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Whole Building Energy Assessments of Existing Commercial Buildings

Jesse Dean
NREL Engineer
Integrated Applications Office

Overview

- Resources developed through FEMP Energy Assessment Training course, taught by DOE National Laboratory experts
  - Consists of morning presentations and group interaction followed by hands-on walkthrough assessments.

- FEMP mission is to facilitate the Federal Government's implementation of sound, cost-effective energy management and investment practices to enhance the nation's energy security and environmental stewardship.

Energy Assessment Training Topical Overview

The objective of the training course is to teach trainees how to conduct comprehensive energy assessments using state of the art assessment and analysis tools

Federal Facility Assessment Guide

Introduction

Why is Undertaking a Facility Assessment So Important?

A few key figures illustrate the magnitude of the opportunity at hand:

- More than 500,000 Federal facilities
- Approximately $20 billion spent annually to acquire or renovate those facilities.
- More than $3.5 billion in facility energy costs

Imagine the spectacular impact if we work to foster sustainable practices, promote efficient energy use, conserve natural resources, protect the environment, and implement innovative technologies on such a grand scale.

As a Federal energy manager, you know that conserving energy at your facility equals energy cost savings, which in turn saves taxpayer dollars. Turning off lights and shutting down electronic devices are simple ways to conserve energy and make a short-term difference in the bottom line.

Energy Use Analysis

Step 1 – Compile monthly electricity and heating fuel bills for the last three years

Step 2 – Determine on peak and off peak rates

Step 3 – Develop annual energy use metric for each building (Btu/year)

Step 4 – Group buildings by type and usage patterns

Step 5 – Prioritize buildings to audit based on energy analysis

Develop annual energy use metric for each building

- Calculate the Energy Use Intensity by converting electricity from kWh to BTU and Natural gas from MMBtu into BTU (as shown below), then total these two numbers and divide by the total square footage of the building for energy intensity.

  - Electricity Usage (Btu) = TOTAL kWh x 3,413 Btu/kWh = ____ Btu
  - Natural Gas Usage (Btu) = TOTAL MMBtu x 1,000,000 Btu/MMBtu = ____ Btu
  - Total Energy Use (Btu) = Electricity Btu + Natural Gas Btu = ____ Btu
  - Energy Use Intensity (Btu/ft2) = Btu / ft2 = ____ Btu/ft2

- Other metrics involve dividing the BTU by number of hospital beds, number of patients, number of employees, etc.

Commercial Office Building: Monthly Energy Profile

- Facility Square Footage: 1,048,588 ft2
- Energy Use Intensity (Btu/ft2)= 135,923,899,314 Btu / 1,048,588 ft2 = 129,626 Btu/ft2

FY 2007						
Month	Electricity (kWh)	Electricity Cost ($)	Natural Gas (MMBtu)	Natural Gas Cost ($)	Blended Electric Rate ($/kWh)	Natural Gas Cost ($/MMbtu)
Oct	1,702,980	$210,695	2,441	$41,346	$0.124	$16.93
Nov	1,719,187	$180,928	5,625	$95,252	$0.105	$16.93
Dec	1,706,360	$179,405	7,507	$127,129	$0.105	$16.93
Jan	1,647,561	$172,841	8,979	$152,051	$0.105	$16.93
Feb	1,369,987	$148,524	10,613	$179,739	$0.108	$16.94
Mar	1,572,267	$170,241	6,246	$105,777	$0.108	$16.94
Apr	1,627,932	$176,876	4,986	$83,452	$0.109	$16.74
May	1,746,887	$188,993	3,437	$58,219	$0.108	$16.94
Jun	2,224,046	$242,833	3,390	$57,403	$0.109	$16.93
Jul	2,109,209	$286,266	3,862	$65,399	$0.136	$16.94
Aug	2,291,444	$250,055	3,968	$67,191	$0.109	$16.94
Sep	2,120,918	$269,802	334	$5,648	$0.127	$16.94
Totals	***21,838,778***	***$2,477,459***	***61,388***	***$1,038,603***	***$0.113***	***$16.92***

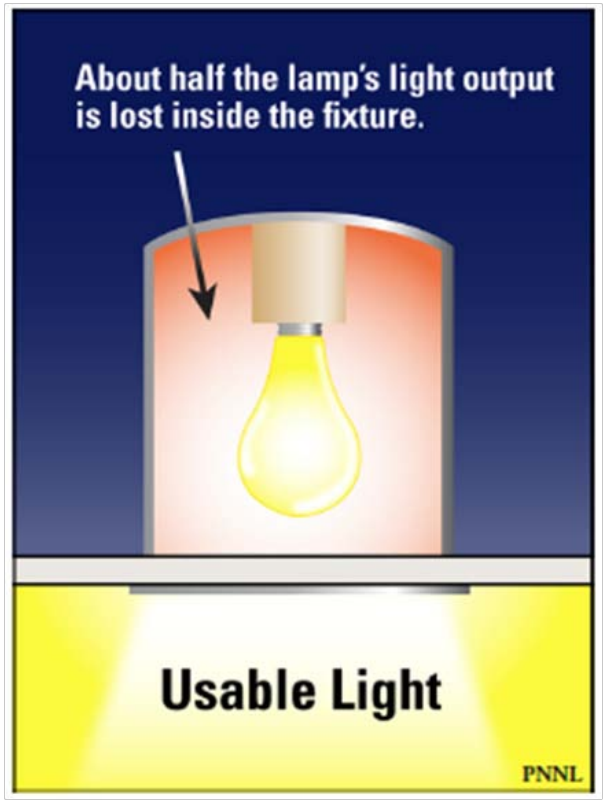
Prioritize Buildings to Audit Based On Energy Analysis

- If an organization has the budget to retrofit three buildings and it's not obvious from the energy analysis which should be prioritized additional metrics could be included:
  - Building age
  - Building condition (broken windows, loose panels or roof tiles, failing lighting systems, etc)
  - Building schedule
  - Does the building have a DDC control
    system or a lighting control system?

OFFICE BUILDINGS	BUILDING AGE (YEARS)	BUILDING CONDITION
Fremont offices	80	Poor
Tulare offices	20	Poor
Beaumont offices	85	Good
Expressway 238 offices	5	Excellent
Jordania offices	10	Poor

Lighting Background

- Lighting accounts for 25% of the total electricity used in the federal sector
- Electric lighting accounts for more than a third of all electricity consumed for commercial use in the United States



General Energy Saving Strategies

1. Optimize use of natural daylight
2. Replace lamps and ballasts with modern, efficient lamps / ballasts
3. Replace incandescent lamps with compact fluorescent lamps (CFLs)
4. Implement task lighting
5. Install state-of-the-art lighting controls

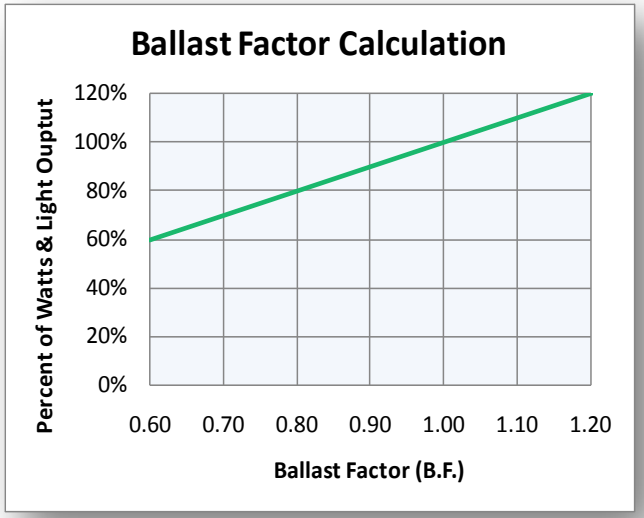
Lighting Energy Conservation Measures

- **Fluorescent Lights and Electronic Ballasts**
  - Replace T-12 lamps and Magnetic Ballasts with Low Wattage T-8 Lamps and Electronic Ballasts
  - Replace Standard T-8 Lamps with Low Wattage T-8 Lamps and Low Ballast Factor Ballasts
  - Install Perimeter Dimming Ballasts
  - Optimize Interior Security Lighting
- **Compact Fluorescent Lights (CFL)**
  - Screw-in Lamp Retrofit
- **Light Emitting Diodes (LED)**
  - Replace Standard Exit Signs with LED Exit Signs
  - Install LED Task Lighting
  - Replace Incandescent and HID/HPS Fixtures with LED Fixtures

Lighting Energy Conservation Measures

- **Lighting Controls**
  - Install Occupancy Sensors in Bathrooms, Conference Rooms and Private Offices
  - Install Central Lighting Controls
- **HID:**
  - Replace magnetic HID ballasts with electronic ballasts and reduced lamp wattage
  - Replace HID lamps and fixtures with high performance T-8 or T-5HO fluorescent lamps
  - Reduce Lighting Levels in Over lit Areas by De-Lamping Ballasts
  - Replace the Current Electronic Ballasts for 32 Watt T-8's with Low Ballast Factor Ballasts
  - Turn off Security Lighting in the Main Lobby During Normal Business Hours
  - Reduce Security Lighting Levels at Night
  - Replace Linear Fluorescent 'Milky White' Lens with Clear Acrylic Prismatic Lens

Lighting Site Assessment Guidance



IESNA Recommended Horizontal Illuminances and		
Space Type	Illuminance (fc)	LPD (Watt/ft²)
Open Offices	30 to 50 (5 to 10 w/ task light)	1.1
Private Offices	50	1.1
Conference Rooms	30	1.3
Corridors	5	0.5
Restrooms	10	0.9
Lobby	10	1.3
Copy Rooms	10	
Classrooms	30	1.4
Gymnasiums	100	1.1
Dining Areas	10	0.9
Kitchen	50	1.2
Labs	50	1.4
Libraries	30	1.2 (reading area), 1.7 (stacks)
VDT Areas	3	
Museums (display areas)	30	1
General Warehousing/Storage	10	0.8
Inactive Storage	5	0.3
General Manufacturing	30	1.2 (low bay), 1.7 (high bay)
Residences (General)	5	
Parking Areas (uncovered)	0.2	0.15

Illumination Engineering Society (IES) Light Level Guidelines

A detailed listing of lighting assessment procedures are provided in the 'Lighting Site Assessment Guidance'. The following information is included in this document:

1. General Lighting Site Assessment Procedure
2. Retrofit versus Redesign Issues
3. Occupancy Sensor Assessment Tasks
4. Daylight Side-Lighting Analysis
5. Daylight Top Lighting Analysis
6. Central Lighting Control System Analysis
7. Low-bay and High Bay Lighting ECMs

Replace Standard T-8 Lamps with Low Wattage T-8 Lamps and Low Ballast Factor Ballasts

- **Technical Guidelines**
  - Replace the current lamps with 25 or 28 Watt T-8's lamps and/or install electronic ballasts with a ballast factor ≤ 0.85
  - Specify high performance T-8 lamps with:
    - A color rendering index (CRI) of 85 or higher
    - A 92% lumen maintenance efficiency over the rated lamp lifetime
  - Lamps switched on and off more than 5 times per day , operated for less than 3 hours at a time or controlled by occupancy sensors should have program/rapid start ballasts to extend lamp life

- **Cost Guidelines**
  - Average lamp cost is between $4 to $10 per lamp
  - Average ballast cost is between $20 to $48 per ballast
  - Labor rate is site and agency specific
    - Average labor time per fixture should be between .5 to 2 hours per fixture

Occupancy Sensor Controls

Proper number, type, and mounting location needed for proper coverage

Infrared

- Small enclosed rooms: private office, conference room, supply room, class room
- Pick up small amounts of movement
- Wall-mounted are most common

Ultrasonic

- Large open spaces: open office, large conference room, lecture halls, hallways, large lunchrooms, and lobbies
- Pick up small amounts of noise
- Ceiling-mounted are most common

Combinations

- Infrared + ultrasonic
- Manual dimming + infrared

Install Occupancy Sensors in Bathrooms, Conference Rooms and Private Offices

- **Technical Guidelines**
  - Type and location of sensor depends on space layout and expected activity
  - Specify program/rapid start ballast type to preserve lamp life
  - Use the number of rooms and area of spaces to estimate number of sensors
- **Cost Guidelines**
  - Average occupancy sensor cost is between $30/sensor - $90/sensor
  - The labor rate is site and agency specific
  - Average labor time per sensor should be between .5 hr/fixture – 2 hr/fixture

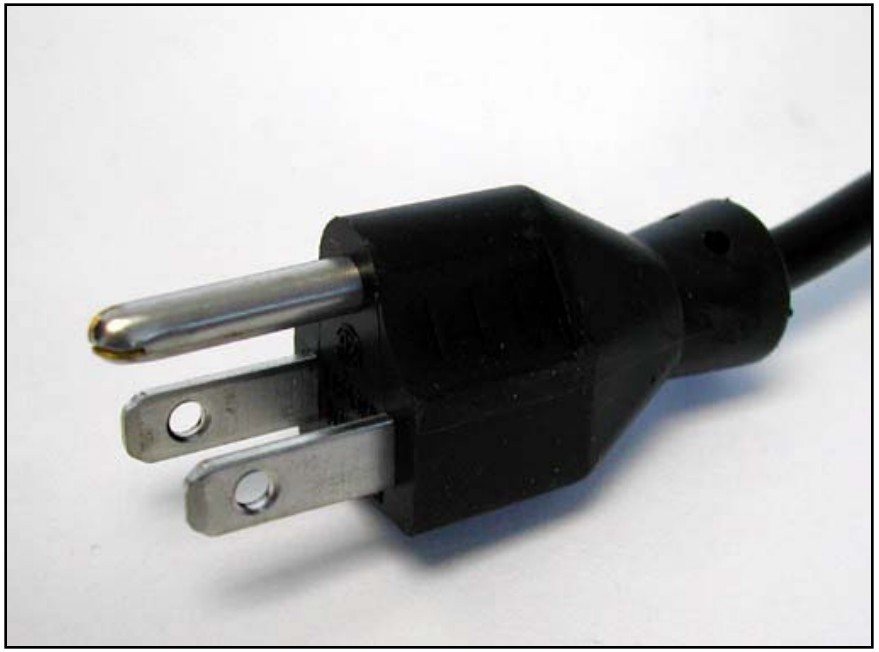
SPACE TYPE	PERCENT REDUCTION (%)
Private Office	15-55
Open Office	15-30
Classroom	10-45
Conference Room	25-65
Restroom	30-75
Warehouse	50-75
Storage	45-65

Energy Impact of Controls and Performance Diagnostics, TIAX LLC for DOE, Nov. 2005.

Plug Loads

- Plug loads are devices that plug into a building's electrical system. They include:
  - Office equipment (fax machines, computers, printers, and copiers)
  - Appliances
  - Soda machines
  - Drinking fountains
  - TVs
  - VCRs

- Plug loads account for 9% of a building's total electrical use

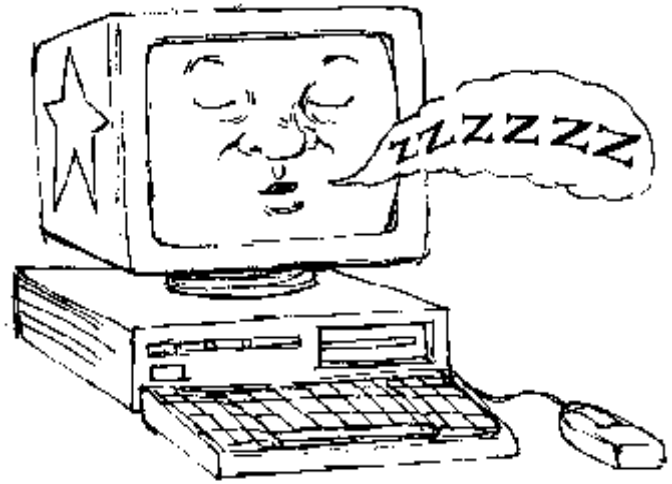


Plug Load ECMs

- Energy conservation measures to reduce plug loads
  - Activate power management on computers and monitors
  - Replace desktop computers with laptop computers and a docking station
  - Replace CRT monitors with LCD monitors
  - Install vending machine misers on refrigerated vending machines and de-lamp advertising lighting
  - Install occupancy sensor controlled surge protectors in offices
  - Replace appliances with Energy Star appliances
  - Others
    - Network printers to reduce the number of personal printers
    - Replace task lighting with LED task lighting
    - Replace office equipment with Energy Star models

Activate Power Management on Computers and Monitors

- Monitor power management (MPM) places monitors into low power sleep mode after a period of inactivity
  - MPM is already activated at over 80% of organizations
- Computer power management (CPM) places computers (CPU, hard drive, etc.) into sleep mode
  - CPM is activated at less than 10% of organizations
  - Saves more power than MPM
- Power management is built into Windows 95,98, ME, 2000, XP and Vista
  - Settings simply need to be activated
- Activating power management can save $50-$100 per computer annually



Replace Desktop Computers with Laptop Computers and a Docking Station

- Laptop computers consume 50-80% less power than desktop computers

Computer Type	Processor Type	Active/ On (Watts)	Suspended (Watts)	Off (Watts)
Docked Laptop	Intel Core 2 Duo	62	3	3
Desktop w/ LCD	Intel Core 2 Duo	76.2	6	3.5
Desktop w/ CRT	Intel Core 2 Duo	145.25	16	7

- Technical Specifications
  - Specify power consumption of:
    - Standby (Off Mode): ≤ 1.0 W
    - Sleep Mode: ≤ 1.7 W
    - Idle State:
      - For GPUs >128 MB : ≤ 22 W
      - For all others: ≤ 14 W
  - Specify 80% minimum efficiency at 20%, 50%, and 100% of rated output and minimum Power Factor 0.9 for internal power supplies
- Cost Guidelines
  - Average laptop and docking station cost is $1,000-$2,400/laptop
  - If implementation costs are too high, the site should incrementally replace existing computers with laptops and docking stations in the normal upgrade cycle

Replace CRT Monitors with LCD Monitors

- Replacing CRT monitors with LCD monitors reduces energy use by 50-75%
- Specify power consumption of:
  - Standby (Off Mode): ≤ 1 W
  - Sleep Mode: ≤ 2 W
  - Idle State:
    - For monitors < 1 megapixel: ≤ 23 W
    - For monitors > 1 megapixel: ≤ 28 W x number of megapixels
- Cost Guidelines
  - LCD monitors cost $150-$360 per monitor, depending on size
  - If implementation costs are too high, the site should incrementally replace existing computers with laptops and docking stations in the normal upgrade cycle

MONITOR TYPE	SIZE	ACTIVE / ON (WATTS)	SUSPENDED (WATTS)	OFF (WATTS)
CRT	15"	61	19	3
	17"	90	9	4
	19"	104	13	4
	21"	135	14	5
LCD	15"	11.7	3.4	0.6
	17"	16.7	4.8	0.8
	18"	25	7.2	1.2
	21"	35.8	10.4	1.8

Thank you!

Jesse Dean ♦ Jesse.Dean@nrel.gov ♦ 303-384-7539