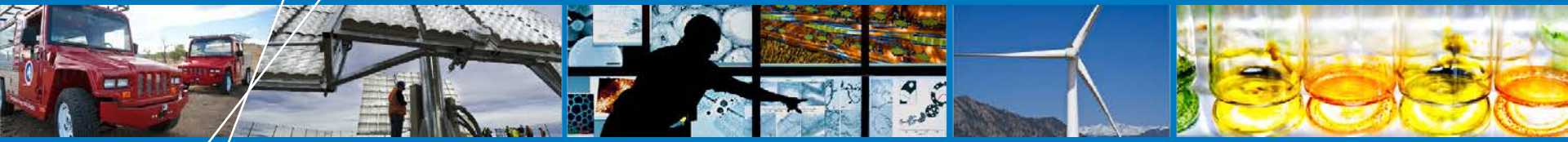
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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



CBEA Webinar

Michael Sheppy

Chad Lobato

November 21, 2011

View Recorded Webinar from November 21, 2011:

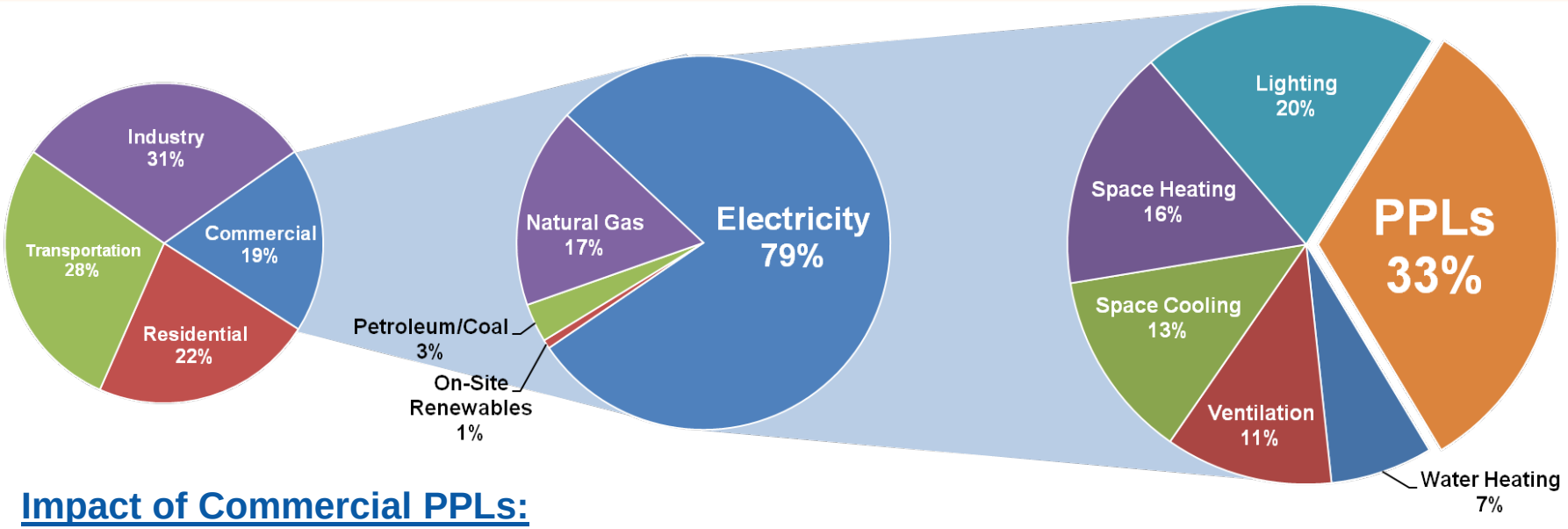
http://www1.eere.energy.gov/buildings/alliances/media/20111121_webinar_assessing_ppls.wmv

Key Questions

- What are plug and process loads (PPLs)?
- Why are PPLs so hard to control?
- How can I use NREL's guides to reduce PPLs in my building?

What are plug and process loads?

Definition: PPLs are building loads that are unrelated to general lighting, heating, ventilation, cooling, and water heating. They typically do not provide comfort to the occupants.



Credit: Chad Lobato/NREL

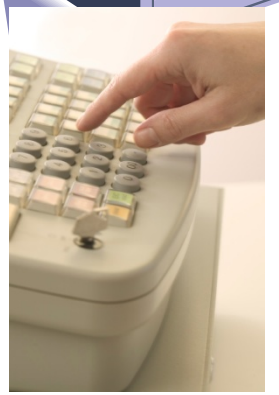
Impact of Commercial PPLs:

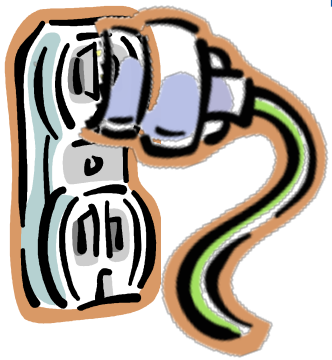
- 5% of U.S. primary energy (DOE *Buildings Energy Data Book* 2010)

PPL Challenges:

- PPLs are not viewed as an integral building system.
- No single decision maker specifies all efficiency strategies.
- PPLs are not addressed by building codes.

Plug Loads: Important Definitions





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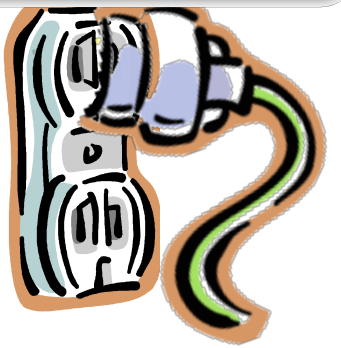
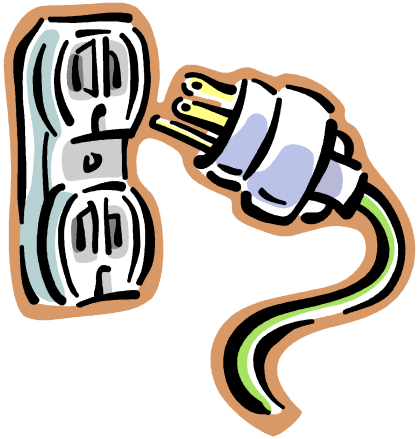


PARASITIC LOAD



DE-ENERGIZED

Credit: Microsoft Office 2007

How did we get here?

NREL/PIX 18638

Office PPLs:

- The design and construction of NREL's Research Support Facility (RSF) sparked in-depth office PPL research.
- As designed, more than 50% of the RSF's annual energy is from PPLs.
- Existing NREL PPL practices would have exceeded the whole-building energy use goals.
  - A 50% reduction in PPL energy use was required.
- NREL developed PPL energy use reduction strategies and retrofits from office PPL research.

Retail PPLs:

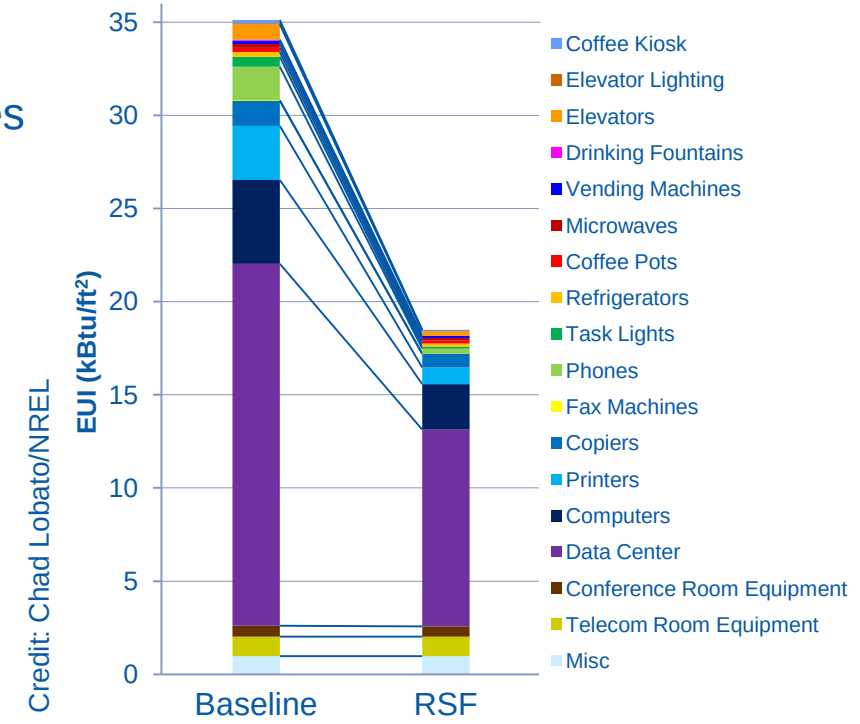
- NREL has worked with Commercial Building Partnership members and performed plug load audits in various retail spaces.
- NREL has performed extensive retail PPL metering studies.
- NREL developed PPL energy use reduction strategies and retrofits from retail PPL research.

Examples of Plug Loads in Office Buildings

- Break rooms and kitchens
  - Refrigerators
  - Small kitchen appliances
  - Vending machines
  - Drinking fountains
- Workstations
  - Computers
  - Monitors
  - Task lights
  - Phones
  - Printers, copiers, scanners, and fax machines
- Vertical transport
  - Elevators
  - Escalators
- Small-scale food service areas
- Conference rooms
- Server rooms/data centers
- Telecom rooms

Low-Energy Workstation:

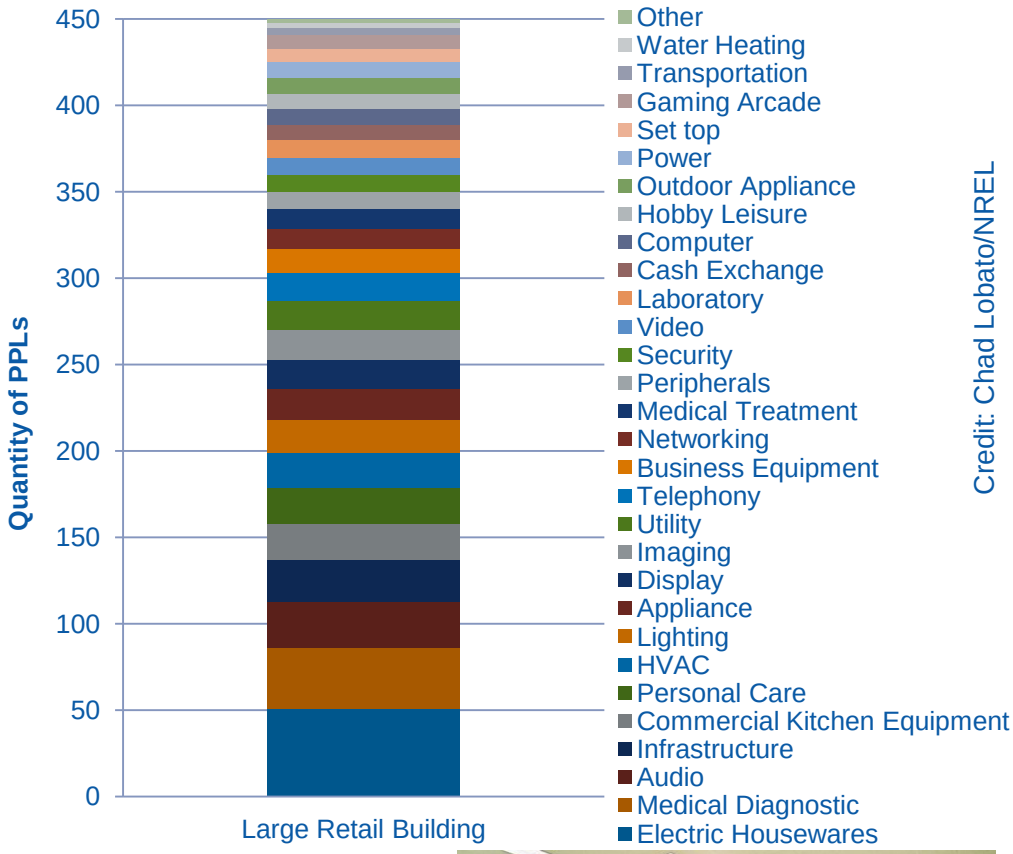
Credit: Matthew Luckwitz/NREL



Credit: Chad Lobato/NREL

Examples of Plug Loads in Retail Buildings

- Point of sale
  - Cash register
  - Demagnetizer
  - Barcode scanner
  - Conveyor belt
- Vending machines
- Refrigerators
- Self-service kiosks
- Electronics section
  - Televisions
  - Radios
  - Computers
  - Clocks
  - Video game consoles
- Office equipment
  - Computers
  - Monitors
  - Task lights
  - Phones
  - Printers, scanners, copiers, and fax machines



Credit: Chad Lobato/NREL

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Things That Affect Energy Use of Plug Loads

Manufacturer dependent:

- In-use power draw
- Parasitic power draw
- Built-in low power functionality
- Built-in automatic on/off functionality
- Built-in battery backup
- Power requirements: voltage and amperage
- Power cycling limitations
- Time to be ready to use from an “off” state
- Availability of energy-efficient replacements
- Device functions

Use dependent:

- Location
- User
- Use pattern
- Implementation
- Device control

NREL/PIX 15781

Why are plug loads so hard to control?

Manufacturer dependent:

- Built-in low power or automatic on/off functionality
  - Built-in functionality can be inconsistent, unreliable, or not included.
- Power requirements: voltage and amperage
  - Off-the-shelf solutions may not be available for higher power devices.
- Power cycling limitations
  - Some devices simply cannot be turned off because of potential damage to the device.
- Time to be ready to use from an “off” state
  - The time delay to reach a “usable” state is too great.
  - Configuration may be required when a device is turned on.
- Device functions
  - The primary function may be for the health and safety of building occupants and thus the device cannot be turned off.

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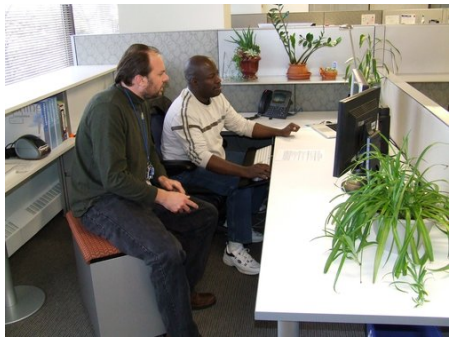

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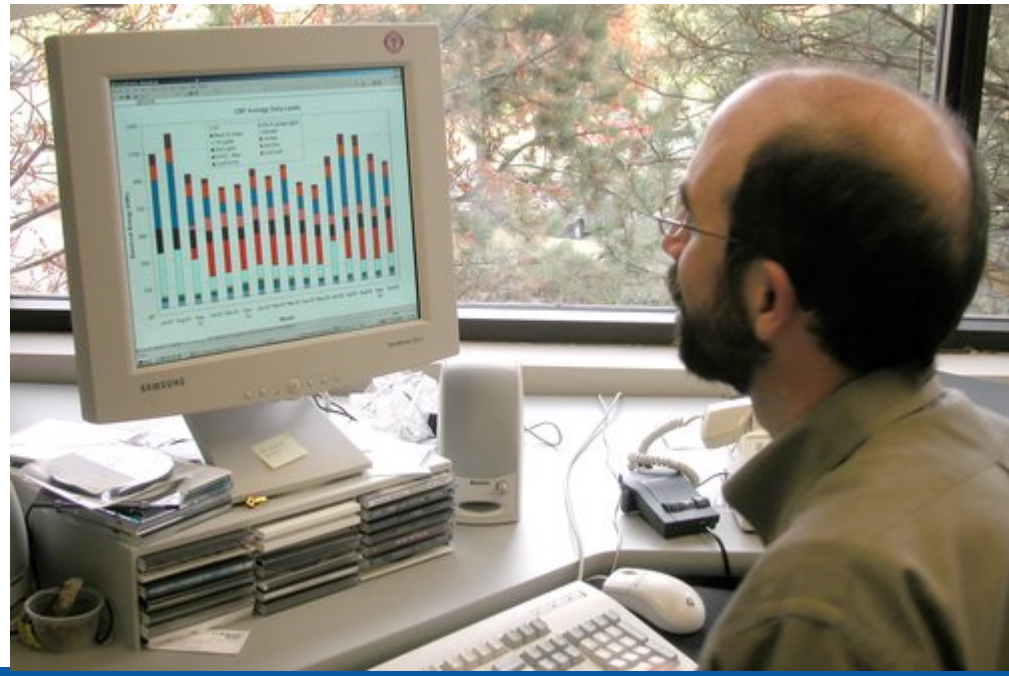
NREL/PIX 19586

Why are plug loads so hard to control?

Use dependent:

- Location
  - A given device may be used differently depending on its location.
- User
  - A given device may be used differently depending on the user.
- Use pattern
  - Device use schedules vary widely.
- Implementation
  - PPLs are often present in large numbers.
  - PPLs are very diverse.
  - PPLs can directly generate revenue.



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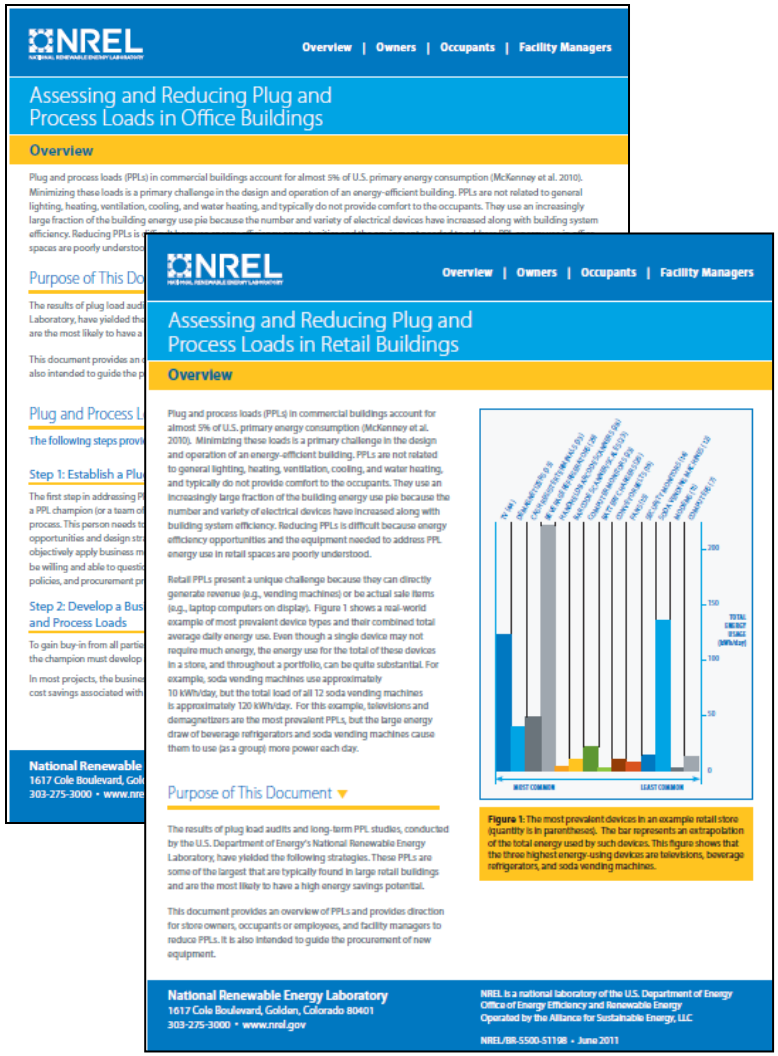
How can I reduce plug loads in my building?



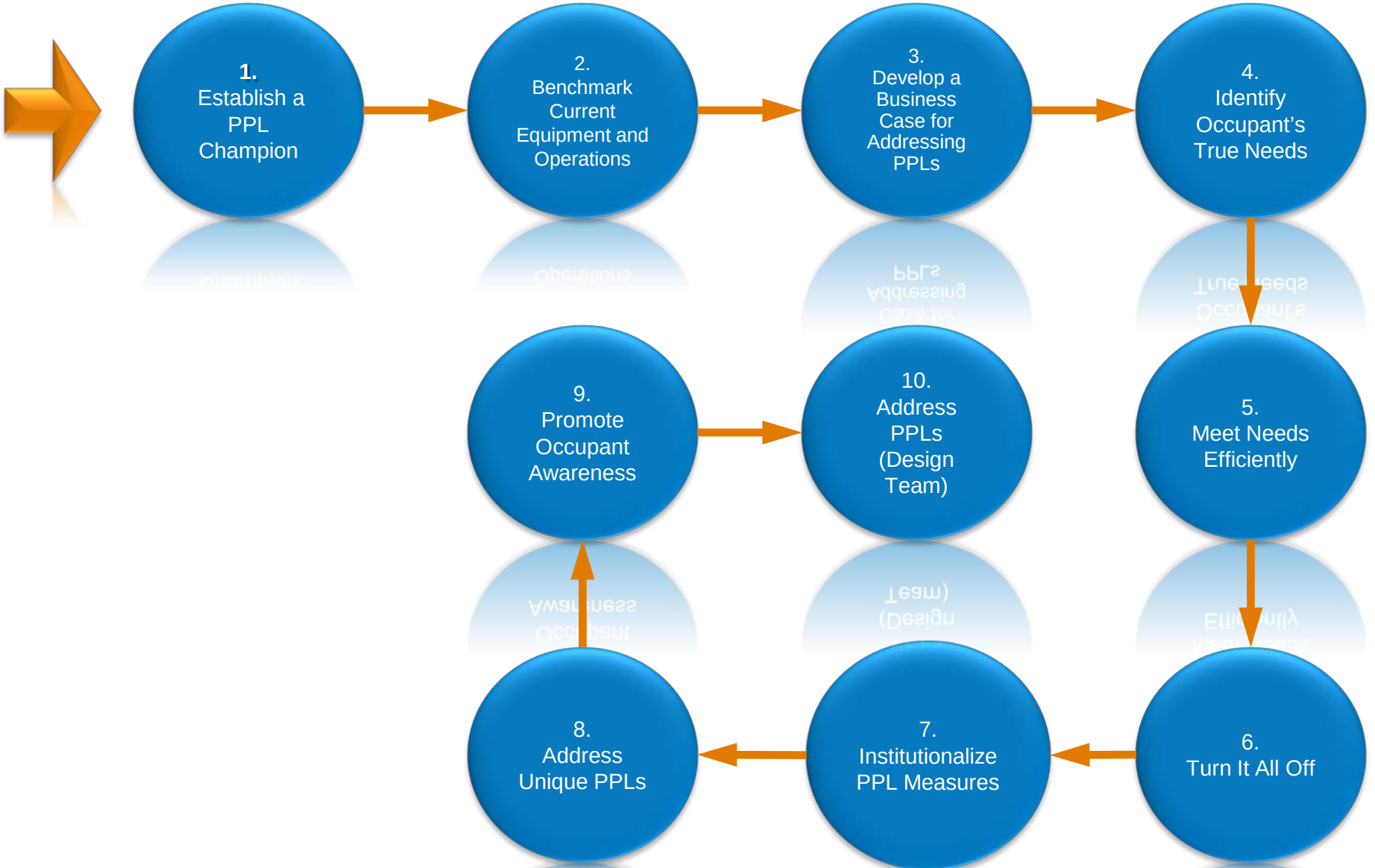
NREL How-To Brochures:

- Assessing and Reducing Plug and Process Loads in Retail Buildings
  - Available here: http://www.nrel.gov/docs/fy11osti/51198.pdf
- Assessing and Reducing Plug and Process Loads in Office Buildings
  - Available here: http://www.nrel.gov/docs/fy11osti/51199.pdf

What do these include?

- 10-step process to evaluate PPLs
- Recommendations based on:
  - Space type
  - Equipment type
- Plug load savings calculator

10 Steps To Address Plug and Process Loads



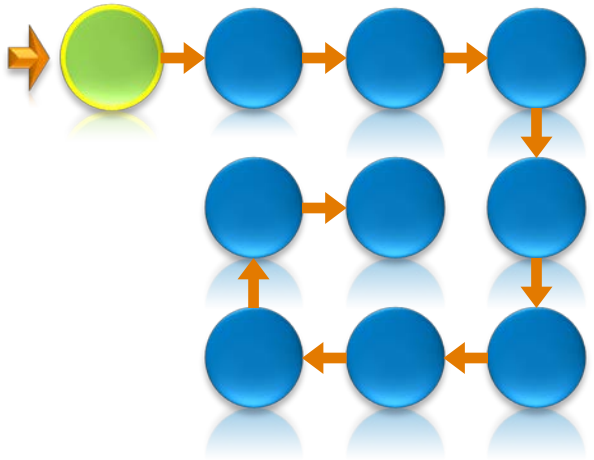
Step 1: Establish a PPL Champion

Purpose:

To initiate and help implement PPL strategies.

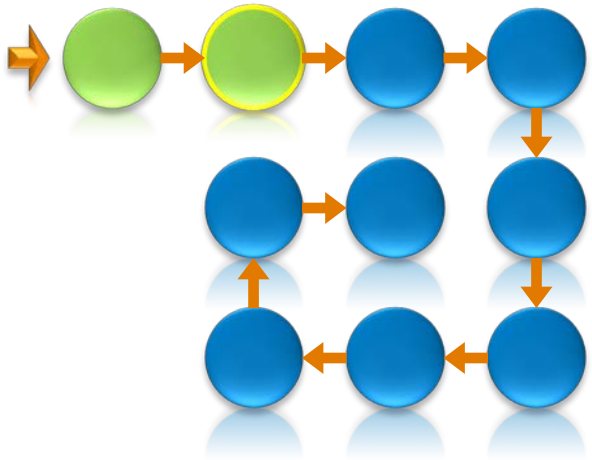
Skills needed:

- Basic understanding of:
  - Energy efficiency opportunities
  - Design strategies
- Ability to:
  - Apply cost justifications
  - Critically evaluate operations, institutional policies, and procurement processes



Step 2: Benchmark Current Equipment and Operations

- Indentify and inventory PPLs.
- Establish baseline for:
  - Current equipment
  - Current operations.
- Establish basis of comparison for financial calculations.
- Understand when equipment is used.
- Indentify PPL strategies that would yield the largest savings.



Step 2a: Perform a Walkthrough and Develop a Metering Plan

The champion will assess PPLs to:

- Gain an understanding of the use pattern.
- Inventory PPLs: types and quantity.
- Identify common and unique pieces of equipment.
- Work with the PPL users to determine how and why each piece of equipment is used.
- Determine if PPL is critical to health, safety, or business operations.
- Develop a metering plan.
  - Meter a subset of common equipment.
  - Meter all “unique” PPLs when possible.

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Step 2b: Select a Plug Load Meter

Meter Features:

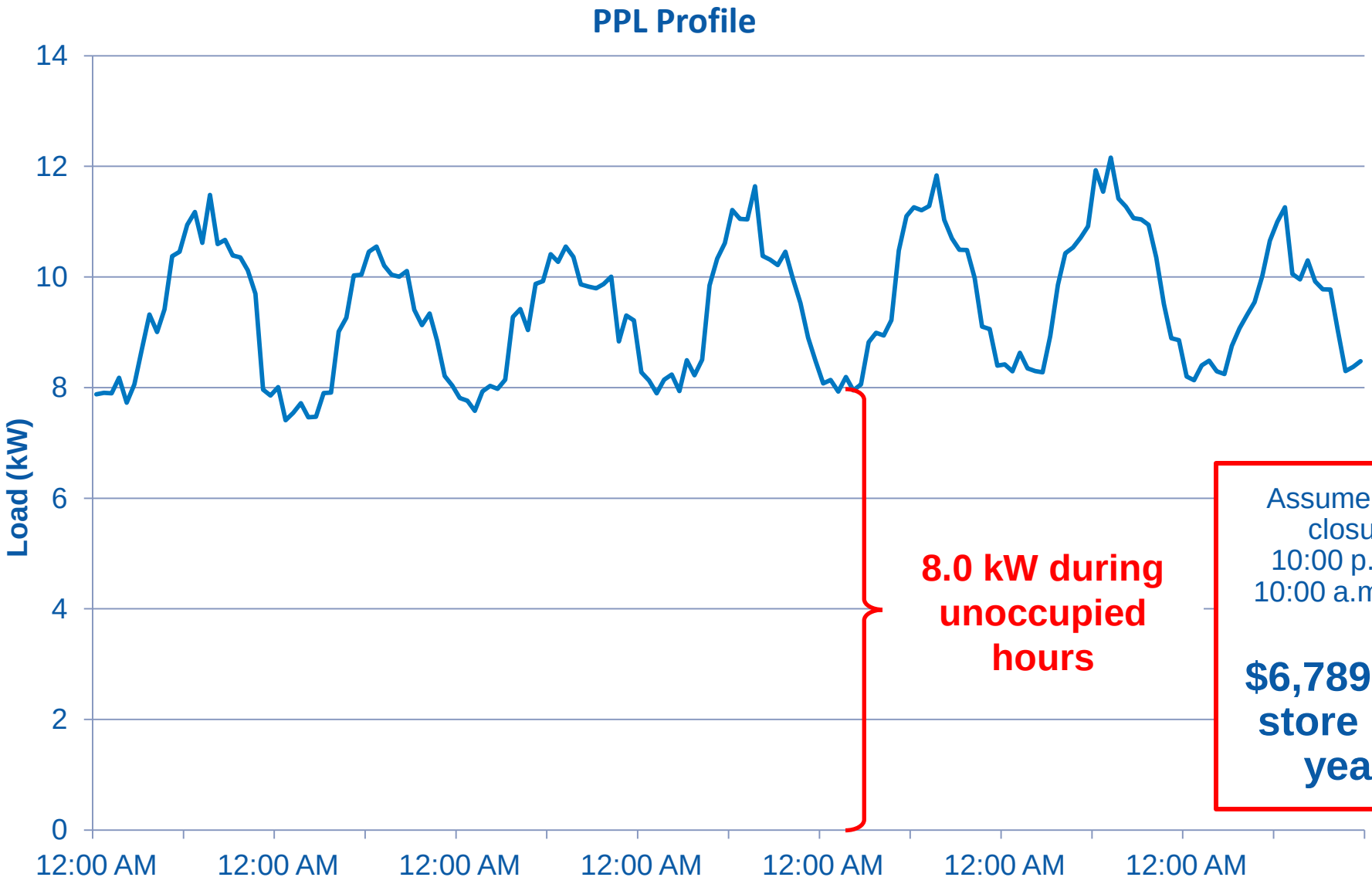
- Ability to measure and log one week of electrical power (Watts) data
- Sampling interval of 30 seconds
- Designed for the type of circuit to be metered
  (e.g., 120 Volt, 15 amp, 60 Hertz)
- Ability to accurately meter loads of 0–1800 W
- External display
- Internal clock that timestamps each data point
- Underwriters Laboratories listing

Step 2c: Meter the Plug Loads

Steps to execute the metering plan:

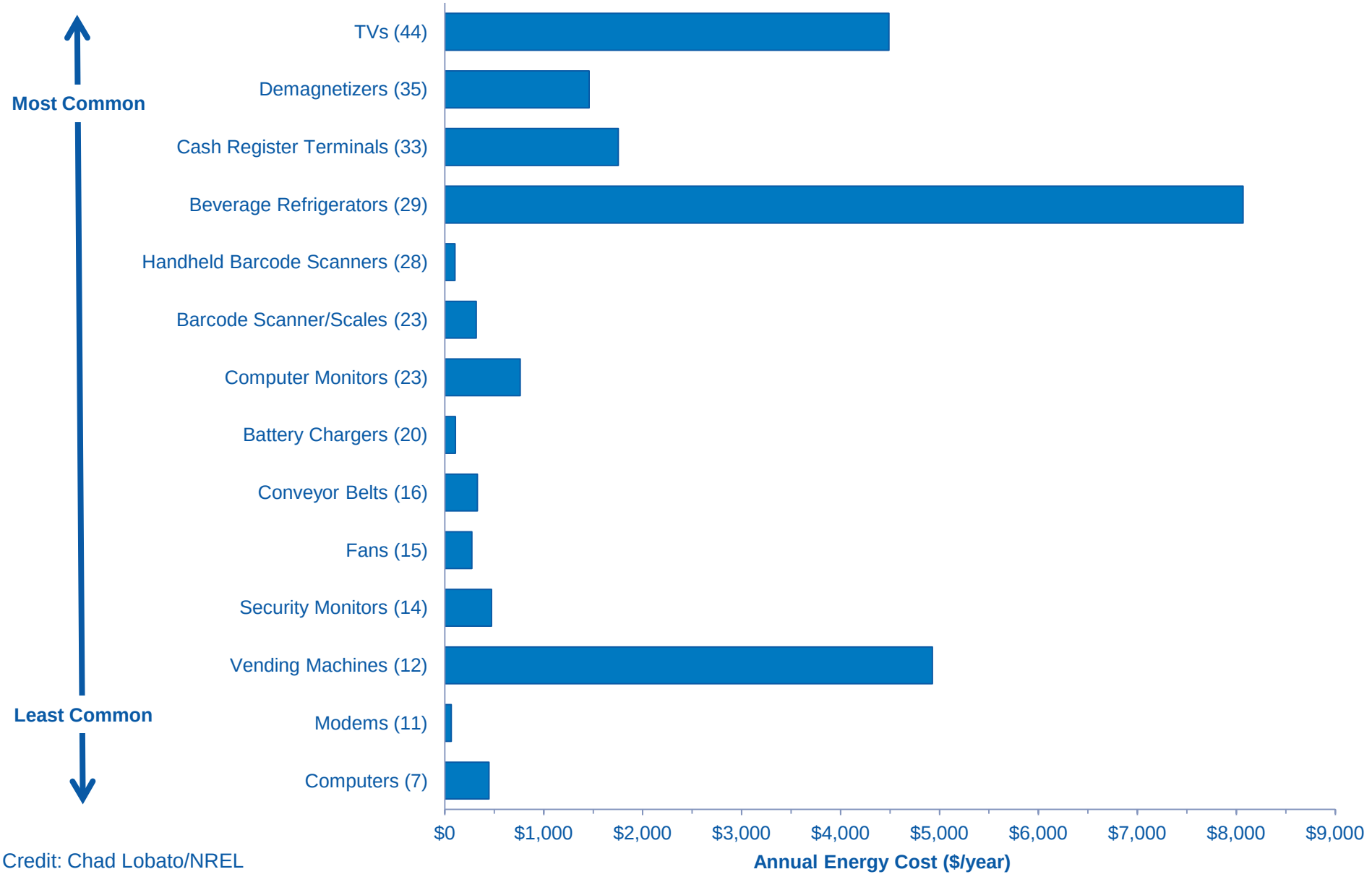
1. Determine whether the PPL can be de-energized.
2. Determine whether installing a meter will interrupt business operations.
3. Inform users that the metering effort is not to monitor their personal activities.
4. Set up the meter to measure electrical power.
5. Power down and unplug the device to be metered.
6. Plug the device into the meter. Plug the meter into an outlet.
7. Clear the memory on the meter and go through any other initial setup.
8. Power on the device to be metered.
9. Meter the device for a typical work week.
10. Calculate the average load during occupied and unoccupied hours.

Step 2d: Analyze Results



Credit: Michael Sheppy/NREL

Step 2d: Analyze Results

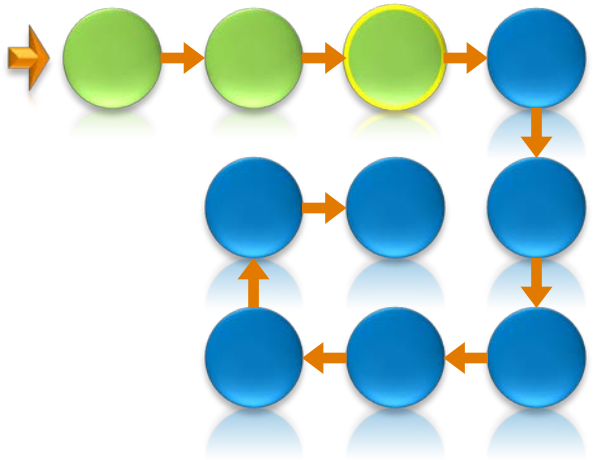


Credit: Chad Lobato/NREL

Step 3: Develop a Business Case for Addressing PPLs

Purposes:

- Establish an initial business case by demonstrating that energy consumption and energy costs can be reduced.
- Energy cost savings alone might not always be enough to justify many PPL strategies.
  - Develop business cases not related to energy.
    - Example: Laptops increase productivity by offering a more flexible computing solution.



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Step 3: Business Case Example

Avoided Cost of Renewables (ACR):

- Equates the cost of PPL efficiency measures to avoided renewable costs.
- Gives all parties a financial incentive to investigate PPLs.

ACR for the RSF:

- Used to justify demand-side efficiency measures.
- In the RSF, every continuous 1 Watt load requires 6.6 Watts of PV (rated peak power) to offset the annual energy use. Every 1 Watt reduction in load resulted in $33 reduction in PV costs.

The total PV cost avoided by PPL reductions exceeded **$4 million.**

NREL/PIX 17842

Step 4: Identify Occupants' True Needs

True need:

Equipment or procedure required to achieve a given business goal or an assigned task.

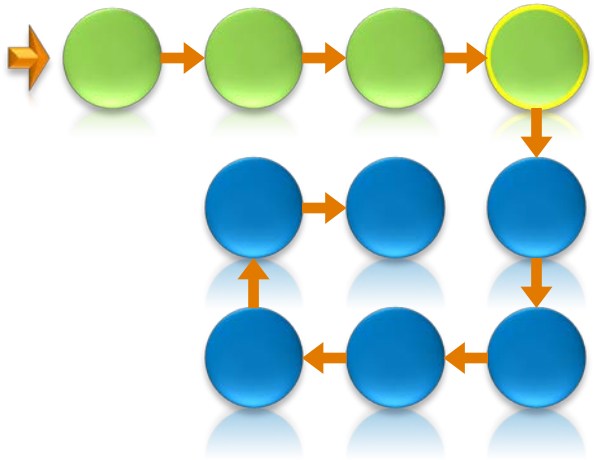
Understand:

What do occupants produce as part of their jobs and what tools do they require?

Every occupant, including those working in sensitive operations, must be accounted for.

Nonessential equipment:

A business case must be made for continued use.



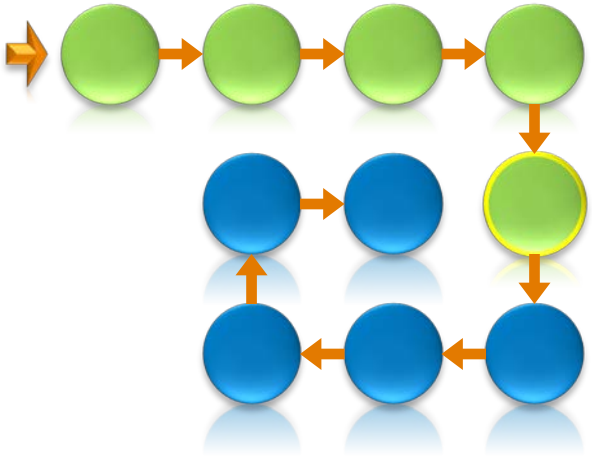
Step 5: Meet Needs Efficiently

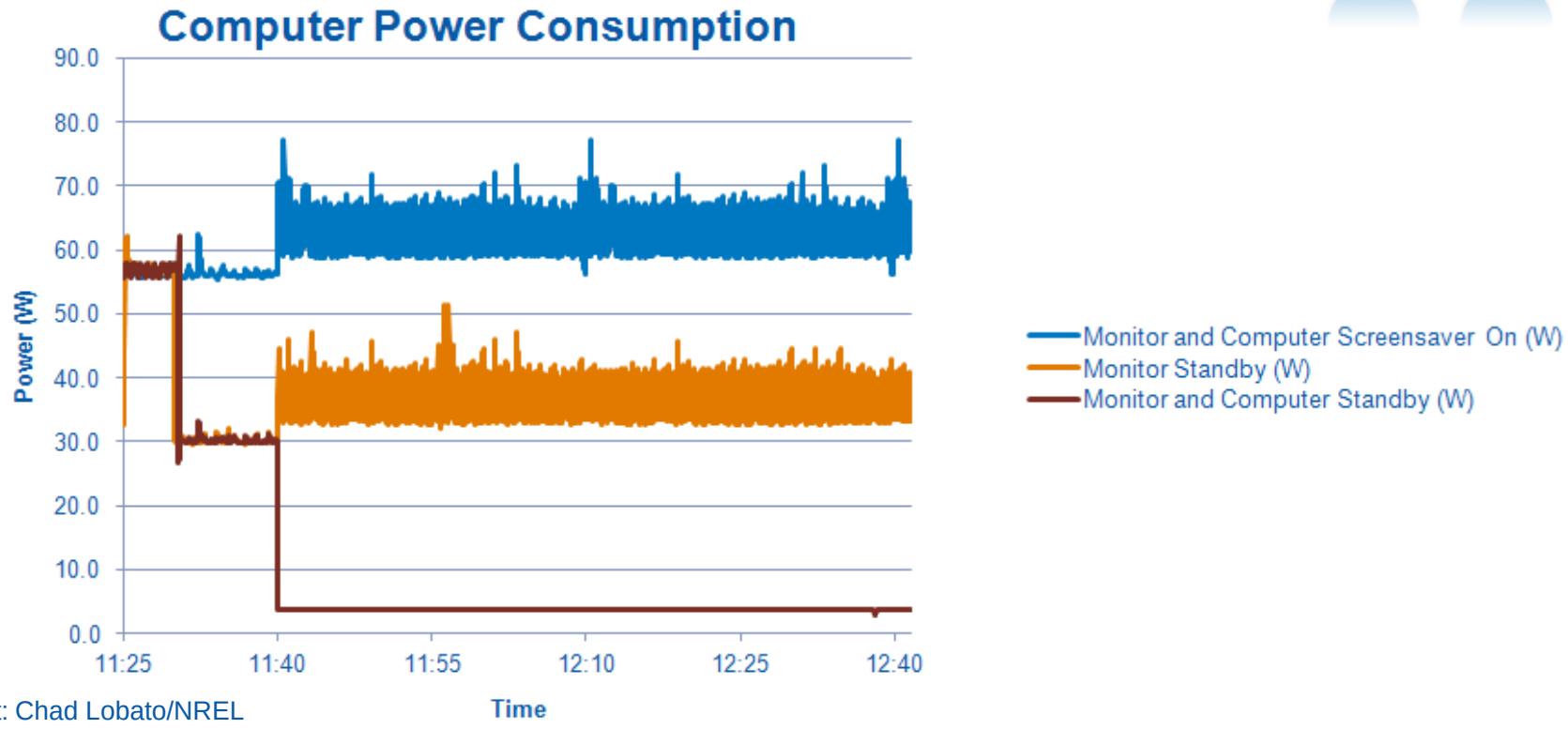
Search energy-efficient equipment databases.

Nonrated equipment:

- Investigate the most efficient model.
- Turn off when not in use (if possible).

Pay attention to parasitic loads.



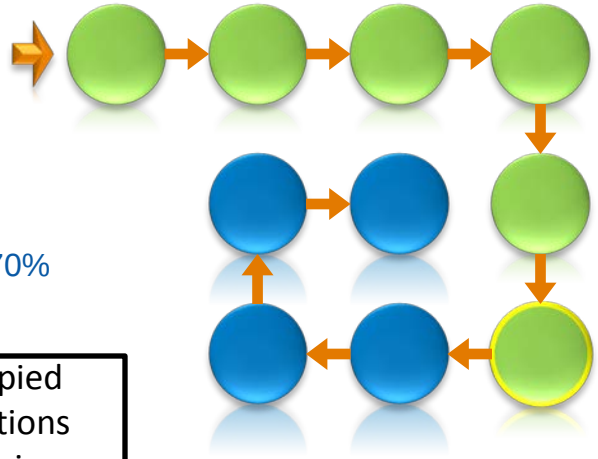


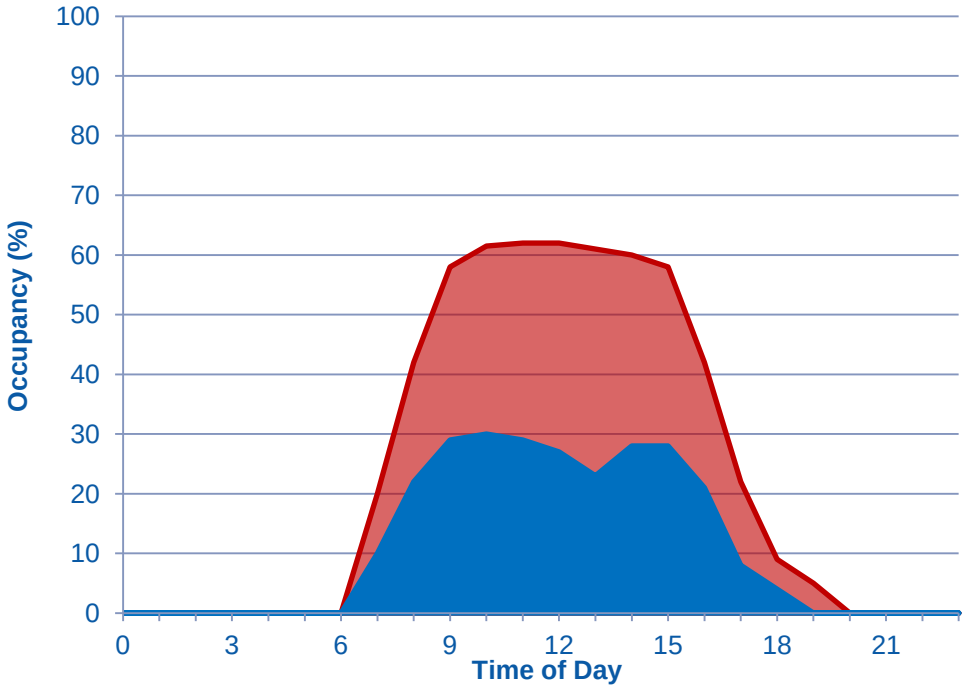
Credit: Chad Lobato/NREL

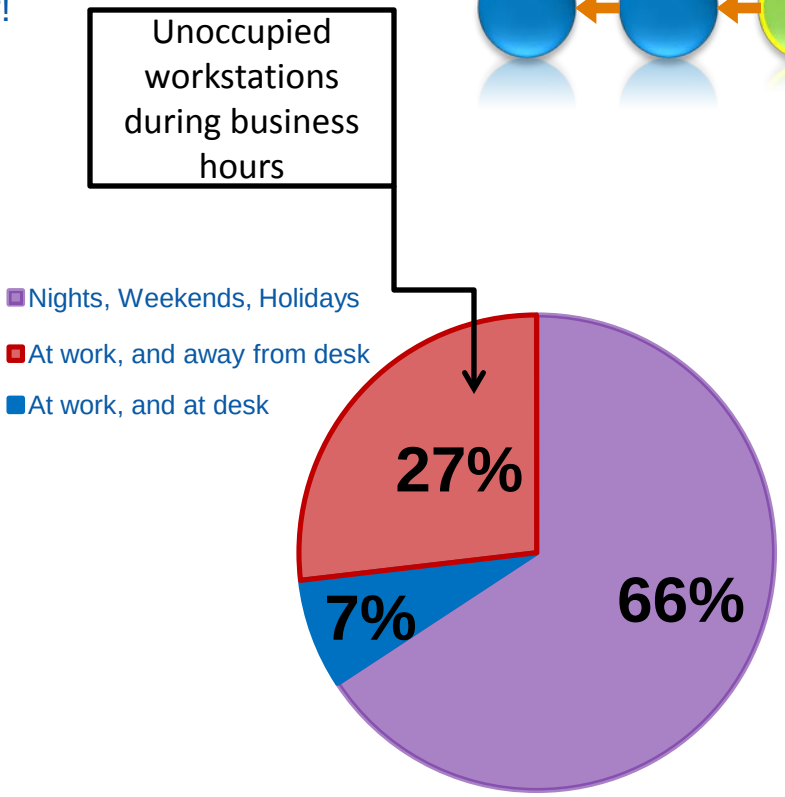
Step 6: Turn It All Off: Office

Opportunities in offices:

- Nights, weekends, and holidays account for 66% of the year.
  - A typical office building is unoccupied during this time.
- During a typical work day, building occupants are at their desks less than 30% of the time.
  - Workstations are vacant and should be powered down during more than 70% of business hours.
- Workstations should only be powered 7% of the year!







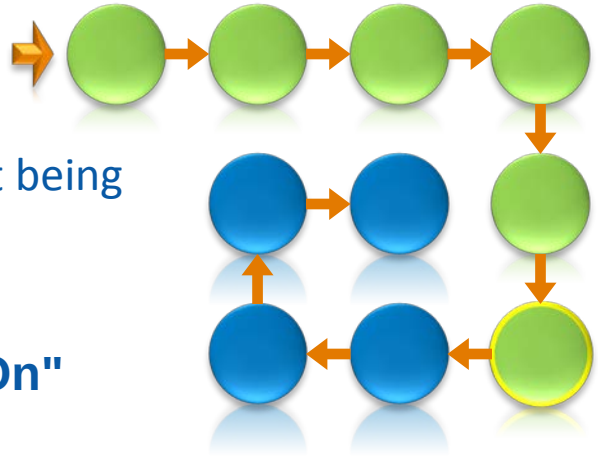
Credit: Chad Lobato/NREL

References:
http://www.gsa.gov/graphics/pbs/WorkPlace_Matters_FINAL508_lowres.pdf

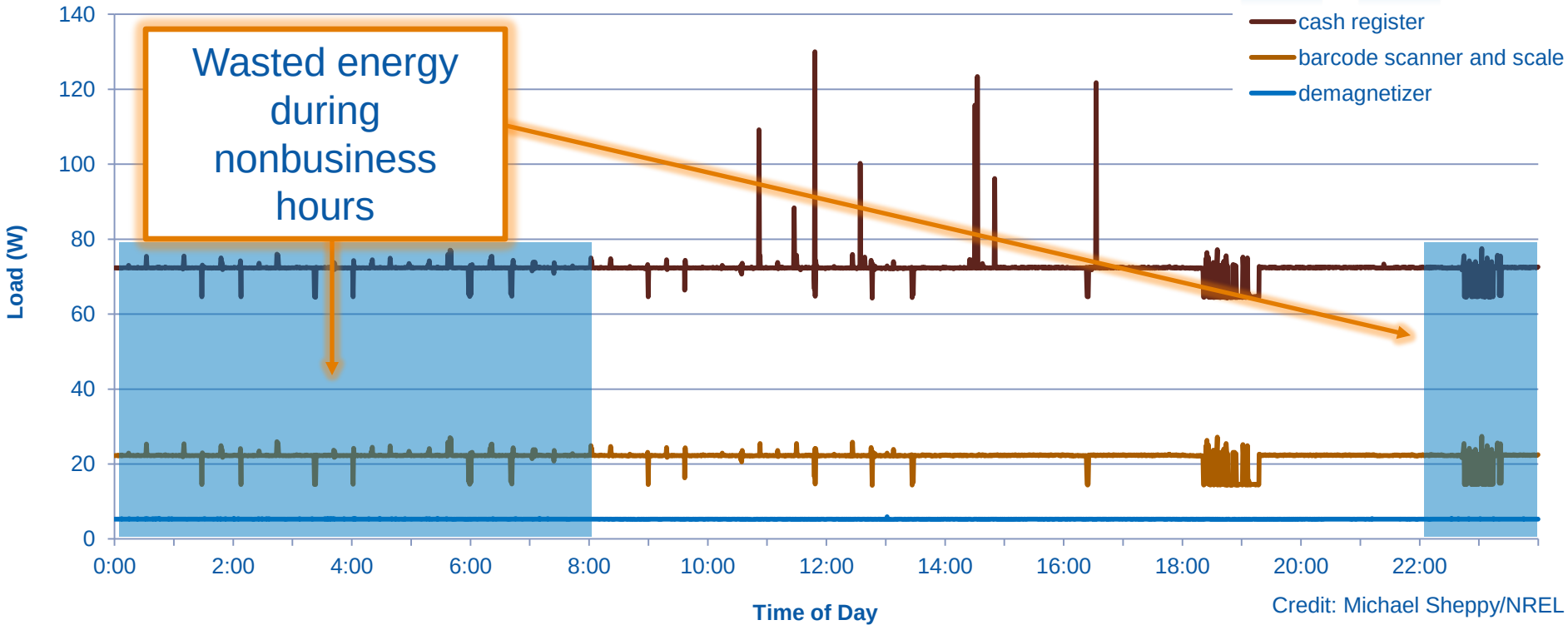
Step 6: Turn It All Off: Retail

Opportunities in retail:

- Turn cash registers off during unoccupied hours.
- Turn cash registers off or put in standby when they are not being used during business hours.

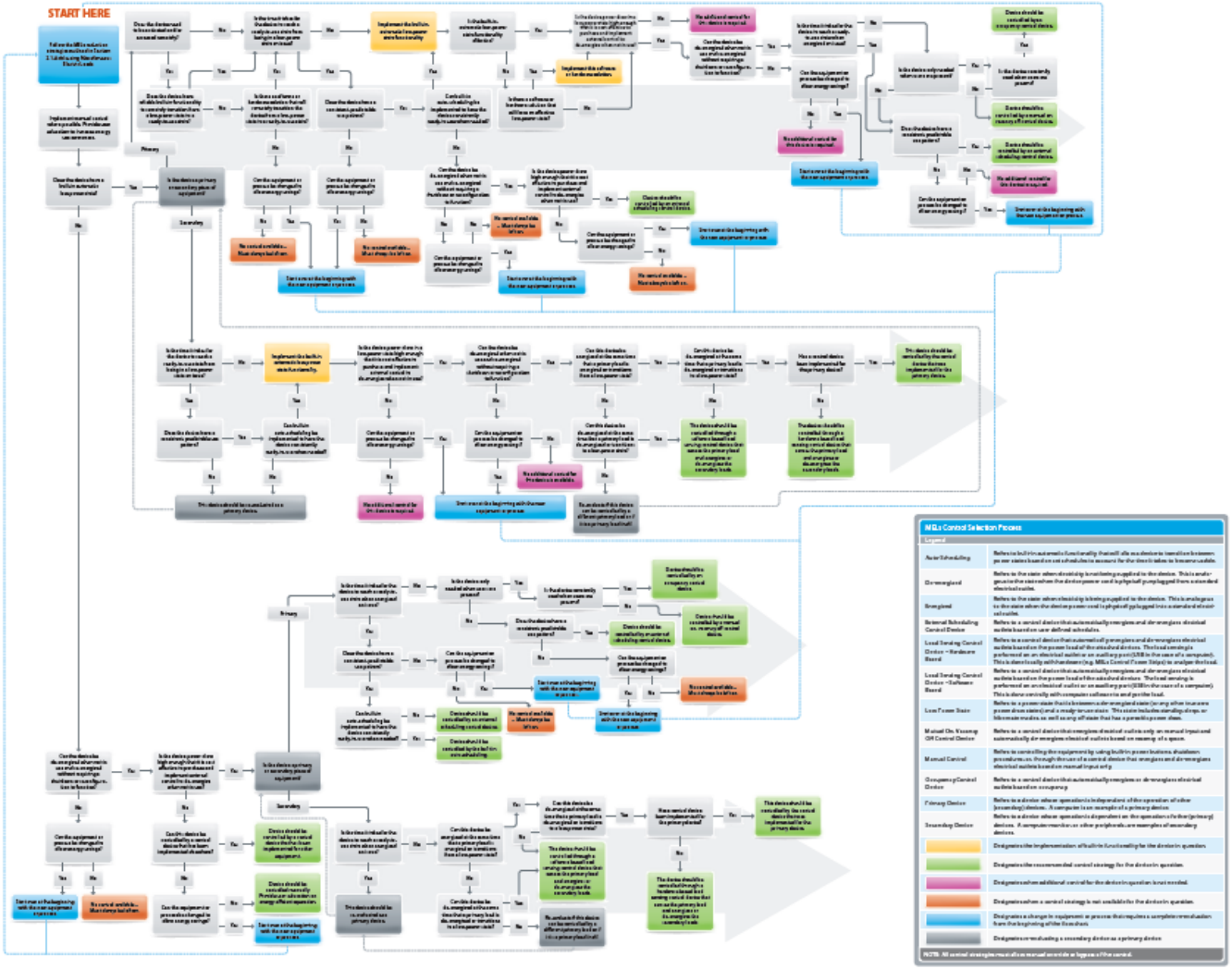


Cash Register Load – "Always-On"



Credit: Michael Sheppy/NREL

Step 6: How To Turn It All Off

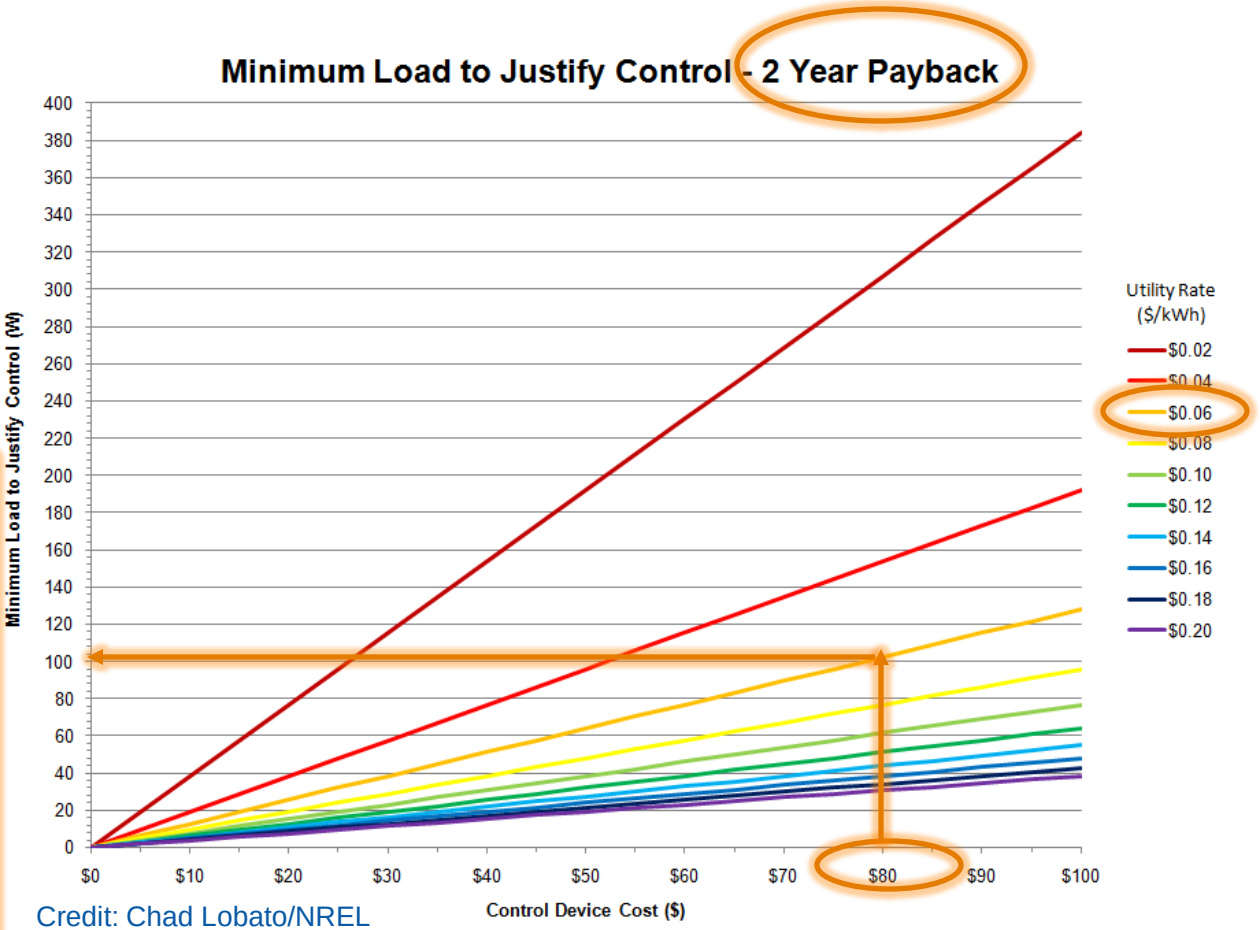


Download at: http://www.nrel.gov/buildings/pdfs/mels_controls_flowchart.pdf

Step 6: Plug Load Control Devices

Credit: Chad Lobato/NREL

Step 6: Plug Load Control Device Cost Justification



Credit: Chad Lobato/NREL

Based on an example office equipment schedule, selected payback, utility rate, and device cost, any load greater than 100 W is cost effective to control.

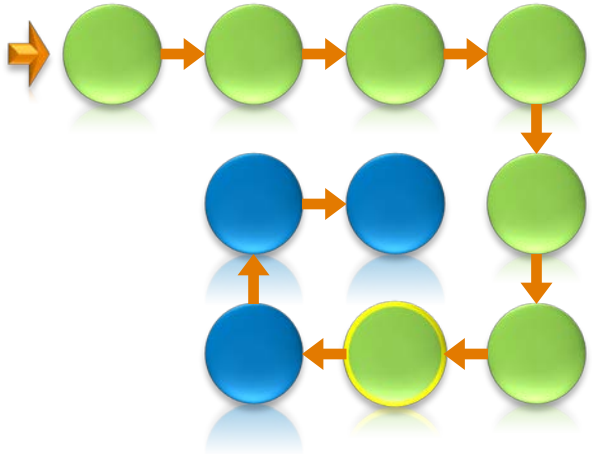
Cost justification charts for other payback periods are available here:
Selecting a Control Strategy for Miscellaneous Electrical Loads

Step 7: Institutionalize PPL Measures

Day-to-day energy efficiency: Depends on the decisions of occupants, facility managers, and owners.

Identify decision makers who can:

- Institutionalize PPL measures through procurement decisions and policy programs.
- Promote buy-in.
- Identify unbreakable and unchangeable policies.



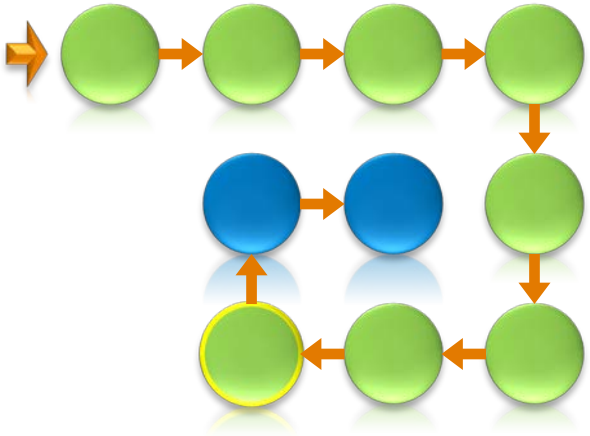
Step 8: Address Unique PPLs

EXAMPLE: Contractors and food service areas.

Building owner should *contractually require* or *provide* the most efficient equipment available.

Case-by-case evaluation:

- Energy-efficient equipment may not be available and may be restricted from being turned off (e.g. ATM).
- Manufacturers may be able to recommend alternatives.



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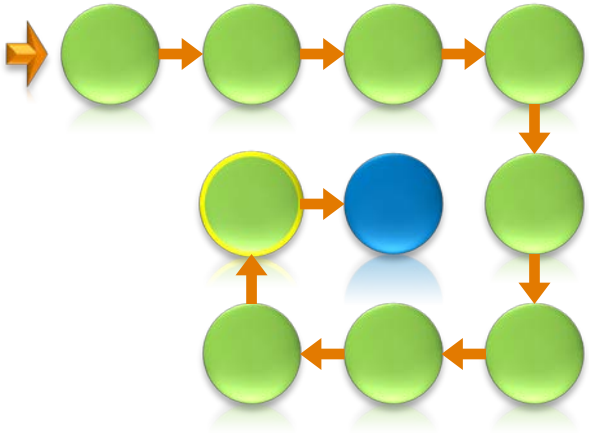
Step 9: Promote Occupant Awareness: Office

- Encourage and allow occupants to “do good.”
- PPL strategies should counteract “bad users.”
- Emphasize the importance of turning off personal electronics when leaving a workspace.



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Credit: Marjorie Schott/NREL

Step 9: Promote Occupant Awareness: Retail

Promoting occupant awareness in retail buildings is just as important as in office buildings.

Employee awareness:

- Use training to gain buy-in from management and employees.
- Use stickers, placards, and emails that remind employees to “do good.”

Customer awareness:

Use signage to:

- Explain energy efficiency measures.
- Inform customers that they are supporting environmentally-friendly practices by shopping at your store.

Example of signage in a big box retail outlet

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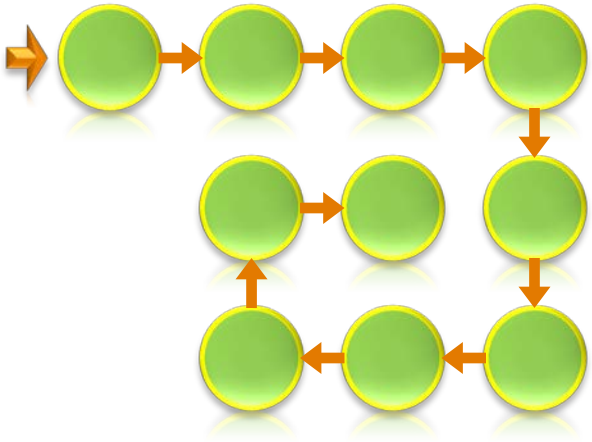
Step 10: Address PPLs (Design Team)



Question standard specifications, operations, and design standards.

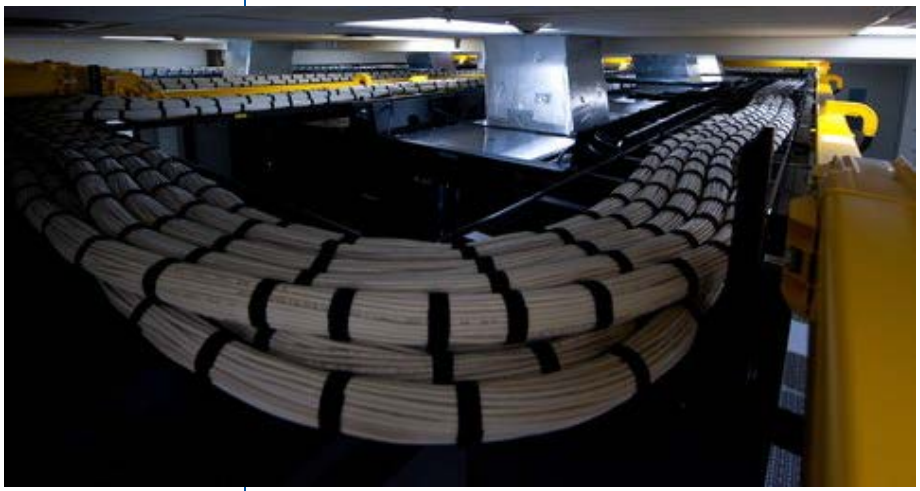
Maximize space efficiency.

Integrate PPL control strategies into the building's electrical system:

- Switches
- Vacancy sensors
- Timed disconnects for outlets
- Controlling outlets through the building management system

Other loads:

- Elevators
- Transformers
- Process cooling systems
- Data centers



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Recommended Strategies

Strategies

liquid crystal display (LCD) monitors saves energy. To achieve the greatest savings, light-emitting diode (LED) backlit LCD monitors should be used. A 19-inch fluorescent backlit LCD monitor will use approximately 30 W while powered on compared to a 22-inch LED LCD monitor that uses 15 W while powered on.

Incandescent or fluorescent tube task lighting should be replaced by efficient compact fluorescent lamps (CFLs) or LED task lighting. Replacing standard phones with low-power voice over Internet protocol (VoIP) phones provides additional workstation savings.

All workstation loads should use power management surge protectors to reduce or eliminate the parasitic loads of all workstation equipment when the space is unoccupied. Figure 2-1 is an example of a low-energy workstation.

iStockPhoto.com and Marjorie Schott/NREL

Figure 2-1 Diagram of an example low-energy workstation

Office workstations are often equipped with personal single-function devices such as printers, scanners, and fax machines. Consolidating these items into shared multifunction devices reduces PPLs and leads to annual energy savings. Further savings can be realized by enabling the power option settings on the multifunction devices to go into standby after 15 minutes of idle time.

Elevators

Elevator car lighting and ventilation are typically powered whether or not the car is occupied. Adding occupancy sensors to control lighting and ventilation will save energy.

Small-Scale Food Service Areas

As with the break rooms and kitchens, replacing aging, inefficient equipment with the most efficient ENERGY STAR equipment will save energy. Food service areas present unique challenges because they are often outfitted and operated by outside vendors. It is important to work with the vendor to supply energy-efficient PPLs that meet their needs. For example, refrigerators should be required to have solid front doors rather than glass doors. A glass door refrigerator can use twice the energy of a similarly sized solid front refrigerator. Multiple mini-refrigerators should be consolidated into fewer full-size refrigerators to save energy.

Food service equipment can have large parasitic loads when the space is unoccupied. Electrical switches, or a similar method, should be provided to easily disconnect power to all non-essential equipment during non-business hours. Cutting the load during non-business hours drastically reduces the annual energy use. If the service is provided by an outside vendor, there should be contractual requirements set in place that will ensure that the equipment is disconnected and powered down during non-business hours.

For equipment that is not rated by ENERGY STAR, those responsible for specification and procurement should work directly with manufacturers to determine the most efficient option. Many manufacturers offer low energy options for their equipment.

Conference Room Equipment

Conference rooms are subject to varying use schedules. A key to PPL energy use reduction is to implement controls that disconnect or turn off equipment when the space is unoccupied. Electrical outlet timers can be used to power down equipment during non-business hours. Occupancy sensors can be used to disconnect power when the rooms are unoccupied during business hours. Beyond load control, the space should be outfitted with energy-efficient equipment. LED backlit LCD televisions and energy-efficient projectors should be used for display purposes.

Server Room

Uninterruptible power supplies (UPS) serve two main functions in server rooms: (1) they condition line power; and (2) they maintain power delivery during power outages until the backup generator (BUG) kicks on. Typical legacy UPS efficiency is around 80%; these devices produce extra heat that requires additional cooling. When procuring a new UPS, the following features are critical:

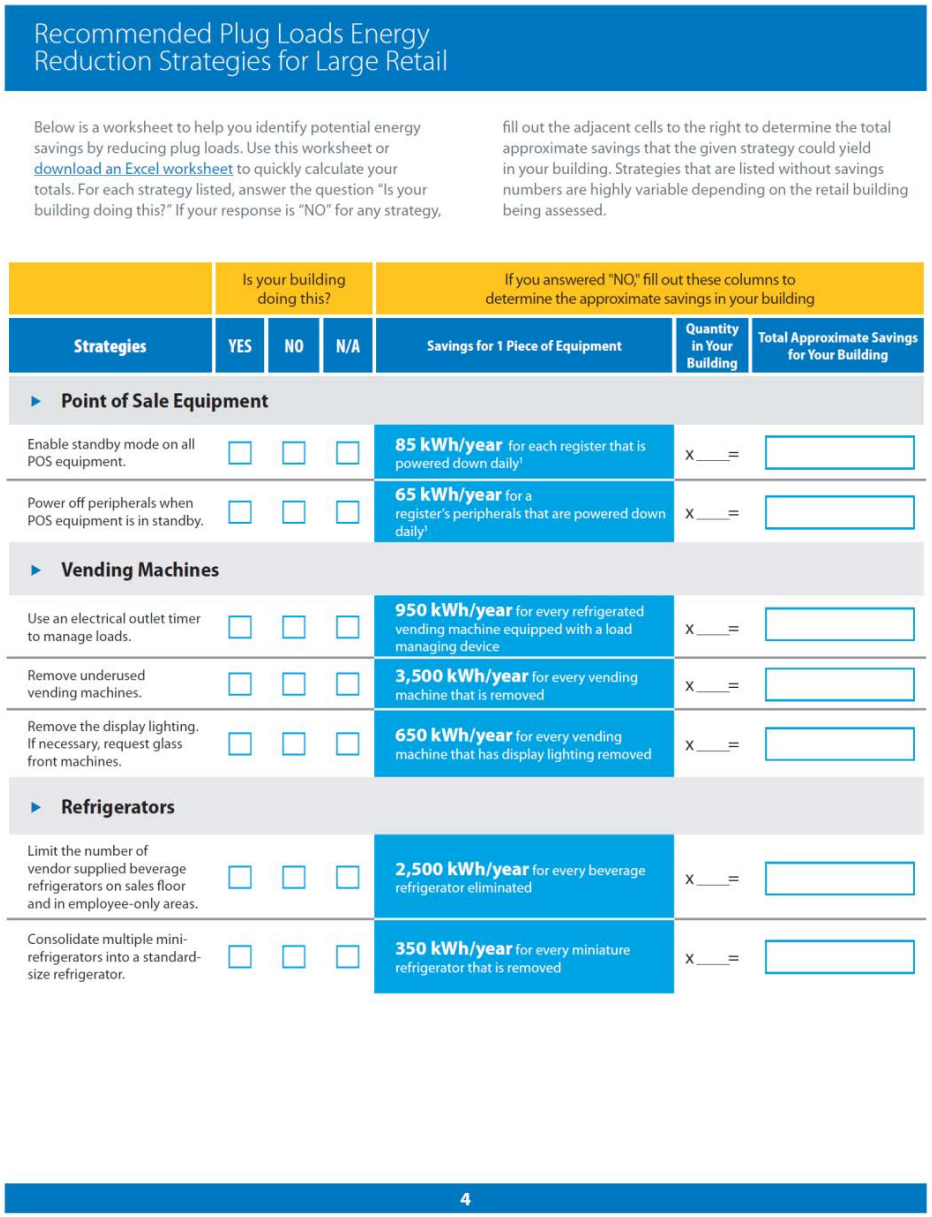
- 95% + energy efficiency
- Scalable design
- Built-in redundancy
- End user serviceable
- Provide uptime until the BUG starts
- Meet the efficiency guidelines of the Server System Infrastructure initiative. The Server System Infrastructure initiative set open industry specifications for server power supplies and electronic bays.

The UPS should be loaded so it operates at peak efficiency. Information about the relationship between loading and efficiency is found in the manufacturer's documentation.

Each how-to brochure provides simple recommendations for reducing plug loads.

- Office brochure provides recommendations for common equipment found in various office space types.
- Retail brochure provides recommendations for common equipment types found throughout a retail building.

Plug Load Savings Calculator



Recommended Plug Loads Energy Reduction Strategies for Large Retail

Below is a worksheet to help you identify potential energy savings by reducing plug loads. Use this worksheet or download an Excel worksheet to quickly calculate your totals. For each strategy listed, answer the question "Is your building doing this?" If your response is "NO" for any strategy, fill out the adjacent cells to the right to determine the total approximate savings that the given strategy could yield in your building. Strategies that are listed without savings numbers are highly variable depending on the retail building being assessed.

	Is your building doing this?			If you answered "NO," fill out these columns to determine the approximate savings in your building		
Strategies	**YES**	**NO**	**N/A**	**Savings for 1 Piece of Equipment**	**Quantity in Your Building**	**Total Approximate Savings for Your Building**
▸ **Point of Sale Equipment**						
Enable standby mode on all POS equipment.	☐	☐	☐	**85 kWh/year** for each register that is powered down daily[1]	x___=	
Power off peripherals when POS equipment is in standby.	☐	☐	☐	**65 kWh/year** for a register's peripherals that are powered down daily[1]	x___=	
▸ **Vending Machines**						
Use an electrical outlet timer to manage loads.	☐	☐	☐	**950 kWh/year** for every refrigerated vending machine equipped with a load managing device	x___=	
Remove underused vending machines.	☐	☐	☐	**3,500 kWh/year** for every vending machine that is removed	x___=	
Remove the display lighting. If necessary, request glass front machines.	☐	☐	☐	**650 kWh/year** for every vending machine that has display lighting removed	x___=	
▸ **Refrigerators**						
Limit the number of vendor supplied beverage refrigerators on sales floor and in employee-only areas.	☐	☐	☐	**2,500 kWh/year** for every beverage refrigerator eliminated	x___=	
Consolidate multiple mini-refrigerators into a standard-size refrigerator.	☐	☐	☐	**350 kWh/year** for every miniature refrigerator that is removed	x___=	

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A simple worksheet is provided in each brochure that allows plug loads to be inventoried and potential savings to be calculated for a given building.

Download the plug load savings calculators here:

- Office:
  http://www.nrel.gov/buildings/docs/office_ppl_reduction_tool.xlsx
- Retail:
  http://www.nrel.gov/buildings/docs/retail_ppl_reduction_tool.xlsx

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Q&A

Any Questions?

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