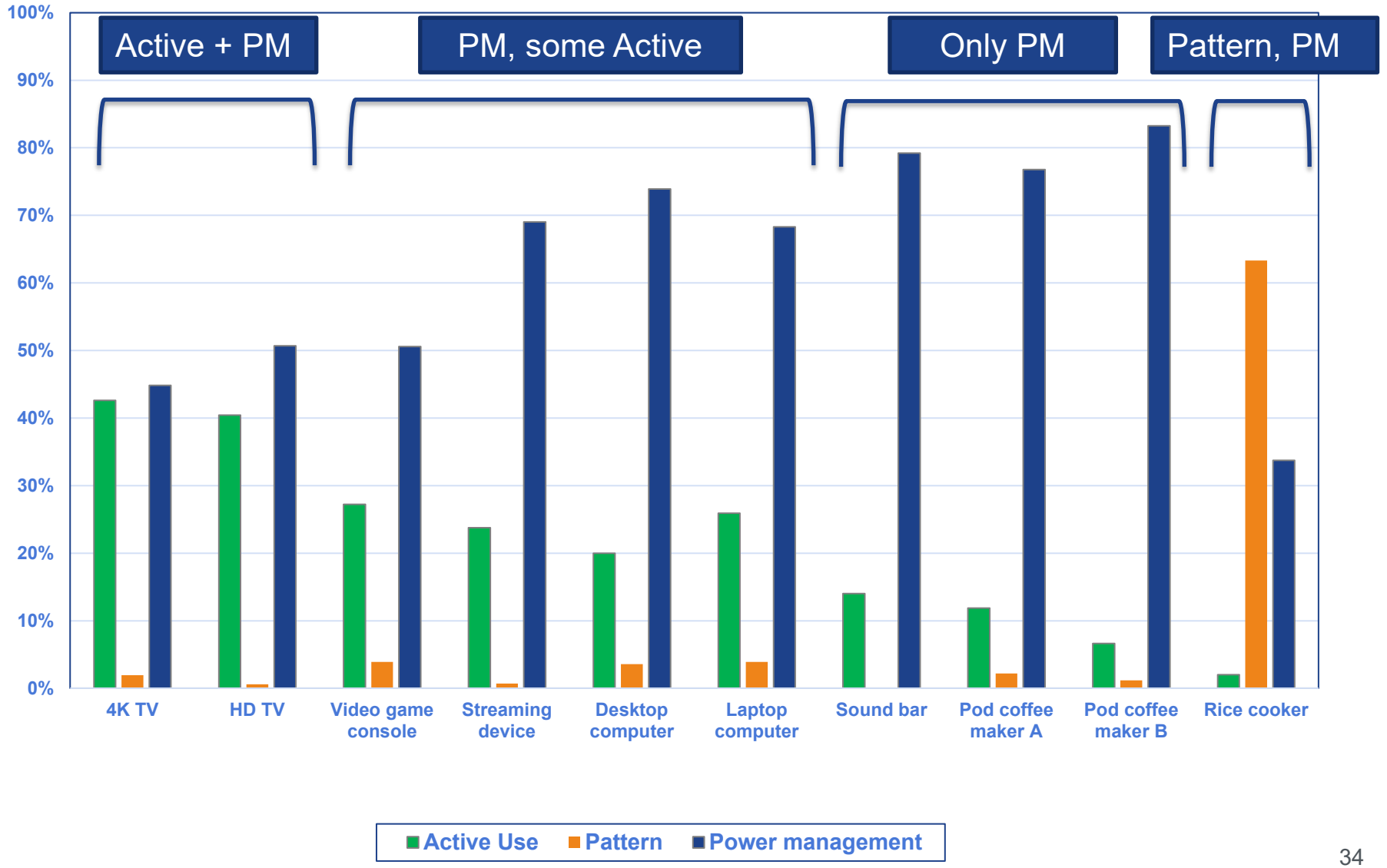
Which aspect of device use drives the variation in energy use?

Power management is a major factor for all devices

Active use varies in *relative* importance

Pattern is only significant for rice cooker



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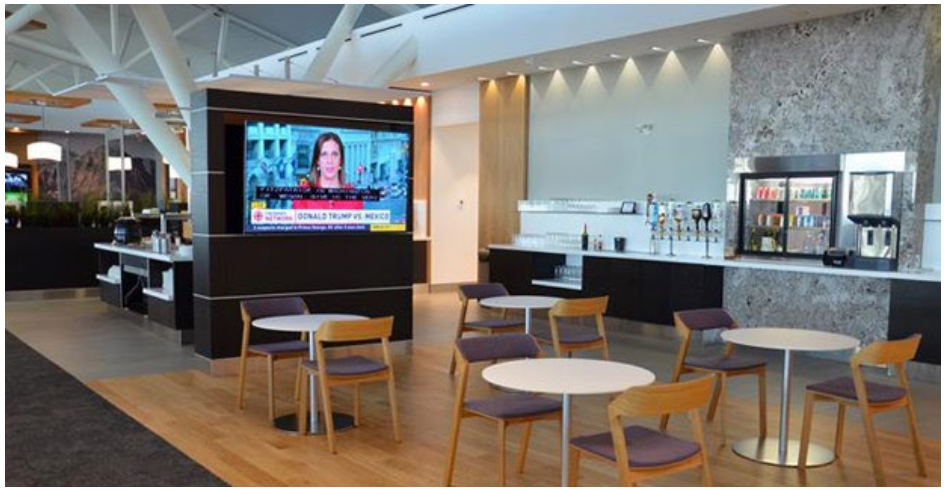
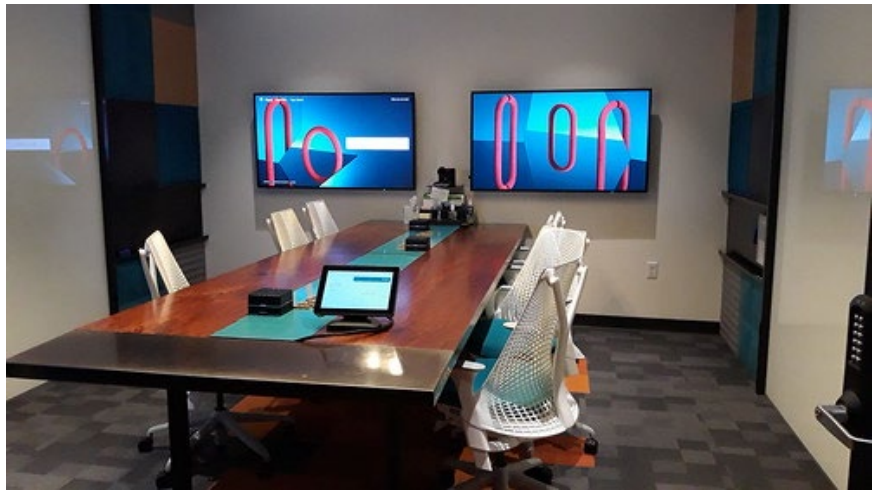
What to do about it

- 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? YES	NO	NA	Does this device turn off during nonbusiness hours? YES	NO	NA
Break Rooms and Kitchens	Full-Size Refrigerators							☐	☐	☐	☐	☐	☐
	Mini-Refrigerators							☐	☐	☐	☐	☐	☐
	Coffee Makers							☐	☐	☐	☐	☐	☐
	Toasters							☐	☐	☐	☐	☐	☐
	Microwaves							☐	☐	☐	☐	☐	☐
	Refrigerated Vending Machines							☐	☐	☐	☐	☐	☐
	Nonrefrigerated Vending							☐	☐	☐	☐	☐	☐
	Water Coolers							☐	☐	☐	☐	☐	☐
	Drinking Fountains							☐	☐	☐	☐	☐	☐
	Water Heaters							☐	☐	☐	☐	☐	☐
	Water Filters							☐	☐	☐	☐	☐	☐
	Dishwashers							☐	☐	☐	☐	☐	☐
	Ovens/Stoves/Ranges							☐	☐	☐	☐	☐	☐

Space	Device	
Workstations	Desktop Computers	
	UPS Units	
	Laptop Computers	
	Computer Monitors	
	Task Lighting	
	Decorative Lighting	
	Phones	
	Peripherals	
	Personal Printers	
	Personal Scanners/Copiers	
	Personal Fax Machines	
	Paper Shredders	
	Space Heaters	
	Fans	
	Radios	
	Electric Pencil Sharpeners	
	Electric Staplers	
	Electric Hole Punchers	
	Label Makers/Printers	
	Digital Photo Frames	
	Cell Phone Battery Chargers	
	Mini-Refrigerators	
	Coffee Makers	

Recommended Plug Loads Energy Reduction Strategies for Office Buildings

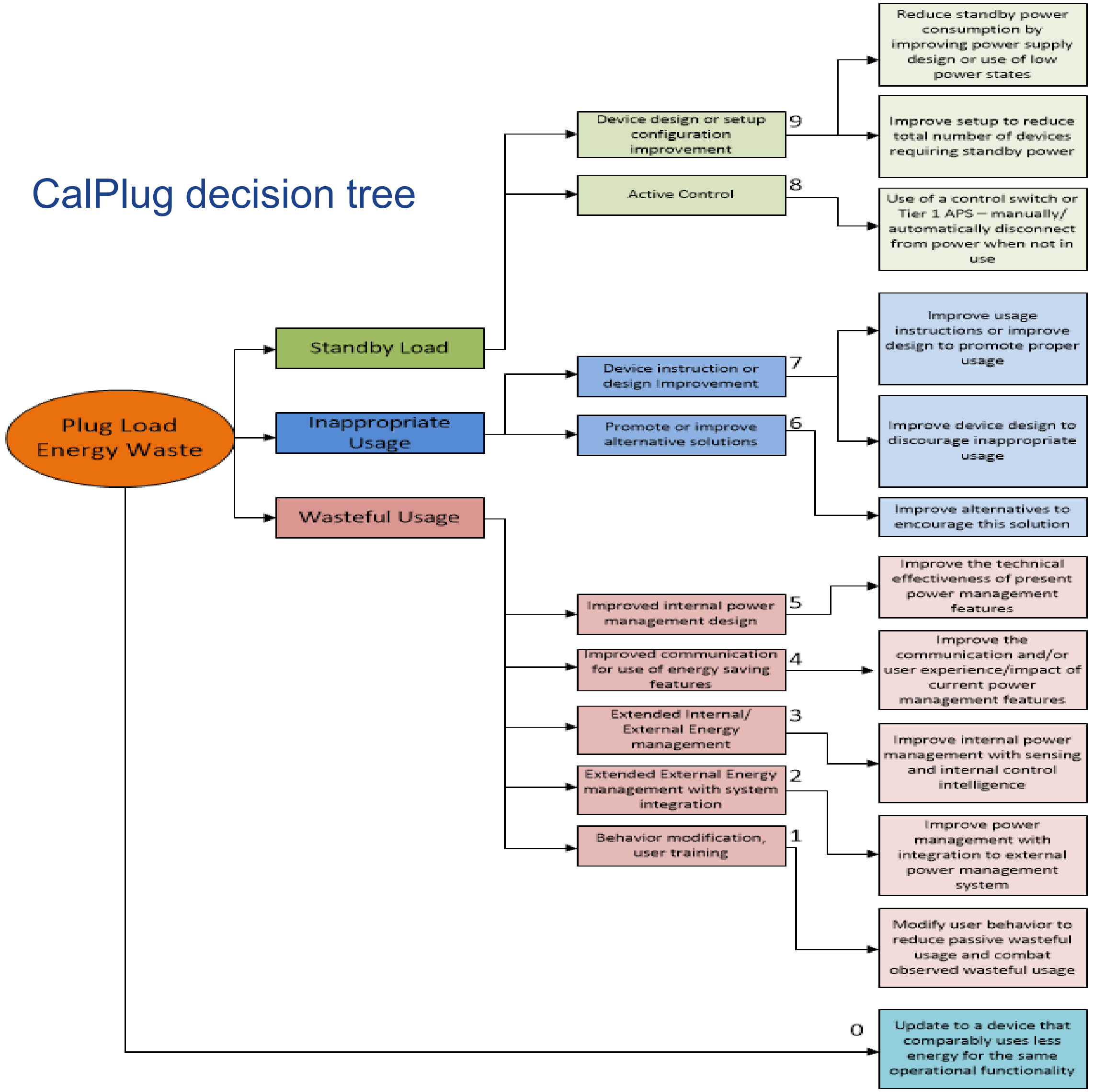
For each strategy listed here, answer the question "Is my building doing this?" If your response is "NO" for any strategy, fill out the adjacent cells to the right to determine the approximate savings the given strategy could yield in your building. Strategies that are listed without savings numbers 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)
Break Rooms and Kitchens							
Remove underused refrigerators	○	◉	○	**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	○	◉	○	**400 kWh/year** for every inefficient refrigerator that is replaced	x ____	=	0
Consolidate personal mini-refrigerators into a full-size shared refrigerator	○	◉	○	**350 kWh/year** for every mini-refrigerator that is removed	x ____	=	0

NREL facility assessment checklist

CalPlug decision tree



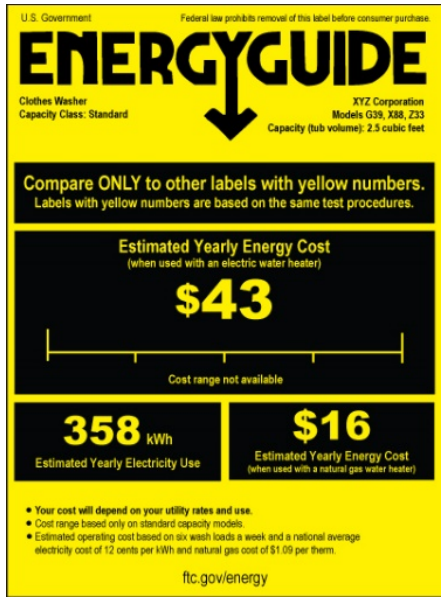
Identifying device usage problems

- 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

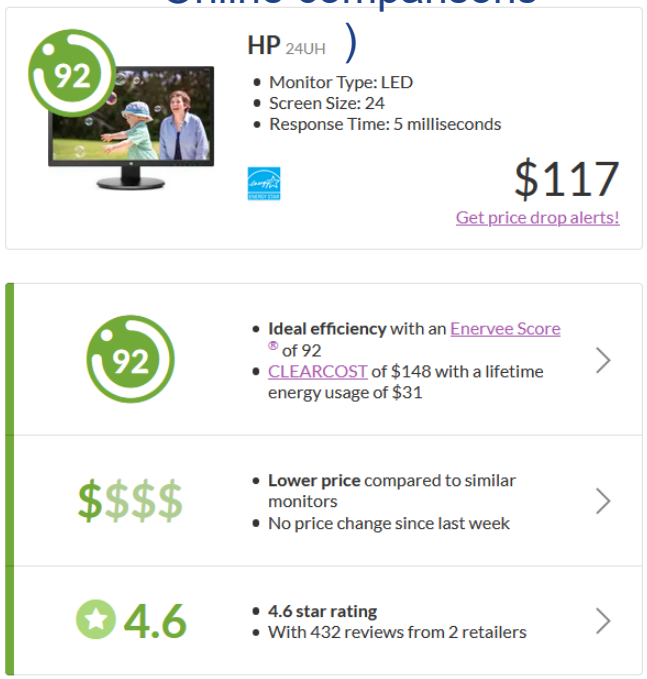
Technology solutions: device level

- Better devices
  - Factor in energy savings

Energy labels

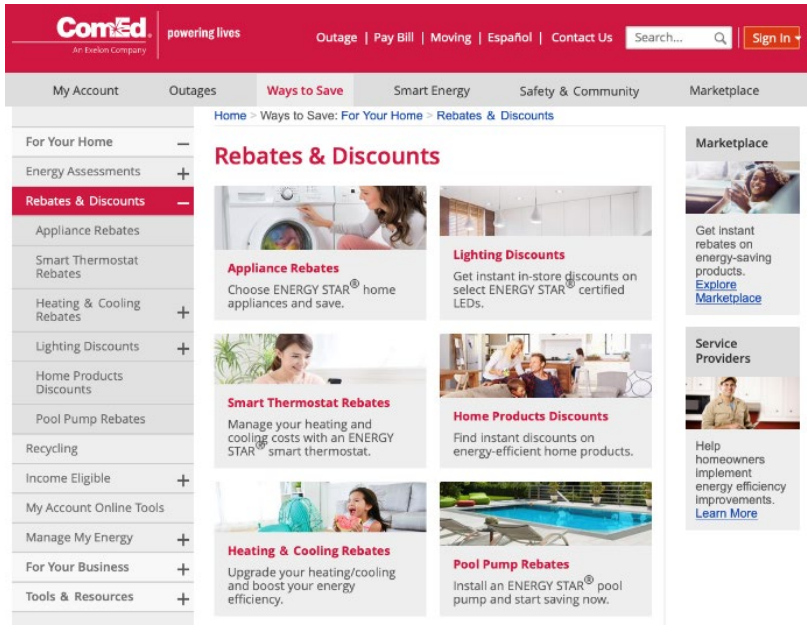


Online comparisons



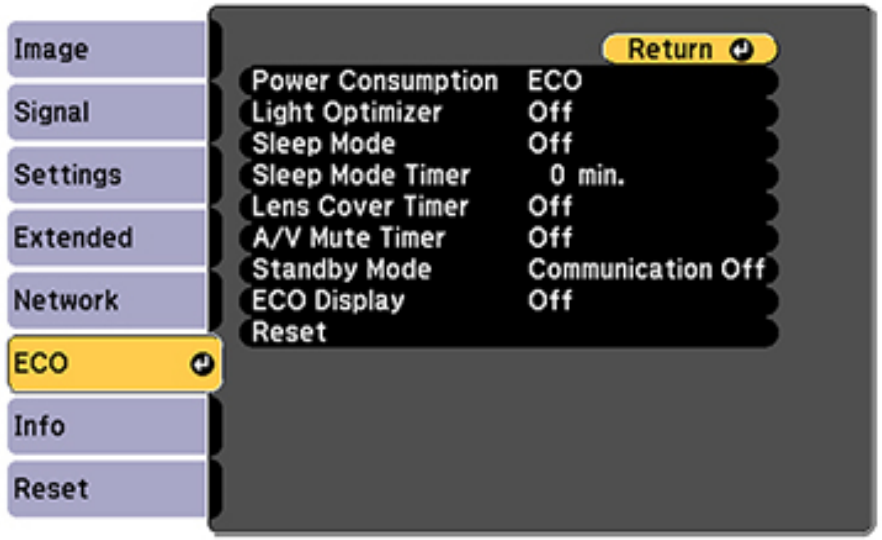
(shown: Enervee)

Utility energy efficiency programs

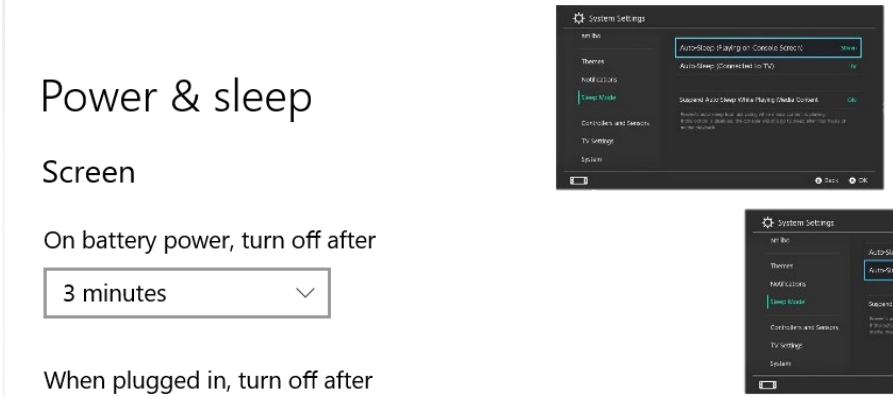


Technology solutions: settings level

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

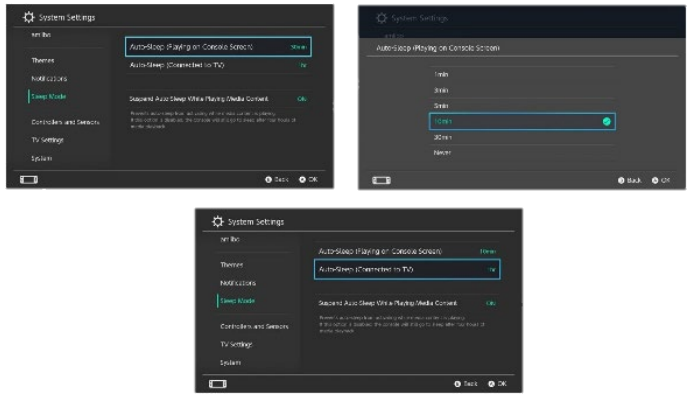


Projector “eco” mode – default disabled



Laptop

Can be complicated….

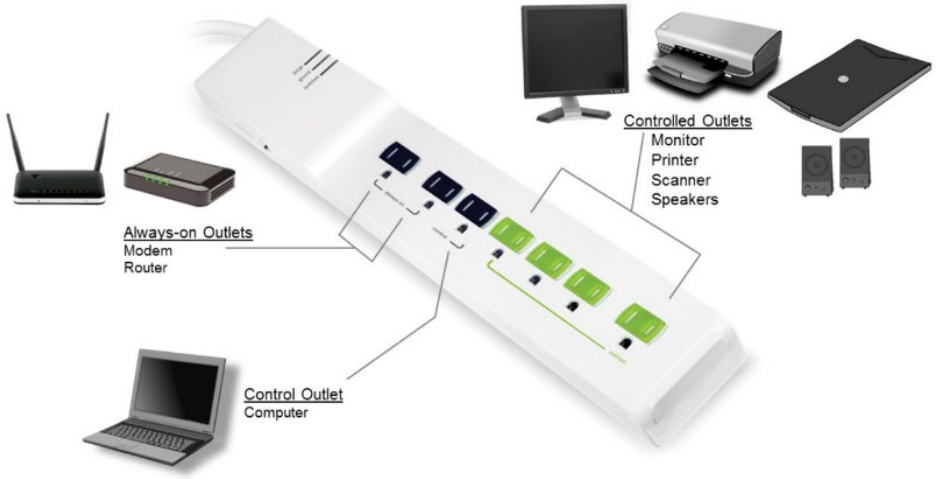


…and may still allow vampire load

Technology solutions: control level

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

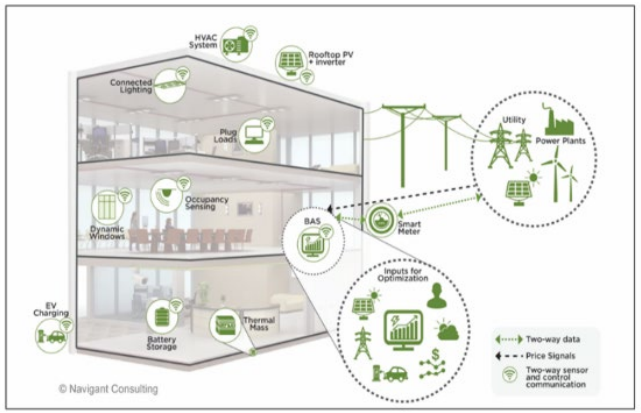
Individual control devices



Control device system

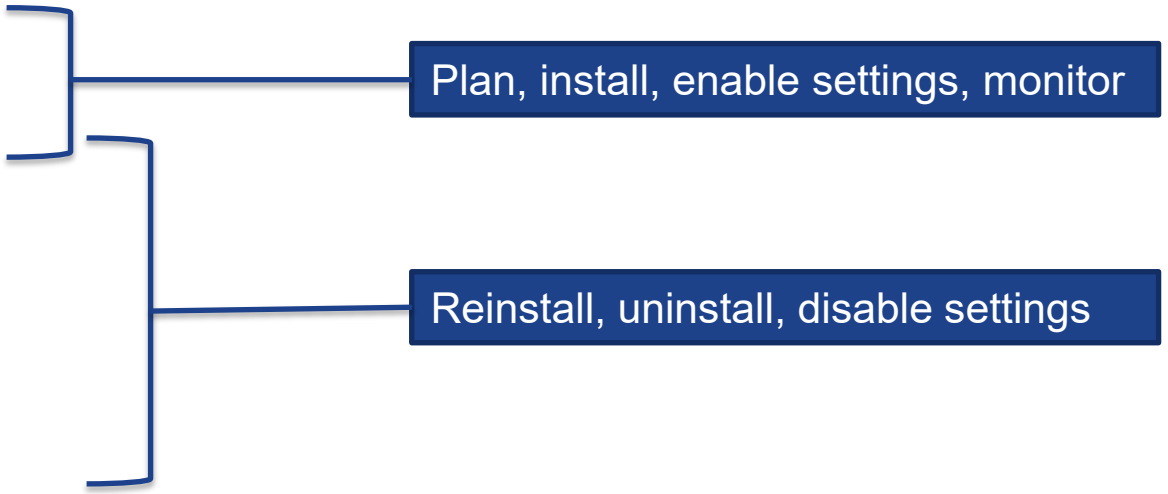
(shown: Sapient)

Controlled outlets and BAS / BEMS / GEBs



Getting users onboard is key to persistence

- Engage stakeholders at every level
  - Owners
  - Facility managers
  - Management
  - Workers
  - Maintenance

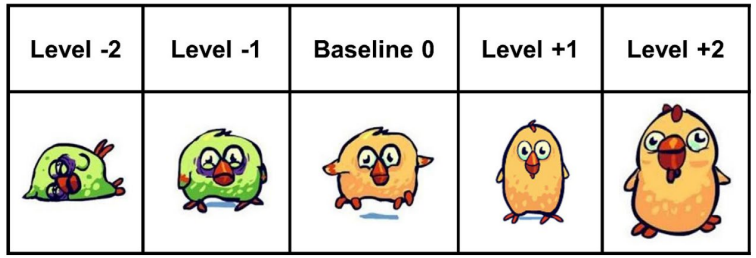


Strategies for informing and engaging

Prompts, reminders

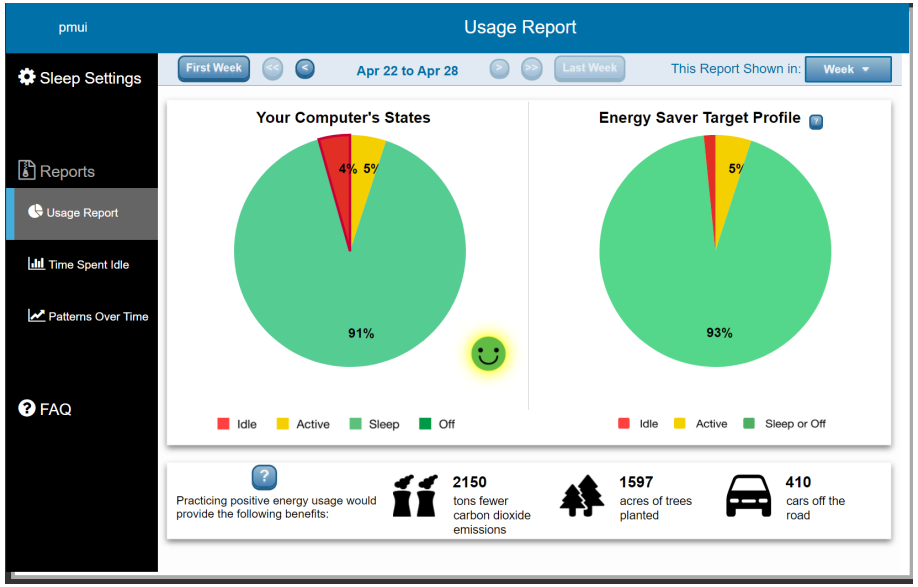
Hackel et al (2016)

Gamification



CoolChoices.com

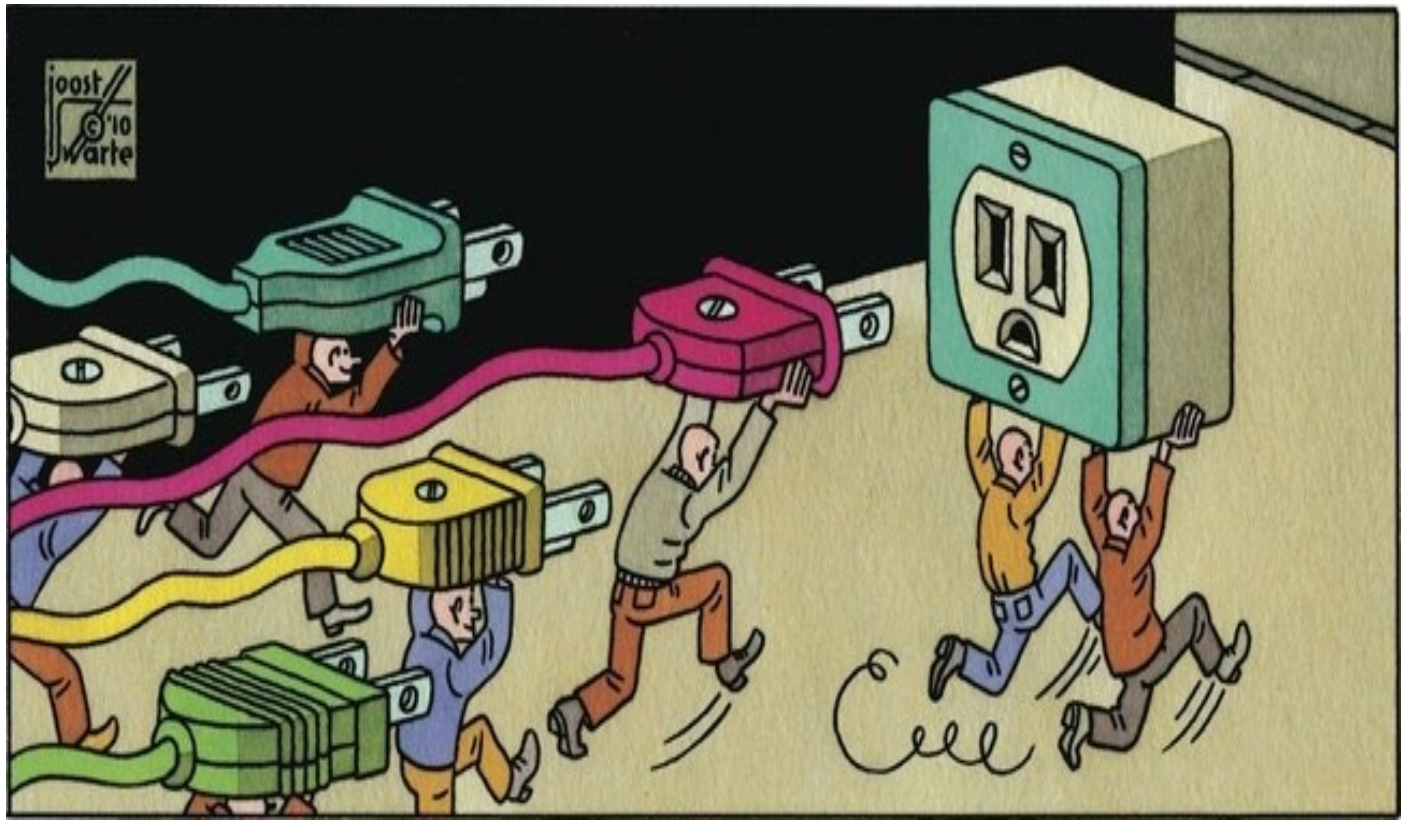
User feedback



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?

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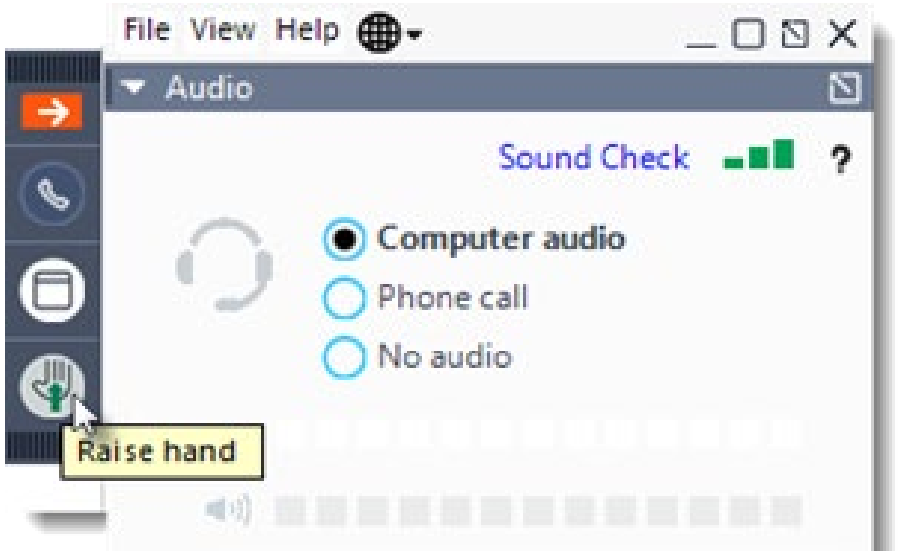
jpixley@uci.edu

Would you like to share an update?

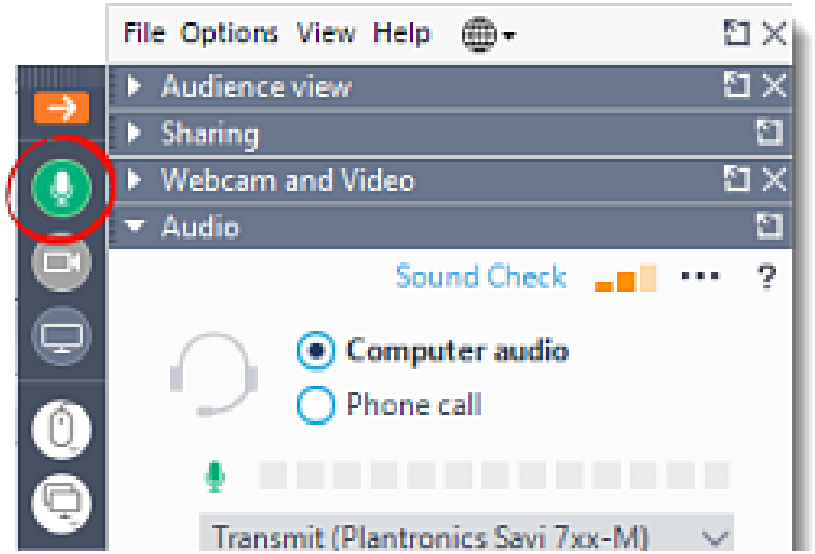
1. Raise Your Hand

- 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