



Energy Conservation Measures for Buildings

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This Tech Tip incorporates the results of 16 energy audits conducted during the late 1990's. The 35 Forest Service buildings

that were audited included office complexes, shops, laboratories, and other types of buildings. We hope this summary helps you

evaluate your facilities for energy conservation measures. Table 1 lists the audited facilities. Table 2 summarizes the audit results.

Table 1—Selected Forest Service facilities that received energy audits during the late 1990's.

Governing Station	State	Classification and Facilities	Number of Buildings
Black Hills National Forest	South Dakota	Supervisor's Office Pactola District Headquarters Hill City Shop Ranger's Quarters	1 Office 1 Office 1 Shop 1 Residence
Tongass National Forest	Alaska	Ketchikan District Office	1 Office 1 Bunkhouse
		Petersburg District Office	1 Office 1 Bunkhouse 1 Warehouse
Chugach National Forest	Alaska	Seward District Office Begich Boggs Visitor Center	1 Office 1 Portable Building 1 Public Facility
Ochoco National Forest	Oregon	Big Summit Ranger Station Rager Ranger Station	1 Office 1 Office
Umpqua National Forest	Oregon	Supervisor's Office	1 Office
Pacific Northwest Research Station	Oregon	Corvallis Forestry Sciences Research Laboratory	1 Laboratory 1 Office
Intermountain Fire Sciences Lab	Montana	Missoula Fire Laboratory Campus	2 Offices 2 Warehouses 2 Laboratories 2 Residences 1 Bunkhouse 1 Shop
Rocky Mountain Research Station	Idaho	Moscow Intermountain Research Station	1 Office 1 Laboratory
Mount Hood National Forest	Oregon	Bear Springs Work Center	1 Bunkhouse 1 Conference Building 1 Warehouse 2 Residences
Northeastern Research Station	New Hampshire	Louis C. Wyman Forestry Sciences Laboratory	1 Laboratory



Table 2—Summary of audit results by energy conservation measure.

Energy Conservation Measure	Number of Average Recommendations	Payback in Years*
Lighting		
T12 to T8 fluorescent lighting retrofit	19	8.8
Lighting occupancy sensors	9	4.6
Exit sign retrofit	5	7.4
Incandescent to T8 fluorescent lighting retrofit	3	7.9
Halogen/compact fluorescent replacement	3	3.3
High-pressure sodium upgrades	2	8.1
HVAC (Heating, Ventilation, and Air-Conditioning) Systems		
Ventilation system modification	4	7.5
Thermostat night setback	3	2.8/Immediate**
Thermostat upgrade	3	7.5
Thermostat calibration	2	Immediate
Ventilation control calibration/installation	2	4.6
Heating system upgrade	2	10.8
Air-conditioning system upgrade	2	8.6
Building Operations and Maintenance		
Energy management system	3	7
Winter shutdown	2	3
Weatherstripping	2	5.1
Insulation	2	
Window upgrade/replacement	2	14.9
Miscellaneous		
Electric motors	3	7.3
Hot water heater	2	3.6
Water-saving systems	2	16.6
Groundwater cooling	1	16

* Average payback period is the number of years when the savings will equal the installation costs.

**Savings are immediate if the thermostat already has a night setback feature or if the temperature is set back manually. The average payback is 2.8 years if a new thermostat is purchased.

Energy-Saving Products

MTDC identified the best energy-saving measures from the audits. Summaries of these measures follow.

Lighting

On average, lighting represents about 22% of a building's annual energy use. Lighting upgrades offer substantial energy savings and can be bundled with other measures to help reduce the total payback period for a project. In most cases lighting improvements should be the first energy conservation upgrade.

By far the most commonly recommended energy conservation

measures were fluorescent lighting retrofits. Of the 35 facilities audited, upgrades from a T12 to a T8 fluorescent lighting system were recommended for 19. The magnetic ballasts used with T12 bulbs must be changed to an electronic ballast when switching to a T8 lighting system. Buildings that were not recommended for a lighting retrofit were those that used too little lighting for the retrofit to be cost effective.

If fluorescent lights are used more than 30 to 35 hours a week (even less if your electricity costs are high), consider a retrofit to T8 bulbs and electronic ballasts.

Retrofitting incandescent fixtures to fluorescent is tricky; the payback does not always justify the cost.

Purchase compact fluorescent light bulbs (Figure 1) that screw directly into incandescent fixtures for energy savings.

Exit signs offer an excellent low-risk opportunity for energy improvements. Older exit signs typically use two 20w incandescent bulbs, which accounts for a significant annual energy use. Exit signs retrofitted to compact fluorescent bulbs or light-emitting



Figure 1—A 15-watt compact fluorescent light bulb that is rated to have the light output of a 40-watt incandescent light bulb.

HVAC Systems

Few heating, ventilation, and air-conditioning (HVAC) systems were recommended for upgrade in these audits. The facilities that were recommended for upgrades were large installations where heavy demand justified the high cost of upgrading air-handling systems. Even without complete HVAC upgrades, system control upgrades and annual maintenance represent opportunities to save money. Does the thermostat have a night setback feature? If not, consider replacing the thermostat with one that does. You might consider installing a thermostat that can be connected to an energy management system during future upgrades.

diodes (LED's) (Figure 2) will save you money, guaranteed!

Automatic lighting controls potentially offer large cost reductions in situations where lighting may be left on when it is not needed. Offices are especially prone to wasting light. Types of automatic controls include timers,

occupancy sensors, and incidental daylight sensors. For more information on lighting, see the Northwest Energy Efficiency Alliance's Web site, the U.S. Environmental Protection Agency's *Greenlights* Web site, and other sources listed at the end of this Tech Tip.

Many of the facilities' HVAC systems were adequately maintained, but had design and specification problems including inadequate ventilation rates, uncalibrated and broken controls, and poor air-intake filtration. Ensure that the ventilation system meets airflow requirements when evaluating your air handling system. An incorrectly functioning ventilation system can diminish heating and cooling system performance, decreasing employee comfort and energy efficiency. For more information, see the MTDC Tech Tip, *Commissioning Existing Buildings*, 9871-2301-MTDC.

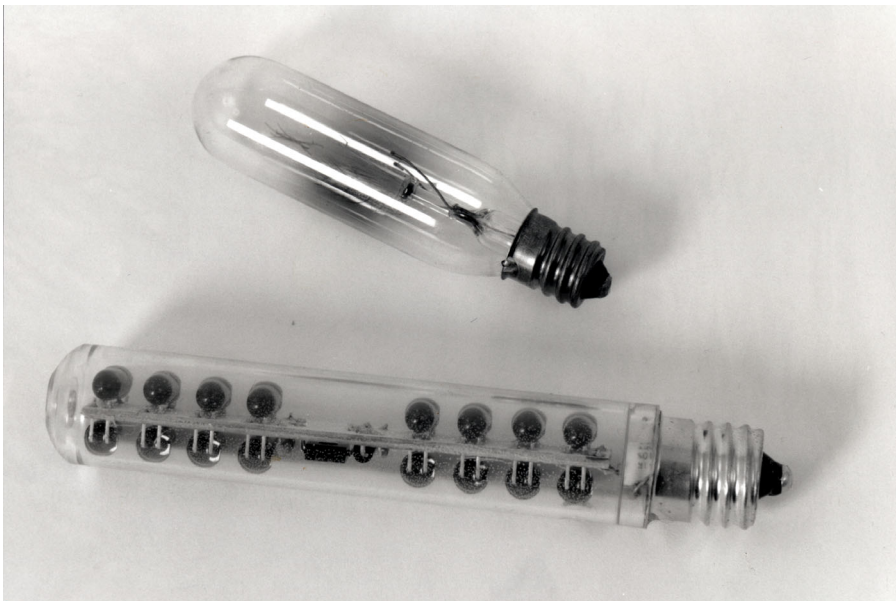


Figure 2—A new energy-efficient light-emitting diode bulb (bottom) in comparison to an older incandescent bulb (top).

Water

Increasing the efficiency of water use will reduce your water bill and your electricity bill. Many of the audits recommended installing low-volume flush toilets and low-flow shower heads and faucets. Drought-resistant grasses that only need a weekly watering could be planted. Because water systems are under pressure, they need regular maintenance. A leaking hot water faucet or pipe can increase annual energy bills.

Energy Management Systems

Energy management systems integrate almost all of a building's energy functions into a master control station, enabling higher efficiency and reduced maintenance. It's like a brain for your building. These systems are expensive. In most cases only the most energy-consuming facilities can economically install a complete system. However, when you are upgrading to newer thermostats, lighting sensors, boilers, or other items, consider purchasing items that will be compatible with an energy management system. Separate components can slowly be installed over time and it is possible to control, observe, and evaluate the lighting, HVAC, and water systems for several buildings from a central location with an energy management system.

Other Measures That Save Energy

It may not be economical to replace some items based solely on energy efficiency. But if these items need to be repaired or replaced, it might be economical to replace them with an energy-efficient piece of equipment. For instance, the energy savings from replacing an older window with a new, energy-efficient window does not justify the replacement cost. However if the window is damaged and needs to be replaced, the added cost of an energy-efficient window will generally be more than repaid by savings in energy costs over the life of the window.

When electric motors fail, they should be replaced with high- or premium-efficiency models. Before purchasing a replacement, verify that the size of the motor is correct. According to the Department of Energy, 90% of

motors in the United States are oversized. Efficiency labels are often misleading. Look at the specifications. Buy a model with at least the recommended efficiency rating with speed matching the old motor. When replacing a fan, consider the cubic-feet-per-second (CFS) rating. The EPA estimates that 60% of fans in the United States are oversized. This would also be a good time to ensure that the ventilation system meets air quality codes.

When an older electric motor rated greater than 7.5 horsepower is replaced with a premium-efficiency motor, energy savings can pay for the new motor in 1 to 3 years.

Tremendous strides have been made in appliance efficiency. Some items can be economically replaced based simply on improved energy efficiency. Replacing a working refrigerator that is more than 15 years old with a new highly efficient model will save money over the new refrigerator's life cycle. A few audits singled out hot water heaters for energy savings. Replace failed appliances with the most energy-efficient model you can find. These are marked with the EnergyStar label (Figure 3).



Figure 3—Energy Star image.

For more information on replacing appliances and other products, refer to MTDC's Tech Tip, *Replacing*

Chlorofluorocarbon Refrigerants, 9871-2835-MTDC; EPA's *Energy Star* Web site; or the Federal Energy Management Program's Web site, *Buying Energy Efficient Products*. Information on these sources is at the end of this Tech Tip.

Operation and Maintenance

Operation and maintenance is the area in which the greatest energy and economic savings are likely to be gained at little cost. Some common procedures that offer immediate savings at little or no cost include:

- Turn off lights, computer monitors, and other items when they are not in use. Most modern equipment is engineered to withstand frequent on-off cycles. The economic benefits of turning equipment off are greater than the benefits of extending the machinery's life by leaving it on.
- Keep everything clean. Lighting and heating systems lose significant amounts of their output when they are covered with dust, dirt, or scale.
- Inspect and repair your weatherstripping at least once a year.
- Make sure your thermostats are correctly calibrated. Older types often "float."
- During winter, set your thermostats back at night.
- During summer, increase your cool-air intake at night.

Utility bills are not fixed costs and should be actively managed. Graphing your utility costs is a great way to monitor energy use. Unexplained cost spikes should be probed.

Graph your energy use on a simple office spreadsheet, then post the graph in a conspicuous place to inform the building's occupants of measures taken to reduce energy consumption. Keeping employees aware of energy use can help them understand that they can help reduce energy costs by turning off unused computers or lights.

Conclusions

Energy-saving measures discovered by these audits can help you know where your facility's energy savings are most likely to come from. Lighting systems offer a low-risk starting point on the path to energy savings. While the audits found that Forest Service facilities were generally in good to excellent condition, most audits noted inefficiencies in some systems, usually the HVAC and operation and maintenance systems. Persons running these systems need to receive support and training for their current system and any upgrades. Large investments in equipment will not produce the projected benefits if the operation and maintenance schedule is inadequate.

Additional Information

Facility Efficiency Guidebooks

EPA, Energy Star Buildings Upgrade Manual
<http://www.epa.gov/appdstar/buildings/manual/index.html>

U.S. Department of Energy, Federal Energy Management Program, Greening Federal Facilities
<http://www.eren.doe.gov/femp/greenfed>
(Two helpful, free manuals covering lighting, HVAC, and other systems that any building manager concerned about energy, engineer, or architect should read.)

Funding Information

U.S. Department of Agriculture, Forest Service, Funding Energy Conservation Projects: An Overview
Engineering Field Notes, Volume 10, May-August 1998
<http://fsweb.wo.fs.fed.us/eng/pubs/efn/1998-2.pdf> (file size 207 kilobytes)

U.S. Department of Energy, Federal Energy Management Program, financing information
<http://www.eren.doe.gov/femp/financealt.html>

Energy-Efficient Products

U.S. Department of Energy, Federal Energy Management Program, Buying Energy Efficient Products
<http://www.eren.doe.gov/femp/procurement/begin.html>
(Extremely helpful information on purchasing energy-efficient products, including everything from air-conditioners and windows to lights and fax machines.)

Lighting

U.S. Department of Energy, Federal Energy Management Program, Federal Lighting Guide
<http://www.eren.doe.gov/femp/resources/fedlightguide.html>
(A guidebook to lighting design and energy efficiency.)

Northwest Energy Efficiency Alliance
<http://www.northwestlighting.com>

EPA Web site devoted to lighting
<http://www.epa.gov/greenlights>

Philips Energy Center Institute
<http://www.lighting.philips.com>

Lightpoint, Sylvania Lighting
<http://www.sylvania.com>

General Electric Lighting
<http://www.gelighting.com>

Pacific Gas and Electric
http://www.pge.com/customer_services/residential/saving_energy

General Sources and Internet Links

EPA, Energy Star
<http://www.energystar.gov/default.shtml>

U.S. Department of Energy, Federal Energy Management Program
<http://www.eren.doe.gov/femp>

CREST (Center for Renewable Energy and Sustainable Technology)
<http://solstice.crest.org/index.shtml>
(An excellent Internet site for energy research, discussion groups, and links to other professional organizations.)

Related MTDC Publications

9871-2835-MTDC *Replacing Chlorofluorocarbon Refrigerants*
9871-2301-MTDC *Commissioning Existing Buildings*

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