

A Project of Bay Area LISC and Build It Green

GREEN REHABILITATION OF MULTIFAMILY RENTAL PROPERTIES

A RESOURCE GUIDE



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ABOUT LISC

BAY AREA LOCAL INITIATIVES SUPPORT CORPORATION

Bay Area LISC is part of the national LISC organization, one of twenty-nine LISC field offices across the country. Since 1981, Bay Area LISC has been working hand-in-hand with communities to transform neighborhoods into healthy ones—good places to live, do business, work, and raise families. LISC provides nonprofit community developers with the skills, information, and financial resources they need to be effective agents of change. As a leading local intermediary with broad-based expertise in affordable housing, community economic development, and organizational development, Bay Area LISC supports the goals of the community development industry by providing critical capacity-building assistance to nonprofit organizations. The Green Rehabilitation Resource Guide is a project of Bay Area LISC's Green Connection program, which was established in 2003 to bring environmentally sound principles into practice among affordable housing developers, managers and regulators. Our multi-dimensional program includes training, development of new tools and templates, peer learning, and financial incentives.

NATIONAL LISC RESOURCES

Bay Area LISC collaborates with two key national LISC programs to create green, sustainable communities:

- The Affordable Housing Preservation Initiative, which is dedicated to reducing the loss of rental housing that is affordable to low-income families, especially the federally-assisted housing facing expiring rent and mortgage subsidies.
- The Green Development Center, which advocates for green policies nationally. GDC supports and accelerates the incorporation of green building principles into the design, construction and management of the full range of projects undertaken by the community-based organizations served by the LISC field offices.

For more information visit www.lisc.org or contact Jennifer Somers, LEED AP, LISC Green Connection Program Officer, jsomers@lisc.org, 415-397-7322 x28.

ABOUT BUILD IT GREEN

BUILD IT GREEN

Build It Green is a nonprofit membership organization whose mission is to promote healthy, energy and resource-efficient buildings in California. Build It Green connects consumers and professionals with tools and technical expertise to build green and collaborates with key stakeholders to accelerate the adoption of green building standards, policies, and programs.

For more information, visit www.BuildItGreen.org or contact Bruce Mast, Build It Green Development Director, bruce@builditgreen.org, 510-845-0472 x111.

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This document provides guidelines for multifamily affordable housing providers and their consultants in preparing a green physical needs assessment. It provides recommendations for housing rehabilitation that incorporates green building principles of energy efficiency, water conservation, resource conservation, and healthy indoor environments. The information in these pages is applicable to both moderate rehabilitation projects, as well as substantial or gut rehabilitations.

WHAT IS A GREEN BUILDING?

Green building is a whole-systems approach to the design, construction, and operations of buildings. Green building emphasizes the interconnectivity and integration of the building site and systems (such as the building envelope, plumbing, mechanical systems and so on) to create a building that conserves natural resources, increases energy efficiency, and improves the healthfulness of the indoor environment.

Although including green strategies at the onset of building design is the most effective way to achieve high performance for the least cost, there are also tremendous advantages to be gained by incorporating green practices into rehabilitation projects.

WHY USE THIS RESOURCE GUIDE?

A 2003 study conducted by Capital E entitled “The Costs and Financial Benefits of Green Buildings” analyzed thirty-three green buildings compared to conventional designs for the same buildings. The researchers found that integrating green and energy efficiency practices is a smart financial investment. The study demonstrates that “a minimal upfront investment in green of about two percent of construction costs typically yields a lifecycle savings of over ten times the initial investment.”¹

Affordable housing developments that integrate green building into their rehabilitation projects benefit from lower energy bills, products that are more durable and require less maintenance, and an overall healthier building environment for the occupants. The objective of this document is to provide a comprehensive tool for nonprofit developers of affordable housing and their consultants to assist them in greening their rehabilitation projects.

The Green Rehabilitation Resource Guide should be used in tandem with the building walk-through or site assessment that usually occurs at the outset of any rehab project. To assist with the building walk-through, a Building Walk-through Checklist and Recommendation Form is provided in the appendix. If applicable, descriptions of property conditions noted during the walk-through should be described on the checklist. Also indicate if the condition needs to be addressed immediately or in the near future. This will help determine if it is necessary to replace or update that building component with more environmentally preferable options during the rehabilitation of the property.

1. The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force, by Greg Kats. Capital E, October 2003, p. v. www.cap-e.com/spotlight/index.cfm?Page=1&NewsID=25770.

STRATEGIC OVERVIEW: WHERE DO I START?

This section provides an overview of where to start when considering a green building and energy efficiency upgrade. First and foremost, it is important to establish the green building priorities for your building.

Use this document to help identify the most pressing needs for your property, as well as other items that will be in need of upgrade in both the short and long term. For example, if you have had complaints about indoor air quality or odors in your building, you will want to focus on measures that help ameliorate those problems. Steps may include installing fans in the kitchens and bathrooms that vent to the outside (Rec. 4.5.1 and 4.8.1). Fans will help control not only odors, but also moisture, which may be contributing to the indoor air quality problems.

Another step that helps protect indoor air quality is to specify no or low-VOC (volatile organic compound) products for any interior building components that need updating, such as paint or flooring (Sections 4.1 and 4.2).

To achieve a true high-performing building from your green rehabilitation efforts, do not consider green building and energy efficiency measures in isolation. Use an integrated design approach to maximize your energy efficiency opportunities; this includes considering the interaction between various building elements, such as lighting, windows and mechanical systems.

It is critical that the project manager convey to the rehabilitation team—your architect, engineer, general contractor, and other building professionals—that integrating green building and energy efficiency practices into your project is a top priority. Making this a goal at the project outset and obtaining buy-in from the project team will help ensure that green building strategies planned at the design phase will actually be incorporated into the building during rehabilitation and operations. Whenever possible, hire project team members who have experience with green building and are committed to the process. Electing a project green “champion” to spearhead all of these activities is key.

When planning your green rehabilitation project, particularly for first-time green developers, start with the low-hanging fruit—those energy efficiency and green building opportunities that are low cost and have short-term paybacks.

ENERGY EFFICIENCY OVERVIEW

Energy efficiency is the cornerstone of any green rehabilitation project. The average payback for most energy efficiency measures is under three years and there are many rebate programs available to help offset the costs of energy retrofits.

In addition to the energy savings, additional benefits of implementing energy efficiency measures include the increased comfort of your tenants. Increased comfort means that there are fewer tenant complaints and fewer maintenance calls. Energy-efficient equipment is also more durable, and will require less maintenance. There will be overall better lighting quality in your buildings and improved building safety as a result.

What's more, the money you save by making your project more energy efficient can help fund other green measures. The energy efficiency measures briefly described here are not a complete list of all measures you should consider for your building; instead, they provide a general idea of where to start. Turn to the specific recommendations in this document for greater detail.

Be sure to use this document when conducting a thorough building walk-through as well as an energy audit. Make a record of project-specific information and a prioritized list of items that should be considered for energy efficiency upgrades, taking into account replacement needs, costs, benefits, and payback.

ENERGY EFFICIENCY: SHORT-TERM PAYBACK (LESS THAN THREE YEARS)

The most common “low-hanging fruit” energy efficiency measures include energy-efficient lighting and appliances. Replace your standard T12 bulbs with T8s, which are more energy efficient, thinner and use an electronic ballast instead of a magnetic ballast (Rec. 3.1.1). Change out both the bulbs and ballasts during a retrofit. Also install energy-efficient appliances; rebates are often available. When choosing appliances, look for the Energy Star label, the U.S. Environmental Protection Agency’s label indicating that the products (such as light bulbs, appliances, and other energy-using equipment) are very energy efficient (Rec. 4.8.1). Installing occupancy sensors on lights in laundry and vending areas is also an easy way to save energy.

Also consider placing controls on boilers; this is another low-cost energy efficiency strategy that should be a part of any green building retrofit (Rec. 3.3.1). If units in your building are often too hot or too cold, using an outdoor reset/cutout control will help with this issue and result in fewer occupant complaints and maintenance calls (Rec 3.3.1).

Installing tank insulation on service hot water heaters is another low-cost measure that will prevent heat loss (Rec. 3.2.2). Weatherizing your building—insulating (Rec. 2.2.3), caulking, weather-stripping and sealing windows, doors and any openings to the outside—is another easy, low-cost way to save energy.

ENERGY EFFICIENCY: MEDIUM-TERM PAYBACK (THREE TO FIVE YEARS)

For service hot water, insulating any accessible pipes will save energy (Rec. 3.2.2). In many older buildings, pipes may have been poorly insulated or not insulated at all. Uninsulated pipes allow a great deal of heat to escape, which drives up the energy needed to maintain a steady supply of hot water.

Replace incandescent and fluorescent exit signs with light emitting diode (LED) exit signs (Rec. 3.1.1). LED exit signs save tremendous amounts of energy (they typically only use two watts) and can last from seven to ten years without needing replacement. In other light fixtures, replace standard incandescent bulbs with compact fluorescent light bulbs (Rec. 3.1.1). CFLs use one-quarter the electricity of a regular light bulb and also last from seven to ten years.

ENERGY EFFICIENCY: LONGER-TERM PAYBACK

Equipment that should be replaced on fail with more energy-efficient models include water heaters (Rec. 3.2.2), air conditioners (Rec. 3.4.2), and boilers (Rec. 3.3.1). Costs will vary depending upon your system. Upgrading windows (Rec. 2.4.2), space heating and cooling, building envelope, and water heating may cost more initially, but will result in greater operating efficiencies over the long term.

If your project does not have the capital to replace HVAC or other costly equipment, consider leasing high-efficiency equipment. The leasing company will cover the installation, maintenance and salvage costs, and depreciation. Cogeneration (combined heat and power) equipment, for example, can be leased. A minimum of 100 units of housing is usually necessary for cogeneration to make sense.

GREEN BUILDING OVERVIEW

Use this document as a tool to help identify areas in your building in need of upgrade. Within this document, you will find detailed information on greener alternatives to conventional building practices. As described in the energy efficiency section above, you should develop green building priority areas and set goals at the outset of your rehabilitation process. Carry these goals through to construction and operations.

The following section provides some starting points and ideas regarding site, indoor environmental quality, material conservation and selection, and water efficiency opportunities.

SITE

When upgrading elements of your site with green alternatives, look for synergistic effects with other building elements. For example, when you evaluate landscaping opportunities, you may find that incorporating larger trees and shrubs next to your building can help decrease air-conditioning loads by shading the building (Rec. 2.4.1). If parking or any site work needs to be replaced, explore porous paving options that will help keep the site cooler as well as reducing stormwater runoff (Rec. 1.2.2).

INDOOR ENVIRONMENTAL QUALITY

In any rehabilitation project, be sure to properly test for lead-based paint and asbestos before beginning any work.

Easy green building measures that improve indoor air quality with little or no additional cost over conventional measures include using no or low-VOC paints, adhesives, sealants and coatings (Rec. 4.1.1).

Since a large percentage of the pollutants that enter a building come from the bottom of our shoes, installing walk-off mats in entryways will help cut down on indoor pollution as well as building maintenance (Rec. 4.2.2). Simple measures to control moisture and odor include installing Energy Star–labeled kitchen and bathroom fans that exhaust to the outside (Rec. 4.5.1 and Rec. 4.8.1).

Select materials that will not adversely impact indoor air quality (IAQ). Avoid interior products with added urea formaldehyde as much as possible. Urea formaldehyde is used as a binder in many pressed wood products, such as particleboard and plywood, and because it is highly volatile, it continues to offgas from the products for a number years.

Every rehabilitation project should develop and follow a construction IAQ management plan during construction that meets or exceeds the control measures outlined in the Sheet Metal and Air Conditioning Contractors Association (SMACNA) *IAQ Guidelines for Occupied Buildings Under Construction*, 1995, Chapter 3.

MATERIALS AND RESOURCES

Reuse building materials whenever possible. If your building is older, it may contain many high quality building materials and beautiful craftsmanship that cannot be replicated with new materials. Hardwood flooring, lighting sconces, ironwork, and building facades are examples of building materials that should be reused and restored if possible.

Reusing building materials reduces construction and demolition waste, may save money compared to buying new, saves the embodied energy that goes into producing new products, and helps maintain the original character of your building.

Every rehabilitation project should develop and follow a construction and demolition waste plan that separates construction waste from debris to be recycled, thus diverting it from a landfill. Consider designating recycling areas on site and recycling cardboard, metal, plastic, gypsum wallboard, brick, acoustical tile, concrete, plastic, clean wood, carpet and insulation.²

For new building materials and finishes, choose materials that will not adversely impact indoor environmental quality. Choose hard-surface flooring over carpeting whenever possible because carpet collects dust and other pollutants that impact respiratory health. If you must choose carpet, look for carpet with the Carpet and Rug Institute Green Label Plus label or carpet that has been tested to meet the State of California's Section 01350 standard (Rec. 4.2.3).

Instead of vinyl flooring, consider natural linoleum (Rec. 4.2.2). It is made of renewable and abundant materials including linseed oil and cork, requires less maintenance (vinyl has to be waxed frequently) and will last 30 to 40 years (compared to 15 for vinyl). Many green building options not only are cost effective, but also simply make sense.

WATER EFFICIENCY

Installing low-flow fixtures is a low-cost/high-benefit measure that will reduce your water and energy bills. Inspect all dwelling-unit plumbing fixtures and specify low-water-use fixtures as necessary (Rec. 4.6.1). Showerheads should use 2.0 gallons per minute (gpm). Install flow limiters or flow control valves in all kitchens and bathrooms. Install High Efficiency Toilets (HETs) that use less than 1.3 gallons per flush (Rec. 4.6.2).

WHAT DOES A GREEN REHAB COST?



The cost and cost effectiveness key used in this document is intended to assist you in making decisions about which green measures to include in your rehabilitation projects. The key was originally developed by Stopwaste.Org's Green Building in Alameda County program for their *Multifamily Green Building Guidelines*. Its purpose is to give people who are new to green building a sense of the relative costs and benefits of each recommended measure. The key uses the symbol  to indicate relative costs and benefits. One black bar indicates low benefit or cost, two bars indicates medium benefit or cost, and three bars equals high benefit or cost. Note that this key reflects the anticipated increase in first cost over conventional practice. The actual costs may vary considerably among projects and will depend on availability, the particular supplier and choice of materials as well as available rebate programs.

In some cases, relative costs or lifecycle cost information is given. When possible, we have also provided specific cost information. For example, for many of the energy-efficient equipment measures, we used costs from the DEER database (www.energy.ca.gov/deer). DEER (Database for Energy Efficient Resources) is a database sponsored by the California Energy Commission and California Public Utilities Commission (CPUC). It provides well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) values. On other measures such as gearless elevators, photovoltaics and efficient lighting, the cost information is relatively straightforward and we have provided actual costs.

2. List of materials from LEED NC Version 2.2, October 2005, Materials and Resources Credit 2.1, Construction Waste Management.

While certain green measures may result in an increase in first costs, integrating green strategies into a project will lower operating costs through energy efficiency savings and reduced maintenance and equipment replacement. However, because the cost of materials and rebate plans usually change annually, the information contained in this document should be used as an initial guide and not as a replacement for a comprehensive cost analysis.

OTHER COST INFORMATION TOOLS

Build It Green's Green Product Directory (www.builditgreen.org/guide) is an online directory that helps building professionals and the public locate suppliers and service providers of green building products within the nine-county San Francisco Bay Area. The Green Product Directory is regularly updated to reflect the introduction of new products, changes in availability or screening criteria, and other new information. Listed products must meet criteria for energy efficiency, resource conservation, water conservation, or indoor environmental quality. These criteria are consistent with measures referenced in the green guidelines produced by Green Building in Alameda County (*Home Remodeling, New Home Construction, and Multifamily Green Building Guidelines*) and StopWaste.Org's *Bay-Friendly Landscape Guidelines*, as well as the LEED Green Building Rating System.

Build It Green does not charge for listing nor accept advertising in the Green Product Directory. A technical review committee oversees the Directory and ensures the quality and integrity of listed content.

HOW DO I MAKE SURE MY GREEN BUILDING IS FUNCTIONING PROPERLY?

A critical part of green building is ensuring that the specified products and systems are installed and functioning properly. Building systems commissioning and retro-commissioning, Home Energy Rating Systems (HERS), and green operations and maintenance training are three strategies to ensure proper facility operations.

COMMISSIONING AND RETRO-COMMISSIONING

Building systems commissioning is a quality assurance process implemented to ensure that installed equipment performs as intended. The benefits of commissioning include reduced maintenance calls, higher energy savings, and increased comfort for building occupants. The commissioning process ensures through documentation and on-site verification that building systems are planned, designed, installed, tested, operated and maintained as they were intended and meet the building owner's project requirements.³ Retro-commissioning refers to carrying out commissioning practices on an existing building to improve its performance.

HOME ENERGY RATING SYSTEMS

The California Home Energy Rating System (HERS) program includes field verification and diagnostic testing to ensure compliance with the California Title 24 energy code. The California Energy Commission has a process for certifying Home Energy Rating System (HERS) raters who perform third-party inspections to verify duct sealing, thermostatic expansion valves (TXVs), refrigerant charge, airflow measurement, and building envelope sealing measures. For more information please see the California Energy Commission Home Energy Rating System Program website at: www.energy.ca.gov/HERS/.

3. www.wbdg.org/project/buildingcomm.php.

FACILITIES' STAFF TRAINING

Training your facilities personnel to properly use and maintain the equipment will enhance the equipment's performance and reduce the need for significant maintenance.

Bay Area LISC's Green Affordable Housing Operations & Maintenance Toolkit and Buyer's Guide is a free tool to help property management and maintenance staff better understand the principles of green building and how these translate into the maintenance and janitorial practices of a building. The toolkit can be downloaded for free from Bay Area LISC's Community Development Exchange website: www.cdexchange.org/asset.

WHERE CAN I FIND MORE INFORMATION?

The green measures outlined in this document are based on the *Multifamily Green Building Guidelines* developed by Stopwaste.org and Build It Green, except where otherwise noted. To obtain more information about a given measure, please refer to the *Multifamily Green Building Guidelines* (www.builditgreen.org/greenpoint-rated/guidelines).

1

SITE CONDITION AND SYSTEMS

- DRAINAGE
- CONCRETE FLATWORK
- SOILS AND LANDSCAPING
- SITE LIGHTING
- PARKING/PEDESTRIAN AND BIKE FRIENDLY COMMUNITIES
- SWIMMING POOLS

DRAINAGE

RECOMMENDATION 1.1.1 STORMWATER RETENTION

Evaluate opportunities to increase stormwater retention on site by replacing or rehabilitating parking lots, sidewalks, and other hardscape features with porous pavement. In addition, seek to incorporate design features into the site that channel runoff to swales, porous surfaces, and holding areas.

This measure reduces water runoff, helps filter and treat stormwater, and protects the local ecosystem.

Description of Measure

In an average undisturbed landscape, only 15 percent of rainwater leaves the site through surface water runoff. More than one-third of the rainwater moves into the soil where organisms break down and naturally filter pollutants before they reach groundwater or surface waterways.

As land is developed with buildings, parking lots and other impervious surfaces, two major changes occur:

- (1) More stormwater runs off the site and strains the storm drain system. On developed sites, as much as 70 percent of all rain and irrigation water flows into waterways (via storm drains) without moving through soil.
- (2) The soil supports less microbial life and is less able to filter harmful chemicals out of the little water that moves through the soil.

Watershed quality decreases rapidly when the total impervious area exceeds 10 percent of a site. Pollutant load also increases. One acre of parking lot, for example, collects as much as four gallons of oil, gasoline and diesel fuel each year. When rainwater runs off the parking lot, these pollutants end up in our waterways. Other pollutants include pesticides, fertilizers, pet waste and suspended soil particles from sparsely vegetated ground.

Cost and Cost Effectiveness

BENEFIT  Pervious paving surfaces can cost more than hard surfaces, but can sometimes reduce the need for costly stormwater treatment systems.

COST  Proprietary treatment products or systems require regular maintenance and are more costly to operate than non-mechanical systems such as swales or ponds.

Benefits

Increasing porous surfaces decreases runoff and protects the health of creeks, wetlands and other bodies of water. Reducing runoff improves soil health because it retains valuable topsoil on-site.

Retaining rainwater on site reduces runoff and filters pollutants. Downstream engineering costs may be decreased as well.

Application

With previously developed sites, plan for no net increase in runoff rate and quantity, or ideally, a net decrease of runoff post-development. Stormwater treatment in urban areas typically includes proprietary treatment systems because of limited space for natural filtering and separation.

CONCRETE FLATWORK

RECOMMENDATION 1.2.1 RECYCLED-CONTENT CONCRETE

For replacement or rehabilitation of sidewalks and other hardscape features such as footings, mat foundations, slab on grade, slabs on metal deck, cast in place and tilt up walls, drives and equipment pads, displace portland cement in concrete mixes with at least 20 percent recycled-content materials (flyash or slag).

This measure increases the durability and strength of the concrete, reduces greenhouse gas emissions associated with cement production, and helps keep flyash out of landfills.

Description of Measure

Flyash is a waste product of coal-fired power plants. In the United States, about 60 million tons of powdered flyash is removed from the exhaust of these power plants every year to reduce air pollution. Less than 30 percent of that flyash is recycled, while the rest is sent to the landfill. Flyash, which can be used to replace 15 to 20 percent of the portland cement in the concrete mixture, improves the concrete's strength and durability.

Cement is made by heating limestone and other minerals to 2700°F in large kilns. For every ton of cement produced, about 1400 pounds of carbon dioxide (CO₂) are released into the atmosphere. The cement industry contributes about 8 percent of all the man-made CO₂ in our atmosphere. CO₂ is one of the primary greenhouse gases that contribute to global warming. Reducing the use of cement in concrete is one way to help reduce global warming.

While most recommended practices suggest limiting the amount of flyash to 15 to 20 percent, using a higher volume of flyash yields greater strength benefits and diverts a larger amount of this waste from landfills. High-volume flyash concrete typically contains more than 30 percent and up to 50 percent flyash in the cement portion of the concrete mix. High-volume flyash can require longer cure times. Consult an engineer for the appropriate concrete mix ratio.

Cost and Cost Effectiveness

BENEFIT  High-volume flyash concrete mixes are available in the San Francisco Bay Area and cost the same as low-volume mixes. However, contractor bids for using high-volume flyash can be high if the contractor is unfamiliar working with it. To avoid unexpected charges, have the structural engineer discuss concrete with the contractor early on.

COST 

Benefits

Flyash improves the performance of concrete by increasing strength, reducing permeability and reducing corrosion of reinforcing steel. The environmental benefits are reduced waste in landfills, lower energy use and greenhouse gas emissions (manufacturing portland cement is very energy intensive).

Application

High-volume flyash is appropriate for use in footings, mat foundations, slabs on grade, slabs on metal decks, cast-in-place and tilt-up walls, drives, sidewalks and equipment pads. Consult with an expert before using high-volume mixes in columns and with post-tension systems.

RECOMMENDATION 1.2.2
COOL SITE

Specify cool site measures for any replacement or rehabilitation of sidewalks and other hardscape features.

This measure reduces the building's cooling costs and minimizes the heat island effect by reducing the amount of heat retained by surrounding asphalt, concrete, and building structures.

Description of Measure

Paved surfaces make up 30 to 40 percent of developed urban areas and contribute to the heat island effect. Since the dark asphalt absorbs the sun's heat, cities are typically as much as 5°F hotter than surrounding rural areas. Higher outdoor temperatures lead to higher temperatures within the building, thus driving up cooling loads.

To keep your site cooler, consider using one or more of the following techniques:

- (1) Light-colored paving materials or pavers with an albedo ≥ 0.30 (equivalent of uncolored concrete)
- (2) Pervious concrete (poured or tile)
- (3) Open-grid paving systems
- (4) Shade from trees, overhangs or other shading elements (calculate tree shading by estimating the diameter of the tree crown five years after planting)
- (5) Tire strip driveways (as opposed to full coverage concrete or asphalt)
- (6) Granite or crushed rock for walkways, driveways and paths
- (7) Mulch for walkways and paths
- (8) Resin-modified emulsion pavement

Cost and Cost Effectiveness

BENEFIT  Costs vary greatly. Adding colorants and pigments to mixes of concrete and asphalt does not generally increase costs. Changing aggregate colors is also typically not expensive.

COST  Concrete is considerably more expensive than asphalt. Resin-modified emulsion pavement is more expensive than concrete in small quantities.

Benefits

Cool sites reduce air-conditioning loads, improve comfort, and extend the life of paving materials. Light-colored paving materials last longer than darker surfaces due to reduced thermal expansion and contraction. Citywide, air quality is improved because cooler air slows the chemical reaction that produces smog.

Application

Cool site measures are most important in urban environments where large areas of asphalt and buildings retain heat and increase the surrounding temperatures.

SOILS AND LANDSCAPING

RECOMMENDATION 1.3.1 LANDSCAPING

As part of any re-landscaping plan, incorporate design features that enhance the soil quality, reduce stormwater runoff and pollution, and encourage beneficial insects and wildlife.

This measure also minimizes ongoing water requirements, maintenance needs, and green waste.

Description of Measure

Conventional landscaping often relies on large lawns, non-native plants, abundant irrigation and heavy use of synthetic fertilizers and pesticides. It also requires frequent mowing, blowing, trimming and removal of plant debris. These practices destroy beneficial organisms, consume significant resources, pollute air and water, and deplete soil of organic matter and nutrients, thereby degrading soil health. The result is an increased production of plant debris, increased dependency on fertilizers and irrigation, as well as greater stormwater runoff, erosion, and pollution of waterways.

Stopwaste.Org's *Bay-Friendly Landscape Guidelines* describe an integrated solution to these problems. Please refer to that publication for specific solutions (www.BayFriendly.org).

Cost and Cost Effectiveness

BENEFIT  Designing and constructing a sustainable landscape does not have to cost more. In fact, significant cost savings can be achieved over time by reducing labor, water, and chemical costs; lowering plant loss and replacement expense; reducing hauling and disposal fees; and preventing or minimizing damage to fencing, sidewalks and other hardscapes.

COST 

It is important to find a landscape architect and a maintenance company that understand and can implement the *Bay-Friendly Landscape Guidelines*.

Benefits

Bay-Friendly practices not only reduce labor, water, chemical costs, and plant replacement expenses; they also build healthy soils, reduce waste, and protect regional ecosystems.

Application

All properties that have significant landscaping.

RECOMMENDATION 1.3.2 IRRIGATION

For landscapes with ongoing irrigation requirements, specify high-efficiency irrigation systems and smart irrigation controllers. Specify controllers that meet the Irrigation Association's definition of smart controller, are weather-based, or can sense rain or soil moisture levels.

This measure saves money and conserves water.

Description of Measure

High-efficiency irrigation conserves a significant amount of water compared to conventional irrigation practices. It delivers water at the appropriate rate to targeted areas. There is no runoff and little water is lost to evaporation.

A system that combines drip and mini-spray emitters is possible but requires separate valves, as they require different pressures and run times to operate efficiently. A drip system should have its own dedicated valve; the setup also includes piping, filter-flush valves, and regulators. For more information regarding drip systems, consult *Drip Irrigation Guidelines*, published jointly by the East Bay Municipal Utility District and the Contra Costa Water District.⁴

While drip emitters deliver water in gallons per hour, sprinklers flow in gallons per minute. Because sprinklers deliver water fast and send it far, they should be used with great care. High-efficiency spray heads use rotary nozzles and spray 1.0 gallons per minute. To prevent runoff when operating sprinklers, equip sprinklers with

4. East Bay Municipal Utility District *Drip Irrigation Guidelines*: (510) 835-3000, www.ebmud.com.

timers and break up total run time into shorter intervals to give the soil time to absorb the water. Sprinkler heads should be placed to avoid overwatering, underwatering, and watering the wrong places. In addition, sprinklers should be directed away from buildings and hardscapes. Fixed spray heads should not be mixed with rotors or impact heads on the same valve; they require different run times and pressure to operate efficiently.

The Irrigation Association defines a smart irrigation controller as a system that monitors and uses information about environmental conditions for a specific location and landscape to determine when to water and when not to, providing exactly the right amount of water to maintain healthy growing conditions. The data used by smart controllers may include soil moisture, rain, wind, the plants' evaporation and transpiration rates, and, in some cases, plant type and more. Metropolitan Water District maintains a list of approved manufacturers of smart controllers at www.bewaterwise.com/rebates02.html. Some local water utilities provide rebates for these devices.

Cost and Cost Effectiveness

BENEFIT



COST



High-efficiency irrigation limits evaporation and runoff while at the same time minimizing the spread of disease and weed growth.⁵ While the initial installation requires upfront costs, drip irrigation

systems significantly reduce excess water use, resulting in both water and financial savings. The cost of high-efficiency irrigation systems varies depending upon the strategy used. In general, the benefit should be high for a relatively low cost.

Benefits

High-efficiency irrigation systems and smart irrigation controllers save both water and money.

Application

Properties with irrigated landscaping.

5. www.stopwaste.org/docs/15300512006bay-friendly_landscape_guidelines_-_chapter_3.pdf.

SITE LIGHTING

RECOMMENDATION 1.4.1
EXTERIOR LIGHTING

For all new exterior lighting fixtures that contribute to light pollution, use full cut-off luminaires (fixtures that emit no light above horizontal) or fixtures certified by the International Dark-Sky Association.

This measure reduces energy costs and light pollution.

Description of Measure

Light pollution occurs when outdoor light fixtures let excess light escape into the night sky. Light trespass occurs when fixtures let light spill onto neighboring properties. Nighttime glare occurs when a light source is significantly brighter than the luminance that the eyes are adjusted to at night. Glare is a nuisance and it reduces visibility and perception.

Overlighting an outdoor area at night isn't the best solution for either security or safety. Instead, exterior lighting that provides low contrast on critical areas and surfaces (such as sidewalks and parking areas) can actually provide better visual acuity. The light color of lamps also affects safety: illuminating objects with products that have high Color Rendering Indexes (CRI) improves visual recognition of people and objects at night.

Use valances and overhangs wherever horizontal light should be controlled, or choose full cut-off fixtures, which reduce light pollution and light trespass because they do not emit light above horizontal at the fixture height.

Also, for areas more than 15 feet away from buildings, the following values should not be exceeded:

- For residential-only areas: 0.2 average foot-candles (FC)
- For mixed-use areas: 0.6 average FC

For parking lots, specify shorter, lower wattage fixtures. Increase the number of fixtures and place them closer together. This decreases losses from glare reflection and overlighting, while providing uniform light.

Cost and Cost Effectiveness

BENEFIT  Generally, the capital cost savings from using lower wattage fixtures and shorter poles for parking lots more than offsets the additional costs of full-cutoff luminaires or add-on valances. Parking lot poles 16-feet high or less can be serviced at a lower cost without a cherry picker. Lower light levels also reduce energy costs.

COST 

Benefits

This measure reduces energy costs and saves electricity since reducing light pollution involves reducing wattage used. It also reduces light trespass, improves relations with neighbors, preserves nocturnal habitats for animals, and keeps the night sky dark enough to view stars.

Application

The need to control light pollution and glare differs depending on whether the building is in an urban or rural area. The following table shows the U.S. Green Building Council's summary of Illuminating Engineering Society of North America's (IESNA) guidelines for designing exterior lighting in various environments. This table provides general guidance; unique site constraints may affect the ability to design to these levels. The goal is to minimize lighting to the greatest extent possible while providing safety with low contrast and good color rendering.

ZONE	DESCRIPTION	REC. MAX ILLUMINANCE (FOOT-CANDLES)
Intrinsically Dark	Parks and residential areas where controlling light pollution is a high priority	0.1
Low Ambient Brightness	Outer urban and rural residential areas	0.1
Medium Ambient Brightness	Urban residential areas	0.2
High Ambient Brightness	Urban areas having both residential and commercial use and experiencing high levels of nighttime activity	0.6

PARKING/PEDESTRIAN AND BIKE FRIENDLY COMMUNITIES

RECOMMENDATION 1.5.1 PERVIOUS PAVEMENT

Evaluate opportunities to increase pervious pavement on site.

This measure not only reduces flooding and excess runoff, but also potentially reduces costly stormwater treatment systems and protects the health of local ecosystems.

Description of Measure

Pervious pavement is typically placed atop a highly permeable layer of gravel and stone above a filter fabric lining. As the rainwater passes through the material, it is filtered before reaching the underlying dirt and groundwater system.⁶ (Refer to Rec. 1.1.1 for other stormwater retention strategies.)

Types of pervious or porous pavement include porous aggregate, porous turf, plastic geocells, open-jointed paving blocks, open-cell paving grids, porous concrete, granite or crushed rock, and soft porous surfacing such as bark or mulch.⁷ For more information see the 2005 book, *Porous Pavements*, by Bruce K. Ferguson.

Cost and Cost Effectiveness

BENEFIT  Pervious paving surfaces can cost more than hard surfaces, but can sometimes reduce costly stormwater treatment systems.

COST 

Benefits

Increasing porous surfaces decreases runoff and protects the health of creeks, wetlands and other bodies of water. Reducing runoff improves soil health because it retains valuable topsoil on site and reduces the volume of runoff entering storm drains.

Application

Properties with paved surfaces.

RECOMMENDATION 1.5.2 COOL SITE

Specify cool site measures for any replacement or rehabilitation of sidewalks and other hardscape features.

This measure reduces the cooling costs of the building by reducing the amount of heat retained by surrounding asphalt, concrete and building structures.

Description of Measure

For a complete description of this measure, see Rec. 1.2.2.

Cost and Cost Effectiveness

BENEFIT  Costs vary greatly. Adding colorants and pigments to mixes of concrete and asphalt does not generally increase costs. Changing aggregate colors is also typically not expensive.

COST  Concrete is considerably more expensive than asphalt. Resin-modified emulsion pavement is more expensive than concrete in small quantities.

Benefits

See Rec. 1.2.2

Application

Cool site measures are most important in urban environments where large areas of asphalt and buildings retain heat and increase the surrounding temperatures.

6. U.S. EPA Fact Sheet on Porous Pavement. www.epa.gov/npdes/pubs/porouspa.pdf.
7. "Porous Pavements", *Environmental Building News* Volume 14, Number 8, describing the 2005 Book *Porous Pavements* by Bruce K. Ferguson, CRC Press Boca Raton, Florida.

SWIMMING POOLS

RECOMMENDATION 1.6.1

RECOMMENDATION: EFFICIENT PUMPS

Consider replacing pool pumps and motors with energy-efficient models, particularly if existing motors exceed $\frac{3}{4}$ horsepower. Pumps and motors should be equipped with an automatic control system capable of controlling both high and low speeds separately. Heated pools should also be equipped with pool covers.

These measures reduce pumping and heating costs while extending the life of the motor.

Description of Measure

According to Pacific Gas and Electric Company (PG&E), quicker pool filtering is not better. While large single-speed pumps and motors may filter more quickly, they use substantially more energy than multi-speed or small single-speed pumps and motors.

Pool pump timers should be set to run during off-peak times, particularly if the pool's electricity usage is billed on a time-of-use rate. In addition, shifting the schedule to off-peak hours avoids contributing to peak-hour stress on the electricity grid. (Off peak starts after 8 p.m. and ends before 10 a.m.)

Low speed operation may not provide adequate circulation if the system utilizes roof-mounted solar water heating units (Rec. 1.6.2). Consider using a separate, small, energy-efficient pump and motor for this application or starting a two-speed pump on high speed and switching to low speed after there is adequate circulation for the water to flow freely.

Pressure and suction side pool sweeps may not have sufficient water flow when the pump is operated on low speed. A booster pump and operation on high speed during pool cleaning may be required. If so, one can still save a substantial amount of energy by operating these pool cleaners on high speed for 1 to 2 hours and completing the remainder of the daily filtration cycle on low speed.

PG&E maintains a list of models and manufacturers of two-speed pumps and motors, variable speed motors, and controllers. See www.pge.com/myhome/saveenergymoney/rebates/seasonal/poolpumps/pumps.jsp.

Also consider using a pool cover. Pool covers add to overall energy savings, control water evaporation, keep water 10° F warmer, reduce summer pool heating costs by up to 90 percent and reduce chemical evaporation by up to 70 percent. A cover also keeps the pool cleaner, which makes the filter run less often and saves even more energy.

Cost and Cost Effectiveness

BENEFIT  Pool pumps costs vary significantly, from \$800 to \$3000 depending on the size of the pool, cost per kilowatt-hour of electricity, hours the pump runs and model selected.

COST  However, by using energy conservation measures including high-efficiency pumps, pool owners can save up to 75 percent of their pumping costs.

Find more information about cost savings at the U.S. Department of Energy's Energy Efficiency and Renewable Energy website:

www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13290.

Benefits

According to PG&E, efficient pool pump and motor systems, operated at low speed, can reduce pumping costs by up to 75 percent. They are also quieter. Efficient pump motors run cooler, which can extend motor life. Most filter types work more efficiently at the lower pumping speeds.

A pool cover saves energy, money and water.

Application

Applicable to properties with swimming pools.

RECOMMENDATION 1.6.2
SOLAR POOL WATER HEATING

Consider using solar pool heaters to heat the pool.

This measure reduces energy costs and associated greenhouse gas emissions and pollution.

Description of Measure

Solar pool heaters use energy from solar collectors installed on the property to heat the water. By adding a conduit to the existing filter system, the solar collectors heat the water as it circulates through the system. When the thermostat reads the desired temperature, the water bypasses the added conduit as it continues its normal filtering cycle.

For more information about solar water heating technologies, see Rec. 3.2.1.

Cost and Cost Effectiveness

BENEFIT  The cost of a solar pool heater depends on three factors: (1) the size of solar collector needed to heat the pool, (2) the efficiency of the solar pool heater (measured in BTUs ft²/day), and (3) current cost of solar equipment.

COST 

For more information about the costs of solar pool heating systems, visit the U.S. Department of Energy's Energy Efficiency and Renewable Energy website:

www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13280.

Benefits

Using solar pool heaters reduces energy costs and the use of fossil fuels to heat the pool. In addition, this measure extends the length of the swimming season, which adds value to the property.

Application

Applicable to all properties with pools and sufficient space to install solar panels.

2

BUILDING CONSTRUCTION

- FOUNDATION AND SLAB
- EXTERIOR WALLS
- ROOFS, GUTTERS, AND DOWNSPOUTS
- WINDOWS
- BUILDING-MOUNTED EXTERIOR LIGHTING
- LAUNDRY FACILITIES

FOUNDATION AND SLAB

RECOMMENDATION 2.1.1
RECYCLED-CONTENT CONCRETE

For replacement or rehabilitation of foundations and slabs, displace portland cement in concrete mixes with at least 20 percent recycled-content materials (flyash or slag).

This measure increases the durability and strength of the concrete, reduces the greenhouse gas emissions associated with cement production, and helps keep flyash out of landfills.

Description of Measure

For a description of this measure, see Rec. 1.2.1.

Cost and Cost Effectiveness

BENEFIT  High-volume flyash concrete mixes are widely available in the San Francisco Bay Area and cost the same as low-volume mixes. However, contractor bids for using high-volume flyash can be high if the contractor is unfamiliar working with it. To avoid unexpected charges, have the structural engineer discuss concrete with the contractor early on.

COST 

Benefits

See Rec. 1.2.1.

Application

Replacement and rehabilitation of foundations and slabs.

[2.2] BUILDING CONSTRUCTION

EXTERIOR WALLS

RECOMMENDATION 2.2.1 RECYCLED-CONTENT EXTERIOR PAINT

For repainting, specify recycled-content paint. The recycled-content should be at least 50 percent and can come from post-industrial or post-consumer sources. VOCs shall not exceed 250 grams per liter for recycled paint.⁸

This measure keeps unwanted paint out of landfills.

Description of Measure

Some paint manufacturers make high quality recycled-content latex paint and primer specifically for exterior use. The paint may come from household hazardous waste collection facilities or unused consumer or industrial paint stock. Manufacturers check the paints for quality and then blend them with a portion of new paint to achieve the desired performance characteristics.

Recycled-content paint is recommended only for exterior use.

Cost and Cost Effectiveness

BENEFIT  Recycled paint may be less expensive than new paint.

.....

COST 

Benefits

Recycled paint keeps unwanted paint out of the landfill and may save money.

Application

For exterior use only. The range of colors available tends to be limited.

When renovating or repainting an older building, test for lead in earlier coats of paint. If lead paint is present, use appropriate disposal and abatement methods.

RECOMMENDATION 2.2.2 SIDING

For rehabilitation or replacement of exterior siding, specify environmentally preferable siding products. Fiber cement, stucco, metal, brick and stone are durable and easy to maintain. FSC-certified wood siding is made with sustainably harvested wood.

Depending on the siding product chosen, this measure may increase durability, reduce waste, maintenance and replacement costs, or support sustainable forestry practices.

Description of Measure

In addition to its aesthetic function, siding protects a building's exterior walls from wind, sunlight, pests and water. The following siding options are environmentally preferable compared to vinyl, conventional wood or composition siding:

- (1) Fiber-cement siding is gaining popularity as a safe, durable product and is made of portland cement, sand and cellulose fibers.
- (2) Stucco is a common siding material in California. It is made of sand, water, and cement. Some stucco has an acrylic finish.
- (3) Brick or stone veneers are often used in new construction to give the façade a classic look.
- (4) Metal siding is gaining popularity due to its durability, lack of maintenance needs, and because it is lightweight.
- (5) Wood siding certified by the Forest Stewardship Council (FSC) comes from sustainably managed forestry operations. Another environmentally preferable option is siding made from reclaimed wood that may come from old buildings, telephone poles, or river and lake bottoms. Wood can hold up with proper maintenance, but the siding options listed above are likely to last longer and require less maintenance than wood.

8. Green Seal Environmental Standard for Recycled-Content Latex Paint: August, 2006. GS43, www.greenseal.org.

Three popular forms of siding are not recommended due to environmental and durability concerns:

- (1) Vinyl siding is a nonrecyclable product that poses a landfill burden. In addition, vinyl manufacture produces dioxin, a persistent environmental toxin.
- (2) Conventional wood siding imposes high maintenance costs and may involve detrimental harvesting practices.
- (3) Composition siding (or hardboard) looks and performs like wood siding and requires ongoing maintenance like wood. It is made with wood fibers from industrial process waste or fast-growing tree species. The product is susceptible to water damage when improperly installed and is not recommended.

Cost and Cost Effectiveness

BENEFIT		Specifying a high quality, durable siding such as fiber-cement, stucco or other non-wood siding will reduce the risk of product failure, thereby saving money.
COST		

Fiber-cement needs to be repainted every 5 to 10 years, but otherwise repairs are generally minor. Costs of fiber-cement and composition siding are comparable. Cracks in stucco may require more frequent maintenance than fiber-cement or composition siding, but are fairly easy to fill. In the Bay Area, stucco typically costs the same as fiber cement. Brick and stone have high material and installation costs but virtually no maintenance costs except where graffiti is a problem.

If specifying wood siding, FSC-certified wood siding is preferable, but may have additional costs. Reclaimed wood siding, though not widely available, is also an environmentally preferable option. Prices will vary.

Benefits

Durable siding materials protect a building from premature deterioration. Longer life spans mean less waste in landfills, reduced maintenance needs, and lower replacement costs.

FSC certification ensures that forestry operations are managed in an economically, socially and environmentally sustainable manner.

Application

Applicable to any exterior wall of a building.

RECOMMENDATION 2.2.3 INSULATION

To the extent that rehabilitation of exterior walls involves open wall cavities or the ability to blow in insulation, insulation levels and quality should be evaluated. Any added insulation should contain no added formaldehyde. Also, look for insulation that contains recycled content.

This measure improves comfort and energy efficiency, and reduces health and environmental concerns associated with conventional insulation products.

Description of Measure

Fiberglass insulation with no added formaldehyde is widely available, and can be used anywhere that fiberglass batts are used. It costs the same as standard batt insulation, although there are currently fewer manufacturers. Typical recycled content of all fiberglass products ranges from 20 to 30 percent.

Cellulose insulation contains more than 75 percent recycled newsprint, does not have added formaldehyde, and insulates as well as high-density fiberglass batts (up to R-3.7 per inch thickness). Cellulose can be dry-blown into attic spaces, packed dry into walls, or damp-sprayed into wall assemblies using water-activated adhesives. Because of cellulose's ability to surround and seal cavities and voids, cellulose performs better thermally and acoustically than fiberglass batts. For shared-wall multifamily applications, cellulose can achieve good noise separation and fire ratings.

Recycled cotton insulation contains up to 85 percent post-industrial recycled natural fibers.

Cost and Cost Effectiveness

BENEFIT

Fiberglass insulation with no added formaldehyde is available from numerous manufacturers at competitive prices. In the San Francisco Bay Area, cellulose typically

costs 20 to 40 percent more than standard fiberglass insulation. Prices may be somewhat lower for large multifamily projects because of labor efficiencies.

Refer to the U.S. Department of Energy web site for information about the estimated payback period of installing additional insulation:

www.eere.energy.gov/consumer/your_home/insulation_airsealing/index.cfm/mytopic=11360.

COST

Benefits

Fiberglass insulation with no added formaldehyde helps protect the health of residents as well as the workers who install the insulation. However, even with no-added formaldehyde products, fiberglass is still a skin and respiratory irritant as well as a known carcinogen if the glass particles are inhaled in excessive quantities.

Wet-blown (or damp-spray) cellulose provides many benefits: It requires no cutting or splitting, and can be installed flush with the air barrier. It surrounds pipes and fills gaps and irregular spaces better than batt insulation, reducing air movement and improving performance. It absorbs sound better than alternatives, is made of recycled newspaper, has no added formaldehyde, and meets the same fireproofing standards as fiberglass insulation.

Application

The best time to conduct an insulation retrofit is when drywall is being removed. New insulation can be installed at this time and then sealed with drywall. If this is not possible, opt for blown-in insulation, which is installed through holes bored in the walls; take care to seal the holes when finished to avoid infiltration or moisture problems. When using blown insulation in an attic, make sure that attic ventilation does not get blocked by the insulation as it may prevent air flow and cause the temperature to rise in the attic.

Use cellulose in common walls to reduce noise transmission between units and in exterior walls to improve thermal and acoustic performance. Blown-in insulation should be properly sequenced with the installation of new walls. Take care to allow damp-sprayed cellulose insulation to dry before installing drywall.

Fiberglass insulation with no added formaldehyde can be used wherever traditional batt insulation is used, including new construction and major renovation where studs will be exposed. Note that batts lose R-value when they are not installed properly.

Some brands of no-added formaldehyde fiberglass insulation do not use any binding agents; instead, the fiberglass strands are tightly wound together to hold their shape. These products are not recommended for walls in some instances because of lack of rigidity.

ROOFS, GUTTERS, AND DOWNSPOUTS

RECOMMENDATION 2.3.1 ROOFING MATERIALS

As part of any roofing rehabilitation, specify durable roofing products.

This measure reduces waste, minimizes replacement costs, and protects the building from moisture.

Description of Measure

Short-lived roofing materials require costly roof replacement and send a significant amount of waste to the landfill. In extreme cases, early failure of a roofing material can damage a building and require more costly repairs.

Avoid wood-shake shingles for several reasons: they have a short life span, require high maintenance, pose a fire hazard, and deplete forests due to the harvesting of trees. Instead, consider the following durable roofing materials for pitched roofs:

- **Tile.** Fiber-cement (concrete) and clay tiles are durable roofing materials. Clay tiles are the most commonly installed type. Some tiles may also qualify as cool roof products. Clay tiles are generally more durable than fiber-cement and clay is a readily available raw material. At the end of the roof's life, tiles are sometimes reused, or can be ground up and used for other purposes.
- **Slate roofing shingles** are durable and relatively environmentally benign. Slate is often recovered from older buildings and reused.
- **Sheet metal products** are becoming more popular for roofing. Some thin-film photovoltaic products can be directly applied on the metal roof, thus reducing the cost of the solar electric system since they do not require mounting brackets. Metal roofs come in varying thicknesses and colors. Most steel metal roofs can be recycled when removed. Metal roofs are also well suited to rainwater catchment systems for landscape irrigation.

Other environmentally sound roofing products are available, made from recycled, alternative, or salvaged materials. For example, some manufacturers make shingles out of recycled plastic resins. It's important to check the fire rating and warranty period of any roofing product.

Cost and Cost Effectiveness

BENEFIT  Tile, slate and metal roofing can be considerably more expensive than asphalt shingles, but the lifecycle cost, which takes into account the reduced replacement needs, can make them more cost-competitive.

COST 

Alternative and composite roofing materials cover a vast range of prices, but most are less expensive than tile.

Benefits

Durable roofing materials reduce waste and decrease replacement costs. They are also more effective at protecting a building from moisture than low-cost options.

Application

Applicable on any pitched roof. In hotter climates and for low-slope roofs, consider cool roof products (see Rec. 2.3.2). If installing photovoltaics, consider a standing-seam metal roof.

If a new roof is being installed, consider also installing a radiant barrier (Rec. 2.3.2).

RECOMMENDATION 2.3.2 COOL ROOF

As part of any roofing rehabilitation, reduce the roof temperature by specifying cool roof products that meet Energy Star levels of efficiency. Installing a radiant barrier can reduce 90 percent or more of roof deck radiant heat.

This measure reduces the air-conditioning load, minimizes the heat island effect, and extends the roof life.

Description of Measure

The roof generally receives more direct sunlight than any other part of the building. Dark roof surfaces absorb sunlight and reradiate it as heat to the surrounding air. In dense urban areas, this creates a heat island effect, increasing outside air temperatures by as much as 5°F

during the hottest time of the day. Heat absorbed by the roof is also transferred inward, increasing interior temperatures and driving up cooling loads.

Cool roofs are roofing systems designed to minimize rooftop temperatures by:

- Reflecting a significant portion of the sun's rays away from the roof (high solar reflectance or albedo), and
- Limiting the amount of heat stored by the roofing material (high emittance).

Total solar reflectance or albedo is the ability of a material to reflect heat away from its surface. Reflectivity is rated as compared to a perfect mirror surface. A reflectivity of 0.70, therefore, is 70 percent as reflective as a mirror.

Emittance is the ability of a material to shed heat. High emittance values mean that heat is shed quickly, thus keeping surface temperatures low. Emittance is rated from 0 to 1.0, with higher numbers indicating greater emittance. A white roof, although highly reflective, is not necessarily a cool roof. White surfaces can get quite hot if they have low emittance. White sand beaches, for example, are highly reflective but store heat and can get very hot.

The most efficient roofing materials are those that are Energy Star-qualified. The Energy Star web site (www.energystar.gov) lists manufacturers and qualified products. To qualify for the Energy Star label, roofing products must meet the following specifications:

- For low-slope roofs (surfaces with a slope of 2:12 inches or less), the initial solar reflectance must be at least 0.65. The material must maintain a solar reflectance of at least 0.50 after three years of installation under normal conditions.
- For high-slope roofs (surfaces with a slope of 2:12 inches or greater), the initial solar reflectance must be at least 0.25. The material must maintain a solar reflectance of at least 0.15 after three years of installation under normal conditions.

Cool roof products come in numerous varieties and colors, classified as four main types. The following information comes from the Flex Your Power website (www.fypower.com/res/tools/products_results.html?id=100123):

- **“Metal Roofs** are durable, fire retardant and almost maintenance-free.” They have a higher solar reflectance than traditional shingles, which blocks heat transfer into the building's top floor. “The one drawback to metal roofs is that they have a low emittance, which means they trap solar radiation

and do not emit the heat. Metal roofs typically have solar reflectance values between 0.50 and 0.70 but their overall efficiency is reduced by their low emittance levels. They perform better when combined with a polymeric coating that helps to offset the low emittance of the metal. These coatings, which are similar to paint, can be factory-applied.”

- **“Roofing Tiles** usually are ceramic. The color of a tile may be applied as a coating or dispersed throughout. Perhaps the most common type of roof tile is the Spanish-style red barrel tile made from fired clay. The modern version of this tile is sometimes a cement tile with a suitable coating. They can have respectable reflectance ratings if they are of a light color. They also have enhanced air circulation compared to other roofing types, because ambient air can circulate below as well as above the tile. Enhanced air circulation helps the roof shed solar heat more readily. Solar reflectance levels for tiles range from a low of 0.18 for red concrete tile to a high of 0.74 for white concrete tile. Tile is more appropriate for steeper-sloping roofs.”
- **“Roofing Membranes** are fabricated from strong, flexible waterproof materials. They may be applied in multiple layers, as in a built-up roof (BUR), or they may consist of a single-ply membrane. Single-ply membranes are rolls of smooth, white plastic materials that are applied over the finish roof. The seams are welded to create a continuous heat barrier. Major types of sheeting materials are polyvinyl chloride (PVC), chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CPSE), ethylene propylene diene monomer (EPDM), and thermoplastic polyolefin (TPO). From a materials perspective, these plastic products are not necessarily the greenest option. When choosing a roofing material, however, it is important to balance the energy savings from reducing air-conditioning loads (or eliminating air conditioning) against the material's impact. Roofing membranes generally have high reflectance and emittance levels (above 0.60), as long as they are of a light color.”
- **“White Reflective Coatings** contain transparent polymeric materials, such as acrylic, and a white pigment, such as titanium dioxide (rutile), to make them opaque and reflective. These coatings typically reflect 70 to 80 percent of the sun's energy. Despite the white appearance, these pigments strongly absorb the 5 percent or so of the sun's energy that falls in the ultraviolet (UV). Thus, the pigments help protect the polymer material and the substrate underneath from UV damage. As long as the coating is white or

light-colored, the roof will have high reflectance and emittance levels.” Liquid-applied products can be applied to traditional asphalt cap sheets, modified bitumen and other substrates. Products include elastomeric coatings, polyurethane coatings, acrylic coatings and paint (on metal or concrete).

Installing a radiant barrier can reduce 90 percent or more of roof deck radiant heat. Radiant barriers are available as foil sheets or as a foil material laminated to oriented strand board (OSB) decking. Radiant barriers must be adjacent to an air gap. In hotter climates, installing a radiant barrier is an extremely cost effective way to reduce roof radiant deck heat and reduce attic temperature.

ROOFING MATERIAL	TOTAL SOLAR REFLECTANCE	EMITTANCE
Liquid-Applied Reflective Coatings	0.30–0.78	0.42–0.91
Metal Roofing		
Bare Galvanized Steel or Aluminum	0.61	0.04–0.25
White (factory-applied coating)	0.59–0.67	0.85
Single-Ply Roof Membrane		
Black EPDM	0.06	0.86
White EPDM	Up to 0.81	Up to 0.92
Paint		
Aluminum	0.80	0.40
White	0.85	0.96
Asphalt Shingles		
Black	0.03–0.05	0.91
Medium Brown	0.12	0.91
Light Brown	0.19–0.20	0.91
Green	0.16–0.19	0.91
Grey	0.08–0.12	0.91
Light Grey	0.18–0.22	0.91
White	0.21–0.31	0.91

This table provides total solar reflectance and emittance values for common roof systems. Source: LBNL Cool Roofing Materials Database, eetd.lbl.gov/coolroof.

Cost and Cost Effectiveness



- For flat roofs with an asphalt cap sheet or modified bitumen, cool roof coatings typically add \$0.75 to \$2.00 per square foot.
- High reflectance single-ply cool roof membranes cost the same as darker membranes. Look for light-colored membranes that have high reflectivity (all have high emittance).
- Radiant barrier sheathing (installed under roofing) adds a few cents per square foot, but typically pays for itself in reduced air-conditioning costs in a few months. Radiant barriers reduce attic temperatures, reduce heat gain in duct work, and reduce 90 percent or more of roof deck radiant heat. They are very cost effective and make particular sense in hotter climates.
- All cool roof materials require some cleaning to keep their performance levels high. Flat roofs may need pressure washing annually to clean the surface. Sloped roofs require less maintenance since they shed dirt and other particulates relatively well.
- Life spans range from 5 to 30 years or more, depending on material chosen.

Benefits

According to Energy Star, qualified cool roofs can lower the roof temperature by up to 100°F. This saves money by reducing air-conditioning loads, and in some cases eliminating the need for air conditioning. Cool roofs in urban environments also help reduce the heat island effect. Cool roofs may also extend the roof’s life. They expand and contract less than dark materials, and therefore do not usually deteriorate as quickly.

Application

Cool roofs are most applicable to hotter inland climates and to urban areas where it is desirable to reduce the heat island effect. Within those regions, cool roofs are applicable to all multifamily housing properties in need of roof replacement.

Many affordable housing and multifamily projects have more than one roof type. Select appropriate cool roof technologies for each surface: reflective coatings or membranes on flat roof surfaces, and metal or tiles on sloped areas.

**RECOMMENDATION 2.3.3
GREEN ROOF**

In addition to cool roof products, consider the installation of green roofs.

This measure reduces cooling costs and minimize stormwater runoff.

Description of Measure⁹

Green roofs are a combination of vegetation and soil planted on a waterproof membrane atop a roof. They reduce roof temperature, cooling costs, and storm runoff. Below is a table describing the various types of green roofs. The U.S. EPA has more information about green roofs at: www.epa.gov/heatisland/strategies/greenroofs.html.

CHARACTERISTIC	INTENSIVE GREEN ROOF	EXTENSIVE GREEN ROOF
Soil	Requires minimum of 1 ft of soil depth	Requires only 1-5 inches of soil depth
Vegetation	Accommodates large trees, shrubs, and well-maintained gardens	Capable of including various vegetative ground cover and grasses
Load	Adds 80-150 lbs/ft ² to structure	Adds approximately 12 lbs/ft ² depending on soil characteristics and the type of substrate
Access	Regular access encouraged	Usually not designed for public accessibility
Maintenance	Significant maintenance required	Annual maintenance until plants fill in
Drainage	Complex irrigation and drainage systems	Simple irrigation and drainage systems

Source: Schloz-Barth, Katrin. 2001. "Green Roofs: Stormwater Management From the Top Down." Environmental Design & Construction. January 15.

Cost and Cost Effectiveness

BENEFIT  According to the EPA, current upfront costs of an extensive green roof in the U.S. starts at about \$8 per square foot including materials, preparation work, and installation. In comparison, the cost of a traditional built-up roof starts at about \$1.25, while cool roof membranes start at approximately \$1.50 per square foot.

COST 

While extensive green roofs cost more than traditional roofs, the summertime energy savings and stormwater benefits can be significant. Installing a green roof can also extend the life of a roof by limiting the UV radiation that hits the roofing material. In addition, green roofs protect from daily temperature fluctuations which can reduce the roofing life span by repeated contraction and expansion.

Benefits

In addition to reducing cooling costs and minimizing stormwater runoff, green roofs also:

- Filter pollution
- Reduce sewage system loads
- Protect underlying roof material from UV and temperature fluctuations
- Provide habitat for small animals
- Absorb carbon dioxide (CO₂)
- Offer an attractive alternative to traditional roofs
- Reduce noise transfer from the outdoors

Application

Green roofs are applicable to all building types. A roof assessment might be necessary to determine the strength and suitable pitch for installation of the green roofs.

9. Source: Environmental Protection Agency, www.epa.gov/heatisland/strategies/greenroofs.html.

WINDOWS

RECOMMENDATION 2.4.1 SHADE

Provide some form of overhang, trellis, landscape or awning to shade all south-facing windows (within 15-degrees east or west of true south) during summer.

This measure reduces heating and cooling needs, saves energy, and increases occupant comfort.

Description of Measure

Overhangs must be designed for the time of year that walls or windows need to be fully shaded (cut-off). This depends on climate conditions and location; in general, the hottest days should coincide with full shading of south windows and walls. On the shortest days of winter, sunlight should be allowed to penetrate fully into the space. Check weather data for your site to determine dates for sunlight control.

Proper sizing of overhangs is important. Sun position calculators will determine the exact dimensions appropriate for a project located at a specific latitude. A sun position calculator can be found at www.geocities.com/senol_gulgonul/sun/.

Cost and Cost Effectiveness

BENEFIT  Overhangs or other shading devices may allow for the elimination or downsizing of air-conditioning systems, which would more than pay for the overhang upgrades. Awnings and overhangs can be simple or complex, and thus range greatly in price.

COST 

Benefits

Properly designed and sized overhangs and window shading reduces heating and cooling needs, saving energy and making the home or building more comfortable.

Application

Generally applicable to all south-facing windows that lack suitable shading or overhangs. Application may be limited by local code requirements related to façade design.

RECOMMENDATION 2.4.2 WINDOW REPLACEMENT

Evaluate opportunities for window replacement in conjunction with exterior wall rehabilitation.

This measure reduces heating and cooling loads and improves comfort. It may also help prevent interior furnishings from fading.

Description of Measure

Windows generally make up a significant fraction of a multifamily unit's exterior walls. They are also generally the weakest link in the building's thermal envelope. Windows can allow unwanted heat into the building during the summer and can account for as much as 25 percent of heat loss in the winter. High-performance windows help control heat gain and loss.

Unfortunately replacing single-pane windows with newer, more efficient ones is generally not cost effective as a stand-alone retrofit. Replacement is generally more cost effective when pursued in conjunction with general wall rehabilitation to address rot, water damage, and other issues.

When specifying windows, it's important to understand these terms:

- U-factor (the inverse of R-value) is a measure of heat transferred by the entire window (frame, sash and glass) either into or out of the building. The lower the U-factor, the more comfort the window will provide on cold days.
- Solar heat gain coefficient (SHGC) is a measure of the solar energy entering the building through the entire window. A lower SHGC will reduce air-conditioning costs and provide more comfort on hot days.
- Relative solar heat gain is the SHGC value of windows, corrected for the wall orientation.

In cool climates that have greater heating loads than cooling loads, heat gain through the windows is beneficial. In these climates, install new windows with a low U-factor (equivalent to high insulating R-value) but a high solar heat gain coefficient (SHGC). In hotter climates, select a low U-factor and a low SHGC.

High-performance windows can achieve R-values (the inverse of U-factor) of 2 to 3 compared to R-1 for standard single-pane windows. In comparison, a wall achieves R-13 or more, making windows the main weak spot for heat loss in any building.

High-performance windows minimize heat gain and loss through these five methods:

- (1) Insulated glazing system: Dual-pane windows insulate better than single-pane. In most instances, dual-pane windows are required by Title 24.
- (2) Spectrally selective coatings: Low-e coatings reduce the loss of heated indoor air in the winter. Certain low-e coatings also block the sun's heat energy from entering a building.
- (3) Frame materials: Low-conductivity frames insulate better. Wood, vinyl, composite and fiberglass all perform better than aluminum. If aluminum frames are used, then a product with thermal breaks between the interior and exterior panes of glass is strongly recommended.
- (4) Tight installation: Sealing around framing and other gaps between the window frame and exterior wall minimizes air leaks. Caulk, foam and weather-stripping ensure a tight installation that will prevent drafts.
- (5) Gas fill: Some high-performance windows have a low-conductivity gas, usually argon or krypton, encapsulated between the two panes of glass. This increases the insulation level of windows. However, it is not certain that the gas will remain in the window throughout the window's life expectancy; the gas is invisible, so it may escape without notice. With the advent of low-e coatings, the benefits of gas-filled windows have somewhat diminished and they are now much less common.

Cost and Cost Effectiveness

BENEFIT  When comparing window costs, be sure to consider the long-term savings and increased comfort

COST  provided by high-performance windows. Vinyl windows and

thermally broken aluminum windows are both somewhat more expensive than standard aluminum windows, costing about \$1 more per square foot. Fiberglass, wood and composite windows are considerably more expensive than vinyl or metal. Low-e coatings add about \$0.30 to \$0.50 per square foot and are definitely cost effective, achieving a payback of three years or less.

Benefits

Low-e coatings reduce heating and cooling needs, save energy, and make the home or building more comfortable. They also reduce the fading of interior furnishings and materials by blocking ultraviolet radiation. Insulated (dual-pane) windows reduce condensation on windows, which helps prevent water damage and potential for mold growth. Changing from a single-pane to a dual-pane high-performance window will also help reduce noise levels.

Application

Applicable to all window replacement projects.

BUILDING-MOUNTED EXTERIOR LIGHTING

RECOMMENDATION 2.5.1
EXTERIOR LIGHTING

For all new exterior lighting fixtures that contribute to light pollution, use full cut-off luminaires (fixtures that emit no light above horizontal) or fixtures certified by the International Dark-Sky Association. An exception to this is lighting placed in areas where shielding is unnecessary to control light pollution, such as fixtures placed under overhangs.

This measure reduces energy costs and light pollution.

Description of Measure

For a description of this measure, see Rec. 1.4.1. For parking lots, specify shorter, lower wattage fixtures. Increase the number of fixtures and place them closer together. This decreases losses from glare reflection and overlighting, while providing uniform light.

Cost and Cost Effectiveness

BENEFIT  Generally, the capital cost savings from using lower wattage fixtures and shorter poles for parking lots more than offsets the additional costs of full-cutoff luminaires or add-on valances. Parking lot poles 16-feet high or less can be serviced at lower cost without a cherry picker. Lower light levels also reduce energy costs.

COST 

Benefits

See Rec. 1.4.1.

Application

See Rec. 1.4.1.

LAUNDRY FACILITIES

RECOMMENDATION 2.6.1 ENERGY STAR LAUNDRY MACHINES

For all residential or commercial-grade clothes washers, purchase or lease products that are Energy Star-qualified with a modified energy factor (MEF) of at least 1.72 and a maximum water factor of 8.0.^{10 11} For all residential-grade clothes dryers, purchase or lease products that are natural gas-fueled and ventless (require no exhaust). In addition, look for a dryer with a moisture sensor that automatically shuts off when your clothes are dry.

This measure reduces energy and water bills.

Description of Measure

Energy Star washing machines are available in commercial and residential models that reduce water consumption by over 40%.¹² Reducing water consumption also reduces water heating energy use. According to the Environmental Protection Agency, Energy Star washing machines use 50 percent less energy compared to conventional washers.¹³

Many Energy Star washing machines are horizontal-axis front-loading models, which spin two to three times faster during the spin cycle than conventional top-loading models, improving water extraction and reducing drying time.¹⁴ They use premium motors and tumble laundry in a low volume of water. Commercial-grade horizontal-axis models are easier to service and maintain, thanks to front-mounted components that allow for service without moving the units. Energy Star-qualified top-loading clothes washers are also available.

Some Energy Star washing machines also use special low-suds soaps in much smaller amounts than conventional soaps. Some models allow users to use conventional soaps and detergents, while others recommend that only high-efficiency soaps be used.

See www.energystar.gov for qualifying models and additional information.

The Energy Star label does not pertain to clothes dryers, as most dryers use the same amount of energy and thus there is little difference between models. Gas-fueled clothes dryers may cost slightly more initially, but will cost less to run over the product's lifetime (provided you already have a gas line hookup).¹⁵

Cost and Cost Effectiveness

High-efficiency clothes washers and gas dryers save water and energy. The cost of water and associated costs of water heating and wastewater treatment are a significant operating expense for multifamily housing. These costs are likely to increase in the future as freshwater supplies shrink, energy costs escalate, and treatment costs rise.

Benefits

High-efficiency laundry equipment saves water, energy and money.

Application

Applicable to all multifamily developments.

10. www.energystar.gov/index.cfm?c=clotheswash.pr_crit_comm_clothes_washers. 11. www.energystar.gov/index.cfm?c=clotheswash.pr_proc_clothes_washers.
12. www.energystar.gov/index.cfm?c=clotheswash.clothes_washers_advanced_technology. 13. www.consumerenergycenter.org/home/appliances/washers.html.
14. www.energystar.gov/index.cfm?c=clotheswash.clothes_washers_advanced_technology. 15. www.consumerenergycenter.org/home/appliances/dryers.html.

3

MECHANICAL SYSTEMS

- LIGHTING SYSTEMS
- PLUMBING SYSTEMS, WATER, AND GAS
- HEATING
- COOLING
- ELEVATOR
- RENEWABLE ENERGY
- RETRO-COMMISSIONING OR EXISTING BUILDING COMMISSIONING

LIGHTING SYSTEMS

RECOMMENDATION 3.1.1
LAMP SPECIFICATIONS

Specify compact fluorescent lamps (CFLs) and T8 linear fluorescent lamps with electronic ballasts as a replacement for incandescent lamps and T12 lamps with magnetic ballasts. When possible, specify hard-wired CFLs for any new and replacement light fixtures. Any recessed cans should be insulation contact air-tight (ICAT) compact fluorescent models.

Specify LED exit signs to replace fluorescent and incandescent exit signs in all feasible applications.

This measure reduces electricity use, maintenance costs, greenhouse gas emissions and pollution.

Description of Measure

Fluorescent lighting is energy efficient and cost effective. It has historically suffered from a reputation of poor quality, but newer fluorescent lamp and electronic ballast technologies have remedied earlier shortcomings. New products have eliminated flicker, deliver instant start times, and provide vastly improved color rendition and color temperatures. In addition, some newer fluorescent lamps can be dimmed like traditional incandescent lamps. This gives more flexibility in designing for daylighting or “mood” lighting, especially in common areas.

The Flex Your Power website provides the following information about energy-efficient lighting:¹⁶ Two lighting terms to know when choosing appropriate lighting are lumen and efficacy.

- A **lumen** is a measurement of light output from a lamp. All lamps are rated in lumens. For example, a 100-watt incandescent lamp produces about 1750 lumens. When looking for a light bulb, consider the lumen output,

rather than the wattage, to determine the light level you need; lumen describes light output, while wattage describes energy used.

- **Efficacy** measures the efficiency of a lamp. This is the ratio of a lamp’s light output to the electric power it consumes, and is measured in lumens per watt (LPW).

There are two types of fluorescent lamps: tubular and compact.

- **Tubular fluorescent lamps** are commonly used for kitchen and office ceiling fixtures. The “T” designation for fluorescent lamps stands for tubular—the shape of the lamp. The number after the “T” gives the diameter of the lamp in eighths of an inch. The T8 lamp is available straight or U-shaped and has become the standard for new construction. It also commonly serves as a retrofit replacement for 40-watt T12 lamps, improving efficacy and performance.” The Super T8 lamp is even more efficient and advanced than the T8.
- **Compact Fluorescent Lamps (CFLs)** combine the efficiency of fluorescent lighting with the convenience and popularity of incandescent bulbs. CFLs come in pin-based and screw-based configurations. Pin-based models are designed to fit only into fixtures that are designed for fluorescent lighting. Screw-based models are designed to fit into fixtures where you would typically use a conventional incandescent light bulb.”

Cost and Cost Effectiveness

BENEFIT		Compact fluorescent lamps (CFLs) come in a range of sizes, uses, and wattage. Lamps are now available for dimmable, three-way, spot, and flood fixtures. The simple payback
COST		for CFLs can be as little as 3 months depending on what type of lamp is purchased, how often the lamp is used, the current cost of electricity, and available Energy Star rebates.

for CFLs can be as little as 3 months depending on what type of lamp is purchased, how often the lamp is used, the current cost of electricity, and available Energy Star rebates.

Since the ballast outlasts the lamp, hard-wired pin based fluorescent fixtures are more cost effective than screw-in CFLs as only the lamp needs to be replaced.

LED exit signs have a typical payback of less than one year to four years depending on cost of the fixture, rebates, and maintenance costs (access Energy Star’s LED exit sign payback calculator at

www.energystar.gov/index.cfm?c=exit_signs.pr_exit_signs).

16. Source: Flex Your Power, www.fypower.com/res/tools/products_results.html?id=100195.

Benefits

The price of good quality CFLs is still higher than simple incandescent lamps. However, since fluorescent lamps produce three to four times as much light per watt than incandescent lamps and last up to 10 times longer, the energy and electricity savings pay for the higher initial cost. A typical CFL will save \$30 in energy costs over its life span. In addition, because it produces about 75 percent less heat, it is safer to operate and can decrease home cooling costs.¹⁷

The long life of CFLs also can greatly increase convenience and security. Using CFLs in outdoor lighting can provide the assurance that security lighting will remain on when needed. CFLs will last at least five years in typical indoor applications, meaning lower maintenance costs.

Replacement costs for hardwired CFLs are lower than for screw-based CFLs because only the lamp needs to be replaced, not the ballasts, which typically last much longer than the lamp. In addition, hardwired CFLs ensure that people don't circumvent the energy savings by replacing the CFL with an incandescent lamp.

LED exit signs consume between 2 and 4 watts, as compared to compact fluorescent (15W) or incandescent (20 to 40W) exit signs.

Application

T8 lamps and CFLs have typically been installed in kitchens and bathrooms due to code requirements for residential housing. However, they are suitable for use in all rooms, garages, outdoor porch lighting and common areas. Hard-wired CFLs can be installed in bedrooms and in recessed fixtures. Wall sconces with CFLs are practical in hallways and bedrooms.

LED exit signs are nearly standard practice today, and replace fluorescent and incandescent fixtures in all applications.

RECOMMENDATION 3.1.2 LOW MERCURY LAMPS

Install low-mercury lamps with mercury content equal to Philips ALTO, GE Ecolux or equivalent products. Require vendors to submit documentation on the amount

of mercury per lamp in milligrams, and hours of rated life, for each lamp type supplied. Specify fluorescent lamps with the lowest amount of mercury per rated hour, provided the lamps meet all other performance specifications.

Assist the property owner in developing a standard low-mercury specification for routine replacement of fluorescent lamps in common areas and dwelling units. Assist the property owner in developing protocols for recycling used fluorescent lamps.

This measure reduces energy costs and the amount of mercury released into the environment.

Description of Measure

All fluorescent lamps contain mercury, an environmental toxin. Although a single fluorescent lamp contains only a small amount of mercury, the overall content of mercury in fluorescent lamps is large given how many fluorescent lamps are used. According to one estimate, 620 million fluorescent lamps are discarded annually in the United States, releasing from 2 to 4 tons of mercury per year.¹⁸ Some manufacturers, including Philips and General Electric, now offer fluorescent lamps (linear and CFL) that contain only a fraction of the mercury used in standard fluorescent lamps.

Some lamps are advertised as "green" or environmentally preferable, but these claims do not ensure the lowest mercury content. Request mercury content from vendors when purchasing lamps to ensure the lowest mercury content lamps are purchased.

Lamps that pass the U.S. EPA's Toxicity Characteristic Leaching Procedure (TCLP) are called TCLP-compliant. These lamps may or may not have the same amount of mercury as an equivalent non-TCLP-compliant lamp. The TCLP is used by the U.S. EPA to determine if something is a hazardous waste. The procedure is designed to

17. www.energystar.gov/index.cfm?c=cfls.pr_cfls.

18. Michael Aucott et al., "Release of Mercury from Broken Fluorescent Bulbs," *Journal of the Air & Waste Management Association*, Vol. 53, February 2003, as cited on www.informinc.org/fact_P3fluorescentlamps.php.

simulate how much of a toxic chemical would leach from a product if the product were put into a landfill; it does not measure how much of the toxic chemical is actually contained in the product or how much may be released under non-landfill conditions. Mercury leaching can be affected by the presence of other chemicals or metals in the product, and so is not an accurate indicator of a lamp's mercury content.

For disposal and recycling questions related to lamps and ballasts, refer to Stopwaste.Org Green Building in Alameda County's publication, *Builders Guide to Reuse and Recycling* (www.stopwaste.org/docs/buildersguide-05.pdf). Lamp and ballast disposal are also addressed in the *Alameda County Recycling Guide* (www.stopwaste.org/docs/recyclingguide.pdf).

Cost and Cost Effectiveness

See Rec. 3.1.1 for cost information.

Benefits

Low-mercury lamps avoid the release of mercury into the environment and the food chain.

Application

Low-mercury lamps can generally be specified wherever a fluorescent lamp is applicable.

PLUMBING SYSTEMS, WATER, AND GAS

RECOMMENDATION 3.2.1 SOLAR HOT WATER

Evaluate opportunities to supply some portion of hot water needs with solar water heating.

This measure reduces energy costs and pollution.

Description of Measure

Solar water heating systems are available in many configurations. Most systems for multifamily housing circulate water to the solar collectors with a small pump and store the solar-heated water in a tank next to the boiler or gas water heater. The systems use the sun to heat the water partway to the set point, and use a boiler or gas water heater to complete the heating process.

Medium-temperature systems that raise water to between 110°F and 180°F are the most common for domestic hot water (DHW) applications. There are a number of solar hot water collector systems. The three most common are described below:

- (1) Integral collector storage (ICS), or “batch.” These systems are passive—they do not require any pumps or motors to circulate the hot water. The water is stored where it is heated (on the roof in most cases). Efficiency: Up to 30 percent.
- (2) Flat plate collector. Water or another liquid is circulated through a glass-covered, sealed box where the fluid is heated by the sun. The resulting water is stored in a tank usually located in the building. Efficiency: Up to 40 percent.
- (3) Evacuated-tube collector. These collectors are constructed so that the fluid heating happens inside a vacuum, thus increasing efficiency. Storage is in a tank inside the building. Efficiency: Up to 60 percent.

Collector systems can be configured in a number of ways, depending on site-specific needs. Most systems (except for batch collectors) require storage tanks; these tanks hold water that has been heated in the collector by the sun and deliver it to the residences. Storage tanks can also have heating elements in them for back-up when the collectors are not providing hot water. Boilers and instantaneous water heaters connected to the system can serve as a back-up so that hot water is always available.

Cost and Cost Effectiveness



A typical multifamily solar hot water system will cost between \$1,000 to \$3,000 per unit, depending on the system’s size. Paybacks range from three to eight years. Large central boilers can be preheated by solar collectors and cost less than individual water heaters in each unit. It is also possible to have one central boiler that serves both for space heating and DHW purposes. The combined savings of eliminating furnaces and reduced energy use can offset the cost of installing a solar water heating system.

Utility-based rebates are sometimes available for solar heating systems; check with installers or visit www.dsireusa.org for more information. In addition, any funds received from utility-based energy conservation incentive programs are exempt from federal taxes. However, the IRS has not specified definitively if solar hot water qualifies as an energy conservation measure and thus further consultation with a tax lawyer is recommended.

Benefits

Solar hot water systems can pay back in as little as three years and reduce the use of gas or electricity for water heating by up to 70 percent.

Application

Solar water heating is appropriate for existing buildings with south-facing roof space for panels and space for appropriate plumbing configurations in their mechanical room.

For information about solar heated pools, see Rec. 1.6.2.

RECOMMENDATION 3.2.2 WATER HEATING EFFICIENCY

Evaluate the feasibility of improving water heating efficiency, either as part of heating system replacement or as a retrofit. Evaluate the plumbing system’s ability to reduce water wasted while waiting at the fixture for hot water to arrive.

This measure reduces energy use and utility bills while improving equipment performance.

Description of Measure

Water heating accounts for a significant portion of energy use in multifamily housing. That cost can be reduced by installing high-efficiency domestic hot water (DHW) appliances such as storage water heaters and gas-fired boilers. The type of heating equipment used depends on how much hot water is needed and how it will be metered on the site.

For centralized DHW systems, it is usually more expensive to purchase a high-efficiency boiler than to use multiple high-efficiency water heaters. However, when water usage is high, a boiler is the least expensive option over time.

If each unit has its own water heating, use a high-efficiency gas storage heater with an energy factor of at least 0.62. For individual units, it is usually cost prohibitive to purchase condensing heaters with energy factors as high as 0.82, but this can be considered for projects that have sufficient budget.

Another option is to supply or supplement water heating needs with tankless water heaters. Tankless or “instantaneous” water heaters are generally more efficient than standard tank systems since they only heat water when it is needed; there is no tank of hot water slowly losing heat 24 hours a day. Tankless systems with electric ignition use even less fuel than systems with a pilot light. Please note that larger vents and larger gas lines may be required.

For all water heating systems, the use of solar collectors can further reduce energy use and take advantage of free energy. Solar systems can augment or preheat water for boilers and storage-tank type heaters (see Rec. 3.2.1).

On-demand water recirculation pumps that work on request from the user (usually by pushing a button located close to the fixture) can save significant amounts of water wasted at the drain and can reduce the large losses of heat that occur in continuous recirculation systems.

Insulate all accessible piping to reduce heat loss through the pipes.

Cost and Cost Effectiveness

BENEFIT  Higher efficiencies on DHW equipment result from better quality components, which also enhances the product's life. For this reason, high-efficiency equipment costs more than the lowest efficiency equipment.

COST  Higher efficiencies on DHW equipment result from better quality components, which also enhances the product's life. For this reason, high-efficiency equipment costs more than the lowest efficiency equipment.

The increased cost is recovered through savings in energy cost savings, reduced maintenance costs, and increased product life.

Installing tank insulation on service hot water heaters is a low-cost measure that will prevent heat loss.

Benefits

High-efficiency water heating equipment saves money by reducing energy use and improving equipment performance. Most high-efficiency boilers and storage tank water heaters also have the benefit of direct venting with sealed combustion. Sealed combustion in gas-fueled appliances reduces the risk of backdrafting combustion gases into the home. Boilers placed in mechanical rooms also benefit from direct venting because often draft hoods or dampers can be eliminated.

Application

High-efficiency central hot water systems apply to multifamily buildings where water use is large. Individual storage tank water heaters can be used where independent hot water systems are desired. Tankless heaters have a number of applications, including remote locations like a bathroom or sink located away from the rest of the DHW system. They can also be installed for entire residences to replace storage tank heaters.

HEATING

RECOMMENDATION 3.3.1 FURNACE AND BOILER EFFICIENCY

Evaluate opportunities to improve energy efficiency as part of any furnace or boiler replacement.

This measure reduces energy costs and associated greenhouse gas emissions and pollution.

Description of Measure

Furnaces must, by law, have a minimum Annual Fuel Utilization Efficiency (AFUE) of 78 percent. The minimum requirement for gas-fueled boilers is a bit lower at 75 percent. Furnaces that meet Energy Star requirements are at least 90 percent efficient. Furnaces with an efficiency greater than 90 percent AFUE are condensing furnaces and may require special condensate acid neutralization in the drain.

Energy Star-labeled boilers must be 85 percent efficient or higher. Manufacturers achieve efficiency improvements in boilers and furnaces by using better components, such as a secondary heat exchanger, electric ignition, and direct or power venting.

For information about the specific efficiencies of boilers and furnaces, go to:

www.aceee.org/consumerguide/heating.htm,
www.energystar.gov/index.cfm?c=boilers.pr_boilers, and
www.energystar.gov/index.cfm?c=furnaces.pr_furnaces.

Cost and Cost Effectiveness

BENEFIT



COST



Gas wall heaters are more expensive than electric baseboard or wall heaters. While gas wall furnaces range from \$350 to \$550, electric wall heaters cost approximately \$250. Electric baseboard heaters

range from \$35 to \$250. However, the operation and monthly cost of electric heat is more expensive and must be considered when choosing the appropriate heater.

Ninety-percent AFUE unit-size furnaces are currently about 30 to 40 percent more expensive than minimally compliant 78 percent AFUE units. Paybacks range from six to ten years.

Condensing furnaces cost considerably more than the standard efficiency furnaces, often as much as 50 to 80 percent more. High-efficiency boilers last a long time, but come in a limited range of sizes at a reasonable cost. Expect to pay 50 to 100 percent premium for a condensing boiler over a minimally compliant boiler.

Also consider placing controls on boilers; this is a low-cost energy efficiency strategy that should be a part of any green building retrofit. If units in your building are often too hot or too cold, using an outdoor reset/cutout control will help with this issue and result in fewer occupant complaints and maintenance calls.

Benefits

High-efficiency equipment saves money through reduced fuel use. Also, by using less fuel, high-efficiency heating equipment emits fewer greenhouse gases and other pollutants into the air compared to standard equipment.

Furnaces with an AFUE greater than 88 percent are often power or direct-vented, or have sealed combustion. In sealed-combustion systems with direct venting, exhaust is piped to the outside, and combustion air is drawn from the outside instead of from indoors. This reduces the risk of backdrafting carbon monoxide, which is potentially harmful to occupants. Sealed combustion with direct venting also allows installation to be done through sidewalls with piping, which reduces the installation difficulties of traveling vertically through multiple floors and the roof.

Application

Applicable to replacement of furnaces and boilers in multifamily buildings.

COOLING

RECOMMENDATION 3.4.1
ENERGY STAR CEILING FANS

Specify Energy Star ceiling fans for installation in all bedrooms and living rooms.

This measure reduces cooling costs and improves occupant comfort.

Description of Measure

Energy Star ceiling fans contribute to improved comfort year around. In the summer, the ceiling fan is operated in the counter-clockwise direction, producing a down draft, which creates a wind-chill effect and enables occupants to feel comfortable at a higher thermostat setting, or with no air conditioning at all. In the winter, the ceiling fan is operated at low speed in the clockwise direction, producing a gentle updraft, which forces warm air near the ceiling down into the occupied space. The thermostat can thus be set lower while maintaining the same comfort level.

Energy Star ceiling fans are superior to conventional ceiling fans because they use less energy, have improved motors and blade designs, and feature reversible operation. Lighting-equipped models have Energy Star light fixtures.

According to Energy Star, ceiling fans should be mounted in the middle of the room and at least 7 feet above the floor and 18 inches from the walls. If ceiling height allows, install the fan 8 to 9 feet above the floor for optimal airflow. Appropriate fan size depends on room dimensions.

ROOM DIMENSIONS	SUGGESTED FAN SIZE
Up to 75 ft ²	29-36 in
76-144 ft ²	36-42 in
144-225 ft ²	44 in
225-400 ft ²	50-54 in

Four mounting types are available to suit a variety of applications:

- **Standard** mounts come with a 3 to 5 inch downrod, which is the metal pipe that extends from the ceiling bracket to the top of the fan. Downrods are usually either 1/2 or 3/4-inch in diameter.
- **Extended** mounts can be used to hang the ceiling fan at the desired 8 to 9 feet from the floor for higher ceiling heights. Downrods can be purchased from 6 inches (9 ft ceiling) to 120 inches (20 ft ceiling). Check with the manufacturer or sales associate to determine the right downrod length.
- **Flush** mounts anchor the fan directly against the ceiling. Most standard fans can be installed as a flush mount, however many manufacturers sell “hugger” or “low profile” ceiling fans that are specifically designed for this purpose. Hugger fans are ideal for rooms that have ceilings under 8 feet in height or in situations where a fan with optional light would hang down too low. Hugger fans will not move as much air as a regular fan because the blades are closer to the ceiling.
- **Sloped** mounts are used for angled or vaulted ceilings.

Cost and Cost Effectiveness

BENEFIT  Ceiling fans cost between \$200 and \$400 each, installed. For best results, specify fans with fluorescent bulbs and high-efficiency motors that are quiet and have at least two speeds. Many models of Energy Star ceiling fans are available.

COST 

Benefits

Ceiling fans improve comfort and reduce heating and cooling costs.

Application

Dwelling units can easily be retrofitted with ceiling fans upon unit turn-over or while still occupied.

RECOMMENDATION 3.4.2
NON-CFC OR HCFC-BASED REFRIGERANTS

Where air-conditioning systems need replacement, avoid CFC or HCFC-based refrigerants. Advanced refrigerants such as HFC-134A, HCFC-407C, or HFC-410A should be specified instead. Trade names for these are Puron, SUVA-410A, GENETRON AZ20, and more.

Monitor leakage of ozone-depleting refrigerants and enter into a maintenance contract to ensure that leakage is less than five percent per year.

This measure reduces the building's contribution to ozone layer depletion and global warming.

Description of Measure

Older refrigerators and air conditioners used chlorofluorocarbon (CFC) refrigerants. CFCs damage the stratospheric ozone layer and contribute to global warming. In compliance with the Montreal Protocol, the United States ended CFC production in 1995. Since then, CFC leaks to the atmosphere have significantly declined.

Today there are numerous CFC substitutes on the market. While some are better than others in terms of ozone-depleting potential (ODP) and global warming potential (GWP) ratings, there are no perfect refrigerants. Eliminating mechanical cooling is the only certain way to reduce ODP and GWP from building cooling.

R-22 is a hydrochlorofluorocarbon (HCFC) refrigerant used in residential cooling systems. While much less destructive to the ozone layer than CFCs, HCFCs do contain chlorine, an ozone-destroying chemical. Also, the manufacture of R-22 creates a by-product that contributes to global warming. Starting in 2010, under the Clean Air Act, manufacturers will no longer be allowed to produce new air conditioners using R-22.

Some new products on the market use an advanced refrigerant called R-410a (known under the trade names Puron, Genetron AZ-20, or Suva 410a). These are a blend of hydrofluorocarbons (HFCs) that do not contribute to ozone depletion, but do have some GWP, though less than R-22. Through-the-wall, mini-split systems, and package terminal units often do not use R-410a advanced refrigerants.

For more information about air-conditioning systems with advanced refrigerants, go to

www.toolbase.org/Technology-Inventory/HVAC/high-efficiency-air-conditioners.

Cost and Cost Effectiveness

BENEFIT		By 2010, manufacturers will not be allowed to produce residential air conditioners that use the HCFC refrigerant, R-22, although its use will be permitted until the year 2030.
COST		

Air conditioners with the advanced R-410A refrigerant cost somewhat more than those with conventional refrigerant. While systems with advanced refrigerants cost more, the price of servicing the older units is expected to rise because of limits on availability of R-22.

Benefits

Using an environmentally preferable refrigerant will reduce the effect buildings have on ozone depletion and global warming.

Application

Applicable to replacement of central residential air conditioners.

RECOMMENDATION 3.4.3
CENTRAL AIR-CONDITIONING SYSTEMS

Where central air-conditioning systems need replacement, specify high-efficiency units with a SEER rating of 15 or higher and an EER of 12.5 or higher for split systems; SEER 14.0 or higher and EER 12.0 or higher for packaged units. The units should also have a thermostatic expansion valve (TXV).¹⁹

Inspect, seal, and performance test all air ducts. Ducts should be pressure tested and verified to allow no more than 6 percent leakage. Also be sure that your system is properly sized.

This measure reduces energy costs and associated greenhouse gases and pollution.

Description of Measure

Seasonal Energy Efficiency Ratio (SEER) is a rating of cooling system efficiency at low temperatures, while Energy Efficiency Ratio (EER) is a high temperature performance rating. The higher the SEER/EER, the less energy is needed to provide comfort. A high SEER/EER ensures that the air conditioner operates at high efficiency during the full range of summer temperatures. Although the SEER rating should be listed on the product, the EER rating may need to be obtained from the manufacturer. It is recommended that both ratings be verified.²⁰

A thermostatic expansion valve (TXV) regulates the flow of refrigerant to the indoor/evaporator coil of a central air conditioner in response to changing cooling conditions. When the cooling load is high, the TXV opens wider to allow more refrigerant to flow through the indoor coil. When the cooling load is low, the TXV reduces the flow of refrigerant, thus creating a more efficient air-conditioning system.

In California's dry climates, adequate air handler airflow rates are required to deliver cooling efficiently. Low airflow rates can lead to ice buildup on the cooling coil and to compressor failure. Therefore, it is necessary to ensure the unit has proper airflow.

There are two types of central air-conditioning systems: split systems and package units. In a split system, the indoor coil and the condenser are separate. A package unit combines the condenser and indoor coil in one outdoor housing unit.²¹ For both types of systems, be sure the system comes with a TXV.

Inspect, seal, and performance test all air ducts. Ducts should be pressure tested and verified to allow no more than 6 percent leakage. If leakage exceeds that threshold, leaks should be located and sealed. Duct connections around plenums, t-wyes, splice collars, and register boots should be sealed with mastic.

ACCA's Manual J Residential Load Calculation Procedure is the accepted industry standard, approved by ANSI and the California Energy Commission, for the proper sizing and selection of HVAC equipment. Many systems are oversized to allow for expected high levels of duct leakage. Thus, when replacing a system that may have been oversized, it is important to fully seal ducts and then recalculate proper system size. In many cases, the old system can be replaced with a smaller, right-sized system, saving money both for equipment purchase and for ongoing operations. A correctly sized system will also perform more efficiently because cooling capacity will match the loads.

Cost and Cost Effectiveness

BENEFIT  High-efficiency central air conditioners cost more than standard units. The cost typically results from improved components, including sound dampening technologies, better compressors, and multi-speed premium motors. Paybacks can be short in hotter climates where air-conditioning loads are substantial. Most manufacturers reserve the advanced refrigerants for their higher efficiency models.

COST 

Properly sizing an air-conditioning system may allow installation of a smaller unit, which costs less to buy and operate. Extra design time is needed, however, to correctly model and design the cooling system to accurately match the load.

19. 2007 Consortium for Energy Efficiency High Efficiency Specifications for Residential HVAC Systems.

20. Buying an Air Conditioner: Remember the EER, Pacific Gas and Electric 2006 Technical Sheet.

21. Buying a Central Air Conditioner: Ask for a TXV, Pacific Gas and Electric 2006 Technical Sheet.

PG&E (as well as other electric utilities) offers rebates for high-efficiency air conditioners. This incentive usually covers the cost of upgrading to a higher efficiency, and can also help offset design costs.

Benefits

Properly installed energy-efficient air conditioners cost less to operate. High-efficiency units are usually top-of-the-line products with better motors and components than standard equipment, and should therefore last longer.

Field research shows that ducts in existing homes on average allow about 30 percent of the heated or cooled air to leak out. By decreasing duct leakage, the system efficiency increases, airflow improves, conditioned spaces heat and cool faster, utility bills decline, and occupants experience greater comfort. Also, leaky air ducts can cause negative pressure in the conditioned space, which can draw many outdoor and indoor contaminants into the space. Sealed ducts will generally produce a more healthy living space.

Installing an air conditioner with a TXV and proper airflow lowers utility bills and saves energy through improved performance. In addition, properly sized air conditioners provide greater comfort, are less noisy, and lasts longer than oversized units.

Application

Applicable to climate zones that require central air conditioning.

ELEVATORS

RECOMMENDATION 3.5.1
PLANT-BASED LUBRICANTS AND/OR
GEARLESS ELEVATORS

For multifamily properties with hydraulic elevators, specify the use of plant-based, biodegradable lubricating oil. Where applicable, explore the potential for gearless elevators that don't require a machine room.

Gearless elevators are more energy efficient and reduce operating costs. Biodegradable lubricants reduce the risk of pollution.

Description of Measure

Elevators use on average between four and ten percent of total building energy use, according to the U.S. Department of Energy. Gearless elevators are two to three times more efficient than conventional hydraulic elevators and 30 to 50 percent more efficient than standard gear elevators. In addition, they are smaller, easier to install and do not require a separate machine room. However, they are limited in size, weight, and height depending on the building structure.

Some interpretations of building codes may not allow elevators without machine rooms. Check with local code officials. Also, check available size limitations. There may not be a gearless elevator available in the size/weight limit desired.

Biodegradable lubricating oils break down quickly and do not cause as much damage if they leak into the ground as do petroleum-based oils.

For more information about gearless elevators, see the U.S. Department of Energy's publication, "Energy Efficient Elevators" (www1.eere.energy.gov/femp/pdfs/29267-5.7.4.pdf) and "The Elevator Revolution" by Nadav Malin in *Environmental Building News* (V.13 n8, August 2004, www.buildinggreen.com).

BIODEGRADABLE LUBRICANT



GEARLESS ELEVATOR



Cost and Cost Effectiveness

While the initial cost of gearless elevators is more expensive, they use less energy than the conventional hydraulic or standard gear elevator. Biodegradable lubricants are more costly than conventional lubricants.

Benefits

Biodegradable lubricating oils are less polluting.

Gearless elevators are more efficient than hydraulic and standard gear elevators. They are smaller and easier to install and provide a smoother ride without the need for hydraulic fluid or the associated heat and maintenance.²²

Application

Lubricating oils that are derived from plants can be used in place of most petroleum-based products.

Gearless elevators are most commonly used in high-rise buildings (more than 30 stories) but are now beginning to be cost effective for smaller buildings as well.

22. www1.eere.energy.gov/femp/pdfs/29267-5.7.4.pdf.

RENEWABLE ENERGY

RECOMMENDATION 3.6.1 RENEWABLE ENERGY

Evaluate the feasibility of adding a photovoltaic system or other renewable energy technologies for onsite electricity generation.

This measure reduces energy bills, pollution and greenhouse gas emissions.

Description of Measure

Photovoltaic (PV) systems convert solar energy into electricity when sunlight strikes the PV cells. Electricity is produced as direct current (DC) power and is then inverted to alternating current (AC) power for residential use. On-site energy generation can provide reduced and relatively constant operating costs compared to ordinary utility use.

Technologies such as PV and wind power are environmentally preferable as they do not consume fuels. However, other technologies are also environmentally beneficial. For example, microturbines provide efficient power while also preheating domestic water, thereby reducing the need for additional water heating energy. Fuel cells also have extremely low air emissions.

Before pursuing any on-site generation options, it is essential to make the property as energy efficient as possible. By improving energy efficiency and reducing overall electricity needs, the property's electricity needs can be met with a smaller, less expensive system.

There are numerous steps to determine if a PV system is a viable option for a particular site. A basic site evaluation includes (1) a calculation of the needed system size to power the property, (2) an assessment of the available unshaded roof space of a property, and (3) an evaluation of the cost effectiveness of the proposed system size.

(1) System size: According to *The Guide to Photovoltaic System Design and Installation*, published by the California Energy Commission, an accepted rule of thumb is that a 1-kilowatt (kW) system will generate between 1,379 and 1,724 kWh per year in San Francisco.²³ Typical generating capacities for a 1 kW system in California cities are shown in the following table.

CITY	ANNUAL KWH GENERATED PER KW CAPACITY
Arcata	1092–1365
Shasta	1345–1681
San Francisco	1379–1724
Sacramento	1455–1819
Fresno	1505–1881
Santa Maria	1422–1778
Barstow	1646–2058
Los Angeles	1406–1758
San Diego	1406–1758

As an example, a recent study noted that the 8,000-square-foot common area of a 15-year old apartment complex in San Francisco used approximately 46,400 kWh in 2004. Based on the conversion above, a system rated between 27 and 34 kW would be sufficient to meet the needs of this common area. The study also found that a typical one-bedroom apartment used about 3,500 to 4,500 kWh per year and would thus need a system rated between 2 and 4 kW.

(2) Unshaded roof space: According to the CEC's Guide, 100 to 150 square feet of unshaded roof area is needed for each kilowatt of system capacity. There will also need to be space in mechanical rooms for system components. A photovoltaic system will require conduit runs and space in mechanical rooms or on the exterior to house a few system components. Using the above property as an example, 27 to 34 kW of installed capacity would require approximately 2,700 to 5,100 square feet of unshaded roof area.

In addition to power and space requirements, a shading analysis and building outline are needed to calculate and optimize the best solar exposure. In Northern California, systems should have a southern exposure and be tilted +/-10 degrees of latitude. The goal is to angle the panels so they receive maximum sun exposure between 9 a.m. and 3 p.m. during the longest days of the year. Other placements are viable but may entail a loss of productivity.

Shading is a critical issue for PV performance. The PV array should not be located in the shadow of other building elements (such as facades and parapets, mechanical or plumbing elements including vent pipes and flues, and landscaping when at full growth). When considering possible shade problems, look both at the site and adjacent buildings that shade the site, as

23. See www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF.

shading constraints from neighboring properties are common, especially in urban settings. Pay particular attention to nearby properties to the south, and consider whether the site to the south might be developed in the future with a taller structure.

- (3) Cost effectiveness of a proposed system: For PV to be cost effective, the most important parameter is the installed cost per kilowatt of generation capacity. The Clean Power Estimator from Clean Power Research provides California residential and commercial electric customers with a personalized estimate of the costs and benefits of investing in a photovoltaic (PV) solar or small wind electric generation system. The Clean Power Estimator takes into consideration customer-specific information in order to provide the best estimate of a given system's costs and benefits. It is available online, free of charge, from the California Energy Commission at

www.consumerenergycenter.org/renewables/estimator/index.html.

If, after the initial evaluation, PV seems viable, hire a C-46 licensed solar contractor to perform a thorough site analysis. The estimate must include system size, expected output of the system, and an estimate of the amount of total electrical load the PV system will offset.

Cost and Cost Effectiveness



While PV systems are expensive, there are numerous incentives to help reduce the initial cost. In addition to the federal tax credit, the California Solar Initiative (CSI) can help reduce system cost. The CSI program applies

to proposed photovoltaic installations on both new and existing structures. As of January 1, 2007, the California Energy Commission's (CEC) New Solar Homes Partnership (NSHP) will focus solely on PV systems for new residential buildings while the California Public Utilities Commission (CPUC) will provide incentives for all other customers.

To ensure proper design, installation, and maintenance, the new incentives are based on how much electricity is produced (or is expected to be produced) by the system rather than providing incentives based on the proposed system size.

For existing structures, the CPUC offers two types of incentives:

- (1) The Performance Based Incentive (PBI) is for systems greater than or equal to 100 kW. These systems will be paid monthly based on the actual energy produced for a period of five years.

- (2) The Expected Performance-Based Buydown (EPBB) is for systems that are less than 100 kW. The EPBB will initially pay a one-time, upfront incentive based on expected system performance. Expected performance will be calculated based on equipment ratings and installation factors, such as geographic location, tilt, orientation, and shading.

The CPUC is also in the process of developing the California Solar Initiative Low Income Multifamily Solar Program for existing multifamily affordable housing. The \$108 million program is expected to be launched by summer 2008.

For more CSI information, go to www.gosolarcalifornia.ca.gov. For information on rebates in California, visit www.dsireusa.org.

In California, the property owner can "net meter" or sell back excess power produced by the system. When the PV system produces more electricity than the property can use, that electricity is sent back to the grid thereby offsetting a portion of the power purchased for the building. At the end of the year, the utility will balance out how much electricity the PV system displaced from the grid and credit that amount to the utility payer, thereby reducing the overall electricity bill. For information about net metering, go to

www.gosolarcalifornia.ca.gov/solar101/net_metering.html.

Benefits

On-site power generation with environmentally preferred sources reduces both air pollution and demand on the power grid. It is considerably more efficient than centralized power generation because there are virtually no distribution losses. Solar, wind and microturbines should produce reliable power for 25 to 40 years; most systems have warranties of 20 years or more. Once these systems have paid for themselves, the energy they produce is essentially free.

Application

On-site power generation can supplement utility power or replace it entirely. By combining systems, such as installing both a PV system and a microturbine, a development may be able to generate 100 percent of its own power on site. The Solara (Community Road) Project developed by Community Housing Works in Poway, California, that opened in spring 2007 is the first affordable housing project to generate 100 percent of its electricity on site. For more information, refer to www.chworks.org/affordable_housing/solara.asp. More common, however, is for a project to generate a portion of its total electricity or heating load, for instance, for common areas or shared facilities.

RETRO-COMMISSIONING OR EXISTING BUILDING COMMISSIONING

RECOMMENDATION 3.7.1 RETRO-COMMISSIONING

Retro-commission the building. Retro-commissioning is a systematic, documented process that identifies operational and maintenance problems in existing buildings and brings the building up to the design intentions of its current usage.

This measure reduces energy use and operating costs, reduces maintenance calls and call-backs, and may improve comfort and health for building occupants.

Description of Measure

Retro-commissioning is a quality-assurance process that is conducted on buildings that have been in operation for some time. Commissioning, on the other hand, is conducted as part of the design and construction process of new buildings.

The California Department of General Services (DGS) provides a clear explanation of the retro-commissioning (RCx) process.²⁴ DGS explains that retro-commissioning typically focuses on energy-using equipment such as mechanical equipment, lighting and related controls. It generally focuses on optimizing existing system performance, rather than replacing existing equipment, although equipment replacement may be necessary.

An audit of the entire building is typically part of the retro-commissioning process, which also includes a review of past energy bills. Interviews with project personnel are also sometimes conducted. This is followed by diagnostic monitoring and functional tests of building systems. The building systems are retested as well as remonitored to fine-tune improvements. Retro-commissioning results in finding and fixing operational problems to help increase the overall performance of the building.

24. www.green.ca.gov/commissioningguidelines.

25. www.eere.energy.gov/buildings/info/operate/buildingcommissioning.html.

26. www.wbdg.org/project/buildingcomm.php.

Cost and Cost Effectiveness

BENEFIT



According to the Department of Energy, the cost of retro-commissioning an existing building that has never before been commissioned can range from 3 to 5 percent of the total annual operating cost.²⁵

COST



According to the Whole Building Design Guide, organizations that have researched commissioning state that for every \$1 invested in commissioning, owners can save \$4 in operational costs over the first five years of occupancy for new construction.²⁶ The payback for retro-commissioning is also often less than five years. The costs of not commissioning include increases in operating costs from inefficient systems as well as the costs to correct equipment deficiencies during the project's life.

Benefits

Benefits of retro-commissioning reduced maintenance calls, reduced call-backs, reduced operating costs, higher energy savings, and increased comfort and overall health for building occupants.

Application

Retro-commissioning makes sense for multifamily residential buildings with central building systems. Building systems commissioning is also a requirement for LEED for Existing Buildings (LEED-EB) certification.

4

DWELLING UNITS

- WALL AND CEILING FINISHES
- FLOORING
- CABINETS
- COUNTERTOPS
- BATHROOM IMPROVEMENTS
- PLUMBING SYSTEMS, FIXTURES, AND FITTINGS
- LIGHTING SYSTEMS
- APPLIANCES

[4.1] DWELLING UNITS

WALL AND CEILING FINISHES

RECOMMENDATION 4.1.1 LOW OR NO-VOC INTERIOR PAINT

Specify paints with low or no volatile organic compounds (VOCs) for painting interior areas, either as part of rehabilitation, unit turn-over, or routine maintenance. Look for products that are Green Seal certified.

Paints that contain less than 5 grams per liter (gpl) of VOCs are classified as zero-VOC. Low-VOC paints should contain less than 150 gpl of VOCs for non-flat finishes, and 50 gpl or less for flat finishes.

Specify wood finishes and stains that are less than 350 gpl VOCs (wood coatings) or 250 gpl VOCs (wood stains) and do not contain carcinogens, aromatic solvents, phthalates, heavy metals and their compounds, reproductive toxins, or ozone-depleting chemicals.

This measure improves indoor air quality and reduces outdoor air pollution associated with VOCs.

Description of Measure

The strong smell that paint normally emits is from the evaporation of volatile organic compounds (VOCs). Most of this offgassing occurs during painting and for a few days after painting, but the health and comfort impacts on painters and occupants can be substantial during that period. Also, some of the VOCs in paints combine with other chemicals in the atmosphere to create smog, so using low or zero-VOC paint also contributes to better outdoor air quality.

VOC ratings are generally reported for the base paint before the product is tinted. Most tints add some VOCs, although a few brands have true zero-VOC tints. Because of the

VOCs in tints, saturated colors usually have higher levels of VOCs than light colors. Some manufacturers only offer low or zero-VOC paints in the light and moderate tints.

In addition, many paints include preservatives that may contain formaldehyde and other harmful compounds. Fortunately, low and zero-VOC paints have reduced levels of these chemicals, but some low and zero-VOC paints do contain these chemicals.

Green Seal is an independent nonprofit organization that certifies products meet rigorous environmental standards. Look for products that are Green Seal certified. Low-VOC interior paints should have the following VOC limits before colorants are added to bases; these limits are based on Green Seal's standard for paints:

- Non-flat: 150 gpl
- Flat: 50 gpl

Most paint companies now carry products that meet these VOC limits.

Since low and zero-VOC paint formulas have been substantially improved over the past few years, concerns about performance and cost of the first generation of low and zero-VOC paints have largely been addressed. All the large manufacturers have proven products, including Benjamin Moore Eco Spec, Kelly Moore Enviro-Cote, Pittsburgh Paints Pure Performance, AFM Safecoat, ICI/ Glidden LifeMaster 2000 and Sherwin Williams Harmony. For a complete list of paints that meet the Green Seal criteria go to

www.greenseal.org/findaproduct/index.cfm#paints.

A variety of water-based stains and finish sealers are now available that perform as well as oil-based products, but with much lower VOC levels.

Cost and Cost Effectiveness

BENEFIT



COST



Some zero-VOC paints are considered premium grade by manufacturers and cost the same as standard premium grade paints. However, more contractor-grade product lines are becoming available in low/zero-VOC varieties; these are priced lower than premium paints. The incremental retail price of most low and zero-VOC paints range from \$0 to \$4 per gallon, depending on brand, quality and product line differences.

Coverage, spreadability and drying time may affect product or labor costs. Some low-VOC products take longer to dry and may not cover or spread as well as standard paints. Check with professional installers on these issues.

Benefits

Low and zero-VOC paints provide numerous benefits over standard paints that are labeled “VOC-compliant” (which merely means they comply with California’s minimum regulatory standards):

- Improved indoor air quality, thereby potentially alleviating asthma, headaches, and lung and eye irritation.
- Reduced toxic waste since no paint thinner is required to clean low/zero-VOC paints
- Reduced ground-level ozone formation, more commonly known as smog. Smog, according to the U.S. EPA, contributes to lung damage, skin cancer and reduced resistance to infection in humans, as well as crop and forest damage and other problems. Using low-VOC products can help reduce these risks.
- Reduced levels of toxic biocides (preservatives), including formaldehyde.
- Increased ability to recycle leftover latex paint. Water-based paints can be recycled into high quality latex paint, whereas oil-based paints and solvents are typically “downcycled” (turned into a product with less value than paint) or incinerated to produce power.

Application

Applicable to all interior painted surfaces except metals, plastics and special high-abuse areas such as over sinks in bathrooms and kitchens. High-abuse areas may require specially formulated latex or oil-based/alkyd paints for their stain-covering and durability properties.

To improve durability and make cleaning easier in heavily used spaces such as corridors, restrooms and laundry facilities, use a semi-gloss or highly reflective paint. When renovating or repainting an older building, test for lead in earlier coats of paint. If lead paint is present, use appropriate disposal and abatement methods.

[4.2] DWELLING UNITS

FLOORING

RECOMMENDATION 4.2.1 LOW-EMISSION FLOORING PRODUCTS AND ADHESIVES

Certain flooring products may emit formaldehyde and other VOCs. As part of any flooring replacement, specify flooring products that have been tested and approved for low emissions according to the California “Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers,” also known as Specification 01350.

Any adhesives used in installing flooring materials should have less than 50 gpl of VOCs.

This measure improves indoor air quality and reduces outdoor air pollution associated with VOCs.

Description of Measure

Common floor coverings such as carpet are primary contributors to problems with indoor environmental quality. Volatile organic compounds (VOC) are present in the binders used the manufacturing of carpet and carpet padding as well as in the adhesives used to lay the carpet. The offgassing of formaldehyde (a VOC) over time is a principal threat to indoor air quality from the installation of commonly used floor coverings like carpet.

The State of California’s Special Environmental Requirements Specification, Section 01350, contains specification language on environmental and public health considerations for sustainable building projects. Section 01350 was developed by the California Integrated Waste Management Board (CIWMB), Department of Health Services and other state agencies and experts. The specification covers many aspects of green building, including energy, materials and water efficiency, and IAQ.

Section 01350 includes product selection guidelines, as well as testing protocols that require manufacturers to have their products tested by independent laboratories for compliance with specific emissions levels. CIWMB maintains a database of products that have passed the test. For more information about Section 01350, go to www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350/.

Cost and Cost Effectiveness

BENEFIT  Low and zero-VOC adhesives and sealants do not cost more than solvent-based products. Some adhesives may be more difficult to locate at retail outlets, though most are available through normal contractor suppliers. See Rec 4.2.2, 4.2.3 and 4.2.4 for recommendations on green flooring products.

COST 

Benefits

Formaldehyde is a known human carcinogen. Choosing flooring products and adhesives with low levels of formaldehyde and other VOCs will contribute to improved indoor air quality and better occupant health.

Application

Applicable to all flooring replacement projects.

RECOMMENDATION 4.2.2
GREEN FLOORING MATERIALS

When replacing carpeting or vinyl flooring in units, specify environmentally preferable flooring materials. Greener material options include natural linoleum, wood, bamboo, cork, concrete, and ceramic tile.

Depending on the product chosen, this measure reduces replacement costs, increases durability, avoids potentially toxic materials, or minimizes the impact of reflooring on the environment.

Description of Measure

Conventional carpet creates pollution during manufacture, generates significant waste when replaced, is difficult to maintain and clean, and provides a habitat for dust mites, bacteria, and other allergy-causing organisms to flourish.

Carpet acts like a sink; it can absorb a host of substances tracked in on shoes, including road oil, anti-freeze, dirt, pesticides, and herbicides. Outdoors, ultraviolet sunlight breaks down some of these chemicals, but in the carpet there is nothing to remove them.

The emissions from conventional carpet and the adhesives used during carpet installation are also regarded as health threats.

Polyvinyl chloride (also called PVC or vinyl) is made from petroleum, a nonrenewable resource. The manufacture of vinyl flooring and other PVC products produces dioxin, a persistent environmental toxin. In addition, vinyl is less durable than linoleum, requiring more material change-outs over the building's life.

Natural linoleum is a durable product that was once the standard resilient flooring in the United States, but has been largely displaced by cheaper vinyl flooring. Vinyl flooring is often called "linoleum," but it is not the same material. In recent years, real linoleum has been making a comeback because of its environmental, health and performance advantages over vinyl.

Linoleum is made from abundant and rapidly renewable materials, including linseed oil (from flax), powdered wood or cork, ground limestone, resin binders and dry pigments, with a natural jute fiber backing. The linoleum manufacturing process uses relatively little energy and very few chlorine or petroleum-based resources.

Bamboo and cork are rapidly renewable materials that are known for their durability and beauty. Also both can be harvested without destroying the plant, and can be regenerated and reharvested in a relatively short period of time. Be sure to check how these products are made, as bamboo floors often use formaldehyde as binders.

Ceramic tile is another flooring option that offers outstanding durability and is easy to maintain.

Wood flooring is another option. If specifying wood flooring, look for FSC-certified hardwood flooring. Engineering flooring is also a popular alternative to solid wood. It has a thin layer of hardwood on top of a high-density fiberboard core. Reclaimed wood flooring is another option that doesn't involve cutting down old-growth forests.

One factor to consider with all flooring products is how to control the dust and particulates that enter the home and impact product life and maintenance. Most pollutants that enter a home are tracked in on the bottom of shoes. An effective way to control pollutants is to have walk-off mats at entryways and a place to remove shoes at apartment entrances. If possible, avoid carpet at apartment entrances and instead install a hard surface such as linoleum, bamboo, or ceramic tile.

Cost and Cost Effectiveness

Linoleum installation must be done by specially trained contractors, which may increase cost. Linoleum takes longer to install than vinyl, which adds labor cost. Linoleum costs between \$3.00 and \$5.00 per square foot installed, depending on type and quantity.

Linoleum generally lasts three times longer than vinyl, and is economical on a materials basis over a 15 to 20 year period. Generally, linoleum is selected for its health and environmental benefits, vibrant colors, and ease of repair rather than for its lifecycle cost benefits.

The costs of reclaimed wood vary greatly and depend upon supply.

FSC certified hardwood flooring also varies greatly in price while wood engineered products will be more affordable. Bamboo and cork flooring should be moderately priced per square foot.

Benefits

Linoleum is a durable flooring material, often lasting three times as long as vinyl. It is easier to clean than carpet, and naturally inhibits microbial growth on its surface. Scratches, cuts, abrasion and cigarette burns in linoleum can be readily repaired.

Hard wood flooring, wood flooring alternatives, and ceramic tile don't trap dust and other particulates the way that carpet does.

Application

Applicable to all projects where new flooring is installed.²⁷

RECOMMENDATION 4.2.3 LOW-VOC CERTIFIED CARPET

Where carpet is installed or replaced, specify low-VOC carpet that is certified by the Carpet and Rug Institute's Green Label Plus program or that has been tested to meet the State of California's Section 01350 standard.

Assist the property owner in developing a specification for ongoing carpet purchases.

This measure improves indoor air quality and reduces outdoor air pollution associated with VOCs.

Description of Measure

Conventional carpet creates pollution during manufacture, generates significant waste when replaced, is difficult to maintain and clean, and provides a habitat for dust mites, bacteria and other allergy-causing organisms to flourish.

Carpet acts like a sink; it can absorb a host of substances tracked in on shoes, including road oil, anti-freeze, dirt, pesticides, and herbicides. Outdoors, ultraviolet sunlight breaks down some of these chemicals, but in the carpet there is nothing to remove them.

The emissions from conventional carpet and the adhesives used during carpet installation are also regarded as health threats.

The Carpet and Rug Institute (CRI) labels low-VOC carpet cushions, carpets and adhesives with the Green Label Plus. CRI Green Label Plus follows the 14-day testing process as required by Section 01350. For carpets, the CRI has an independent laboratory test for 7 chemicals required by Section 01350, plus an additional 6 chemicals required by CRI. These are as follows: Acetaldehyde, Benzene, Caprolactam, 2-Ethylhexanoic Acid, Formaldehyde, 1-Methyl-2-Pyrrolidinone, Naphthalene, Nonanal, Octanal, 4-Phenylcyclohexene, Styrene, Toluene and Vinyl Acetate.²⁸

For adhesives, the CRI has an independent laboratory test for 10 chemicals required by Section 01350, plus an additional 5 chemicals required by CRI. These include: Acetaldehyde, Benzothiazole, 2-Ethyl-1-Hexanol, Formaldehyde, Isooctylacrylate, Methylbiphenyl, 2-Methyl-Pyrrolidinone, Naphthalene, Phenol, 4-Phenylcyclohexene (4-PCH), Styrene, Toluene, Vinyl Acetate, Vinyl Cyclohexene, and Xylenes (m-,o-,p-).²⁹

Green Label Plus carpets and adhesives must also undergo a three-tiered testing program including an initial test demonstrating that it meets Section 01350 and the additional CRI criteria, quarterly testing to demonstrate that the carpet meets the total volatile organic compounds criteria, as well as annual testing to demonstrate that the carpet meets the TVOC emissions criteria plus stringent emissions criteria for 13 individual compounds.³⁰

If carpets are to be installed that aren't Section 01350-compliant or labeled with the CRI Green Label Plus, insist that the:

27. For more information refer to the *Multifamily Green Building Guidelines*, www.multifamilygreen.org.

28. www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/carpet-and-adhesive.cfm.

29. *Ibid.*

30. *Ibid.*

- Installer first unrolls them and allows them to ventilate off-site for three weeks prior to installation (this may depend on availability of space, in which case an extra charge will result).
- Installer uses no adhesives for carpet padding or carpet, only tack strips or double-sided tape.
- After installation, property manager keeps windows open whenever possible to air out toxins.
- After installation, installer or maintenance manager shampoos and then seals with AFM Safecoat carpet toxin lock-out system products (www.afmsafecoat.com/products.html) or similar type product. Research products presently used for the cleaning, maintenance, and pest management and seek to develop and improve standards for the safest products and procedures. AFM (American Formulating & Manufacturer) has a line of cleansing products called SafeChoice. They offer all purpose cleaners, degreasers, and carpet shampoos that are odorless, dye free, nontoxic, non-irritating, and biodegradable.

Cost and Cost Effectiveness

BENEFIT		Choosing carpet and adhesives that have been certified by the Carpet and Rug Institute Green Label Plus Program or Section 01350 ensures that the products have met rigorous testing to improve indoor air quality and are products with very low VOC.
COST		

Benefits

Low-VOC carpeting, cushion and adhesives improve indoor air quality by reducing offgassing.

Application

Low-emission carpet can be used everywhere standard carpet is used.

RECOMMENDATION 4.2.4

CARPET TILES AND RECYCLED-CONTENT CARPET

Consider carpet tiles rather than sheet roll when recarpeting common areas. This allows for easy replacement or relocation of tiles in high traffic areas.

Explore using recycled-content carpet when feasible.

When replacing carpet, products should meet Section 01350 of the California Code or Carpet and Rug Institute's Green Label Plus requirement (see Rec. 4.2.3).³¹

This measure reduces waste, strengthens markets for recycled products, and may reduce recarpeting costs.

Description of Measure

One method to minimize the environmental and health consequences of carpeting (described in Rec. 4.2.3) is to limit its use: don't use wall-to-wall carpeting if you don't need to. To further reduce waste and improve indoor air quality (IAQ), use a durable carpet with high recycled content and low levels of volatile organic compounds (VOCs), and use a low-VOC adhesive or physical attachment.

Depending on the kind of sheet carpet used, carpet cushion (or underlay) may be needed. Carpet cushion can improve carpet's insulation properties, reduce wear from foot traffic and furniture, and prolong appearance. It is available in a variety of thicknesses, the most common being ¼ and ½ inch. Carpet cushions, made from bonded urethane, jute, synthetic fiber and rubber, are available with high percentages of recycled materials.

Recycling carpet at the end of its useful life is important. Many carpet manufacturers are implementing programs for pickup, reuse or recycling of old carpet. Some

31. CA Dept. of Health, www.dhs.ca.gov/deod/ehlb/IAQ/VOCS/LORS/Section_01350_preface.htm and The Carpet and Rug Institute, www.carpet-rug.org/drill_down_2.cfm?page=8&sub=3.
 32. "Selecting Carpet & Rugs." The Carpet and Rug Institute, carpet-rug.org/drill_down_2.cfm?page=13&sub=9&requesttimeout=350.

manufacturers also offer carpet leasing as a way to promote recycling and possible reuse. Check with vendors for such take-back programs.

Carpet tiles provide options for high traffic areas, with easy installation and replacement. Carpet tiles can also come with moisture barriers that reduce potential bacteria growth as well as long-term maintenance costs.³² However, if sheet roll is used:

- Specify carpet with recycled content in the fibers and backing.
- Consider a multi-use carpet pad made of jute or cotton rather than the low grade and single-use foam typically used. There are also pads made out of coarse wool with a jute backing by Applefleece and Earthweave. Envirofelt is a carpet pad that is made out of recycled rubberized felt waffle.
- Establish protocol for recycling carpet taken out of units. This is typically agreed upon at the time of purchase with either the carpet distributor or the carpet manufacturer. The service includes pulling up and hauling away the carpet free of charge.

Cost and Cost Effectiveness

BENEFIT		Tiles are typically double the price of carpet rolls but are fully recyclable.
COST		Carpet tiles may save money since damaged tiles can be selectively replaced. However, this may require stocking spare tiles in case the product line is discontinued.

Benefits

Purchasing carpet tiles reduces the need for full recarpeting because when an area is worn or stained, only some of the tiles need to be replaced. In addition, tiles are easily installed and potentially reduce long-term maintenance costs.

Recycled carpet helps promote markets for recycled products. Recycled-content carpet made from soda bottles (PET plastic) offers vibrant colors and high stain resistance thanks to the plastic's natural stain-deterring properties. Recycled nylon carpet, more common in commercial-grade products, performs the same as nonrecycled products. Some nylons can be processed back into carpet fiber, while others are ground up and used for backing materials. Natural fiber carpets are made from renewable resources that are replenished in less than ten years.

Application

High recycled-content carpet can be used everywhere standard carpet is used. Areas with high traffic, such as entrances, lobbies and community areas, can benefit from resilient commercial-grade sheet or tile carpeting. If the budget allows, use durable commercial carpet for the residences as well.

[4.3] DWELLING UNITS

CABINETS

RECOMMENDATION 4.3.1 DURABLE AND HEALTHY CABINETS

For any cabinet replacement, specify durable cabinets with no added formaldehyde. Assist the property owner in developing a standard specification for durable and healthy cabinet replacement and upgrades upon unit turnover.

This measure improves indoor air quality and reduces resource use.

Description of Measure

Durable cabinets save money and minimize waste. When selecting products made with composite woods, look for durability and low toxicity. Uncoated particleboard, for example, is prone to swelling when wet and can fall apart much more quickly than other materials in kitchens and bathrooms. Key features that contribute to durability include:

- All casework is built with exterior-grade plywood or no added-formaldehyde medium density fiberboard (MDF), assembled with adhesives, screws and bolts.
- Cabinet doors are hardwood.
- Full extension drawer slides have ball bearings.
- Cabinet joints are dovetail construction.
- Hinges are stainless steel and attach to doors from two directions.

Many composite woods are produced with formaldehyde binders that offgas for years after installation. The U.S. EPA classifies formaldehyde as a probable human carcinogen; it can also cause skin, eye and respiratory irritation.

Formaldehyde glues in composite wood products come in two forms: urea and phenol. Urea-formaldehyde binders are more common. Phenol-formaldehyde binders are used in exterior applications because they help waterproof the wood; the waterproofing quality makes phenolic glues offgas more slowly and in lower quantities than urea glues, reducing harmful effects on indoor air quality. MDF, plywood and other face stock are available with no added formaldehyde; most use MDI (methyl diisocyanate) resins instead.

Alternatives to composite woods with added urea formaldehyde are: exterior-grade plywood; MDF with no added formaldehyde; powder-coated MDF; oriented strand board (OSB); and straw MDF. For higher-end applications, solid wood, no-added formaldehyde bamboo plywood, and biocomposites (wheat, straw or sunflower seed hulls) are possibilities.

Conventional wood products can be replaced with FSC-certified wood. These can be solid wood, plywood or MDF products. Other alternatives to conventional wood include materials made from rapidly renewable resources grown and harvested within a 10-year cycle, such as bamboo, wheat straw and rice hulls.

Cost and Cost Effectiveness

BENEFIT		Availability and cost vary greatly. Most options cost more initially than standard practice, but durable cabinets save money over time due to decreased damage, reduced maintenance, and longer product life.
COST		

Benefits

Interior products with no added formaldehyde help protect indoor air quality. Formaldehyde added to wood products offgases for years after the product is manufactured. In low levels, it is not considered harmful to humans. But with cabinetry, closed doors and drawers can allow the formaldehyde gas to collect and increase in concentration. When a cabinet is opened, a cloud of formaldehyde is released, often directly into the breathing zone.

Selecting low-VOC and water-based adhesives, sealants and coatings further improves IAQ.

Durable cabinetry lasts longer and reduces replacement costs and construction waste over time. Using rapidly renewable resources such as bamboo and wheat straw reduces the use of trees and helps preserve forests.

Application

Replacement and refurbishment of kitchen and bathroom cabinetry.

[4.4] DWELLING UNITS

COUNTERTOPS

RECOMMENDATION 4.4.1 DURABLE AND HEALTHY COUNTERTOPS

For any countertop replacement, specify durable products with no added formaldehyde. Assist the property owner in developing a standard specification for durable and healthy countertop replacement and upgrades upon unit turnover.

This measure improves indoor air quality and reduces waste and resource use.

Description of Measure

Typical countertops consist of thin plastic laminate (about 1/16-in.) glued to a particleboard substrate. Laminates are made with sheets of resin-saturated paper bonded together under pressure. The topmost sheet is the decorative layer, which could be a solid color or printed pattern or picture. Conventional particleboard and many other composite woods are produced with formaldehyde binders that offgas for years after installation. As noted in Rec. 4.3.1, the U.S. EPA classifies formaldehyde as a probable human carcinogen that should be avoided whenever possible.

When specifying laminate countertops, specify high-pressure laminates, which are thicker and more durable than cheaper low-pressure (sometimes called post-formed) laminates. Also specify an alternative substrate, such as an MDF underlayment with no added formaldehyde. Suitable products include Medite II and wheatboard, a straw-based MDF. If a no-added formaldehyde board is not used, all unlaminated countertop surfaces should be treated with two coats of a low or zero-VOC sealer or paint prior to installation. If the countertops are replaced with a typical laminate, specify a low-VOC (70 to 100 gpl) non-flammable contact cement, rather than the typical high-VOC (700 to 700 gpl) contact cement.

For durability that can rival or exceed solid surface or stone but at a fraction of the cost, consider tile. Tile can be made from just about any material including ceramic, porcelain, glass, stone, concrete, terrazzo, or even metal. Tile is generally installed with thinset adhesive over cement backer board to ensure a moisture resistant, thermally stable bonding surface. To minimize grout joints and associated maintenance, choose larger format tiles, ideally full counter depth. Flat tiles will provide a more even, easier to clean surface. Epoxy grout is more hazardous to health until it has cured but has superior strength, durability, mildew and stain resistance than conventional grout.

Performance characteristics depend on the tile material. Glazed ceramic or porcelain tile is water and stain resistant and should not require sealing.

Cost and Cost Effectiveness

BENEFIT		Material and installation costs vary greatly. Durable countertop materials reduce waste and save money over time due to decreased damage, reduced maintenance, and longer product life.
COST		

Benefits

Interior products with no added formaldehyde and low-VOC, water-based adhesives, sealants and coatings help protect indoor air quality.

Application

Replacement and refurbishment of kitchen and bathroom countertops.

BATHROOM IMPROVEMENTS

RECOMMENDATION 4.5.1

ENERGY STAR BATHROOM FANS

Evaluate opportunities to install Energy Star bathroom fans. The fans should be equipped with appropriate controls and exhaust to the outdoors.

This measure reduces energy costs and minimizes the occurrence of mold or rot.

Description of Measure

To the extent physically and financially feasible, all bathrooms should have a fan that is vented to the exterior and have controls that exhaust moisture automatically. Control strategies include:

- Timer connected to the light switch that runs for a pre-set time after being turned on (independent of being turned off).
- Continuously running ventilation fan.
- Humidistat sensor that automatically runs when moisture is present.

All fans should be Energy Star qualified. See www.energystar.gov for product lists.

Cost and Cost Effectiveness

BENEFIT



Energy Star–qualified bathroom and utility fans provide energy savings and are quieter than standard models.

COST



In addition, Energy Star fans that include lighting use 65 percent less energy than standard models.

Benefits

Properly ventilating bathrooms will reduce the possibility of rot, mold, and other moisture problems. Energy Star–qualified ventilation fans provide better efficiency and comfort with less noise, and use high-performance motors that last longer.

Application

Bathroom configurations that permit fans that will vent to the outside.

[4.6] DWELLING UNITS

PLUMBING SYSTEMS, FIXTURES, AND FITTINGS

RECOMMENDATION 4.6.1 LOW WATER-USE FIXTURES

Inspect all dwelling unit plumbing fixtures and specify low water-use fixtures as necessary. Showerheads should use 2.5 gallons per minute (gpm) or less, kitchen faucets 2.0 gpm or less, and bathroom faucets 1.5 gpm or less. Flow limiters or flow control valves should be installed in all kitchens and bathrooms.

This measure reduces water and energy costs.

Description of Measure

Flow limiters are built into the faucet or are screwed on. Aerators or laminar flow devices are considered flow limiters. Permanent flow control valves are installed underneath the sink/faucet and restrict the amount of water entering the faucet. Low-flow fixtures that meet the above standard are easy to find and competitively priced.

Cost and Cost Effectiveness

BENEFIT  Low-flow showerheads and faucets are cost effective and usually pay for themselves within one year. Some laminar faucets will cost more than aerator faucets.

COST 

Benefits

Low-flow fixtures save water and money. In addition, low-flow faucets and showerheads save energy by reducing the amount of hot water used.

Application

Applicable in all projects. Water-saving opportunities in residences include kitchen and bathroom faucets and showerheads.

RECOMMENDATION 4.6.2 HIGH EFFICIENCY TOILETS

As part of any toilet replacement, specify High Efficiency Toilets (HETs) that use less than 1.28 gallons per flush). Evaluate the cost effectiveness of replacing existing toilets with higher efficiency models independent of other rehabilitation activities.

This measure saves money and water.

Description of Measure

Install HETs that meet the rigorous performance requirements of North American water agencies. These fixtures are identified as meeting or exceeding a 250 gram waste removal threshold as defined in the Maximum Performance (MaP) testing report or passing the Uniform North American Requirements (UNAR) standard. A complete listing of HETs and the MaP and UNAR reports can be downloaded from the product webpage of the California Urban Water Conservation Council: www.cuwcc.org/products_tech.lasso.

One type of HET is the dual-flush toilet, which allows users to choose between a short flush and a longer flush.

Cost and Cost Effectiveness

BENEFIT  HETs are cost effective and pay for themselves within one year in most cases.

COST 

Benefits

HETs save water and money.

Application

Applicable in all projects.

LIGHTING SYSTEMS

RECOMMENDATION 4.7.1
LAMP SPECIFICATIONS

Specify compact fluorescent lamps (CFLs) and T8 linear fluorescent lamps with electronic ballasts as a replacement for incandescent lamps and T12 lamps with magnetic ballasts. When possible, specify hard-wired CFLs for any new and replacement light fixtures. Any recessed cans should be insulation contact air-tight (ICAT) compact fluorescent models.

Specify LED exit signs to replace fluorescent and incandescent exist signs in all feasible applications.

This measure reduces electricity use, maintenance costs, greenhouse gas emissions and air pollution.

Description of Measure

For a complete description of this measure, see Rec. 3.1.1.

Cost and Cost Effectiveness

BENEFIT  See Rec. 3.1.1.
.....
COST 

Benefits

See Rec. 3.1.1.

Application

See Rec. 3.1.1.

APPLIANCES

RECOMMENDATION 4.8.1
ENERGY STAR APPLIANCES AND KITCHEN FANS

Specify Energy Star refrigerators, dishwashers, and clothes washers as part of any appliance replacement. Additionally, select refrigerator models that are listed on the American Council for an Energy Efficient Economy (ACEEE) website at www.aceee.org. Evaluate the cost effectiveness of replacing appliances with higher efficiency models prior to the end of their useful life.

This measure saves water, energy, and money.

Description of Measure

Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. It is a voluntary labeling program that aims to reduce greenhouse gas emissions by helping consumers to purchase the most energy-efficient products available. Energy Star sets standards for energy efficiency that roughly target the upper 20 percent of current off-the-shelf technologies. Products that meet the energy efficiency requirements are eligible for the Energy Star label. In addition to saving energy, many qualified products also save water.

Major home appliances that are eligible for the Energy Star label include:

- Refrigerators
- Dishwashers
- Clothes washers

Energy Star qualified refrigerator models use at least 15% less energy than required by current federal standards and 40% less energy than the conventional models sold in 2001.³³ They are more efficient because they are built better, with high-efficiency compressors, improved insulation, and more precise temperature and defrost control.

Energy Star dishwashers save water heating energy by using an internal water heater to boost temperatures inside the dishwasher, which allows the home's water heater to be reduced to 120°F. This can save significant water heating costs. They also have more efficient motors and advanced sensors that determine the length of the wash cycle and the temperature of the water necessary to clean dishes, allowing for shorter cycles for light loads.

Energy Star washing machines are available in commercial and residential models that reduce water consumption by over 40%.³⁴ Energy Star washing machines also save water heating energy. According to the Environmental Protection Agency, Energy Star washing machines use 50 percent less energy compared to conventional washers.³⁵ See Rec 2.6.1 for details.

Cost and Cost Effectiveness

BENEFIT  Energy Star criteria are developed to be cost effective for the national average cost of electricity, which is substantially lower than California rates. In addition, Energy Star products are often eligible for rebates thereby increasing the cost-effectiveness of the product.

COST 

Energy Star refrigerators are widely available from most major appliance sources at competitive costs.

Energy Star dishwashers use an internal water heater to boost temperatures inside the dishwasher. This means that household water heaters can be turned down to 120°F, saving water-heating costs.

Energy Star qualified kitchen range, bathroom, and utility fans provide energy savings and are quieter than standard models and assist with odor and moisture issues. In addition, fans that include lighting use 65% less energy than standard models. For kitchen fans, ensure that the fans exhaust to the outside.

Rebates are frequently available for qualifying appliances, and can offset a significant portion of any incremental cost increases. Clothes washers may be eligible for multiple rebates. For information about rebates, go to

www.energystar.gov/index.cfm?fuseaction=rebate_rebate_locator

or PG&E's website, www.pge.com/rebates.

Benefits

Energy Star appliances save money, water and energy. Most of these products are superior in quality and performance to unqualified models. While some Energy Star appliances may cost more upfront, in general they all cost less to operate over time

Application

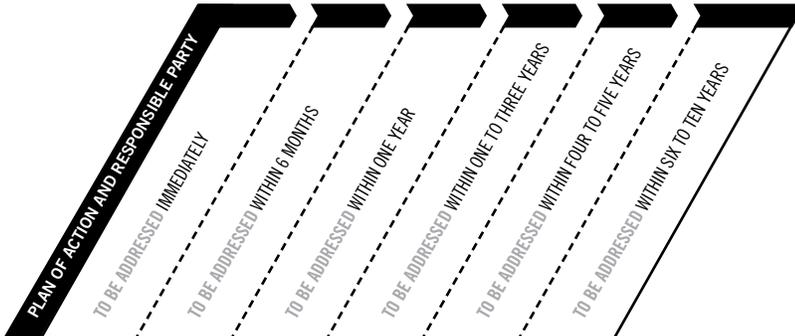
Install in place of standard home appliances. Appliance replacement can be performed independently or as part of dwelling unit rehabilitation.

33. www.energystar.gov/index.cfm?c=refrig.pr_refrigerators.

34. www.energystar.gov/index.cfm?c=clotheswash.clothes_washers_advanced_technology.

35. www.consumerenergycenter.org/home/appliances/washers.html.

BUILDING WALK-THROUGH CHECKLIST AND RECOMMENDATION FORM



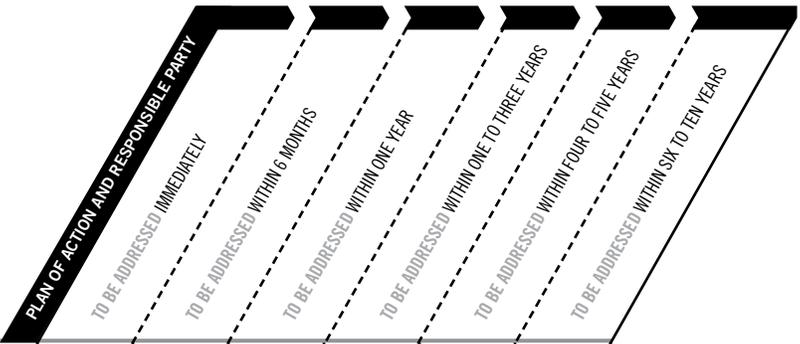
SITE CONDITION AND SYSTEMS

		PLAN OF ACTION AND RESPONSIBLE PARTY	TO BE ADDRESSED IMMEDIATELY	TO BE ADDRESSED WITHIN 6 MONTHS	TO BE ADDRESSED WITHIN ONE YEAR	TO BE ADDRESSED WITHIN ONE TO THREE YEARS	TO BE ADDRESSED WITHIN FOUR TO FIVE YEARS	TO BE ADDRESSED WITHIN SIX TO TEN YEARS
Drainage	Increase pervious surfaces to reduce water runoff, filter and drain stormwater.							
Concrete Flatwork	Displace portland cement in concrete mixes with at least 20% recycled content (flyash or slag).							
Soils and Landscaping	Incorporate design features that enhance soil quality and encourage beneficial pollinators and wildlife.							
	Use “smart” irrigation controllers and high-efficiency irrigation systems.							
Site Lighting	Use full cut-off luminaires or fixtures certified by the International Dark-Sky Association.							
Parking/Pedestrian and Bike Friendly Community	Provide bike parking and storage for residents, visitors, and employees.							
Swimming Pools	Replace pumps and motors with energy-efficient models and use pool blankets on heated pools.							
	Use solar pool heaters to heat the pool.							

BUILDING CONSTRUCTION

Foundation and Slab	Implement “cool site measures” such as using light-colored materials, planning for shade, and mulch for walkways and paths.							
Exterior and Interior Walls	Use recycled-content paint and/or low-VOC paint.							
	Specify durable siding, such as fiber cement, stucco, metal, brick, stone, or certified sustainable wood.							
	Evaluate insulation levels and quality to ensure that any added insulation contains no added formaldehyde.							
Roofs, Gutters, and Downspouts	Specify durable roofing products to reduce waste, minimize replacement costs, and protect the building from moisture.							
	Use cool roof products that meet Energy Star levels of efficiency.							
	Install a green roof to reduce cooling costs and minimize stormwater runoff.							
Windows	Provide shade, such as an overhang, trellis, landscape, or awning, to all south-facing windows.							
	Replace inefficient windows with high-performance windows.							
Building Mounted Exterior Lighting	For all new exterior lighting fixtures that contribute to light pollution, use full cutoff luminaires or fixtures certified by the International Dark-Sky Association.							
Laundry Facilities	Install Energy Star qualified residential and commercial-grade clothes washers.							

BUILDING WALK-THROUGH CHECKLIST AND RECOMMENDATION FORM



MECHANICAL SYSTEMS

		PLAN OF ACTION AND RESPONSIBLE PARTY	TO BE ADDRESSED IMMEDIATELY	TO BE ADDRESSED WITHIN 6 MONTHS	TO BE ADDRESSED WITHIN ONE YEAR	TO BE ADDRESSED WITHIN ONE TO THREE YEARS	TO BE ADDRESSED WITHIN FOUR TO FIVE YEARS	TO BE ADDRESSED WITHIN SIX TO TEN YEARS
Lighting Systems	Use compact fluorescent lamps and other high-performance lighting such as linear fluorescents.							
	Install low-mercury lamps and assist the property owner in recycling used fluorescent lamps.							
Plumbing Systems, Water, and Gas	Use solar hot water heating to supply hot water needs.							
	Work with a plumber to improve hot water heating efficiency.							
Heating	Replace boiler or furnace with a more energy-efficient model.							
Cooling	Use Energy Star ceiling fans in bedrooms and living rooms.							
	Replace air conditioning systems with non-CFC or HCFC-based refrigerants.							
	Replace central air conditioning systems with high-efficiency units.							
Elevator	For hydraulic elevators, use plant-based lubricants, or opt for a gearless elevator.							
Renewable Energy	Explore options for onsite electricity generation.							
Existing Building Commissioning	Retro-commission the building.							

DWELLING UNITS

Wall and Ceiling Finishes	Specify paints with low or no volatile organic compounds (VOCs) for painting interior areas.							
Flooring	Use low-VOC and no-added formaldehyde flooring options.							
Cabinets	Use durable, no-added formaldehyde cabinets and assist the property owner in developing a standard specification for upgrades upon unit turnover.							
Countertops	Use durable, no-added formaldehyde countertop products and assist the property owner in developing a standard specification for upgrades upon unit turnover.							
Bathroom Improvements	Use Energy Star fans in bathrooms that exhaust to the outdoors to reduce the occurrence of mold or rot.							
Plumbing Systems, Fixtures, and Fittings	Install low water-use faucets and showerheads to reduce water and energy costs.							
	Install high-efficiency toilets or dual-flush toilets to save money and water.							
Lighting Systems	Specify CFLs and T8 linear fluorescent lamps with electronic ballasts and LED exit signs.							
Appliances	Use Energy Star refrigerators, dishwashers, and clothes washers as part of any appliance replacement.							



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