Incrementally Greener —
Improving Sustainability Through Operations and Maintenance

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Cover—The Lolo Pass Visitor Center serves recreationists and tourists throughout the year on the border of the Lolo and Clearwater National Forests on U.S. Highway 12. Sustainability and energy efficiency are especially important at this highly visible location that experiences severe winter weather.

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Introduction

Ordinary operations and maintenance work can be a great opportunity to improve sustainability in offices, warehouses, crew quarters, homes, utilities, and other facilities. Many small, incremental changes can make a big difference in sustainability over time without a major capital outlay and can help improve employee satisfaction and service to our customers.

This report explains how to improve sustainability by making small changes in building and site maintenance and operations practices. First, let's look at why sustainability should be improved.

Highlights...

- Federal regulations require the Forest Service to conserve energy and use resources sustainably.
- Small changes in operations and maintenance practices can improve sustainability.
- Sustainability improvements can lower operations and maintenance costs.

Sustainability Is the Right Thing To Do

Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable practices often are referred to as "green" practices because they help protect living things, including green plants. Sustainability is very much in keeping with the U.S. Department of Agriculture (USDA) Forest Service motto, "Caring for the land and serving people." The built environment constructed and maintained by the Forest Service should reflect the values advocated by the agency, particularly the agency's commitment to land stewardship—in other words, sustainability. The built environment should be complementary to the natural environment (figure 1), and constructed using techniques, materials, and equipment that are sustainable.

Sustainability Is Required

Rising energy costs and concerns about global warming and depletion of nonrenewable resources have made sustainability a major issue. The Federal government, the largest energy user in the country, has made a commitment to reduce its energy and water use by switching to renewable energy sources and implementing other sustainable practices.

Federal regulations requiring energy efficiency or sustainability include the National Energy Conservation Policy Act (NECPA), as amended by the Energy Policy Act of 2005 (*http://purl.access.gpo.gov/GPO/LPS65979*) and Executive Order 13423, January 2007—Strengthening Federal Environmental, Energy, and Transportation Management (*http://www.whitehouse.gov/news/releases/2007/01/20070124-2.html*).

Figure 1—The materials used in the Red Canyon Visitor Center in the Powell Ranger District of the Intermountain Region's Dixie National Forest complement the surrounding red rock canyon. The visitor center also is designed to be long lasting and energy efficient.

USDA Departmental Regulation 5500–001, Facilities Energy and Water Conservation and Utilities Management (*http://www.ocio.usda.gov/directives/doc/DR5500-001.htm*), sets specific requirements for energy-use reduction, purchase or generation of renewable energy, installation of energy-use tracking equipment, reduction of greenhouse gas emissions, reduction of water use, and purchase of energy-efficient equipment and appliances. Rangers, forest supervisors, regional foresters, and station directors should be particularly interested in meeting these requirements because progress must be reported and may affect individual job performance ratings.

Sustainability Makes Sense

Making sustainability improvements to existing facilities can save money over time by reducing the maintenance, operations, and energy costs of facilities. The durability of buildings, equipment, and appliances can be increased also. With rising energy costs, reductions in water availability in many parts of the country, and no reasonable expectation of significantly increased funding for maintenance and operations, it makes sense to take advantage of opportunities to reduce future expenses.

Upper Buffalo Wilderness, Ozark National Forest.

The key to improving sustainability through operations and maintenance is to be aware of opportunities and to take advantage of them. This report describes ways to identify your opportunities.

Choose improvements that are cost effective over the life of a building. Elaborate shading to reduce unwanted heating by the sun may be cost effective for buildings in Arizona or Puerto Rico, but not for buildings in southeast Alaska. In contrast, upgrading to an ultraefficient heating system may be cost effective in Minnesota or Alaska, but not in Florida.

Energy Audits

An energy audit, which may be free through your local utility or State Department of Environmental Quality, can identify cost-effective measures to reduce energy use.

See the Forest Service internal Web page (*http://fsweb.wo.fs.fed.us/eng/programs/facilities/sus_green/audit.htm)* for more information on energy audits.

Sometimes energy audits recommend retrocommissioning to investigate energy-saving opportunities for complex heating, ventilation, air conditioning, and building control systems.

Commissioning

Commissioning is a comprehensive process that examines all of a building's operating systems and identifies changes needed to optimize the building's performance and satisfy the owner's operational needs. Changes that can be done quickly usually are completed as part of the commissioning process. More elaborate changes are scheduled for completion later, often by other specialists. Retrocommissioning is the term used for commissioning an existing building that has never been commissioned. Recommissioning is performed on buildings that were commissioned during construction.

Both retrocommissioning and recommissioning focus on equipment that uses energy. Heating, ventilation, air conditioning (HVAC), and building control systems often have significant problems that nobody's aware of. Fixing these problems can save a lot of money over a few years.

Commissioning can identify opportunities for savings in both new and old buildings. For instance, the Forest Service's Missoula Technology and Development Center (MTDC, figure 2), was built in 2002. A 2005 review of the HVAC system found that nearly 30 percent of the solenoids for the heat valves on the air distribution boxes weren't working properly. The system also had other minor glitches. Fixing these problems meant MTDC's energy bill remained the same during the winter of 2005 and 2006 compared to 2004 and 2005 even though energy rates increased about 20 percent. The system review and repairs more than paid for themselves the first year after they were completed.

Large buildings or groups of buildings with complex heating, ventilation, air conditioning, and control systems may benefit from retrocommissioning or a similar process if they are experiencing any of the following four problems:

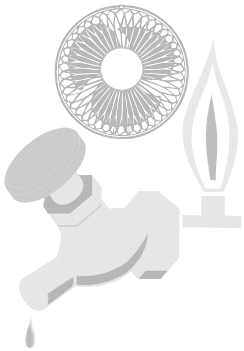
- Airflow or pressurization problems
- Recurring equipment failures
- Indoor air quality or temperature control problems
- High energy bills compared to similar buildings

Figure 2—The Forest Service's Missoula Technology and Development Center in Missoula, MT, was designed to be cooled using well water instead of refrigeration and heated using very efficient boilers. Energy use was reduced 20 percent by repairing solenoids that control valves in the air distribution boxes.

According to the Northwest Energy Efficiency Alliance and its partner utility companies, the energy costs of big buildings with any of the four problems listed above can be reduced by 5 to 15 percent. Other savings will be gained from improved employee productivity and lower operations and maintenance costs.

Commissioning costs a lot—an average of 25 cents per square foot for an existing building. However, the payback time in energy savings for complex equipment is usually less than 5 years.

More information about commissioning is available at the Northwest Energy Efficiency Alliance's Web page *(http://www.betterbricks.com/default.aspx?pid=commissioning).*



Equipment and Systems

When energy was cheap, it didn't matter much whether equipment and systems were efficient, so most of them weren't. However, even older, inefficient equipment works better if:

- Distribution systems don't leak and are properly insulated
- Coils, burners, filters, and ductwork are clean
- Burner and refrigerant pressure are adjusted properly
- Everything is in good repair

Yearly equipment checks, servicing, and adjustment ensure that equipment and systems are working properly. This is NOT the place to skimp on the operations budget—you'll pay more later if you do.

In areas with low energy costs or mild climates, it may be cost effective to perform thorough maintenance and hang onto older inefficient systems and equipment until they fail. In areas with high energy costs or harsh climates, it may not be worth refurbishing and retaining older systems or equipment because just a few years of energy cost savings would pay for new equipment.

To get the most out of old or new equipment, upgrade the building envelope and insulation as described in the *Building Envelope* section. Doing so will ensure that existing equipment doesn't use more energy than necessary and will allow new equipment to be sized appropriately, so it will operate more efficiently.

Forced-air furnaces and hot water systems manufactured before about 1990 had efficiencies in the range of 56 to 70 percent. Today, standard heating systems have efficiencies of around 80 percent and some systems may be 97 percent efficient, converting nearly all fuel to useful heat. Especially where fuel costs are high, it can be cost effective to replace old, worn out, inefficient, or significantly oversized furnaces or boilers with modern high-efficiency models. Old coal burners that were converted to oil or gas are prime candidates for replacement, as are gas furnaces with pilot lights rather than electronic ignitions.

Have a mechanical engineer or heating contractor run a heat-loss calculation to size your new furnace. In cold climates, it usually makes sense to invest in a system with at least a 90-percent efficiency rating. In milder climates with lower annual heating costs, the extra investment required to go from 80- to 90-percent efficiency may be hard to justify.

More information on furnace replacement and energy-efficient furnaces is available at the U.S. Department of Energy Web site (*http://www.eere.energy.gov/buildings/info/homes/heatfurnace.html).*

Consider including other newer technologies when replacing furnaces and boilers. Preheating devices use radiation fins between the intake and exhaust air (air-to-air heat exchange) or heat from the sun on a large surface (solar preheating) to warm the intake air or water so the furnace or boiler doesn't have to work as hard. Passive solar heating or systems to preheat furnace or ventilation intake air or boiler water may be cost effective in areas that get a lot of winter sunshine.

In areas where biodiesel or wood chips are readily available, consider a furnace or water heater designed to use biofuel.

Information about wood chip furnaces and boilers is available in the publication *Wood-Chip Heating Systems* (*http://www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf*) and at the *Fuels for Schools and Beyond* Web site (*http://www.fuelsforschools.org/*).

Ground-source heat pumps are energy-efficient systems that provide significant cost benefits in many areas. These systems use the relatively constant temperature below the frostline as part of a refrigerator-like system that harvests heat from the ground in the winter and dumps excess heat

into the ground in the summer. Your unit's facilities engineer or your regional mechanical engineer is a good source of information on what's practical in your area.

Cooling equipment efficiency has improved about 20 percent since the mid 1990s. In addition, chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants commonly used before 1995 are being phased out and will become increasingly more expensive and difficult to obtain. Although air conditioners and heat pumps can be expected to operate for 20 or 30 years, the recent increases in efficiency and the phaseout of CFC and HCFC refrigerants usually make it more cost effective to replace rather than fix older air conditioners and heat pumps that need significant repairs.

More information on energy-efficient space cooling is available at the U.S. Department of Energy's Web site (*http://www.eere.energy.gov/buildings/info/homes/coolingefficiently.html).*

More information on the phaseout of CFC and HCFC refrigerants and on alternative refrigerants is available at the internal Forest Service Web site *(http://fsweb.mtdc.wo.fs.fed.us/toolbox/haz/haz23.htm).*

Changing the cooling system in existing buildings usually is not cost effective except during a major building renovation. In some cases, use of refrigerated air conditioning systems can be reduced dramatically or eliminated altogether. In climates where hot days normally are followed by cold nights, a system that flushes the building with outside air at night can save all or most of the cost of refrigerated air conditioning. Ground water can be used instead of a refrigeration system to cool air in some places.

Depending on a building's shape and orientation, a cooling tower could be added to the building. Cooling towers use natural convection to draw hot air into the tower, where the air is cooled by the evaporation of water and falls back down the tower into the building.

More information about how cooling towers work is available in an article at *http://www.thefarm.org/charities/i4at/lib2/aircool.htm*.

In very mild climates or during some seasons, opening windows to allow cross breezes can disperse heat from equipment and office activities and keep the inside of the building at an acceptable temperature.

More information on passive cooling is available in the *Sourcebook for Green and Sustainable Building* (*http://www.greenbuilder.com/sourcebook/PassSolGuide3.html*).

Buildings that receive little use during evenings or weekends are prime candidates for **programmable thermostats** (figure 3). Programmable thermostats can be set to ensure that the heating and air conditioning are reduced when they are not needed. Models can be purchased with override switches so that employees working outside standard hours can enjoy full heating and cooling while they are in the building. These inexpensive devices ($50 to $150 depending on features, plus installation costs) could potentially pay for themselves in as little as 1 month with reduced heating costs and should be installed in nearly every Forest Service building that is heated or cooled.

Figure 3—Programmable thermostats are extremely cost effective energy-saving devices that should be used in nearly every Forest Service building that is heated or cooled.

Except in areas with extremely high energy costs, it usually is not cost effective to retrofit existing buildings to use solar, wind, geothermal, or other **renewable energy sources**. Renewable energy may be worth considering in areas where renewable resources are particularly abundant, when grants can be obtained, or when partnerships can be arranged to offset some or all of the initial costs.

More information about using renewable energy is available at the U.S. Department of Energy's *Energy Efficiency and Renewable Energy* Web site (*http://www.eere.energy.gov/*).

Information on possible financial aid for renewable energy projects is available on the Forest Service's internal Web site (*http://fsweb.wo.fs.fed.us/eng/facilities/2004_doe_funding.htm).*

When **appliances and equipment** wear out, replace them with energy-efficient models. The ENERGY STAR program is operated jointly by the U.S. Environmental Protection Agency and the U.S. Department of Energy. Among other things, the program develops specifications for low energy use in appliances and equipment, tests appliances and equipment against the specifications, and authorizes use of the ENERGY STAR logo (figure 4) on appliances and equipment that meet the specifications.

Information on equipment and appliances rated by ENERGY STAR is available at the ENERGY STAR Web site (*http://www.energystar.gov/index.cfm?c=home.index).*

Figure 4—The ENERGY STAR logo is attached to equipment and appliances that meet strict requirements for energy-efficient operation.

The temperature on **water heaters** can be adjusted by turning the control on the water heater's thermostat. Most thermostats are on the front of the tank, but some are behind an access plate. Energy savings can be from 3 percent to 5 percent for every 10 degrees that the temperature is lowered. Don't turn the temperature down too much, though. Hot water in pipes and tanks should be at least 120 degrees Fahrenheit to prevent growth of bacteria, such as those that cause Legionnaires' disease. Water temperature should be at least 140 degrees Fahrenheit for dishwashing. Some dishwashers come with a preheater so that the temperature on the water heater does not have to be set that high.

If a water heater tank is not well insulated, insulation will pay for itself in about a year. Storage-type water heater tanks that are warm to the touch should be insulated with a precut jacket or blanket, which costs around $10 to $20. Choose a blanket with an insulating value of at least R–8. Some utilities sell blankets at low prices, offer rebates, or install them at low or no cost. Check with your local utility company.

Timers for electric water heaters turn the water heater off at night when hot water isn't needed and/or during your utility's peak demand times, saving 5 to 12 percent on water heating costs. Timers cost $60 or more, but pay for themselves in about a year when they are installed on older water heaters. Timers aren't as cost effective or useful on gas water heaters or on electric water heaters manufactured after 1998 when more insulation and higher efficiency were required.

Consider installing a tankless water heater when the old storage-type water heater wears out. Tankless water heaters don't waste energy keeping water hot. They only heat water when it is needed, and use 25 to 50 percent less energy than tank-type water heaters.

The cost of tankless heaters depends on how much hot water they supply and whether they are gas or electric. Electric heaters cost less to purchase, but are more expensive to operate. Small electric heaters that can supply 2 gallons of water per minute at a temperature 40 degrees Fahrenheit above the supply water can cost as little as $200, plus installation. Tankless gas water heaters powerful enough to supply 5 gallons per minute while raising the water's temperature 60 degrees Fahrenheit could run $1,000 or so, plus installation.

If hot water is needed in distant parts of the building, more than one tankless heater may be needed, but some hot water piping can be eliminated. Complicated installations with several heaters probably will not be cost effective unless the building is being renovated.

Insulating hot water pipes reduces heat loss, raises water temperature 2 to 4 degrees Fahrenheit at the tap, and delivers hot water more quickly, allowing the temperature to be lowered at the water heater. Pipe sleeves made with polyethylene or neoprene foam are the most commonly used insulation, but fiberglass insulation is available also. Tape, wire, or clamp the insulation every foot or two to secure it to the pipe. Keep combustible insulation at least 8 inches from the flue of gas water heaters. Pipe insulation is cheap—less than $1 for a 6-foot length of preformed polyethylene foam insulation for ½-inch diameter pipe—but installing the insulation is fairly labor intensive.

Although most people consider **exhaust fans** to be a device to control odors, their main benefit is removing moisture-laden air from the inside of a building. Warm, wet air contributes to a number of facility problems, including premature failure of finishes and growth of mold. Sometimes a stove hood or bathroom fan merely recirculates room air after running it through a filter. Recirculating fans don't

reduce the moisture in the air. Unless the filters are cleaned or replaced regularly, they don't improve odor problems, either. They just blow air around and use energy. Replace all recirculating fans with exhaust fans.

When selecting an exhaust fan, look for a high volume rating, expressed in cubic feet per minute (cfm) and a low noise rating, expressed in sones. A fan with a rating of 2 sones is twice as loud as a fan with a rating of 1 sone.

An average-sized home bathroom needs a fan that will exhaust at least 100 cubic feet per minute. A fan louder than 1.5 sones may be too annoying to use. Select a fan rated below 1.5 sones, preferably 1.0 sone or less. Fans that meet these requirements cost about $100 at home and electrical supply stores.

To assure that a bathroom fan is used, wire it into the light switch so that the fan goes on when the light is turned on. Usually, fans controlled by manual timer switches are not practical for Government buildings because there's no way to assure that the switches will be turned on.

Standard electric hand dryers in restrooms use a lot of electricity and aren't very effective. Paper towels are expensive and can create a lot of waste in high-use restrooms.

In high-use restrooms, such as those at visitor centers, consider replacing towel dispensers and older hand dryers with an **energy-efficient hand dryer** such as the Xcelerator (*http://www.exceldryer.com/products/xlerator.asp*), the Jet Towel (*http://www.mitsubishijet-towel.com/*), or the AirMax (*http://www.worlddryer.com/AirMax.html*).

These hand dryers are operated by infrared sensors and dry hands completely in just a few seconds. They use up to 80 percent less energy than other hand dryers, making them more cost effective over time than ordinary hand dryers or hand towels, even though their initial cost is about $420 plus installation.

The **VendingMiser** (figure 5) is a two-part device approved by the Coca-Cola and PepsiCo companies that cuts power to refrigerated soda vending machines during hours when they are not normally used. Automatic sensors mounted at the top of the vending machine are connected to power controllers at the electric outlet that only supply power to the machines when needed to keep drinks cold. The devices "learn" typical vending machine use patterns to help determine when to power up and down. A VendingMiser

Figure 5—VendingMisers (at top of machines and inset) limit power use by vending machines when no customers are present. The fluorescent tubes in the door of the Coke machine have been removed, although you can't tell it by looking at the machine. The lights in the door of the Pepsi machine are still in place. The Pepsi machine door does not need to remain lighted in this bright lunchroom. This photo has been digitally altered.

costs $143.20 for an indoor model and $151.20 for an outdoor model through the General Services Administration (GSA).

The VendingMiser has a payback period of less than 1½ years if electricity costs 7¢ per kilowatt-hour or about 2½ years if electricity costs 4¢ per kilowatt-hour. Similar products are available for glass front coolers, snack machines, and other electrical devices that can be shut down periodically based on use. Some utility companies, States, and municipalities offer rebates of $45 to $120 for installing these products, reducing the payback time.

More information about the VendingMiser is available at *http://www.tufts.edu/tie/tci/pdf/VendingMiserHandout.pdf* and *http://www.usatech.com/energy_management/index.php.*

The **lights in vending machine doors** are usually high-output 3-foot-long fluorescent lamps. Disconnecting the ballast and lamp can save about $20 per year if electricity costs 4¢ per kilowatt-hour. Door lights are not needed unless the machine is in an unlit space (see figure 5). Most vending machines have other lights near the pay slots or lights on the product choice buttons to let people know the machine is in operation. A few machines may need a small sign to reassure customers that the machines are operating.

Lighting

To get the most benefit from your windows and light fixtures, brighten interior surfaces by repainting them with **white or light-colored paint**. Dark surfaces absorb light. More light from light fixtures or windows is needed to provide the same amount of illumination to working surfaces in rooms with dark walls, ceilings, floors, and furnishings than in rooms with white or light pastel surfaces. The difference is dramatic. One office needed just half as many light bulbs after changing from dark to off-white paint and from dark-brown to light-tan carpet. In areas where light-colored walls don't provide the desired ambiance, consider using darker accent colors on just a few walls or parts of walls.

In areas with strong sunlight most of the year and significant cooling loads, the benefits of light interiors are sometimes offset by the need to provide more cooling because the light, bright spaces "feel" hotter. In such cases, darker colors may be a better choice inside the building.

Older light fixtures and light bulbs, especially incandescent and metal halide light bulbs, are energy wasters. So are older fluorescent starters, ballasts, and tubes. Not only are they electricity hogs, but up to half of the energy that they use produces heat instead of light. This heat increases the energy needed for air conditioning. Older fluorescent fixtures that have reached the end of their useful life should be replaced by more energy-efficient fixtures that use T–8 or T–5 fluorescent tubes (figure 6).

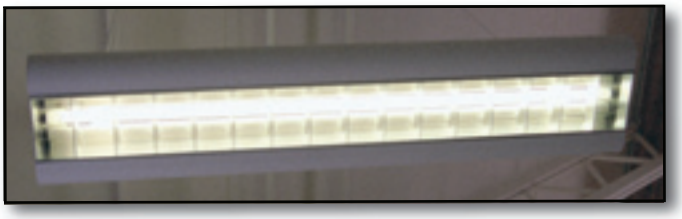


Figure 6—This light fixture has three T-5 fluorescent tubes. Controls allow turning one, two, or all three tubes on, so that light levels can be adjusted for individual preference and the amount of daylight in the room. Most of the light from the fixture is directed down, but some light shines on the ceiling, which helps reduce the contrast between the ceiling and fixture.

Incandescent light bulbs that burn out should be replaced by compact fluorescent bulbs in most cases. Compact fluorescent bulbs are more expensive to purchase, but their longer lamp life and lower energy use make them several times less expensive to purchase and operate than incandescent bulbs. In a year or so, the cost of new fluorescent fixtures can be recovered through energy savings when you're replacing metal halide and older fluorescent light fixtures. The same is true when you replace incandescent bulbs with compact fluorescent bulbs.

Be careful when purchasing compact fluorescent bulbs. Bulb life and the color of the light produced vary greatly by model and manufacturer—be sure to check the label for the rated life of the bulb and for a color rending index (CRI) of 82 or higher. Also, be cautious about replacing incandescent bulbs with compact fluorescent bulbs in exterior fixtures in cold climates, because some fluorescent ballasts don't work in cold temperatures. Most compact fluorescent bulbs will not work with dimmer switches.

More information about replacing lamps and fixtures will be in a forthcoming tech tip.

Two of the biggest energy wasters in office, shop, and warehouse buildings are lights left on when nobody's using the space and lights that stay on even when the daylight streaming through windows or skylights is much brighter than the lights themselves.

Occupancy sensor switches (figure 7) use motion or heat to detect the presence of people. They turn lights off after a certain amount of time when no one is in the room, and turn the lights back on again as soon as someone enters. Occupancy sensor switches that simply replace regular light switches are available for about $30 from home supply and hardware stores or for $50 from the GSA.

Figure 7—In 2006, occupancy sensor switches replaced standard switches in all the offices, restrooms, machine rooms, and service rooms at MTDC. Each office had two switches to make it possible to control one, two, or all three fluorescent tubes in the light fixtures. Very few people used all three tubes at once, so only the most-used switch was replaced. Energy savings are expected to pay for the cost of the new switches in about a year.

Photocell switches sense illumination levels and turn off lights when they aren't needed. Generally, photocells must be hard wired into lighting circuits or built into light fixtures. Different types of photocells are needed for different situations. Have an electrical engineer determine the product that is best for your particular situation. The photocells should be installed by a licensed electrician. Prices vary from $12 to $200, not including installation.

It may not be cost effective to add photocells or occupancy sensors to open office spaces that are illuminated by several banks of lights controlled by a single switch. An occupancy sensor would turn on all the lights even if just one person was using the room. A photocell would turn all the lights on or off based on the light level where it is located. In some cases, the wiring can be changed so that each switch operates fewer fixtures, which may make photocell or occupancy sensor switches practical.

Daylit hallways are particularly good candidates for light control by photocells. Individual offices, bathrooms, and service rooms (such as janitor closets and duplication or storage rooms) are particularly good candidates for occupancy sensor switches. The payoff time for photocells and occupancy sensor switches may be as short as 1 year.

Exit lights are often energy wasters, because they stay on 24 hours a day. If you have old exit lights that use incandescent bulbs, replace them with light-emitting diode (LED) exit signs. Exit signs with LEDs typically use 10 to 50 times less energy than those with incandescent lights. LED signs or bulbs will pay for themselves in energy savings in as little as a year.

LED exit signs are available for as little as $70 through the GSA ($100 with battery backup). Cheaper models are available online and in lighting stores, but be sure they provide enough illumination to comply with your local building codes.

LED bulbs that screw into incandescent light bulb sockets are available for around $30. These replacement bulbs might be a good choice if your incandescent exit signs are in good condition. If you have an exit light that uses a fluorescent tube, it may not be cost effective to change the fixture until it quits working.

Exterior light fixtures can waste energy and a lot of money if they provide ineffective illumination or light things that don't really need to be lit. Take a walk around your site some dark night and note areas with too much or too little lighting, areas that don't need lighting, and areas with dangerous shadows or glare.

Overly bright lighting at night can cast harsh shadows or create glare that prevents people from seeing potential hazards. A more uniform but lower light level may provide more security and safety. Because of the way human eyes work, bluish light provides the best vision at night. Practically speaking, this means that a metal halide or fluorescent (white or bluish) bulb will provide more effective illumination than a much brighter high or low pressure sodium bulb (orange or yellowish) or mercury vapor bulb (usually pinkish, but the color may change over time).

Sodium and mercury vapor lights don't provide very effective lighting, but they are common because they have relatively low initial cost and the bulbs last a long time. Light fixtures using mercury vapor bulbs should be replaced as soon as budgets allow because of their high energy costs and concerns about disposal of mercury in the bulbs. Instead of just changing exterior light bulbs when they burn out, consider converting them to electrodeless induction fluorescent, metal halide, or LED lamps.

Electrodeless induction fluorescent lamps are not commonly available yet, but they should be in a few years. Electrodeless induction fluorescent lamps made by both Phillips and Sylvania have a 100,000-hour lamp life (more than three times the life of sodium or mercury vapor lamps), are extremely energy efficient, provide very good illumination quality, and will start in temperatures as low as –30 degrees Fahrenheit.

Metal halide lamps are common and are a good choice, but they have a shorter bulb life than LED or electrodeless induction lamps. Standard metal halide ballasts won't start in temperatures below 10 degrees Fahrenheit, but cold-start ballasts are available that will work down to about –20 degrees Fahrenheit.

LED lamps are becoming more common. Because the individual bulbs are tiny and cast light in a tight beam, they can be very energy effective for low-light, widely distributed applications, such as a series of lights along pedestrian paths. Depending on the site and fixture selected, energy-efficient exterior light fixtures may pay for themselves in reduced energy and maintenance costs in a year.

Motion sensors and photocell controls can cut energy use for exterior lighting dramatically and in some cases provide better intruder deterrence than lights that are on all the time. Motion sensors may save enough electricity to pay for themselves in as little as half a year.

Light trespass and light pollution are becoming prominent issues. Light trespass occurs when light from a fixture "trespasses" onto a neighbor's property. Light pollution is caused by light shining up into the sky. As an agency dedicated to "caring for the land and serving people," the Forest Service should take these issues seriously. Also, it's not cost effective to pay for electricity to light someone else's property or, even worse, the sky.

If it's not possible to tilt fixtures to focus light where it's wanted, you may be able to add shields or shrouds that reflect or direct light in the desired direction. Shields for some common exterior light fixtures are available commercially for $20 to $200.

Sources of information about manufactured shields for outdoor lights include the International Dark-Sky Association (*http://www.darksky.org/resources/information-sheets/is159.html*) and Outdoor Lighting Associates (*http://www.greenearthlighting.com/products.asp?cat=2*).

If existing fixtures can't be modified to solve these problems, it may be cost effective to change to a different fixture.

It also may be cost effective to have a **lighting engineer** who is an expert in energy efficiency evaluate the site and make recommendations about cost-effective lighting changes, both inside and outside.

The Lighting Design Lab (*http://lightingdesignlab.com/*) provides inexpensive classes and events and free consultation to Federal agencies in Washington, Oregon, Idaho, and Montana through partnerships with the Federal Energy Management Program and local utilities. Similar programs may be available in other parts of the country.

Financing Operations and Maintenance Energy Improvements

It is usually difficult for Forest Service offices to finance major energy improvements without assistance unless the improvements are part of a capital improvement project. Fortunately, resources are available outside the Forest Service to help finance energy efficiency improvements.

Detailed information is available at the Department of Energy's *Financing Solutions for Federal Buildings* Web site (*http://www1.eere.energy.gov/financing/federal_energy_managers.html*).

Energy Saving Performance Contracts (ESPCs) and Super ESPCs allow Federal agencies to contract with energy service companies to perform energy efficiency upgrades. The service company:

- Conducts a comprehensive energy audit
- Identifies improvements that will save energy and reduce utility bills
- Arranges financing to develop and install energy and water conservation equipment and renewable energy upgrades

The agency is guaranteed that over the life of the contract the combined cost of paying for the improvements added to the new lower energy bill won't be any greater than the energy bill before the improvements. After the contract ends, the agency has a more efficient building or site and much lower energy costs.

This financing option allows agencies to implement energy improvements with little or no initial capital investment. The net cost to the Federal agency is minimal. However, tens of thousands of square feet must be upgraded at once to generate enough savings to make this approach profitable for the service company. Several units may need to work together.

More information is available at the Department of Energy's Super ESPC Web site (*http://www.eere.energy.gov/femp/financing/superespcs.html*).

Another option is the **Utility Energy Service Contract** (UESC). These contracts are similar to ESPCs, but are handled by the local power company. Under a UESC, the power company typically arranges financing to cover the capital costs of the project. The utility is repaid over time from the cost savings generated by the energy efficiency measures. The agency saves time and resources by using the financing and contracting services that normally have been negotiated ahead of time by the power company. A local power company may be more receptive to small projects than ESPC providers would be.

A UESC that can be used by any Forest Service unit in the Southern California Edison service area is at *http://fsweb.wo.fs.fed.us/eng/programs/facilities/sus_green/excontra.htm*.

A UESC may be available in your area, or you may be able to use the UESC with Southern California Edison as an example to negotiate a similar agreement with your power company. An areawide contract may be available through the GSA with your power company.

Check the GSA Web site (*http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/procuring_energy_R2H915_0Z5RDZ-i34K-pR.pdf).*

Most States and many utility companies also have energy incentives or other programs that are available to Federal agencies. These programs vary by State. The programs include: lighting retrofits or other energy efficiency equipment rebates, energy audits, education programs, demand exchange programs, renewable energy credits, incentives for energy-efficient construction, peak load reduction incentives, biomass energy equipment subsidies, and technical assistance.

Visit the Federal Energy Management Program's State Energy Management Programs Web site (*http://eere.energy.gov/femp/program/utility/utilityman_energymanage.html)* to find out what's available in your area.

Funding provided by nontraditional sources allowed the Forest Service's Coeur d'Alene Nursery to reduce energy use dramatically by replacing or modifying refrigeration, lighting, and HVAC systems.

The tech tip, *Modern Systems Cut Energy Use 80 Percent at the Coeur d'Alene Nursery*, contains information that can help other units reduce energy use and finance energy reduction work. It is available at *http://www.fs.fed.us/t-d/pubs/htmlpubs/htm06732326/* (Username: t-d Password: t-d).

Landscaping

Changes in landscaping can be an inexpensive way to reduce energy and water usage and landscape maintenance costs. If done carefully, the changes may pay for themselves in just a few years.

To reduce time spent mowing lawns, the cost of irrigation, and the need for chemical fertilizers and pesticides, switch to **Xeriscaping (water-wise landscaping)**. Xeriscaping uses careful landscape design and plant selection to minimize the need for irrigation.

Your unit's landscape architect can provide plans and advice about making the transition to Xeriscaping. Once established, carefully Xeriscaped areas that use native or adapted species require little to no irrigation or fertilization and become resistant to weeds, cutting down significantly on operations costs.

People associate the Forest Service with landscapes that have a natural appearance (figure 8). Xeriscapes can be designed to conform to those expectations, in contrast to standard suburban or urban-style landscaping.

For a quick overview of Xeriscaping, take a look at the Water-Wise Gardening poster (*http://www.bouldercolorado.gov/files/Utilities/Water_Conservation/xeriscape.pdf*) from the city of Boulder, CO.

For more information, visit the Colorado Springs Utilities Web site, *What is Xeriscape?* (*http://www.csu.org/environment/xeriscape/*) or the University of Georgia's *Guide to Developing a Water-Wise Landscape* (*http://pubs.caes.uga.edu/caespubs/pubcd/B1073.htm*).

Figure 8—When the McKenzie Ranger District office in the Pacific Northwest Region's Willamette National Forest was renovated, the landscaping was replaced with native plants in a setting similar to the surrounding forest. The native plants don't need to be irrigated.

Trim vegetation away from structures to ensure air circulation near siding and roofing. Vegetation traps moisture that can cause building materials to fail prematurely. Adjust irrigation sprinklers so they don't spray directly onto the siding or foundation. Overwatering near foundations can contribute to moisture problems inside basements and crawl spaces. Drip irrigation directs all of the water to plants' roots and is a better choice than spray irrigation for plants near a building's foundation.

In areas prone to wildfires, **remove dense plantings** near structures. They could provide ladder fuels that ignite structures during a wildfire. Replacing or repairing an unnecessarily damaged or destroyed structure uses a lot of resources—not a sustainable practice.

For more information on improving the fire resistance of structures and sites, visit the National Interagency Fire Center's *Protecting Your Home from Wildland Fire* Web site (*http://www.nifc.gov/preved/protecthome.html*) or Colorado State University's *Protect Your Home, Forest and Property from Wildfire* Web site (*http://www.csfs.colostate.edu/protecthomeandforest.htm*).

Plant trees at strategic locations to provide **shade** for structures and reduce cooling costs. In areas with cold winters, deciduous shade trees planted to the south and west of structures will allow light and heat from the sun to enter during the winter when they're needed, but will keep light and heat out during the summer. Plant the trees far enough from the structure that their canopies block the sun but the leaves or needles don't fall on the roof. Shade trees may not be practical in desert climates because of the need for irrigation, but shade structures can serve the same purpose (figure 9). In areas prone to wildfires, trees and shrubs should be a safe distance from structures.

Figure 9—The wraparound veranda in the courtyard of the Sabino Canyon Visitor Center in the Santa Catalina Ranger District of the Southwest Region's Coronado National Forest provides shading that keeps the sun from heating the inside of the building.

Building Envelope

The building envelope consists of everything that separates the contents of the building from the weather. Improving the performance of the building envelope can save a bundle in energy costs.

The importance of adequate **insulation** in both hot and cold climates can hardly be overstated. Adding insulation to older buildings that don't meet current energy codes usually pays for itself quickly in buildings with significant heating or cooling costs. Adding blown-in or batt insulation to attic spaces and foam insulation to crawl space walls is usually inexpensive. Insulation immediately increases employee or resident comfort and reduces heating and cooling bills. When adding attic insulation, be sure to block out space to allow air to flow from roof eaves to ridge or gable vents so that you don't create a condensation problem.

When siding modifications become necessary, it may be cost effective to also add insulation to exterior walls. Adding insulation can affect moisture transfer through walls. Climates differ, so check with a knowledgeable engineer or architect for moisture control and insulation techniques that are appropriate for your area.

Building entrances can be big energy wasters. Frequently-used entrances in buildings that have significant heating or cooling requirements usually should have an "air lock" entry system consisting of inner and outer doors with several feet of space between them to limit the amount of conditioned air that escapes the building as people come and go. Adding a vestibule and porch or covered terrace to the main entrance of a building also can make the front entry more welcoming and easier for visitors to find.

Exterior doors can waste energy if they are not insulated or if they don't have good weather seals around the edges. Consider replacing older, uninsulated metal doors, especially if they are in poor condition. Add weather seals around any doors that don't have them. Generally, seals that are designed to compress when the door closes work better than other types.

Windows admit sunlight that can greatly reduce the need for expensive artificial lighting. They also let employees see outdoors, which is important for their well being and morale. However, windows can be big energy wasters. The single-pane aluminum and steel frame windows that were commonly installed in the mid 20th century are extremely good at transferring heat and cold between the indoor and outdoor environments—the opposite of energy efficiency. When they break or wear out, it is generally better to replace these windows rather than to repair them if the building interior is heated or cooled. Choose new windows with frames that minimize conduction of heat or cold between inside and outside to cut energy bills. Wood, vinyl, fiberglass, and aluminum frames with thermal breaks each have advantages and drawbacks.

Windows with low-emissivity coatings and an inert gas such as argon between the double panes are a good energy investment in harsh climates. Low-emissivity coatings reduce radiant heat transfer through the glass. Inert gases have a higher resistance to heat flow than does air. If solar heat gain or glare are problems, consider adding shade plants or devices outside the windows to block the heat and glare while still allowing filtered light to enter the building (figure 10).

Check with your unit archeologist or architectural historian before making a decision to replace windows on historically significant structures. Replacement of original windows may not be appropriate. Interestingly, restored wood windows in historic buildings combined with carefully crafted wood storm windows often perform nearly as well as the latest window models.

Adding skylights or light tubes also can reduce the need for artificial light. Light tubes are similar to skylights, but use a reflective tube to conduct light from the roof down into the room. While skylights can be difficult to install in an existing building, light tubes often can be installed relatively easily between existing roof trusses or joists.

Figure 10—Light filters through the overhanging trellis shading the glass doors of the conference room at the International Institute of Tropical Forestry, a Forest Service research and technology transfer station in Puerto Rico.

Building Materials

During maintenance work that requires demolition, remove materials carefully and use salvaged materials for repairs where practical. Doing so not only cuts down on landfill fees, but minimizes the difficulties of matching undisturbed materials and the costs of new materials. If reuse isn't possible, check to see whether a local business dealing in salvaged building materials will accept some or all of the materials you remove. Some drywall, ceiling tile, and carpet manufacturers will take salvaged materials back for reprocessing. Look on the back of the material for the manufacturer's name and give them a call to see whether they take their materials back.

Check out the U.S. Environmental Protection Agency's *WasteWise* Web site (*http://www.epa.gov/wastewise/targeted/challenge/cbuild.htm*), GSA's *Construction Waste Management* database (*http://www.wbdg.org/tools/cwm.php*), and The Forest Products Lab's *Directory of Wood-Framed Building Deconstruction and Reused Building Materials Companies, 2005* (*http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr150.pdf*) for more information on reusing and recycling building components.

Siding and roofing materials come in such a variety that it's tempting to simply replace them in kind when the existing materials wear out. Instead, consider whether different materials might help cut energy use and whether it would be cost effective to use roofing or siding made from renewable, recycled, or recyclable materials. For instance, "cool roof" material that reflects ultraviolet radiation from the sun can decrease the amount of air-conditioning needed in buildings and reduce peak cooling demand by 10 to 15 percent. "Cool roofs" are available in recycled and recyclable materials such as steel or recycled rubber "slate" tiles.

More information about cool roofs is available at the California Energy Commission's *Consumer Energy Center* Web site (*http://www.consumerenergycenter.org/coolroof/*).

When the membrane or built-up surface of a "flat" roof must be replaced, consider changing to a **green roof**. Green roofs consist of drought-resistant plants growing in lightweight soil on top of a waterproof membrane. Green roofs reduce storm water runoff rates by 40 to 75 percent, decrease the air conditioning costs attributable to heat transfer through the roof by up to 75 percent, lengthen roof membrane life by up to 50 percent, reduce noise transfer from outside the building, and decrease the urban "heat island" effect. Green roofs can be installed instead of ballast.

Modular green roof systems are available that weigh as little as 15 pounds per square foot even when fully saturated with rainwater. Lightweight modular green roofs are relatively expensive ($9 per square foot), so they are likely to be cost effective only where air conditioning or storm water disposal costs are high, or where rebates or incentives are available. The City of Seattle has estimated that the cost premium for a green roof over the 40-year life of the roof is only about 10 percent. Check with a structural engineer to make sure the building can support the weight of a green roof.

More information about green roofs is available at *http://www.epa.gov/heatisland/strategies/greenroofs.html*.

More information about lightweight, modular green roofing systems is available at the Green Grid (*http://www.greengridroofs.com/*) and Green Tech (*http://www.greentechitm.com/systems/roof.asp*) Web sites.

When repainting or replacing wornout materials, check to see whether you can get **natural materials** (such as wool, jute, and coconut fiber) or **materials with recycled content** that meet your requirements for a similar price. Natural materials usually don't give off irritating fumes, so they can be better for employee health. Using materials with recycled content conserves nonrenewable resources.

For the best value over the product's complete life cycle, be sure to compare the material's durability, cleaning, and maintenance requirements. Whenever possible, use **low volatile organic content** (VOC) materials, particularly with materials such as sealants, adhesive, and paints.

For assistance in choosing "green" materials, visit the *Green Materials and Construction* page of the Forest Service Engineering internal Web site at *http://fsweb.wo.fs.fed.us/eng/programs/facilities/sus_green/greenmats.htm* or the Environmental Protection Agency's *Environmentally Preferable Purchasing* Web site at *http://yosemite1.epa.gov/oppt/eppstand2.nsf.*

Plumbing That Conserves Water

Water conservation can reduce utility bills substantially. In areas without a public water supply, using plumbing that conserves water means water systems can be smaller and will cost less to construct and operate.

Faucets and fixtures that use less water are the norm for new construction. Their effectiveness has improved dramatically from the days of low-flow toilets that required multiple flushes and flow-restricted shower heads that barely dribbled water. When older fixtures or faucets break or reach the end of their useful life, replace them with water-efficient fixtures. In areas where water costs are high or the water supply is limited, it may be cost effective to replace older fixtures and faucets that still work.

Most toilets manufactured before 1994 use 5 to 7 gallons per flush. If you have older toilets in high-use areas, and your water costs are high or your water supply is limited, replacing them with new **low-flow toilets** will be cost effective.

There are differences in effectiveness among low-flow toilets. Pressure flush, dual flush, air assist, vacuum flush, and gravity models with 1.6-gallon flushes or ultralow flushes of less than 1 gallon are available in all price ranges. Studies have determined the models that work best. Surprisingly, cost does not necessarily indicate flushing effectiveness. Some of the most effective low-flow toilets cost about $100.

Waterless urinals don't flush. Instead, urine flows through a specially designed trap containing a fluid barrier that prevents sewer vapors from escaping into the restroom air. Urine sinks through the fluid barrier, overflows into the central tube, and runs down to the sewer line.

The urinals at MTDC (figure 11) are all waterless. About 60 employees work in the office/shop/laboratory building. The attached training center is used by outside groups of up to 200 people. The waterless urinals work well because staff and maintenance personnel are trained to use and maintain them properly. The eight waterless urinals save about 60,000 gallons of water each year.

More information on low-flow toilets and waterless urinals is available at the Forest Service's internal Web site *Water Conserving Fixtures and Products* (*http://fsweb.wo.fs.fed.us/eng/programs/facilities/sus_green/fix_pro.htm*).

Figure 11—Waterless urinals work well if they are used and maintained properly. The six waterless urinals at MTDC save about 60,000 gallons of water each year.

Another way to save water is to install new **low-flow shower heads** and **faucet aerators**. A flow of less than 2.5 gallons per minute is considered low flow for both sink faucets and shower heads. Flow rates usually are stamped on the side of sink faucet aerators, but you may have to measure the volume of water per minute in the shower using a pan or bucket. Low-flow faucet aerators usually cost $5 to $10. Low-flow shower heads cost from $8 to $50.

Faucets that are controlled by **infrared sensors** can save a lot of water—and the energy to heat the water—in heavily used restrooms. These faucets are common in public restrooms and have good public acceptance. In many areas, they experience less wear and vandalism than standard faucets. When replacing wornout sink faucets in heavily used restrooms, consider spending more for sensor-controlled faucets. Expect to pay at least $200. Photovoltaic-powered sensor faucets are available for $400 and up. Their sensors are powered by indoor lighting and eliminate the need for batteries or an electric connection.

Collecting Rainwater

If the structure is in an area with high water costs or a limited water supply, it may be cost effective to collect rainwater for use in plumbing systems. This is called rainwater harvesting. The least complex systems simply collect the water that comes off the roof, provide a way to separate dirt and debris, and use the water to irrigate the landscape.

More complex systems can be used for flushing toilets, fire protection, or even potable water. Complex systems usually require intricate plumbing and possibly a disinfection system. They aren't cost effective for existing structures except in unusual circumstances.

More information about rainwater harvesting is available at Montana State University (*http://www.montana.edu/wwwpb/pubs/mt9707.html*) and from the Texas Water Development Board (*http://www.twdb.state.tx.us/assistance/conservation/alternative_technologies/rainwater_harvesting/rain.asp*).

Cleaning Products

Changing to sustainable cleaning products probably isn't going to have a significant effect on the operations budget, but it will improve indoor air quality and may help improve the productivity of employees, especially employees who are sensitive to chemicals.

Cleaning supplies that are less toxic and contain fewer volatile organic compounds are becoming increasingly common and are available from the GSA and in stores in most communities. In most cases, these products work as well as the standard products. The price premium is vanishing.

As supplies are replaced and budgets allow, be sure that the products purchased are the least likely to have adverse affects on cleaning staff and building occupants.

Information on environmentally preferable cleaning products is available through the U.S. Environmental Protection Agency (*http://www.epa.gov/oppt/epp/pubs/products/cleaner.htm*) and the Office of the Federal Environmental Executive (*http://www.ofee.gov/gp/greenjanitorial.html*).

Executive Order 13101 sections 503 and 601 (*http://www.ofee.gov/eo/13101.htm*) require Federal agencies to purchase environmentally preferable and biobased products when doing so is cost effective.

Recycling

Recycling is the best known part of the waste reduction triangle—reduce, reuse, recycle (figure 12). Reducing means limiting the materials and supplies you purchase to the amount that is actually needed. Purchasing durable materials and supplies that can be washed, refilled, or refinished many times makes reuse more practical. Reducing, reusing, and recycling all reduce the amount of waste produced.

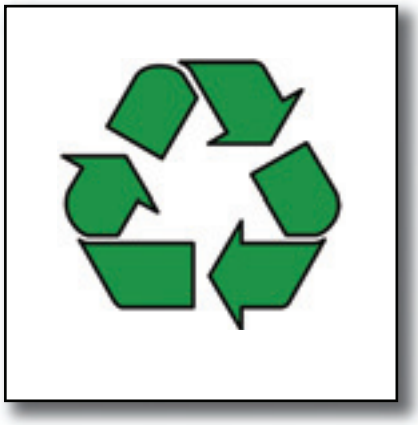


Figure 12—This familiar logo was drawn by college student Gary Anderson for use during the first Earth Day in 1970. Now it's recognized worldwide as the symbol of recycling, recycled content, and recyclable materials. The mantra *Reduce, Reuse, Recycle* is also associated with the symbol.

Few administrative sites will make much money by selling recycled materials. However, administrative sites with garbage collection fees based on volume may save money by diverting recyclables from their waste stream. Recycling is a visible way of emphasizing that the Forest Service cares for the land, so it's important to recycle wherever practical. In most areas of the country, recycling services are available for a broad range of materials.

The best way to encourage recycling is to make it easy for people to "do the right thing" by providing convenient recycling containers (figure 13). Ideally, offices should have a paper recycling container beside each waste basket. Aluminum and plastic recycling containers should be provided near vending machines. Containers or storage areas for flattened cardboard should be located near the space where products or shipments are usually unboxed. Containers for newsprint, glass, and other recycled products should be near the places where these items are used. Return mailers for printer ink and copier toner cartridges should be located near the equipment.

Figure 13—Recycling paper is easier when there's a recycling container next to every wastebasket.

In most cases, it's more time and cost effective for a recycling collector to go around a building or site periodically collecting the contents of recycling containers than for each employee to haul materials to a central collection point. It's also more likely that people will recycle rather than throw recyclables away if recycling is easy and convenient.

Some materials that require regular replacement over the life of a building contain hazardous materials. For instance, fluorescent tubes and mercury vapor, metal halide, and high- and low-pressure sodium lamps contain mercury; ballasts in old light fixtures may contain PCBs (polychlorinated biphenyls); and batteries may contain lead or cadmium. For these materials, recycling is not only the responsible thing to do but may avoid extra charges at the landfill for disposing of hazardous materials.

More information about handling and disposing of these materials is available in the *Hazmat in Buildings* section of the *Facilities Toolbox* on the Forest Service's internal computer network at *http://fsweb.mtdc.wo.fs.fed.us/toolbox/haz/haz16.htm*.

Doing Well by Doing Good

This report has explained how small changes in operations practices and thoughtful maintenance choices can gradually improve the sustainability of Forest Service buildings and sites. Making cost-effective sustainability improvements also saves money. Keep this report where you can find it—it will continue to help you do well by your budget while doing good for the land.

Boundary Waters Canoe Area Wilderness, Superior National Forest.

About the Author

Kathleen Snodgrass came to MTDC as a project leader in 2001. She graduated from Washington State University in 1974 with a bachelor of science degree in architectural studies, then spent about 10 years in highway design and construction with the Idaho Division of Highways. She began her career with the Forest Service in 1984. Kathie worked in facilities, landscape architecture, land line, and general engineering on the Nez Perce National Forest for around 10 years, and was the forest's facilities architect for about 7 years before coming to MTDC.

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This report explains how small changes in operations practices and thoughtful maintenance choices can improve the sustainability of Forest Service buildings and sites, and how making cost-effective sustainability improvements can save money.

Keywords: administrative sites, air conditioning, boilers, cleaning, commissioning, doors, energy audits, energy conservation, energy efficiency, ESPC, exhaust, financing, furnaces, green, infrared, insulation, landscaping, lighting, low flow, maintenance, occupancy sensors, operations, photocells, recycling, renewable energy, sustainability, UESC, VendingMiser, waterless urinals, windows, Xeriscaping

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