Build It GREEN
Smart Solutions from the Ground Up

2008–2011 Edition

MULTIFAMILY
GREEN BUILDING GUIDELINES

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GREEN BUILDING
In Alameda County

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ABOUT THE GUIDELINES

These Guidelines were produced through collaboration between Green Building in Alameda County and Build It Green. They are designed for the multifamily residential building industry in California. They offer:

» Cost-effective suggestions to minimize construction-related waste, create healthier and more durable residences, reduce operating costs for owners and support local manufacturers and suppliers of resource-efficient building materials.

» Methods to reduce the environmental impacts of building in California communities, including infill development, energy efficiency, indoor environmental quality, solid waste management, water conservation and resource conservation.

ABOUT GREEN BUILDING IN ALAMEDA COUNTY

The Green Building in Alameda County program works with building professionals and local governments in Alameda County, California, to increase the supply and capacity for green building, and engages in consumer outreach to increase the demand for green building. Green Building in Alameda County is a program of StopWaste.Org, which is the Alameda County Waste Management Authority and Source Reduction and Recycling Board operating as one public agency.

ABOUT BUILD IT GREEN

Build It Green is a professional non-profit membership organization whose mission is to promote healthy, durable, energy- and resource-efficient buildings in California. Supported by a solid foundation of outreach and education, Build It Green connects consumers and building professionals with the tools and technical expertise they need to build quality green homes. Build It Green fosters collaboration with key stakeholder groups to accelerate the adoption of green building standards, policies, and programs. (For more information, see the Resources section at the end of these Guidelines.)

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DISCLAIMER

MULTIFAMILY GREEN BUILDINGS: THE BIG PICTURE

Why green building matters

Green building means improving our design and construction practices so that the homes we build today will last longer, cost less to operate and won't harm people's health. Green building also involves protecting the climate, conserving natural resources and improving the built environment so that people, communities and ecosystems can thrive.

Although all sectors of the economy affect the environment, the building sector's impacts are particularly large. Buildings, it turns out, account for nearly half of all greenhouse gas emissions annually in the United States. Green buildings help rein in these emissions because they use less fossil fuel–based energy for heating and cooling, water heating, lights and appliances. While green building principles encourage building energy-efficient new homes, perhaps more importantly, they also emphasize improving the energy performance of existing homes. Given that in 2006 California had more than 13 million housing units—31% of which were in multifamily buildings—retrofitting existing buildings is a key strategy for climate stabilization.

Using energy to keep lights burning and air conditioners humming isn't the only way that buildings contribute to global warming. Water use is also intimately tied to the production of greenhouse gases, a result of the tremendous amount of energy used to treat and distribute water. In fact, California's single largest energy user is the California State Water Project, which moves water from the San Francisco Bay and Delta to Southern California. Natural Resources Defense Council reports that the "amount of energy used to deliver that water to residential customers in Southern California is equivalent to approximately one-third of the total average household electric use in the region." Efforts to reduce residential water use not only conserve a resource that's in increasingly short supply, they also help reduce greenhouse gas emissions associated with water distribution.

Waste reduction and recycling, two fundamental green building strategies, can also have a profound effect on climate stabilization. Take lumber, for example. Reusing or recycling wood waste during construction and demolition activities keeps wood out of landfills, which reduces the amount of methane produced when organic materials decompose. Methane is twenty-one times more potent as a greenhouse gas than carbon dioxide. Recycling and buying recycled-content products also protects the climate because making products from recycled materials typically uses less energy than making goods from virgin resources.

Land use decisions also play a critical role in climate stabilization. A recent study by the Urban Land Institute, "Growing Cooler: The Evidence on Urban Development and Climate Change," provides evidence that carbon dioxide emissions "will continue to rise, despite technological advances, as the growth in driving overwhelms planned improvements in vehicle efficiency and fuel carbon content." Better community planning—including the compact, transit-oriented, mixed-use developments encouraged by green building—has significant potential to reduce the miles that residents drive, the study concludes.

For these and many other reasons, policymakers, building professionals and residents across the state are embracing green building as one of the principal solutions to the environmental challenges confronting us.

WHAT'S NEW

The 2008 edition of the *Multifamily Green Building Guidelines* consist of 66 recommended measures grouped into six sections: Planning & Design, Site, Structure, Systems, Finishes & Furnishings and Operations & Maintenance.

Although the section categories are the same as in the 2004 edition of the Guidelines, the measures have been thoroughly revised and updated to reflect the current state of the green building industry. Some original measures have been consolidated; for example, the measures encompassing passive solar heating, thermal mass flooring, daylighting, and building placement and orientation have been combined into one new measure *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).*

Also, a number of new measures have been added to each section:

- **Planning & Design:** AA3–Alternative Transportation, AA9–Affordability
- **Site:** A1–Protection of Soil, Water and Vegetation during Construction, B2–Source Water Efficiency
- **Structure:** C1–Acoustics, C2–Mixed-Use Design Strategies, C3–Commissioning, D2–Structural Pest and Rot Controls, E3–Vegetated Roofs, F2–Quality Installation of Insulation
- **Systems:** G2–Efficient Domestic Hot Water Distribution, G3–Water Submetering, J1–Building Performance Exceeds Title 24
- **Finishes & Furnishings:** K2–Recycled Paint, K6–Reduced Formaldehyde in Interior Finishes, L2–Low-Emitting Flooring
- **Operations & Maintenance:** N2–Transit Options, N4–Energy Monitors

Each section also now includes a brief case study that relates to the section's content. In addition, the Case Studies section at the back of the Guidelines includes new and updated in-depth project profiles.

What is green building?

Green building is a whole-systems approach to the design, construction and operation of buildings—from the early stages of development to the final finishes to the day-to-day operations and maintenance of the building. To move forward with greening your retrofit or new construction project, it is helpful to understand these five principles of green building:

1. Plan for livable communities
2. Use energy wisely
3. Improve indoor environmental quality and health
4. Conserve natural resources
5. Conserve water

PLAN FOR LIVABLE COMMUNITIES

For much of the twentieth century and continuing even today, zoning codes and conventional development practices encouraged the construction of homes ever further from city and town centers. With residential zoning segregated from commercial uses, people living in far-flung suburbs became completely dependent on automobiles to get from place to place.

Over the past few decades, the negative effects of sprawl have become increasingly apparent. Farmland and fertile soil are being paved over at an alarming rate. Plant and animal species are going extinct as buildings take the place of natural habitats. Carbon dioxide is accumulating in the atmosphere as vehicle miles traveled steadily increase. Time once available for family, community and personal activities shrinks as people spend more hours in their cars. Some experts even attribute the growing obesity epidemic to sprawl, as people drive more and walk less.

Today, increasing numbers of community leaders, building professionals and residents are learning how green building can help them create better neighborhoods and address these quality-of-life and environmental issues. Green building offers sensible solutions that improve an individual building's or development's performance while providing broad-based economic and community benefits. These benefits range from cleaner air to reduced traffic congestion, from more appealing recreational opportunities to a more diversified municipal tax base.

EXAMPLE STRATEGIES

» Infill and mixed-use developments that increase economic vitality and make the most of existing infrastructure *(Measures AA1 and AA4)*

» Policies, sites and designs that make it easier for people to drive less *(AA2, AA3, N2)*

» Planning and design decisions that encourage neighborliness and outdoor activities *(AA2, AA5, AA6)*

» Durable and low-maintenance materials and design strategies that help keep homes affordable year after year *(AA9, E1, E2)*

» Cool site strategies that reduce the urban heat island effect *(A5)*

USE ENERGY WISELY

VAN METER WILLIAMS POLLACK

Multifamily green buildings can blend harmoniously with contemporary design. The Nueva Vista project in Santa Cruz creates inviting spaces—inside and out.

New and remodeled residential buildings in California must comply with the most stringent energy code in the country. However, given the state's projected population growth, even this may not be enough to keep demand for energy in check. With homes accounting for roughly 31% of the electricity consumed in the state, it is clear that developers and owners of multifamily buildings have a significant role to play in helping our society address energy-related concerns.

Energy efficiency is the cornerstone of every multifamily green building. Improving energy efficiency and using renewable energy sources are effective ways to reduce the potential of energy supply interruptions, improve air quality, reduce the impacts of global warming and slow the rate at which we need to build new power plants. Improving energy efficiency also makes good sense for building owners, residents and commercial tenants: an energy-efficient building saves money by reducing utility bills year after year.

EXAMPLE STRATEGIES

» Passive solar heating, overhangs on south windows, deciduous trees on west and south sides *(Measure AA7)*

» Upgraded insulation *(F1, F2),* structural insulated panels *(D7),* high performance low-e windows *(D8)*

» High efficiency heating *(H0)* and air conditioning *(H2)* equipment, and energy-efficient appliances *(M1)*

» Solar water heating for space heating and domestic hot water *(I1);* photovoltaics for onsite electricity generation *(I2)*

IMPROVE INDOOR ENVIRONMENTAL QUALITY AND HEALTH

On average, Americans spend 90% of their time indoors, yet the air in new homes can be ten times more polluted than outdoor air, according to the U.S. Environmental Protection Agency. A common source of indoor air pollution in new and remodeled homes is the offgassing of chemicals found in many building materials, including cabinets, furniture, paint, floor finishes, adhesives and sealants. That "new house smell" is a telltale sign that there are harmful chemicals in the indoor environment. Fortunately, the building products industry is responding to these concerns by developing safer products, which are now commonly available at costs comparable to conventional products.

Poor indoor air quality is also often caused by dust and dirt tracked in on people's feet, and by other biological contaminants, such as mold that grows as a result of moisture infiltration due to inadequate ventilation, poor design and maintenance, and other factors. Green buildings are designed and maintained to reduce these and other sources of indoor air pollution.

Noise pollution is another indoor environmental concern, particularly in multifamily buildings. In fact, the World Health Organization now recognizes noise as a serious health hazard rather than merely a nuisance. Designing multifamily buildings for less noise usually results in a quieter environment for occupants, which may reduce sleep disturbances and stress levels, increase satisfaction with the building, and make the homes more attractive to potential buyers and renters.

EXAMPLE STRATEGIES

» Noise and vibration control *(Measure C1)*

» Kitchen and bathroom fans that exhaust to the outside to remove moisture from the home *(H3)*

» Track-off systems at entryways *(K1)*

» Low- or no-VOC paints, coatings and adhesives *(K3, K4)*

» Pressed-wood products with reduced formaldehyde *(K6)* and flooring with low VOC emissions *(L2)*

CONSERVE NATURAL RESOURCES

FIRST COMMUNITY HOUSING

Common rooms, such as this building at Murphy Ranch in San Jose, are an integral part of multifamily living.

Conventional building construction and operation consume large quantities of wood, water, metals, fossil fuels and other natural resources. Even though most materials used to build a home are put to good use, vast quantities are wasted. Much of this waste is avoidable. Careful management of the construction process makes a big difference.

There are many effective building strategies that conserve natural resources, as well as providing benefits such as cost savings. Some strategies reduce the amount of new material needed for construction, such as by reusing lumber, trim and fixtures from existing buildings or employing advanced framing techniques that reduce lumber requirements without compromising structural integrity.

Durability is both a conservation and cost savings strategy: durable products sometimes cost more upfront, but because they don't have to be replaced as frequently as their less durable counterparts, they save money for the building owner and are easier on the environment. Recycling and buying recycled-content products are also fundamental conservation strategies: recycling keeps valuable materials out of the landfill and reduces the demand for virgin resources to manufacture new products. Recycling also helps protect the climate, because making recycled-content products typically requires less energy than making products from virgin materials.

EXAMPLE STRATEGIES

» Reuse/recycling of construction and demolition waste *(Measure A2)*

» Recycled flyash in concrete *(D1)*

» Advanced framing techniques *(D3),* engineered lumber *(D4),* Forest Stewardship Council (FSC)-certified framing lumber *(D5)*

» Recycled-content decking, ceramic tiles, carpet and other products *(K5, M6)*

» Flooring made from rapidly renewable resources such as cork, linoleum, bamboo *(L1)*

CONSERVE WATER

California's water resources can no longer be taken for granted. In the future, according to the state's Department of Water Resources, "warmer temperatures, different patterns of precipitation and runoff, and rising sea levels will profoundly affect the ability to manage water supplies." The state's prosperity and ability to meet the needs of its growing population hinge on having adequate supplies of clean, fresh water.

California residences use 5.6 million acre-feet of applied water annually. Homes built and landscaped to use water wisely make a tremendous contribution to protecting our shared resources. Conserving water also reduces expenses for the residents, and it reduces greenhouse gas emissions because treating and pumping water consumes a tremendous amount of energy.

Multifamily developments can take advantage of a new generation of cost-effective, high efficiency appliances and landscape water management systems. They can also use recycled water or rainwater for some of their nonpotable water needs.

EXAMPLE STRATEGIES

» Low-water landscaping and high efficiency irrigation *(Measure B1)*

» Water reuse and rainwater harvesting *(B2);* green roofs *(E3)*

» High efficiency faucets and showerheads with below-standard flow rates *(G1)*

» Water submeters to encourage conservation *(G3)*

» Water-efficient dishwashers and clothes washers *(M1, M2)*

Role of integrated design in green building

Too often, design and building disciplines remain highly fragmented: developers and funders select (or are given) a site; architects design the building; mechanical and electrical engineers design HVAC and lighting; and so on. It is rare, for instance, to involve the mechanical engineer in architectural decisions, even though those decisions might significantly affect equipment costs and energy use.

To minimize the cost and maximize the benefits of green building, use an integrated design process that involves people who represent these perspectives:

» Owner

» Occupant (may be represented by an experienced property manager)

» Architect

» Mechanical/electrical/plumbing engineers

» Civil engineer/landscape architect

» Builder/contractor

» Maintenance/operations personnel

Integrated design aims to connect as many members of a project team as possible. Introduce integration early. Hold meetings early with all the major stakeholders. Tour the site. Discuss green strategies early on and set clear goals from the beginning. Whatever the goals are—providing healthy interiors, for example, or creating a zero net energy building—every team member must be aware of the goals and committed to achieving them.

Integrating the design process allows for creative solutions to complex problems. Questions can be raised and answered openly through a charrette or team meeting. New technologies or practices are explored as a group, allowing enthusiasm, skepticism and solutions to surface at the same time. Misconceptions can be cleared up, and changes to standard practice can be highlighted.

How green building can reduce costs

While the health and environmental benefits of green building are well established, many people still assume that green building costs more. But taking an integrated approach to design, as described above, can actually reduce construction and operating costs. The key to saving money is to evaluate opportunities as early as possible in the design process because the range of cost-effective solutions narrows as the design progresses.

A contractor, for example, can be engaged early in design to help steer the design away from expensive solutions and toward cost-effective ones. The options available during schematic design can include strategies such as using structural insulated panels (SIPs) instead of conventional wood framing. Such a change can often save money, energy and labor, but would be costly to do once construction documents were underway.

Just as the contractor can help the design team find cost-effective green solutions, so can the other team members. The mechanical engineer may be able to recommend increasing the exterior wall thickness to accommodate more insulation, which could result in reducing the size and cost of the heating system. If the developer is concerned with achieving HUD noise ratings and is part of this conversation, she may ask the engineer whether using special sound-rated windows will also help reduce cooling needs.

For every recommendation in these Guidelines, we have carefully weighed the measure's cost against its benefits to justify its inclusion. While not all measures will be applicable to your project, the measures included are relevant and reasonable for multifamily developments built and renovated today.

Some of the recommended measures do cost more initially, but this additional cost needs to be evaluated in the context of longer-term benefits provided, such as utility cost savings, better indoor air quality and longer building life. When considering green building measures, it is very important to balance upfront design, product and construction costs with these other significant benefits (this process of evaluating the long-term costs of design decisions is often referred to as "lifecycle cost analysis").

Funding affordable housing involves unique challenges and opportunities, particularly if the design includes green building measures that may cost more upfront but provide long-term benefits. For good information about funding affordable, green multifamily buildings, visit the Green Affordable Housing Coalition's website at www.greenaffordablehousing.org.

Green building can be seen as pushing the design and construction industry to do things that may be new, such as integrating the design process. Learning new practices sometimes costs money. But green buildings are more than just buildings. They are the end result of collaboration between people on all levels of design and construction who are committed to improving homes for today and the future.

Green Building Timetable

The table below allows you to quickly scan all the measures in these Guidelines to get a feel for when each measure becomes a priority during the development process. During the initial community planning phase, for example, critical decisions arise such as whether to choose an infill site or develop the project for mixed uses. But other measures, such as specifying engineered lumber or energy-efficient appliances, can be decided later, during design development. Use this table as a general tool for planning purposes, and refer to it as your projects progress.

DEVELOPMENT PHASE	COMMUNITY PLANNING	SITE PLANNING	CONCEPTUAL DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION	POST-CONSTRUCTION & OCCUPANCY
PLANNING & DESIGN							
AA1 Infill sites	✓						
AA2 Design for walking and bicycling	✓	✓					
AA3 Alternative transportation	✓	✓					
AA4 Mixed-use developments		✓	✓				
AA5 Outdoor gathering places		✓					
AA6 Design for safety and vandalism deterrence		✓		✓			
AA7 Passive solar design, daylighting and natural ventilation		✓	✓				
AA8 Adaptable buildings			✓	✓			
AA9 Affordability	✓		✓				
SITE							
A1 Protection of soil, vegetation and water during construction		✓			✓	✓	
A2 C&D waste management					✓	✓	
A3 Construction environmental quality					✓	✓	
A4 Recycled aggregate					✓		
A5 Cool site		✓	✓	✓			
B1 Sustainable landscaping					✓		✓
B2 Source water efficiency				✓	✓		
B3 Light pollution reduction				✓	✓		

STRUCTURE	COMMUNITY PLANNING	SITE PLANNING	CONCEPTUAL DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION	POST-CONSTRUCTION & OCCUPANCY
C1 Acoustics: Noise and vibration control				✓	✓		✓
C2 Mixed-use design strategies			✓	✓	✓		
C3 Commissioning		✓	✓	✓			
D1 Reduced portland cement in concrete				✓	✓		
D2 Structural pest and rot controls				✓			
D3 Construction material efficiencies				✓			
D4 Engineered lumber				✓			
D5 FSC-certified wood for framing lumber					✓		
D6 Raised heel roof trusses			✓	✓			
D7 Structural insulated panels and other solid wall systems		✓		✓			
D8 Window replacement					✓		
E1 Drainage planes and durable siding					✓		
E2 Sustainable roofing options				✓			
E3 Vegetated roofs			✓	✓			
F1 Insulation					✓		
F2 Quality installation of insulation						✓	

SYSTEMS	COMMUNITY PLANNING	SITE PLANNING	CONCEPTUAL DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION	POST-CONSTRUCTION & OCCUPANCY
G1 Water-efficient fixtures					✓		
G2 Efficient domestic hot water distribution			✓	✓			
G3 Water submetering			✓	✓			
G4 Water heater replacement					✓		
H0 Heating equipment				✓	✓		
H1 Radiant hydronic space heating				✓	✓		
H2 Air conditioning with non-HCFC refrigerants					✓		
H3 Advanced ventilation practices			✓	✓			
H4 Garage ventilation				✓	✓		

(SYSTEMS, continued)

DEVELOPMENT PHASE	COMMUNITY PLANNING	SITE PLANNING	CONCEPTUAL DESIGN	DESIGN DEVELOPMENT	CONSTRUCTION DOCUMENTS	CONSTRUCTION	POST-CONSTRUCTION & OCCUPANCY
I1 Solar water heating			✓	✓			
I2 Photovoltaic systems			✓	✓			
J1 Building performance exceeds Title 24		✓	✓				
J2 Building diagnostics				✓		✓	

FINISHES & FURNISHINGS

K1 Entryways					✓		
K2 Recycled paint					✓		
K3 Low/no-VOC paint and other coatings					✓		
K4 Low-VOC adhesives and sealants					✓	✓	
K5 Environmentally preferable materials for interior finish					✓		
K6 Reduced formaldehyde in interior finishes					✓		
K7 Durable cabinets					✓		
K8 Environmentally preferable interior furniture				✓	✓		
L1 Environmentally preferable flooring					✓		
L2 Low-emitting flooring					✓		
M1 Energy- and water-efficient appliances					✓		
M2 Central laundry			✓	✓			
M3 Recycling and waste collection				✓			
M4 Lighting				✓	✓		
M5 Elevators				✓	✓		
M6 Outdoor play structures		✓		✓			

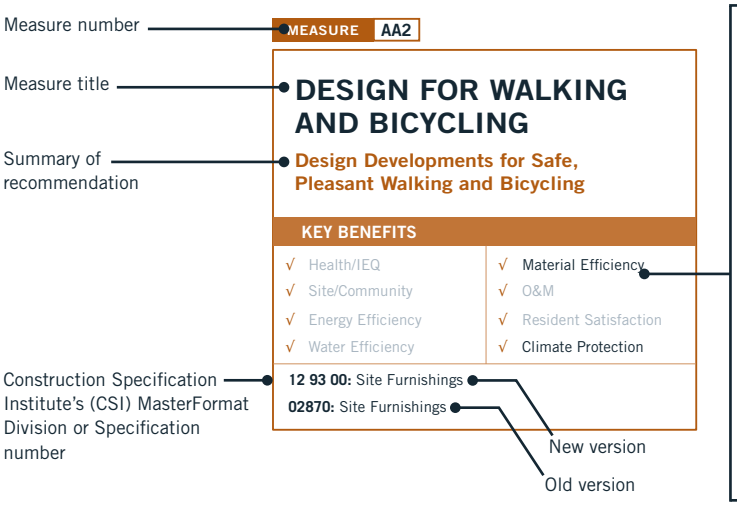
OPERATIONS & MAINTENANCE

N1 Operations and maintenance procedures					✓		✓
N2 Transit options	✓						✓
N3 Educational signage							✓
N4 Energy monitors					✓		✓

Green Building Measures

While separating green building strategies into individual measures may give the impression that they can be used in isolation, in reality each measure is closely integrated with many other design strategies. To encourage teams to work across disciplines and embrace an integrated design approach, each measure contains many cross-references to related measures. For example, the Heating Equipment measure *(Systems: H0)* contains a cross-reference to *Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation.*

The individual measures are presented with a consistent layout so you can scan them for relevant information. Each measure begins with an "at-a-glance" graphic, as shown in the example below.



This measure's principal benefits:

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate the building, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money, and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operation and location.

Following the "at-a-glance" graphic, each measure includes the following information:

RECOMMENDATION. A brief statement summarizing the recommended action or actions.

DESCRIPTION. An overview of the relevant design and construction issues, providing context for the Recommendation.

BENEFITS. Summary of benefits the measure offers, including cost savings for developers, owners and residents; waste reduction; energy and resource conservation; community benefits; environmental protection; indoor air quality improvements; and much more.

APPLICATION. Types of projects where the Recommendation is most relevant.

DESIGN DETAILS. Special design and construction details to consider when implementing the Recommendation.

CODE CONSIDERATIONS. Relevant local, state or federal code issues that may apply, above and beyond standard code considerations.

CONSIDERATIONS FOR RESIDENTS. Effect of the measure on residents, including benefits and special information the residents should know.

COST AND COST EFFECTIVENESS. In some cases, specific cost information is provided. In other cases, relative cost or lifecycle cost information is given.

BENEFIT	★★☆
COST	$$$

The symbols ★ and $ are used as rough indicators of each measure's relative benefits and costs. ★ or $ equals low benefit or cost, ★★ or $$ equals medium benefit or cost, and ★★★ or $$$ equals high benefit or cost. The cost reflects the anticipated increase over standard practice. Actual costs may vary considerably among projects and will depend on availability of materials.

RESOURCES. Additional websites, agencies, industry organizations or publications to consult for more information about this particular green building strategy.

RELATED CASE STUDIES. Cross-references to relevant project profiles in the Guidelines.

⚠ indicates cautionary notes or clarifications that the project team should take into account.

PLANNING & DESIGN

PLANNING & DESIGN

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PLANNING & DESIGN

The measures in this section encompass fundamental planning and design decisions that, for the most part, need to be made very early in the development process. The choices made at this stage, such as site selection and access to transportation alternatives, will have a profound effect on the project's success from an environmental, economic and social perspective. Many of the recommendations in this section address ways in which a development can help strengthen a community's economy and improve quality of life for all its citizens.

BENEFITS

This table lists the Guidelines' Planning & Design measures, and shows the primary benefits of each. Many of the measures in this section provide broad-based social and environmental benefits that go well beyond improving an individual building's performance. For example, people who live in mixed-use developments *(AA4)* rather than conventional suburban developments are more likely to get physical exercise by walking to nearby shops and neighborhood services.

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
AA1 Infill sites	✓	✓	✓		✓		✓	✓
AA2 Design for walking and bicycling	✓	✓					✓	✓
AA3 Alternative transportation		✓	✓				✓	✓
AA4 Mixed-use developments		✓	✓		✓		✓	✓
AA5 Outdoor gathering places	✓	✓					✓	
AA6 Design for safety and vandalism deterrence		✓				✓	✓	
AA7 Passive solar design, daylighting and natural ventilation	✓	✓	✓			✓	✓	✓
AA8 Adaptable buildings		✓			✓	✓	✓	✓
AA9 Affordability		✓				✓	✓	

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate the building, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operation and location.

CORE CONCEPTS

CONNECTIONS TO THE NATURAL ENVIRONMENT

Fundamental to green design is the relationship between a building and the natural environment. While affordable housing projects typically have more site constraints than market-rate housing, every site presents unique opportunities. The design team should carefully assess the site's natural elements—including solar access, wind conditions and existing plant and animal life—and strive to design in harmony with those elements to reduce energy use, increase livability and protect the environment *(AA7, B1).*

LAND USE AND CLIMATE CHANGE

Planning and design decisions that support compact, transit-oriented, mixed-use developments *(AA1 through AA5)* have significant potential to reduce miles that residents drive. In fact, more compact development is an essential strategy for climate stabilization, according to the Urban Land Institute and many other organizations that study land use, transportation and climate change.

INTEGRATED DESIGN

For a project to make a significant difference in terms of economic and environmental sustainability, as well as quality of life for building residents and the community at large, it's best to take an integrated approach to design. The recommended Planning & Design measures presented here are fundamental to integrated design, and should be addressed with as much care, time and resources as the project can bear. *(For more about integrated design, see the Guidelines' introduction.)*

COMMUNITY SUPPORT

An important aspect of green multifamily housing is creating conditions that foster economic and social well-being in the community. Many of the measures in this section offer tremendous community benefits, ranging from reduced traffic congestion *(AA1 through AA4)* to more attractive opportunities for recreation *(AA2, AA5, AA6)* to greater economic vitality *(AA1, AA4).* For the developer, engaging municipal representatives and community leaders early in the design process can pave the way to a much more successful project.

CODE ISSUES

In some municipalities, density, zoning and other code issues may sometimes conflict with green design strategies, such as infill *(AA1)* and mixed-use developments *(AA4),* and improved pedestrian and bicyclist access *(AA2)*. Early in the planning process, the development team should identify potentially problematic code issues and work with the appropriate officials to overcome these barriers.

COST

For local municipalities, the measures in this section can provide many economic benefits. Developments designed to reduce dependence on cars *(AA1 through AA4)* help ease traffic congestion, which can improve business productivity. Mixed-use developments *(AA4)* encourage economic vitality and a diversified municipal tax base. Infill projects help revitalize older urban areas.

For the developer, some of the recommended Planning & Design measures can be done with little or no extra cost if incorporated early. Cost increases can often be offset or minimized by adopting an integrated design approach *(see the introduction to these Guidelines).*

CASE STUDY

LOCATION, LOCATION, LOCATION:

THE TICKET TO AFFORDABILITY, SUSTAINABILITY, VAND MIXED-USE SUCCESS *Oxford Plaza, Berkeley, CA*

Oxford Plaza and David Brower Center

On a lot in downtown Berkeley that previously served as a surface parking lot, Resources for Community Development (RCD) is building a mixed-use project that will provide 97 apartments for households making from 20% to 60% of area median income.

The 100,839-square-foot urban infill project, scheduled for completion in January 2009, includes five stories of housing over one story of retail. An adjacent development on the site, the David Brower Center, is devoted to environmental education and activism and mission-driven retail space. The Brower Center partnered with RCD to develop the commercial space in both buildings.

Oxford Plaza's location is crucial to its viability as an affordable, sustainable, mixed-use development. With a BART subway station one block away, a bus hub two blocks away, and the UC campus and downtown Berkeley within easy walking and bicycling distance, residents will have excellent access to employment, shopping, recreation and educational resources.

The central location also means that the project's residents will generate much lower than normal auto traffic volumes. To replace the surface parking that had been a revenue source for the City of Berkeley, Oxford Street Development, LLC (a partnership of RCD and the David Brower Center, Inc.), built an underground garage on the site, but both the housing and retail uses are designed with less than the standard zoning requirements for car parking.

In addition to its urban infill location and mixed-use, high density design, other green features include a solar thermal system for radiant hydronic space heating and domestic hot water *(H1, I1);* low- and no-VOC paints, adhesives and flooring *(K3, K4, L2);* and rainwater collection for irrigation *(B2).* These green credentials are likely to be a strong selling point for potential retail tenants, especially those with a sustainability focus. Oxford Plaza's ground-floor commercial space was designed so that it could accommodate one larger retailer or as many as four smaller retailers.

RCD, in creating Oxford Plaza, is developing a dynamic community where the retail and the surrounding downtown neighborhood will be supported by the residents of the affordable housing above it. "People sometimes have the misconception that lower income people don't have money. In fact, they have the same need for basic necessities and services," said Lisa Motoyama, RCD's director of housing development "The working families that will be living at Oxford Plaza will have the added income support that affordable rent provides so that they will be able to shop, eat and enjoy a movie or play in downtown Berkeley."

In locating affordable housing close to jobs, transit and shopping, the City of Berkeley can expect a decrease in commuter traffic, congestion and pollution, and an increase in the number of dollars fueling the local economy, adding to the vibrancy of downtown.

For more information, visit www.rcdev.org

MEASURE AA1

INFILL SITES

Develop Higher Density Housing on Previously Developed Sites, Reuse Buildings and Restore Brownfields

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Develop higher density housing on existing urbanized sites (known as infill sites) that have sewer lines and utilities in place.

Redevelop existing buildings rather than demolishing them.

Restore and redevelop brownfields or choose a site in a designated redevelopment area.

Avoid building on environmentally sensitive sites.

Description

New development often takes place on the fringes of existing urban and suburban development. Residents of these outlying areas depend on cars because pedestrian, bicycle and public-transit travel is usually impractical. Suburban sprawl has been linked to a host of environmental and social problems, including:

- Greenhouse gas emissions and other air pollution from vehicles
- Loss of land for food production, recreation, wildlife habitat and other essential needs
- Inefficient use of public infrastructure
- Less time for family, community and physical activity
- Loss of business and individual productivity from traffic congestion

Higher density infill development addresses these and many other environmental, social and economic problems, while providing housing that reflects today's changing demographics, including a declining number of people per household. Infill development encompasses new construction as well as the adaptive reuse of existing buildings. Many types of existing buildings can be redeveloped for multifamily housing, including hotels, warehouses, factories, schools, department stores, and of course buildings that were originally residential *(for information about designing buildings so that they can be adapted in the future, see Planning & Design: AA8–Adaptable Buildings).*

Redevelopment areas often contain brownfield sites, which the U.S. Environmental Protection Agency defines as "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant." Federal and state legislation, programs and incentives exist to help developers and property owners manage brownfield redevelopment.

Do not locate projects in environmentally sensitive locations such as steep slopes, prime farmland or parkland, within 100 feet of wetlands, or in an area identified as habitat for any species on federal or state threatened or endangered species lists.

Benefits

Developments in dense urban cities typically have a smaller environmental footprint than developments in less dense areas. The strategies in this measure expand the local tax base, foster job growth, make use of existing infrastructure, avoid greenfield development and improve quality of life and environmental quality in the community.

Where there is access to public transit or commercial activities, denser developments offer the advantage of shorter commutes, less dependence on cars, and transit-oriented walkable communities *(Planning & Design: AA3–Alternative Transportation and AA2–Design for Walking and Bicycling).*

Rehabilitating buildings minimizes demolition waste and reduces the need for new construction materials *(Site: A2–Construction and Demolition Waste Management).* Redeveloping buildings and brownfields can contribute to a community's sense of place and help keep its history alive by preserving sites that have cultural, architectural or historical value.

Protecting environmentally sensitive sites supports ecosystems that provide essential services and benefits to humans and other species.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Higher density infill development and avoidance of environmentally sensitive sites are applicable to all multifamily projects. Opportunities for building reuse and brownfield redevelopment will depend on a variety of factors, including site availability and programmatic needs.

Design Details

HIGH DENSITY INFILL

Integrate the building and its site with the existing neighborhood. Multifamily buildings, even if they are high density, should complement the neighborhood's existing development patterns. Avoid a bulky or monotonous appearance by stepping back higher stories from the street and breaking down the scale of large building volumes.

Passive solar heating and cooling, natural ventilation and daylighting can be challenging to accomplish on many high density infill sites. From the outset of the design process, actively seek opportunities to incorporate these strategies *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).*

Identify ways to facilitate social interaction, such as creating pocket parks, plazas or mixed-use developments *(Planning & Design: AA4–Mixed-Use Developments and AA5–Outdoor Gathering Places).*

BUILDING REUSE AND BROWNFIELD REDEVELOPMENT

Adapting a building that was not originally intended for residential use can present unique design challenges. Many commercial buildings, for example, have deep floorplates that make it harder to provide adequate daylight, natural ventilation, views or outdoor social gathering places for the residents. Adaptive reuse is not a new concept, however, and many architecture firms specialize in finding creative ways to make buildings livable, such as by incorporating skylights, light wells, clerestories and interior landscaped courtyards.

Many historic or industrial buildings have large, flexible spaces that are ideal for mixed-use purposes or a residential project's community facilities. Preserving and restoring an older building's original interior and exterior architectural details honors the community's history, adds visual interest and may even increase the units' marketability. Many people are drawn to living in older buildings precisely because of their distinctive character.

Consult remediation or brownfield experts if you are considering a site that has been contaminated. It may be best to avoid excavating a site and to leave contaminated soil in place. Some contaminated sites will be inappropriate for residential use if it is cost prohibitive to bring them up to acceptable standards.

Code Considerations

Policymakers can facilitate infill development by designating appropriate sites for development. Also consider revising building and zoning codes to favor higher density development in target areas; this could include relaxing height limits and parking requirements, and providing incentives for green infill developments. Policymakers and community members can support community planning processes that lead to local area plans or master plans. These processes help a neighborhood articulate its vision for development and can improve the public review process for specific development proposals. Neighborhood plans reduce uncertainty for the developer when they identify desired community facilities and development types.

Older buildings typically require significant upgrading to meet current building and energy codes. Renovations of some older buildings may have to comply with local or state design regulations for historically significant structures.

A city's redevelopment agency will have a redevelopment plan that sets out guidelines and requirements. Redevelopment of brownfield sites may be governed by state or federal regulations.

Considerations for Residents

People living in infill developments are more likely to shop, work and play close to home. They will have more public transportation options and opportunities for social interaction.

When brownfields are redeveloped, community residents benefit from improved environmental, economic and neighborhood quality. Residents of redeveloped brownfield sites may have concerns about the potential for lingering contamination. Developers should address these concerns openly and proactively.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

For the developer, infill projects may require additional design time because high quality design is critical to gaining community acceptance. Taxpayers benefit from infill development because cities pay more to provide services to suburban development than to infill development.

The cost effectiveness of reusing existing buildings varies widely, depending in large part on how extensively the building needs to be modified to meet current market needs and code requirements.

JOHN EDWARD LINDEN

MetroHollywood provides affordable housing, commercial space and daycare facilities immediately adjacent to the Hollywood/Western Metro Red Line Station in Los Angeles.

Brownfield sites can have very high cleanup costs, but some municipalities may be willing to incur these expenses in order to encourage development of neglected areas.

Some cities may offer incentives such as property transfers, grants and loans to encourage private development in redevelopment areas. These can provide significant economic benefits to developers.

Resources

INFILL

» **Local Government Commission** has an elected official's checklist for compact residential projects, "Building More Livable Communities: Design Guidelines for Multifamily Housing": www.lgc.org/freepub/land_use/guidelines/multifamily_housing.html; LGC also publishes the book, *Building More Livable Communities: A Policymaker's Guide to Infill Development:* www2.lgc.org/bookstore

» **Northeast-Midwest Institute's** online book, "Strategies for Successful Infill Development" can be downloaded for free from: www.nemw.org/infillbook.htm

» **U.S. Environmental Protection Agency's** smart growth publications include "Creating Great Neighborhoods: Density in Your Community": www.epa.gov/smartgrowth/publications.htm#comm

» **Urban Land Institute** has books and online resources on urban infill development, including "Higher-Density Development: Myth and Fact" and "Growing Cooler: Evidence on Urban Development and Climate Change," which documents that residents of compact, mixed-use, transit-served communities do less driving, an essential factor in combating climate change: www.uli.org

ADAPTIVE REUSE

» **California's Office of Historic Preservation** has fact sheets, design guidelines and information about tax incentives and codes pertaining to redevelopment of historic properties: http://ohp.parks.ca.gov

BROWNFIELD REDEVELOPMENT

» **Center for Creative Land Recycling** has resources on brownfield redevelopment: www.cclr.org

» ***Environmental Building News*** article, "Building on Brownfields" (March 1999), provides a good introduction to the subject; fee to access: www.buildinggreen.com

» **U.S. Environmental Protection Agency's** brownfields website has extensive resources: www.epa.gov/brownfields

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

» Crossroads, p. 234

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DESIGN FOR WALKING AND BICYCLING

Design Developments for Safe, Pleasant Walking and Bicycling

KEY BENEFITS

√ Health/IEQ	Material Efficiency
√ Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 12 93 00: Site Furnishings

OLD: 02870: Site Furnishings

Recommendation

Design buildings, sidewalks, pathways, streets and crossings to encourage walking and bicycling.

Build secure bicycle storage facilities on the site.

Description

Walking and bicycling are the cheapest and most sustainable forms of transportation, but they are often incompatible with conventional car-based development patterns.

Convenience, safety and aesthetics are key factors in promoting travel by foot and bicycle. Residents of developments well connected to nearby amenities are more likely to walk or bike to their destinations. Sidewalks and street crossings should be designed to provide safe and convenient pathways. Clearly differentiated vehicle, bicycle and pedestrian spaces will reduce traffic accidents. Articulated building facades and ground-floor commercial activity create a pleasing pedestrian environment.

Benefits

Walking and bicycling are excellent, inexpensive forms of physical activity that promote health. They provide alternatives to travel by car, a major source of greenhouse gas emissions, air pollution and energy use.

Traffic-calming measures may lead to lower pedestrian injury rates, greater neighborhood economic activity and increased public safety. Children, seniors and people with disabilities benefit most from increased mobility and safety.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all projects. *(For related information, see Planning & Design: AA1–Infill Sites, AA3–Alternative Transportation, AA5–Outdoor Gathering Places and AA6–Design for Safety and Vandalism Deterrence.)*

Bicycle and pedestrian-friendly developments should, at a minimum, have these characteristics:

» Sidewalks are physically, psychologically or functionally separated or buffered from the roadways.

» Traffic-calming measures are implemented.

» The housing development provides dedicated, covered and secure bicycle storage for residents.

» In mixed-use projects, the development provides additional secure bicycle storage for nonresidential tenant employees and visitors.

Design Details

PROJECT FOR PUBLIC SPACES

Striped bicycle lanes with proper signage are appropriate for streets with lower traffic volumes and speeds.

ROAD NETWORK CONNECTIVITY

Work with the city's transportation department to create a roadway system in your development with multiple roadway connections that better distributes traffic. Blocks should not exceed 300 feet.

Cul-de-sacs and one-way streets are strongly discouraged because they reduce connectivity and increase travel distances, which contributes to global warming. One-way streets also encourage speeding and circling.

SIDEWALKS

Design sidewalks to be separated from roadways and to connect with existing city walkways. Base the sidewalk widths on street size and level of pedestrian activity. A width of at least 5 feet is necessary in residential areas, while 6 to 7 feet is recommended to incorporate trees and meet requirements of the Americans with Disabilities Act. Eight to 12 feet is needed on streets with retail, services, transit and higher levels of pedestrian activity. Eight feet is the minimum width to allow two groups of two people to pass each other.

Incorporate trees and other landscaping along the sidewalk to provide shade and stormwater management *(Site: B1–Sustainable Landscaping),* a buffer between pedestrians and cars, and an enhanced streetscape. Place buffering and pathway elements including landscaping features, trash receptacles, light fixtures and street furniture such as bus shelters and benches so they do not impede the flow of pedestrians. On-street parking can also provide a buffer between pedestrians and moving vehicles.

PEDESTRIAN CROSSINGS

Locate street crossings no more than 300 feet apart. In areas with heavy pedestrian activity, more frequent spacing is recommended. Street crossings can be made safer by using crosswalk striping, enhanced signing, bulbouts or refuge islands. These measures can be used alone or in combination.

Bulbouts extend the sidewalk into the roadway to reduce the crossing distance for pedestrians. Bulbouts can be landscaped to make the streets more attractive. They can also make inset parking (spaces that appear to be recessed from the roadway) easier and safer.

Refuge islands can be located in the middle of a crosswalk, either as a stand-alone feature or part of a median. They provide a pedestrian stopping point and are particularly helpful when the roadway is very wide and has high traffic volumes.

Crosswalks should be wide enough to accommodate a wheelchair. If there are corner ramps, there needs to be enough space within the crosswalk to allow a person in a wheelchair to turn toward the direction of travel once she or he has descended to street level.

TRAFFIC CALMING

High speeds and heavy traffic volumes increase accidents and discourage social interaction in neighborhoods, which can lead to public safety problems *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).* Work with the city's engineering or public works department to implement these measures:

1. Designate bicycle lanes with proper signage and striping. A standard bike lane is 5-feet wide. Wider lanes are better for reducing conflicts with the "door zone" when there are parking spaces between the curb and the bike lane. Bicycle lanes are safest when physically separated from moving traffic by a curb or plastic dividers. Physically separated lanes are particularly important on streets leading to destinations children are likely to visit, such as schools, parks and community centers.
2. Striped bicycle lanes with proper signage are appropriate for streets with lower traffic volumes and speeds.
3. On predominately residential streets, if separate bike lanes aren't possible, use a 14-foot mixed travel lane for cars and bikes.
4. Connect bicycle lanes to a bicycle network that links to important destinations within the development and to a citywide bicycle network.
5. Design 10-foot vehicle travel lanes, rather than the standard 12 feet, to discourage fast driving.
6. Consider narrowing roads in areas with a lot of foot traffic. For example, a four-lane roadway can be redesigned into two travel lanes, one turning lane, two bike lanes and a wider sidewalk.
7. Consider speed humps, rumble strips and raised crosswalks to reduce speeding.
8. Plant trees along streets or use lampposts with banners as a vertical element to create visual interest and the perception of a narrower street, which reduces speeding.
9. Install design features at the development's key access points that provide a sense of entry and signal to drivers that the street environment has changed and they need to reduce speeds.
10. Consider limited vehicle access in mixed-use neighborhoods in the style of European street design (known in the Netherlands as "woonerf") where vehicles, pedestrians and bicyclists share the streets, but pedestrians and bicyclists have priority as road users and vehicles are limited to traveling at a walking pace.

Wave racks with wide spacing between slots will accommodate more bikes than narrow racks. Individual lockers offer the most security.

BICYCLE PARKING AND STORAGE

Outdoor bicycle racks must be well lit, secure and placed in a paved area. When possible, provide covered bicycle parking, such as underneath building overhangs.

Place racks in locations with high foot traffic and good visibility, such as near a building entrance or gathering place *(Planning & Design: AA5–Outdoor Gathering Places and AA6–Design for Safety and Vandalism Deterrence).* If the development has multiple buildings or entrances, consider placing separate racks at each location to increase convenience.

When selecting bicycle racks, look for these features:

1. Both the bike frame and one wheel can be attached to the rack with a standard U lock.
2. The rack should be firmly secured to the ground and sturdy enough to resist disassembly by thieves.
3. The inverted U rack accommodates two bicycles locked parallel to the rack. The inverted U is often preferred to grid or wave designs because it allows a bicycle's frame and wheels to be secured in two places, and provides better stability to keep the bike upright. U racks should be at least 30 inches long, with 36 inches preferred. Otherwise they may be used to park only one bike.
4. Spacing between bike slots must be wide enough to accommodate mountain-bike handlebars (typically 20 to 24 inches). For a grid or wave rack, a minimum width of 30 inches between verticals is recommended. Otherwise, the rack can only be used at full capacity if access is available from both sides.

Bike racks must be placed properly to maximize their capacity. Optimal spacing varies depending on the specific model. Check the manufacturer's literature for recommendations.

Convert garage parking spaces into bicycle parking that will serve many more residents. For example, a single 16-by-8-foot car stall can accommodate twenty bikes in a two-level bike rack.

Individual lockers provide the most security and convenience for bicyclists, but they are expensive and require more space.

For very large developments or public facilities, multilevel racks can accommodate more bicycles in a smaller space, although they are expensive.

Code Considerations

Local codes may be a barrier to pedestrian- and bicycle-friendly design. Codes typically require road widths that exceed the recommended 10-foot lane width, while specified sidewalk widths are too narrow to accommodate multiple users. Regulations on signs, underground utilities, lighting and tree placement often don't facilitate pedestrian activity or traffic calming.

Policymakers can adopt strategies to promote walking and bicycling, such as:

- Place street furniture in locations that do not obstruct pedestrian traffic.
- Promote mixed-use development and retail activity at the street level *(Planning & Design: AA4–Mixed-Use Developments).*
- Eliminate minimum parking requirements for developments with good transit service *(Planning & Design: AA3–Alternative Transportation).*
- Adopt parking policies that encourage walking within a destination area and sharing spaces among user groups.
- Designate safe biking and walking routes and properly fund their maintenance.
- Support the installation of secure bicycle parking racks in convenient public places.
- Promote the development of bicycle parking facilities at major transit centers, such as the Bikestations located in a number of California cities *(www.bikestation.org).*
- Implement traffic calming strategies.

Considerations for Residents

Quality-of-life improvements include greater mobility, safety and opportunities for physical activity. Additional benefits include lower transportation expenses and a reduced carbon footprint.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Bicycle parking costs from $220 (installed) for a basic U rack that accommodates two bikes to $600 and up per bike for storage lockers. Car parking costs $7,000 to $30,000 per space (2007 costs).

Many pedestrian site design features cost nothing if incorporated early. The cost for fixing problematic infrastructure varies greatly. Striping crosswalks and installing street humps are relatively inexpensive, but widening sidewalks and installing refuge islands are costly. However, these actions may reduce injuries and fatalities.

Resources

- **ARCAT** lists bicycle rack and locker manufacturers: www.arcat.com/divs/sec/sec02871.shtml
- **City of Davis,** which is well known for its bicycle-friendly design, has extensive information including the city's "Comprehensive Bicycle Plan": www.ci.davis.ca.us/bicycles
- **City of Portland** has Bicycle Parking Facilities Guidelines:

  www.portlandonline.com/transportation *(see Getting Around Portland/Transportation Options/Bicycles/Bicycle Parking)*
- **Local Government Commission** has bike and pedestrian design guidelines and other resources: www.lgc.org
- **Non-Profit Housing Association** has information about planning for residential parking: www.nonprofithousing.org *(see Action Center/Tool Box)*
- **University of California, Berkeley's** Campus Bicycle Plan has guidelines for improving bicycle access and safety: http://pt.berkeley.edu/transportation_alternatives

Related Case Studies

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ALTERNATIVE TRANSPORTATION

Make It Easier for People to Drive Less

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Choose a site where people can easily walk to many neighborhood services and to public transit stops.

Reduce the development's parking capacity.

Description

Housing located where people can easily walk to public transit stops and places they need to go regularly, such as jobs, stores, schools, restaurants and parks, is often called transit-oriented development (TOD). Caltrans defines TOD as "moderate to higher density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment, and shopping opportunities designed for pedestrians without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use."

According to a recent study by the Urban Land Institute, "Growing Cooler: The Evidence on Urban Development and Climate Change," more compact development is an essential strategy for climate stabilization. The study's authors provide evidence that carbon dioxide emissions "will continue to rise, despite technological advances, as the growth in driving overwhelms planned improvements in vehicle efficiency and fuel carbon content." Better community planning—compact, transit-oriented, mixed-use development—has significant potential to reduce the miles that residents drive, the study concludes.

For affordable housing, it is particularly important to choose a site within easy walking distance of public transit and neighborhood services. A national study published in 2007 and funded by the Federal Transit Administration and the U.S. Department of Housing and Urban Development found that proximity to public transportation plays a large role in determining a household's expenses. "While families who live in auto-dependent neighborhoods spend an average of 25 percent of their household budget on transportation, families who live in transit-rich neighborhoods spend just 9 percent," according to the study.

In addition to choosing a transit- and pedestrian-friendly site, reducing the amount of onsite parking helps reduce a community's negative environmental impacts and contributes to a more pedestrian-friendly community. Excessive parking adds to construction costs, and may contribute to the heat island effect *(Site: A5–Cool Site)* and stormwater runoff *(Site: A1–Protection of Soil, Vegetation and Water)*. It also encourages residents to drive when it may not be necessary, which contributes to traffic congestion, air pollution, and global warming.

For information about onsite transit information kiosks and other strategies to encourage residents to use public transit, see Operations & Maintenance: N2–Transit Options.

Benefits

Developments in transit-oriented, pedestrian-friendly communities make it easier for people to do without a car or to drive less, thereby reducing their greenhouse gas emissions, increasing walking and biking trips, and saving them money. Dedicating less space to parking allows more of the land and construction budget to go toward site amenities including open space, parks, community rooms or more housing units.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

When selecting a development site, choose a location with good pedestrian access to neighborhood services. Pedestrian access is most meaningful, and reduces the most car trips, when the site is close to places that many people visit frequently. Give preference to sites within one-half mile of as many of these types of facilities as possible: day care centers, community centers, public parks, drug stores, grocery stores, restaurants, schools, libraries, farmer's markets, after-school programs, and convenience stores where meat and produce are sold.

It's less critical that the site be near facilities that people don't visit as frequently, such as banks, places of worship, fire stations, hardware stores and theaters. These facilities tend to generate less daily traffic and instead have spikes in use at certain times of the day or week.

Design Details

PEDESTRIAN ACCESS TO TRANSIT AND SERVICES

Choose a site that's close to public transit stops, preferably no more than one-quarter mile from one or more bus stops, and/or no more than one-half mile from a commuter train or light-rail transit system stop. Find locations where good transit service already exists, or where future service improvements are planned, such as an historic town center or redevelopment district.

Design for a safe and enjoyable walk from the project site to neighborhood services and transit stops *(Planning & Design: AA2–Design for Walking and Bicycling and AA6–Design for Safety and Vandalism Deterrence).* Integrate the development into the surrounding environment by including walkways to public transit. Walkways landscaped with native plants and trees may also be able to serve as wildlife corridors and bike paths *(Site: B1–Sustainable Landscaping).* Include a variety of walking and bike paths providing direct and convenient connections to transit hubs, shopping centers, other trails and parks. Balance the route's directness with visibility and safety. Paths that pass active areas are more likely to be used and less likely to attract graffiti or collect garbage than routes that go through areas with few people around.

Provide crosswalks linking directly to transit stops, and use sidewalk extensions to reduce crossing distances on wider streets *(Planning & Design: AA2–Design for Walking and Bicycling).*

Install—or encourage the transit agency to install—bus shelters at major bus stops. Shelters should protect riders from the elements, provide some seating, and have clear information about bus routes and frequency of service.

PARKING & CAR SHARING

Reduce onsite parking. If the project includes off-street parking for residents, provide less than 1.0 parking space per residential unit, if allowed by local code. If that is not possible, provide less than 1.5 parking spaces per unit.

One way to discourage car ownership is to "unbundle" parking from housing. If parking is included with a housing unit, residents will effectively pay for it regardless of whether they need it. When housing units and parking spaces are rented or sold separately, residents who don't need a space can save money.

Multifamily developers can also reduce their overall parking requirements by allocating spaces for designated car-share vehicles. Car-sharing programs allow residents and neighbors to enjoy the convenience of driving when they need to, while avoiding the expense and hassles of ownership.

PRACTICA CONSULTING

Bus shelters should protect riders from the elements and provide some seating.

Also look into whether the city has Transportation Demand Management programs for new residential projects. There may be policies that provide free or discounted transit passes to projects that discourage car use *(Operations & Maintenance: N2–Transit Options).*

Minimize the visual impact of parking structures. Situate garages and parking structures so that they do not dominate the street. Visually screen parking garages because they can discourage pedestrian activity. Consider wrapping ground-floor retail around a parking structure to hide it from view. Avoid using surface parking lots because they create gaps in street activity and are an inefficient use of land. If mature vegetation exists or is planned for the site, design underground garages so they will not interfere with root systems.

On-street parking is recommended because it acts as a buffer between sidewalks and moving vehicles. However, diagonal parking can cause serious conflicts with bicycles because it is harder for drivers to see them. Minimize driveway widths and frequency of spacing because they create additional hazards for pedestrians *(Planning & Design: AA2–Design for Walking and Bicycling).*

Code Considerations

Zoning or planning codes typically regulate the minimum (and sometimes the maximum) number of off-street parking spaces required for particular uses. Some jurisdictions have moved toward reducing parking requirements for multifamily, mixed-use and affordable housing developments in urban centers and other transit-friendly locations.

Transit agencies usually have a standard for bus shelters, signage and other transit-related street features.

Design teams should identify potential code obstacles early and work with local officials to resolve them.

Considerations for Residents

Transit-oriented, pedestrian-friendly developments make it easier for people to drive less or even not own a car. This saves money, reduces global warming impacts and potentially contributes to a healthier lifestyle. According to a recent study by the Metropolitan Transportation Commission, people in the San Francisco Bay Area who live and work within a half mile of transit are four times more likely to walk and ten times more likely to use transit than those who don't. If parking spaces are unbundled from housing, residents who don't need parking will save money.

Building more residential units next to transit supports higher ridership levels, which in turn supports better and more frequent transit service. It also increases customer traffic to local stores and services, improving the local economy.

Pedestrian-friendly developments near many neighborhood services can improve quality of life by making it more convenient and enjoyable for people to shop, work and play close to home, and by reducing the time spent on congested roads.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

A site with good access to public transit and neighborhood services may cost the developer more to purchase if the location is particularly desirable, but a good location can also increase the units' marketability. Reducing the number of parking spaces can reduce construction costs.

For affordable housing developments, choosing a transit- and pedestrian-friendly location is a critical affordability strategy.

Resources

» **California Transit-Oriented Development** (TOD) Database provides information about more than twenty transit villages in California: http://transitorienteddevelopment.dot.ca.gov

» **Car-share companies** in California include: City CarShare (www.citycarshare.org), Flexcar (www.flexcar.com) and Zipcar (www.zipcar.com); for information about other companies and car sharing in general: www.carsharing.net

» **Great Communities Collaborative** publishes a toolkit that includes handouts to inform communities about key aspects of transit station area plans: http://greatcommunities.org/index_files/toolkit.htm

» **Metropolitan Transportation Commission's** toolbox/handbook, "Reforming Parking Policies to Support Smart Growth" is a guide for communities interested in planning and implementing parking policies and programs that are supportive of transit-oriented development: www.mtc.ca.gov/planning/smart_growth/parking_seminar/Toolbox-Handbook.pdf

» **Reconnecting America/Center for Transit-Oriented Development's** website has resources and tools to support transit-oriented development, including case studies, best practices and policy information: www.reconnectingamerica.org

» **Urban Land Institute's** publications include "Growing Cooler: Evidence on Urban Development and Climate Change," which documents that residents of compact, mixed-use, transit-served communities do less driving, an essential factor in combating climate change: www.uli.org

» **U.S. Environmental Protection Agency** promotes smart growth, including creating walkable neighborhoods and providing a variety of transportation choices: www.epa.gov/smartgrowth

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

» Crossroads, p. 234

» Oxford Plaza, p. 15

» Sara Conner Court Apartments, p. 221

MEASURE AA4

MIXED-USE DEVELOPMENTS

Incorporate Nonresidential Uses in Multifamily Housing Developments

KEY BENEFITS

Health/IEQ	√ Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Provide space for shopping, employment, social, cultural or community facilities within a multifamily housing development.

Description

Mixed-use developments combine more than one use (for example, residential, retail and office) in a single building or development area. This type of development was prevalent until the early twentieth century, when municipalities adopted zoning codes that segregated residential from commercial and industrial uses. Single-purpose zoning is environmentally unsustainable because it creates dependence on automobiles, increases carbon dioxide emissions that contribute to global warming, and uses land inefficiently. Some experts also believe it has contributed to a decline in civic engagement.

This measure addresses the social, economic and environmental benefits of mixed-use multifamily developments *(For design strategies, see Structure: C2–Mixed-Use Design Strategies).*

POWERHAUS STUDIO

888 7th Street, designed by David Baker + Partners Architects, is a new mixed-use development in San Francisco with affordable and market-rate homes.

Demographic, economic and environmental factors are driving market demand for developments where people can work, shop, play and meet their daily needs close to where they live. Also, the shrinking supply of available undeveloped land is fostering new interest in urban redevelopment *(Planning & Design: AA1–Infill Sites).*

Benefits

Mixed-use developments:

- Create a sense of place and provide more opportunities for social interaction
- Increase neighborhood economic vitality
- Strengthen and diversify the municipal tax base
- Provide more than one source of project cash flow for the developer
- Increase transportation options such as walking, biking, car sharing and public transit, and reduce vehicle trips and associated greenhouse gas emissions
- Use land, public infrastructure (such as roads, water and sewer), and facilities more efficiently
- Reduce regional imbalances between jobs and housing

Application

SIZE	Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		Retrofit
USE	√ Residential		√ Commercial

Most new multifamily housing projects can successfully incorporate nonresidential uses, except on the most severely constrained sites. An integrated design approach is critical to the success of any mixed-use development *(for more about integrated design, see the introduction to these Guidelines).*

Consider dedicating a portion of the development's nonresidential spaces to neighborhood services, such as stores, libraries, child care centers, fitness centers, restaurants and community centers.

Design Details

Mixed-use developments often call for different, and often more complex, construction methods than single-use developments *(for design guidance, see Structure: C2–Mixed-Use Design Strategies).* In addition, community and development considerations for mixed-use projects may call for somewhat different strategies, as described below.

IDENTIFY COMMUNITY NEEDS

Engage municipal representatives and community leaders early in the design process. Providing amenities that are desired by the community will increase local support for the project.

Identify services and facilities that are currently lacking in the community and determine whether it is economically feasible to incorporate any of them into the project. Commonly desired amenities include grocery stores and child care facilities. Design the project so that neighbors can also use plazas, meeting rooms or other facilities.

ADDITIONAL STRATEGIES FOR MARKET-RATE HOUSING

Market-rate developers may also consider these strategies for successful mixed-use projects:

» Conduct market research to identify the appropriate size and type of retail and/or commercial uses.

» Seek legal expertise to address building leasing, governance issues, ownership agreements and zoning requirements.

CREATING A SENSE OF PLACE

Locate retail uses on the ground floor to create visual interest and clear destinations for pedestrians. Retail uses should have direct access from the street and should engage the street with lighting, outdoor seating, signage and displays oriented to the street.

Mixed-use buildings should be built close to the sidewalk on the property line. Setbacks are not recommended for buildings with ground-floor retail unless the setback provides a place for businesses to have outdoor seating or displays. A setback should never be used to provide parking between the building and the sidewalk.

Design building facades that are aesthetically varied and stimulating with windows that provide a connection between the interior and exterior. Tinted windows and deep arcades are strongly discouraged because they reduce visibility and make retail less accessible. Corner buildings should overlook both street frontages and create a sense of place. *(For additional design strategies that support walking and bicycling, outdoor gathering places and safety, see Planning & Design: AA2, AA5 and AA6.)*

Code Considerations

Local zoning codes determine where mixed-use buildings may be constructed, the types of uses allowed, and their shape and size. Code requirements for residential, office, retail and parking uses differ and may be incompatible. Some local jurisdictions and planning authorities have regulations that prohibit or restrict mixed-use development. Design teams should identify code problems early and work with local officials to resolve them.

Policymakers can promote mixed-use development by removing special variances, providing zoning flexibility, assisting in financing and assembling property development rights.

Considerations for Residents

Residents of mixed-use buildings are more likely to shop, work and play close to home. They have more opportunities for social interaction and leisure time, and may have increased transportation options.

In mixed-use buildings, residents may be particularly concerned about increased noise and traffic from commercial activities and deliveries, privacy issues, separation of trash and recycling areas, and parking separation or shared parking areas *(Structure: C2–Mixed-Use Design Strategies).*

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Mixed-use developments may be more complicated to finance than residential-only buildings, in part because lenders are accustomed to single- and separate-use financing economics and policies. Also, interest and down payments tend to be higher due to the difficulty of securing mixed-use mortgages. However, mixed-use projects create multiple cash flows that can help make a project's economics more favorable to investors.

Commercial leases are different from residential leases, and co-tenancy and other ownership structures may be more complex in mixed-use buildings compared to residential buildings.

Resources

» **Bay Area Local Initiatives Support Corporation** (LISC) provides resources on mixed-use development: www.cdexchange.org/commercial

» **Project for Public Spaces** offers information about mixed-use development: www.pps.org/mixed_use

» **Southern California Association of Governments** has useful publications, including "Facilitating Small-Scale Mixed-Use Development: What the Westside Cities Could Do": www.scag.ca.gov/livable

» **Urban Land Institute** has many books and online resources on mixed-use development, including the report, "Growing Cooler: Evidence on Urban Development and Climate Change," which documents that residents of compact, mixed-use, transit-served communities do less driving, an essential factor in combating climate change: www.uli.org

Related Case Studies

» Crossroads, p. 234

» Oxford Plaza, p. 15

MEASURE AA5

OUTDOOR GATHERING PLACES

Create Pleasant Outdoor Gathering Places for Residents

KEY BENEFITS

√ Health/IEQ	Material Efficiency
√ Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: Division 2: Existing Conditions, **Division 12:** Furnishings

OLD: Division 2: Site Construction

Recommendation

Provide outdoor spaces of different sizes and degrees of public access that encourage sociability and outdoor activities.

Description

Well-designed public spaces increase opportunities for social interaction and neighborliness. Multifamily housing often provides community rooms or other indoor facilities but often fails to provide adequate outdoor community spaces.

Successful outdoor spaces offer more than just a place to sit outside. In residential areas, outdoor gathering spaces vary in their functions and their public accessibility. For example, a building's shared patio or roof garden can be a pleasant private gathering space for its residents and guests, but may be off-limits to other people. A public plaza, park or square, on the other hand, should be inviting and accessible to a variety of people—residents, neighbors, local workers and visitors.

Public spaces in residential areas also vary in the types of activities they support. For example, a children's play area should offer not only play equipment but comfortable seating for accompanying adults, a drinking fountain and good visual and physical access to residences.

Areas dedicated to a single use like seating, natural areas, pathways or active recreation areas are less valuable as social gathering spaces than those offering a variety of activities. Yet these places do promote physical activity and can bring residents closer to nature.

Benefits

Vibrant outdoor spaces encourage interaction and deter crime. Outdoor social gatherings can reinforce a sense of community and ownership. Public outdoor spaces can also be used for performances, festivals and markets, strengthening cultural identities and creating business opportunities. Attractive outdoor areas may increase the development's marketability.

Outdoor recreation areas and walkways improve public health by encouraging people to exercise. Trees and other vegetation not only help keep the site and building cooler, they may even improve people's sense of well-being.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Developments in urban areas should maximize connections from the site to nearby activities. On high density sites, take particular care to design the outdoor spaces to include natural elements, including trees and other vegetation, water features, walkable green roofs and more *(Site: B1–Sustainable Landscaping and Structure: E3–Vegetated Roofs).* Consider clustering buildings on a site so that a significant portion of the site can be set aside for outdoor recreation. This is especially crucial in urban environments where parks and relaxation spaces may be scarce. Rural sites can take advantage of parks and open space.

With retrofit projects, look for opportunities to convert unused or underused outdoor spaces into appealing gathering areas.

Design Details

Residential developments should have a variety of outdoor spaces that range from private patios to shared courtyards to public areas where nonresidents are welcome. Although spaces with restricted access may meet a development's need for open space, they may have limited benefit as social gathering spaces even when they are actively programmed. It is important to design and locate public spaces in a way that makes their purpose (public or private) and function explicit.

A development's sense of place arises from aesthetics as well as functional elements. Boring, out-of-scale or bland buildings create an unwelcome feeling, even if the development has useful amenities. Gathering places should provide interesting views of surroundings and should incorporate a diversity of natural elements *(Site: B1–Sustainable Landscaping)*.

USES AND ACTIVITIES

Before beginning design, discuss with current or future residents the kinds of activities they would like to engage in. Develop a list of potential programming ideas before designing the outdoor space.


DAVID BAKER + PARTNERS ARCHITECTS

Mabuhay Court is a low-income senior housing development in San Jose that provides gathering space in the interior courtyard.

Avoid single-use facilities. Depending on their scale, outdoor gathering places should be designed for at least five to ten functions. For example, residents could use a patio for relaxing, reading, meeting neighbors, learning about news and community events from a bulletin board, and having lunch. In a larger space, like an internal courtyard, in addition to the activities listed above, residents might want space for kids to run around and for people to play bocce, badminton or Frisbee, or room to throw a block party.

A small neighborhood plaza can have places to sit in the sun and the shade, a play area, a community barbeque pit with picnic tables, and a flexible open area for community events or outdoor café seating.

Good parks and plazas need to have multiple activities and destinations at their core as well as their edges. A diversity of activities—such as a farmers' market, playground, picnic area, corner bar or sidewalk café—will attract a variety of people and keep a neighborhood lively and safe at all times of day.

ACCESS AND LINKAGES

Design sites and buildings to inspire adults and children and encourage them to walk, exercise, play and spend time outside *(Planning & Design: AA2–Design for Walking and Bicycling and AA6–Design for Safety and Vandalism Deterrence).* Well-designed outdoor gathering places are visible and easy to get to. People need to see that there is something to do and that others are already using the space. Parks, sports facilities, community gardens, play areas and other outside recreation venues function best when adjacent to schools, day care centers, community centers, libraries and other frequently visited places. If adjacent streets are too dangerous for older people and children to cross, or if the character of a place (such as whether it's public or private) is unclear, the place won't be used.

Linkages are opportunities to connect different elements, creating a people-friendly environment that encourages sociability. Linkages can be between spaces, uses or elements within a space. For example, if a day care center is next to a playground and a food kiosk, more activity will occur than if these facilities were located separately. If a bench, trash receptacle and telephone are placed separately, with no connection to each other, then each may receive very limited use or even be abused. But when they are arranged together along with other amenities such as a coffee cart or newsstand, people are more likely to use them.

OUTDOOR "ROOMS" & ACTIVE EDGES

Lay out the site so that buildings form a series of connected outdoor spaces or rooms of varying shapes and designs. These spaces or rooms can then accommodate a variety of uses. Smaller spaces may serve a cluster of units, while larger areas may function more as a commons for all the residents. Extend smaller residential units by connecting them directly to patios, porches and other outdoor spaces. Locate windows and doors of the surrounding units so that they look out onto these spaces to enhance safety *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).* Patios with low fences that encourage interaction with passersby may be appropriate in certain locations.

Design areas where residents can garden or have potted plants near their homes. Consider including community garden space so that residents can garden and even grow some of their food.

Plazas and parks in urban areas are safer and busier if they adjoin uses or buildings that can "spill out" into the space and provide eyes on the areas. For example, a café or community center next to a plaza can use the outdoor space for outdoor dining or programming, and provide a degree of surveillance of the space. Most successful plazas have active uses rather than just residential units along their edges.

PEDESTRIAN PATHS

Pathways connect people to each other and the surrounding environment. Pathway design is integral to landscape design *(Site: B1–Sustainable Landscaping)* and building placement, and should be considered early in the design process.

Design pathways to accommodate the wide range of people and equipment that will share the paths: bikers, walkers, strollers, furniture movers, shopping carts, wheelchairs and more. Having adequate space will encourage residents to spend more time socializing, even if a bicyclist or moving crew are passing by *(Planning & Design: AA2–Design for Walking and Bicycling).*

Where paths intersect, place benches, boulders and other elements close by (although out of the direct pathway) to encourage people to linger and chat. Sand boxes, for example, are a good place for kids to play while adults talk.

OUTDOOR FURNISHINGS

Well-designed and well-placed amenities, such as seating, shade trees, bike racks and bulletin boards entice people to use outdoor spaces; they signal that someone took the time and energy to design amenities that respond to their unique needs.

Many areas, whether transitional or designed for longer stops, can be enhanced to create pleasant gathering places. Chairs and benches provide spaces to rest, pause or talk with neighbors. Nontraditional elements like ledges, boulders and other landscaping elements can also provide seating. Encourage people-watching by allowing seated people to see in multiple directions and have a clear view of transitory areas on site.

Adequate and pleasing lighting, as well as weather protection such as awnings, shade trees or umbrellas, make a space more usable. Trash receptacles, landscaping and planters also contribute to the space.

MANAGEMENT

Ninety percent of the success of a public space can be attributed to active management. Successful public space managers ensure that the space is 1) safe and secure; 2) well programmed; 3) clean and well maintained; and 4) actively engaging the community to meet their needs and involve them in ongoing events and programs. Whether the manager is the property manager for the entire development or an organization that only manages the public spaces, coordination with the other uses, residents and the surrounding community is critical to the success of the public space.

KBMA

Providing a diverse range of seating features in the landscape will encourage outdoor interaction.

Code Considerations

Local codes such as zoning, parking capacity and fire department access may affect the design of social gathering places. If a local code is in conflict with preferred strategies, work with local officials early in the design process to find good solutions.

Considerations for Residents

Residents benefit from increased access to outdoor activities that promote physical and mental health and neighborliness. Well-designed outdoor gathering spaces may increase the home's market value and draw more desirable commercial activity to the neighborhood.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

There is evidence that walkable neighborhoods with excellent outdoor amenities and a strong sense of community have higher property values and are attractive to homebuyers.

Well-designed outdoor gathering spaces will require additional design time; however, including smaller outdoor gathering spaces should not add significant costs to a project. Larger-scale projects, such as public parks and large plazas, will increase costs but may increase the development's marketability.

Resources

» ***Environmental Building News*** has an article, "Biophilia in Practice: Buildings That Connect People with Nature" (July 2006); fee to access: www.buildinggreen.com

» **Local Government Commission** has fact sheets on good design for public outdoor spaces: www.lgc.org

» **Project for Public Spaces** has information on place-making, parks, public squares and more: www.pps.org/parks_plazas_squares

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

» Crossroads, p. 234

» Fox Courts, p. 47

» Sara Conner Court Apartments, p. 221

DESIGN FOR SAFETY AND VANDALISM DETERRENCE

Design Buildings and Landscapes to Promote Safety and Reduce Vandalism

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: Division 2: Existing Conditions, **Division 9:** Finishes

OLD: Division 2: Existing Conditions, **Division 9:** Finishes

Recommendation

Design buildings and landscapes to promote safety and deter crime.

Take steps to protect the development against vandalism and graffiti during and after construction.

Description

Designing buildings to dissuade criminal behavior is known as crime prevention through environmental design (CPTED). While it may be possible to deter crime with tall fences, video surveillance and bright lights, these elements also deter outdoor play and neighborliness. They should be used only when absolutely necessary. The most secure communities have design elements that foster rather than discourage human interaction.

CPTED strategies for promoting safety include encouraging community interaction, controlling access to the site, creating comfortable conversation and seating areas near building entrances so that people can keep an eye on their neighborhood, and reinforcing the territorial differences between private and public areas.

Vandalism may occur during and after construction, which can lead to early failure of building elements. It is also frustrating for residents and facility staff, and can lead to costly repairs and a decreased sense of community value and safety. During construction, monitor the site and restrict access to areas prone to vandalism and graffiti. Once a building is occupied, designs that promote interaction among neighbors, walkable areas and good maintenance will lessen vandalism *(Planning & Design: AA2–Design for Walking and Bicycling and AA5–Outdoor Gathering Places).*

Benefits

Designing with both human interaction and safety in mind improves quality of life for residents and neighboring communities. CPTED encourages neighborly interaction, can deter crime, and may reduce private security and public law enforcement costs.

Deterring vandalism results in cleaner, safer communities and reduces building repair and maintenance costs. Quick response to incidents will increase residents' morale and discourage future vandalism.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to many retrofit projects and all new construction projects, especially in crime-prone areas.

Design Details

PROTECT THE CONSTRUCTION SITE

Early involvement of the community with the project can help protect against graffiti, theft, trespassing and vandalism on the construction site. Neighbors and community groups with a stake in the development are more likely to pay attention to activities on the site.

Neglected areas invite disrespect and crime more than clean, well-tended spaces. Regularly clean job sites and provide adequate physical barriers around vandalism-prone areas such as back walls and alleyways.

KEMA

This job site was not vandalized, but it looks as it though it could have been. A clean and well-maintained site and building discourages vandals.

PROVIDE A CONSTRUCTIVE OUTLET FOR YOUTH

Most vandalism and graffiti is caused by teens and young adults. Providing basketball courts, parks, walking and biking opportunities *(Planning & Design: AA2–Design for Walking and Bicycling)*, computer centers and afterschool programs are good ways to encourage positive behavior. Art programs, especially those geared to public art such as murals, banners and posters, can be used to channel energies in a positive way, provide visual variety, and instill a sense of community pride in youth.

MANAGE ACCESS TO THE SITE

Make all entrances to the building and site highly visible. Main entrances should be prominent, well lit and clearly visible from the street and common areas. Create clearly marked access ways with good lighting and clear sightlines to prevent hiding spots. Cluster common indoor areas—such as lobbies, mailrooms and laundry areas—around main entrances to help define the development's access pathways *(Finishes & Furnishings: M2–Central Laundry).*

Use high quality metal or solid-core doors with durable hardware and locksets, especially in remote areas on the site. Entries should be well lit with shields or valances to reduce light pollution (*Site: B3–Light Pollution Reduction),* motion sensors, and steps or pathways to help distinguish public from private zones. If a reception area is located near the main entrance, position the reception desk to provide a clear view of approaching visitors and use adequate vision glazing.

Residents will be more likely to use outdoor areas if they are active and secure *(Planning & Design: AA5–Outdoor Gathering Places).* How a space is managed has a great effect on how well it will be used. Spaces will be used less if they have no supervision (either by management or users) or if access is overly restricted (such as severely limiting hours of use, requiring special keys, codes or authorizations, or not allowing access to guests or the public).

Break up parking lots into smaller localized lots that reduce walking distances to units. Design windows in kitchens, living rooms, dining areas, balconies and other well-used spaces to look out on parking lots and open areas. Clearly mark all visitor parking spots and make them easily visible.

In below-grade or enclosed parking structures, provide a limited number of entryways. These should be well lit and clearly visible to passersby and residents. Eliminate potential hiding spots that are out of view, such as dark and enclosed stairways.

ENCOURAGE COMMUNITY INTERACTION

Create visual connections between interior and exterior spaces. Design units so that kitchen windows look onto prominent circulation paths. Living rooms can overlook streets and other outdoor spaces.

Create semi-private outdoor spaces *(Planning & Design: AA5–Outdoor Gathering Places).* Take clues from successful patterns in the surrounding community. Porches, balconies and even a front door area sheltered by a deep eave provide comfortable places to sit, if benches or chairs are available. When residents keep an eye on their neighborhood, crime may be significantly deterred.

Create public gathering places such as comfortable seating areas (or a low sitting wall) at the intersection of two or more paths or in a community garden, or picnic tables near a play area. These gathering spaces should be easy to supervise from the surrounding units.

Retail space in mixed-use developments, when located on the ground floor with access from the street, increases daytime activity and generally improves security *(Planning & Design: AA4–Mixed-Use Developments).*

DESIGN FOR NATURAL SURVEILLANCE

Design all home entries so that residents inside their homes, including children and those in wheelchairs, have views of visitors at the door either through a secure window or a door viewer (peephole). Provide windows that overlook communal areas and have a line of sight to stairways, play areas and other potentially unseen spots. Design balconies to look out on common areas.

Unmonitored windows may attract vandalism more than windows in visible locations. Consider using raised-floor construction or otherwise raising the height of ground-floor windows to put them out of easy reach.

Design landscaping to allow for surveillance. Keep shrubs and hedges to less than 3-feet tall near buildings to prevent people from hiding behind them. Consider planting flowerbeds underneath windows so that someone standing in them looks suspicious. Burglar-proof plants, such as thorny bushes, near windows are also helpful. Trim tree branches up to 6 feet off the ground to increase visibility around trees.

FF RST COMMUNITY HOUSING

The courtyard at Betty Ann Gardens in San Jose has many elements for natural surveillance: balconies that look toward a central area, benches to encourage leisure time, and proper site lighting.

Lighting helps with surveillance and safety at night. Lighting does not have to be bright but it should be uniform. Remember to shield fixtures *(Site: B3–Light Pollution Reduction).* Consider using motion sensors or photocell controls on outdoor lighting to save energy *(Finishes & Furnishings: M4–Lighting).*

PROVIDE TERRITORIAL REINFORCEMENT

Gates and fences are one way to discourage trespassing, but landscaping and other attractive visual cues may be better ways to help differentiate private from public areas. Design building entries to promote a feeling of ownership. Steps, fences, pathways, lighting and overhangs can create a transition space between public and private areas in low density housing. In dense buildings, various strategies can be used to create a buffer between public spaces and private units, such as providing relief in interior corridors at unit entries, creating a recessed doorway with a small overhang for a porch-like entry, or distinguishing the unit's entry with a special light fixture. Areas without these buffer zones may seem unwatched, which may encourage crime.

DESIGN TO DISCOURAGE GRAFFITI

Avoid large, clear wall areas that invite graffiti. Design staggered surfaces instead of smooth and flat ones. Alternatively, encourage children or local artists to paint murals in these areas.

Darker paint, especially at ground level, helps discourage graffiti. Also, it is easier to paint over graffiti on dark surfaces (graffiti may show through light-colored paint). On surfaces likely to attract graffiti, either apply an anti-graffiti coating, which is usually a water- or oil-based clear coat that can be easily cleaned, or plan to repaint the top coat periodically.

Vines and fast-growing creepers are an economical way to protect walls and fences from tagging. However, rodents and other pests could be a concern when vines cover walls. Use a detachable metal grid or other structure to grow vines on, so that maintenance crews have access to the building's walls when they need repainting.

MAKE MAINTENANCE A PRIORITY

To effectively provide safety, a building and its grounds need to be well tended. Maintain landscaping and provide good storage for bicycles and children's toys on the ground floor. Promote good housekeeping of common areas, and locate the janitor closets in convenient places to make it easier to do regular and special maintenance.

Create a vandalism management plan to counteract damage that may occur. Remedy any vandalism and graffiti within twenty-four hours. Show clear ownership and pride in the development by conducting regular maintenance and cleaning. When cleaning up graffiti, use the least toxic means available. Harsh cleaners may be needed to clean porous surfaces like brick.

Code Considerations

Lighting requirements generally stipulate a minimum and average footcandle level for outdoor areas. Funders or cities may have requirements for entryway designs or security features in crime-ridden neighborhoods. The recommendations presented here will enhance the security of any project that meets these other requirements.

Some jurisdictions may have anti-blight ordinances that require cleanup of graffiti and construction jobsites both during and after construction. Developers and property managers should check with local officials for details.

Considerations for Residents

CPTED strategies can reduce crime, improve relationships with neighbors, and improve community appearance and quality of life.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

These strategies may add some minimal design time and potentially some cost for benches, overhangs and similar elements. To avoid increasing cost, use elements with dual functions, such as overhangs on south exposures. Prioritize site planning and minimize added features to reduce cost.

Resources

» **Local Government Commission** has a fact sheet, "Designs and Codes that Reduce Crime around Multifamily Housing": www.lgc.org

» **Project for Public Spaces** has resources on designing secure public spaces: www.pps.org/civic_centers/info/how_to/security

» **U.S. Department of Housing and Urban Development's** Affordable Housing Design Advisor includes a Design Considerations Checklist with photos of buildings designed for improved security and natural surveillance: www.designadvisor.org

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

» Crossroads, p. 234

MEASURE AA7

PASSIVE SOLAR DESIGN, DAYLIGHTING AND NATURAL VENTILATION

KEY BENEFITS

√ Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 8: Openings

OLD: Division 8: Doors and Windows

Recommendation

Orient and design buildings to take advantage of solar access for heating, cooling and daylighting, and prevailing winds and other site conditions for natural ventilation.

Description

In the days before ready access to inexpensive fossil fuels, builders and building designers had to understand how building placement, orientation, massing and layout affected comfort and energy use. But in recent decades, due to low energy costs and advances in HVAC technology, it has been easy to ignore passive design principles and still provide well lit, comfortable buildings. But every time we design and construct buildings that use more fossil fuel–based energy than necessary, we contribute to global warming, air and water pollution and depletion of global fossil fuel reserves.

To successfully design a building with passive systems so that it meets energy performance and comfort expectations, carefully analyze the site and building design options from the start of the planning and design process. Fundamental considerations such as the site's climate, solar orientation, wind patterns and surrounding structures and topography must be taken into account as early as possible. Once a building's basic form and layout have been decided, it can be exceedingly difficult to make changes later to incorporate passive systems.

It's also essential to follow an integrated design approach in which all key members closely collaborate to ensure the passive systems work as intended and are well coordinated with the building's other systems *(For more on integrated design, see the Introduction to these Guidelines).*

PASSIVE SOLAR DESIGN

The basic approach to passive solar design is to allow sunlight to enter a space during winter when the sun is low in the sky, and cut off sunlight during the hottest times of summer, when the sun is higher. The incoming solar energy is captured in a thermally massive material within the building, which later reradiates the energy as heat. Balancing this delay so that it happens at night, when temperatures are cooler, is achieved through building orientation, insulation, shading, thermal mass sizing and appropriate window glazing.

DAYLIGHTING

Daylight can provide illumination suitable for most tasks without the use of electric light, thereby reducing a building's energy use and global warming impacts. Good daylighting also helps create an appealing indoor environment, and is thought to elevate people's moods. Daylighting in homes is typically done through side lighting (windows and glass doors) and top lighting (skylights or tubes). Daylighting in common areas can be achieved through view windows, clerestory windows and skylights.

NATURAL VENTILATION

Naturally ventilated buildings use wind or temperature and air pressure differentials to cool and ventilate a building through its windows or other openings, without relying on fans. While natural ventilation won't entirely supplant mechanical HVAC systems in multifamily buildings, it can go a long way toward eliminating or reducing the need for air conditioning, thereby reducing energy use.

Natural ventilation can help satisfy people's desire to be more connected with outdoor conditions, and may improve indoor environmental quality by diluting indoor air pollutants and allowing moisture in the home to escape. However, indoor environmental quality may be negatively affected by excessive dust or noise from outside.

Benefits

Passive solar design and natural ventilation can reduce heating and cooling requirements by 30% to 50% or more. The reduced heating and cooling loads may justify smaller, simpler HVAC systems, which can reduce the project's first costs. Daylighting can offset some of the electric lighting load.

Effective daylighting and natural ventilation may improve indoor environmental quality. Well-designed passive systems may improve a building's marketability, since people are drawn to spaces that provide sunlight, daylight and fresh air.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily housing projects, including mixed-use projects. Providing good solar access and natural ventilation is more challenging with retrofit projects and buildings in dense urban areas. Multistory developments face challenges with incorporating thermal mass, especially on floors above ground level.

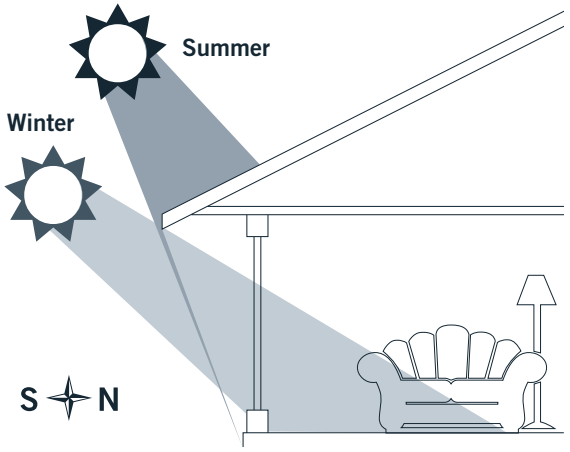
Design Details

PASSIVE SOLAR HEATING AND COOLING

Here is an overview of the basic principles; consult a passive solar design expert for specific recommendations.

» **Use street orientation to improve solar access.** For new subdivisions, plan streets and lot layouts to provide shading of streets and buildings. Deciduous trees provide shade during the hottest times of the year without blocking winter sun. Narrow streets are easier to shade with trees. Consider alleyways, greenbelts and similar methods to provide good solar access to all buildings.

» **Control solar access with building orientation.** Locate buildings on an east-west axis to facilitate passive solar design and placement of rooftop solar systems *(Systems: Section I–Renewable Energy).* To the greatest extent feasible, orient individual units so that living spaces face south. Passive solar apertures should be aligned toward true south (not magnetic south), but do not have to be directly facing south. Even at 25 degrees off south, 90% of the total solar insolation (a measure of solar energy striking the earth) still falls on a wall. On north, west and east-facing walls, minimize the window area while still allowing for daylighting and natural ventilation. Use spectrally selective coatings to reduce solar heat gain on east- and west-facing windows *(Structure: D8–Window Replacement).* North windows rarely get direct sunlight and therefore create cold spots, but are excellent for daylighting.



Proper overhang design on south windows will keep out the summer sun while allowing sunlight into the space on winter days.

» **Insulate and reduce air infiltration.** For passive solar heating to be effective, the building must be insulated to a very high level and infiltration reduced so that stored heat won't be lost too quickly *(Structure: F1–Insulation; Systems: H3–Advanced Ventilation Practices and J1–Building Performance Exceeds Title 24).*

» **Control solar access with exterior shading devices.** Design shading devices on south-facing walls and windows for the time of year that they need to be fully shaded (cut-off). In general, the hottest days should coincide with full shading of south windows and walls; check weather data for the site to determine dates for sunlight control. On the shortest days of winter, sunlight should be allowed to penetrate fully into the space. Overhangs, awnings, trellises and landscaping can provide shading. For retrofit projects, consider adding exterior shading to south- and west-facing windows.

» **Provide thermal mass.** Dark mass surfaces directly in contact with sunlight absorb solar radiation more than light surfaces, and will slowly reradiate the energy as heat. Thermal mass can be incorporated in floors such as tile or concrete. Heavyweight concrete stores and conducts heat better than lightweight mixes. Other

KEMA

Dark colored tiles absorb and store the sun's heat in a passive solar house.

options for thermal mass include walls consisting of two layers of 5/8-inch gypsum drywall, or a masonry or tile fireplace surround. Proper modulation of the interior temperatures is achieved by carefully sizing thermal mass; consult an expert.

Covering slab floors with carpet, wood, linoleum or similar materials is counterproductive to passive solar design. These materials insulate the concrete mass from the effects of solar gain.

» **Install windows with appropriate low-e coating.** While an appropriate low-emissivity (low-e) coating can significantly improve a window's energy efficiency, the wrong coating can thwart a passive solar design by blocking desirable solar heat gain. When choosing a window, it's important to know the specific U-factor and solar heat gain coefficient (SHGC) appropriate for the building's climate, the window's orientation and other factors *(Structure: D8–Window Replacement).*

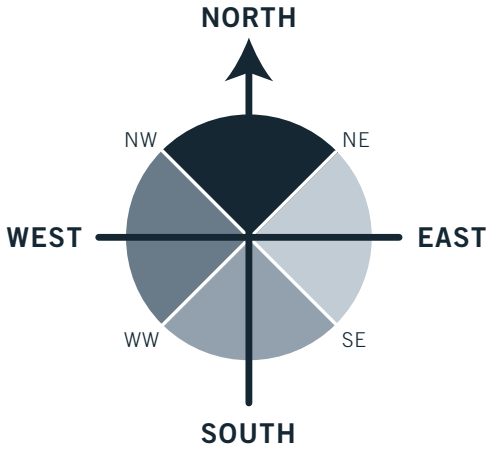
DAYLIGHTING

Daylighting design must be done early in the design process when determining building placement, orientation, massing and layout. The following describes the general sequence of daylighting design:

» **Analyze the site's solar access as part of an integrated design strategy.** Consider features that may obstruct daylight, such as neighboring structures or trees. North light is ideal for daylighting because it provides glare-free, indirect light. Look for ways to position rooms that are predominantly occupied during the day in the zones that have the best access to daylight. Keep in mind that too much glazing isn't necessarily a good thing if it introduces glare or unwanted heat gain, or if it provides too little privacy.

» **Size and locate the windows appropriately.** When sizing and positioning windows, keep in mind the basic guidelines shown in the following diagram. One inexpensive technique for getting daylight deep into a room is to use high windows (with a raised sill) that reach nearly to the ceiling. In general, a window can provide illumination into a room to a depth of about 1.5 times the window's height. Another way to increase both daylighting and natural ventilation is to use single-loaded corridors, with residential units along only one side of the corridor.

» **Use exterior shading elements.** As with passive solar design, size overhangs to shade the majority of the south-facing window area in summer and none in winter. In general, keep windows on east and west walls as small as possible. Side fins and wing walls may be effective for east and west exposures if larger windows are needed.



Basic guidelines for window size, location and overhangs.

NORTH
Medium to large windows for daylighting and views
Regular or high sills are okay
Overhangs for rain protection only

WEST
Small or no windows to minimize heat gain and glare
Use light shelves and reflected light wherever possible
Regular sill height
Overhangs for rain protection only
Consider side fins and walls where windows are essential

EAST
Small windows to minimize heat gain and glare
Best in bedrooms
Regular sill heights
Overhangs for rain protection only
Consider side fins and walls where windows are essential

SOUTH
Medium to large windows for daylighting, heating and views
High sills are best
Use light shelves and reflected light for daylighting
Overhangs are critical for controlling heat gain

» **Consider interior shading elements.** These include curtains, drapes and blinds, as well as light shelves that bounce daylight into a room. While light shelves are not normally needed in multifamily projects because of the shallow floorplate depth, they may be useful for the ends of central corridors and other common spaces. Light-colored walls and ceilings reduce glare and get light further into a room. For areas where detail tasks are performed, such as reading and computer work, control glare by providing reflected or diffuse lighting with shading devices, light shelves or tinted glazing, and with atrium or courtyard designs that block direct light.

» **Evaluate opportunities for skylighting.** Consider adding fixed or operable skylights wherever windows cannot provide sufficient daylight or where ventilation needs are highest, such as the top of a stairwell. Tubular skylights are excellent for top-floor bathrooms and halls. Select well-insulated products to improve energy efficiency.

» **Use photocontrols for nonessential electric lighting.** In common areas, photocontrols help ensure energy savings by keeping electric lights off or dimmed when there is adequate daylight.

» **Integrate electric lighting design with daylighting.** As part of an integrated design approach, consider the electric lighting design in conjunction with daylighting to avoid unnecessary electrical configurations.

» **Consider visible transmittance (VT) when selecting windows.** VT is the amount of light passing through the glass; higher VT values allow in more light. For daylighting fenestration in both new construction and retrofit projects, maximize VT while also choosing the U-factor and SHGC that are suitable for the climate and the fenestration's orientation *(Structure: D8–Window Replacement).*

NATURAL VENTILATION

Making natural ventilation work well requires careful adherence to building science principles and close integration with the entire design team. Here are some general strategies:

» **Analyze site conditions.** Before determining building placement and orientation, check local weather station data for wind speeds and direction. Consider setting up an onsite monitoring system if winds seem particularly strong.

» **Site building to take advantage of prevailing winds.** Try to site the building so that obstacles such as other structures do not block summer winds and to take advantage of prevailing winds and pressure differences. Also, buildings and landscaping can be designed and oriented to help deflect cold winter winds.

» **Design for cross ventilation.** Design windows to catch prevailing breezes. Ideally, each room would have an operable window on at least two walls to enhance cross ventilation. For sufficient airflow, there needs to be a pressure difference between the inlet and outlet openings. Certain window styles, such as casement windows, are more suited to cross ventilation because they have a larger opening area than windows such as sliders.

» **Design for stack ventilation.** High operable windows, skylights or cupolas combined with low operable windows can create a stack effect. Rising hot air exhausts at the higher openings, drawing in cooler air through the lower openings.

» **Consider air flow within the unit.** Openings between rooms, such as transom windows, grilles or open floor plans, facilitate air flow through the unit. If possible, design double-aspect units that provide ventilation and daylight from at least two sides.

» **Take into account security and noise concerns.** Window openings should be operable yet secure so people feel safe leaving windows open when at home. Some window manufacturers include small operable vents in the window frames to provide fresh outdoor air without having to open the window. During design, identify neighboring sources of noise and dust and attempt to reduce those effects through the building's placement, design and landscaping.

» **Cool the incoming air.** Consider planting shade trees on the building's windward side to lower the air temperature of inflowing air. A body of water on the building's windward side can also cool the inflowing air through evaporative cooling.

» **Integrate natural ventilation with passive solar design and daylighting.** Natural ventilation can be used at night to dissipate heat stored in thermal mass and cool the building. Look for opportunities to have openings serve multiple purposes—ventilation, daylighting, views, passive solar design—but carefully evaluate conflicting priorities.

» **Consider ceiling fans.** If natural ventilation on its own will not provide adequate comfort on most days, consider supplementing it with ceiling fans *(Systems: H3–Advanced Ventilation Practices).*

Housing for senior citizens and others who are particularly vulnerable to the effects of prolonged heat may need to be equipped with some mechanical cooling to ensure safety during heat waves.

Code Considerations

California's Building Energy Efficiency Standards (Title 24) is limited in its ability to account for passive solar heating. Code requires that all buildings have some form of mechanical heating. A credit is available for thermal mass; consult a Title 24 expert for information.

In low-rise residential buildings, natural ventilation alone is not adequate to meet the requirements of ANSI/ASHRAE Standard 62.2 as required by Title 24–2008. Mechanical ventilation in the form of a continually operating or demand-controlled exhaust or supply fan is required. For high-rise residential buildings, the design must ensure that sufficient fresh air is supplied, but natural ventilation may be all that is required. *(For more information, see Systems: H3–Advanced Ventilation Practices; for code issues related to windows, see Structure: D8–Window Replacement.)*

Considerations for Residents

Residents may benefit from reduced heating and cooling bills and better indoor environmental quality. Teach residents about the strategies used so that they don't unintentionally circumvent the design. A throw rug, for example, will reduce a mass floor's ability to store heat.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

The strategies in this measure may increase design time. Passive solar design may increase material costs for items such as shading devices or extra concrete or drywall for thermal mass. However, passive design strategies are probably the best way to reduce first costs associated with system sizing *(Systems: HO–Heating Equipment)* and provide ongoing savings throughout the building's life.

A basic level of daylighting and natural ventilation can usually be provided for no increase over standard construction costs. Skylights, clerestories, tall windows, cupolas, deep overhangs, awnings and other nonstandard design features may increase costs. Strategies more common in office buildings, such as light shelves, automatic lighting controls and specialized glazing, can significantly increase costs.

Resources

- **California's utility companies** provide resources for passive systems design, including modeling tools, solar calculators and climate data. Check with your utility.
- **Green Affordable Housing Coalition** has fact sheets on passive solar design and daylighting for affordable housing: www.greenaffordablehousing.org
- **National Oceanographic and Atmospheric Administration** (NOAA) has climate data including design temperatures, degree-day averages, and more: www.noaa.gov
- **National Renewable Energy Laboratory** provides solar insolation values: www.nrel.gov/rredc
- **U.S. Department of Energy** offers passive solar and daylighting fundamentals: www.eere.energy.gov/buildings/info

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- Sara Conner Court Apartments, p. 221

ADAPTABLE BUILDINGS

Design for Accessibility and Future Changes in Building Use

KEY BENEFITS

Health/IEQ	√ Material Efficiency
√ Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 1: General Requirements

OLD: Division 1: General Requirements

Recommendation

Build to improve access today and in the future for people of diverse physical abilities.

Design for flexibility. Consider making ground-floor space adaptable for multiple uses. Incorporate diverse floor plans to accommodate a variety of living needs.

Description

Multifamily buildings accommodate people with a diverse range of needs, including residents who are aging or permanently or temporarily disabled. Also, over the course of a building's life, residents' needs may change. And in mixed-use buildings, the need for retail or other commercial space may change over time.

Developments that provide a mix of unit types and floor plans and that incorporate universal design principles can better accommodate shifting needs, allowing buildings and neighborhoods to better serve a diverse range of people over the long term.

It can be costly to renovate a building to accommodate changing needs. Waste can be minimized, and money saved, if buildings are designed with future adaptation in mind. Future changes can be simpler and more cost effective when planned for early in the design process.

Benefits

Universal design principles make buildings more accessible to more people, and make it more likely that people can stay in their homes as their physical abilities change.

Designing for future adaptability will reduce costs significantly when changes or renovations become necessary. Adaptive design also minimizes waste associated with occupant or technology changes. It can also increase a building's longevity.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Useful for all new developments, especially those without long-term restrictions on occupancy, or those in urban environments where use is more likely to change over time.

Design Details

UNIVERSAL DESIGN

Universal design incorporates a range of accessibility features, from easy-to-use door handles to adequate lighting to elevators compliant with the Americans with Disabilities Act (ADA). Many universal design features are required in multifamily housing projects by the Fair Housing Act (FHA) and California Building Code (CBC). Universal design is not strictly limited to designing for the elderly or disabled; instead it focuses on providing increased accessibility for all occupants.

Best practices for flexible accessibility include providing these features in units:

- Provide accessible entries (minimum 34-inch clear opening width with a zero-step entrance).
- Use lever hardware on interior doors instead of knobs.
- Make hallways at least 44 inches wide (California Building Code may require wider hallways in some circumstances).
- Provide an accessible full bathroom on the primary floor.
- Make the kitchen accessible with adequate clearance for all major fixtures and appliances.

Other recommended universal design strategies include:

- Provide accessible routes of travel to the dwelling units.
- Minimize the number of hallways and structural walls inside units so they can be easily altered.
- Place a bedroom on the primary floor of multistory units.

ADAPTIVE DESIGN

Adaptive design refers to designing a building so that as it ages, it can readily accommodate technology upgrades, changes in use and other modifications that may or may not be foreseen. Significant alterations might include additions to projects, such as a second phase of construction or additional units. In cases where future development on the site may occur, consider clustering buildings and focus on building upward instead of outward. Building up rather than out saves energy and building materials; it also reduces the initial development footprint, which may allow for future expansion.

If a project includes retail or commercial space, anticipate that the use may change. Keep floor plans open, reduce bearing walls to allow for more flexibility, and eliminate awkward spaces that could not readily be converted to residential use later. Also consider the reverse: Residential units may eventually be converted to commercial use.

FIRST COMMUNITY HOUSING

Ample storage and an open floor plan allow for flexible use of this studio unit.

In live/work units that serve both residential and commercial purposes, include at least one dedicated entrance to the commercial zone that is not the entrance typically used for residential access. This helps ensure that the units can be fully functional as both a commercial and residential space.

In all adaptive designs, the ability to preserve finishes whenever possible is desirable. Selecting durable, detachable, long-lasting materials will reduce waste and replacement costs.

To facilitate future disassembly or adaptation, incorporate connector systems such as bolts and screws rather than nails. Nails are more difficult to remove and degrade the material, preventing future reuse. In addition, by allowing the connector system to be visible rather than concealing the system behind walls, future modifications to the structure will be more transparent to occupants.

Dimensional planning is one way to keep options open for future build-out and expansion. Buildings that are constructed on 2- or 4-foot modules can be more easily adapted, with less waste from demolition and reinforcement.

Framing part of the roof conventionally instead of using prefab trusses can allow for expansion into the attic.

Consolidate utilities in chases and locate spaces requiring utilities (such as kitchens and baths) around these areas. Creating a centralized and elevated utility raceway will allow wiring and cables to be updated without affecting the wall structure. This technique also minimizes the amount of drilling through studs to accommodate wiring, thus preserving the studs for disassembly and future reuse.

Code Considerations

Consider possible scenarios that could affect occupancy or space usage in the near future, including periodic city or county general plan amendments and local housing regulations. Also, look at zoning population projections, planned residential development and other demographic indicators that identify future growth patterns, before deciding on future adaptation goals.

The Americans with Disabilities Act, the Fair Housing Act and the California Building Code guide accessibility requirements for multifamily developments. Extending code-compliant design strategies to more areas than required does not affect code compliance.

Considerations for Residents

Accessibility features may allow residents to stay in their homes longer than might be otherwise possible. Residents with temporary disabilities also benefit from accessibility features. And features such as wider door clearance make life a little easier for everyone.

To inform future occupants about the building's universal and adaptive design strategies and to make it easier for them to make changes to the building, keep documentation with the building that includes building plans as well as diagrams and descriptions of key systems and design details.

Cost and Cost Effectiveness

BENEFIT	★★½
COST	$$$

Planning for future adaptation at the beginning of a project is an investment with long-term savings and quality-of-life benefits. Upfront costs may be incurred for additional design time, accessibility consultants, and changes in materials, handles, fixtures and wiring.

Resources

- **AARP** has information on universal design: www.aarp.org/universalhome
- **California Tax Credit Allocation Committee** (CTAC) requirements for universal design and other sustainable building methods can be downloaded from: www.treasurer.ca.gov/ctcac
- **Lifecycle Building Challenge** has resources about designing adaptable buildings, including design for deconstruction case studies: www.lifecyclebuilding.org
- **Trace Center,** a part of the College of Engineering at the University of Wisconsin–Madison, has compiled universal design guidelines: www.tracecenter.org/world/gen_ud.html

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234

MEASURE AA9

AFFORDABILITY

Build Housing That Is Sustainable and Affordable Now and over the Long Term

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Dedicate some or all of a development's units to households making 80% or less of the area median income (AMI). Ensure that some of those units have multiple bedrooms for larger families.

Description

While many Californians feel the pinch of escalating housing prices, people with low incomes (generally defined as 80% or less than the AMI) are particularly hard hit by the state's affordable housing crisis. High rents and mortgages aren't the only hurdle. For people to be able to afford to live in their homes, the day-to-day costs of utilities, maintenance and transportation must be manageable.

Lack of affordable housing affects the community and environment in myriad ways. For example, if people can't afford to live in the community where they work, they may have no choice but to endure long commutes, often by car. Commuting costs erode personal income, hours spent commuting take away from time spent with family, friends and neighbors, and commuting by car contributes to traffic congestion, air pollution and global warming.

To be sustainable in economic, social and environmental terms, housing needs to be built well, affordable today and over the long term, sited close to transit and neighborhood services, and located in the communities where people work. To achieve this level of sustainability, many developers of affordable housing across the state—from Habitat for Humanity affiliates to local community development corporations—are embracing green building.

Green building improves the quality of affordable housing, reducing the likelihood that substandard housing will contribute to poor health from mold, lead poisoning, VOCs or other contaminants *(see Finishes & Furnishings).* Good acoustics *(Structure: C1)* and good quality daylighting *(Planning & Design: AA7)* and electric lighting *(Finishes & Furnishings: M4)* may reduce stress and improve quality of life. Neighborhoods designed for safe walking and bicycling and congenial socializing *(Planning & Design: AA2 and AA5)* encourage healthier lifestyles and stronger community bonds.

Benefits

Green building strategies improve the quality of affordable housing, make it more energy efficient and more durable, and reduce global warming impacts.

Developer/owners benefit from lower operating costs, reduced risk of liability claims related to toxic contaminants in or around the building, and better community relations in the local jurisdiction. Developer/owners who embrace green building may also have an advantage in the competitive process of applying for low-income housing tax credits.

Green affordable housing has important public benefits. It emphasizes durability, which extends the life of the existing housing stock and reduces costs compared to having to build new housing. And it can reduce taxpayers' dollars spent on utilities: each year, according to Global Green, public housing authorities spend more than $1 billion on utilities in the United States. Green features such as better indoor air quality and safe, walkable communities may reduce public costs for healthcare.

Green affordable housing improves quality of life for the community at large in many ways. These include making it easier for people to spend their income locally rather than on housing and transportation costs, reducing commute times so that people can spend more time with family and in the neighborhood, conserving water, and reducing pollution and greenhouse gas emissions.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		Commercial

Dedicate all or some of the units in a multifamily development to households making 80% or less of AMI. Ensure that some of those units have multiple bedrooms. Check with local jurisdictions for specific requirements.

Design Details

Involve the local community early in the planning process to gain support for the project and identify ways in which the project can help meet local needs, such as by providing outdoor community spaces *(Planning & Design: AA5),* building space to accommodate neighborhood

services in a mixed-use building *(Planning & Design: AA4),* providing attractive and resource-conserving landscaping *(Site: B1)* and other amenities.

Designing homes that are smaller than average yet still function well is a key affordability strategy. Smaller homes tend to cost less to buy or rent and to live in over the long term. Building smaller homes, however, should not preclude providing multiple bedrooms to accommodate larger families. In urban areas in particular, the scarcity of affordable housing units with multiple bedrooms creates a hardship for many families with low incomes. Affordable housing should also incorporate universal design strategies so that people can stay in their homes as they age or their physical abilities change *(Planning & Design: AA8–Adaptable Buildings).*

For housing to be truly affordable, it needs to be located within easy walking distance of public transit and neighborhood services *(Planning & Design: AA1–Infill Sites and AA3–Alternative Transportation).*

Like all housing, affordable housing should be beautiful and should foster a sense of pride and community among residents and neighbors *(see Planning & Design measures).*

Code Considerations

Some jurisdictions actively support green affordable housing and even offer incentives to green developers, such as expedited permit approvals. But despite the urgent need for more affordable housing, not all communities encourage it within their borders. Green affordable housing developers can gain support from community members, leaders and officials by articulating the benefits of building green, not just for the residents but for the environment and the community at large.

Considerations for Residents

Reduced utility and maintenance costs make the homes more affordable now and in the long term. Green homes are healthier homes, a particularly important consideration for people with low incomes who may not have access to quality healthcare. Multifamily development projects that follow the recommendations in the Planning & Design section provide residents with enhanced opportunities, including better access to jobs, transit, schools, healthcare and other vital needs.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Some green building products and construction methods are comparable or even cost less than their conventional alternatives. These include measures such as efficient use of construction materials *(Structure: D3)* and water-conserving fixtures *(Systems: G1).*

Green building strategies that increase energy efficiency, reduce maintenance needs or contribute to longer building life will lower the operating costs of the individual units and the building as a whole. Inability to pay utility bills is often a factor when residents with low incomes lose their homes or apartments. Higher first costs may be justified for some green building measures if they can reduce operating costs so that people can afford to remain in their homes.

Funding affordable housing involves unique challenges and opportunities, particularly if the design includes green building measures that may cost more upfront but provide long-term benefits. *(For good information about funding affordable, green multifamily buildings, visit the Green Affordable Housing Coalition's website at www.greenaffordablehousing.org.)* A variety of programs can help fund some green features:

- Federal Low Income Housing Tax Credit Program
- California Energy Commission's Emerging Renewable Program for Affordable Housing
- Local utility rebates and incentive programs *(see Resources below)*
- Foundations

In California, the Federal Low Income Housing Tax Credit program is administered by the Tax Credit Allocation Committee (TCAC). The program's tax credits are allocated to affordable housing projects though a competitive process that encourages green building practices, such as exceeding California's Building Energy Efficiency Standards *(Systems: J1–Building Performance Exceeds Title 24),* using energy-efficient appliances *(Finishes & Furnishings: M1)* and more.

For homebuyers, mortgage programs are available that make it easier for borrowers to qualify for loans to buy homes with certain sustainability improvements; these include Energy Efficient Mortgages *(www.hud.gov/offices/hsg/sfh/eem/eemhog96.cfm)* and Location Efficient Mortgages *(www.locationefficiency.com).*

Resources

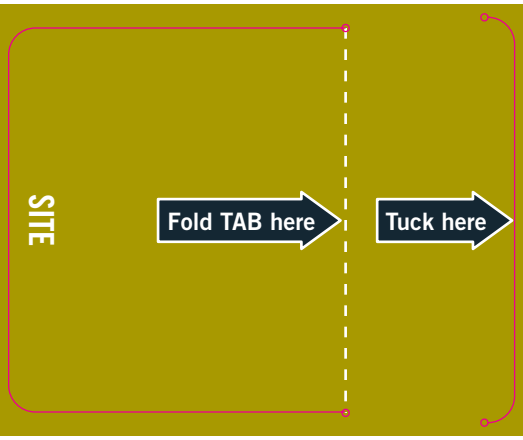
- **Affordable Housing Energy Efficiency Alliance,** funded by California utility ratepayers, provides information to help the affordable housing market incorporate energy efficiency: www.h-m-g.com/multifamily
- **Bay Area Local Initiatives Support Corporation's** (LISC) Green Connection program provides resources for affordable housing owners and developers, including a green financing program: www.bayarealisc.org/programs
- **California's Housing & Community Development** department lists state income limits for low, very-low and extremely-low income categories: www.hcd.ca.gov/hpd/hrc/rep/state/incNote.html

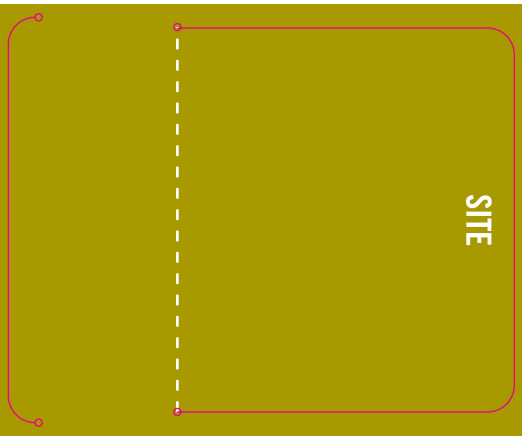
- **California Multifamily New Homes** program offers cash incentives, design assistance and other support for multifamily and affordable new construction in PG&E's service territory: www.h-m-g.com/multifamily
- **Designed for Comfort** offers cash incentives, design assistance and other support to owner/developers of affordable multifamily and supportive housing for energy efficiency retrofits within the service territories of Southern California Gas Company or Southern California Edison: www.designedforcomfort.com
- **Enterprise Community Partner's** publications on green affordable housing include "Affordable Housing's Green Future" and "An Even Greener Plan for Affordable Housing: How States Are Using the Low Income Housing Tax Credit to Advance Healthier, Efficient and Environmentally Smart Homes": www.enterprisecommunity.org
- ***Environmental Building News*** has these articles, "Greening Affordable Housing" (March 2005) and "Building Green on a Budget" (May 1999); fee to access: www.buildinggreen.com
- **Global Green** has many useful resources, including the report, "Blueprint for Greening Affordable Housing" and the Public Housing Authority Toolbox: www.globalgreen.org
- **Green Affordable Housing Coalition** has fact sheets, case studies and other resources: www.greenaffordablehousing.org
- **U.S. Department of Housing and Urban Development's** Affordable Housing Design Advisor offers detailed guidance on designing high quality affordable housing: www.designadvisor.org

Related Case Studies

- Carmen Avenue p. 230
- Crossroads, p. 234
- First Community Housing, p. 161 and p. 209
- Fox Courts, p. 47
- Oxford Plaza, p. 15
- Pepperwood Apartments, p. 121
- Sara Conner Court Apartments, p. 221

SITE





The measures in this section are designed to:

- Protect the health of construction workers and future residents
- Conserve water and other natural resources
- Prevent pollution of air, topsoil and waterways
- Reduce light pollution and the urban heat island effect

These measures describe best practices for reducing waste, pollution and environmental degradation on the jobsite while the building is under construction. They also address landscaping and site design strategies that reduce global warming impacts, protect watersheds, defend buildings against wildfires, and safeguard the health of humans and other species.

The three R's—reduce, reuse and recycle—are at the heart of a number of these measures. Even if some of these procedures seem like commonsense, such as reducing jobsite waste, it's important to have clear policies and to train subcontractors and hold them accountable for following these practices. On a project where the builder makes an effort to manage waste, for example, up to 80% of construction and demolition debris can be diverted from landfills. Much of this material can be put to good use—either reused on site, recycled or donated. This can save contractors money by reducing the need for purchased materials and by lowering disposal fees.

The recommended practices in this section are good for people's health, good for the environment, and good for business. Healthier jobsites mean increased productivity and reduced liability. Healthier buildings may result in fewer callbacks after occupancy. Healthier air, soil and waterways improve the quality of life on site, in the community and beyond.

SITE

BENEFITS

This table lists the Guidelines' Site measures and their primary benefits.
(See the individual measures for details.)

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
A1 Protection of soil, vegetation and water during construction				✓				✓
A2 C&D waste management		✓						✓
A3 Construction environmental quality	✓	✓				✓	✓	
A4 Recycled aggregate					✓			✓
A5 Cool site		✓	✓	✓		✓		
B1 Sustainable landscaping		✓	✓	✓	✓		✓	✓
B2 Source water efficiency		✓		✓			✓	✓
B3 Light pollution reduction		✓	✓				✓	✓

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate the building, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operation and location.

CORE CONCEPTS

CODE ISSUES

In California, the minimum requirement for construction and demolition (C&D) waste recycling *(A2)* is 50%, although some local jurisdictions have higher minimums. Some city and county ordinances mandate that a C&D Waste Management Plan be approved prior to obtaining building and demolition permits.

With trends in California toward tighter control of waste and pollution, it is likely that C&D waste management regulations will remain in force or even become more stringent in the future. Following this section's recommended practices will help developers and builders stay ahead of the regulatory curve. It can also help enhance their reputation among stakeholders, including funders, building officials, subcontractors, workers and residents.

In some cases local landscaping requirements may discourage or even prevent sustainable landscaping practices *(B1).* Work with Planning Department staff to explore exemptions from these local requirements, especially during the Design Review process for new construction.

SCHEDULING

Some of these site measures require particular attention to scheduling. For example, a construction indoor air quality (IAQ) management plan *(A3),* spells out appropriate strategies for minimizing construction-related IAQ problems. The plan will often specify that porous materials like carpet and furniture should only be installed after finish materials such as paints and sealants have cured, and that carpeting and furniture be aired out before installation. The plan may also require the contractor to schedule a preoccupancy flush-out of the building's interior to reduce the potential for post-occupancy IAQ problems.

SPECIFICATIONS AND CONTRACT DOCUMENTS

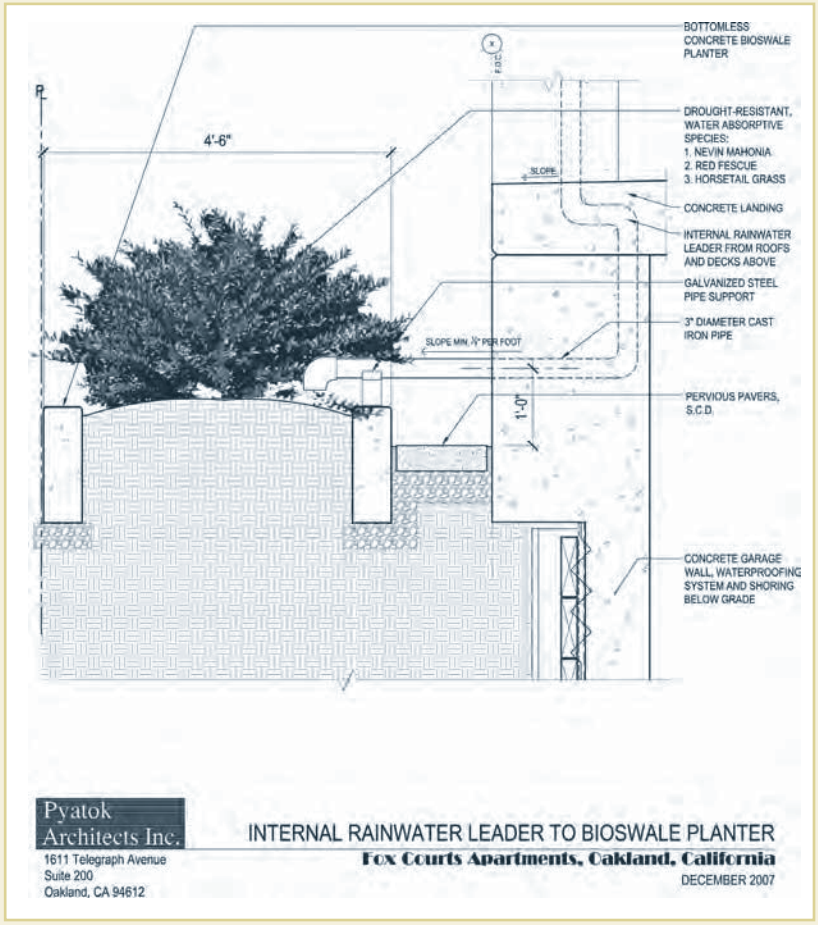
In the Bidder's section of the project summary, include the required diversion levels of construction and demolition (C&D) waste *(A2).* Also, include language in the specification Section 01505 requiring C&D diversion. Contract documents should specifically state the role of each party in the construction waste management and construction indoor air quality (IAQ) management plans, from architect to subcontractor. The documents should clearly hold a responsible party accountable for failure to meet waste management and pollution prevention goals *(see the individual measures in this section for details).*

COST

Some of these procedures may increase costs initially but save money over the life of the building. An IAQ management plan *(A3),* for example, will likely result in additional labor and time to develop and implement, but if it is well executed it may result in fewer call backs, and may extend the life of the HVAC system.

Other practices add little or no extra cost. The cost of recycled aggregate *(A4),* for example, is similar to standard aggregate. With the availability of mixed C&D recycling facilities in many regions of the state, implementing a C&D waste management plan *(A2)* requires no more labor than standard industry practice. Sustainable landscaping *(B1)* can actually save money over time by reducing labor, water and chemical costs, lowering plant loss and replacement expense, and reducing hauling and disposal fees.

CREATIVE SOLUTIONS FOR URBAN STORMWATER MANAGEMENT *Fox Courts, Oakland, CA*



Fox Courts' bioswale planters capture a portion of the rainwater runoff from the roof.

Fox Courts, a new 80-unit apartment building in Oakland's Uptown district, broke ground in late October, 2007. Developed by Resources for Community Development (RCD), the project will provide permanent affordable rental homes for people with incomes ranging from 30% to 60% of the area median income. Fox Courts is being built green from the ground up, and will bear a GreenPoint Rating when complete.

One of the challenges facing the design team, which included Pyatok Architects and civil engineer Van Maren and Associates, was how to manage stormwater runoff on a densely built urban site. "There's almost no exposed ground on the site," said architect Jordan Rose, "so storage was out and natural percolation was out for the whole site." Although grandfather conditions meant that the site didn't have to comply with code requirements for post-construction stormwater pollution management, RCD decided to take voluntary steps to detain and filter stormwater runoff.

Alongside the property is a 25-foot by 218-foot alley that's been converted to a pedestrian mews connecting two streets. Although only a five-foot-wide strip of the mews is on Fox Courts' property, the design team recognized an opportunity for stormwater retention. Along the length of the 218-foot strip, large, bottomless concrete planters will be sunk into the soil. Gutters from roofs and decks facing the mews will drain into these bioswale planters and then into the soil, capturing roughly 10% of the drainage from the Fox Courts site. Any overflow from the planters will spill over the planters' low curbs and onto pervious paving installed in the five-foot strip. The bioswale planters will be planted with creeping red fescue, horsetail grass and Nevin's mahonia, species chosen for their ability to handle inundation in the rainy months and minimal irrigation in the dry months.

RCD and the design team view the mews landscaping as a demonstration project that shows one creative way to capture rainwater on dense urban sites. "It'll be pretty visible," Rose said. "People walking through the mews can see the gutters emptying right into planters."

For the landscaping of Fox Courts' two courtyards, the design team specified large double-walled, above-ground planters that reduce the need for irrigation water. To water the plants, the maintenance staff unscrews a cap at the top of the planter and uses a hose to fill the water-storage bladder between the planter's walls. Water trickles into the soil from the bladder's bottom. Besides being a more effective way to deliver water to a plant, watering from the bottom also uses much less water than irrigating the surface. It's a low tech, low maintenance solution that eliminates the need for an irrigation system and reduces water use.

For more information, visit www.rcdev.org

MEASURE A1

PROTECTION OF SOIL, VEGETATION, AND WATER DURING CONSTRUCTION

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 31 10 00: Site Clearing

NEW: 02230: Site Clearing

Recommendation

During grading and construction, protect topsoil from erosion and compaction and manage stormwater runoff. Preserve existing healthy trees and other valuable vegetation.

Description

Healthy topsoil is teeming with bacteria, fungi, worms and other beneficial organisms. These organisms live within the top 2 to 6 inches of soil, creating soil structure, storing nutrients and cycling them to plants, protecting plants from pests, improving water infiltration and storage, and filtering out pollutants.

Despite its value, on most construction sites topsoil is compacted by heavy equipment or removed altogether, beginning a cycle of high water and chemical dependency. Similarly, existing trees and other mature vegetation are often cleared from a construction site. Mature vegetation provides valuable ecological services, from preventing soil erosion and silting of waterways, to absorbing and storing carbon dioxide, to providing habitat for countless species.

PRACTICAL CONSULTING

Silt fencing often fails.

Although stripping a site may make building easier, it can take years or even decades for the property to recover its ecological health. Through careful planning and construction practices, topsoil as well as healthy trees and other plants can be protected so that they continue to provide economic, aesthetic and ecological benefits.

It's also critical—and required by law—to manage construction activities to control stormwater runoff and minimize pollution. Excessive stormwater runoff can erode the site's soil and carry pollutants and sediment into waterways.

The strategies in this measure address protection of soil, water and vegetation during construction. Strategies to manage stormwater runoff throughout the building's life are not covered here but are regulated by federal, state and local law *(see Resources).* Best practices for continued stormwater management include minimizing impervious surfaces by including features such as pervious paving and green roofs *(Structure: E3–Vegetated Roofs);* channeling runoff to swales, porous surfaces and holding areas *(Site: B1–Sustainable Landscaping);* and installing systems that filter and treat stormwater as it leaves a site.

Benefits

In healthy soil that hasn't been compacted, plants thrive and trees are able to grow to their normal height. Healthy soils can also significantly reduce stormwater runoff, reduce fertilizer and pesticide requirements, improve water quality and conserve irrigation water. Protection of existing mature vegetation helps prevent soil erosion, keeps the building and surrounding environment cooler in the summer, keeps plant waste out of landfills, preserves habitat and adds value to the community. Keeping sediments and pollutants out of storm drains helps protect local creeks, reservoirs and the ocean.

Application

SIZE	√ Low Rise	√ Mid Rise	High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily housing, but most relevant to sites on undeveloped land or sites with existing landscaping or open space. Renovations of infill sites built to the lot line can add beneficial soils and habitat by including new landscaped areas *(Site: B1–Sustainable Landscaping).*

Design Details

For additional information, see Site: B1–Sustainable Landscaping.

PROTECT TOPSOIL

» **Retain natural topographic features that slow and store storm flows** to minimize site disturbance. Limit

clearing and grading to the roads, utility rights-of-way, building pads, and the minimum additional area needed to maneuver equipment (a 10-foot perimeter around the building site). Avoid clearing and grading areas sited for landscaping whenever possible.

» **Design for minimum building and hardscape footprints and little or no grading.** When grading is unavoidable, identify areas to be paved as places to store topsoil during construction. Remove existing horticulturally suitable topsoil (at least the top 6 inches if the topsoil is deep) before other grading and store for future use. Do not store in piles larger than 6-feet high and protect it from erosion.

» **Protect soil from compaction.** Heavy equipment can compact soil as deep as 2 feet below the surface of the soil. Compacted soils do not have adequate space for air or water, which plants' roots need to thrive. To reduce soil compaction, specify a limited construction area before construction begins. Install temporary fences to restrict heavy equipment, including cars. Areas that will be paved or built over are good sites for parking equipment. If using heavy equipment, select those with flotation tires or wide tracks to distribute load. Limit foot traffic and working the soil, especially during the wet season.

» **After construction, evaluate the quality of the stockpiled soil and amend with compost, if needed.** Send topsoil samples for analysis and request recommendations be based on an organic approach to soil management (rather than synthetic additives). Any new soil that needs to be added shall be similar to existing soil in pH, texture, permeability and other characteristics, unless soil analysis reveals that a different type of soil is appropriate for the site. Specify compost produced by participants in the U.S. Composting Council's Standard Testing Assurance Program. Re-spread after grading and construction.

» **Defend against erosion** by keeping as much vegetation on the construction site as possible, which minimizes soil exposure to erosion, especially along slopes and waterways. The resulting loss of topsoil depletes the soil of its organic, living component and clogs waterways. Do not remove mature trees and shrubs, especially near waterways; protect them with fencing. Other best practices for erosion prevention include scheduling grading for the dry season; controlling erosion with compost or mulch berms, blankets, tubes or socks; constructing sediment traps and sediment basins; using silt fencing sparingly (it fails often and creates waste after the project); terracing steep slopes, and hydroseeding or planting cover crops to reduce bare soil.

PROTECT EXISTING VEGETATION AND NATURAL AREAS

» **Establish protected zones.** Jurisdictions typically require protective fencing around trees at the dripline and around other plants that are to be preserved; it is good practice to extend this no-disturbance zone well beyond driplines and landscape beds. Keep heavy equipment out of protected zones and minimize foot traffic; build boardwalks if heavy foot traffic is expected. Avoid changing the grade around protected trees or cutting their roots.

» **Protect natural areas.** On sites with mature trees, wetlands or other natural areas, look for ways to protect those areas and consider providing wildlife corridors from them to adjacent parks, wetlands and natural areas.

Consider the effects of land clearing. Aim for balanced fill whenever possible—if soil does need to be removed, store and reuse the topsoil *(see above)* for landscaping and use subsoil for fill.

» **Preserve or relocate mature vegetation.** Complete a landscape survey to determine the feasibility of preserving (or relocating when necessary) mature trees, shrubs and native vegetation. Decisions to preserve topsoil and vegetation must be made early (before the building is designed or any work on site is done) as part of an integrated design process. The resulting plan must be clearly communicated to the project team throughout the design and construction process.

» **Minimize the footprint and cluster units.** Minimizing the development footprint and providing permanent open spaces, either as wildlife preserves or parks, can help protect the local ecosystem. Building upward instead of outward will help minimize the developed area, especially in rural or suburban areas.

PRACTICA CONSULTING

Mulch socks help prevent erosion on a construction site.

» **Restore wetlands.** Creeks or wetlands can be augmented or restored with natural swales and stormwater retention ponds. Wetlands and riparian zones are critical natural resources and are well regulated. If your project will affect a creek or wetland, consult state and federal agencies with jurisdiction over these natural resources early in the design process.

MANAGE STORMWATER DURING CONSTRUCTION

During grading and construction, use stormwater best management practices (BMPs) to control erosion and prevent sediment and pollutants from entering storm drains *(for handbooks on BMPs in California, see CASQA information in Resources, below).* Erosion control protects soil surfaces, whereas sediment control traps soil particles after they have been dislodged. Stormwater BMPs during construction include the strategies described above for defending against erosion, as well as these actions:

» Cover construction materials and stored topsoil exposed to rain; store wastes under cover and dispose of properly.

» Install temporary concrete washout areas for use by contractors to prevent pollution from entering storm drains.

» Educate onsite workers to practice good housekeeping and implement best management practices to prevent stormwater pollution.

» Inspect and maintain control measures before and after each rainstorm.

Code Considerations

Stormwater management is subject to federal, state, regional and local requirements. Projects that impact five acres or more are subject to the National Pollutant Discharge Elimination System (NPDES) under the federal Clean Water Act.

The State of California requires projects that disturb one or more acres of soil or projects that disturb less than one acre but are part of a larger common plan of development that in total disturbs one or more acres to develop and implement a Storm Water Pollution Prevention Plan (SWPPP) under the General Permit for Discharges of Storm Water Associated with Construction Activity (Construction General Permit, 99-08-DWQ).

There are also many regional and local regulations for stormwater management, tree conservation or landscaping. Contact your local municipality for details and assistance.

Considerations for Residents

Residents may benefit from increased property values, protection of local streams and waterways, and lower energy bills (if mature shade trees are preserved).

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$ $ $

Costs can be reduced if topsoil doesn't have to be imported or hauled off site and if existing vegetation is preserved. New landscaping is more likely to thrive in healthy topsoil, which will reduce plant replacement and ongoing landscaping costs.

Resources

» **Bay-Friendly Landscape Guidelines** explain how to design, construct and maintain landscapes to support ecological health: www.BayFriendly.org

» **California Environmental Protection Agency's State Water Resources Control Board** has links to many resources for California developers, engineers and contractors:

www.swrcb.ca.gov/stormwtr/bmp_database.html (stormwater best management practices);

www.swrcb.ca.gov/stormwtr/construction.html (Stormwater Pollution Prevention Plans)

» **California Environmental Resources Evaluation System** (CERES) has information about wetlands management, regulatory permitting and policies: www.ceres.ca.gov/wetlands

» **California Stormwater Quality Association** (CASQA) has brochures, fact sheets and other information about stormwater management during construction, including the *New Development and Redevelopment Handbook:* www.casqa.org

» ***Environmental Building News*** has an article on treatment systems, "Cleaning up Stormwater: Understanding Pollutant Removal from Runoff" (Feb. 2002); fee to access: www.buildinggreen.com

» **University of Massachusetts** Building Materials and Wood Technology department's article, "Preserving Trees During Construction," has detailed information about planning for tree preservation: www.umass.edu/bmatwt/publications/articles/preserving_trees_during_construction.html

» **Washington State Department of Ecology's** publication, "Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13," describes best management practices for soil quality, stormwater retention and water quality:

www.compostwashington.org/PDF/SOIL_MANUAL.pdf

Related Case Studies

None

C&D WASTE MANAGEMENT

Reduce, Reuse and Recycle Waste Created at the Jobsite

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: **01 50 00:** Temporary Facilities and Controls, **01 74 19:** Construction Waste Management and Disposal, **02 41 19:** Selective Structure Demolition

OLD: **01505:** Temporary Facilities and Controls, **01524:** Construction Waste Management, **01732:** Selective Demolition

Recommendation

Identify the types and estimate quantities of waste generated at the jobsite. Follow a Construction and Demolition (C&D) Waste Management Plan and divert at least 50% of the construction and demolition materials from landfills by reducing, reusing or recycling waste generated at the jobsite.

Where local facilities are available, divert 100% of heavy and inert materials, such as concrete, asphalt and dirt.

Description

Construction and demolition materials constitute about 22% of the disposed waste stream statewide. C&D waste generally consists of wood, drywall, metals, concrete, dirt, insulation, cardboard and more. Many of these materials can be reduced, reused or recycled. Cardboard, for example, can be readily recycled in most areas of the state.

A C&D Waste Management Plan is a crucial component of managing waste during project demolition and construction. Training onsite personnel before demolition or construction begins is extremely important in ensuring that a C&D Waste Management Plan is successful.

Benefits

C&D waste management can save contractors money by reducing the need for purchased materials and by lowering disposal fees.

Keeping C&D materials out of landfills conserves natural resources, slows the rate at which landfills reach capacity, and reduces methane emissions created when landfilled materials break down. Methane is 20 times more potent as a greenhouse gas than carbon dioxide, and landfills account for 34% of methane emissions in the United States, so reducing the amount of waste sent to landfills can significantly reduce greenhouse gas emissions. Recycling 1 ton of cardboard boxes, for example, reduces greenhouse gas emissions by the equivalent of 4 tons of carbon dioxide.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all new construction, renovation and demolition projects.

Design Details

For a model Specification Section 01505 for Construction and Demolition Waste Management and a sample C&D Waste Management Plan, see www.StopWaste.org.

PROJECT SPECIFICATIONS

Include the required diversion levels in the Bidder's section of the Project Summary. Also include language in the Specification Section 01505 requiring C&D diversion. Be sure the contract documents hold a responsible party accountable for failure to meet the waste management goals.

C&D WASTE MANAGEMENT PLAN

Require the contractor to develop and implement a C&D Waste Management Plan. This plan will typically require the contractor to:

» Check bid package and local jurisdiction to determine diversion opportunities.

» Include a good-faith estimate of each type of construction waste that would be created if no diversion occurred.

STOPWASTE.ORG

Jobsite recycling bins.

- Develop means and methods for reusing and recycling C&D materials, usually through separating some types of debris, delivering mixed debris to a mixed C&D recovery facility, or a combination of both. This includes contacting local recycling facilities and haulers to identify required terms and conditions.
- Furnish copies of the plan to all onsite supervisors, each subcontractor, the owner and the architect.
- Train onsite personnel to implement the Waste Management Plan before demolition or construction begins.
- Document the results of the waste management efforts, including the date, type and amount of waste reused or recycled.

SCHEDULING AND COMPLIANCE

For C&D waste management to be most effective, the goals must be addressed in a project's Design Documents phase. C&D waste management can disrupt construction sequencing if, for example, demolition has to be halted to recover salvageable materials; scheduling should allow for salvaging and deconstruction activities.

Require contractors to cover the required Waste Management Plan with subcontractors in preconstruction meetings and to include contract language requiring that all subcontractors comply with the plan. This includes making sure that the construction team understands that construction waste recycling bins are not to be used as receptacles for workday garbage. Also, recycling bins must be secured against illegal dumping.

Consider imposing fines or other penalties for failure to comply with the waste management requirements.

Code Considerations

The minimum requirement for C&D recycling in California is 50%, although some local jurisdictions have higher minimums. City and county ordinances often mandate that a C&D Waste Management Plan be submitted and approved prior to obtaining building and demolition permits.

Considerations for Residents

No effect on residents.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Planned management of C&D waste has been proven to reduce the amount of material delivered to landfills and reduce project costs due to decreased disposal fees.

LABOR COSTS AND JOBSITE LOGISTICS

If the jobsite allows for multiple bins, most contractors choose to source-separate materials such as concrete, metals and cardboard, since disposal rates are lower for source-separated material and some materials, such as metals, can generate revenue. Some contractors find that separating materials requires additional labor.

Mixed C&D recovery facilities are increasingly the preferred recycling choice, especially if there are space or time constraints at the jobsite, or if the materials are difficult to separate on site, such as demolition materials from tenant improvement projects. Mixed C&D facilities receive, sort and recycle loads of mixed materials from construction or demolition sites if 60% or more of the total load consists of recyclable materials. Recycling rates vary, but most mixed C&D facilities recycle 50% to 70% of the material delivered.

COST EFFECTIVENESS OF SALVAGING

Unless the salvaged materials are valuable—such as quality timber, ornate hardware or stained glass windows—the labor cost of salvaging may exceed the materials' market value. In this case, the owner must determine if salvage is worth the extra expense. Nonprofit salvage companies may offer a tax-deductible donation receipt for the value of the salvaged goods to help offset the additional cost.

Resources

- **California Integrated Waste Management Board** provides information about C&D waste management, including a database of C&D materials recyclers searchable by material type and location. www.ciwmb.ca.gov/ConDemo
- **StopWaste.Org** provides extensive information about C&D waste management, including a model C&D ordinance, a model Specification Section 01505, a sample Waste Management Plan for recycling C&D materials and the *Builders' Guide to Reuse & Recycling, A Directory for Construction and Demolition Materials:* www.StopWaste.org

  U.S. Environmental Protection Agency publishes the Waste Reduction Model, an online tool to estimate the greenhouse gas emissions benefits of recycling C&D materials: www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Related Case Studies

- Carmen Avenue, p. 230
- Colony Park, p. 227
- Crossroads, p. 234
- Sara Conner Court Apartments, p. 221

CONSTRUCTION ENVIRONMENTAL QUALITY

Improve Indoor Air with an IAQ Management Plan and Building Flush-Out

KEY BENEFITS

√ Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 01 40 00: Quality Requirements, **01 74 13:** Progress Cleaning, **01 74 16:** Site Maintenance, **01 74 23:** Final Cleaning

OLD: 01400: Quality Requirements, **01740:** Cleaning

Recommendation

Develop and execute a Construction Indoor Air Quality (IAQ) Management Plan for construction and preoccupancy phases, and conduct a preoccupancy building flush-out.

For renovation projects, follow the best practices in SMACNA's *IAQ Guidelines for Occupied Buildings Under Construction.*

Description

During construction, there are many opportunities to contaminate a building and adversely affect indoor air quality. Some of these contaminants are short lived; others may persist for the life of the building.

One way to minimize contamination is to develop and carry out a Construction IAQ Management Plan. Such a plan spells out appropriate strategies for minimizing construction-related IAQ problems.

To further reduce the potential for IAQ problems, flush out the building spaces by circulating fresh air for a specified time to allow finish materials to offgas.

Benefits

Implementing an IAQ Management Plan during construction can reduce indoor air quality problems for workers in the short term and occupants in the long term.

A properly executed preoccupancy building flush-out may save money by helping to reduce call-backs, extend the life of ventilation systems, and reduce problems associated with sick building syndrome.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all new construction and renovation projects.

Design Details

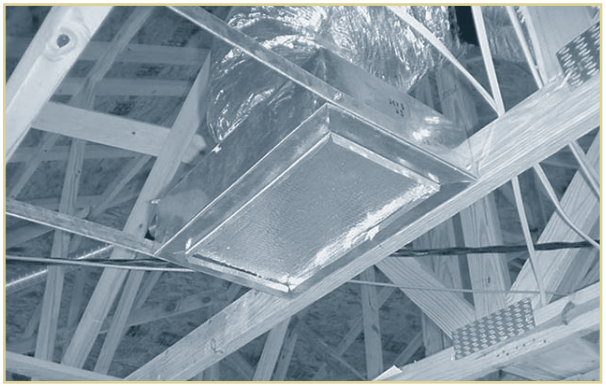
ROLES AND RESPONSIBILITIES

In Contract Documents, specifically state the role of each party in the Construction IAQ Management Plan, from architect to subcontractor. In project meetings, regularly discuss the IAQ plan and goals and involve all relevant parties, including subcontractors.

Some developers will use an architect to help draft the plan; this can be an effective time to also discuss the project's other green building goals. Architects should help identify materials that reduce IAQ problems, such as products with low levels of volatile organic compounds (VOCs). *(See Finishes & Furnishings for information about selecting low-toxic materials.)* The architect should list products that have potential for causing problems, and offer control measures for handling those materials.

The builder and general contractor are typically responsible for implementing the plan during construction and before occupancy.

AUSTIN ENERGY GREEN BUILDING PROGRAM



This supply vent register has been blocked to reduce contamination of the ductwork during construction.

DURING CONSTRUCTION

IAQ management practices during construction deal primarily with protecting the HVAC systems (assuming forced-air ventilation, heating or air conditioning systems are installed) and protecting building materials from moisture.

HVAC systems can accumulate a lot of dust and contaminants during construction if they are not protected. Once inside the system, these contaminants are difficult to remove and may remain for years. Reducing or

eliminating HVAC system use (especially on the return side) during construction will help keep particulates, VOCs and other contaminants out of the system.

If the HVAC system must be used during construction, provide temporary filters on the return ducts and seal all registers and penetrations as needed to reduce contamination. Change the filters regularly prior to completion and again before occupancy. For systems that provide fresh air, ventilate using 100% outside air throughout construction.

If the HVAC equipment is not operated during construction, keep the ducts covered and do athorough building clean-up prior to running the system.

Here are more housekeeping ideas to protect IAQ during construction:

» Collect and review Material Safety Data Sheets (MSDS) for all proposed materials to identify hazards and obtain guidance on safe use.

» Cover and protect HVAC equipment until installed.

» Keep materials like wood, drywall and insulation away from moisture sources to avoid mold growth. Use dehumidifiers during the rainy season to help keep the building dry, especially when applying products with high moisture content, such as gypsum concrete or damp-spray cellulose insulation in wood-framed structures.

» If using damp-spray cellulose insulation, allow it to dry thoroughly before enclosing cavities *(Structure: F2–Quality Installation of Insulation)*.

» Clean up spills immediately.

» Clean work areas regularly to avoid contaminant buildup and improve safety.

PREOCCUPANCY

After construction is finished clean the jobsite properly. Clean all surfaces thoroughly. Brush, vacuum and clean fans and ducts, and change HVAC filters before performing testing and balancing.

Install porous materials, like carpeting and furniture, only after finish materials such as paints and sealants have cured. To reduce offgassing of VOCs into the building, air out carpeting and furniture for a period (up to two weeks) before installing *(Finishes & Furnishings: K8–Environmentally Preferable Interior Furniture)*.

Once the site is clean, conduct a thorough flush-out of building's indoor air. This allows for proper curing of paints and finishes, offgassing of materials, and filtration of the ventilation system. The Sheet Metal and Air Conditioning Contractors' National Association's (SMACNA) best practices for flush-out stipulates 14,000 cubic feet of outside air per building square foot. For buildings without HVAC systems, use natural ventilation. Many projects combine these practices by opening all the windows and running the HVAC system simultaneously for nine hours a day over two weeks.

If scheduling constraints don't allow time for airing out materials or flushing out the building prior to occupancy, the design team should place even greater emphasis on specifying low-VOC products, materials and furnishings.

Code Considerations

Construction workers must wear appropriate devices to protect against dust and VOCs. Adequate ventilation must be provided. In any rehabilitation project, properly test for lead paint and asbestos before beginning any work. OSHA and other regulations guide these practices.

Considerations for Residents

Protects residents' health and may increase their satisfaction with the building.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Implementing an IAQ Management Plan during construction can result in additional labor due to contractor scheduling and training sessions. Running ventilation systems on 100% outdoor air during construction and preoccupancy flush-out can increase energy costs prior to occupancy.

Resources

» Most of the material for this measure was derived from the ***LEED for New Construction Reference Guide v2.2;*** fee to purchase: www.usgbc.org

» ***Environmental Building News*** has an article, "Construction IAQ Management" (May 2002) and a paper, "Best Sustainable Indoor Air Quality Practices in Commercial Buildings"; fee to access: www.buildinggreen.com

» **Sheet Metal and Air Conditioning Contractors' National Association** (SMACNA) publishes useful IAQ management guidelines, including *IAQ Guidelines for Occupied Buildings Under Construction and Indoor Air Quality: A Systems Approach;* fee to purchase: www.smacna.org

» **U.S. Environmental Protection Agency** has construction IAQ management information for schools that is also applicable to multifamily buildings: www.epa.gov/iaq/schooldesign/construction.html

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

» Sara Conner Court Apartments, p. 221

RECYCLED AGGREGATE

Specify Recycled Aggregate for Fill, Backfill and Other Uses

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 01 74 19: Construction Waste Management,
32 11 00: Base Courses

OLD: 02700: Bases, Ballasts, Pavements, and Appurtenances
01524: Construction Waste Management

Recommendation

Specify recycled aggregate whenever Caltrans Class II materials are specified. Aim for 100% recycled aggregate in unbound applications.

Description

Aggregate is used for road base and subbase, fill under slabs, backfill and other uses. Extraction of virgin aggregate from sources such as riverbeds and quarries dramatically disturbs the surrounding environment. Furthermore, the energy used to extract, process and deliver aggregate to a project site contributes more greenhouse gas emissions than using a recycled product.

Recycled aggregate—typically clean, crushed concrete or asphalt—is generally available as an alternative to virgin materials. This concrete and asphalt is removed from demolished buildings and sitework, and is processed and cleaned for reuse onsite or at another site.

Concrete and asphalt are expensive to landfill, and many cities in California require construction site waste recycling, so there is plenty of recycled aggregate available.

Benefits

Construction and demolition (C&D) materials account for almost 22% of the disposed waste stream in California, according to the California Integrated Waste Management Board's 2004 Waste Characterization Study. Keeping concrete and asphalt out of landfills benefits the state and makes good use of the material.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable wherever Class II aggregate is specified, for example as backfill drainage, and under parking and access roads, sidewalks and building slabs.

Design Details

If a project is built on a formerly developed site, consider crushing concrete on site to supply aggregate for the new development.

Code Considerations

Many local jurisdictions in Northern California use Caltrans specifications for recycled aggregate. In Southern California, the *Standard Specifications for Public Works Construction* (popularly known as the Greenbook) is commonly used *(see Resources).* Check with the local building department to ensure that recycled aggregate can be used without complications from the city.

STOPWASTE.ORG

Concrete being sorted for reuse as aggregate.

Considerations for Residents

No effect on residents.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Depending on availability and type of base, the cost of recycled aggregate is similar to standard aggregate, typically between $5 and $20 per ton (2007 costs).

Resources

» **Build It Green Product Directory** has information on sourcing recycled aggregate and other green sitework and construction materials: www.BuildItGreen.org/products

» **California Integrated Waste Management Board** (CIWMB) provides extensive information about recycled aggregate and related topics: www.ciwmb.ca.gov

Statewide Recycled Content Products Directory: www.ciwmb.ca.gov/RCP/Construction.asp

Information on recycled aggregate, including specifications for Northern California (Caltrans) and Southern California (Greenbook): www.ciwmb.ca.gov/ConDemo/Aggregate

C&D Recycling Toolkit to help builders and contractors plan for C&D reuse and recycling: www.ciwmb.ca.gov/ConDemo/Toolkit

» **Caltrans' Specifications for Aggregate Base and Subbase** can be downloaded from: www.ciwmb.ca.gov/ConDemo/Specs/CaltransAgg.htm

» **The "Greenbook"** (*Standard Specifications for Public Works Construction*) can be purchased from: www.bnibooks.com

» **U.S. Environmental Protection Agency** publishes the Waste Reduction Model, an online tool to estimate the greenhouse gas emissions benefits of recycling C&D materials: www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html

Related Case Studies

» Carmen Avenue, p. 230

» Colony Park, p. 227

MEASURE A5

COOL SITE

Reduce the Heat Island Effect

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	Resident Satisfaction
√ Water Efficiency	Climate Protection

Division 3: Exterior Improvements

Division 2: Existing Conditions

Recommendation

Reduce the heat island effect by:

» Using light-colored paving materials with a high albedo.*

» Installing open-grid paving systems.

» Using a cool roof.

» Providing shade with trees, overhangs and building elements to cover portions of hard surface paving.

**Albedo—or total solar reflectance—is the fraction of solar energy a material reflects away from its surface and back into space. The higher the albedo, the greater the reflectivity.*

Description

Paved surfaces make up 30% to 40% of developed urban areas, and contribute to what is called the heat island effect, a type of thermal pollution. Little sunlight is reflected off dark asphalt, so its temperature rises far above the ambient air temperature. As a result, cities experience temperature rises of as much as 5°F above surrounding rural areas. Higher outdoor temperatures lead to higher temperatures inside buildings, driving up cooling loads.

Dark-colored roof surfaces can also contribute to the heat island effect. 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 albedo) and limiting the amount of heat stored by the roofing material (high emittance).

Benefits

Cool sites help people feel more comfortable. Citywide, air quality is improved because cooler air slows the chemical reaction that produces smog. Reducing the heat island effect also limits impacts on wildlife. Cool site techniques reduce air conditioning loads, saving energy and reducing global warming impacts.

Light-colored paving and roofing materials last longer than darker surfaces due to reduced thermal expansion and contraction. Additionally, pervious or open-grid paving reduces runoff that adds to stormwater surges in city drainage systems and stream over-sedimentation *(Site: A1–Protection of Soil, Vegetation and Water during Construction).*

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

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

Design Details

COOL PAVING STRATEGIES

The most effective way to reduce thermal pollution is to reduce paved areas. However, paved areas should not be wholly eliminated; children, for example, spend much of their play time on paved surfaces. Nevertheless, reducing paved areas can result in lower material costs and improved ecosystems. For paved areas that can't be eliminated, consider these strategies:

» **Light-colored materials.** Choose light-colored pavers, aggregates or top coats, preferably with an albedo (reflectance) of 0.30 or higher. Parking lots, sidewalks, roads, driveways and other surfaces can have coatings or integral colorants added to increase reflectance. Even light gray and tan colors may reduce surface temperatures by 20°F to 40°F. Consider using light-colored concrete, or, if paving with asphalt, applying a white aggregate as a chip seal layer, or a light-colored surface coating such as a zinc-oxide slurry mix.

» **Pervious concrete (poured or tile).** Pervious concrete allows rainwater to flow through the paving material to the soil beneath, reducing the amount of water running off the site and into municipal stormwater systems. Pervious concrete reduces the heat island effect by not absorbing, storing and reradiating heat

like other paved surfaces and also by allowing the moist earth underneath to cool the paving material. When specifying pervious concrete, take slope and existing soil conditions into account and hire a geotechnical engineer to help with design decisions.

» **Open-grid paving systems.** Install prefabricated concrete or plastic paving systems. The openings can be filled with light-colored gravel to improve reflectivity. Alternatively, grasses or other groundcover can be planted in the openings to provide cooling through evaporation while also retaining and filtering stormwater on site.

» **Tire strip driveways.** Consider installing a strip-style driveway that uses concrete only for the tire tracks.

» **Granite or crushed rock.** Use decomposed granite or other compacted crushed rock instead of asphalt for non-handicapped parking stalls and walkways. Gravel reflects and sheds heat better than paving and is preferable for stormwater management because of its porosity.

» **Mulch for walkways and paths.** Mulches are used to form an attractive surface layer on the soil to control weeds, protect plant roots from temperature fluctuations and reduce water loss from the soil. Some mulch products are appropriate for paths and walkways *(Site: B1–Sustainable Landscaping).*

» **Resin modified emulsion pavement.** For developers looking to try something new, these products are an alternative to asphalt. They use clear binders made of tree resins instead of petroleum products. Light-colored aggregates suspended in the resin as coloring will increase reflectivity.

COOL ROOFS

To increase energy savings and minimize the heat island effect, select roofing materials that have high reflectance and emittance properties *(Structure: E2–Sustainable Roofing Options)* or consider a vegetated roof *(Structure: E3–Vegetated Roofs).*

SHADING HARD SURFACES

Shading asphalt areas will greatly reduce surface temperatures. One of the best methods is to plant trees, which provide shade, cool the air through evapotranspiration and absorb carbon dioxide. Here are some recommendations for shade trees *(also see Site: B1–Sustainable Landscaping).*

» Calculate shading by estimating the diameter of the tree crown after five years.

» Select trees that are appropriate for the site in terms of soil type, water use and exposure.

Streets with trees provide natural cooling on hot days.

» Choose trees that will be allowed to grow to their natural shape and size in the allotted space.

» Do not allow smaller-size substitutions after the plans have been approved.

» Ensure trees are actually planted and that they are not removed after planting.

Trellises and other architectural elements can also provide shade *(Planning & Design: AA7–Passive Solar Design).* Covered parking spaces shade cars and provide a convenient place to mount photovoltaic panels *(Systems: I2–Photovoltaic Systems).*

Code Considerations

Some jurisdictions may require that hard surface materials have a minimum reflectance value to reduce the heat island effect. Some municipalities may also have ordinances that require a minimum number of trees be planted in parking lots and on sidewalks. Check with local officials for preferred tree species.

Considerations for Residents

Cool site strategies make the outside environment more comfortable, improve air quality, reduce car temperatures in parking lots, and may slightly reduce cooling costs.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

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

Resources

- **American Concrete Pavement Association** offers technical resources about concrete pavement practices: www.pavement.com
- **Collaborative for High Performance Schools** *(CHPS) Best Practices Manual, Volume II—Design* has details about cool sites: www.chps.net
- **Cool Roof Rating Council** has an online directory of cool roofing products: www.coolroofs.org
- **Energy Star Roofing Products** website provides information about Energy Star–qualified roof products: www.energystar.gov
- **Flex Your Power**, the state of California's energy efficiency outreach program, has information on cool roofs: www.fypower.org/com/tools/products.html
- **Interlocking Concrete Pavement Institute** has technical information on designing, specifying and installing permeable pavers: www.icpi.org
- **Lawrence Berkeley National Laboratory's** (LBNL) Heat Island Group has information about strategies to reduce the heat island effect: http://eetd.lbl.gov/HeatIsland

Related Case Studies

None

MEASURE B1

SUSTAINABLE LANDSCAPING

Create Sustainable Landscapes, Build Healthy Soils and Reduce Waste

KEY BENEFITS

Health/IEQ	√ Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: **32 92 00:** Turf and Grasses, **32 93 00:** Plants

OLD: **02920:** Lawns and Grasses, **02930:** Plants

Recommendation

Design, construct and maintain sustainable landscapes that use resources wisely and protect the environment.

Work with the local ecosystems to foster soil health, reduce runoff and pollution, prevent and reuse plant waste, and conserve water and other natural resources.

Description

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, 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 local waterways.

Sustainable landscapes are designed to work with nature to reduce waste, protect watersheds and safeguard the health of humans and other species. These are the core principles of sustainable landscaping:

» **Construct resource-efficient landscapes.** Conventional residential landscapes are often designed without regard for climate and soil conditions. Typically, they require high inputs of water and chemicals and produce excessive plant debris from pruning and mowing activities. Invasive plants used in landscaping often escape into natural areas, where they can spread rapidly, crowd out native plants, degrade wildlife habitat and increase the wildfire fuel load. Landscaping at multifamily developments typically favors ornamental over edible plantings and rarely provides areas where residents can grow food. Resource-efficient landscapes use plants and techniques that are better suited to local soils, wildlife and climate, and provide opportunities for residents to garden and grow food.

» **Use fire-safe landscaping techniques.** California's hot, dry climate makes fire protection an important consideration for landscape design, especially because new residential developments are increasingly located adjacent to areas that may be prone to wildfires. Simple landscaping design practices can help defend the buildings by reducing fuel accumulation and interrupting the fire path.

» **Minimize turf areas.** Lawns (or turf) are useful for recreation and relaxation, but turf requires frequent cutting, watering and application of fertilizers or other chemicals to stay green during California's long dry season.

» **Plant trees.** Trees help lower cooling costs, increase comfort in the summer, provide beauty and habitat, slow stormwater runoff, help stabilize slopes, and absorb carbon dioxide, a greenhouse gas.

» **Group plants by water needs (hydrozoning).** Different plants have different water requirements. Hydrozoning involves dividing the landscape into zones of low, medium and high water use to prevent overwatering.

» **Install high efficiency irrigation systems.** Efficient irrigation systems apply only the amount of water that the plants need with little or no waste through runoff, overwatering or overspray.

» **Incorporate compost to promote healthy topsoil.** A robust, living soil with sufficient organic content is the foundation of a water-conserving, resource-efficient, low-impact landscape. Adding good quality compost before planting brings life to the soil and feeds existing soil organisms, fueling many natural processes that supply nutrients, minimize disease and improve soil quality.

» **Mulch all planting beds.** Mulch is any material spread evenly over the surface of the soil. Organic materials, including chipped landscape debris, are preferable over inorganic materials because they supply nutrients over time and provide wildlife habitat.

» **Use salvaged or recycled-content materials for landscape elements.** Landscape elements present many opportunities for using salvaged or recycled materials. Recycled-plastic lumber or recycled-composite lumber makes a durable landscape edging *(Finishes & Furnishings: M6–Outdoor Play Structures).* Broken concrete can be used to make a very attractive retaining wall or path, and tumbled glass cullet can be used to create beautiful walkways.

» **Use porous hardscaping.** Hardscape that allows water to penetrate into the soil directly beneath it reduces stormwater runoff and improves water quality. This can take the form of pervious asphalt or concrete, pavers (such as broken concrete) or crushed rock *(Site: A5–Cool Site).*

Benefits

The strategies listed above significantly reduce landscaping water use while fostering soil quality and plant health. Onsite community gardens and private planting areas give residents the opportunity to grow food and enjoy the physical, social and emotional benefits of gardening. Shade trees mitigate climate change impacts by keeping buildings and surrounding areas cooler and absorbing carbon dioxide. Fire-safe landscaping protects lives and assets. Using salvaged or recycled-content materials for hardscaping reduces waste and in some cases increases the longevity of the installation.

Sustainable landscaping is also good business. In many cases, implementing the practices recommended in these Guidelines can:

» Reduce labor, water and chemical costs;

» Prevent plant loss and replacement expenses;

» Reduce hauling and disposal fees;

» Protect worker health and safety; and

» Meet the needs of the owners and community by creating attractive, functional and low-maintenance landscapes.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Sustainable landscaping principles can be incorporated into all multifamily developments.

Design Details

Follow these environmentally sound practices when designing and installing landscaping for multifamily developments:

CONSTRUCT RESOURCE-EFFICIENT LANDSCAPES

Evaluate the climate, exposure and topography of the site. Have the soil professionally analyzed for texture, nutrients, organic matter content and pH, especially if the topsoil was not protected during construction activities *(Site: A1–Protection of Soil, Water and Vegetation during Construction).* If soil amendments are advised, ask the laboratory to recommend organic or environmentally friendly amendments.

Select drought-tolerant species that are appropriate for the site's soil and microclimates, such as California natives, Mediterranean or other well-adapted species. Plant a variety of trees, shrubs and other perennials and limit annuals. Don't plant invasive species that are problematic locally and eliminate any from the site before planting *(for a list of invasive species in your area, see Resources).*

Give plants plenty of room to mature, reducing the need for pruning and shearing. Include a site for composting and mulching plant debris.

Consider designating some of the grounds as a community garden where residents can grow food and flowers. If the site won't accommodate a full-fledged community garden, look for ways to provide smaller planting areas where residents can garden. Raised beds or planting tubs, for example, can be located near the units' entrances, adjacent to common areas such as a playground, or even on an accessible roof.

USE FIRE-SAFE LANDSCAPING TECHNIQUES

For sites adjacent to fire-sensitive open space or wildlands, identify critical fire vectors, including:

» The building's exposure to prevailing winds during the dry season;

» Steep slopes, especially south- and west-facing, that can increase wind speed and convey heat; and

» Vegetation type, particularly species that burn readily.

Specify mitigations to fire vectors including the establishment of a defensible zone immediately surrounding the structure that uses one or more of these firescaping strategies:

» Avoid plants with high oil content or that tend to accumulate excessive dead wood or debris. Use plants with low fuel volume and/or high moisture content.

» Adequately space trees and keep branches pruned to 6-foot minimum above ground. Keep dense shrub plantings separate from trees to minimize fuel ladders.

» Plant trees and tall shrubs where limbs and branches will not reach the building or grow under overhangs as they mature.

» Avoid finely shredded bark mulch.

» Construct roofs, siding and decks with fire-resistant materials. Consider alternatives to fences, such as rock or concrete walls.

MINIMIZE TURF AREAS

Replace decorative lawns with water-conserving California native or Mediterranean groundcovers or perennial grasses, shrubs or trees. If turf is desired or needed for recreational uses, specify no more than 25% of the total landscaped area as turf or substitute turf with varieties requiring low watering, such as Carex pansa. *(For more information about sustainable lawn care, see Resources.)*

Do not specify turf for street medians or any areas less than 8 feet wide. Avoid planting turf on slopes exceeding 10% or in irregularly shaped areas that cannot be irrigated efficiently.

PLANT TREES

Protect or augment the existing tree cover on the site, particularly to the west of the building, by planting California native or other Mediterranean tree species that are drought tolerant and appropriate for the site's soil and microclimates. Plant trees to shade walls, windows and paved areas. If the building design includes passive solar heating, use deciduous trees on the building's south and west sides *(Planning & Design: AA7–Passive Solar Design).* Avoid planting trees too close to the building and utilities. Give trees plenty of room to mature, reducing the need for pruning and shearing. Deciduous fruit and nut trees have an added advantage of providing food for residents.

If construction activities have compacted the soil, consult an arborist or landscape architect for planting guidance *(Site: A1–Protection of Soil, Vegetation and Water during Construction).* Pay particular attention to areas where soils are engineered to prevent settling, such as under sidewalks, parking lots and near foundations. Without proper design, trees planted in these soils often die in seven to ten years. Use a structural soil designed for urban tree planting, which will result in long-lived trees and improved stormwater management *(see Resources).*

MICHAEL HILGEN

A vibrant landscape fosters pride among residents.

HYDROZONING

Group plants by water needs, creating irrigation zones based on the plants' water requirements and their exposure. Delineate each hydrozone on the site, irrigation and planting plans. Place thirstier plants in relatively small, highly visible areas and if possible, in spots that naturally collect water. Plant the larger areas with drought-tolerant species. Install separate irrigation valves for different zones. Consider that some California natives do not tolerate water in the summer after they are established; be sure to separate them from plants that need ongoing irrigation.

INSTALL HIGH EFFICIENCY IRRIGATION SYSTEMS

Design the irrigation system to meet or exceed the requirements of your local water conservation ordinance. Install drip, subsurface or low-flow irrigation systems in place of standard systems for all landscape applications. Design and install irrigation systems to achieve an irrigation operational distribution uniformity of 70% or greater in all turf areas and 80% in all other landscaped areas. Operate the irrigation system at no more than 72% of reference evapotranspiration for the irrigated area. Also:

» Specify a dedicated irrigation meter for irrigated landscaping of 5,000 square feet or more;

» Specify automatic, self-adjusting irrigation controllers, equipped with a moisture sensor and/or rain sensor shutoff, for all irrigation systems; or

» Specify a smart irrigation controller that has at a minimum the following capabilities: 1) automatic periodic adjustments to the irrigation program, accomplished through external sensors, internally stored historical weather data or a provider-supplied signal, 2) multiple start times, 3) run-times able to support low-volume applications, 4) irrigation intervals for days of the week or same-day intervals, and 5) more than one operating program (for example, A=turf, B=shrubs, C=water features). If necessary, turn off the irrigation system or valve for the landscape or hydrozone that includes only low water use California natives, once the plants are fully established.

INCORPORATE COMPOST TO PROMOTE HEALTHY TOPSOIL

Assess the soil quality on site *(see Construct Resource-Efficient Landscapes, above).* Incorporate 2 to 4 inches of compost into the top 6 to 12 inches of soil, or as much as is required to bring the soil organic matter content to 3.5% for turf and 5% for planting beds, except for plant species that will not thrive in such soils. Use fully stabilized compost certified by the U.S. Composting Council (USCC) as a soil amendment where appropriate—stabilized compost has been properly matured and can be safely handled, stored and applied to the soil. Loosen all planting and turf areas to a minimum depth of 6 inches prior to final landscape grading. Occasionally topdress with compost on turf and around established shrubs and trees.

MULCH ALL PLANTING BEDS

Apply and maintain a minimum of 3 inches of organic mulch (such as woodchips or leaves) to all soil surfaces or at least until plants grow to cover the soil. Do not place mulch directly against any plant stem or tree. Designate areas under trees and away from hardscapes or storm drains as repositories for fallen leaves to remain as mulch. Buy mulch produced from urban plant waste debris or from local suppliers within a 150-mile radius. Do not buy forest mulch because it usually comes from distant forests and most often does not provide the same level of nutrients as compost and mulch made from local, urban and mixed-plant debris.

USE SALVAGED OR RECYCLED-CONTENT MATERIALS FOR LANDSCAPE ELEMENTS

Use salvaged or recycled-content materials for hardscapes (planting beds, patios, decks, walls, walkways and driveways) and other landscape features (for example, edging, benches, play equipment). If recycled plastic or composite lumber is not appropriate, use FSC-certified sustainably harvested wood *(Structure: D5–FSC-Certified Wood for Framing Lumber and Finishes & Furnishings: M6–Outdoor Play Structures).*

USE POROUS HARDSCAPING

Minimize water runoff by specifying as little hardscape as possible. When hardscape is unavoidable, specify porous hardscape such as pervious concrete. Consult with a landscape architect and/or civil engineer to establish a drainage regime that captures the maximum utility of stormwater events onsite *(Site: A5–Cool Site).*

Code Considerations

Landscaping, including fire management and water conservation, may be subject to a variety of local codes. Consult your local code official or landscaping expert for details. In some cases local landscaping requirements may discourage or even prevent sustainable landscaping practices. Work with Planning Department staff to explore exemptions from these local requirements, especially during the Design Review process for new construction projects.

Considerations for Residents

Avoiding exposure to pesticides is an important benefit for residents; children and pets that play outdoors and come in contact with soils and plants are especially vulnerable. Pesticides are also easily brought into the home and deposited on floors and carpets via foot traffic.

A healthy, vibrant landscape presents a positive image to the community and fosters pride among the building's residents. Composting and other community gardening efforts can encourage community interaction, and teach residents about the effect of their actions on the local environment.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

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 expenses; reducing hauling and disposal fees; and preventing or minimizing damage to fencing, sidewalks and other hardscapes. It is important to find a landscape architect and maintenance company that understands and can implement the sustainable landscaping principles described in these Guidelines.

Resources

- ***Bay-Friendly Landscape Guidelines,*** as well as other StopWaste.Org resources, provide information on sustainable landscaping design and maintenance: www.BayFriendly.org
- **Build It Green Product Directory** includes information on landscaping products: www.BuildItGreen.org/products
- **California Department of Water Resources** offers helpful publications, including *A Guide to Estimating Irrigation Water Needs of Landscape Plantings* in California: www.owue.water.ca.gov/docs/wucols00.pdf
- **California Friendly Garden Program** offers the *California Friendly Gardening Guide* and more resources for sustainable landscaping: www.bewaterwise.com
- **California Integrated Waste Management Board** provides information on resource-efficient landscaping and links to related sites: www.ciwmb.ca.gov/Organics/Landscaping
- **California Invasive Plant Council** website lists invasive plants to avoid planting or to remove from your site, and other information about sustainable landscaping: www.Cal-IPC.org
- **California Native Plant Society** has information about native plants: www.cnps.org
- **East Bay Municipal Utility District's** book, *Plants and Landscapes for Summer-Dry Climates,* has information about plants suited to climates and microclimates found throughout California: www.ebmud.com
- **Local water agencies** may offer commercial landscape irrigation audits, irrigation upgrade programs, landscape partnerships, and tips for landscaping and irrigating wisely. Check with your local water agency.
- ***The Organic Lawn Care Manual:*** *A Natural, Low-Maintenance System for a Beautiful, Safe Lawn,* by Paul Tukey (Storey Publishing, 2007) provides in-depth information on sustainable lawn care and design: www.storey.com
- ***Sustainable Landscape Construction:*** *A Guide to Green Building Outdoors,* by J. William Thompson and Kim Sorvig (Island Press, second edition, 2007), describes how to construct outdoor environments based on sustainability principles: www.islandpress.com
- **University of California's Statewide Integrated Pest Management Program** has numerous online resources: www.ipm.ucdavis.edu

Related Case Studies

- Carmen Avenue, p. 230
- Colony Park, p. 227
- Fox Courts, p. 47
- Sara Conner Court Apartments, p. 221

SOURCE WATER EFFICIENCY

Reuse Wastewater and Harvest Rainwater

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: **22 14 00:** Facility Storm Drainage
22 40 00: Plumbing Fixtures

OLD: **15160:** Storm Drainage Piping
15410: Plumbing Fixtures

Recommendation

Use recycled water and/or captured rainwater for nonpotable uses such as landscape irrigation and flushing toilets and urinals.

Description

California's water resources can no longer be taken for granted. In the future, according to the state's Department of Water Resources, "warmer temperatures, different patterns of precipitation and runoff, and rising sea levels will profoundly affect the ability to manage water supplies." Multifamily developments that use recycled water or rainwater for some of their nonpotable water needs help ensure that there will be adequate water supplies for California's growing population.

When irrigating landscaping with water from any source (potable, recycled or rainwater), always use high efficiency irrigation systems *(Site: B1–Sustainable Landscaping).*

RECYCLED WATER

Recycled water is former wastewater (sewage) that has been treated and purified for reuse for nonpotable uses such as flushing toilets and urinals, washing clothes, irrigating nonagricultural land, filling decorative fountains, fighting fires, and irrigating crops that will be peeled or boiled before being consumed. Municipally provided recycled water has a long history in California. Los Angeles County's sanitation districts, for example, have provided treated wastewater for landscape irrigation in parks and golf courses since 1929. Recycled water is often distributed with a dual piping network that keeps recycled water completely separate from potable water. In the United States, recycled water is always distributed in purple pipes to distinguish it from potable water.

An alternative to municipally treated recycled water is an onsite graywater system. Graywater is wastewater that has been used in sinks, baths, showers or washing machines. In a residential system, untreated graywater may be used for subsurface irrigation but to flush toilets and urinals, graywater must be treated. Some products use graywater directly from a sink to flush a toilet or even combine the two into one fixture.

Check with an expert and local code official if you plan to treat blackwater (water containing sewage) onsite.

RAINWATER HARVESTING

Rainwater harvesting involves collecting and storing rain from roofs or a surface catchment system for future use. The water is generally stored in tanks or directed via swales or pipes into groundwater recharge or catchment basins onsite.

Benefits

Using recycled water and rainwater conserves potable water supplies, lowers water and sewage bills, reduces the need for developing new sources of freshwater, and reduces discharge of treated wastewater into water bodies.

Rainwater harvesting may reduce stormwater runoff, erosion and topsoil loss. Using rainwater for irrigation may improve plant growth. An added benefit is that recycled water and rainwater are not generally subject to watering restrictions.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily projects. Water catchment and graywater recycling for use inside the building can be difficult for retrofit projects. However, harvesting rainwater for recharging groundwater or irrigation use is possible for most projects.

Design Details

Always use high efficiency irrigation systems when using recycled water, rainwater or potable water for landscaping *(Site: B1–Sustainable Landscaping).*

RECYCLED WATER

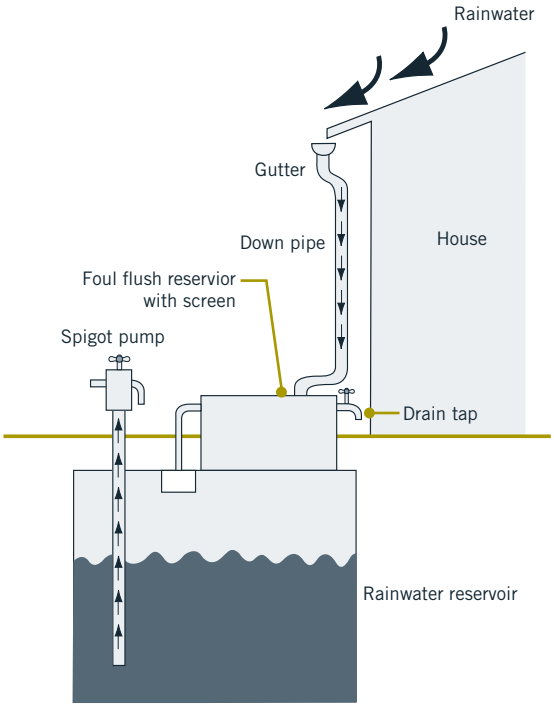
Check for the availability of municipally treated recycled water (purple pipe) at your project site.

As an alternative to municipally treated recycled water, wastewater can be treated onsite and reused for irrigation and other nonpotable uses. Onsite wastewater

treatment systems include constructed wetlands, a mechanical recirculating sand filter or an anaerobic biological treatment reactor *(see Resources)*. The building's facilities staff must be trained on how to effectively operate and maintain the system.

RAINWATER HARVESTING

A rainwater harvesting system consists of three basic elements: the collection system, the conveyance system and the storage system. There are two main types of rainwater harvesting systems, roof and ground catchment.



Roof catchment consists of a metal roof (or other roofing material that does not contaminate the rainwater), a cistern, and plumbing (which may require a pump) that leads to the cistern. Use roof catchment for collecting rainwater for irrigation and flushing toilets.

Use ground catchment, such as bioswales and retention basins, to mitigate stormwater runoff and recharge the aquifer onsite. Compared to rooftop catchment techniques, ground catchment provides an opportunity for collecting water from a much larger area.

Harvested rainwater may contain contaminants and pollutants, such as animal and bird feces, mosses and lichens, dust and pesticides. The highest concentrations of contaminants occur after the first rain. First-flush mechanisms, which divert the initial flow of rainwater into a holding barrel, can help reduce potential contamination. If people or pets may have contact with the captured rainwater, the water may first need to be analyzed by a lab for safety *(see Code Considerations)*.

KEMA

Swales are attractive landscape features that absorb and filter stormwater runoff, reducing pollution.

Code Considerations

Recognizing the strains that climate change, population growth and other issues are putting on water resources, especially in the western United States, codes and regulations are starting to more fully address rainwater harvesting and water recycling. Check with the local water agency for code information relevant to your project.

For water that's recycled either by the municipality or onsite, codes are first and foremost concerned with preventing people, livestock, plants and foodstuffs from coming into direct contact with the water. Municipally provided recycled water that has been treated to tertiary standards can be used for toilets, urinals and trap seal primers; cooling makeup; and irrigation. Graywater recycled onsite can only be used for subsurface irrigation unless it is treated and disinfected using chemical treatment and methods such as reverse osmosis to ensure sufficient quality water. As per the Uniform Plumbing Code Appendix J, recycled water must be piped as a separate system from potable water with suitable precautions against cross-contamination.

Harvested rainwater is typically considered to be recycled so it falls under the usage guidelines of national and state codes for recycled water, which limit its use to toilet flushing and subsurface irrigation. In some instances, local health code requirements and authorities may have

New York High-Rise Cuts Municipal Water Use in Half

The Solaire, a 27-story green residential tower in New York City, was designed with water conservation in mind. The 357,000-square-foot building, which was completed in 2003, has an onsite blackwater treatment system that processes 100% of the building's wastewater. Water recaptured by the system supplies the cooling towers for the building's air conditioning systems as well as all the toilets. In addition, 5,000 gallons per day of the treated recycled water irrigates an adjacent public park. A 10,000-gallon storage tank in the basement holds rainwater that's used to irrigate a roof garden and green roof. Compared to a conventional apartment building, the Solaire uses 50% less municipal water, and uses no potable water outdoors.

For more information: www.thesolaire.com

more rigorous requirements and may not allow use of nonpotable water for irrigation or indoor applications. Check local building and health codes to verify what is allowed locally.

Considerations for Residents

It is important to educate residents about proper use of recycled water and harvested rainwater *(Operations & Maintenance: N3–Educational Signage).* Project managers should assure residents that the water is safe for nonpotable application.

Appropriate education about the building's rainwater harvesting or recycled water systems may increase the residents' awareness about water issues and sensitivity to natural cycles.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Recycled water can be up to ten times cheaper than potable water for holders of Consumptive Use Permits (for high volume water users). Some areas already have purple pipe infrastructure; other projects may have to include purple pipe in their own construction costs.

Areas with high potable water costs may find onsite water recycling or rainwater harvesting cost effective.

Preventing runoff from reaching the public storm drain system by capturing it onsite can be a significant cost saving strategy when it helps avoid the cost of upgrading stormwater infrastructure (a common requirement of urban municipalities with older infrastructure). For governments, encouraging onsite rainwater capture and recycled water can help reduce the costs associated with mitigating pollution in water bodies (largely caused by stormwater runoff).

Resources

- **American Rainwater Catchment Systems Association** provides links to many publications about rainwater harvesting: www.arcsa-usa.org
- ***Bay-Friendly Landscape Guidelines*** provide information on source water efficiency: www.BayFriendly.org
- ***Consulting-Specifying Engineer*** magazine has an article, "Reclaimed Water and the Codes" (April 1, 2007): www.csemag.com/article/CA6434236.html
- **Local water agencies** provide information on local codes and permit requirements
- **Oasis Design** provides resources about graywater systems in California: www.oasisdesign.net
- **Texas Water Development Board** publishes the "Texas Manual on Rainwater Harvesting": www.twdb.state.tx.us/publications/publications.asp
- **United Nations Environment Programme** has information about rainwater harvesting systems: www.unep.or.jp/ietc/Publications/Urban/UrbanEnv-2/3.asp
- **U.S. Environmental Protection Agency** provides an "Onsite Wastewater Treatment Systems Manual: www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf; and constructed wetland case studies: www.epa.gov/owow/wetlands/construc/
- **Water Reuse Association** provides a list of allowed uses of recycled water in California: www.watereuse.org/ca/usestable.html

Related Case Studies

- Fox Courts, p. 47
- Oxford Plaza, p. 15
- Sara Conner Court Apartments, p. 221

MEASURE B3

LIGHT POLLUTION REDUCTION

Design Outdoor Lighting to Minimize Glare and Light Pollution

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 26 56 00: Exterior Lighting

OLD: 16520: Exterior Lighting

Recommendation

Select exterior lighting fixtures that have the minimum light output necessary for safety and visual acuity, and shield fixtures to keep excess light from leaving the site. Specifically, use full cutoff luminaires that are certified by the International Dark-Sky Association to emit no light above horizontal at the fixture height.

Description

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. In urban settings, light pollution from buildings reduces views of the night sky and wastes energy. And in rural areas, light trespass and glare can disturb the nocturnal environments of birds, mammals and other creatures.

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 *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence, Finishes & Furnishings: M4–Lighting).*

Full cutoff luminaires (fixtures that do not emit light above horizontal at the fixture height) meet the intent of this measure.

Benefits

Light pollution reduction saves energy because reducing light pollution often involves using lower-wattage fixtures and lighting controls to illuminate areas only where and when needed. Reducing light trespass may improve relations with neighbors and preserve nocturnal habitats for animals. Light pollution reduction helps keep the night sky dark enough for viewing stars.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

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.

ENVIRONMENTAL ZONE	DESCRIPTION	RECOMMENDED MAXIMUM INITIAL ILLUMINANCE VALUES* IN FOOTCANDLES (FC)
Intrinsically Dark (LZ1)	Parks and residential areas where controlling light pollution is a high priority	0.01
Low Ambient Brightness (LZ2)	Outer urban and rural residential areas	0.1
Medium Ambient Brightness (LZ3)	Urban residential areas	0.2
High Ambient Brightness (LZ4)	Urban areas having both residential and commercial use and experiencing high levels of nighttime activity	0.6

**Illuminance values are measured at the eye on a plane perpendicular to the line-of-sight.*

The goal should always be to minimize lighting to the greatest extent possible while providing safety with low contrast and good color rendering.

2008 TITLE 24 GENERAL HARDSCAPE LIGHTING POWER ALLOWANCE

TYPE OF POWER ALLOWANCE	LIGHTING ZONE 1 (LZ1)	LIGHTING ZONE 2 (LZ2)	LIGHTING ZONE 3 (LZ3)	LIGHTING ZONE 4 (LZ4)
Area Wattage Allowance (AWA)	0.036 W/ft²	0.045 W/ft²	0.092 W/ft²	0.115 W/ft²
Linear Wattage Allowance (LWA)	0.36 W/lf	0.45 W/lf	0.92 W/lf	1.15 W/lf
Initial Wattage Allowance (IWA)	340 W	510 W	770 W	1030 W

The table above lists the maximum outdoor lighting power allowances that will be allowed starting in 2009, per California's 2008 Building Energy Efficiency Standards (Title 24). They differ somewhat from the U.S. Green Building Council's recommendations. Note that there are no areas in California designated as Lighting Zone 4 unless the local jurisdiction specifically adopts an ordinance so stating.

Design Details

First, avoid outdoor lighting where it is not needed. Where lighting is needed, such as on sidewalks, porches and balconies at night, keep the brightness to an appropriate level. Use valances and overhangs wherever horizontal light should be controlled, and specify fixtures with full cutoff to avoid uplight or glare. Eliminate all unshielded fixtures, such as floodlights.

The International Dark-Sky Association's (IDA) Fixture Seal of Approval Program provides third-party certification of luminaires that do not pollute at night. Any manufacturer may submit a luminaire for review. The IDA evaluates fixtures based on the amount of upward light they produce. Currently, the IDA only approves fixtures deemed full cutoff and fully shielded, although new categories of certification are being developed that will include assessment of upward light, forward light, backward light and glare zone.

DEFINITIONS

» **Shielding** describes techniques and devices that limit light pollution and trespass. Shielding occurs by tucking lights under overhangs, or by using fixture covers that control glare or direct light downward.

» A **full cutoff luminaire** has zero candela intensity at an angle of 90 degrees above the vertical axis (nadir) and at all angles greater than 90 degrees from nadir. That is, no light is emitted above horizontal at the fixture height.

GUIDELINES FOR REDUCING LIGHT POLLUTION

» Specify white high intensity discharge (HID) lamps, compact fluorescent lamps (CFLs), or light emitting diodes (LEDs) that give reasonable color rendition at low brightness *(Finishes & Furnishings: M4–Lighting).*

» Shield all lamps that have an initial lamp brightness greater than 1,000 lumens. Fixtures with initial lumens greater than 3,500 should meet IESNA's guidelines for full cutoff *(see Resources).* Specify IDA-approved fixtures; these meet IESNA guidelines.

» Minimize or eliminate feature lighting, such as lighting on architectural embellishments or signage. When it is necessary to highlight details or features, use downlighting instead of uplighting.

» Turn off all nonessential lighting after normal operating hours, or use motion sensors, photocells or time clocks to control lighting.


PRACTICA CONSULTING

Full cutoff luminaires help reduce light pollution.

» 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 and making maintenance less costly.

» To prevent light trespass, locate outdoor lights at a distance farther than 2.5 times their mounting height from the project's property lines *(recommendation from U.S. Green Building Council's LEED for New Construction Reference Guide v2.2).*

» After installation, commission fixtures to verify that lights are directed properly and are performing as intended.

Code Considerations

Code requirements for safety always override this measure, but generally the strategies recommended here are acceptable to code officials. Some local codes may restrict certain pole heights. On some projects, conditions of approval may require following these or similar guidelines to avoid neighbors' complaints. *See Application section above for information about 2008 Title 24 outdoor lighting power allowances.*

Considerations for Residents

Low-contrast exterior lighting can actually improve safety and lighting quality compared to an overlit environment. Many people believe that high levels of exterior lighting are needed at night to provide safety and security. However, it's the *quality* of lighting that has a large impact on safety. Low-power lighting that specifically illuminates the necessary areas can be just as effective as nondirectional general lighting. Also, light color is as important for visual acuity as brightness, especially for seniors. Further, some research has shown that lighting controlled by motion sensors (off until something enters the field) is a better crime deterrent than lighting that is constantly on.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

High efficiency lights such as CFLs or LEDs can reduce energy and maintenance costs.

There may be slight capital cost increases for purchasing a higher number of shorter pole lights, compared with fewer tall lights, which is standard. However, parking lot poles 16-feet high or less can be serviced at lower cost without a cherry picker.

There may be a slight cost addition for full cutoff luminaires or add-on valances; however, it is more common that full cutoff fixtures are the same price as fixtures that spill more light.

Lower light levels also reduce energy costs.

PRACTICA CONSULTING

Light fixtures that cast light upward waste energy, reduce views of the night sky, and can disturb residents.

Resources

» **Illuminating Engineering Society of North America** (IESNA) has developed the *Recommended Practice Manual: Lighting for Exterior Environments* (IESNA RP-33-99) and *Lighting for Parking Facilities* (RP-20-98); fee to purchase: www.iesna.org

» **International Dark-Sky Association** (IDA) addresses light pollution and trespass, and lists products with the IDA Fixture Seal of Approval: www.darksky.org

» ***LEED for New Construction Reference Guide v2.2*** has details on estimating light pollution and trespass; fee to purchase: www.usgbc.org/leed

» **New Buildings Institute's** *Advanced Lighting Guidelines* has a well-written explanation of light pollution and guidance on solutions: www.newbuildings.org/ALG.htm

» **New England Light Pollution Advisory Group** (NELPAG) has information about light pollution: http://cfa-www.harvard.edu/nelpag/nelpag.html

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

STRUCTURE

STRUCTURE

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STRUCTURE

This section addresses the building's structure and envelope, including concrete, framing, roofing, windows, drainage planes and insulation. It also addresses special acoustical considerations for multifamily buildings and special structural considerations for mixed-use buildings.

Most of these recommended measures represent improvements to, not drastic departures from, standard construction practices. For example, engineered lumber *(D4)* can replace many types of solid-sawn lumber; it is sometimes slightly more expensive, but is typically more dimensionally stable, straighter, lighter and stronger. Some measures do present practices that may be new to the design and construction team but offer considerable benefits. Using structural insulated panels *(D7)* instead of conventional wood-frame construction, for example, saves wood, offers enhanced structural performance, reduces air infiltration and speeds up construction time.

It's important that each of these measures be considered within an integrated design process *(see the Guidelines' introduction).* This will help maximize the building's performance and energy efficiency while reducing costs for individual measures.

BENEFITS

This table lists the Guidelines' Structure measures and their primary benefits.
(See the individual measures for details.)

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
C1 Acoustics: Noise and vibration control	✓						✓	
C2 Mixed-use design strategies		✓	✓	✓			✓	✓
C3 Commissioning	✓		✓	✓		✓	✓	✓
D1 Reduced portland cement in concrete					✓	✓		✓
D2 Structural pest and rot controls	✓				✓	✓	✓	
D3 Construction material efficiencies	✓		✓		✓			✓
D4 Engineered lumber					✓			✓
D5 FSC-certified wood for framing lumber					✓			✓
D6 Raised heel roof trusses			✓		✓		✓	✓
D7 SIPS and other solid wall systems			✓		✓		✓	✓
D8 Window replacement	✓		✓			✓	✓	✓
E1 Drainage planes and durable siding	✓				✓	✓		
E2 Sustainable roofing options		✓	✓		✓	✓	✓	✓
E3 Vegetated roofs		✓	✓	✓	✓	✓	✓	✓
F1 Insulation	✓		✓		✓		✓	✓
F2 Quality installation of insulation			✓		✓		✓	✓

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate the building, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operation and location.

CORE CONCEPTS

CONTRACTOR EXPERIENCE

Some of the products and techniques described in this section require experience or specialized skills that aren't found on every construction crew. For example, the techniques for designing and working with high-volume flyash concrete *(D1)* are new to some engineers and contractors. Similarly, if installing damp-spray cellulose insulation *(F2),* you need an experienced subcontractor who knows how to avoid moisture-related problems. With steel framing *(D3),* a more skilled labor force is needed. As early as possible in the design phase, the project team should identify any measures that might diverge from standard practice.

PRODUCT AVAILABILITY

Many of the materials recommended here are readily available. High-volume flyash mixes *(D1)* are widely available, as is recycled-content insulation with no added formaldehyde *(F1),* engineered lumber *(D4),* and high performance windows *(D8).* Other products may require more effort to obtain. While FSC-certified hardwoods *(D5),* for instance, are generally more readily available than FSC softwoods, supply fluctuates, which affects both availability and price. Early in the design phase, the project team should flag any products or materials that might have longer lead times or require extra effort to source so that the contractors can work to ensure that they will be on hand when needed.

For an online, up-to-date listing of manufacturers and suppliers of many green products and materials in California, refer to the Build It Green Product Directory at www.BuildItGreen.org/products *(see the Resources section at the end of these Guidelines for more information).*

COST

An integrated design approach will help reduce construction costs as well as operating costs. For example, it may be possible to downsize or eliminate the air-conditioning system if the design includes a cool roof *(E2)* combined with other energy-saving features, such as overhangs, increased insulation, high performance windows and proper building orientation.

Other measures may cost more than conventional construction if the product itself is more expensive, the technique is more labor intensive, or the contractors have limited experience with the technique and therefore submit higher bids. For example, studies have estimated that, overall, installed steel framing *(D3)* costs anywhere from 0% to 7% more than wood framing, mostly because of increased labor costs. However, steel prices are more constant than wood prices, resulting in longer price guarantees from manufacturers, which helps with project budgeting.

Compared to conventional wood framing, advanced wood framing design *(D3)* does require some additional effort during design and careful oversight of the framing contractor in the field. But it can reduce lumber use by as much as 11% to 19%, while also providing more room for insulation and increasing the building envelope's energy efficiency. Refer to the individual measures for more information about the savings and costs associated with the structural components of green multifamily housing.

HEALTHY BUILDINGS, USA

FRAMING WITH STEEL: ONE BUILDER'S PERSPECTIVE *Napa, CA*

HEALTHY BUILDINGS USA

Healthy Buildings, USA, a design/build firm based in Napa, specializes in cold formed (light gauge) steel framing, including panelized and modular construction. The company has been building steel-framed homes since 1999, including several multifamily projects in the Bay Area.

"Initially we did it for speed and economic reasons. We wanted to get projects built faster," said Bob Massaro, Healthy Building's chief executive officer. "But we quickly found other benefits. If you ordered steel with high enough recycled content, you could qualify for LEED and GreenPoint Rated credits for recycled-content materials." Steel typically has 25% to 30% recycled content, Massaro said, with some steel members exceeding 50%. Specifying steel with these types of recycled content has no affect on performance or price.

With steel framing, "you also get a better building," Massaro said. "The walls are straight and you don't have problems with wood framing," such as shrinking, cracking or warping. Another advantage is less waste, especially when working with prefabricated panels. "We don't frame at the site. We order panels, so there's very little waste," Massaro said. Compared to conventional wood structures that are framed at 16 inches on center, steel is typically framed at 24 inches on center, which saves additional material.

More insurance companies are encouraging builders to use steel to reduce liability, according to Massaro. He has seen some insurers reduce premiums on builder's risk and worker's compensation policies, and has heard of at least one company that will insure a steel building against mold. Steel is an inorganic material, so mold doesn't grow on it.

Massaro is quick to point out the pitfalls of building with steel, including its high thermal conductivity. "You have to have a thermal break on the outside of steel," he said, which typically means rigid foam insulation that's 1-inch thick.

For builders considering making the switch to steel framing, Massaro cautions that they have their eyes open. "You can't easily convert from wood to steel," he said. "There's a steep learning curve. It's very different, down to tools you use, the procedures, the training required. There's a steep cost in making that switch." But for Healthy Buildings, which has been building with steel for nearly a decade, the switch was worth it. "If you combine the speed of panelization with the waste reduction and the high recycled content," Massaro said, "it's overall a better package."

For more information about framing with steel, see Structure: D3–Construction Material Efficiencies.
For more information about Healthy Buildings, USA, go to www.healthybuildingsusa.com.

MEASURE C1

ACOUSTICS: NOISE AND VIBRATION CONTROL

Create a Quiet Living Environment by Designing to Reduce Noise and Vibration

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: **02 22 16:** Acoustic Assessment, **06 16 29:** Acoustic Underlayment, **09 51 00:** Acoustical Ceilings, **09 80 00:** Acoustic Treatment,

OLD: **09510:** Acoustical Ceilings

Recommendation

Design multifamily developments to reduce noise and vibration from sources inside and outside the buildings.

Description

Sound is considered an environmental and health pollutant when noise levels exceed the comfort range of humans. Studies indicate that excessive noise can make people less healthy, experience more sleep disturbances and show more signs of stress.

People are sensitive to unwanted sounds in their home, so proper acoustical design is critical to a successful residential project. This involves not only complying with building codes, but also designing to meet industry standards of care. This may include strategies such as reducing noise intrusion into bedrooms or mitigating plumbing and ventilation system noise.

Multifamily housing units share common partitions, which can contribute to excessive noise. This can be a particular concern in some affordable housing developments that are only designed to meet minimum building code standards for acoustics. In addition, developments these days are often built in locations where environmental noise adversely affects residents' sleep and health, such as near freeways, busy intersections and train tracks.

Benefits

Designing to reduce unwanted noise often increases resident satisfaction with the building and makes homes more attractive to potential buyers. In mixed-use buildings, a design that acoustically isolates the residential from the commercial uses can greatly reduce residents' complaints about noise. An acoustical engineer can play an important role in helping improve the marketability of a project in a cost-effective manner.

Sound-rated exterior windows, walls and doors designed to control exterior noise intrusion may improve the building's thermal envelope, resulting in a more energy-efficient home *(Systems: J1–Building Performance Exceeds Title 24).*

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

While noise and vibration control are applicable to both the residential and nonresidential spaces of all multifamily developments, appropriate design strategies depend upon the specific project.

In areas with higher population densities, there is typically more outside noise and multifamily buildings have more shared partitions; however, people may be more accepting of higher noise levels in urban areas. For multifamily buildings in suburban areas, ambient noise levels may be lower, which may make residents more aware of noises made by neighbors. In both situations, noise and vibration control are important.

Design Details

The California Building Code (Title 24, Appendix Chapter 12) addresses acoustical code requirements for multifamily housing. However, housing that is considered market rate in California typically should be designed to exceed code by 5 to 10 Sound Transmission Class (STC) points.* The acoustical code does not address mitigation of all sources of unwanted noise. This section lists some of the more common sources of unwanted noise in multifamily buildings and describes some general strategies for mitigating them.

ACOUSTICAL CONSULTANTS

It is beneficial to retain an acoustical consultant to review the design drawings and specifications to address exterior noise intrusion and interior unit noise and vibration control issues. The acoustical design recommendations and details should be included in the contract documents to ensure that the design will be implemented by the contractor. Numerous lawsuits in California have been filed against multifamily developers due to residents' claims about noise problems. Many owners, builders and architects hire an acoustical consultant early in the design process to reduce their potential liability for future problems.

** STC is a rating derived from the noise reduction of a partition. Greater STC values indicate greater sound reduction, hence better performance.*

» **Exterior Noise.** Title 24 addresses requirements for reducing noise inside homes from exterior environmental noise, such as from cars and trains. After taking into account average noise levels and other site factors, an acoustical consultant can provide recommendations to meet the project goals, such as sound-rated exterior windows, walls and doors with specific STC ratings.

» **Single-Event Noise in Noise-Sensitive Spaces.** Title 24 does not address regularly occurring single-event noise (such as loud diesel trucks), nor do most municipal codes. However, single-event noise is the primary cause of sleep disturbance. The industry standard for mitigating these types of noise sources, especially in market-rate housing, is to generally not exceed 50 dBA in bedrooms and 55 dBA in living rooms.** One mitigation strategy is to include laminated sound-rated windows at exterior facades that are exposed to single-event noise sources. An acoustical consultant can provide more specific recommendations.

» **Airborne and Structure-borne Noise.** Although Title 24 addresses inter-party construction, the code requirements do not provide adequate sound isolation for many homeowners. One strategy to reduce noise between party walls is to construct a double-stud wall with batt insulation in both stud cavities and multiple layers of gypsum board on each exterior face.

Thoughtful room layout design can reduce unwanted noise and partition costs. For example, locating noise-generating rooms of one dwelling unit (such as a kitchen) next to noise-sensitive rooms of another unit (such as a bedroom) could cause sleep disturbance and general annoyance. However, if a kitchen or a bathroom were placed next to another unit's kitchen, then occasional noise transfer would likely cause fewer complaints. Similarly, problems can arise if hard-surfaced floors in a kitchen or bathroom of one unit are placed above another unit's bedroom.

Take care to avoid sound leaks. Often leaks occur via pipe penetrations, uncaulked partition perimeters and electric boxes. Reduce sound leaks by sealing outlet boxes with pads, caulking partition perimeters, sealing penetrations through partitions, gasketing entry doors and following other quality construction practices. If a partition is poorly caulked or a door is left ungasketed, the leak could cause sound-rated partitions to fall below minimum standards.

Cabinet and closet door noise transfer is not addressed by code but it is often annoying to neighbors and easy to mitigate. Where cabinets or sliding closet doors are on shared walls, provide resilient material (such as felt pads or hydraulic closers) to reduce closure impact.

» **Mixed-Use Noise and Vibration.** Title 24 addresses acoustical requirements for adjacent commercial and residential spaces. It is important to be particularly careful about reducing noise transfer from commercial to residential spaces because residents are more likely to be disturbed by noise from restaurants, entertainment venues and other nonresidential uses than by noise from residential spaces. Good practices include adequately separating residential from commercial spaces and providing clearances for plumbing piping and mechanical ducts. In addition, incorporating language into the tenant improvement guidelines that require commercial tenants to include acoustical design strategies into their build-outs will reduce the potential for conflict over noise *(Structure: C2–Mixed-Use Design Strategies).*

» **Mechanical Ventilation Noise and Vibration.** Title 24 does not address mechanical ventilation noise and vibration. Many cities, however, have noise ordinances that address mechanical noise transfer across property lines, although not between dwelling units. The *ASHRAE Handbook* provides guidelines to reduce noise and vibration from various mechanical ventilation equipment, including rooftop equipment, garage exhaust fans and commercial floor HVAC. For ventilation systems within residences, it is recommended to reduce supply and return air fan noise and noise generated by grilles and registers. Since mechanical ventilation systems vary in multifamily buildings, consult an acoustical consultant for assistance in selecting quiet ventilation equipment and designing the ventilation system to meet the project goals.

» **Miscellaneous Machinery Noise and Vibration.** Miscellaneous mechanical noise isn't covered by Title 24. However, as stated above, many cities' noise ordinances include mechanical noise limits at property lines although not between residences. Best practices include designing to reduce noise and vibration from pumps, motorized garage door openers and elevator equipment adjacent to units.

» **Plumbing Noise and Vibration.** This isn't covered by Title 24, but ASHRAE's Section 47.30 ("Noise from Plumbing Systems") recommends 35 dBA maximum in bedrooms, living rooms and dining rooms. This recommendation includes having no piping or piping supports touching framing and gypsum board. During design, pay attention to the potential for excessive plumbing noise transfer, water noise transfer, and so on.

» **Impact Noise.** Title 24 does not address stair impact noise. Best practices include connecting stair stringers adjacent to dwelling units only at the top and bottom landings. If a retrofit is needed, installing carpet and padding on the stairs may help reduce the impact noise.

** *dBA is an A-weighted sound pressure level or noise level that represents the noisiness or loudness of a sound. A-weighting is specified by the ISO, EPA, OSHA and others for use in noise measurements.*

» **Floor Squeaks.** Although not a Title 24 requirement, reducing floor squeaks is considered good building practice. The American Plywood Association provides guidelines, such as screwing and gluing the subfloor to the joists instead of nailing it (nails have a tendency to come loose or fall out, potentially causing plywood subflooring to squeak).

» **Trash Chute Noise.** This is not a Title 24 requirement. However, it is relatively inexpensive to mitigate trash chute noise during design and very hard to fix post-construction. Best practices include resiliently isolating the chutes at each floor, using a retarder with each hopper door, and coating the chute with a sound-deadening product *(Finishes & Furnishings: M3–Recycling and Waste Collection).*

Code Considerations

California Building Code (California Code of Regulations, Title 24), Appendix Chapter 12 addresses acoustical code requirements for multifamily housing. It covers exterior sound transmission control, airborne sound insulation, penetrations or openings in construction assemblies and impact sound insulation.

Considerations for Residents

Designing for less noise and vibration usually results in a quieter environment for occupants, which may increase their satisfaction with the building, reduce sleep disturbances and reduce stress levels.

Noise Reduction Priorities

This list prioritizes the sources of unwanted noise, factoring in the importance of reducing complaints and litigation risks as well as the ability to remediate the issue post-occupancy.

Exterior noise reduction, for example, is a top priority. If not addressed during design, it might lead to significant complaints, litigation and expensive retrofit measures. Stair impact noise has less impact on residents and can often easily be remediated with carpet and padding on the stairs.

1. Exterior Noise
2. Airborne and Structure-borne Noise
3. Single-Event Noise in Noise-Sensitive Spaces
4. Mechanical Ventilation Noise and Vibration
5. Plumbing System Noise and Vibration
6. Miscellaneous Machinery Noise and Vibration
7. Mixed-Use Juxtapositions
8. Trash Chutes
9. Floor Squeaks
10. Stair Impact Noise

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

If appropriate acoustical treatments are specified prior to construction, they are relatively inexpensive to incorporate. Correcting acoustical deficiencies after a project is occupied can be expensive and disruptive. In addition to direct material and labor costs, there may be indirect costs such as loss of floor space due to increased partition thickness, and the cost of increasing duct sizes to accommodate acoustical lining. Each acoustical design element provides a benefit that should be balanced against its direct and indirect costs.

For new construction, planning is the most cost-effective method for meeting the project's acoustical needs. For example, a single-stud wall with batt insulation in the cavity might achieve acceptable acoustic separation between a mechanical room and a public bathroom. But a concrete block wall or double-stud construction might be required to separate the same mechanical room from a bedroom. Similarly, not locating noise-sensitive rooms adjacent to commercial spaces in a mixed-use project will save a significant amount of money and time, especially if residents complain and the building manager is forced to retrofit.

For retrofits, costs vary greatly depending on the noise or vibration issue being addressed. For example, renovation to improve party-assembly noise reduction may be expensive since this work requires floor-ceiling and/or party wall deconstruction to allow for mitigation. Similarly, reducing noise and vibration from trash chutes in an existing building may require significant expense and effort. However, some mechanical equipment vibration issues can easily be reduced by installing the correct vibration isolators at the mechanical units and adding flexible duct and pipe connections.

Resources

» ***Acoustics: Architecture, Engineering, The Environment,*** by Charles M. Salter Associates, Inc. (William Stout Publishers, 1998). Chapter 18 focuses on residential-specific noise and vibration issues and mitigation strategies in multifamily housing.

» **American Society of Heating, Refrigerating and Air-Conditioning Engineers** *2007 ASHRAE Handbook, Chapter 47*, "Sound and Vibration Controls," provides technical guidelines for mitigating noise and vibration caused by HVAC equipment and plumbing piping: www.ashrae.org

Related Case Studies

None

MIXED-USE DESIGN STRATEGIES

Address Residential and Commercial Tenants' Design Needs

KEY BENEFITS

Health/IEQ	Material Efficiency
√ Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Carefully design mixed-use buildings to take into account the unique requirements of residential and commercial spaces.

Description

Design strategies for mixed-use multifamily projects differ in many ways from design strategies appropriate to residential-only projects. To ensure compatibility of residential and commercial uses in a mixed-use building or development, the developer and design team must pay special attention to certain site, systems and structural considerations.

Measure AA4 in the Planning & Design section discusses the community and environmental benefits of mixed-use multifamily developments. This measure addresses specific green design considerations that are unique to mixed-use multifamily buildings.

Benefits

Successfully integrated residential and commercial spaces may improve the project's marketability. Many residential tenants are drawn to living in proximity to restaurants, shops and neighborhood services, while commercial tenants may benefit from greater foot traffic and a livelier neighborhood thanks to the round-the-clock presence of residents.

By addressing potential conflicts between residential and commercial uses early in the design process, the owner reduces the potential for complaints and higher vacancy rates because of tenant dissatisfaction.

Mixed-use green buildings with commercial spaces that are open to the public can help educate the community about the advantages of energy efficiency, waste reduction and healthy buildings *(Operations & Maintenance: N3–Educational Signage).*

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to the new construction of mixed-use buildings and developments.

For retrofit projects, many of the design details described below also apply, especially shared views and common areas, bicycle and car parking, loading areas and garage ventilation, waste and recycling collection, utility meters, plumbing drain and waste systems, and green tenant improvement guidelines.

Design Details

From a development and design perspective, mixed-use multifamily projects present certain challenges that residential-only projects don't face. Some of the more significant issues are described here. Also provided are recommendations for green tenant improvement guidelines. These help ensure that the spaces built out by commercial tenants will save energy and natural resources, reduce waste and provide healthier spaces for workers and the community.

DESIGN STRATEGIES

» **Shared views and common areas.** Although residential and commercial spaces should be physically separated, visual connections are often desirable and can help create a distinctive sense of place. For example, some successful mixed-use communities have residential balconies that overlook public spaces *(Planning & Design: AA5–Outdoor Gathering Places and AA6–Design for Safety and Vandalism Deterrence).* However, excessive sound and light from commercial uses should be avoided so that residential tenants are not disturbed *(Site: B3–Light Pollution Reduction and Structure: C1–Acoustics).*

Shared common areas may be appropriate if the commercial use is not overpowering; for example, small offices or shops might be compatible with residential common areas, whereas restaurants and nightclubs wouldn't be. Private entrances to residential units should be separate from commercial spaces and provide the residential tenants with a degree of privacy. However, front doors that open onto public streets or an attractively designed area that gives residents access to the commercial spaces can add appeal and encourage neighborliness.

» **Bicycles and cars.** Consider providing increased bicycle parking to accommodate the commercial spaces' workers and visitors. Also consider providing showers for employees who bike to work. For some mixed-use projects, shared car parking works well. Residential parking, which is typically in higher

888 7th Street, designed by David Baker + Partners Architects, will place mixed-income housing over commercial retail uses San Francisco's Mission Bay neighborhood.

demand at night, may be made available to the public on weekdays while they are patronizing the building's commercial enterprises. Local planning authorities may allow a reduction of overall parking due to this combined use *(Planning & Design: AA2–Design for Walking and Bicycling and AA3–Alternative Transportation)*.

» **Loading areas and garage ventilation.** Separate commercial loading areas visually and physically from residential areas. Garages must be well ventilated *(Systems: H4–Garage Ventilation)*. Also consider carbon monoxide monitoring, especially for high-traffic commercial uses. Interior loading areas should directly exhaust truck idling fumes to the outside. Do not allow fuel-powered emergency generators to be used in garages or, if necessary, isolate them and vent them outside away from residential units.

» **Waste and recycling collection.** Provide separate areas or bins for commercial and residential waste and recycling collection. If that's not possible, provide a generously oversized waste and recycling collection system to accommodate both uses. Allocation of responsibility for garbage bills should be clearly defined if facilities are owned in common *(Finishes & Furnishings: M3–Recycling and Waste Collection)*.

» **Utility meters.** Install separate utility meters or submeters for every unit *(Systems: G3–Water Submetering; Operations & Maintenance: N4–Energy Monitors)*. At a minimum, meter the commercial and residential uses separately.

» **Renewable energy systems.** If photovoltaics will be included, determine how the generation credit will be allocated and include this information in tenant leases. In mixed-use buildings, the photovoltaic system usually only powers common areas. If a solar hot water system is installed, the owner should decide how to allocate the energy savings when a commercial tenant uses more hot water than residents *(Systems: Section I–Renewable Energy)*.

» **Mechanical systems.** Design separate systems for commercial and residential spaces to avoid contamination. Exhausts and intakes should also be separated by use.

» **Plumbing drain and waste systems.** Separate the residential and commercial plumbing and waste systems, or include provisions to avoid contaminating residential spaces with vapors from chemicals in the commercial drains. For instance, floor drains in residential units should be equipped with trap primers, which keep water in the floor drain trap to prevent sewer gas from contaminating spaces. Another reason to separate the systems is to minimize the possibility that food service grease will clog residential lines.

» **Structural issues.** Mixed-use buildings present special structural challenges because code and user requirements differ for each type of use. Structural implications that must be taken into account include location of entries and exits, stacking of structural columns, placement of heating and ventilation shafts and mechanical and plumbing systems, building security and access controls, fire protection systems and escape routes.

GREEN TENANT IMPROVEMENT GUIDELINES FOR COMMERCIAL TENANTS

Owners of mixed-use multifamily buildings should provide their commercial tenants with green tenant improvement guidelines. When commercial tenants follow green guidelines for the build-out of their spaces, they're not only doing good for the public and the environment, they're also reducing their operating costs and may be increasing their organization's productivity and profitability.

Owners should be aware of the economic and environmental sustainability issues associated with long-term leases: the longer a tenant stays in a space, the greater the stake they have in the community. Also, the installation of energy-saving equipment becomes more economical the longer the tenant is in the space. A five-year lease is ideal where feasible.

Green tenant improvement guidelines should make it clear which improvements are required of the tenant, and which are recommended but not mandatory. What follows is a suggested list of required and recommended actions:

Efficient Water Use

» ***Required:*** If tenants are responsible for landscaping, use environmentally responsible landscaping strategies, including native or low-water plants and drip irrigation instead of spray heads *(Site: B1–Sustainable Landscaping).* Consider graywater reuse if the jurisdiction allows it *(Site: B2–Source Water Efficiency).*

» ***Required:*** Install low water-use toilets, showers, lavatories and service sinks *(Systems: G1–Water-Efficient Fixtures)*.

Renewable Energy and Energy Efficiency

» ***Recommended:*** Ensure that mechanical systems are as energy efficient as possible, and commission building systems *(Structure: C3–Commissioning; Systems: Section H).*

» ***Recommended:*** Design lighting for maximum efficiency and effectiveness *(Finishes & Furnishings: M4–Lighting).*

» ***Recommended:*** Purchase renewable energy credits to offset fossil fuel use.

Interior Design and Improvements

» ***Required:*** Provide a place for the storage and collection of recyclables if no other space is available as part of the base building *(Finishes & Furnishings: M3–Recycling and Waste Collection).*

» ***Required:*** At all entry doors, provide walk-off mats to trap dust and debris. Mats should be cleaned regularly *(Finishes & Furnishings: K1–Entryways)*.

» ***Required:*** Prohibit smoking.

» ***Required:*** For restaurants, install a plumbing grease trap and mechanical grease scrubber.

» ***Required:*** For tenant build-outs that affect acoustics (such as speakers in the ceiling, HVAC equipment and plumbing piping), include strategies to reduce the amount of noise and vibration that may disturb adjacent residences *(Structure: C1–Acoustics).*

» ***Recommended:*** Provide bicycle storage, changing rooms and shower facilities *(Planning & Design: AA2–Design for Walking and Bicycling).*

» ***Recommended:*** Design the interior layout to ensure that it provides daylight to about 75% of the spaces, and that 90% of seated spaces have access to some exterior view *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).* Incorporate universal design principles *(Planning & Design: AA8–Adaptable Buildings).*

Indoor Air Quality and Low-Emitting Materials

» ***Required:*** Before occupancy, flush out the space by circulating fresh air for a specified time to allow finish materials to offgas *(Site: A3–Construction Environmental Quality)*.

» ***Recommended:*** Specify low-VOC and urea formaldehyde–free adhesives, sealants, paints, coatings, carpet systems and furniture *(Finishes & Furnishings section).*

» ***Recommended:*** Use refrigeration equipment with refrigerants that minimize greenhouse gas emissions and ozone depletion *(Systems: H2–Air Conditioning with Non-HCFC Refrigerants).*

Waste Reduction and Environmentally Preferable Materials

» ***Required:*** During construction, recycle at least 50% to 75% of demolished material *(Site: A2–Construction and Demolition Waste Management).*

» ***Recommended:*** Reuse as much of the interior's nonstructural components as possible, including cases, counters and wood flooring *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

» ***Recommended:*** Use finish materials with a high recycled content *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

» ***Recommended:*** For casework, cabinets and other finishes and furnishings, use environmentally preferable materials such as FSC-certified wood and rapidly renewable resources *(Finishes & Furnishings section).*

» ***Recommended:*** Choose construction materials, finishes and furnishings that are locally or regionally manufactured.

Code Considerations

In areas where mixed use is allowed, commercial uses may have smaller setbacks than residential, allowing the design to maximize rentable space. Some commercial uses may require a conditional use permit as part of the plan submittal.

Systems installed in or on commercial spaces may have restrictions related to exhaust, physical location, building height and setback requirements. Attachments and anchorages for commercial systems adjacent to residential space need to be patched, insulated and waterproofed per code.

Considerations for Residents

When the commercial and residential uses of a mixed-use development are thoughtfully designed and carefully constructed, residents can benefit from many amenities, including proximity to shops, restaurants and other services, while still enjoying their private homes. Also, the presence of commercial occupants in the development can contribute to a sense of security.

For commercial tenants, a mixed-use location may increase customer traffic from residents and community members. Employees may enjoy the more vibrant social atmosphere of a mixed-use development and can take advantage of the building's amenities, which may include restaurants and cafes, a library, day care facilities and other services.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Mixed-use buildings may cost more initially due in part to increased structural complexity. Cost increases can be minimized by adopting an integrated design approach. Despite higher costs, mixed-use developments can be a valuable investment for a number of reasons. Although the commercial leasing market tends to be more volatile than the residential market, commercial space can be more lucrative per square foot. It is also possible to build the residential units and the shell of the commercial space and then allow the tenant to make green improvements. This shell-type construction can be less expensive than adding more residential space. *(For more information, see Planning & Design: AA4–Mixed-Use Developments.)*

Resources

» **Bay Area Local Initiatives Support Corporation** (LISC) provides resources on mixed-use development: www.cdexchange.org/commercial

» **Building Owners and Managers Association** (BOMA) lists energy conservation tips for tenants: www.boma.org/Advocacy/FederalLegislativeRegulatoryIssues/EnergyResources/TenantConservationTips.htm

» **City of Portland, Oregon's** Office of Sustainable Development has a useful document for project managers, "Creating a High Performance Workspace: G/Rated Tenant Improvement Guide": www.portlandonline.com/osd/index.cfm?a=bcbiac&c=ecbgi

» **Flex Your Power's** website includes suggestions for how commercial tenants can work with landlords to improve energy efficiency: www.fypower.org/com/sbs

» **Local utilities** offer incentives for energy efficiency improvements; check with your local utility representative and visit www.savingsbydesign.com

» **Seattle's *Daily Journal of Commerce*** published a helpful article on structural considerations, "Mixed Use and Maximum Value": www.djc.com/news/ae/11139451.html

» **Southern California Association of Governments** has useful publications, including "Facilitating Small-Scale, Mixed-Use Development: What the Westside Cities Could Do": www.scag.ca.gov/livable

» **Urban Land Institute** has many books and online resources on mixed-use development: www.uli.org

Related Case Studies

» Oxford Plaza, p. 15

COMMISSIONING

Conduct Commissioning on Building Systems

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 01 91 00: Commissioning, **23 08 00:** Commissioning of HVAC, **Various others**

OLD: 01810: General Commissioning Requirements, **01815:** Commissioning of HVAC, **Various others**

Recommendation

Assure quality of design and construction by appointing a third-party commissioning coordinator or knowledgeable member of the design team to conduct commissioning activities.

Description

Green building designs and energy-efficient systems will only save money and provide other expected benefits if they perform as intended. Commissioning is a quality-assurance process that helps ensure that the building and its systems are designed and constructed to meet the owner's operational needs and the design specifications. At a minimum, these systems should be commissioned: HVAC, hot water, lighting controls, and photovoltaics or other renewable energy systems.

Commissioning is most effective if the commissioning coordinator (CC) is an integral member of the team, from pre-design through post-construction. The CC documents the entire commissioning process, providing a record that assists with goal setting and decision making throughout design and construction.

Commissioning is fundamentally different than other review or inspection activities. Commissioning assesses the building systems within the design phase to promote integration, maintainability and lifecycle value. But commissioning goes beyond assessing individual components or systems; it also addresses how components and systems interact and how they affect the performance of the whole building. During construction, the commissioning activities provide a systematic approach to the installation, startup, configuration and operations of the building systems to ensure compliance to design and the owner's goals, and to provide a building that is functioning at optimum condition at turnover.

ENSURING CONTINUITY AND INTEGRATED DESIGN

Traditionally, the design and construction of a building occurs in sequential phases, with each discipline (architecture, structural engineering, mechanical engineering, lighting and so on) doing their work relatively independently and then handing off their contribution to the next team in line. As a result, team members from the various disciplines often make independent decisions without fully appreciating how those decisions affect other systems and the building as a whole.

Commissioning helps provide continuity throughout design and construction by communicating the owner's goals and evaluating all decisions against those goals. Commissioning also helps ensure that the building systems and components are well integrated so that the building performs as expected. Comfort, indoor air quality and energy efficiency can all benefit from commissioning's systematic approach.

Benefits

The commissioning process yields a better building by encouraging the design and construction teams to understand and respond to the owner's goals, communicate well, interact closely and make integrated decisions about the performance of the whole building environment. Successful building commissioning provides the owner and occupants with an optimally functioning building at the time of turn-over and the knowledge to successfully operate and maintain the building.

A successful commissioning process should result in lower energy and maintenance costs, fewer call-backs, less warranty work, and greater comfort and satisfaction for the residents.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Studies have shown that commissioning as a percentage of total construction is most cost effective with larger buildings, as similar efforts are required for all size buildings. Commissioning of new buildings has the added value of taking advantage of design phase commissioning, which can significantly enhance systems integration.

Retro-commissioning is the practice of commissioning buildings that have been in operation for some time. A significant advantage of retro-commissioning is that actual operational data can be used as a yardstick against which to measure proposed improvements. Also, if the building had been commissioned when it

was first built, the initial setpoints developed at first commissioning can be re-evaluated during the retro-commissioning process.

Commissioning any building—whether it is done by a third party as described in this measure, or completed with informal practices—is an improvement over current design and construction practices.

Design Details

Commissioning can take various forms. The following outline describes activities, timelines and responsibilities for a typical commissioning process.

FIRST STEPS

1. **Hire a commissioning coordinator (CC).** This may be a third-party professional or a competent and interested member of the design or construction team. The CC coordinates and documents the commissioning activities listed below and verifies that the owner's project requirements are being executed. It is best to have the same CC throughout design, construction and post-construction phases. The CC needs to be able to act independently, so he or she should not have responsibilities on this project that conflict with his or her commissioning responsibilities. Although the CC must be able to coordinate and communicate effectively with the owner and design and construction teams, he or she generally has no authority to demand specific actions but will make recommendations as to the best course of actions based upon their experience and integrated perspective. In essence, the CC is a witness, documenter, consultant and facilitator of the commissioning process.
2. **Include commissioning expectations in contract documents.** This can be included in the specifications, or could be a summary document in the designer's and contractor's contract documents.

DESIGN PHASE

1. **Define project goals and record owner's project requirements (OPR).** Documentation is critical to a successful commissioning process. Creating the owner's project requirements (OPR) document is the first step in communicating to the design team. Although the design team should include the owner's goals in the construction documents, it's still important to have an OPR document, because it explicitly addresses the owner's goals. Without such a document to continually refer to, team members may lose sight of key goals. The OPR serves as a guideline for the entire project, and addresses many issues, including:
   - » General building features
   - » Building occupant requirements
   - » Indoor environmental quality requirements
   - » Environmental, sustainability and energy efficiency goals
   - » HVAC system requirements
   - » Lighting system requirements
   - » Plumbing system needs
   - » Landscaping vision
   - » Cleaning and janitorial needs
   - » Maintenance support
   - » Budget and schedule

   Timeline: Pre-design
   Responsibility: Owner, CC
2. **Define Basis of Design (BoD).** Architects and mechanical/electrical/plumbing (MEP) engineers create the BoD, a document that describes how they intend to meet the owner's requirements.

   Timeline: Design Development
   Responsibility: Design Team
3. **Conduct Plan and Specification Review.** The CC reviews drawings and specifications for compliance with OPR and BoD.

   Timeline: Roughly halfway through construction documents phase
   Responsibility: CC
4. **Establish Commissioning Requirements.** Create commissioning requirements in the contract documents. This provides all parties with the necessary conditions and expectations that the building is to meet the OPR and will undergo verification of compliance. If the CC can incorporate the commissioning requirements into the design team's contract documents, this step would be second on this list.

   Timeline: Prior to bid documents
   Responsibility: CC, Design Team

CONSTRUCTION PHASE

1. **Develop Commissioning Plan.** This is presented to the commissioning team at the commissioning kickoff meeting. It provides an outline of the commissioning sequences, identifies the responsible parties, provides timeline expectations, and defines the deliverables for each person involved in the commissioning process.

   Timeline: Within 30 days of construction start

   Responsibility: CC

2. **Hold Commissioning Kickoff Meeting.** Because this process is often new for many participants, this meeting should be mandatory. The commissioning plan (above) is presented at this meeting.

   Timeline: Within 30 days of construction start

   Responsibility: CC, Design Team, GC, Subs of commissioning equipment

3. **Review Submittals.** Review submittals to ensure that the equipment and components being installed meet OPR and BoD requirements. If there is no formal submittal review process, the CC should coordinate a different process for ensuring compliance.

   Timeline: Before equipment is approved

   Responsibility: CC, Design Team

4. **Obtain O&M Submittals.** Collect O&M Manuals prior to startup. These documents provide manufacturers' information for startup, operations and maintenance. They are included in the final commissioning report provided by CC and given to the owner.

   Timeline: 30 days prior to startup

   Responsibility: GC

5. **Define and Coordinate Startup Activities.** Define a coordinated approach to startup. Review contractor's normal startup checklist and coordinate individual startups within the overall startup sequence. After startup is complete, the party responsible for that equipment should sign off the checklist. This checklist is then incorporated into the commissioning report.

   Timeline: 10 day notice to CC

   Responsibility: GC

6. **Conduct Test and Balance Procedures.** This process is completed after successful startup procedures and recorded as the balanced setpoint for future commissioning activities. Test and balance is needed for both air and hydronic distribution systems.

   Timeline: 10 day notice to CC

   Responsibility: GC

7. **Conduct Functional Testing.** This process creates testing procedures to verify that the installation, configuration, calibration and operating parameters have been set properly for components, sub-systems, systems, and whole building interaction and that these settings meet the OPR.

   Timeline: 14 day notice to CC when equipment is ready

   Responsibility: GC

POST-CONSTRUCTION PHASE

1. **Maintain Issues Logs.** The CC maintains a record of all deficits throughout the commissioning process and provides assurance to the owner that these issues have been addressed.

   Timeline: Throughout the commissioning process, including startup, functional testing and warranty review

   Responsibility: GC, CC

2. **Ensure Training.** The CC verifies that the individual contractors provide training to the building owner, facilities personnel and in some cases the occupants. The training should include hands-on interaction with the equipment and its functions. For the occupants, this may involve teaching them how to use certain equipment. For maintenance staff, training will be more thorough training, including emergency conditions, preventative maintenance, and other control information. This training process should be formalized by creating a training agenda.

   Timeline: Within 10 days after substantial completion

   Responsibility: GC, Subs, CC

3. **Submit Commissioning Report.** The CC collects all commissioning documentation and submits them to the owner.

   Timeline: After final completion

   Responsibility: CC, provide to owner

4. **Conduct Warranty Review Process.** The CC conducts a formal or informal interview and survey with residents and tenants to collect comments regarding occupant and facilities experience. This should be conducted during the equipment warranty period and should include review of problems that arose during design and/or construction. A report documenting issues should be generated and used to complete warranty issues. The CC assists with coordinating and communicating with the contractors and owner.

   Timeline: 8 to 10 months after occupancy

   Responsibility: CC, Owner, Occupants, Maintenance

Code Considerations

Commissioning is not in conflict with any codes nor is it duplicated by any code requirements. California's Building Energy Efficiency Standards (Title 24) now requires field verification, or compliance standards, for water heating equipment, windows, air distribution ducts, HVAC equipment, building envelope tightness, insulation and lighting systems. Title 24 requires the installing contractor to verify that various requirements have been met. Because there are currently few enforcement mechanisms and little in the way of training, Title 24 relies on contractors to be their own witness to compliance.

Title 24's requirements are similar to the startup checklists in the commissioning process. While Title 24's field verification requirements generally focus on proper installation of specified components, commissioning goes well beyond that to also focus on operations and integration of the equipment.

Considerations for Residents

In a sense, residents are the ultimate commissioning agents. The residents' experience of their building is affected by many of the attributes that the commissioning process manages. During the warranty review period, the CC should check in with commercial tenants and residents to get feedback on how well the building is meeting their needs. For the owner, occupant satisfaction is one important measure of sustainable economics. Accurate identification of the target occupant during the OPR phase, coupled with a successful design and construction process, will help ensure that residents are satisfied with the building.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

When the subject of commissioning comes up, one of the first questions that owners ask is, "How much does it cost?"

Many owners, design and construction teams, and others experienced in commissioning say that commissioning is one of the most valuable aspects of green building. That's because the quality assurance it provides affects all aspects of the building process.

While costs vary widely, they often depend on how much experience the CC and design and construction teams have with the commissioning process, as well as the owner's level of commitment to the commissioning process. Costs are generally lower when teams are well versed in the commissioning process.

In some cases, commissioning leads to lower first costs; for example, the integrated design process supported by commissioning may result in the downsizing of equipment. More significantly, commissioning can result in substantially lower energy and maintenance costs, fewer change-orders and call-backs, and less warranty work. Many of these savings persist throughout the building's life.

Resources

Commissioning multifamily developments is still relatively new. Currently, most commissioning resources focus on commercial buildings.

» **Building Commissioning Association** provides online publications and resources to its members: www.bcxa.org

» **California Commissioning Collaborative's** On-line Commissioning Library has nearly 300 articles, papers and sample commissioning documents: http://resources.cacx.org/library

» **Energy Design Resources** offers commissioning guidelines and related publications on energy-efficient building design:

www.energydesignresources.com/category/commissioning/

» **Lawrence Berkeley National Laboratory's** (LBNL) Design Intent Tool is a database that provides a structured approach to recording design decisions affecting a facility's performance in areas such as energy efficiency:

http://ateam.lbl.gov/DesignIntent/home.html

» **LBNL's** report, "The Cost-Effectiveness of Commercial-Buildings Commissioning" is available at: http://eetd.lbl.gov/emills/pubs/cx-costs-benefits.html

» **Oak Ridge National Laboratory** published the report, "A Practical Guide for Commissioning Existing Buildings":

http://eber.ed.ornl.gov/commercialproducts/retrocx.htm

» **Portland Energy Conservation, Inc**. has extensive information about commissioning existing buildings and new construction: www.peci.org/commissioning.htm;

PECI's Functional Testing Guide is at: www.peci.org/ftguide/

Related Case Studies

» First Community Housing, p. 209

REDUCED PORTLAND CEMENT IN CONCRETE

Use Flyash or Slag to Displace a Portion of Portland Cement in Concrete

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 3: Concrete

OLD: Division 3: Concrete

Recommendation

For concrete work, displace portland cement content in concrete mixes by incorporating recycled pozzolans such as flyash or slag.

Description

Concrete is typically composed of aggregate, sand, water, portland cement and other admixtures. Manufacturing portland cement consumes considerable energy, resulting in high emissions of greenhouse gasses. Reducing portland cement in concrete by displacing it with waste materials such as flyash and slag can reduce environmental problems associated with the production of portland cement.

Flyash is a waste product of coal-fired electrical 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% of that flyash is recycled; the rest is placed in landfills. Reducing the amount of portland cement in concrete by incorporating flyash is an effective method of recycling flyash.

Slag, or ground granulated blast-furnace slag (GGBFS), is a byproduct of iron manufacturing. When iron is manufactured using a blast furnace, two products—slag and iron—collect in the bottom of the hearth. Molten slag rises to the top and is turned into granules, which are then dried and ground to a suitable fineness, resulting in slag. The granules can be incorporated into concrete.

Both flyash and slag may be used in the same concrete; this is called a tri-blend and is becoming more popular. Less common cement replacement admixtures include silica fume (a waste product of the silicon industry,) rice hull ash and metakaolin (a clay). Special concrete blends are sometimes referred to as high volume flyash or high performance concrete.

Benefits

Flyash and slag improve the performance of concrete by increasing its strength, reducing permeability and reducing corrosion of reinforcing steel. Longer cure times may result in less cracking.

Flyash is composed of tiny spherically shaped particles that act like ball bearings, improving the concrete's workability and aiding placement of concrete into formwork and around reinforcing steel. Consequently, less water is needed in the mix, reducing or eliminating bleed water.

Using flyash or slag in concrete can be associated with lower energy use (manufacturing portland cement is very energy intensive) and fewer greenhouse gas emissions. Cement is made by heating limestone and other minerals to 2700°F in large kilns. For every ton of cement produced, about 1,400 pounds of carbon dioxide (CO_2) are released into the atmosphere. CO_2 is one of the primary greenhouse gases that contributes to global warming. Portland cement manufacture also introduces mercury, sulfur dioxide and other toxins and particulates into the air. Reducing the use of cement in concrete is one way to help reduce both pollution and global warming.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Flyash and slag mixes can be used for any application where conventional concrete is appropriate, including footings, mat foundations, slabs on grade, slabs on metal decks, cast-in-place and tilt-up walls, columns, driveways, sidewalks and equipment pads. Depending on the application and level of cement reduction desired, varying concrete mix designs are appropriate. In most cases the project team should consult an engineer.

Design Details

Although flyash and slag have been used in concrete for decades, the techniques for designing and working with pozzolan concrete are still new to many engineers and contractors, making it important to discuss their use with the engineer and contractor early in the design phase.

Considerations for specification include: type of pozzolan used (Class F Flyash is common in California but cannot be used as a one-to-one replacement for portland cement), level of cement reduction, strength gain, water-cement ratio, curing and more. Some suppliers offer pre-engineered flyash and slag mixes for standard applications or are experienced with alternative mixes and can be helpful with specifications.

Concrete with flyash or slag reaches its ultimate strength more slowly than typical mixes, although this can be partially addressed by the use of low-water mixes. In some cases, this added time can affect construction scheduling, so be sure to discuss this with the engineer. If lower early strength is acceptable, specifying 56-day rather than 28-day strengths can significantly reduce the amount of portland cement required.

KEMA

Code Considerations

ASTM sets standards for the chemical composition of flyash and slag but does not specifically limit the amount of flyash that may be added to concrete. In standard construction, the amount of flyash specified in concrete has been limited to about 30%, however, green building projects have incorporated up to 60% flyash or slag for some applications. This resistance to changing standard practice may be a larger barrier than any locally applicable codes.

Considerations for Residents

Flyash use in concrete is a widely accepted green building practice. By nature of its production, flyash can contain trace contaminants such as mercury, heavy metals and radon. To date, the risk of exposure to these contaminants from leaching or vapor emissions for residential building applications has been found to be minimal and not significantly different than what would result from portland cement or natural soils.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Flyash and slag concrete mixes are available in California and can cost the same or more than conventional mixes, depending on the percentage of cement reduction and special admixtures that might be required. In addition, contractor bids for using flyash or slag can be higher if the contractor is unfamiliar with working with it. To avoid surprises, have the structural engineer discuss concrete with the contractor early on.

Resources

» **American Coal Ash Association** compiles flyash production and utilization data and resources for specifying flyash in concrete**:** www.acaa-usa.org

» **Build It Green Product Directory** lists sources of concrete with flyash and slag content: www.BuildItGreen.org/products

» ***Cement Americas*** magazine provides useful information on the benefits of various cement blends: www.cementamericas.com

» **Coal Ash Research Center,** University of North Dakota provides environmental analysis and a consumer guide to flyash containing products: www.undeerc.org/carrc

» ***Making Better Concrete*** by Bruce King (Green Building Press, 2005) is an excellent guideline to specifying and working with flyash and other pozzolans in concrete: www.greenbuildingpress.com

» **Portland Cement Association** provides resources for the specification, application and use of all types of cement, concrete construction and concrete products, including flyash: www.cement.org

» **Slag Cement Association** provides similar resources for slag: www.slagcement.org

Related Case Studies

» Carmen Avenue, p. 230

STRUCTURAL PEST AND ROT CONTROLS

Design and Build Structural Pest Controls

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: **07 24 19:** Water Drainage Exterior Insulation and Finish System, **10 81 00:** Pest Control Devices

OLD: **07243:** Water Drainage Exterior Insulation and Finish System

Recommendation

Install structural pest controls as part of an Integrated Pest Management (IPM) plan to safely and effectively prevent pests from damaging building materials.

Description

Ants, termites and other pests can damage cellulose-based building materials, but some chemical treatments designed to deter pests may also be toxic to humans and other species. Pests are attracted to water, food and rotting wood. Permanent, structural pest controls can stop pests along their typical pathways of entering the building. *For information about IPM measures unrelated to structural pest controls, refer to Resources below.*

PRACTICA CONSULTING

Locate all new plants at least 36 inches from the foundation.

Benefits

Physical pest controls reduce the need to use unsafe chemicals such as pesticides, insecticides, rodenticides or fumigants. They are often more effective than chemical controls (as chemicals require frequent reapplication) and increase the durability of the building's structural elements, reducing the time and money needed for repairs.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily buildings.

Design Details

Install continuous, durable termite shields around all foundation slab edges and penetrations, and separate all exterior wood-to-concrete connections with metal or plastic fasteners or dividers. Install termite shields around all pipes (or other elements) penetrating the foundation, at the junction of the foundation or piers and the wall framing, and wherever slab perimeter insulation is installed.

Effective termite shield materials include sheets of galvanized steel or copper, steel mesh or plastic. Perform regular inspections in buildings using wood as a structural material, regardless of treatment and prevention methods.

When structural wood elements (such as posts, stairs and decks) are in constant contact with concrete or soil, they remain moist for prolonged periods and eventually rot. Create a separation to allow water to drain and wood to easily dry out.

CLEARANCE AROUND FOUNDATIONS

Locate all new plants at least 36 inches from the foundation. This keeps roots away from the foundation, reduces the chance of pests traveling from branches onto the building, reduces excess irrigation water near the foundation and siding, and allows the property manager to more easily inspect for termite tunnels around the foundation.

OTHER STRATEGIES

Other structural pest controls include extending the distance between sole plates and the soil beyond the code minimum, and using pest-resistant framing materials such as steel, concrete or borate-treated wood. Siding with an effective drainage plane will also help reduce moisture that attracts pests *(Structure: E1–Drainage Planes and Durable Siding).*

Code Considerations

The California Building Code (Title 24) outlines Decay and Termite Protection in Division Two, Section 2306A. There are code requirements for treated or insect-resistant wood at mudsills within 18 inches of dirt.

Considerations for Residents

Structural pest controls increase building durability and longevity, and can reduce maintenance costs. Reducing the use of pesticides may help protect the health of residents, pets and other animals, vegetation and local waterways.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Nontoxic pest prevention may initially cost up to 25% more than chemical controls, but the long-term benefits of structural solutions tend to offset the higher upfront costs. Ongoing chemical costs will be reduced or eliminated if alternative pest prevention strategies are implemented.

Resources

- **Austin Energy Green Building's Sourcebook** contains a section on IPM in the Health and Safety Chapter: www.austinenergy.com
- **Bio-Integral Resource Center** has information about IPM solutions to pest problems: www.birc.org
- **Natural Pest Management Association** is a trade association for the professional pest control industry: www.pestworld.org
- **University of California's Statewide Integrated Pest Management Program** has numerous online resources: www.ipm.ucdavis.edu

Related Case Studies

None

CONSTRUCTION MATERIAL EFFICIENCIES

Use Advanced Framing Techniques; Reuse Construction Scraps

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: **06 10 00:** Rough Carpentry, **05 12 00:** Structural Steel Framing, **06 48 00:** Wood Frames

OLD: **06100:** Rough Carpentry, **05120:** Structural Steel, **06460:** Wood Frames

Recommendation

Design wood-framed buildings using advanced framing techniques.

Maintain a reuse pile for scrap wood, sheathing, drywall, siding and other building materials.

When using steel framing, prevent thermal bridging with adequate exterior foam insulation.

Description

A lot of material and money can be saved by designing wood-framed buildings with advanced framing techniques (also known as Optimum Value Engineering, or OVE). These techniques reduce the amount of lumber used to construct a building while maintaining structural integrity and meeting the building code.

Because lumber and sheet material is typically milled in 2-foot increments, laying out a building on a 2-foot module can significantly reduce the labor time and material waste from off-cuts. Other advanced framing opportunities include spacing studs on 24-inch or 19.2-inch centers, sizing headers for the load, using ladder framing at perpendicular wall intersections, replacing jack studs with framing anchors, and constructing two-stud wall corners.

Another way to reduce labor is to purchase panelized or pre-engineered building systems. Panelized systems include prefabricated walls, floors and roof components. Exterior sheathing and finish can be applied prior to erection. Some manufacturers offer pre-engineered systems in which building components are factory-assembled. Installing pre-engineered systems usually requires crew training from the supplier. It is not uncommon for panelized walls to be erected in one-fourth the time of stick-built structures, which is a particular advantage during inclement weather *(Structure: D7–Structural Insulated Panels and Other Solid Wall Systems).*

As an alternative to wood framing, consider steel framing. Steel typically contains 25% to 30% postconsumer content, with some companies now offering over 50% postconsumer recycled steel. Steel is fully recyclable and can be made back into high-value steel.

The biggest downside of steel framing is increased heating and cooling loads as a result of **thermal bridging,** which is associated with a material's conductivity. Steel's conductivity is more than 200 times that of wood. When framing with steel, include thermal breaks and ensure there is appropriate insulation (minimum of 1 inch) to minimize thermal bridging. Even with thermal breaks, however, most steel-framed structures are less energy efficient than similar wood-framed buildings.

During construction, save money and material by storing scrap ends and other small pieces in well-organized cut-piles and reusing the materials instead of throwing them away. Materials that can be readily reused include wood studs, sheathing, joists, drywall, siding, piping, metal products, roofing and even fiberglass insulation. Properly cover and store reusable materials so that they are not damaged. Reuse piles should be an integral part of the Construction and Demolition (C&D) Waste Management Plan *(Site: A2–Construction and Demolition Waste Management).*

Benefits

Advanced framing methods and cut-piles reduce costs and consumption of wood and other building products and may reduce related labor costs. Panelized and pre-engineered building systems may reduce waste and labor costs.

Steel framing with thermal breaks increases the R-value of the thermal envelope.

The greatest benefits of steel, panelized and pre-engineered framing products may be realized as new construction methods are developed. Steel, for example, can span greater distances than wood. Replacing standard stud framing with new designs using steel, panelized or pre-engineered systems may yield superior results.

Application

Wood-framed construction:

SIZE	√ Low Rise	√ Mid Rise	High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		Commercial

Steel-framed construction:

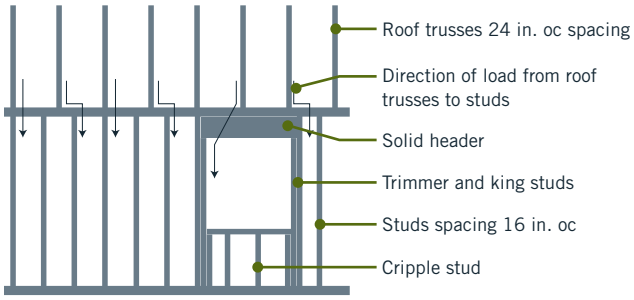
SIZE	Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		Retrofit
USE	√ Residential		√ Commercial

This measure does not apply to concrete wall construction.

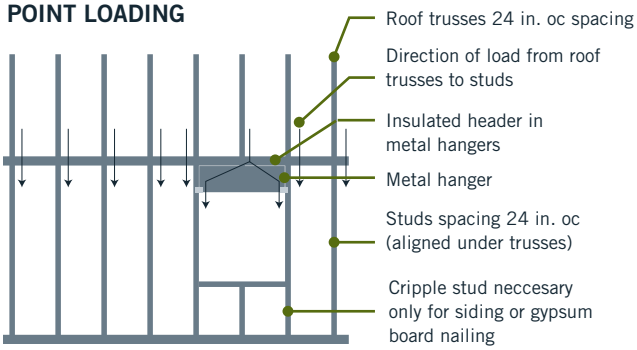
POINT LOADING TRUSSES

Point loading is preferable to standard loading. When truss loads are stacked directly over 24 in. on-center (oc) framing, it reduces the framing materials required and increases the insulation capacity of walls

STANDARD LOADING



POINT LOADING



Design Details

To reduce wood waste at the jobsite, have lumber delivered precut or preassembled from the supplier. Also consider the following advanced framing techniques for wood-framed buildings. Provide detailed framing drawings (including framing elevations and plans), and thoroughly brief and supervise the framing crew on the advanced framing strategies called for in the drawings.

» **Place studs on 24-inch or 19.2-inch centers.** Based on the conventional construction provisions in the California Building Code (CBC), 2x4 studs can be spaced at 24-inch centers for both nonbearing and bearing walls on the top level (that is, carrying as much as the roof and ceiling). Two-by-four studs can also be spaced at 24-inch centers for walls supporting one floor only. Where 2x4 studs on 16-inch spacing is required, 2x6 studs at 24-inch spacing is always acceptable (that is, for walls supporting one floor, roof and ceiling). This substitution may not reduce the volume of lumber used but will improve the energy efficiency of the exterior envelope.

  In many cases, 2x4, 2x6 or engineered studs can be used depending on structural requirements and the space needed for insulation, but it is recommended to use the largest stud spacing possible based on the engineer's calculations. All projects can place studs for interior non-load-bearing walls at 24-inch centers. Thicker decking, drywall and other finish materials may be required to span the wider dimension if there is excess deflection.

» **Eliminate headers in non-load-bearing walls.** While not installing headers where they're not required might seem like common sense, out in the field it's not always obvious to framers which walls are non-load bearing. Ensure that drawings clearly indicate which walls are bearing and thus require structural headers.

» **Size headers for load or install insulated box headers.** Rather than installing the same size header at all locations for the worst-case condition, require the engineer to design each header and develop a header schedule with at least three different sizes that are practical to implement. On the jobsite, distinctly different header sizes should be readily apparent, based on different placements and structural needs within the building. Another option is to build a standard size insulated box header for all conditions, which ensures energy efficiency but avoids challenges of framing with various size headers.

» **Use ladder framing at perpendicular wall intersections on exterior walls.** Exterior wall intersections generally use excessive lumber and are very difficult to insulate. Rather than using vertical framing at these locations, install flat horizontal blocking between studs to attach the perpendicular wall.

» **Build wall corners with two studs and drywall clips.** Most wall intersections are constructed with three or even four studs. Instead, use a two-stud detail supplemented with metal clips to support the drywall.

» **Use framing anchors instead of jack studs for header spans that do not exceed three feet.** Jack studs can be eliminated when framing anchors are adequate to carry the header load (generally, spans that are no wider than three feet). Ensure that jack studs are installed only when required to carry loads or offer nailing surfaces for finishes.

Other advanced framing techniques include:

» Design based on 2-foot modules

» Roof rafter framing and joists at 24 inch on center

» Stacked framing and single top plates

» Let-in bracing or tension straps to replace bracing sheathing

CUT-PILES

A cut-pile requires an open, clean space to store materials. Cover and store all materials appropriately and keep them dry. Sheetrock, wood, sheathing and other porous materials can absorb moisture, which may lead to mold growth and indoor air quality problems. When storing materials in a loose pile, be sure to consider safety. Provide large signs in bold colors to designate reuse piles and differentiate them from recycling and waste materials.

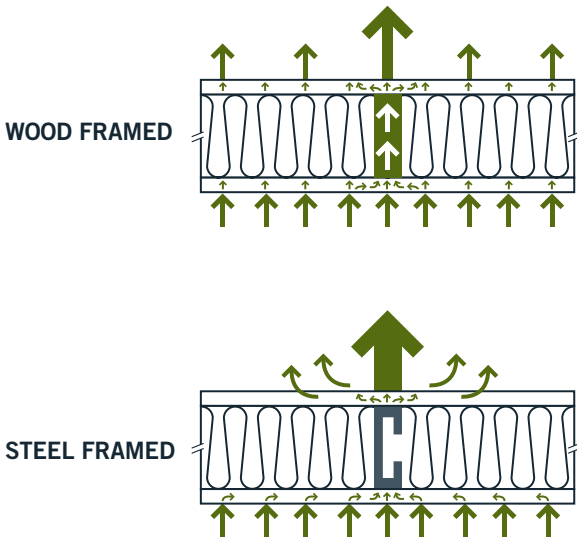
Separating dimensional materials for reuse also makes it easier to donate unused materials once the project is finished, because materials are already sorted *(see Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

STEEL FRAMING

The decision to use steel framing over wood must be made early in the design phase. Coordination with the engineer and contractor to align system routing through steel framing is critical to minimize cutting in the field and to take advantage of precut openings in steel members.

Because of steel's high conductivity, heat and cold easily move through the metal from the exterior to the interior of the building envelope (or vice versa), largely bypassing insulation, as shown in the illustration below.

To lessen thermal bridging, use a thermal break to isolate the steel from any direct contact with the exterior or interior. On the inside, sheetrock is usually sufficient. On the exterior walls and roof, the thicker the foam sheathing (R-value of 3.8 to 7 per inch of thickness depending on the type of foam) the better the wall assembly will perform.



An insulated steel frame wall without measures to control thermal bridging will only perform 50% to 70% as well as a similarly built wood wall. Steel studs like the "C" channel shown here can effectively bypass much of the wall's insulation.

Overall, strategies should reduce the transfer of heat where steel walls rest on concrete foundations, where roof truss members connect the attic to the interior, and where the bottom floor joists are located over unconditioned spaces. Other measures include:

- Space studs at 24-inch centers and insulate between studs to increase overall R-value of walls. Two-by-six studs are recommended for greater cavity insulation unless using thick external foam sheathing.
- Use thinner (25-gauge) steel studs for nonbearing walls (thinner steel means less conductance).
- Install a thermal break to the exterior, such as insulated sheathing. If the insulated sheathing is installed directly onto the studs with metal connectors, then thermal bridging through the metal connectors will occur. First install sheathing to the studs, then apply insulation to the sheathing.

Steel-Framing Skills

In a one-for-one replacement of wood framing, a more skilled labor force is needed to frame with steel. Steel framing is typically installed by a commercial framing crew, not a residential crew, which can mean higher labor rates. This is primarily because steel walls are in-line framed. Floor joists and roof rafters align with the wall studs, and studs are fastened to a top and bottom track instead of wood plates. Steel tracks are not capable of transferring vertical loads, so bracing is needed, requiring more skill than wood framing.

Additionally, steel frames are screwed together instead of nailed. Nail guns are very fast and easy to use, making steel framing more labor intensive. However, screwed steel members can be disassembled during remodeling or deconstruction. Cutting steel framing with chop saws and electric snips also requires more skill than lumber cutting. Automatic-feed screw guns with self-drilling screws, pneumatic sheathing pin nailers, and portable plasma torches are increasingly used to reduce labor time, and promise to make steel more competitive.

Code Considerations

Advanced framing issues are addressed in the International Residential Code section R602, which covers wood wall framing components. It includes specific provisions for single top plates with rafters or joists centered over studs (R602.3.2), studs spaced at 24 inch on center (R602.2.4) and two-stud corners (Figure R602.3.2).

Check with local codes and a structural engineer to ensure that the proposed advanced framing techniques and entire framing assembly comply with state and local framing codes, including seismic requirements.

Cut-piles must follow all OSHA and local jobsite safety regulations.

For steel, request mill certificates from the roll-former and/or have steel members stamped with thicknesses and yield strengths to reduce confusion during installation and building inspections.

If a panelized system is proposed, be certain local code officials have reviewed and approved the system *(Structure: D7–Structural Insulated Panels and Other Solid Wall Systems).*

Considerations for Residents

Steel does not offgas or need pest controls *(Structure: D2–Structural Pest and Rot Controls).* Steel-framed buildings without thermal breaks can have problems with fungal or mold growth because of condensation in the walls. Thermal breaks can significantly reduce this concern. Occupants may have somewhat higher energy costs with steel versus a wood building, even with thermal breaks.

Cost and Cost Effectiveness

WOOD FRAMING		STEEL FRAMING	
BENEFIT	★★☆	BENEFIT	★★☆
COST	$$$	COST	$$$

Advanced framing techniques can result in large cost savings since both material use and waste are reduced. According to the Natural Resources Defense Council, efficient wood use in low-rise residential buildings can result in an 11% to 19% reduction in wood use *(see Resources).* Studies conducted in the 1990s by the National Association of Home Builders found cost savings ranging from $0.24 to $1.20 per square foot. In a 2,000-square-foot house this amounts to net savings of approximately $500 to $2,500, which goes directly to profit.

Panelized and pre-engineered building systems can increase material cost by 15% or more, but can reduce labor and installation time and cost.

Cut-piles require minimal labor. Subcontractor training and start-up take some effort, but the savings in material costs are more than worth it. Studies of single-family developments found that using cut-piles during the construction of an average California single-family home saves $800 in lumber costs.

Steel prices are more constant than wood prices, resulting in longer price guarantees from manufacturers. This helps with project budgeting, and, unlike lumber, reduces the stressful purchase and delivery timing game that contractors often face because of volatile lumber prices.

Studies estimate that, overall, installed steel framing costs anywhere from 0% to 7% more than wood framing, mostly because of increased labor costs. But this can vary significantly by assembly type: Steel floor assemblies cost less than engineered wood I-joist floors, while interior walls are consistent with wood costs. Adding appropriate thermal bridging control measures can make exterior walls more expensive than wood.

Resources

- ***Environmental Building News*** has an article, "Steel or Wood Framing: Which Way Should We Go?" (Jul/Aug 1994); fee to access: www.buildinggreen.com
- ***Home Energy*** magazine has two articles, "Steel Framing: How Green?" and "Steel Stud Walls: Breaking the Thermal Barrier" (Jul/Aug 2001); fee to access: www.homeenergy.org
- **Natural Resources Defense Council (NRDC)** publishes a booklet, "Efficient Wood Use in Residential Construction" (1998): www.nrdc.org/cities/building/rwoodus.asp
- **Steel Framing Alliance (SFA)** publishes guidelines for addressing thermal bridging: www.steelframingalliance.com
- **Steel Recycling Institute** has information about using and recycling steel construction materials: www.recycle-steel.org
- **ToolBase Services,** provided by the NAHB Research Center, has information about advanced framing techniques and steel framing: www.toolbase.org

Related Case Studies

- Healthy Buildings, USA, p. 73

ENGINEERED LUMBER

Use Resource-Efficient Engineered Lumber Instead of Solid-Sawn Lumber for Studs, Joists, Headers and Beams

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 06 10 00: Rough Carpentry

OLD: 06100: Rough Carpentry

Recommendation

Specify engineered lumber instead of solid-sawn lumber wherever appropriate.

Description

Solid-sawn lumber in sizes 2x10 and greater typically comes from old-growth forests. Engineered lumber products, on the other hand, come from small-diameter, fast-growing plantation trees. Engineered lumber includes these manufactured wood structural materials:

- **Glued laminated timber (glulam):** Layers of dimensional lumber bonded together. Can span great distances.
- **Laminated veneer lumber (LVL):** Thin wood veneers bonded together. Useful for long spans and as headers.
- **Laminated strand lumber (LSL):** Long strands of wood fiber bonded together. Used where straightness is desired, such as for studs and rim joists.
- **Parallel strand lumber (PSL):** Very strong engineered product made of long veneer strands laid in parallel and bonded together. Used for high density applications, such as headers and beams.
- **Insulated engineered header:** Foam insulation sandwiched between panels, typically OSB, to create a strong, lightweight insulated header to reduce thermal loss at window and door areas.
- **I-Joist:** Structural product (also known as I-beam) with an "I" configuration. The web material is typically OSB sandwiched by either PSL or dimension lumber. Used for floor and roof joists.
- **Oriented strand board (OSB):** Cross-oriented wood strands from fast-growing species are bonded together. Used for sheathing, subfloors and many other applications.
- **Finger-jointed stud:** Short pieces of dimensional lumber bonded together to create longer studs.

The wood fiber in engineered lumber products is bonded together using various glues including methylene diphenyl isocyanate (MDI) and phenol formaldehyde.

Benefits

Engineered lumber can help improve energy efficiency by complementing optimum value engineering (OVE) framing techniques that increase insulation levels *(Structure: D3–Construction Material Efficiencies and F1–Insulation).*

Engineered lumber manufacturing uses trees efficiently by making large structural products out of wood chips and young trees. Engineered lumber is more dimensionally stable and straighter than conventional lumber because it does not have a grain and therefore does not expand and contract as much as solid wood.

Engineered wood I-joists use up to 50% less wood fiber to perform the same structural function as similarly sized solid-sawn lumber, and they will not twist, warp or split. They are stronger, lighter and can span greater distances than 2x10s or 2x12s; in some cases, this may eliminate the need for a support wall. Since engineered lumber can span greater distances and bear greater loads, labor is reduced.

OSB is as strong as traditional plywood and is less expensive. OSB will have lower formaldehyde related emissions than interior grade plywood made with urea-formaldehyde binders, contributing to healthier indoor air quality.

Engineered beams such as glulams, parallel strand lumber, laminated strand lumber and laminated veneer lumber replace the need to use old-growth timber, while providing superior structural characteristics.

Finger-jointed studs are straighter and stronger than solid-sawn studs, helping eliminate crooked walls and reducing material waste *(Finishes & Furnishings: K5–Environmentally Preferable Interior Finishes).*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I-joists used for floor joists.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all buildings where solid-sawn lumber is used.

Design Details

Plan for the use of engineered lumber from the beginning of the design phase. Take advantage of design synergies that can result in energy savings and materials reduction, such as advanced framing *(Structure: D3–Construction Material Efficiencies).*

Here are some strategies for designing with engineered lumber:

» Joists: Replace with wood I-joists or engineered trusses.

» Non-load-bearing header: Replace with small members (double 2x6s).

» Structural headers and beams: Use engineered headers and beams.

» Floor joists: Design on 19.2-inch centers to improve cost efficiency.

» Finger-jointed studs: Only use in vertical applications and integrate into the seismic engineering design.

When available, choose engineered lumber products made with FSC-certified wood content *(Structure: D5–FSC-Certified Wood for Framing Lumber)*.

Use engineered lumber that is not made with urea formaldehyde (UF) binders. Phenol formaldehyde binders don't emit as much formaldehyde as UF binders but may still affect indoor air quality *(Finishes & Furnishings: K6–Reduced Formaldehyde in Interior Finishes).*

Code Considerations

Wood selected for a project can affect indoor air quality. All wood products naturally contain formaldehyde. Engineered lumber may have elevated formaldehyde emissions when compared to dimensional lumber. Interior grade, engineered wood products made with urea formaldehyde, typically, have the highest emissions. Thus, selecting engineered lumber with low formaldehyde emissions will help protect indoor air quality.

Considerations for Residents

Wood selected for a project can affect indoor air quality. All wood products naturally contain formaldehyde emissions when compared to dimensional lumber. Interior grade engineered wood products made with urea formaldehyde typically have the highest emissions. Thus, selecting engineered lumber with low formaldehyde emissions will help protect indoor air quality.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Engineered lumber is cost competitive or slightly more expensive than conventional lumber. Some products, like I-joists, will require less labor to install, but may require that the laborers be more skilled. Engineered studs can save time because they create straighter walls, resulting in less shimming needed to true walls.

Resources

» **Build It Green Product Directory** has information on sourcing engineered wood products: www.BuildItGreen.org/products

» **Engineered Wood Association (APA)** provides information on the benefits and uses of engineered lumber: www.apawood.org

» ***Environmental Building News*** published the article "Structural Engineered Wood: Is It Green?" (Nov. 1999); fee to access: www.buildinggreen.com

Related Case Studies

» Colony Park, p. 227

» Crossroads, p. 234

FSC-CERTIFIED WOOD FOR FRAMING LUMBER

Use Wood Products Certified by the Forest Stewardship Council (FSC)

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 06 10 00: Rough Carpentry, **06 40 00:** Architectural Woodwork, **09 60 00:** Flooring

OLD: 06100: Rough Carpentry, **06400:** Architectural Woodwork, **09600:** Flooring

Recommendation

Specify FSC-certified wood for wood framing, including dimensional lumber and panel products.

Description

The Forest Stewardship Council (FSC) is a non-governmental organization that promotes standards for sustainable forestry certification worldwide and accredits forestry certifiers. FSC principles include management for biological diversity, long-term forest health and the long-term economic well-being of local communities.

FSC tracks and monitors wood throughout the chain-of-custody—as it moves from harvesting to manufacturing and distribution and finally to the point of sale—to ensure that the customer is actually getting a certified sustainably harvested product.

FSC authorizes third-party certifying organizations to carry out certification. In the United States, these organizations are SmartWood and Scientific Certification Systems (SCS). These groups certify forest lands and chain-of-custody forest products based on FSC standards.

Benefits

FSC certification guarantees that forests are managed in a way that will assure the long-term availability of wood while protecting the health of forests and the natural resources they contain and support.

Application

SIZE	√ Low Rise	√ Mid Rise	High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

FSC-certified lumber looks and performs the same as non-certified lumber. It can be used in place of framing materials made from conventionally harvested wood. FSC-certified wood is available as framing lumber in dimensions from 2x4 through 2x12, as plywood, and as other engineered wood products *(Structure: D4–Engineered Lumber).*

Design Details

Include FSC-certified wood as a product requirement in specifications as an add/alternate to ensure that it gets priced out in construction estimating bids.

It is important to coordinate with FSC suppliers in advance to ensure availability and secure the best pricing. FSC-certified hardwood is more readily available and cost effective than FSC-certified softwood. The larger the size of the project, the more challenging it will be to secure enough FSC-certified softwood for a wood-framed building. Contractors may bid higher prices for framing with FSC-certified lumber if there are concerns about possible delays in product delivery. To manage costs, work with the framing contractor early in the project to meet FSC-certified wood procurement goals. Also, keep wood costs in check by using efficient framing techniques.

For more information about environmentally preferable wood products, see Structure: D3–Construction Material Efficiencies, D4–Engineered Lumber and D6–Raised Heel Roof Trusses; and Finishes & Furnishings: L1–Environmentally Preferable Flooring.

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Code Considerations

There are no code issues with certified wood.

Considerations for Residents

FSC-certified wood has no direct effect on occupants.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

FSC-certified hardwoods are easier to find and more affordable than FSC-certified softwoods. FSC softwood prices are generally higher than non-certified lumber, while FSC hardwoods are generally about the same price. Expect to pay the following premiums for FSC-certified softwood (based on 2007 market conditions):

- Framing: 5% to 10%
- Panels: 15% to 20%
- Timbers: 5% to 10%

Resources

- **Build It Green Product Directory** has information on sourcing FSC-certified wood: www.BuildItGreen.org/products
- **Forest Certification Resource Center** provides information about forest product certification programs (including FSC) and a searchable database of certified forests and forest products: www.certifiedwood.org
- **Forest Stewardship Council (FSC)** has information about FSC certification and maintains online lists of FSC products and manufacturers: www.fsc.org

Third-Party Certifiers of Wood Products
These independent certification organizations provide chain-of-custody certification services:

- **Rainforest Alliance's SmartWood program:** www.smartwood.org
- **Scientific Certification Systems:** www.scs1.com

Related Case Studies

None

RAISED HEEL ROOF TRUSSES

Specify Trusses with Raised Heels for Better Insulation

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 06 17 53: Shop-Fabricated Wood Trusses

OLD: 06170: Wood Trusses

Recommendation

Where trusses are used for pitched roofs, specify trusses with raised heels to accommodate increased insulation.

Description

For low-rise construction, trusses designed to accommodate increased insulation at the perimeter of the building are called raised heel trusses or energy heel trusses. The heel raises the height of the truss at the exterior-wall top plates so that the full depth of insulation can be installed at the building's perimeter. With conventional trusses, the perimeter intersection of the wall and roof framing often experiences increased heat loss since conventional trusses reduce insulation to less than 6 inches.

Some trusses are made from FSC-certified lumber *(Structure: D5–FSC-Certified Wood for Framing Lumber).*

Benefits

Raised heel trusses save energy and reduce associated greenhouse gas emissions by eliminating the insulation's weak spots along the entire perimeter wall associated with standard truss heels.

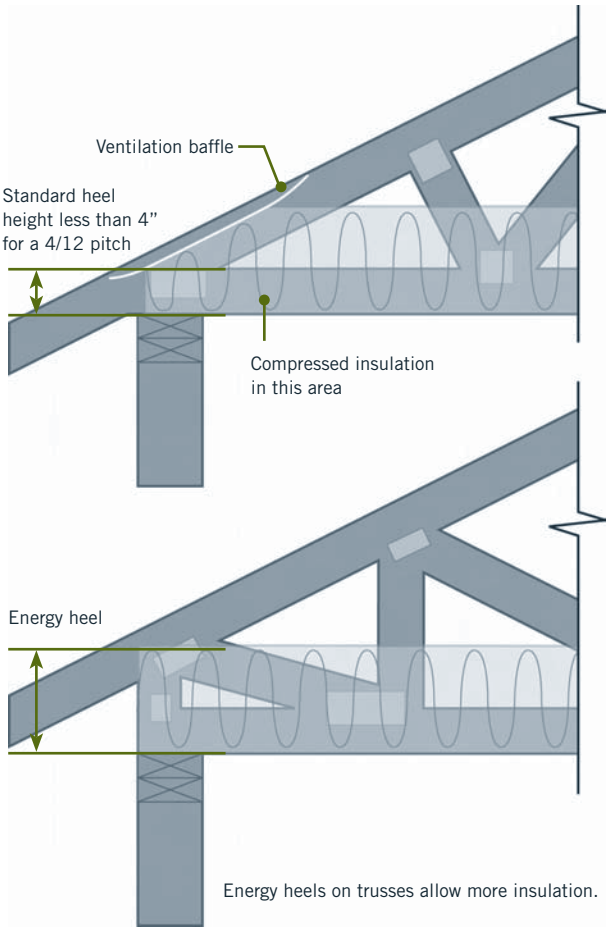
Application

SIZE	√ Low Rise	Mid Rise	High Rise
TYPE	√ New Construction		Retrofit
USE	√ Residential		Commercial

Can be installed where conventional trusses are used. Like any truss, raised heel truss designs need to be specified from the manufacturer. Most applicable to low-rise construction of three stories or less where sloped roofs are common. In most cases, raised heel trusses are not applicable to high rise or flat roof buildings.

Design Details

As shown in the diagram, an energy heel raises the standard roof height several more inches to create room for additional insulation. More material will be used for bracing; also, the increased height may require small modifications to exterior soffit and trim details *(for other recommendations related to energy-efficient framing and insulation, see Structure: D3–Construction Material Efficiencies and F1–Insulation, and Systems: H3–Advanced Ventilation Practices).*



Energy heels on trusses allow more insulation.

Code Considerations

There are no special code considerations for raised heel trusses.

Considerations for Residents

Raised heel trusses make homes more comfortable and reduce energy use because they allow for more attic insulation near the perimeter wall. This results in fewer hot or cold spots around the exterior walls.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Raised heel roof trusses can sometimes be more expensive than traditional roof trusses due to the added bracing material required to ensure a consistent load path from roof to wall. If planned from the beginning of the design development stage, the cost premium can be minimized. Also, because the exterior sheathing wall will have to be extended, additional exterior finishing materials will be needed. While this can add a few hundred dollars to the cost of construction, the occupants will recoup this money over time through reduced energy bills.

Resources

Any truss maker can build raised heel trusses.

» **HGTVPro** provides an educational article and video about raised heel trusses: www.hgtvpro.com/hpro/best_practices

Related Case Studies

» Sara Conner Court Apartments, p. 221

SIPS AND OTHER SOLID WALL SYSTEMS

Use Solid Wall Systems for Walls, Roofs and Floors

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 06 12 00: Structural Panels

OLD: 06120: Structural Panels

Recommendation

Use solid wall systems, such as structural insulated panels (SIPs), for structural exterior walls, roofs and floors in place of frame construction.

Description

SIPs consist of rigid expanded polystyrene foam (such as Styrofoam) sandwiched between two panels of oriented strand board (OSB). They come in nominal 4-inch to 12-inch thickness and have an insulation value range from R-4 to R-7 per inch of foam core.

Insulating concrete forms (ICFs) are another type of solid wall system. ICFs are concrete walls made with foam insulation forms that remain in place as a permanent part of the wall assembly. Their insulation value ranges from R-3 to R-6 per inch, depending on the type of plastic foam used.

There are many other solid wall systems that use various combinations of materials. These products tend to have high insulation values to increase energy efficiency, and good structural qualities. Some are made with recycled or rapidly renewable materials.

Benefits

Compared to frame construction, SIPs, ICFs and other solid wall systems are more energy efficient, offer enhanced structural performance, provide excellent soundproofing and reduce air infiltration. They can be erected quickly, allowing for faster construction. They save wood by eliminating much of the lumber used in conventional framing.

Application

SIZE	√ Low Rise	√ Mid Rise	High Rise
TYPE	√ New Construction		Retrofit
USE	√ Residential		√ Commercial

Use SIPs and other solid wall systems in multifamily buildings as insulated exterior walls, roofs or floors where one would typically use wood-frame construction.

SIPs can be used for up to three stories on wood frame and are not limited for use with steel frame.

Design Details

SIPs are fairly interchangeable with a frame construction design if the decision to use them is made early in the design process. Although SIPs are not new to the construction industry, their use is not widespread so builders may need education on how to build with them. Consider these design details:

- SIP construction results in very airtight buildings. Always provide mechanical ventilation to compensate *(Systems: H3–Advanced Ventilation Practices)*.
- To keep costs down, use a 2x2-foot grid to lay out the major exterior walls, doors and windows *(Structure: D3–Construction Material Efficiencies)*.
- Specify SIPs that come with special foam-sealing channels, or another comparable system, for sealing between panels during erection. This reduces moisture damage to the building exterior *(Structure: E1–Drainage Planes)*. To further seal panels, tape interior panel joints with quality SIP tape.
- Where termites are a problem, use SIPs made with foam and OSB treated to repel insects.
- Predetermine electrical runs so the manufacturer can form chases inside the foam for wire or pipes.
- Do not place plumbing within SIPs.
- During construction, store panels under cover, out of the sun and off the ground to protect them from moisture.
- Install a 15-minute fire barrier (for example, minimum of ½-inch drywall) between the SIPs and living spaces.
- Make sure specifications are exact to avoid waste; SIPs are difficult to recycle.
- Use panel scraps for constructing headers, filler sections above windows and other uses *(Structure: D3–Construction Material Efficiencies)*.

ICFs are either separate panels connected with plastic ties or preformed interlocking blocks. These forms provide a continuous insulation and sound barrier. They also provide a backing for drywall on the inside and exterior siding on the outside.

ICF products differ in the design of their shapes and component parts. ICFs come in block, panel and plank systems. Block systems have the smallest individual units. The block systems are factory-molded with interlocking edges that allow them to fit together. ICFs also come in waffle grid, screen grid and flat wall configurations.

Code Considerations

ICC Evaluation Service, Inc. (ICC-ES), a subsidiary of the International Code Council, tests, evaluates and lists SIPs and ICFs. This information helps building officials with the approval of SIPs, ICFs and other solid wall products.

When using SIPs for residential construction, ensure the manufacturer's product is marked with an "Insignia of Approval" from California's Department of Housing and Community Development. Code officials look for these in the field.

ICFs must meet building codes' standard prescriptive structural design requirements for cast-in-place concrete walls. The plastic foam insulation on the interior surface requires special attention to meet the thermal barrier provisions of Section 2603.4 in the 2007 California Building Code.

For other solid wall systems, contact your local building official.

Considerations for Residents

Solid wall systems reduce energy bills, reduce sound transmission *(Structure: C1–Acoustics)* and improve comfort.

These solid wall systems also have the added benefit of no added formaldehyde *(Structure: D4–Engineered Lumber).*

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

The cost of solid wall systems is more expensive initially than the cost of raw materials for conventional construction. However, SIPs, ICFs and other solid wall systems are already insulated and sheathed. Therefore, in many cases the total installed cost of a solid wall or roofing system is virtually the same as for a stud-frame wall because of shorter construction time and the savings in site labor, material waste and clean-up fees.

Resources

- **Build It Green Product Directory** has information about sourcing solid wall systems: www.BuildItGreen.org/products
- **California Energy Commission** has information about SIPs, including videos about code issues, construction requirements and more: www.energyvideos.com/bld.php?P=CA&A=5&S=sip
- **Insulated Concrete Form Association (ICFA)** is a trade association representing the ICF industry: www.forms.org/index.php
- **Structural Insulated Panel Association (SIPA)** is a trade association representing the SIP industry: www.sips.org; SIPA has specific information on the 2007 inclusion of SIPs into the International Residential Code: http://sips.org/content/index.cfm?pageId=195

Related Case Studies

None

WINDOW REPLACEMENT

Replace Single-Pane Windows with High Performance Dual-Pane Windows

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 08 50 00: Windows, **08 80 00:** Glazing

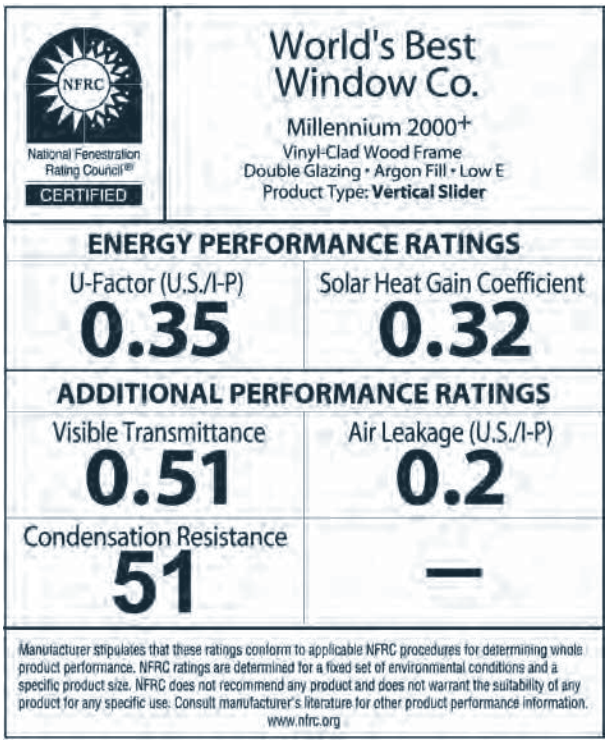
OLD: 08500: Windows, **08800:** Glazing

Recommendation

For retrofit projects, replace single-pane windows with high performance dual-pane windows with appropriate low-emittance (low-e) glazing.

Description

Older multifamily buildings often have single-pane windows that drive up energy costs, make the homes uncomfortable, and allow too much noise in from outside. Although it's expensive to replace windows, the benefits are compelling. Today's high performance windows have specific characteristics that greatly improve energy efficiency, including double glazing, low-conductivity frames, coatings on glazing surfaces that reduce heat gain and loss, tight sealing of the window's components, and low-conductivity gas fills. High performance windows can achieve R-values of 2 or 3 compared to R-1 for standard single-pane windows.



A sample NFRC label found on factory-made windows.

When specifying replacement windows or windows for new construction, it is important to understand the terms below. Also, always look for National Fenestration Rating Council (NFRC) label. This is the best source of energy performance data and is useful for comparing products *(for more about the NRFC label, see Resources).*

» **U-factor** (the inverse of R-value) measures the rate of heat loss by the window assembly (frame, sash and glass) in Btu/hr-ft²-°F. U-factor ratings generally fall between 0.2 and 1.2. The lower the U-factor, the more comfort the window will provide on cold days.

» **Solar heat gain coefficient (SHGC)** measures the fraction of solar heat entering the building through the entire window (measured between 0 and 1). The higher the SHGC, the more solar heat will pass through the product; conversely, the lower the SHGC, the less solar heat will be transmitted. Thus, a lower SHGC will reduce air-conditioning costs and provide more comfort on hot days. The type of low-e coating and the glazing surface on which it is applied largely determines the SHGC.

» **Relative solar heat gain** is the SHGC value of windows, corrected for the wall orientation.

» **Visible transmittance (VT)** is a measure of available daylight that will be transmitted through the product. The higher the VT the more daylight will pass through. For purposes of energy code compliance, VT is only applicable to the calculation of energy savings of automatic daylighting controls on interior lighting.

» **Air tightness** is another important performance consideration. According to Energy Star, a rating of 0.2 cfm/ft (cubic feet per minute of air leakage per linear foot of window edge) or lower is considered good. The best windows have a rating of 0.1 cfm/ft or lower.

WINDOW CHARACTERISTICS

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

» **Insulated glazing system.** Dual-pane windows insulate better than single pane. In most instances (but not all), dual-pane windows are required by California's Building Energy Efficiency Standards (Title 24).

» **Spectrally selective low-e coatings.** Low-emissivity (low-e) glazing has very thin coatings that are relatively transparent to visible light. Originally, low-e coatings were only designed to reduce the loss of heated indoor air (that is, they had a lower U-factor). However, starting around 1995, glass manufacturers began using coatings designed to minimize

transmission of any radiation except that which makes up visible light. These coatings are known as spectrally selective low-e coatings; they both reduce heat loss during the heating season (lower U-factor) and reduce the amount of the sun's heat energy that enters a building (lower SHGC).

Spectrally selective glazing can filter out 40% to 70% of the heat normally transmitted through insulated window glass. When specifying windows, keep in mind that window manufacturers now offer a variety of low-e coatings that allow for high, moderate or low SHGC. The appropriate low-e coating depends on a number of factors, including climate, the window's orientation and whether the building is designed for passive solar heating *(Planning & Design: AA7–Passive Solar Design).*

» **Frame materials.** Low-conductivity frames insulate better. Wood, vinyl, composite and fiberglass all perform better than aluminum. If aluminum frames are selected, then a product with thermal breaks between the interior and exterior panes of glass is strongly recommended.

» **Tight installation.** Sealing around framing and other gaps between the window frame and exterior wall minimizes air leaks. Caulk, foam and weatherstripping ensure a tight installation that will prevent drafts.

» **Gas fill**. Some high performance windows have a low-conductivity gas, usually argon or krypton, encapsulated between the panes of glass. This increases the window's insulation level. However, it's not certain that the gas will remain in the window throughout the window's life expectancy. With the advent of low-e coatings, the benefits of gas-filled windows have somewhat diminished and they are much less common. Don't pay a premium for gas-filled windows unless they are factory-filled and encapsulated to achieve a higher initial percentage of gas to air as well as a better seal to reduce leakage.

Benefits

High performance windows control heat gain and loss and associated HVAC costs, reduce noise levels, improve occupant comfort, increase daylight and views, and reduce furniture fading. In some instances where single-pane windows are old and drafty, installing high performance windows can increase the livable areas of a room.

Insulated windows reduce condensation on windows, which helps prevent water damage and mold growth.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	New Construction		√ Retrofit
USE	√ Residential		√ Commercial

This measure applies to retrofit projects. For new construction, Title 24 requires the use of high performance windows *(Systems: J1–Building Performance Exceeds Title 24).*

Design Details

When designing fenestration for a new multifamily building, critical issues include the building's orientation, window placement and passive solar design opportunities. These are discussed in *Planning and Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation,* as are related considerations that apply to both retrofit and new construction projects, including daylighting and external shading.

For retrofit projects, it may be difficult if not impossible to alter window orientation or introduce passive solar design. Instead, key design considerations for window replacement projects include specifying the appropriate U-factor and SHGC for the building's climate zone *(see Code Considerations),* reducing noise, ensuring quality installation to increase durability, and considering adding external shading devices to south-facing windows.

» **U-factor.** A lower U-factors means less thermal transmission. The general recommendation for California climates is a U-factor less than or equal to 0.40, except the mountainous Climate Zone 16 *(see Code Considerations).* Windows with a U-factor lower than 0.40 currently have a fairly high incremental cost.

The overall U-factor for the window encompasses both the window pane and frame, so choose low-conductivity frame materials. Likewise, be sure to choose windows with nonmetallic spacers to avoid thermal bridging at the edge of the insulating glass unit. For aluminum windows, choose products with thermal breaks to reduce conductive losses.

» **Solar heat gain coefficient (SHGC).** In heating-dominated climates with mild summers (where cooling loads are not significant), low-e coatings with high SHGC will allow greater winter solar gains and result in overall energy savings. In buildings designed for passive solar heating, if low-e coatings with high SHGC are not available, don't use low-e glazing on south-facing windows. In cooling-dominated climates, if overhangs on south-facing windows are impractical, use glazing with low SHGC to reduce unwanted heat gain. *(See Code Considerations for details.)*

- **Noise reduction.** For buildings on noisy streets or in other areas where noise is a problem, consider installing special sound-rated windows that have a stiffer or thicker pane of glass, larger air gaps or better gaskets *(Structure: C1–Acoustics).*
- **Durability.** Poorly detailed windows can allow water to enter the wall cavity, creating conditions for mold to grow. Ensure that windows are properly flashed and sealed *(Structure: E1–Drainage Planes and Durable Siding).*
- **External shading.** On retrofit projects, look for opportunities to add some form of overhang, trellis, landscaping or awning to shade all south-facing windows (within 15-degrees east or west of true south) during summer *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).*

Code Considerations

For either new construction or remodeling, if you are using Title 24's prescriptive method of compliance, check the allowed U-factor and SHGC for the site's climate zone. Maximum allowed west-facing glass is 5% of floor area.

If you are using Title 24's performance method of compliance, a higher amount of glazing is allowed in west-facing walls, but the design needs to compensate elsewhere for the additional energy use. This is accounted for in the simulation software.

As of 2005, Title 24 requires that replacement fenestration products meet the U-factor and SHGC requirements of the Prescriptive Package D. In 2009 that will mean a U-factor of no more than 0.40 and an SHGC of no more than 0.40 except in the high mountains and the north coast down to Santa Cruz, where there is no SHGC requirement.

When replacing windows, verify that all applicable codes are met or updated to meet egress and fire ratings. Sometimes replacement windows create a smaller opening that will impact the minimum and maximum dimensions to meet code. Also, a change in style or operating function of the windows may impact egress and life safety code requirements.

Considerations for Residents

High performance windows typically will reduce energy bills and create a more comfortable home. Special sound-rated windows can reduce noise transmission.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

High performance windows reduce heating energy costs by 27% to 39% and cooling energy costs by 16% to 32%, according to the Efficient Windows Collaborative. For new construction, high performance windows are cost effective. Replacing single-pane windows with more efficient ones is generally not cost effective on the basis of energy savings alone; however, it can be cost effective when pursued in conjunction with wall insulation and rehabilitation to address rot, water damage and other issues. Because windows represent a smaller portion of wall area, replacing them tends to have less impact on overall thermal performance than insulating walls, roofs and floors.

Consider replacing windows before replacing the HVAC system because high performance windows can reduce HVAC loads, allowing the downsizing of the HVAC system *(Systems: H0–Heating Equipment).*

Resources

- **Affordable Housing Energy Efficiency Alliance Handbook** provides Title 24 performance method assistance: www.h-m-g.com/multifamily/aheea/handbook.htm
- **California Energy Commission's** Consumer Energy Center provides basic information on high performance windows: www.consumerenergycenter.org/home/windows/todays_windows.html
- **Efficient Windows Collaborative** provides extensive information about high performance windows, including product and code considerations based on climate zone: www.efficientwindows.org
- **Flex Your Power** provides information about rebates and incentives from California utility companies: www.flexyourpower.org
- **National Fenestration Rating Council** administers a rating and labeling system for the energy performance of windows, doors and skylights: www.nfrc.org

Related Case Studies

- Pepperwood Apartments, p. 121

MEASURE E1

DRAINAGE PLANES AND DURABLE SIDING

Construct an Effective Drainage Plane and Use Durable Siding Materials

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	Climate Protection

NEW: Division 7: Thermal and Moisture Protection

OLD: Division 7: Thermal and Moisture Protection

Recommendation

Design and construct the building envelope to drain moisture away from building elements.

Use long-lasting, noncombustible siding materials.

Description

Install effective drainage planes on all wall surfaces, including around all window and door openings. A definitive drainage plane includes a rain screen assembly or a gap between the siding and exterior sheathing, creating a space that allows moisture to drain away from building elements rather than get trapped in the wall assembly. Wherever there is a break in the drainage plane, such as at windows, doors, joints and other transition areas, install a self-adhesive waterproofing product to help shed water.

Sidings made of metal, stone, brick, stucco and fiber-cement offer a durable and noncombustible building exterior.

Benefits

Drainage planes help prevent water intrusion that can lead to rot, mold and mildew, and may eventually result in structural problems for the building and health problems for occupants.

Durable siding materials can reduce repainting and maintenance, protect the building from fire, and may lower insurance rates, especially in fire-prone areas.

Application

SIZE	√ Low Rise	√ Mid Rise	High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Primarily applicable to low-rise and mid-rise multifamily buildings.

Design Details

It is prudent to have a waterproofing consultant review all flashing, waterproofing, roofing, and door/window sill details. The consulting fees will be a fraction of the cost of remediation if one improperly designed or installed detail allows water infiltration. The construction documents can specify that the contractor will hire a consultant and notify the owner/architect of any details that require additional review. Most contractors are willing to do this, since it can reduce their potential liability for water infiltration problems.

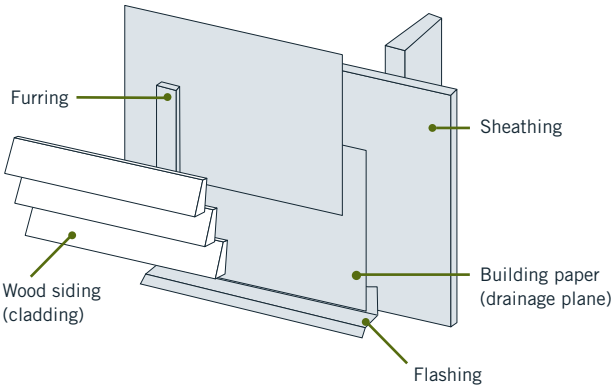
SIDING AND FLASHING

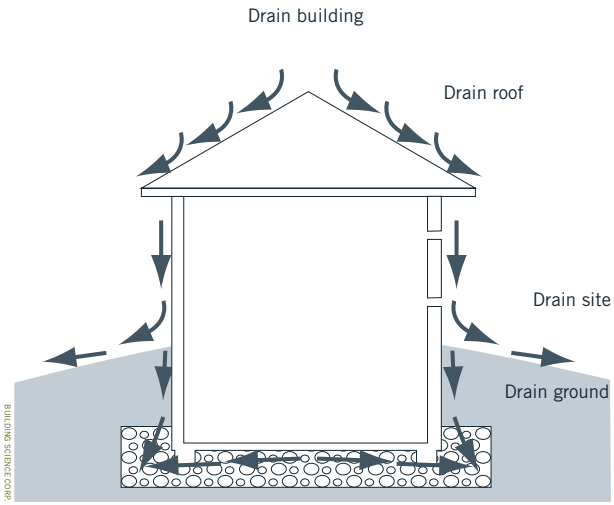
A definitive drainage plane between the siding and the sheathing can be accomplished in a variety of ways depending on the siding type. Typically, oriented strand board (OSB) sheathing is covered with house wrap or building paper; the bottom layer of each piece must overlap the layer below it to help shed water. However, house wrap or building paper is not entirely effective unless it provides a definitive ventilated drainage plane, such as with sturdy corrugated building paper that creates vertical channels between the house wrap and siding, or with a rain screen wall system that physically isolates the siding from the house wrap.

Wrap window and door openings, joints and other transition areas with a self-adhesive waterproofing product. Take special care with windows and doors to ensure that moisture behind the siding runs over the window flashing and drains to the exterior.

ROOF AND EAVES

Extend the eaves at least 2 feet beyond walls to reduce the intrusion of water on the walls, windows, doors, and at the wall-eave intersection. Design roof surfaces with a positive slope and shed water through gutters and downspouts away from the building at grade.

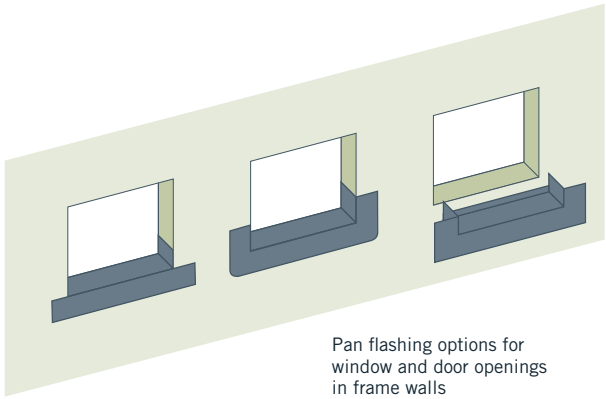




To help prevent rot and mold, design and construct the building so that moisture drains away from building elements.

Related Case Studies

» Sara Conner Court Apartments, p. 221



Pan flashing options for window and door openings in frame walls

Code Considerations

There are no special code considerations for this measure.

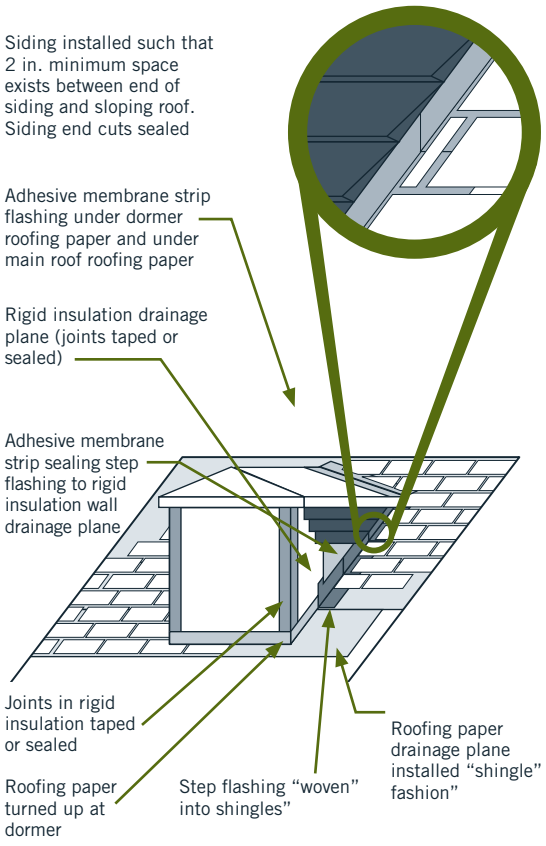
Considerations for Residents

Drainage planes help avoid creating conditions where mold can grow. To avoid costly repairs and potential health problems, instruct occupants to look for early signs of mold or rot, and to immediately report water marks on drywall and plumbing problems.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Most moisture shedding and mold avoidance techniques are low or no cost; they merely require proper detail specifications by the architect and attention to detail by the builder during construction. Proper care during construction is much more cost effective than having to remove roof or wall assemblies to fix moisture problems like mold or rot.



Resources

- **Building Science Corp.** offers detailed articles on moisture and drainage plane issues: www.buildingscience.com
- **Build It Green Product Directory** has information on sourcing drainage plane materials: www.BuildItGreen.org/products
- **Energy and Environmental Building Association** publishes the *Water Management Guide,* a book about minimizing water intrusion into homes. Their website also has articles about water management: www.EEBA.org

MEASURE E2

SUSTAINABLE ROOFING OPTIONS

Use Long-Lasting Roofing Materials That Minimize Heat Gain

KEY BENEFITS

Health/IEQ	√ Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 7: Thermal and Moisture Protection

OLD: 07300: Shingles, Roof Tiles, and Roof Coverings

Recommendation

Specify cool roofs to reduce cooling loads and minimize the heat island effect.

Use radiant barriers.

Specify durable, fire-resistant roofing materials.

Description

The roof generally receives more direct sunlight than any other part of the building. Dark roof surfaces absorb sunlight and reradiate it as heat into the attic and to the surrounding air. This heat gain stresses roof-mounted air handling equipment, warms HVAC ducts in the attic, and shortens the roofing material's life. What's more, it raises outside air temperatures, a phenomenon known as the urban heat island effect *(Site: A5–Cool Site).* Cool roofs and radiant barriers help mitigate roof heat gain.

Another important roofing consideration is longevity; durable roofing products last longer and are more fire resistant than their less durable counterparts.

COOL ROOFS

Cool roofs minimize rooftop temperatures by reflecting a significant portion of the sun's rays away from the roof (high solar reflectance or albedo) and reducing the amount of heat stored by the roofing material (high emittance). It is helpful to understand these two terms:

» **Total solar reflectance or albedo** is the ability of a material to reflect heat away from its surface. Reflectivity is rated on a scale of 0 to 1.0 as compared to a perfect mirror surface. A reflectivity of 0.70, therefore, is 70% as reflective as a mirror. Solar radiation that is not reflected by the roof is absorbed and reradiated as heat.

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Cool roofs have high reflectance and emittance properties.

» **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.

Cool roof products come in many materials and colors. A white roof 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 table on the next page provides total solar reflectance and emittance values for common roof systems.

RADIANT BARRIERS

Radiant barriers are thin reflective materials (usually made of aluminum) used to reduce attic temperatures, reduce heat gain in duct work, and reduce 90% or more of the roof deck's radiant heat. They are generally more effective at reducing summertime attic temperatures and subsequent cooling loads than mitigating wintertime heating loads. To be effective, radiant barriers must be open to air on at least one side.

DURABLE ROOFS

Durable roofing components are able to better withstand the sun's heat and ultraviolet light. There are many options for durable roofing components:

» **Asphalt composition shingles** come in various quality levels, designated by the product's life expectancy. Twenty- to fifty-year shingles are available. Products with forty- to fifty-year ratings are superior because of better backing materials and asphalt coatings.

REFLECTANCE AND EMITTANCE OF VARIOUS ROOFING MATERIALS

	TOTAL SOLAR REFLECTANCE	EMITTANCE
LIQUID-APPLIED REFLECTIVE COATINGS	0.30–0.78	0.42–0.91
METAL ROOFING		
Bare Galv. 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
Gray	0.08–0.12	0.91
Light Gray	0.18–0.22	0.91
White	0.21–0.31	0.91

Source: LBNL Cool Roofing Database, http://eetd.lbl.gov/coolroof

Asphalt does have environmental downsides: it is made with nonrenewable petroleum products, and asphalt shingle recycling is currently not common practice. Asphalt composition shingles are among the most disposed of building materials. However, some manufacturers offer asphalt shingles with recycled content. Rainwater runoff from an asphalt composition shingle roof is not safe to drink and can only be collected for nonpotable uses *(Site: B2–Source Water Efficiency).*

» **Cast-concrete tiles** are fire resistant and can look very similar to fiber-cement roofing. Don't install cast-concrete tiles in cold climates because hail and freeze-thaw cycles can permanently damage them. Cast-concrete tiles require extra structural work to support them as they are heavier than other roof options.

» **Clay tiles** are a popular, durable option in California. Because of their shape, air flows around them, which creates a cooling effect for the building. Clay tile does not work well for solar applications *(Systems: Section I–Renewable Energy)* and is expensive. Hail can shatter clay tile so it is not advised in colder climates.

» **Fiber-cement composite roofing** is made of portland cement, sand, clay and wood fiber. It is durable, fireproof and recyclable. Fiber-cement composite tiles or shakes are not recommended in cold climates or high altitudes because they do not perform well in freeze-thaw or hail-prone environments. Fiber-cement roofing is expensive to replace and cannot be walked on.

» **Liquid-applied product**s are white and 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).

» **Metal** roof choices include copper, steel and aluminum. Metal roofs are fireproof, lightweight and can last much longer than asphalt shingles, but they can cost more than other roofing options. Metal roofs come in varying thicknesses and styles including panels, shingles, shakes and tiles. Choose a lead-free option with recycled content. Most steel roofs can be recycled. Rainwater catchment systems work very well on metal roofs *(Site: B2–Source Water Efficiency).* Snow can easily slide off of metal roofs, which helps prevent damage caused by ice buildup. Also, it is possible to integrate some photovoltaic systems with a standing seam metal roof by either clipping panels directly to the ridges or laying thin film laminates between the ridges *(Systems: I2–Photovoltaic Systems).*

» **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 and moisture barrier. Single-ply membrane materials include 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 may not be the greenest option: they are made from fossil fuels and there is no recycling infrastructure to take back products at the end of their life. Most end up in landfills or are incinerated, which creates a host of

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Durable roofing materials include clay tile (foreground) and cast-concrete tile (background).

environmental toxins. 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.

» **Slate** roofing shingles, which are cut or split from slate, are relatively environmentally benign to produce. Properly installed slate roofs can last over 100 years with only periodic maintenance. Slate comes from the mid-Atlantic and northeastern states and Europe, so for buildings in California, the transportation energy may offset slate's other environmental benefits. Slate roofing can be recovered from older local buildings and reused, thereby reducing transportation impacts.

Avoid cedar and wood-shake shingles for several reasons: fire hazard, short life span, high maintenance, and depletion of forests due to the harvesting of trees.

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

Benefits

Cool roofs reduce the urban heat island effect, reduce the building's cooling load and improve comfort. They may also extend the roof's life; they expand and contract less than dark materials, and therefore don't usually deteriorate as quickly.

Radiant barriers significantly reduce cooling costs.

Fire-resistant roofing materials can save homes from fires, as roofs are typically the first part of a building to ignite. Durable roofing materials reduce waste and decrease replacement costs.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Cool roofs are most applicable to hotter, interior climates of California, especially in urban areas where it is desirable to reduce the heat island effect. Within those regions, cool roofs are applicable to all multifamily housing projects. Cool roofs are not appropriate for areas that have virtually no cooling load.

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.

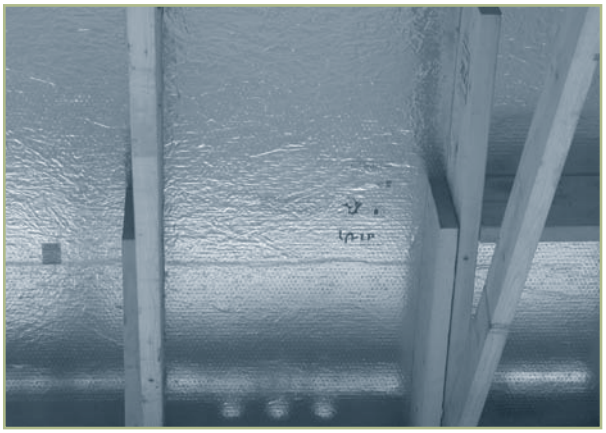
Existing buildings can be retrofit with radiant barriers.

All projects benefit from durable roofs.

If installing photovoltaics on a pitched roof, consider a standing-seam metal roof *(Systems: I2–Photovoltaic Systems).*

Design Details

In the 2005 California Building Energy Efficiency Standards (Title 24), cool roof materials are defined as having a reflectance greater than 0.75 and emittance greater than 0.70. An exception is concrete and clay tile roofing materials, where reflectance must be greater than 0.75 and emittance greater than 0.40. The 2008 update to the Standards will contain more specific criteria; the minimum aged reflectance and emittance required in the Prescriptive Packages will vary by climate zone, roof slope and weight of the roofing material *(see Code Considerations).*



GOTOSTAGOLS

Radiant barrier shealthing is placed in the attic with the foil face toward the interior.

For new construction, consider cool roofs early in schematic design to maximize their benefits. It may be possible to downsize or eliminate the air-conditioning system if the design includes a cool roof combined with other energy-saving features, such as proper building orientation and overhangs *(Planning & Design: AA7–Passive Solar Design),* increased insulation *(Structure: F1–Insulation)* and high performance windows *(Structure: D8–Window Replacement).*

Roof sheathing with a radiant barrier is an integral component of a cool roof system. For retrofit projects that are not reroofing, radiant barriers can be stapled to existing roof sheathing. Install radiant barriers with the foil surface facing down toward the attic. This reduces radiant heat gain to ducts and insulation located below the radiant barrier. Proper flashing details will also help increase the roof and building life *(Structure: E1–Drainage Planes and Durable Siding).*

Code Considerations

Title 24 gives credit for cool roofs, which can help with compliance. Once the 2008 Standards take effect, the current measure of reflectance will be replaced with aged reflectance, and only products with Cool Roof Rating Council (CRRC) certified aged-reflectance ratings will receive credit within the compliance process.

Local jurisdictions may not allow light-colored roofs on sloped sections near roadways due to glare and other visibility concerns. In these areas, use materials with the highest reflectivity and emittance possible under the local code.

Alternative or recycled-content products may or may not meet local fire and other code requirements. Check with local jurisdictions and manufacturers.

Considerations for Residents

Cool roofs save money by reducing cooling loads during summer months. However, they can increase heating loads during winter months. Consequently, they are most useful in high cooling load regions and least useful in regions with high heating loads and low cooling loads.

Radiant barriers also reduce cooling costs.

Durable roofing products reduce maintenance and reroofing costs.

Cost and Cost Effectiveness

COOL ROOFS

BENEFIT	★★★
COST	$$$

For flat roofs with an asphalt cap sheet or modified bitumen, cool roof coatings typically add $0.75 to $2.00 per square foot (2007 costs). The life span of a cool roof coating can range from five to thirty years or more, depending on the material chosen.

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).

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.

RADIANT BARRIERS

Radiant barrier sheathing adds a few cents per square foot, but typically pays for itself in reduced air conditioning costs in a few months.

DURABLE ROOFS

Asphalt shingles are the least expensive roofing material, but have significant disadvantages over more durable and more fire-resistant products. The asphalt products with the lowest lifetime ratings (twenty years) are very inexpensive but their quality can be very poor. Specifying a higher quality, longer life asphalt will reduce installation and replacement costs. Higher quality products have heavy-duty backing, which minimizes tearing and ripping during installation and reduces the risk of product failure during its expected lifetime.

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 attractive. These roofing materials are also more fire resistant than asphalt or wood products.

Fiber-cement roofing is more expensive than shingles, but less than tile.

Prices of alternative and composite roofing materials vary widely, but most are less expensive than tile.

Resources

- **Building Green**, publisher of *Environmental Building News,* has an article, "Roofing Materials" (Jul/Aug 1995), and information about cool roofs and other roofing products (fee to access): www.buildinggreen.com
- **Build It Green Product Directory** has information about sourcing cool roof, radiant barrier and durable roofing products: www.BuildItGreen.org/products
- **California Energy Commission** has information about cool roofs: www.consumerenergycenter.org/coolroof
- **Cool Roof Rating Council** provides rating criteria, testing procedures and certification of cool roofs: www.coolroofs.org
- **Energy Star** maintains a listing of cool roof products: www.energystar.gov (click on "Roof Products" in the Products section)
- **Lawrence Berkeley National Laboratory (LBNL)** maintains a Cool Roofing Materials Database http://eetd.lbl.gov/coolroof
- **Oak Ridge National Laboratory's** Radiation Control Calculator can help estimate the potential savings for cool roofs: www.ornl.gov/roofs+walls (click on "interactive calculators" and run the "radiation control calculator")

Related Case Studies

- Carmen Avenue, p. 230
- Colony Park, p. 227
- Sara Conner Court Apartments, p. 221

MEASURE E3

VEGETATED ROOFS

Install a Vegetated Roof on Low-Slope Roof Areas

KEY BENEFITS

Health/IEQ	√ Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 07 33 00: Natural Roof Coverings, **07 55 63:** Vegetated Protected Membrane

OLD: Division 7: Thermal Moisture and Protection

Recommendation

Consider installing vegetated roofs on a portion of or all low-slope roof areas.

Description

Vegetated roofs, also known as green or living roofs, consist of vegetation planted in an engineered planting medium installed on top of a waterproof roofing membrane. There are three green roof categories: extensive, semi-intensive and intensive.

Extensive Green Roof: The best option for roofs without a high load bearing capacity, or for sites where the green roof will not function as a roof garden. The planting media is commonly 3 to 6 inches deep and the plants are drought-tolerant species.

Semi-Intensive Green Roof: A hybrid of extensive and intensive, and well suited to roofs that can bear the weight of fully saturated planting media at depths of 6 to 12 inches. Common in applications where the roof is visible from surrounding buildings and there is limited roof access.

Intensive Green Roof: Well suited where it is desirable to provide vegetated open space on the roof for building occupants. Soil depths are typically greater than 1 foot to support a larger variety of plant communities, including trees and food gardens.

The table below compares these types of green roofs.

	EXTENSIVE	SEMI-INTENSIVE	INTENSIVE
Maintenance	Low	Periodically	High
Irrigation	No or low	Periodically	Regularly
Plant communities	Mosses, sedums, herbs and grasses	Grasses, herbs, and shrubs	Lawn or perennials, shrubs and trees
System build-up height	2-8 in.	5-10 in.	6–16 in.; >36 in. on underground garages
Weight	13–30 lbs./ sq. ft.	25–40 lbs./ sq. ft.	35–100 lbs./ sq. ft.
Costs	Low	Middle	High
Use	Ecological protection layer	Designed green roof	Park-like garden

Source: International Green Roof Association (IGRA) www.igra-world.com/green-roof-types

Benefits

Green roofs have many benefits, including:

» **Reduced cooling costs.** On a sunny day, black roof surfaces can reach up to 175°F. Vegetated surfaces stay cooler, which helps keep the building interior cooler.

» **Filtration of pollution.** Particulates, hydrocarbons, volatile organic compounds (VOCs), pesticides and heavy metals often contaminate rainwater in urban areas. Green roofs help mitigate this problem because the plants and microorganisms they support filter and break down pollutants, and may also bind heavy metals to soil particles.

» **Reduced stormwater runoff and sewage system loads.** Depending on the depth and moisture level of the soil, the rainfall intensity, and the types of vegetation on the roof, a green roof can reduce runoff by 50% to 60%. Some can absorb a full inch of rainfall during a rain event.

» **Protection of underlying roof material.** Installing other materials over the underlying roof membrane protects it from exposure to ultraviolet light and extreme temperature and weather conditions, which may serve to double or even triple the life of the membrane.

» **Habitat for small animals.** Green roofs provide habitat for birds and other wildlife in urban areas where there may be limited green space.

» **Climate change mitigation.** A green roof's potential for carbon sequestering (removal of carbon dioxide from the atmosphere and storage as organic matter in living and nonliving systems) is fairly low because the soil matrix is thin and total build-up of vegetative matter is modest. However, since green roofs also keep buildings cooler, they reduce the burning of fossil fuels that contribute to global warming.

- **Attractive alternative to traditional roofs.** Some green roofs give people a place to be outside and provide an attractive sight from surrounding buildings.
- **Less noise transfer from the outdoors.** Green roofs provide sound insulation, especially from low frequency noise that standard roof insulation does not block effectively. A little goes a long way; just 5 inches of soil will reduce noise levels by 40 decibels, according to *Environmental Building News.*

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all building types, with low-slope roofs particularly suitable. With retrofit projects, a roof assessment will be necessary to evaluate the existing roof's design, functions, conditions, strength and pitch. Always consult a structural engineer to evaluate structural load issues.

Green roofs can be used in conjunction with photovoltaic or solar thermal systems *(Systems: Section I–Renewable Energy).* Roof areas that are not used for green roofs should be designed as cool roofs *(Site: A5–Cool Site).*

Design Details

Green roofs offer an excellent integrated building design solution because of their many potential benefits. Important attributes to consider early in the design process include:

- Roof slopes
- Structural loading capacity
- Existing roof materials
- Nature of any drainage and waterproofing systems
- Electrical and water supply in place
- Sun and wind exposure
- Who will have access to roof
- Who will do maintenance

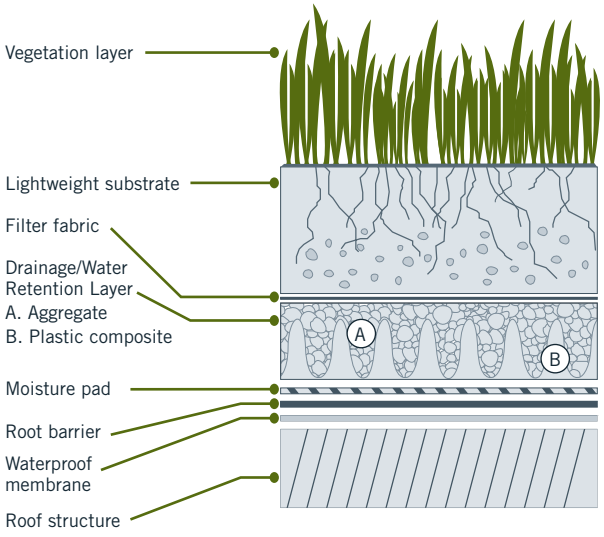
Consult a structural engineer, green roof consultant/landscape architect, and green roof substrate manufacturer before installing a green roof. An integrated roof system can be purchased or components can be specified and purchased separately. The primary components of green roofs are described below.

Roof deck. Most types of roof decks are suitable as bases for a green roofs; steel, concrete, and wood decks are all acceptable. Design the roof to bear the load generated by the type of green roof chosen. Low-slope roofs are ideal for green roofs, because there must be some slope in order to prevent water from pooling. For roof pitches greater than 20%, take stabilization measures to protect the plantings and soil from erosion.

Roof membrane. The waterproofing membrane keeps rain out of the building. Premature failure of a roof membrane is very costly because it usually requires removal of part or all of the green roof system, including soil and plants. Choose a waterproofing membrane with an expected service life of more than 20 years. Roof membranes must be designed to survive water pooling and weather-related expansion or deflection, and must resist root penetration and chemical damage from acid rain or fertilizers.

Green roof membranes can be divided into two groups: liquid-applied asphaltic or bitumen roofing (modified bitumen is most common for green roofs), and single-ply membranes, such as PVC (polyvinyl chloride), EPDM (ethylene propylene diene monomer) rubber, and TPO (thermoplastic olefin). Roots can penetrate asphaltic, bitumen or EPDM rubber roofing, so projects using these membrane types must also use a root barrier. In contrast, most single-ply membranes are root resistant. Avoid using EPDM for green roofs because the adhesives used for sealing seams tend to degrade from the constant presence of moisture, shortening the membrane's lifespan. To prevent leakage problems in the future, plan to flood test installed roof membranes for at least 24 hours before installing other green roof components.

Choice of membrane also affects leak detection. Liquid-applied membranes, because of their fully adhered nature, make leak detection easy because water cannot travel across the deck. With a loose-laid membrane, water can travel beneath the membrane before creating cracks in the roof deck, making it more difficult to

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Green roofs reduce cooling costs and slow stormwater runoff.

determine the location of the source leak. For loose-laid membranes, consider leak-detection systems that detect enhanced electrical current flow resulting from the presence of water.

All green roof membrane manufacturers provide detailed instructions for installing the roof membrane to adhere to their warranty specifications.

Root barrier. To reduce root penetration, especially on bitumen roofing, install a root barrier. Typical root barriers can be a layer of heat-welded PVC, TPO or HDPE (high density polyethylene). If installing loose-laid barriers, overlap the barriers by at least 5 feet to prevent root growth through the barrier gap.

Insulation. Although a green roof adds to the roof's overall R-value, adequate roof insulation is still important. Many green roof experts recommend placing extruded polystyrene (closed-cell) insulation above the waterproofing membrane. This allows the insulation to be salvaged during reroofing. Another option is to install the moisture-permeable insulation on the roof deck, below the roof membrane. Polyisocyanurate or rigid fiberglass may be used in this application.

Drainage/retention layer. To remove excess rainwater and prevent soil saturation, roof drainage is necessary. The drainage layer generally includes one or more layers of geotextile filter fabric to exclude soil and silt. A special aeration layer may be included between the insulation and drainage/retention layer to enable the insulation to dry.

Planting media. To work effectively in the harsh and highly variable environment of a roof, the green roof planting medium generally should be both lightweight and absorbtive; a common mix is 75% lightweight inorganic and 25% organic material. Organic materials can clog the filter fabric and drainage layer as they decompose, so high organic-content potting or planting soil is only used in unique applications such as intensive green roofs over parking garages. Some projects have solved the decomposition issue by using a gel that functions as an artificial soil, but this has not been widely tested.

Plantings. Plants must be able to tolerate the variable weather conditions expected on the roof. Succulents (typically the genus *Sedum*) are recommended for extensive green roofs; with deeper planting media, a variety of plantings may be used. Consider plantings that will not be fire hazards in dry conditions. Whenever possible, use native, non-invasive plant species, but note that more extreme climate conditions on roofs may require plants adapted to harsher climates. Also, design for plant community succession; over time new species will undoubtedly appear on the roof (as they do in all plant communities), so consider the impacts this will have on maintenance.

Modular green roof systems. Some manufacturers offer modular green roof systems. These often consist of interlocking roof trays that arrive fully planted, with all layers above the roof membrane already assembled. Roof trays can be used to create both extensive and intensive green roofs. Modular roof systems allow for a simplified installation process, and because the modules are generally small enough to be brought to the roof by elevator, the cost of a crane is eliminated. When the roof needs to be repaired or reconfigured, modules can be removed temporarily, without significantly disturbing the vegetation. Some experts worry that moisture will linger on the roof surface beneath the planting trays and that some roof membranes may be vulnerable to these conditions; also, moving or dragging the modules could damage older membranes if not done carefully. Where possible, use modules made of organic material to avoid the environmental impacts of manufacturing plastic modules.

Other components. When considering additional roof components, such as lighting, water, fire barrier, and pedestrian features, make sure that these components do not hinder the roof's critical functions.

Seismic concerns. In seismic zones, additional structural engineering may be required to account for the additional weight placed higher in the building structure.

Code Considerations

Check with your local municipality for green roof regulations. Often there are no specific regulations for green roofs other than the standards that apply to ballasted roofs. The recent wildfires in California along the urban/wildland interface may affect how code officials look upon building green roofs in fire-prone areas.

Some trade organizations, such as the National Roofing Contractors Association (NRCA) and ASTM International are in the process of developing guidelines for green roof installations and products. Some green roof products sold in the United States have certification from FLL, a German organization that has developed detailed guidelines for green roof construction; the 2002 edition of FLL's publication, "Guideline for the Planning, Execution and Upkeep of Green-Roof Sites," is available in English *(see Resources).*

Some municipalities are beginning to include density bonuses for green roofs. A density bonus awards a project with an increased building height allowance if the project includes a green roof in its design. Green Roofs for Healthy Cities' policy task force is researching green roof policies in North America.

Considerations for Residents

Green roofs help address the lack of green space in many urban areas, foster pride in the building, and may provide a safe, attractive area where residents can relax outside and socialize with neighbors. Green roofs also lower utility bills and roof maintenance costs.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

According to the U.S. EPA, extensive green roofs in the United States start at about $8 per square foot; intensive green roofs can cost up to $25 per square foot. In comparison, traditional built-up roofs cost as little as $1.25 per square foot, while cool roof membranes cost $1.50 or more per square foot (2007 costs).

Grants may be available for green roofs in the near future; at the moment, many cities are looking into incentive programs, including Chicago; Portland, Oregon; Seattle; Toronto, Canada; areas around Washington, D.C.; New York City; and Atlanta.

Although green roofs cost more than traditional roofs, the summertime energy savings and stormwater benefits can be significant. Installing a green roof may also extend the life of a roof.

While green roofs offer significant energy-saving potential, there are less expensive ways to accomplish similar savings—such as installing reflective roofs *(Site: A5–Cool Site)* and increasing insulation levels *(Structure: F1–Insulation).*

Resources

- ***Environmental Building News*** has an article on green roofs, "Using Roofs for More than Keeping Dry" (Nov. 2001); fee to access: www.buildinggreen.com
- **Greenroofs.com** is a portal offering basic information, a product and service directory, and research links: www.greenroofs.com
- **Green Roofs for Healthy Cities,** a nonprofit industry association, provides general information about green roofs, as well as training, conference and research information: www.greenroofs.org
- **International Green Roof Association (IGRA)** provides information and resources: www.igra-world.com
- **Landscape Research, Development and Construction Society (FLL),** in Germany, has published its comprehensive green roof guidelines in English. To purchase: www.f-l-l.de/english.html
- **Penn State Center for Green Roof Research** demonstrates and promotes green roof research, education and technology transfer in the northeastern United States: http://hortweb.cas.psu.edu/research/greenroofcenter
- **U.S. Environmental Protection Agency** provides information on benefits and costs associated with green roofs: www.epa.gov/hiri/strategies/greenroofs.html
- **Whole Building Design Guide** includes an article, "Extensive Green Roofs," that details the features and benefits of green roofs: www.wbdg.org/resources/greenroofs.php

Related Case Studies

None

MEASURE F1

INSULATION

Use Recycled-Content and/or Low-Emitting Insulation

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 07 21 00: Thermal Insulation

OLD: 07210: Building Insulation

Recommendation

For wall, ceiling and floor insulation, specify insulation that:

» Has at least 75% recycled content;

» Has passed the California Integrated Waste Management Board's Section 01350 air emissions testing protocols; and/or

» Has no added formaldehyde.

Description

Many insulation products are available with environmentally preferable attributes, such as high recycled content or lower emissions of chemicals that may pollute indoor air. In addition to choosing environmentally preferable insulation, choose insulation that will provide high thermal performance for the particular application.

This measure addresses insulation materials. Structure: F2–Quality Installation of Insulation addresses proper installation of insulation.

RECYCLED-CONTENT INSULATION

» **Cellulose insulation** contains more than 75% postconsumer recycled-content newsprint. 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, properly installed cellulose performs better thermally and acoustically than batt insulation. For shared-wall multifamily applications, cellulose can achieve good noise separation and fire ratings.

» **Cotton batt insulation** includes 85% preconsumer recycled content from industrial denim waste. It comes in unfaced batts from 3.5 in. to 8 in. thick and can be layered for additional insulation value. It does not require protective clothing for installation and is very easy to work with.

SECTION 01350–COMPLIANT INSULATION

California Integrated Waste Management Board (CIWMB), along with the Department of Health Services and other state agencies and experts, developed specification language on environmental and public health considerations for state building projects. This specification language is known as Section 01350. A key part of Section 01350 is emissions testing protocols to identify low-emitting materials that will help protect indoor air quality. Manufacturers wishing to meet these specifications can have their products tested by independent laboratories that follow Section 01350's testing protocols. The Section 01350 testing protocols are based on ventilation rates for commercial and institutional facilities, which are higher than the ventilation rates used in residential construction.

Currently all insulation products comply with Section 01350, but look for residential ventilation protocols in the future that may change this.

NO-ADDED FORMALDEHYDE INSULATION

Phenol formaldehyde is used as a binder in conventional fiberglass insulation. The formaldehyde can offgas during and after installation *(Finishes & Furnishings: K6–Reduced Formaldehyde in Interior Finishes).* Fiberglass batt insulation with no added formaldehyde is widely available and can be used anywhere that conventional fiberglass insulation is used. Fiberglass is also available in a loose form that is blown into walls and attics similar to the way cellulose insulation is installed. Loose blown-in fiberglass does not use a binder and therefore does not have added formaldehyde.

Other insulation materials do not contain formaldehyde.

Benefits

Recycled-content insulation keeps useful materials out of the waste stream.

Section 01350-compliant insulation helps protect indoor air quality.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Fiberglass insulation with no added formaldehyde and cotton can be used wherever traditional batt insulation is used, including new construction and major renovation where studs will be exposed. Use cellulose in common walls to reduce noise transmission between units and in exterior walls to improve thermal and acoustic performance. Dry-blown insulation can be used in new and retrofit projects.

Design Details

For installation details, see Structure: F2–Quality Installation of Insulation.

Code Considerations

Fiberglass, cellulose and cotton insulation products all meet Class 1 fire ratings. Foam insulation typically must be covered with a fire barrier such as ½-inch gypsum drywall.

Considerations for Residents

Formaldehyde is classified as a known carcinogen by the State of California's Proposition 65 regulation and by the World Health Organization. Reducing residents' exposure to formaldehyde by installing Section 01350-compliant insulation helps create a healthier home.

Cellulose and cotton batt insulation can be more effective than fiberglass batts at reducing airborne sound transmission as well as noise from plumbing and other sources *(Structure: C1–Acoustics)*.

Cost and Cost Effectiveness

California's energy utilities and local governments offer rebates and tax incentives for installing insulation. These financial incentives change periodically, and tend to cover retrofits *(see the DSIRE database in Resources)*.

BENEFIT ★★☆ COST $$$

No-added formaldehyde fiberglass insulation
No-added formaldehyde fiberglass batts cost the same as standard fiberglass insulation, although there are currently fewer manufacturers. Because fiberglass batts are the industry standard, there is no premium for installation.

Loose blown-in fiberglass has higher installation costs than batt insulation.

BENEFIT ★★★ COST $$$

Cellulose insulation
Materials costs are less than standard fiberglass but installation costs are higher. The installed cost for cellulose insulation can be anywhere from the same to twice that of standard fiberglass batt insulation but similar to blown-in fiberglass. Prices may be somewhat lower for large multifamily projects because of labor efficiencies. When properly staged, cellulose can be installed in less time than traditional batt insulation.

BENEFIT ★★★ COST $$$

Cotton batt insulation
Approximately 50% higher than fiberglass batt insulation in material cost and has similar installation costs.

BENEFIT ★★★ COST $$$

Foam insulation
Spray foam insulation is the most expensive insulation option. The installed cost for spray foam insulation can be anywhere from two to four times more than standard fiberglass batt insulation. As with cellulose, spray insulation can be installed in less time than traditional batt insulation.

Resources

» **Build It Green Product Directory** has information about sourcing recycled-content and low-emitting insulation: www.BuildItGreen.org/products

» **California Integrated Waste Management Board** provides information about Specification Section 01350: http://ciwmb.ca.gov/greenbuilding/specs/section01350

» **Database of State Incentives for Renewables & Efficiency (DSIRE)** provides information about incentives for insulation in California: www.dsireusa.org/library/includes/naima_state.cfm?state=ca

» **U.S. Department of Energy** has information about choosing and installing insulation in the online publication, "A Consumer Guide to Energy Efficiency and Renewable Energy": www.eere.energy.gov/consumer

Related Case Studies

» Pepperwood Apartment, p. 121

» Crossroads, p. 234

MEASURE F2

QUALITY INSTALLATION OF INSULATION

Install Insulation Correctly

KEY BENEFITS	
Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 07 21 00: Thermal Insulation

OLD: 07210: Building Insulation

Recommendation

Properly install building insulation to achieve high thermal performance.

Description

When insulation is installed effectively, it reduces heat flow through building assemblies such as walls, ceilings and floors, improves comfort and reduces heating and cooling energy use and costs. Besides reducing energy use, properly installed insulation reduces the potential for condensation and mold by maintaining an even building temperature.

Insulation's performance is indicated by its R-value; the higher the R-value, the more insulating the material is. The full R-value of insulation can only be achieved with proper installation. If insulation is installed incorrectly—for example if gaps remain or if batt insulation is compressed—the insulation's performance will decrease dramatically.

This measure addresses proper installation techniques. Structure: F1–Insulation addresses the environmentally preferable attributes of different types of insulation.

Benefits

Properly installed insulation reduces a building's energy use and associated greenhouse gas emissions, and helps maintain thermal comfort.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Insulation is typically installed not only in walls and ceilings but also in many other applications, including basement walls, floors above vented crawl spaces, cathedral ceilings, floors over unheated garages or porches, knee walls, and in between certain interior walls for added sound control.

Design Details

Insulation is made from many different kinds of materials (including fiberglass, mineral wool, cellulose, foam and cotton) and takes many different forms (including batts, loose fill, sprayed-in-place and rigid boards). The most common types of insulation for residential buildings are fiberglass and cellulose.

Batt insulation products come in R-values ranging from R-11 to R-38 for fiberglass and R-13 to R-30 for cotton. Fiberglass, cellulose, foam, and rock and slag wool insulation can be blown in an attic to nearly any R-value.

BATT INSULATION

Batt insulation products can be made from fiberglass, cotton, mineral wool or slag. In general, batt insulation does not prevent air flow and heat leakage as effectively as insulation that fills the wall cavity, such as damp-spray cellulose or spray foam insulation. Of particular concern are areas around piping, plumbing, penetrations, and window and door frames, and areas adjacent to studs, top plates and mudsills.

SPRAYED-IN-PLACE INSULATION

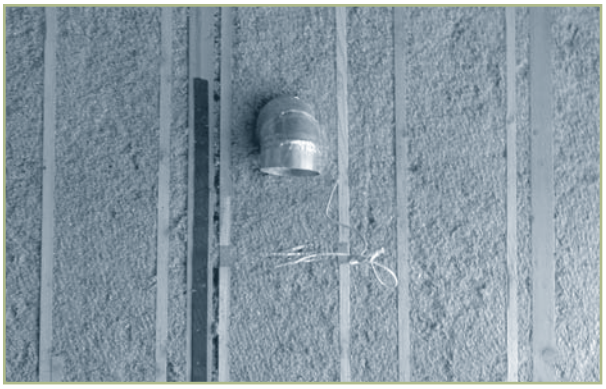
Sprayed-in-place insulation, such as damp-spray cellulose and spray foam insulation, seals all penetrations and self-adheres to the cavity. When effectively installed, it virtually eliminates air leakage through the cavity. Install sprayed-in-place insulation after all plumbing, wiring, penetrations and wall detailing has been completed. If changes are made after the insulation is installed, repair the areas disturbed with like material to ensure a continuous thermal envelope.

RIGID BOARD INSULATION

Rigid insulation is dense foam board used either in full panels or cut to size to fit cavities and odd dimensions. It is generally used in roof, slab-edge or under-slab installations. Cut boards to fit snugly to ensure a continuous thermal envelope; fill gaps with a like material.

LOOSE-FILL INSULATION

Loose-fill insulation, which may be fiberglass, cellulose or mineral wool, is installed in retrofit applications by blowing it into cavities. Because it is loose, it can be disturbed by foot traffic (such as in attics), air movement, or adjacent construction or maintenance work. In retrofit applications it is often difficult to fill the wall cavity completely due to blocking and other obstructions.



Cellulose insulation completely fills voids that would otherwise be difficult to insulate with fiberglass.

However, loose-fill insulation that is properly installed to the recommended density has been shown to have minimal settling over time. Fiberglass is not recommended for use in unprotected, loose applications such as attics because it can become airborne and there is concern about long-term effects of fiberglass inhalation. Use loose-fill cellulose in attics where traffic or disturbances are minimal.

DRY-BLOWN INSULATION

In certain situations, dry-blown cellulose or fiberglass is used to fill wall cavities in new construction. Netting is used to hold the insulation in place. Settling is less of a concern in new construction where obstructions can be seen and filled around and the installation density can be monitored. This method typically increases costs by 10% above damp-spray cellulose due to increased labor for installing netting.

MOISTURE

Exceedingly damp or wet insulation will have a lower R-value, although insulation will retain its original R-value if it can adequately dry out. Sustained moisture after installation will promote mold and mildew growth in the wall cavity and can lead to additional indoor air quality problems.

Pay careful attention to moisture levels when installing damp-spray cellulose insulation because it is more moisture absorbent than fiberglass and rock and slag wool insulation. Avoid installing damp-spray insulation during wet months. Install drywall only after testing the cellulose for moisture content—it should not exceed 25%. Only use cellulose treated with boric acid; avoid ammonium sulfate–treated cellulose insulation because of odor and corrosion issues. If moisture issues during installation are a concern, consider blowing dry cellulose into walls using a netting system.

BATT INSTALLATION TECHNIQUES

Here are installation tips for achieving maximum R-values from batt insulation *(excerpted from the California Energy Commission's Insulation Inspection Checklist; see Resources):*

- **Leave no gaps and fill all cavities.** Use the "six sides test" to check that the batt is connecting on six sides of the stud cavity. Make sure that the batt thickness matches the stud thickness and that cavity spaces around windows and door jambs are filled. Fit the batts snugly around all penetrations. Use proper stapling techniques.
- **Don't compress the batts.** If batts are compressed, their performance will be greatly reduced.
- **Cut batts to fit around obstructions.** Cut it to butt-fit around wiring and plumbing or separate the batt so that one layer can be behind the wiring and one layer in front of the wiring.
- **Pay attention to details.** Insulate external channels, corners, areas around tubs and showers, and attic access; fill small spaces; insulate rim joists and cover top plates; cover lighting fixtures rated as Insulation Contact Air-Tight (ICAT).
- **Leave all venting clear.** Provide a minimum 1-in. clearance around venting.

CELLULOSE INSTALLATION TECHNIQUES

Here are some installation tips for achieving maximum R-values for cellulose insulation:

- Make sure walls, ceilings and floors are properly prepared for cellulose installation. Having to run wire or adjust conduit after the insulation is in place is costly, and reduces the effective R-value if the insulation is not properly restored.
- For ceilings, spread dry cellulose over ceiling joists or blow into tight cavities to increase the ceiling's R-value. It is important to maintain attic or ceiling ventilation pathways, especially in cathedral ceiling applications.
- For dry-blown cellulose in walls, the installer should avoid excessive cellulose behind the netting as it may make it difficult to keep the drywall flat. To help keep the walls and ceilings flat, it is best to use 5/8-in. drywall.
- For dry-blown cellulose in attics, install R-value markers every 8 ft (connected to the trusses) that visually show the depth needed to achieve the desired R-value.

» Install insulation at the proper depth. Count on loose-fill cellulose settling by 20%. Installers should over-blow by these percentages or to the manufacturer's specifications. Cellulose manufacturers are required by federal law to provide the settled thickness on the product packaging.

RETROFIT CONSIDERATIONS

It is very important to update insulation before installing new heating or cooling systems; otherwise the energy efficiencies gained from these new systems will be lost by lack of insulation *(Systems: H0–Heating Equipment and H2–Air Conditioning with Non-HCFC Refrigerants).*

The attic is usually the top priority when retrofitting a multifamily building. Installing attic insulation isn't usually difficult. When blowing insulation into an attic, make sure that the attic ventilation does not get blocked by the insulation as it may prevent air flow and cause the temperature to rise in the attic.

Exterior walls are also important. The best time to conduct a wall insulation retrofit is when drywall is being removed. New insulation can be put in at this time and then sealed with drywall. If drywall is not being removed, loose-fill insulation can be blown in through holes bored in the walls. Take care to seal holes afterward to avoid moisture infiltration.

Code Considerations

California's Building Energy Efficiency Standards (Title 24) require insulation. Although these Guidelines were published before the 2008 Standard were finalized, the draft 2008 update to Title 24 contained these general prescriptive requirements for insulation in framed new construction:

» Floors, raised: R-19 in all climate zones.

» Floors, concrete: R-4 in climate zones 12 and 15; R-8 in climate zones 1, 2, 11, 13, 14 and 16; not required in other climate zones.

» Walls: R-19 in climate zones 11 to 13; R-21 in climate zones 1 and 14 to 16. R-13 is required in all other climate zones.

» Roofs/Ceilings: R-38 in climate zones 1 and 11 to 16. R-30 is required in all other climate zones. In addition, a radiant barrier is required in climate zones 2, 4 and 8 through 15, the climate zones where air conditioning is more common *(Structure: E2–Sustainable Roofing Options).*

Considerations for Residents

Effectively installed insulation increases comfort, decreases sound transmission between rooms and between the inside and outside of the building, reduces utility costs and may increase resale value.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Installing insulation properly takes additional time but saves energy and may increase residents' satisfaction with the building. It is much less expensive to install insulation correctly the first time rather than later retrofitting the building and tearing down walls to improve the insulation quality.

Effective installation of insulation may allow the heating and cooling equipment to be downsized, potentially resulting in considerable cost savings.

Resources

» **California Energy Commission** outlines procedures for proper installation of insulation; download Attachment I-2, the Insulation Inspection Checklist, for a general guideline for installing insulation effectively: www.energy.ca.gov/efficiency/qualityhomes/insulation.html

» **Cellulose Insulation Manufacturers Association (CIMA)** provides information about standard practice for installing cellulose insulation: www.cellulose.org

» **North American Insulation Manufacturers Association (NAIMA),** a trade association of manufacturers of fiberglass, rock wool and slag wool insulation products, has installation information: www.naima.org

Related Case Studies

» Village Walk, p. 151

SYSTEMS

SYSTEMS

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This section addresses three categories of multifamily residential building systems:

» Plumbing fixtures and systems

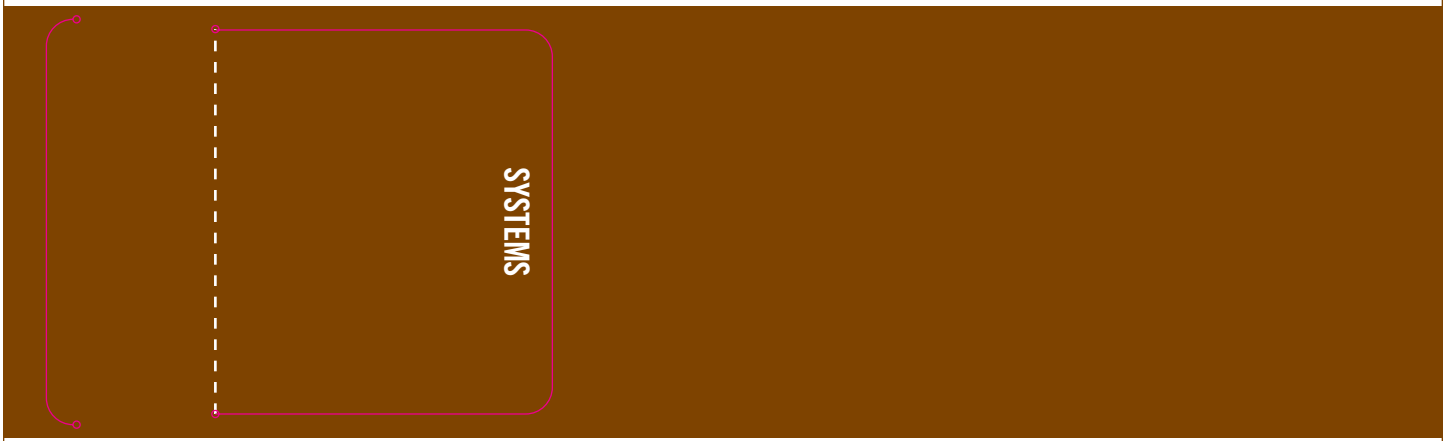
» Heating, ventilation and air conditioning

» Renewable energy systems

This section also addresses overarching performance issues, including designing the building to exceed California's Building Energy Efficiency Standards (Title 24) and testing the building for thermal envelope and HVAC system effectiveness.

The recommended measures in this section provide three main benefits: climate protection, energy efficiency and better indoor environmental quality. Improving energy efficiency and using renewable energy sources are effective ways to reduce the risk of energy supply interruptions, improve outside air quality, reduce the impacts of global warming, and slow the rate at which we need to build new power plants.

For both retrofit projects and new construction, energy efficiency and indoor environmental quality are complementary goals. They save money for building owners and residents year after year and typically increase the residents' satisfaction with their homes. Buildings with high efficiency heating and cooling equipment *(H0, H1, H2)* tend to be more comfortable. Effective duct systems *(J2)* and advanced ventilation practices *(H3)* conserve energy while providing better indoor air quality.



BENEFITS

This table lists the Guidelines' Systems measures and their primary benefits.
(See the individual measures for details.)

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
G1 Water-efficient fixtures				✓				✓
G2 Efficient domestic hot water distribution			✓	✓			✓	✓
G3 Water submetering			✓	✓		✓	✓	✓
G4 Water heater replacement	✓		✓	✓		✓	✓	✓
H0 Heating equipment	✓		✓			✓	✓	✓
H1 Radiant hydronic space heating	✓		✓			✓	✓	✓
H2 Air conditioning with non-HCFC refrigerants			✓		✓	✓		✓
H3 Advanced ventilation practices	✓		✓			✓	✓	✓
H4 Garage ventilation	✓		✓			✓	✓	✓
I1 Solar water heating			✓			✓	✓	✓
I2 Photovoltaic systems			✓			✓	✓	✓
J1 Building performance exceeds Title 24			✓				✓	✓
J2 Building diagnostics	✓		✓			✓	✓	✓

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate thebuilding, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operations and location.

CORE CONCEPTS

INTEGRATED DESIGN

A few of these measures, such as water-efficient fixtures *(G1)* and water heater replacement *(G4),* could be treated as independent strategies that can be added to a project at any stage in its development. But the majority are closely tied to other recommended measures in these Guidelines and should be evaluated as part of an integrated design process. Decisions about the size and type of heating and cooling equipment *(H0, H1, H2),* for example, should be made in conjunction with early decisions that affect the heating and cooling loads, such as building orientation and massing *(AA7),* glazing location and area *(AA7, D8),* wall and roofing thickness, and insulation *(F1).*

Integrated design involves careful planning and evaluation, which may add first costs. To maximize this design-time investment, look for synergies with other green measures, with the goal of reducing costs in some areas to pay for other upgrades. For example, if a building is designed with energy-efficient features such as increased insulation *(F1),* high performance windows *(D8),* air sealing and high efficiency duct systems *(J2),* it may be possible to install smaller, more efficient heating systems *(H0, H1),* and to eliminate or downsize mechanical cooling systems *(H2). (For more about integrated design, see the introduction to these Guidelines.)*

COST

Some of the Systems measures, such as low-flow fixtures *(G1),* offer quick paybacks or cost no more upfront than conventional multifamily housing design. Other measures may increase first costs, either because of added design time or higher equipment costs, but save money in other areas. For example, eliminating or downsizing air-conditioning systems *(H2)* will more than pay for most window and overhang upgrades.

For market-rate and affordable multifamily buildings, incentives are available for environmentally preferable renewable energy systems *(I1, I2)* and for exceeding Title 24 energy efficiency standards *(J1).*

SPECIALIZED EXPERIENCE

To successfully incorporate some of the recommended Systems measures, such as solar water heating and photovoltaic systems *(I1, I2),* it may be necessary to seek designers or subcontractors with specific expertise. Commissioning *(J3),* a quality assurance process that helps ensure the building and its systems perform as intended, is typically carried out by a third-party commissioning coordinator. Certified Home Energy Rating System (HERS) raters can be hired to conduct various tests to measure duct leakage and efficiency *(J2).*

GREEN REHAB HELPS KEEP APARTMENTS AFFORDABLE

Pepperwood Apartments, Rancho Cucamonga, CA

LINC HOUSING

LINC Housing rehabbed Pepperwood Apartments to reduce energy and water consumption.

In 2006, LINC Housing converted Pepperwood Apartments, a 230-unit market-rate complex built in 1984 in Rancho Cucamonga, into affordable housing. LINC took this step to help ensure that local families wouldn't be priced out of their neighborhoods as the region experiences rapid growth. In keeping with their commitment to improving housing affordability and reducing their properties' environmental impacts, LINC rehabilitated all of Pepperwood's units to reduce energy and water consumption.

To improve energy efficiency and comfort, LINC replaced the apartments' single-pane windows with dual-pane windows *(D8).* Weather-stripping was added around exterior doors. No-added formaldehyde fiberglass insulation *(F1)* was blown into the attics to bring the R-value up to at least 19.

Two compact fluorescent light bulbs *(M4)* were installed in each unit, thanks to a rebate from Southern California Edison. Outdoor lighting in the carports and common areas was upgraded to energy-efficient fluorescent fixtures. All the units received new Energy Star–qualified gas-fired water heaters *(G4)* with an energy factor of 0.62. New packaged through-the-wall HVAC units *(H0, H2)* were installed in all the apartments (Energy Star–qualified, 11.0 EER models in the studios, and 12 SEER models in the one-and two-bedroom apartments).

To conserve water, LINC installed low-flow (1.6 gallons per flush) toilets and water-conserving showerheads and faucet aerators in all the bathrooms *(G1).*

To verify the performance of these upgrades, LINC hired a consultant to analyze Pepperwood's electricity and water consumption pre- and post-rehab. The results are very encouraging, even though the initial analysis covered only three months for electricity and two months for water (gas usage data was unavailable).

After adjustments for weather and other variables, electricity savings ranged from 7% for studio apartments to 25% for one- and two-bedroom apartments, with an overall average savings of 21%. For the entire complex of 230 apartments, this translates into an estimated savings of 204,700 kilowatt-hours (kWh) per year. With an electricity rate of $0.15/kWh, the annual savings for Pepperwood's tenants will be nearly $31,400.

Water savings are also impressive: an estimated annual reduction in water consumption of nearly 1.6 million gallons compared to pre-retrofit water use. At the water district's current rates, this is a savings of more than $2,840. Four of Pepperwood's seven buildings showed average apartment water savings of more than 27 gallons per day.

"This was the first time we conducted a measurement and verification analysis on one of our properties," said Brett Mascaro, a LINC project manager. "Although this analysis covered just a few months, now we're looking at doing a year-long analysis at Pepperwood. And this is something we're going to start doing on other properties in our portfolio, especially those with high operating expenses."

For more information, visit www.linchousing.org.

MEASURE G1

WATER-EFFICIENT FIXTURES

Specify Faucets, Showerheads, Toilets, and Urinals That Use Less Water

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 22 40 00: Plumbing Fixtures

OLD: 15410: Plumbing Fixtures

Recommendation

Install water-efficient faucets, showerheads, toilets and urinals that meet these specifications:

» Kitchen faucets: 2.0 gpm

» Pre-rinse spray valves in commercial kitchens: 1.6 gpm

» Bathroom lavatory faucets: 1.5 gpm, WaterSense qualified

» Showerheads: 2.0 gpm

» High efficiency toilets: 1.28 gpf, WaterSense qualified (including dual-flush)

» High efficiency or waterless urinals: .5 gpf

(gpm = gallons per minute gpf = gallons per flush)

Description

As part of any new construction or fixture replacement project, specify high efficiency faucets, showerheads, toilets and urinals. Fixtures that meet the recommended standards are easy to find and competitively priced. *(For information about water-efficient clothes washers and dishwashers, see Finishes & Furnishings: M1–Energy- and Water-Efficient Appliances and M2–Central Laundry.)*

WaterSense is a U.S. Environmental Protection Agency (EPA) labeling program similar to Energy Star except that it addresses water conservation rather than energy conservation. The WaterSense label currently covers toilets and lavatory faucets and in the future will be extended to showerheads and irrigation components.

High efficiency toilets (HETs) reduce flush volumes by no less than 20% compared to conventional ultra-low flow (ULFT) toilets that use 1.6 gallons per flush. Single-flush HETs use 1.28 gallons or less. Dual-flush HETs allow users to choose one of two flushes: they use 0.8 to 1.0 gallons per flush for liquids and 1.6 gallons per flush for solids. In actual operation, dual-flush HETs average about 1.2 to 1.4 gpf. Pressure-assist HETs use a pressurized tank that creates for a more forceful flush with less water. Some of these models can have louder flushes than traditional models.

High efficiency urinals (HEUs) are gaining in popularity. Flushing HEUs use as little as 1 pint of water (0.125 gallons) per flush. They have been well received by building professionals and users throughout the United States. Waterless urinals use a sealant fluid with a lower density than urine, thus allowing urine to drain while preventing odors from escaping. Waterless urinals have been in use in U.S. commercial buildings for over 15 years. Urinals are also being installed in some residences.

Flow limiters are built into the faucet or are installed as after-market fittings. Aerators or laminar flow devices are types of flow limiters.

Flow control valves are installed under the sink at the junction of the angle-stop and faucet, and can limit water flow down to 1.5 to 0.5 gpm per side (hot and cold).

Benefits

Water-efficient fixtures reduce water and sewer costs, reduce demand on water supplies and treatment facilities, and reduce heating energy consumption and associated greenhouse gas emissions.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable in all projects, including residences, common areas and commercial spaces.

For existing buildings, evaluate the cost effectiveness of replacing existing fixtures and fittings with higher efficiency models independent of other retrofit activities. In existing buildings where fixtures and fittings will not be replaced, flow limiters or flow control valves can be installed in all kitchens and bathrooms as a temporary measure until the next replacement occurs.

Design Details

Water-saving fixtures have been around for many years, but many of the first high efficiency toilets were not well designed and performed poorly. Today's high efficiency

fixtures, however, have been completely reengineered and perform as well as or better than standard fixtures.

Faucets. Water flow is reduced by aeration or laminar flow:

» Aeration injects air into the stream of water, displacing much of the water content.

KEMA

Faucets with laminar flow restrict water use.

» Laminar flow uses multiple small diameter parallel streams of water that are not aerated.

Showerheads. Federal law since 1994 mandates that all showerheads sold in the United States use 2.5 gpm or less. Despite this, some showerheads actually use much more than 2.5 gpm, and shower towers that include multiple showerheads or jets can total 12.5 gpm or more. A better option is a good quality low-flow showerhead designed to use 2.0 gpm or less while providing a satisfying shower.

Flow rate is typically reduced by flow restriction or aeration. Aeration with multiple flow settings provides better performance. In retrofit projects, seek affordable showerheads that can maintain a steady flow rate even if water pressure fluctuates.

The thermostatic mixing valve should be tested and rated to function at the flow rate of the selected fixture. Standard thermostatic mixing valves are designed to work at 2.5 gpm. If the thermostatic mixing valve is not properly matched to the flow rate, scalding may occur.

Toilets. To ensure that HETs continue to operate as intended over time, give the building staff information about where to buy replacement parts for particular models. Consider stocking specialty parts onsite for ready access.

Urinals. Waterless urinals eliminate many of the plumbing issues associated with flushing fixtures. However, for most models, sealant traps must be changed approximately every one to three months to prevent odor problems and restore the trap seal. Drain line restrictions due the crystallization of urine salts have been reported in some waterless urinal installations. Also, maintenance staff cannot empty buckets into waterless urinals because it can permanently disrupt the sealant. It is critical to train maintenance staff to address these issues properly.

Code Considerations

There are no code issues with HETs or high efficiency showerheads and faucets. Check with local code authorities regarding use of waterless urinals.

Considerations for Residents

Select fixtures that perform well so as not to reinforce occupants' perceptions that high efficiency fixtures work poorly *(for product information, see Resources).* Minor maintenance will keep faucet aerators from becoming clogged—unscrew the aerator, clean it and screw it back on. Only use original equipment manufacturer (OEM) products when repairing toilets so as not to compromise performance.

High efficiency showerheads help provide warmer showers. The reduced water delivery rate allows the water heater to maintain a more constant temperature.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

High efficiency toilets, urinals, showerheads and faucets are cost effective and pay for themselves within one year in most cases. Water-efficient toilets are a TCAC tax credit item.

Rebates and incentives (most often for retrofit projects) are available for high efficiency fixtures from local municipalities and utility companies.

Resources

» **California Urban Water Conservation Council (CUWCC)** provides a wealth of information on toilets, urinals, showerheads and more, including manufacturer and distributor locations: www.cuwcc.org; CUWCC also provides Maximum Performance (MaP) testing reports of toilets: www.cuwcc.org/maptesting.lasso

» **WaterSense**, a program of the U.S. Environmental Protection Agency, promotes water-efficient products and services: www.epa.gov/watersense

» **Water utilities** often offer incentives and information for high efficiency fixtures. For a list of California water districts, see the UC Berkeley Water Resources Center Archives: www.lib.berkeley.edu/WRCA/district.html

Articles About Waterless Urinals

» ***Cleaning and Maintenance Management*** has an article, "Working with Waterless" (Aug. 2006): www.cmmonline.com/article.asp?IndexID=6636322

» **Texas A&M University's** Fourteenth Symposium on Improving Building Systems in Hot and Humid Climates included a paper, "Waterless Urinals: Features, Benefits, and Applications" (May 2004): www.estesmcclure.com/research/Waterless%20Urinals%20FBA.pdf

» **U.S. Army Corps of Engineers** published "Waterless Urinals: A Technical Evaluation" (Apr. 2006): www.hqda.army.mil/acsim/fd/virlibrary/virtualLibrary/docs/Waterless%20Urinals%20Technical%20Evaluation.pdf

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

» Oxford Plaza, p. 15

» Pepperwood Apartments, p. 121

» Sara Conner Court Apartments, p. 221

EFFICIENT DOMESTIC HOT WATER DISTRIBUTION

Design Water and Energy-Efficient Plumbing Systems

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 22 11 16: Domestic Water Piping

OLD: 15140: Domestic Water Piping

Recommendation

Design efficient plumbing distribution systems to reduce wasted water, energy and materials.

Description

Much of the energy used to heat water for domestic purposes is lost in long runs of large diameter pipes that connect fixtures to distant water heaters. A variety of plumbing design strategies can reduce heat loss, speed the rate of hot water delivery to the user, and most importantly, reduce water wasted down the drain while waiting for hot water to arrive at a plumbing fixture. Multifamily buildings typically have hot water circulation systems to reduce waiting time, but continuous or timed pump operation wastes too much energy; a better option is an on-demand hot water circulation pump.

Benefits

On-demand hot water circulation pumps and efficient plumbing layouts save water and energy, reduce utility bills, and reduce greenhouse gas emissions associated with heating and pumping energy. Efficient plumbing layouts also reduce plumbing material use.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

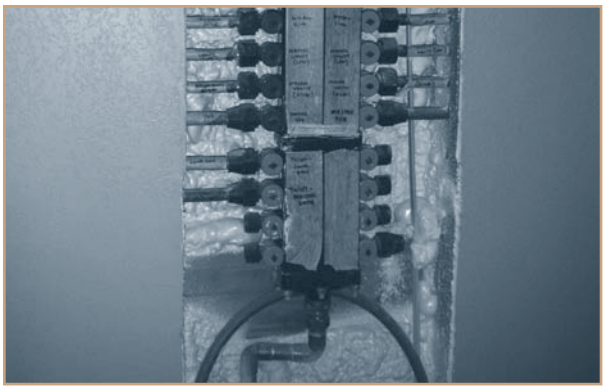
Applies to all multifamily projects.

Design Details

Efficient plumbing design options vary depending on building type, size and configuration. The design team needs to assess these and other factors to determine the right control strategy, loop layout, and number and placement of hot water sources. The following guidelines describe a number of best practices for efficient plumbing distribution systems.

The ultimate gauge of design success is the speed of hot water delivery and the water and energy efficiency of the entire system. An efficient system will not waste more than two to four cups of water at the fixture while waiting for hot water to arrive.

Insulate all hot water pipes. Insulating pipes keeps water in the pipe warm longer, reducing the amount of water wasted down the drain while waiting for hot water to arrive. It also keeps the water warmer during the usage periods, which means less hot water is needed for a given output temperature or the water heater can be set a few degrees lower, reducing storage water heater standby losses. California's Building Energy Efficiency Standards (Title 24) specifically requires the insulation of all ¾ inch or larger pipe from the water heater to the kitchen. Follow Title 24 pipe insulation standards for insulation thickness. A no-cost option for insulating piping run through attics, crawl spaces or walls is to bury them in the insulation.



PRACTICA CONSULTING

Engineered parallel piping can save water and water heating energy compared to typical branched piping.

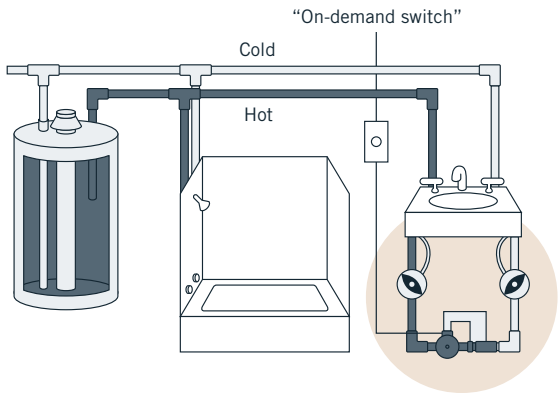
Use engineered parallel piping. Often termed home run, manifold or parallel piping, this alternative to typical branched piping can save water and water heating energy, if the system is well designed. Small diameter flexible pipes are run directly to the fixtures from a manifold (with branched outlets) located near the water heater. This decreases the volume of water in the individual pipe and reduces friction losses and possible leaks imposed by elbows and other fittings.

Parallel piping typically uses cross-linked polyethylene (PEX) pipe, although copper or chlorinated polyvinyl chloride (CPVC) could be used as well. Use PEX only where codes permit it. With low-flow fixtures, 3/8-in. diameter piping should be adequate for sinks; 1/2-in.

piping should be used for other fixtures. Prepare an engineered piping plan that shows the location and diameter of hot water pipes. This ensures that pipe efficiency is actually gained, that lengths are kept to a minimum, and that sufficient flow will be provided.

Use engineered parallel piping with demand-controlled circulation loops. A parallel piping system can still waste some water while waiting for hot water to arrive at the fixture. Each time hot water is pulled from a fixture, the plumbing system must discharge the water in the small pipe from the fixture to the manifold as well as the water in the large diameter pipe that connects the manifold to the water heater. To reduce the water loss in the large pipe, install a circulation loop between the water heater and the manifold that is run by an on-demand pump. This design may allow for installation of the manifold closer to the fixtures or even the use of two or more manifolds, thereby reducing the length of the piping from the manifold to the fixtures.

Use structured plumbing with demand-controlled circulation loops. In buildings with traditional branched piping systems, another way to greatly shorten hot water delivery time is to install an on-demand hot water circulation system. These systems consist of a pump with on-demand controls (push button or motion-sensor activated) that circulates water from the existing hot water line through the cold line or via a dedicated return loop to the water heater. (The term structured, like the term engineered, means that the pipe system is thoughtfully designed from the outset to optimize the circulation system's service capability.) Only one pump is needed to supply hot water to all fixtures in the same circulation loop. All pipes carrying circulated hot water must also be insulated. On-demand hot water circulation works for all systems: storage or tankless water heaters *(Systems: G4–Water Heater Replacement),* and copper, CPVC or PEX pipe.



Demand-controlled circulation loops save water and energy by shortening hot water delivery time.

Use central core plumbing. The most effective means of reducing energy and water loss, as well as material use, is to locate the water heater very close to (such as within 15 feet in plan view) all hot water fixtures, including bathrooms, the kitchen and laundry. This can be accomplished by stacking or clustering rooms that need water, and creating a central plumbing core. This strategy could also apply with multiple plumbing cores.

Code Considerations

All plumbing systems must be installed in accordance with state and local plumbing codes. The strategies in this measure conform with these codes.

Considerations for Residents

Residents will benefit from reduced waiting time for hot water and lower energy costs.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

If efficient plumbing is designed from an early stage, there should be very little if any cost added. In retrofit cases, there will be some increase in cost due to moving systems or re-piping. In some retrofit cases, the most efficient plumbing layout will not be possible considering building programming or structural complications.

Resources

» **California Urban Water Conservation Council** (CUWCC) has a comprehensive collection of articles and research reports on residential hot water distribution: www.cuwcc.org/res_hot_water.lasso

» ***Home Energy*** magazine's 2007 special edition issue, "Water/Energy," includes articles about residential water efficiency: www.homeenergy.org

» **ToolBase Services,** provided by the NAHB Research Center, has information about on-demand recirculation pumps:
www.toolbase.org/Technology-Inventory/Plumbing/hot-water-recirculation

Related Case Studies

» Colony Park, p. 227

WATER SUBMETERING

Install Submetering Devices to Reduce Water Use

KEY BENEFITS			
	Health/IEQ		Material Efficiency
	Site/Community	√	O&M
√	Energy Efficiency	√	Resident Satisfaction
√	Water Efficiency	√	Climate Protection

NEW: 33 10 00: Common Work Results for Water Utilities

OLD: 02500: Utility Services

Recommendation

Install water submeters for individual units to encourage residents to conserve water.

Description

Submeters measure the water consumption of individual units, allowing building owners and managers to accurately allocate water and sewer costs to residents. When residents are responsible for their own water and sewer costs, they are more likely to reduce water use.

Benefits

Submeters help conserve water and save money by increasing awareness of water consumption.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily projects.

Design Details

Submetered buildings generally have a master meter owned by the water utility agency; total usage is billed to the property owner. The property owner installs submeters on tenant spaces, and tenants are billed for their share. Sometimes the building manager may add the water cost to the tenant's rent rather than issue a separate bill.

Another option is to pay a third party to read the meter, bill and collect for the service. Some third-party companies also provide meter installation and maintenance services. Automatic Meter Reading (AMR) systems automatically read meters and produce electronic bills.

Code Considerations

In 2003, the U.S. Environmental Protection Agency changed federal policy to allow owners of multi-unit housing complexes to submeter water without being regulated as a water supplier.

In California, regulations require water submeters to be type approved, sealed and tested before installation, visible to residents and building officials, and installed by registered service technicians. Before installing a submeter, the device has to be submitted to the local Weights and Measures agency, which tests and certifies meters.

Considerations for Residents

Residents have more control over their water and sewer costs; their bills may either go up or down depending on how much water they use.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Research has shown that once master-metered customers are given a price signal in the form of a monthly bill, even if that bill is small, usage decreases. Consequently, although submetering has higher upfront costs than master metering, customers will change water use habits and reduce their water use over time, creating savings.

A study conducted by Industrial Economics Inc. for the National Apartment Association (NAA) and the National Multi Housing Council (NMHC) estimated that submetered properties used between 18% and 39% less water.

Building owners typically pay for submeter installation (during new construction or retrofit) but often indirectly pass this cost on to the residents, just like all other services of a building, via rent costs. However, California law states that residents cannot be charged a startup fee or other ancillary charges associated with a water submetering system and that a building owner is only allowed to charge for water at the same rate that would be applicable if the user received water directly from the local water agency. Some owners may charge tenants a county-regulated service fee for inspection and testing of the meters, which can also help pay for the cost of submeter installation.

Resources

» **American Water Works Association** offers information and articles on submetering: www.awwa.org

» **California Apartment Association** has articles on submetering: www.caanet.org

» **California Urban Water Conservation Council** has articles on submetering: www.cuwcc.org

» **U.S. Environmental Protection Agency** conducted a study of multifamily housing that showed submetering reduced water use by 16.4%: www.aquacraft.com/Projects/submeter.htm

Related Case Studies

» Colony Park, p. 227

WATER HEATER REPLACEMENT

Replace Water Heaters with Energy-Efficient Equipment

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: **22 30 00:** Plumbing Equipment, **22 34 00:** Fuel-fired Domestic Water Heaters, **22 35 00:** Domestic Water Heater Exchangers

OLD: **15480:** Packaged Domestic Water Heaters, **15480:** Domestic Water Heaters

Recommendation

When replacing domestic water heating systems, specify:

» Natural gas storage-tank or tankless models with an energy factor (EF) of at least 0.62, or

» Boilers with an annual fuel utilization efficiency (AFUE) of at least 85%.

» Supplement water heating needs with solar heating systems.

Description

Water heating accounts for a significant portion of energy use in multifamily housing—sometimes many times higher than heating and cooling combined. Reduce energy use by installing high efficiency storage-tank or tankless water heaters or central boilers. The type of water heating equipment required depends on how much hot water is needed, how it will be metered, and several other considerations.

Tankless or instantaneous water heaters can be more efficient than standard storage-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. However, depending on the occupants' hot water usage patterns, tankless water heaters may actually increase both water and energy use. Tankless systems with electric ignition use less energy than systems with a pilot light.

Solar collectors that preheat water for boilers and storage-tank heaters can further reduce energy use *(Systems: I1–Solar Water Heating).* Central boilers are particularly well suited for combining with solar water heating.

Benefits

High efficiency water heating equipment reduces energy use and associated greenhouse gas emissions, improves equipment performance and saves money.

Most high efficiency boilers and storage-tank water heaters have direct venting with sealed combustion, which reduces the risk of backdrafting combustion gasses into the home. Boilers in mechanical rooms benefit from direct venting because often draft hoods or dampers can be eliminated.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Although this measure applies to retrofit projects, much of the information is applicable to new construction.

In retrofit applications, high efficiency central hot water systems make sense in multifamily applications with significant water use *(see Systems: H0–Heating Equipment for information about retrofitting boilers with controls to improve performance).* Individual storage-tank water heaters can be used where independent hot water systems are desired. Tankless heaters are useful in a number of applications, including remote locations like a bathroom or sink located away from the rest of the domestic hot water system. They can also be installed for entire residences to replace storage tank heaters.

In very energy-efficient buildings, tankless heaters can be combined with other equipment to provide hot water for space heating and domestic use. However, most tankless water heaters are not appropriate for radiant heating systems because the small temperature differential between the inlet and outlet often results in inordinate on/off cycling *(Systems: H1–Radiant Hydronic Space Heating).*

PRACTICA CONSULTING

Two high efficiency, Energy Star-qualified boilers for space conditioning and water heating (left and center) and storage-tank water heater (right).

For new construction projects, specify efficient water heating systems through an iterative energy modeling process that evaluates tank sizes, configurations, plumbing line runs, and expected operating and first costs *(Systems: J1–Building Performance Exceeds Title 24).*

Design Details

Building configuration is a key factor in choosing a replacement strategy. For centralized domestic hot water systems, a boiler is often the least expensive option over time in large projects. That's because compared to several small water heaters, there are significant efficiency gains achieved by reducing the total surface area to heat the same amount of water. High efficiency boilers make sense in compact developments where space is limited and distances between the boiler and end-use fixtures are not great. Otherwise, long plumbing runs, even if properly insulated, can negate the benefits of centralized hot water systems.

From a conservation standpoint, a central boiler system without individual meters may not provide the same energy usage feedback to tenants as individual water heaters with individual gas meters. But the loss in user efficiency is often offset by the increased efficiency of a central system.

If each unit has its own water heater, use one of the widely available high efficiency gas storage heaters with at least 0.62 EF. The minimum federal standard, which varies slightly by tank size, is 0.58 for a 50-gallon water heater.

High efficiency equipment may require or allow somewhat different installation than standard efficiency units. Some systems may need a condensate neutralization drain, but do not require expensive Type B vent piping. Central systems that provide hot water to multiple units will require adequate space in equipment rooms.

Heating efficiency, recovery factor, piping design and system usage need to be taken into account when selecting a system. Shorter pipe runs and pipe insulation help reduce energy losses and prevent water being wasted while waiting for the hot water to reach the tap *(Systems: G2–Efficient Domestic Hot Water Distribution).*

Code Considerations

Replacement of water heating equipment, as well as pipe insulation, needs to comply with the plumbing, mechanical and energy sections of the California Building Code.

Considerations for Residents

Residents and owners will benefit from reduced water heating costs. Sealed combustion models help protect indoor air quality.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Water heaters with 0.60 EF are so common that there is no incremental cost for them, and in most locations in California there is little or no incremental cost for 0.61 or 0.62 EF. Water heaters with 0.64 EF will reduce water heating costs roughly 10% compared to a minimally efficient model, and often have a low enough incremental cost that payback is under a year.

For individual dwelling units, it is usually cost prohibitive to purchase condensing water heaters with energy factors as high as 0.82, but this can be considered for projects that have sufficient budget or where low-temperature venting (for example, using PVC pipe) is desirable.

Higher efficiencies on domestic hot water equipment are obtained through better parts and components, which result in longer-lasting products. This is why high efficiency equipment sometimes costs significantly more than the lowest efficiency equipment. The increased cost is recovered through generally lower installation costs, significant energy savings, longer product life and maintenance savings.

With an investment in design and first costs, a combined domestic hot water and space heating system can provide both radiant hydronic heat and potable hot water. Some cost reductions can result from combining systems, such as eliminating ductwork and furnaces.

Boilers can last forty to fifty years while individual water heaters typically last less than fifteen years, which can make a big impact on how a project finances a new construction or retrofit domestic hot water project.

Resources

» **Build It Green Product Directory** has information about sourcing water heating products: www.BuildItGreen.org/products

» **Flex Your Power** has information about water heater and boiler rebates in California: www.flexyourpower.org

» **U.S. Department of Energy's Energy Efficiency and Renewable Energy** (EERE) website provides information about higher efficiency equipment and links to manufacturers: www.eere.energy.gov/buildings

Related Case Studies

» Pepperwood Apartments, p. 121

HEATING EQUIPMENT

Choose High Efficiency Heating Equipment; Add Controls to Existing Boilers

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 23: Heating, Ventilating and Air Conditioning

OLD: Division 15: Mechanical

Recommendation

Select high efficiency heating systems.

In retrofit projects, add controls to boilers to increase boiler performance and occupant comfort.

Description

This measure discusses mechanical space heating equipment only. *(For related measures, see Systems: G2–Efficient Domestic Hot Water Distribution, G4–Water Heater Replacement, H1–Radiant Hydronic Space Heating, H2–Air Conditioning with Non-HCFC Refrigerants and H3–Advanced Ventilation Practices.)*

In retrofit projects, before replacing heating systems, minimize the heating load with insulation, high performance windows and other energy-efficiency measures.

Most multifamily buildings have either:

- Independent, unit-sized furnaces in each dwelling;
- Multi-unit or independent hydronic heating *(Systems: H1–Radiant Hydronic Space Heating);*
- Independent electric baseboard heating;
- Package terminal heat pumps; or
- Electric or gas wall heaters.

To keep construction costs low, many affordable housing projects utilize low-cost wall-mounted or baseboard electric heaters. These are poor choices because electric heating is inefficient and expensive, and many do not meet current requirements of California's Building Energy Efficiency Standards (Title 24).

Compared to heating with electricity, gas heating is more economical and environmentally preferable. Natural gas is combusted directly at the place of use, with minimal distribution losses. Electricity is often transported great distances from where it is generated, becoming less than 40% efficient due to losses during generation and transmission.

High efficiency heating. Manufacturers increase boiler and furnace efficiency by improving components such as a secondary heat exchanger, electric ignition and direct or power venting. These improvements may increase product life and lower installation costs.

A central unit-sized furnace with a programmable setback thermostat is generally more efficient than multiple wall or baseboard heaters with individual controls. A setback thermostat on a central heating system allows residents to turn down the heat in the entire apartment without having to go from room to room adjusting settings on individual heaters.

Natural gas-fueled heating equipment that meets Energy Star criteria has an annual fuel utilization efficiency (AFUE) of at least 90% for furnaces and 85% for boilers *(Systems: G4–Water Heater Replacement).*

Boiler controls. Conventional non-condensing boilers fire at one fuel-burning rate, meaning that they turn on when the thermostat calls for heat, and turn off when the heat is satisfied or when override controls cut the cycle short. The high temperature limit, usually 180°F, is designed to be hot enough to meet demand on the coldest day of the year. Consequently, on most days, maintaining this high water temperature results in off-cycle heat loss.

Boiler controls help overcome this heat loss by estimating changes in heat demand and controlling maximum boiler water temperature, firing time and/or circulating pump cycling and speed. The most common type of boiler control is the outdoor reset control. When outdoor conditions are warm, the control lowers the boiler water temperature to as low as 140°F for non-condensing boilers, and lower for condensing boilers. Other controls, like two-stage thermostats and time-delay relays delay burner firing until all residual heat from the previous firing has been used.

Benefits

High efficiency equipment reduces fuel use, which saves money and decreases greenhouse gas emissions that contribute to global warming.

Furnaces with an AFUE greater than 88% 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.

Installing boiler controls will save energy and result in fewer occupant complaints and maintenance calls.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Adding controls on boilers is only applicable to retrofit projects. For new construction projects, it is more cost effective to select boilers with built-in controls.

Design Details

Specify furnaces and boilers that meet Energy Star requirements. Furnaces with an efficiency greater than 90% AFUE are of the condensing type and may require special condensate acid neutralization in the drain. However, they can generally be vented with much less expensive vent piping.

If a building is designed with energy-efficient features such as passive solar design *(Planning & Design: AA7),* good insulation *(Structure: F1 and F2),* air sealing and high efficiency duct systems *(Systems: H3)* and high performance windows *(Structure: D8),* it may be possible to install smaller, more efficient heating systems.

ALTERNATIVE HEATING SYSTEMS

In some projects, alternative heating systems, such as district heating or geothermal heat pumps, may make sense. Both district and geothermal heating and cooling systems have high first costs and long payback periods, so they should be considered long-term investments.

District heating. Large multifamily projects might consider district heating systems, which distribute heat generated in a centralized location, usually a cogeneration plant. District heating systems pipe heat through either water or steam, and deliver heat to housing units through heat exchangers. Wasted heat from cogeneration can also be used to run condensers for district cooling. If using a district heating system, minimize distances heat or steam must travel to minimize heat loss.

Geothermal heat pumps. Geothermal systems pipe water or refrigerant in a closed loop between the building and a surrounding land mass or body of water. Since the temperature of land and water masses remains relatively constant throughout the year, the heat pump transfers heat from the land or water mass to the building in the winter and transfers heat from the building to the land or water mass in the summer. Note that this type of technology has space implications in that it requires enough property for underground or underwater piping.

Solar water heating. A solar water heater can be combined with the heating system to preheat the boiler feed when domestic water demand is satisfied *(Systems: I1–Solar Water Heating).*

Code Considerations

Prescriptive compliance with Title 24 requires gas heating rather than electric heating for all new construction and new equipment replacements—with the exception of heat pumps. Furnaces must have a minimum AFUE of 78%, while gas-fueled boilers must have a minimum AFUE of 75%.

Under the performance-based compliance method, electric heating is allowed as long as more efficient measures are adopted elsewhere in the project.

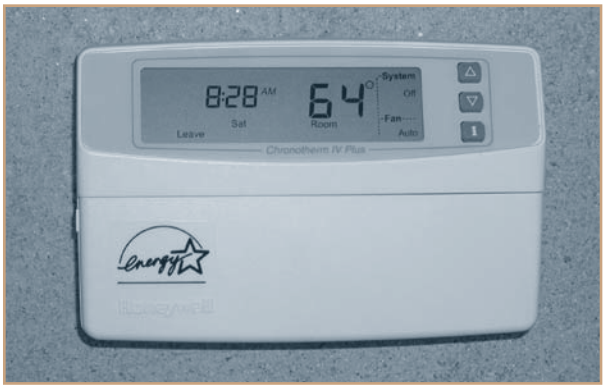
Considerations for Residents

High efficiency gas heating provides residents with greater comfort because the home is evenly heated, reducing cold spots. Furnaces also pose less of a fire hazard than electric wall units. High efficiency gas furnaces cost considerably less to operate than electric or gas wall heaters and may last longer.

Sealed-combustion, direct venting central furnaces reduce the possibility of backdrafting of combustion gasses, a potential health problem.

Programmable thermostats conserve energy by allowing for setback when residents are away or asleep.

KEMA



Choose programmable thermostats that meet Energy Star criteria.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Unit-size furnaces with a 90% AFUE are currently about 30% to 40% more expensive than minimally compliant 78% AFUE units. The payback period is roughly six to seven years.

Upgrading a furnace to a high efficiency model can save as much as $900 over the life of the furnace.

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

For conventional boilers, add-on controls may cost from $150 (time-delay relay) to over $1,000 (reset with automatic post purge), and save up to 12% or more of fuel used (2007 costs). The cost-benefit ratio of boiler controls depends largely on the existing system. The cost of purchasing and installing the necessary controls to achieve high energy savings can vary dramatically and depends on the size, age and type of boiler; plumbing configuration; and burner specification. For this reason, boiler controls have not gained market share although they have been available for at least thirty years.

Although passive measures should generally be considered first, in some cases, note that window replacement can cost more per dwelling unit than replacing HVAC systems.

Resources

- **American Council for an Energy-Efficient Economy (ACEEE)** has information about choosing efficient furnaces and boilers: www.aceee.org/consumerguide/heating.htm; an Emerging Technologies Report covers residential boiler controls: www.aceee.org/emertech/2006_BoilerControls.pdf
- **Build It Green Product Directory** has information about sourcing energy-efficient heating equipment: www.BuildItGreen.org/products
- **Energy Design Resources** publishes reports on energy-efficient HVAC design and technologies: www.energydesignresources.com
- **Energy Star**–qualified gas furnace models are listed at: www.energystar.gov
- **Flex Your Power** has information about California rebates, furnace technology details, and purchasing advice: www.flexyourpower.org/res/naturalgas
- **U.S. Department of Energy's** Energy Efficiency and Renewable Energy website discusses the benefits of higher efficiency furnaces and boilers, and provides links to manufacturers:
  www.eere.energy.gov/buildings/info/multifamily
  www.eere.energy.gov/buildings/info/components/hvac

Related Case Studies

- Pepperwood Apartments, p. 121
- Village Walk, p. 151

MEASURE H1

RADIANT HYDRONIC SPACE HEATING

Use Radiant Hydronic Systems for Comfortable, Efficient Heating

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 23: Heating, Ventilating and Air Conditioning

OLD: Division 15: Mechanical

Recommendation

Combine domestic water heating with a high efficiency radiant hydronic system for space heating.

Description

Radiant heating systems radiate heat from a hot surface instead of blowing warm air from a furnace. Hydronic heating systems use hot water, not electricity, as their heat source. The two types of radiant hydronic systems—in-slab and baseboard—operate at different water temperatures, but can be used in combination or separately with a single boiler or water heater.

Good energy efficiency is achievable because with radiant hydronic heating, people feel comfortable at setpoints 5°F to 10°F lower than with forced air. This is partly a result of heating from the feet upward—an optimal heating pattern for comfort. It's also partly a result of eliminating drafts in heating mode, which tend to cause people to feel chilled and turn up the heat. And it's also because people's sense of thermal comfort has more to do with radiant heat exchange with materials than the temperature of the surrounding air.

In-slab systems. Radiant hydronic floor heating has been popular in the United States for more than fifty years. Early in-slab systems used copper pipes embedded in concrete floors. Modern systems use flexible cross-linked polyethylene (PEX) piping and have much more sophisticated controls that learn how much heat the concrete stores, and therefore when to turn on and off to maintain a setpoint with a minimum use of energy. Leaks are also much less likely to appear in modern systems, and if they do occur, they are easier to repair than in earlier systems.

Baseboard systems. These pump hot water through radiators located in different areas or zones throughout the living area. Baseboard systems have not changed much in the last fifty years, although they too are now plumbed with PEX tubing and have better controls.

Benefits

Radiant heat feels good because it heats objects, not air. In a tightly built home, radiation warms the occupants and the surfaces surrounding them. Comfort is achieved at a lower temperature setpoint than with forced-air heating, saving energy. In-floor radiant heating also has an aesthetic advantage because grilles and registers aren't needed.

In buildings that don't need central air conditioning, a large advantage of radiant hydronic heating systems is the elimination of all ducts and fan units. The related components (pipes and pumps) take up no interior space, making architectural design simpler and potentially reducing deck-to-deck height needs. Combined hot water/space-heating systems have the greatest potential for economic savings, especially when high efficiency and long-life equipment are selected.

Radiant heating also improves indoor air quality. These systems have no ducts that can collect dust and other particulates and then blow them into the living area. Radiant hydronic heating systems are generally much quieter than forced-air systems.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		Commercial

Radiant hydronic heating with a central heat source (such as a boiler or water heater) is most appropriate for buildings with a shared gas meter.

Design Details

COMMON INSTALLATIONS FOR HYDRONIC HEAT

» **Slab-on-grade.** PEX tubing is tied to the rebar inside the foundation slab. Slabs-on-grade should have 2 inches or more of extruded polystyrene perimeter insulation to control heat loss to the ground.

» **Thin-slab.** PEX tubing is stapled to the subfloor before the thin slab is poured on top. This is generally used on above-grade floors with gypsum concrete. Rigid foam PEX guides can be laid on top of the plywood subfloor to hold the PEX in place prior to the pour.

» **Baseboard.** PEX tubing is plumbed through walls, ceilings or floors to reach the baseboard radiators.

ZONING AND CONTROLLERS

Although complex zoning is easily accomplished with radiant hydronic systems, it is rarely needed in multifamily housing. Generally, one or at most two zones per unit are adequate. A two-zoned system between living and sleeping areas will provide greater control and more precise heating regimes. For two-zone design considerations, see the *Residential Compliance Manual* for California's 2005 Building Energy Efficiency Standards *(www.energy.ca.gov/title24/2005standards/residential_manual.html, Section 4.5.2 Zonal Control).*

New controllers are available with smart chips that learn occupant heating patterns to optimize efficiency. New controllers can also account for thermal lag, which is the time it takes a slab floor to heat up and reach a room's desired temperature. This lag time can be lengthy, so an intelligent controller can effectively wake up a home to the correct temperature, or shut down so that the rooms are not overheated during sleeping hours.

In certain applications, especially in colder climates, a recirculating pump may be added to the system to eliminate the lag time and to keep the floors at a constant baseline temperature. To mitigate the increased heat losses that circulation systems cause, insulate piping to higher levels than required by code *(Systems: G2–Efficient Domestic Hot Water Distribution)*.

HOT WATER SYSTEMS

In-slab systems use water heated to 120°F or less while baseboard systems use 130°F to 160°F water. Water is provided at these temperatures by central boilers or high efficiency water heaters. The relatively low water temperatures needed for in-slab heating makes it a good match for solar hot water systems *(Systems: I1).*

Some hydronic systems use hot water from small residential water heaters to heat fan coils in a forced-air system. Unless they have a modulating gas valve, on-demand water heaters *(Systems: G4–Water Heater Replacement)* are not recommended for radiant heating systems. The low delta between inlet and outlet temperatures makes them inefficient; most will constantly cycle in this application.

Boilers used to feed radiant hydronic systems can be very small—generally less than one-half the size of the water heaters they replace. For combined space and water heating systems, select a high recovery rate on the heating unit.

Radiant heating systems are ideal for use in conjunction with condensing boilers. The relatively low return temperatures can be sent directly to a condensing boiler, simplifying the system and enabling higher efficiencies.

Some systems can use a water heater for both space heating and domestic hot water. These combined systems are an option for very well sealed and well insulated homes or for mild climates. According to Lawrence Berkeley National Laboratory, this type of system will work if you need less than 75,000 Btu/h of heating capacity.

TUBING

In-slab systems embed piping inside the concrete with wire to minimize cracking. Always specify PEX tubing, which has fewer joints and is stronger, more flexible, and cheaper to install than metal tubing. Since PEX is available in rolls up to 1,000 feet, all joints can be made outside the slab. Space PEX tubes between 6 and 12 inches apart (or use the manufactured spacing guides). With wood floors, space the tubes at the lower end of this range to allow for even expansion and contraction.

Wall panels can also be configured for hydronic heating, and metal-fin systems are available to expand the radiant surface area within a wall or floor.

LIGHT ENERGY SYSTEMS

Radiant heating PEX tubing is installed prior to lightweight concrete being poured in this suspended floor application.

MULTISTORY BUILDINGS

For multistory installations, use baseboard heaters in upper floors to avoid added structural requirements for thin-slab floors. Another option is to use engineered wood products that have a radiant barrier face with embedded tubing. Flooring is installed over this substrate. PEX tubing can be installed on structural steel pan-decking prior to pouring thin slab floors.

COMMISSIONING

It is very important to commission the system thoroughly—from planning and design through occupancy *(Structure: C3–Commissioning).* Include thermal comfort questions in post-construction occupant interviews.

Code Considerations

Systems are available that meet all local codes and regulations. Tubing can be either metal or an approved plastic, such as PEX.

A supplemental ventilation system must be used to meet minimum air change requirements if no forced-air equipment is installed *(Systems: H3–Advanced Ventilation Practices).*

Considerations for Residents

Radiant heating is better for indoor air quality than forced-air heating as long as adequate outside air is provided. People with allergies often prefer radiant systems because they do not stir up dust, pollen, pet dander and other indoor air contaminants. Also, radiant heat is quieter: there is no noise from rattling ducts and grilles. Radiant heating can provide uniform, controlled heating that eliminates cold spots.

People new to radiant heating are often initially uncomfortably warm because they set the thermostat at 70°F to 72°F. But most people will be comfortable with the radiant system set at 60°F to 65°F. Energy savings are possible when occupants are educated about setting their thermostats lower.

A tightly sealed house (such as one built to Energy Star standards) without forced air needs supplemental ventilation to provide outside air. When exhaust fans are running, low infiltration rates could cause unwanted negative pressure in the residence, leading to backdrafting of gas-fired appliances and other sources of indoor air contaminants.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

High efficiency radiant hydronic heating systems cost less to operate than gas-fired furnaces, and much less than electric heat. Adding solar water heating can further reduce operating costs. First costs may be higher than furnaces, however, making these systems most cost effective when combining space and domestic water heating systems to eliminate a mechanical air distribution system.

In spaces with vaulted ceilings, radiant hydronic heating can save money because the area above the occupants can remain unconditioned while the occupied zone remains comfortable. This eliminates the energy needed to heat the whole space.

In-slab systems can cost from $5 to $15 per square foot to install, depending on complexity. Baseboard heaters range from $15 to $25 per linear foot installed. PEX tubing costs about $0.50 per foot (2007 costs).

Boilers used to supply hot water are a good investment because they provide long-term cost savings. They add considerable first cost over storage tank water heaters, but have long warranties. Some boilers last fifty years or more. Generally speaking, there is a direct relationship between the cost and quality of the boiler and its lifetime maintenance costs.

Central hot water is generally more efficient, but when individual systems are required for individual dwelling units, high efficiency tank-type water heaters (0.64 or higher Energy Factor) are often the most cost-effective choice *(Systems: G4–Water Heater Replacement).*

A cost-reducing measure in multistory developments could be to supply in-slab radiant heating on the ground floor and baseboard heaters upstairs.

Resources

» **Build It Green Product Directory** has information about sourcing radiant hydronic heating products: www.BuildItGreen.org/products

» ***Environmental Building News*** has an article, "Radiant-Floor Heating: When It Does—and Doesn't—Make Sense," (Jan. 2002); fee to access: www.buildinggreen.com

» **U.S. Department of Energy, Energy Efficiency and Renewable Energy** has information about radiant floor heating: www.eere.energy.gov/buildings

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

» Oxford Plaza, p. 15

» Sara Conner Court Apartments, p. 221

AIR CONDITIONING WITH NON-HCFC REFRIGERANTS

Specify High Efficiency A/C

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 23 70 00: Central HVAC Equipment

OLD: 15700: Heating, Ventilating and Air Conditioning

Recommendation

Install 14 SEER/11 EER or higher air conditioning with a thermostatic expansion valve (TXV).

Stay a step ahead of refrigerant phaseouts by specifying non-HCFC–based refrigerants.

Monitor refrigerant levels using an EPA-certified service company.

Description

Compressor-based air conditioning has two important environmental impacts:

» Energy consumption

» Potential ozone depletion from leaking refrigerants

Energy Consumption

All unitary air conditioners have an energy efficiency ratio (EER), which reports steady-state efficiency at 95°F outdoor and 80°F indoor temperature. Seasonal energy efficiency ratio (SEER) is also used for rating smaller air conditioners (< 65,000 Btuh). SEER was developed by the U.S. Department of Energy to better indicate average seasonal performance. Although SEER is a good determinant of energy use in hot humid climates, it is not a very good indicator of energy use in hot dry climates such as California. In California, rather than focusing on SEER, it is more important to look for higher EER values.

The higher the EER, the less energy is used to provide comfort. The SEER should be listed on the product, but the EER may need to be obtained from the manufacturer.

Central air-conditioning systems are either split systems or package units. In a split system, the evaporator fan and coil are an indoor unit and the compressor/condenser are a separate outdoor unit. The two components are connected by a refrigerant line. A package unit combines all the components into one outdoor unit.

A thermostatic expansion valve (TXV) is a refrigerant regulation device that helps the air conditioner operate at maximum efficiency over a wide range of conditions. The TXV regulates the flow of refrigerant to the indoor evaporator coil of a central air conditioner in response to changing conditions. In hot weather when cooling demands are high TXVs open wide to allow more refrigerant through; conversely, they reduce the flow of refrigerant when cooling loads are lower.

REFRIGERANTS

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. Some are better than others in terms of ozone-depleting potential (ODP) and global warming potential (GWP) ratings, but 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 byproduct 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. It will be allowed for repairs until 2030.

Some products on the market use an advanced refrigerant called R-410A, which is a blend of hydrofluorocarbons (HFCs) that do not contribute to ozone depletion, but do have some GWP. Other advanced refrigerants include HFC-134A and HFC-407C.

Benefits

Air conditioners with a high EER and a TXV reduce energy use, which saves money and decreases greenhouse gas emissions that contribute to global warming. High efficiency units are usually top-of-the-line products with better motors and components than standard equipment, and should therefore last longer.

Right-sized air conditioners provide greater comfort, are less noisy and last longer than oversized units.

Environmentally preferable refrigerants have less of an effect on ozone depletion and global warming.

Evaporative Cooling

With California's dry climate, evaporative cooling can be a superior alternative to refrigerant-based air conditioning. Sometimes called swamp coolers, evaporative coolers work by pulling fresh outside air through media dampened with water, cooling the air through evaporation. Warm dry air has a low wet-bulb temperature, which enables evaporative coolers to significantly lower air temperature without the use of refrigerants. These systems use significantly less energy than a refrigeration system.

Recent improvements in the technology have reduced the amount to humidity released into the interior space. Called indirect-direct evaporative coolers (IDECs) or two-way evaporative coolers, these systems precool outside air before passing it through the evaporative media to reduce the amount of humidity added to the air. They produce cool air with a relative humidity between 50% and 70%, depending on the climate, compared to a traditional system that produces about 80% relative humidity air.

Evaporative cooler sizing is based on the fan's ability to circulate cool air throughout the conditioned space. To approximate the system's size, divide total square feet by two (assuming 8-foot ceilings). Work with a manufacturer representative or mechanical engineer to properly size your system. A list of manufacturers is available from the Evaporative Cooling Institute *(see Resources).*

When sized correctly in the right climate, two-stage evaporative coolers can reduce energy consumption by 60% to 75% over conventional air-conditioning systems. Where indoor air quality is a concern, another benefit of IDECs is that they use 100% outdoor air.

Evaporative coolers use a lot of water, which has environmental and economic costs. Testing by Davis Energy Group on an advanced IDEC found that total water consumption averaged between 30 and 55 gallons a day (assuming 5 hours of run time), depending on the speed of the motor. When opting for an evaporative cooler, look for ways to reduce water use elsewhere in the project.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily buildings that have air conditioning.

Design Details

Choose air conditioners with a SEER of 14 to 21 and an EER of 11 or greater. These units are installed like any other air-conditioning equipment. Look for Energy Star–qualified products to ensure high efficiency.

Some air conditioners come with a factory-installed TXV; others accept a TXV as installer-supplied equipment.

SYSTEM SIZING

Many of the advantages of high efficiency air conditioners will be lost if the system is oversized, a common problem in residential buildings. Larger, more powerful equipment is often installed to ensure performance goals are met even with leaky, poorly designed ductwork. Also, air conditioners are notorious for performing at less-than-published efficiencies out-of-the-box. New air conditioners must be tested and balanced properly to ensure good working order.

If a building is designed with energy-efficient features such as good insulation *(Structure: F1 and F2)*, high performance windows *(Structure: D8),* air sealing and high efficiency duct systems *(Systems: H3)*, a right-sized air conditioner will provide better comfort and performance. A right-sized unit cycles on/off less than an oversized system, thus operating at a higher efficiency, and provides more uniform and consistent performance. Oversized units are loud, create cold zones and stress the equipment more than a properly sized unit.

Adequate airflow rates are also important for air handlers, especially in California's dry climates. Low airflow rates can lead to ice buildup on the cooling coil and to compressor failure. At higher altitudes, this is even more of an issue due to the thinner air, and fans should be somewhat oversized to ensure an adequate amount of heat is transferred into the coils.

Careful ductwork sealing, insulation, sizing and placement significantly increases the efficiency of cooled air delivery *(Systems: J2–Building Diagnostics).*

REFRIGERANT HANDLING AND CHARGING

Use advanced refrigerants like R-410A to stay a step ahead of the R-22 phaseout in 2010. This will make maintenance less expensive over the equipment's life.

CFC-free refrigerants such as R410A don't deplete the stratospheric ozone layer.

Take care with refrigerant handling. Always select a reputable dealer employing service technicians who are EPA-certified to handle refrigerants.

Field studies suggest that approximately 75% of installed cooling equipment may have an incorrect amount of refrigerant, which can lead to inefficient operation and even premature failure. Regularly check refrigerant levels to optimize energy efficiency and prevent premature component failure. There are three methods to verify the correct refrigerant level as recommended by equipment manufacturers: super-heat, sub-cooling or weighing. Ask your contractor or building maintenance staff how often they verify the refrigerant level is correct.

Code Considerations

When conducting energy modeling to comply with California's Building Energy Efficiency Standards (Title 24), claiming an EER of greater than 11 activates the High EER HERS credit, which requires field verification. Claiming a higher than minimum SEER has no impact on modeled energy performance.

Considerations for Residents

Correctly sized high efficiency air conditioners reduce energy costs, improve comfort and produce less noise. Environmentally preferable refrigerants have no direct effect on occupants.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

High efficiency central air conditioners typically cost more than standard units because they have better components. Payback can be short in hotter climates where air-conditioning loads are substantial. Most manufacturers reserve the advanced refrigerants for their higher efficiency models.

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

California utilities offer rebates for high efficiency air conditioners. This incentive may cover the cost of upgrading to a higher efficiency and can help offset design costs.

TXVs are particularly cost effective, especially when they are factory installed for new construction. Most higher efficiency models come with TXVs factory installed.

Refrigerant charge testing can also save money. An incorrect refrigerant level can lower efficiency by 5% to 20% and may eventually cause premature component failure resulting in costly repairs that could otherwise be prevented.

Air conditioners with the advanced R-410A refrigerant cost somewhat more than those with conventional refrigerants; however, R-410A is not harmful to the ozone layer. While systems with advanced refrigerants cost more, the price of servicing the older units is expected to rise due to the R-22 phaseout.

Resources

» **Consortium for Energy Efficiency** has information on energy-efficient air conditioners for multifamily buildings: www.cee1.org

» **Energy Star** has information about sizing, installing and maintaining air-conditioning equipment: www.energystar.gov

» **Evaporative Cooling Institute** has a member directory of evaporative cooling manufacturers and consultants: www.evapcooling.org/members.htm

» **Southern California Edison** published a white paper in 2003, "EER/SEER As Indicators of Cooling Efficiency": www.energy.ca.gov/title24/2005standards/archive/documents/measures/01/1_2002-03_SCE-ANDER.PDF

» **U.S. Environmental Protection Agency** has information on ozone depletion from refrigerants: www.epa.gov/ozone/snap

» **ToolBase Services,** provided by the NAHB Research Center, has information about high efficiency air conditioning: www.toolbase.org

Related Case Studies

» Pepperwood Apartments, p. 121

MEASURE H3

ADVANCED VENTILATION PRACTICES

Strategies for Reduced Air Infiltration and Natural and Mechanical Ventilation

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: **23 34 00:** HVAC Fans, **23 72 00:** Air-to-Air Energy Recovery Equipment

OLD: **15785:** Air-to-Air Energy Recovery Equipment, **15830:** Fans

Recommendation

Provide operable windows and skylights for natural ventilation.

Install Energy Star–qualified ceiling fans in all bedrooms and living rooms.

Install effective exhaust systems in bathrooms and kitchens.

Build residences that are tightly sealed to increase energy efficiency. Use heat recovery ventilators and energy recovery ventilators in conjunction with outside air intake to save energy and balance pressure differences. Have a HERS rater conduct infiltration testing, duct testing, and sealing if needed.

Description

Today's residential buildings are constructed more tightly than in the past. But air leakage still accounts for up to 25% of the heating and cooling energy used by a typical residence. Reducing air leaks saves energy, although tighter construction does affect ventilation and may necessitate ventilation systems to provide adequate air changes.

Tighter construction and imbalanced forced-air HVAC systems can cause significant differences in pressure from outside to inside. Temperature and wind on the outside constantly change the ambient pressure, causing drafts and leaks. Residents may notice doors slamming shut behind them or air being pulled under doorways. In unusual cases, these pressure differences can cause backdrafting, a potentially life-threatening condition where fumes from gas combustion appliances are sucked back inside the home rather than being exhausted outside. Mechanical ventilation systems help address these conditions.

Ventilation is especially important in bathrooms and kitchens, not just to exhaust odors but to remove moisture that can cause mold and other problems. Appropriate kitchen ventilation also helps remove carbon monoxide, nitrogen dioxide and other pollutants produced by gas cooking appliances, as well as particulates produced by cooking food.

Benefits

Sealing air leaks improves energy efficiency and acoustical performance. Ventilation (natural or mechanical) improves indoor air quality. Efficient bathroom and kitchen exhaust systems reduce energy use compared to standard models, are quieter, and reduce moisture and indoor air quality problems.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all new construction and major renovations. Dwelling units can easily be retrofitted with ceiling fans upon unit turn-over or while still occupied.

Design Details

REDUCED AIR INFILTRATION

The most common leakage spots in new homes include sill plates, top plates, electrical and plumbing penetrations, boxes around windows, duct penetrations, attic hatches, recessed light fixtures and door frames.

Weatherstripping, house wraps *(Structure: E1–Drainage Planes and Durable Siding),* sealants, foams and tapes are common solutions to reduce infiltration. Use foam to seal penetrations between floors through top plates, plumbing and electrical penetrations *(Structure: Section F–Insulation; Finishes & Furnishings: K4–Low-VOC Adhesives and Sealants).* Seal ducts with mastic *(Systems: J2–Building Diagnostics).*

Additional strategies for reducing infiltration include:

» Caulk or use foam spray around all penetrations.

» Seal any hole going from a living space to an attic, including inside-the-wall plates.

» Seal all penetrations to the outside between floors and stud cavities.

» Use foam sealing in vertical penetrations between floors and lateral penetrations between stud cavities.

» Isolate residential units from one another to limit air flow between floors. This reduces leaks and protects air quality (for example, by keeping a neighbor's cigarette smoke out of the unit).

NATURAL VENTILATION

Most affordable housing funders require operable windows. Windows help provide natural ventilation even if there are only one or two exterior walls. To promote natural ventilation, locate windows to take advantage of prevailing winds and use a combination of low and high windows or operable skylights to induce cross-ventilation. Also consider passive solar features: south-facing windows help with solar heating and provide good ventilation when coupled with north-facing operable windows *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).* Some window manufacturers include small operable vents in the window frames to provide fresh outdoor air without opening the window.

CEILING FANS

Ceiling fans improve a home's comfort by circulating air. Energy Star–qualified models are energy efficient thanks to improved motors, blade designs and fluorescent light kits; also, they can be operated to either draw warm air upward in the summer or push it downward in the winter. Select models with Energy Star–qualified compact fluorescent light fixtures, or purchase an Energy Star–qualified light kit *(Finishes & Furnishings: M4–Lighting).*

Install Energy Star ceiling fans and light kits in areas where occupants tend to spend more time, such as bedrooms and family rooms. Anchor ceiling fans to ceiling joists. Energy Star recommends mounting fans in the middle of the room, at least 7 feet above the floor and 18 inches from walls. Fan size and mounting type depend on the room's dimensions.

MECHANICAL VENTILATION

Minimum ventilation requirements for low-rise residential buildings are specified in ANSI/ASHRAE Standard 62.2, which is referenced by California's 2008 Building Energy Efficiency Standards (Title 24). Mechanical ventilation requires a continually operating or demand-controlled exhaust or supply fan, usually located in a hallway. For a typical studio or one-bedroom apartment, the minimum continuous ventilation can be provided by a fan that exhausts or supplies 30 cubic feet per minute (cfm). For a two- or three-bedroom apartment, the requirement is 45 cfm. Mechanical ventilation is usually achieved with the HVAC system. Required mechanical ventilation should not be achieved by constant running of standard bathroom and kitchen exhaust fans.

An independent supply system can also be installed to provide fresh air and balance pressure differences. Supply ventilation systems should provide as much air as is being exhausted to neutralize pressure differences and eliminate the risk of backdrafting. Locate intakes away from sources of pollution, odor and dust, such as areas where smoking, barbequing, idling trucks, garbage and garages are present.

To minimize pressure differences inside the home, provide transfer grilles between rooms where necessary. This is commonly done in single-family homes, but it can be an acoustical concern.

Mechanical ventilation systems are significantly more energy efficient when coupled with an air-to-air heat exchanger to capture some of the energy lost through exhausted air.

Heat recovery ventilators (HRVs) use heat exchangers to heat or cool incoming fresh air using outgoing air. **Energy recovery ventilators (ERVs**) exchange moisture as well as heat making them useful in hot, humid climates and very cold climates.

In most California climates HRVs are sufficient, but have not generally been cost effective. However, now that code requires mechanical ventilation for low-rise residential buildings, the cost effectiveness of HRVs should be reexamined on a case-by-case basis.

Once the home is built, have a Home Energy Rating System (HERS) rater perform a blower door test to measure infiltration leakage and ventilation duct efficiency *(Systems: J1–Building Performance Exceeds Title 24).*

BATHROOM AND KITCHEN VENTILATION

Install Energy Star–qualified bathroom fans vented to the outside. Exhaust all bathroom ventilation fans to the outdoors, not to the attic, and install backdraft dampers at the end of the duct. Choose quieter fans with a rating of 1.5 sones or less.

Put all bathroom fans on timers or humidistats. This ensures proper run-time to adequately remove moisture from the room. Timers are triggered when the fan is turned on. The fan then runs for a set time, such as 15 to 30 minutes. Put bathroom fans on a separate switch from lights so they don't have to be on at the same time.

Humidistat controllers are even better, as they automatically switch the fan on when moisture in the air reaches a threshold level, and shut down when the moisture level subsides.

Install kitchen range-hood exhaust systems vented to the outside. Choose high efficiency Energy Star–qualified units. They are typically designed to be quieter (less than 4 sones), so people will be more likely to use them. Don't buy overpowered hoods that may cause backdrafting of combustion appliances.

Code Considerations

Parts 2, 4 and 6 of California's Building Code (Title 24) address minimum ventilation requirements for low- and high-rise residential buildings. In low-rise residential buildings, natural ventilation alone doesn't meet the requirements of ANSI/ASHRAE Standard 62.2 as required by Title 24–2008. A continually operating or demand-controlled exhaust or supply fan is required. As of the printing of these Guidelines, experts differed on how to address the inherent conflict of requiring mechanical ventilation even when natural ventilation strategies are pursued. For high-rise residential buildings, the design must ensure that sufficient fresh air is supplied, but natural ventilation may be adequate.

Infiltration sealing is standard practice in California but ensuring it is done effectively requires diligence. Leakage tests can identify problem areas *(see above).*

Title 24–2008 requires the bathroom fan to be on a separate switch than the lights.

Considerations for Residents

Reducing infiltration will cut heating and cooling costs. Natural and mechanical ventilation will help maintain healthy indoor air quality. Quiet ceiling and exhaust fans encourage use.

Residents generally take a primary role in managing ventilation conditions by using the mechanical system or by opening and closing windows in conjunction with using the mechanical system. Installing systems that are easy to use and understand will increase energy efficiency and comfort. In the orientation program for new residents, include information on how to operate the ventilation system *(Operations & Maintenance: N1–Operations and Maintenance Procedures).*

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Most contractors do some infiltration sealing, but taking extra care will provide a better quality home. This may increase labor costs.

Natural ventilation requires careful design. To maximize this added investment in design time, look for synergies with green measures elsewhere in the building, with the goal of reducing costs in some areas to pay for other upgrades.

Ceiling fans reduce heating and cooling costs, paying for themselves quickly in energy savings.

Mechanical ventilation systems cost extra because they are independent systems requiring ductwork and fans. Supply air systems with filters are relatively inexpensive compared to other HVAC equipment. Costs vary depending on the project size.

Energy Star–qualified exhaust fans cost about $100 to $150, whereas non-Energy Star exhaust fans cost as little as $30 (2007 costs). Although the payback is slower (two to three years), paying a premium for Energy Star fans may help avoid major repair costs due to mold and moisture.

Resources

» **ANSI/ASHRAE Standard 62.2–2007** Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings specifies minimum ventilation rates and indoor air quality acceptable to human occupants: www.ashrae.org

» **BuildingGreen** lists energy and heat recovery ventilators; fee to access: www.buildinggreen.com

» **Building Science Corp.'s** report, "Healthy and Affordable Housing: Practical Recommendations for Building, Renovating and Maintaining Housing," discusses proper sealing. Also see their publications on strategies to avoid backdrafting, mold and more: www.buildingscience.com

» **Build It Green Product Directory** has information about sourcing ventilation products: www.BuildItGreen.org/products

» **Energy Star** has fact sheets about infiltration reduction and ventilation systems: www.energystar.gov/homes

Related Case Studies

» Crossroads, p. 234

» Sara Conner Court Apartments, p. 221

GARAGE VENTILATION

Design Parking Structures for Safe Air Quality and Low Energy Use

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 23: Heating, Ventilating and Air Conditioning

OLD: Division 15: Mechanical

Recommendation

Design naturally ventilated parking structures with appropriate measures to avoid indoor air pollution from car exhaust.

When mechanical ventilation is necessary, use demand controls to reduce fan use.

Description

Parking structures must maintain safe air quality. To do this, they often use large, energy-consuming fans that may run 24 hours a day. A better solution is to design open parking structures that allow for air flow and natural ventilation. Partial walls with openings for steel mesh may be used to screen the view of cars and provide security.

When mechanical ventilation is required, install carbon monoxide (CO) sensors to control the fans. This is called demand-control ventilation, and has the potential to save 50% to 90% of the energy used by the fans for very little upfront cost.

In addition to ensuring that the air quality within parking structures is safe, there are concerns about occupant health from underground and ground-floor parking structures. Indoor air quality (IAQ) can be compromised from car exhaust seeping into adjacent units. Noise pollution from cars, car alarms and garage exhaust fans can also be a problem.

Strategies that address IAQ concerns through proper ventilation and air sealing can reduce exhaust problems *(Systems: H3–Advanced Ventilation Practices).* Also, well-insulated buildings will cut down on noise pollution from cars *(Structure: C1–Acoustics and F1–Insulation).* Adequate visibility, parking spacing and lighting will reduce security concerns *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).*

Benefits

Naturally ventilated parking structures can result in quieter, better quality ventilation compared to mechanical ventilation because of the greater volume of outdoor air from breezes and open walls.

Demand controls used with mechanical ventilation save fan energy.

Application

SIZE	Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applies to below-grade, tuck-under and ground-floor parking garages.

Design Details

Before designing the parking structure, consider how neighborhood aesthetics and access could be affected by an enclosed garage. Pedestrian access and street-level retail or housing could be compromised *(Planning & Design: AA1–Infill Sites, AA2–Design for Walking and Bicycling and AA4–Mixed-Use Developments; also Structure: C2–Mixed-Use Design Strategies).*

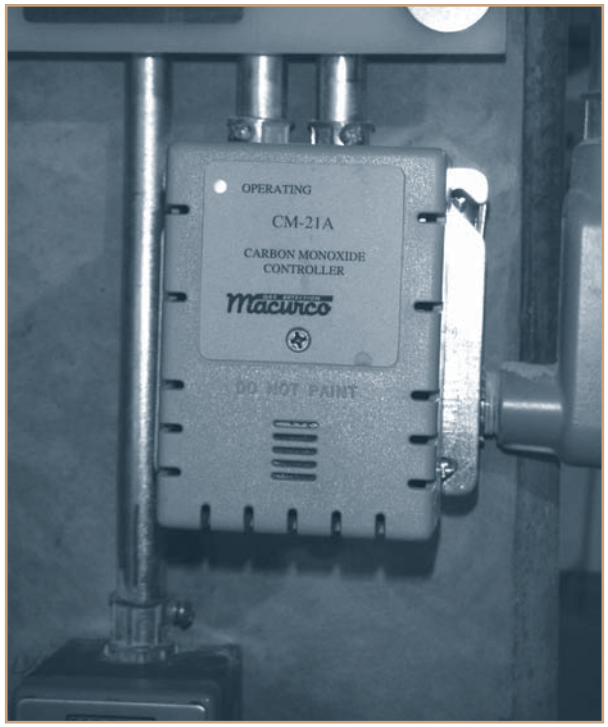
REDUCE INFILTRATION

Air pollution from parking garages can enter living spaces if a pathway is present. Seal all penetrations to the building envelope with sealants and other weatherproofing materials, especially on the floor adjacent to parking spaces. Tape drywall joints and apply joint compound carefully in these areas. Thermally isolate the units from the parking area.

Consider locating entrances to housing away from the parking area, or seal corridors and hallways from drafts. Double-door entrance assemblies with weatherstripping work well, especially in corridors. Also, consider positively pressurizing the entryways and corridors to reduce drafts through the building *(Systems: H3–Advanced Ventilation Practices).*

PROVIDE NATURAL VENTILATION

Natural ventilation in parking areas can be done through openings in the perimeter walls in ground-floor parking. Using semitransparent barriers at the wall openings, such as vandalism-proof grating, fencing and trellises, will allow air to enter and circulate in the parking area. The security grating can be nearly opaque to block views into the garage, if necessary.



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In parking garages with mechanical ventilation, carbon monoxide–based demand controls can reduce fan energy use.

USE DEMAND CONTROLS WITH MECHANICAL VENTILATION

If necessary, underground parking facilities can be mechanically ventilated by using continuously operating fans that exhaust air to the outside. These fans are relatively inexpensive to purchase but can be costly to operate. Consider specifying a demand-control ventilation system with a CO sensor instead of a continuous fan. The CO sensor will activate the fans when a threshold is met, and shut them off once the contaminants have been exhausted to safe levels.

Often these fan systems will run only a fraction of the time a constant fan will operate, saving significant energy and reducing noise. Take care to place exhaust fans away from residential windows and air intakes so they do not pollute residences.

Code Considerations

Garage ventilation must comply with minimum air changes per hour and other ventilation standards set by California's Building Energy Efficiency Standards (Title 24) and by other jurisdictions.

Considerations for Residents

Occupants will benefit from healthier indoor air quality and a quieter building.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Adding ventilation strategies that promote good IAQ should not add significant costs. A demand-control ventilation system typically pays for itself in less than a year.

Resources

» **American Society of Heating, Refrigerating and Air-Conditioning Engineers** (ASHRAE) *Application Handbook,* 2003 Edition, Chapter 13.10 provides information on parking garage ventilation: www.ashrae.org

Related Case Studies

» Sara Conner Court Apartments, p. 221

SOLAR WATER HEATING

Use Solar Collectors to Preheat Domestic Hot Water

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 22 30 00: Plumbing Equipment, **23 56 00:** Solar Energy

OLD: 13600: Solar and Wind Energy Equipment

Recommendation

Use solar collectors for preheating a central water heater or boiler or install a solar water heating system for each dwelling unit.

For renovations, evaluate opportunities to supply some portion of hot water needs through solar water heating.

Description

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 water heater. The systems use the sun to preheat the water, and use a boiler or water heater to complete the heating process. Systems are classified into two groups; active and passive.

An active system uses a controller and sensors to turn a pump on when there is sufficient heat gain in the collectors. Benefits include reduced roof loads and more space for collectors on the roof (assuming storage is in the building), more freeze protection options for roof components, and the potential for storing a higher quantity of water.

A passive system uses a thermosiphon loop, where the water being warmed by the sun in the collector naturally rises and is replaced by cooler water from the storage tank. These systems require the stored water to be placed above the collector system, often adding substantial roof weight load, if placed on the roof. Advantages include no added electrical load and reduced maintenance by eliminating controllers, sensors and pumps. Freeze protection of collector and water storage is typically limited to using antifreeze in the collector loops, but leaving the potable water lines exposed to freezing potential. Such designs work well for coastal and temperate climes but may not be suitable to hard-freeze conditions.

Medium-temperature systems that raise water to between 110°F and 150°F are the most common for domestic hot water (DHW) applications. There are a number of types of collectors. The three most common are described below:

» **Integral collector storage (ICS) or "batch" collector.** 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). Solar fraction*: Up to 45%.

» **Flat plate collector.** Water or another liquid is circulated through copper tubing in 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. Solar fraction: Up to 60%.

» **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. Solar fraction: Up to 75%.

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. It is recommended that separate storage tanks be used for collecting the water, allowing the preheated water to be used as needed by the gas or electric water heating appliance. Boilers, storage tank water heaters and instantaneous water heaters all benefit from the solar heated water and serve as a back-up so that hot water is always available *(Systems: G4–Water Heater Replacement).*

Solar hot water systems can be used for both domestic hot water and space heating, often integrating a heat exchanger to maintain potable water separation from the space heating closed loop design *(Systems: H1–Radiant Hydronic Space Heating).*

* *Solar fraction is the portion of the water heating load serviced by the solar system. A solar fraction of 45% correlates to a 45% reduction in the water heating load.*


PHT SOLARSUNEARTH

Fifty-seven flat plate collectors installed on a San Francisco roof.

Benefits

Solar water heating reduces both air pollution and demand for nonrenewable energy sources. Solar hot water can substantially reduce a building's carbon footprint at a much lower cost than photovoltaic (PV) electricity systems *(Systems: I2–Photovoltaic Systems).*

Unlike PV, solar hot water does not require a utility meter. Water heating is supplemented by the solar system and the owner/tenant is then only charged for the fuel used to heat water to the desired temperature.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to most multifamily new construction and renovation projects. Solar hot water systems require south-facing roof space for panels and space for appropriate plumbing configurations in a mechanical room.

If the design team is considering hydronic space heating, solar water heating can be an effective preheater. If the hydronic heating is used in a radiant slab, it is particularly effective, as the delivered temperature to the slab can easily be provided by the solar hot water system *(Systems: H1–Radiant Hydronic Space Heating).*

Design Details

Consult a solar hot-water designer who is knowledgeable about multifamily construction early in the design process to help the architect plan for appropriate roof loads, adequate space on the south-facing roof and in the mechanical room, and appropriate plumbing configurations.

The best performance for domestic hot water use occurs when panels face due-south with a pitch equal to the latitude where the installation occurs. However, if placed within 45 degrees of south at a moderate pitch, the system can still operate at efficiencies up to 90% of the ideal position. Systems used primarily for hydronic space heating will benefit from a steeper angle, taking advantage of the winter sun's lower position. The collectors should not be shaded by trees or buildings.

Code Considerations

Solar water heaters can significantly reduce fuel needed to heat water, and therefore help with energy code compliance. When modeling a building for compliance with California's Building Energy Efficiency Standards (Title 24), solar hot water systems earn significant credit towards exceeding code minimums.

Solar water heating has been in use in the mainstream residential and commercial construction market for over 40 years. Most code officials and jurisdictions are aware of solar water heating and should not raise any difficulties with issuing permits.

Considerations for Residents

Residents will receive hot water at the same temperatures as without solar, even if the sun is not shining, assuming there is a backup water heater.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Solar hot water systems are an added first cost, but with great benefits. Along with substantial energy credits for new construction when modeling for Title 24 compliance, solar hot water also experiences a faster payback than the more expensive PV electricity systems.

A typical multifamily solar hot water system will cost roughly $1,000 per building occupant, depending on the system's size. Paybacks are in the three to ten year range, depending on system size and backup heating source (natural gas, propane or electric).

Rebates are available for solar water heating systems. A law passed in 2007 increased rebate funds in California for solar hot water systems; check with installers 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; consult with a tax lawyer.

Central water heating systems can be preheated by solar collectors and cost less than individual water heaters in each unit, due to reduced piping and redundant equipment. It is possible to have one central boiler that serves both space heating and DHW purposes. The combined savings of eliminating furnaces and reducing energy use can offset the cost of installing solar water heating *(Systems: G4-Water Heater Replacement)*.

If solar water heating is not financially feasible, consider preplumbing and reserving south-facing roof space and an area in the mechanical room for a storage tank. It is considerably less costly to run the piping and sensor wiring within the structure during construction than to install it later. Generally, an insulated supply and return copper pipe between the mechanical room and the roof with a low voltage wire is all that is needed to minimize effort during a future installation. Penetrating the roof with the piping during preplumbing will also maintain the roofer's warranty. Having the roof structure assessed for the additional load is suggested during design development, though most contemporary roofs require no additional structural elements.

Resources

- **Build It Green Product Directory** has information about sourcing solar hot water systems: www.BuildItGreen.org/products
- **California Energy Commission** has information on solar hot water systems, including rebate programs: www.consumerenergycenter.org
- **California Solar Energy Industries Association** has a searchable directory of California solar experts, including consultants, contractors, manufacturers and distributors:

  www.calseia.org/component/option,com_directory/Itemid,70
- ***Environmental Building News*** has an article, "Is Solar Still Active? Water Heating and Other Solar Thermal Applications" (Jul/Aug 1999); fee to access: www.buildinggreen.com
- **Database of State Incentives for Renewables & Efficiency** (DSIRE) provides information about incentives by state: www.dsireusa.org
- **Flex Your Power** provides information about rebates and incentives from California utility companies: www.flexyourpower.org
- **Northern California Solar Energy Association** has information on solar hot water systems and list of contractors and suppliers: www.norcalsolar.org

Related Case Studies

- Danco Communities, p. 220
- Oxford Plaza, p. 15

MEASURE I2

PHOTOVOLTAIC SYSTEMS

Generate Electricity On Site with Photovoltaics

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 48 14 00: Solar Energy Electrical Power Generation Equipment, **26 31 00:** Photovoltaic Power Collection

OLD: 16200: Electrical Power

Recommendation

Install a photovoltaic (PV) system on site to generate electricity from sunlight.

Description

Onsite photovoltaic systems can provide reduced and fairly constant electricity costs compared to purchasing electricity from the local utility. PV systems are also environmentally preferable because they do not consume fossil fuels. They work by converting solar energy into electricity when sunlight strikes the PV cells. Electricity is produced as direct current (DC) power. An inverter then converts the DC power into alternating current (AC) power for residential use.

Also consider solar water heating (Systems: I1) in addition to or in lieu of a PV system.

INTERCONNECTED VS. INDEPENDENT POWER

Photovoltaic systems can be either utility interconnected or independent.

» **Utility interconnected systems** dominate the California market and are recommended for multifamily projects. These systems are always connected to the utility grid. When the onsite system is producing power, the utility meter simply slows or runs backward, depending on the building's internal load. By staying connected to the grid, these systems do not need batteries or energy storage devices (unless uninterrupted power is desired).

Interconnected systems take advantage of net metering laws, which allow energy generated in excess of use to be credited by the utility to the customer's utility bill. The excess power is credited at the same rate at which it would be purchased, up to the point where the net utility bill for the year reaches zero dollars. California law restricts the sale of self-generated electricity to utilities.

Due to current economics, most grid-tied systems are designed to provide 60% to 75% of the total electricity needed. For multifamily buildings, designing for 100% offset is rare because it is currently difficult for photovoltaic systems to compete economically with the base tier price per watt from the utility. As the price per watt from photovoltaics reaches grid parity, building owners will be more likely to choose electricity exclusively from clean, renewable sources and to size PV systems to achieve larger offsets.

By combining systems, such as installing both a PV system and a microturbine, a development may be able to generate 100% of its own power on site. (Caution: check with utilities for rules regarding more than one renewable onsite generation system.)

Adding to the challenge, most multifamily projects have limited roof space. As a result, most multifamily photovoltaic systems are used to offset only the common area's electrical demand.

» **Independent power**, which is often called "off the grid," is not recommended for multifamily projects. In these applications, batteries store energy produced by the PV system. Off-the-grid applications are not connected to the utility grid and are typically used on remote rural sites.

PHOTOVOLTAIC MODULES

There are a variety of photovoltaic technologies available, with varying efficiencies and costs.

» **Monocrystalline silicon cells** are the most efficient type of PV module, but are relatively costly because they are created using a complicated manufacturing process.

» **Multicrystalline silicon cells** are cheaper to produce than monocrystalline cells but are less efficient.

» **Amorphous or thin-film silicon cells** are the cheapest and least efficient type of PV modules. Amorphous silicon can be deposited on a wide range of substances, which makes it ideal for curved surfaces typical of building-integrated photovoltaic applications.

MOUNTING OPTIONS

Photovoltaic panels can be pole-mounted, roof-mounted or integrated into the building skin.

» **Pole-mounted** systems have arrays mounted on poles set in the ground. They can be installed at a fixed angle, adjustable angle or on a single- or dual-axis


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Rooftop photovoltaic panels generate electricity from sunlight.

tracking system. Tracking systems allow the panels to change angles for optimal energy production throughout the year; however, these mechanical systems must be checked periodically to be sure they are performing properly.

» **Roof-mounted** systems are generally fixed angle, but may also be installed on tracking systems.

» **Building-integrated** photovoltaics are installed as a part of the building itself, and take the place of a portion of the building envelope's materials. Photovoltaics can be integrated into virtually any part of the building skin, including roof tiles, glass façades, overhangs or curtain walls. However, energy production efficiency decreases considerably as the angle of the PV cells approaches 90 degrees, especially if low-efficiency thin-film silicon is being used.

Benefits

Photovoltaic systems reduce air pollution and demand on the electricity grid. They are considerably more efficient than centralized power generation. Because electricity is generated where it is being used, distribution losses are minimized compared to electricity that travels over the utility's distribution network. Primary power loss occurs in the inverter, where DC power is converted to AC power.

Solar power systems produce reliable power for 25 to 40 years, although most systems experience a decline in output overtime. Most systems have warranties of 10 years; the panels alone are often warranted for 25 years.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

PV systems can be installed in both new and retrofit situations.

Design Details

Before considering onsite energy production, focus design dollars on reducing energy use to the greatest extent possible *(Systems: J1–Building Performance Exceeds Title 24).* Energy-efficient buildings will require smaller PV systems. Also, teach residents and staff about the basics of energy efficiency to reduce the demand for onsite power systems *(Operations & Maintenance: N1–Operations and Maintenance Procedures and N3–Educational Signage).*

Hire an expert or enlist the help of a nonprofit organization *(such as Community Energy Cooperative; see Resources)* that specializes in onsite systems and procurement to help make the process easier. They can help with sizing a system, working with suppliers, overcoming code and permit barriers, and obtaining rebates. Meet early in the design process with your design team and outside experts to identify goals and budgets for the PV system. Provide information to the project's decision makers to build agreement for incorporating onsite energy generation.

Allow adequate unshaded space on plans for the PV system. This requires a clear roof area of roughly 100 to 150 square feet for each kilowatt of power. For large PV installations with multiple inverters, reserve space in mechanical rooms for conduit, disconnect switches and inverters. Finally, include a water spigot on the roof for washing off panels as part of maintenance.

Code Considerations

Photovoltaic systems must pass established code approval processes that include utility interconnection regulations and laws, city or county permits and rebate documentation review.

Considerations for Residents

Displays that show energy generated from onsite systems can increase residents' interest and cooperation *(Operations & Maintenance: N3–Educational Signage).* The effects of photovoltaics are otherwise invisible to homeowners, as the integration between the PV and utility systems is seamless. Current regulations do not allow grid-tied systems to operate in the event of a power outage; grid-tied systems only provide electricity during power outages if they have battery back-ups.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Costs, rebate and incentive information are as of December 2007 *(for current information, see Resources).*

There are many rebates and incentives available to reduce the cost of PV systems in California. Actual PV system costs, after rebates and incentives, can range from $4.00 to $7.00 per watt installed, depending on

the complexity of the installation, available rebates and incentives, and other factors.

TAX CREDITS

All solar projects are eligible for a federal tax credit of up to $2,000. Not all affordable housing developers will be able to obtain federal tax credits directly. Additional tax credits for affordable housing projects are available from the California Tax Credit Allocation Committee (TCAC) .

REBATES

For new market-rate construction, the California Energy Commission has launched the New Solar Homes Incentive Program (NSHP), which offers an incentive of $2.50 per watt for residential projects where solar will be installed on less than 50% of the development's units, and $2.60 per watt in developments where solar will be installed on more than 50% of units.

The Energy Commission offers higher incentives to **new affordable housing** developments: $3.50 per watt for systems installed on individual residential units and $3.30 per watt for systems installed on common areas. NSHP incentive levels will decline over time as capacity goals are reached.

For **existing market rate homes**, the California Public Utilities Commission (CPUC) offers incentives of up to $2.50 per watt through the California Solar Initiative (CSI). For systems smaller than 100 kW, the incentive is paid upfront based on equipment ratings and installation factors. For systems larger than 100 kW, incentives are paid each month for five years, based on actual energy performance.

For **existing affordable housing**, the CPUC has adopted the CSI Single Family Low Income Incentive Program, which provides $4.75 to $7.00 per watt to qualifying low income households. The CPUC is currently developing a similar program for existing multifamily low-income housing. All electric customers in PG&E, SCE and SDG&E service territories are eligible for CSI incentives.

POWER PURCHASE AGREEMENTS

The advent of Power Purchase Agreements (PPA) have made solar power more affordable to developers. Under this scenario, a third-party vendor leases a project's roof area and installs a utility-interconnected PV system. The vendor recoups the tax credits, rebates and net metering benefits. In return, the developer is sold power at a rate that may be less than the utility's rate. Price escalation is factored in, but terms and conditions are negotiable. Most PPAs allow for building owners to purchase the PV system at a reduced cost after some number of years of operation.

Resources

- **California Energy Commission** provides an online publication, "A Guide to Photovoltaic (PV) System Design and Installation": www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF; and provides information about incentive program requirements, funding and eligibility: www.consumerenergycenter.org
- **California Public Utilities Commission's California Solar Initiative Program** administers incentives for existing homes: www.cpuc.ca.gov/PUC/energy/solar
- **California Solar Energy Industries Association** has a searchable directory of California solar experts, including consultants, contractors, manufacturers and distributors:
  www.calseia.org/component/option,com_directory/Itemid,70
- **Cooperative Community Energy** provides information for affordable housing projects seeking PV and other self-generation systems, and can help with procurement, low-interest loans, and identifying businesses to lease the system and take advantage of additional tax credits and incentives: www.cooperativecommunityenergy.com
- **Go Solar California** has comprehensive information regarding all solar programs in California, including information about incentives: www.gosolarcalifornia.ca.gov
- **GRID Alternatives** has a Solar Affordable Housing Program: www.gridalternatives.org
- **U.S. Department of Energy's Solar Energy Technologies Program** provides educational information about many solar technologies, including photovoltaics: www1.eere.energy.gov/solar

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- Danco Communities, p. 219
- Sara Conner Court Apartments, p. 221
- Village Walk, p. 151

MAKING A COMMITMENT TO RENEWABLE ENERGY *Village Walk, San Lorenzo, CA*

A NEW NORTHERN CALIFORNIA NEIGHBORHOOD WITH SOLAR PANELS ON EVERY ROOF

At Village Walk, a new residential development in San Lorenzo, California, each of the 28 townhomes will have its own 1.51-kilowatt rooftop photovoltaic system. Slated for completion in December 2008, Village Walk is the first solar project for its developer, The Olson Company.

"Solar is an expensive hurdle," said Matthew Weber, the company's assistant director of operations, but "we feel like we're doing the right thing for the environment and the city, even if it's going to cost us a bit more." State rebates and a federal tax credit help bring the cost down, although it's still significant. The Olson Company purchased the PV systems outright, paying for them through the normal construction loan process.

"We're hoping it drives [sales] traffic and is important enough to individuals that they'll choose us as opposed to another builder," said Weber. "We're known for a quality product—quality construction, quality finishes, quality hardware. Photovoltaics is another quality feature we're providing."

Each solar electric array is wired into each individual electric subpanel so that generation from each unit will appear as a credit on that unit's electric utility bill. To maximize benefits to the homeowners, The Olson Company selected a time-of-use residential rate schedule that credits peak energy production (between noon and 6 PM on weekdays) at significantly higher rates than off-peak production.

To further trim each home's energy use as well as reduce peak demand on the electric utility grid, The Olson Company focused on increasing energy performance over Title 24 requirements *(J2).* Energy efficiency measures include Energy Star–qualified appliances *(M1)* and bathroom ventilation fans, spectrally selective low-e windows *(D9),* right-sized HVAC systems *(H0),* tankless water heaters *(G4),* HERS inspections for quality insulation *(F2),* duct leakage testing *(J2),* and a variety of other measures. Village Walk is a LEED for Homes pilot project.

More information: www.olsonhomes.com

MEASURE J1

BUILDING PERFORMANCE EXCEEDS TITLE 24

Exceed Minimum California Building Energy Code Requirements

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Various Sections

OLD: Various Sections

Recommendation

Use energy-efficient design strategies to exceed California's Building Energy Efficiency Standards (Title 24).

Follow an integrated design approach. Use building simulation software to model the energy systems and optimize the building's energy performance.

For retrofit projects, follow the guidelines in the Title 24 *Residential Compliance Manual*, chapter 8: Additions, Alterations, Repairs.

Description

All multifamily new construction as well as most alteration and addition projects in California must comply with the state's Building Energy Efficiency Standards for Residential and Nonresidential Buildings. These Standards, which make up Title 24, Part 6 of the California Code of Regulations, are commonly referred to simply as Title 24. The California Building Standards Commission has revised Title 24 every three years since 1989. The 2005 Title 24 Standards have been effective since October 1, 2005, and the 2008 Standards are estimated to go into effect in 2009.

Title 24 is generally more stringent than most other energy codes in the United States. But if California's building industry and building owners want to make a significant reduction in the greenhouse gas emissions associated with the construction and operation of buildings, they must be even more aggressive about finding energy savings than the state currently mandates. Further, the state has adopted a goal of net zero energy for all new residential buildings by 2020, so exceeding code now is a rational step toward meeting the code in 2020.

For low-rise multifamily buildings (three stories or less), a best practice is to pursue Energy Star certification, which is awarded to homes that are designed and constructed to achieve a certain level of energy-efficient performance. In addition, a third-party verification of energy savings can be performed by a certified Home Energy Rating System (HERS) rater to ensure quality design and installation, including testing for tight construction and ducts and adequate ventilation.

High-rise multifamily buildings (four stories or more) are not eligible for Energy Star certification. Exceeding Title 24 for these buildings involves using integrated design strategies, energy modeling and other strategies to optimize energy performance.

Benefits

Exceeding Title 24 results in reduced greenhouse gas emissions, lower utility costs and increased comfort. Another benefit is higher quality construction, thanks to better air sealing, increased insulation, high efficiency equipment and other measures. Advanced framing measures reduce wood use. Owners generally realize higher property values for more energy-efficient buildings.

Builders and developers benefit from improved tenant/owner satisfaction (a result of better thermal comfort and lower utility bills), higher construction quality control, and Energy Star marketing tools and co-promotional advertising opportunities.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Title 24 energy standards apply to the new construction and major renovation of all residential and most commercial buildings in California.

Energy Star is applicable only to low-rise (three habitable stories or less) multifamily buildings. Dwelling units must be individually metered for electricity to receive incentives for HERS testing from Pacific Gas & Electric Company (PG&E) and Southern California Edison (SCE).

There is currently no Energy Star designation for high-rise residential buildings.

Design Details

ENERGY EFFICIENCY CONSIDERATIONS

To optimize the building's energy performance and exceed Title 24, focus on these factors:

- **Proper orientation:** Minimize heating and cooling costs by designing the building to be shaded in the summer and receive the sun's warmth in the winter. To the extent possible, orient the long side of the building to the south and provide overhangs to shield windows from the summer sun *(Planning & Design: AA7–Passive Solar Design).*
- **Effective insulation:** Properly installed and inspected insulation in floors, walls and attics reduces energy use and increases comfort *(Structure: F2–Quality Installation of Insulation).*
- **High performance windows:** Energy-efficient windows employ advanced technologies, such as protective coatings and improved frames, to help keep heat in during winter and out during summer *(Structure: D8–Window Replacement).*
- **Tight construction and ducts:** Sealing holes and gaps in the home's envelope and in heating and cooling ducts reduces energy use as well as drafts, moisture, dust, pollen and noise *(Structure: C1–Acoustics; Systems: H3–Advanced Ventilation Practices, H4–Garage Ventilation and J2–Building Diagnostics).*
- **Efficient heating and cooling equipment:** Energy-efficient heating and cooling systems not only use less energy to operate, they can also reduce indoor humidity and improve the home's overall comfort. Note that while reducing or eliminating air conditioning saves energy, this strategy may either positively or negatively affect a project's Title 24 compliance margin depending on the specific climate zone *(Systems: H0–Heating Equipment, H1–Radiant Hydronic Space Heating and H2–Air Conditioning with Non-HCFC Refrigerants).*
- **Efficient Products:** Choose Energy Star–qualified products including lighting fixtures, compact fluorescent light bulbs, ventilation fans, and appliances such as refrigerators, dishwashers and washing machines *(Systems: H3–Advanced Ventilation Practices and H4–Garage Ventilation; Finishes & Furnishings: M1–Energy- and Water-Efficient Appliances, M2–Central Laundry and M4–Lighting).*

INTEGRATED DESIGN

Make energy efficiency central to the overall design by utilizing an integrated design approach from the very beginning. During the design process, the design team or a building energy simulation consultant should conduct computer energy modeling to ensure that the design optimizes the building's energy use and exceeds Title 24. These steps will result in increased energy efficiency and may also reduce costs for individual components and equipment. Suggestions include:

- Orient buildings properly to maximize solar gain and natural ventilation *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).*
- Limit windows on the east and west walls to cut morning and afternoon heat gain in summer, and reduce heat loss in winter *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation).*
- Use advanced framing techniques that place studs 24-inches on center and give greater insulation values to the wall assemblies *(Site: D3–Construction Material Efficiencies).*
- Specify sealed combustion furnaces with high efficiencies that improve indoor air quality *(Systems: H0–Heating Equipment).*
- Include non-ozone depleting refrigerants in high EER cooling equipment *(Systems: H2–Air Conditioning with Non-HCFC Refrigerants).*
- Downsize onsite energy generation needs (photovoltaics, microturbines, solar water heating, etc.) by improving insulation, equipment efficiencies, lighting and more *(Systems: Section I–Renewable Energy).*

ENERGY STAR QUALIFIED HOMES PROGRAM

Energy Star is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). It is a voluntary program that strives to reduce greenhouse gas emissions through energy efficiency.

The Energy Star label is given to new low-rise homes (3 stories or less) designed and tested to perform 15% better than the energy code under which they are permitted. Energy Star–qualified homes also include additional energy-saving features that typically make them 20% to 30% more efficient than standard U.S. homes. In California Title 24 is the relevant energy code *(see Resources).*

Energy efficiency retrofits are available through the Home Performance with Energy Star program *(see Resources).*

High-rise residential buildings are not eligible for Energy Star designation.

HERS VERIFICATION

To be eligible for financial incentives from PG&E's California Multifamily New Homes program and SCE's California New Homes program, homes in those service territories must receive a third-party Home Energy Rating System (HERS) verification. HERS verification can be obtained through three providers recognized by the California Energy Commission *(see Resources).*

During a HERS home inspection, the rater will:

- Perform construction and plan reviews
- Check duct sealing with a duct-blaster test
- Test for envelope sealing/reduced infiltration through a blower-door test

» Verify Air Conditioning Contractors of America (ACCA) Manual D duct design *(Systems: J2–Building Diagnostics)*

» Verify refrigerant charge and airflow measurement or thermostatic expansion valves (TXV) on split system cooling equipment *(Systems: H3–Air Conditioning with Non-HCFC Refrigerants)*

Code Considerations

Since 1978, all residential buildings (including new construction and most additions and alterations) and most commercial buildings within California have had to meet minimum energy efficiency standards contained in Title 24, Part 6 of the California Code of Regulations. If a design does not conform exactly to one of Title 24's prescriptive packages, energy calculations must be performed to demonstrate compliance with the Standards. Using state-certified software such as EnergyPro or MICROPAS, qualified consultants can generate a complete Title 24 report, which includes all the compliance forms. To calculate the project's energy efficiency beyond the code-mandated level, the program compares the project's energy use (known as the proposed energy budget) with the energy budget of a minimally code-compliant project (known as the standard energy budget).

In California, requirements for buildings three stories or less fall within the residential portion of Title 24. Although the low-rise residential lighting and water heating requirements still apply to buildings four stories and taller, envelope and space conditioning requirements fall within Title 24's commercial/high-rise residential building section.

PG&E's California Multifamily New Homes program and SCE's California New Homes program currently use the 2005 Title 24 Standards as the code baseline for measuring building energy performance. The 2009 to 2011 programs will be based on the 2008 Title 24 Standards *(see PG&E and SCE websites in Resources).*

In 2008, Title 24 will be revised to include higher levels of energy efficiency. Although these Guidelines cover some of the anticipated changes, the specific changes from the 2005 Title 24 Standards were not adopted at the time these Guidelines were published.

EMPHASIS ON PEAK SAVINGS

There will be even greater emphasis on peak demand impacts in the 2008 Standards than in the 2005 Standards. For example, the Standards will require air conditioners to have a higher energy efficiency ratio. EER gives a better indication of demand than the seasonal energy efficiency ratio (SEER) typically used to indicate an air conditioner's energy performance *(Systems: H2–Air Conditioning with Non-HCFC Refrigerants).* Title 24 will also require lower solar heat gain coefficient (SHGC) glazing in most climate zones *(Structure: D8–Window Replacement).* SHGC measures how well glazing blocks the transmission of heat-producing sunlight.

Title 24's Time-Dependent Valuation (TDV) gives greater penalties for building features such as:

» West-facing glass, which must be 5% or less of the total floor area for low-rise buildings, or less than 40% of the total wall area for high-rise buildings. Otherwise, other energy efficiency trade-offs are necessary.

» Oversized, unshaded windows and skylights, which result in higher solar gains in hot climates, and thus increased cooling energy use.

Considerations for Residents

People living in homes that exceed Title 24 energy standards benefit from increased comfort and lower energy costs. Heating and cooling of the rooms is more uniform. Duct sealing and advanced ventilation strategies help maintain good indoor air quality.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Buildings that exceed Title 24 energy standards and Energy Star–qualified homes have tighter building envelopes, reducing the need for heating and cooling, and thus reducing operating costs.

To ensure that systems interact properly, some review and consulting in passive solar design and energy simulation will probably be necessary. This should be part of an integrated design process to maximize benefits and reduce first costs.

The cost of a HERS rating varies according to whether the rater performs visual inspections or diagnostic testing. For the Energy Star program, one model in each building must be tested; subsequently, one-in-seven sampling is possible. However, if tight ducts or thermostatic expansion valves (TXVs) on air conditioners are used for Title 24 or Energy Star compliance, then all units must be verified, increasing costs.

For multifamily projects in PG&E and SCE territory, performance-based incentives are available for low-rise and high-rise multifamily projects exceeding 2005 Title 24 energy efficiency standards by at least 15%. A larger incentive is offered for inland projects achieving at least 20% beyond Title 24. All low-rise projects must meet additional Energy Star requirements. Check with PG&E and SCE for program details and changes.

Multifamily housing projects that meet the Energy Star criteria are eligible for additional funding to help offset the HERS rating costs and increased efficiency measures.

Nonprofit and affordable housing developers that design and build to green standards or exceed Title 24 Standards can be eligible for money from a variety of sources including utilities, the state's tax credit programs, local governments, and foundations *(see Resources).*

Resources

» **California Building Energy Efficiency Standards** (Title 24) and compliance manuals can be downloaded from: www.energy.ca.gov/title24/index.html

» **Energy Star** has information about:

Energy Star–qualified homes: www.energystar.gov/homes

Energy efficiency retrofits: www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_index

» **HERS providers** recognized by the California Energy Commission:

California Home Energy Efficiency Rating System (CHEERS): www.CHEERS.org

Certified Energy Rating & Testing Services (CalCERTS): www.CALCERTS.com

California Building Performance Contractors Association (CBPCA): www.cbpca.org/HERS/

» **Pacific Gas & Electric's** (PG&E) California Multifamily New Homes program offers incentives to developers of multifamily projects exceeding Title 24: www.h-m-g.com/multifamily/cmfnh

» **Southern California Edison's** (SCE) California New Homes Program (CANHP) offers incentives to developers of multifamily projects exceeding Title 24: www.sce.com/RebatesandSavings/BuilderandBuyer/CaliforniaNewHomesProgram

Related Case Studies

» Colony Park, p. 227

» Oxford Plaza, p. 15

» Sara Conner Court Apartments, p. 221

» Village Walk, p. 151

MEASURE J2

BUILDING DIAGNOSTICS

Properly Size, Seal, Insulate and Test Ducts

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 01 75 13: Checkout Procedures, **07 08 00:** Commissioning of Thermal and Moisture Protection, **23 05 93:** Testing, Adjusting, and Balancing for HVAC

OLD: 01750: Checkout Procedures, **07080:** Commissioning of Thermal and Moisture Protection, **15950:** Testing, Adjusting and Balancing

Recommendation

Design, size, seal and insulate forced-air duct systems appropriately. Locate ducts within conditioned areas where possible.

Test the building for thermal envelope and HVAC effectiveness.

Apply low-rise residential energy standards for duct performance to high-rise residential projects.

Description

Up to 30% of the energy used to heat and cool a building can be lost through leaky ducts and poor duct design. In all multifamily buildings, whether served by a central furnace or boiler or individual HVAC units, duct design, sizing, installation, insulation, and sealing are crucial for achieving desired performance and comfort.

With forced-air heating and cooling systems, the return ducts deliver air back to the heating and cooling system for conditioning. Typically, equipment is designed to condition return air that is at or near room temperature. Leaky return ducts allow cold air in the winter and hot air in the summer to be drawn from the outdoors back into the HVAC system, reducing efficiency.

Ducts in exterior walls, attics and uninsulated spaces can also lose a significant amount of heated or cooled air to the outside through conduction. Locating ducts within the conditioned space, properly insulating supply and return ducts and reducing the length of duct runs will improve performance.

Often, HVAC systems are oversized to supply enough conditioned air to overcome losses from leaks, conduction and configuration problems. If these problems are fixed, it may be possible to install a smaller replacement system that uses less energy and provides greater comfort.

Once the home is built and the ducts sealed and tested by the contractor, a certified Home Energy Rating System (HERS) rater should perform a field inspection, including various tests to measure infiltration leakage and ventilation duct efficiency.

Benefits

Well-designed duct distribution systems reduce energy costs and greenhouse gas emissions, improve comfort and may allow for smaller HVAC equipment to be installed.

Duct testing can uncover potential problems in leakage and distribution, and may cut maintenance costs by reducing complaints about heating and cooling inconsistencies.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

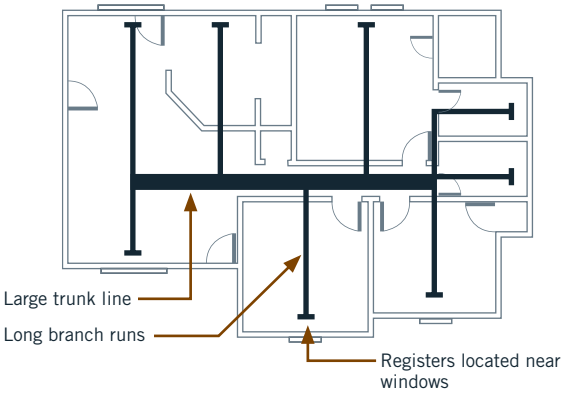
Duct effectiveness measures are applicable wherever a forced-air HVAC system is used *(Systems: H0–Heating Equipment)*.

Design Details

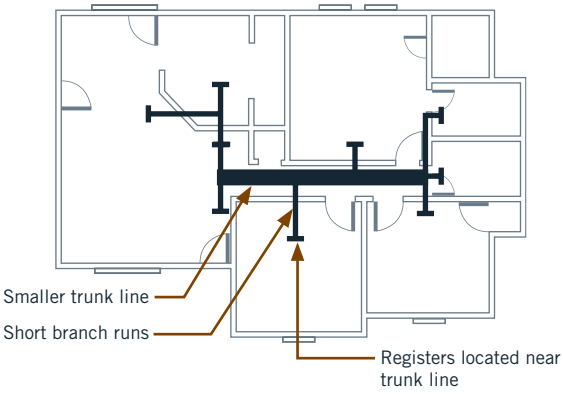
For maximum effectiveness, design duct layout and chases early. Proper design, especially in an already energy-efficient building, may allow for equipment downsizing. Strategies include:

- Minimize duct runs by locating registers close to the building's core and away from windows.
- Size the heating and cooling equipment using Air Conditioning Contractors of America (ACCA) Manual J load calculations.
- Design the duct system using ACCA Manual D Duct Design guidelines.
- Locate ducts in conditioned areas of the building, such as within a ceiling plenum in hallways or between floors in a multistory building.
- Use draw bands and mastic to seal duct joints and around elbows. Don't use duct tape.
- Keep duct runs short with few bends.
- Insulate all ducts located in unconditioned areas (such as attics, crawl spaces and exterior walls) to R-8. For ducts located within the conditioned envelope, insulating to R-4.2 is adequate.

STANDARD AIR DISTRIBUTION SYSTEM



HIGH-EFFICIENCY AIR DISTRIBUTION SYSTEM



Efficient duct design and placement can result in simpler systems with lower energy use. The top illustration shows a perimeter ducted system. In buildings with increased insulation, short duct runs to the center of the building will supply ample heating while reducing materials and heat losses.

Whether remodeling or constructing a new building, have the building tested for thermal envelope and HVAC effectiveness to help uncover errors and fix potential problems with installation or maintenance. Inspection and diagnostic evaluations should include the following three measures:

» Use a certified HERS rater to test the duct system's air delivery in cubic feet per minute (cfm). The results should be within 10% of design flow calculations. Pressurize ducts and verify that leakage is under 15% for retrofits and 6% for new construction.

» Have a blower door test performed to estimate the interior natural air changes per hour (NACH) for the whole house. The NACH should be close to or less than 0.35; if it isn't, make any necessary improvements and test again.

» Perform a combustion safety test if needed to ensure carbon monoxide is not backdrafting into the home from an open-combustion fireplace, water heater or furnace.

When replacing an existing HVAC 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 ongoing operations. A correctly sized system will also perform more efficiently because cooling/heating capacity will match the loads.

Code Considerations

California's Building Energy Efficiency Standards (Title 24) include provisions for duct testing in low-rise (3 stories or less) and high-rise (4 stories or more) residential buildings.

LOW-RISE RESIDENTIAL BUILDINGS

New construction. The prescriptive method of compliance with Title 24 requires duct sealing and testing in all new homes. But the vast majority of projects follow the performance method of compliance, which allows tradeoffs between conservation measures. As a result, duct testing is done in less than half of all new homes built today. However, duct sealing and testing should always be considered because it is easy to do, inexpensive and results in significant energy savings.

Remodels and additions to existing homes. When a home is remodeled or an addition built, the existing HVAC system commonly is extended or a new HVAC system is installed. If a new HVAC system is installed as part of the remodel or addition, the code considerations are the same as for new construction. Even if duct sealing and testing is not required per Title 24, it should be considered due to its ease and energy effectiveness.

If the existing HVAC system is extended to new areas or duct work is replaced (40 linear feet of duct work or more), the duct system must be sealed and tested. The duct leakage must be reduced to less than 15% of fan flow or the leakage must be reduced by 60% of the pre-work condition.

Replacement HVAC systems in existing homes. When a furnace or air conditioning system in an existing home is replaced, Title 24 requires (in most climate zones) that the duct system be sealed and tested. The duct leakage must be reduced to less than 15% of air flow or the total leakage must be reduced by 60%. Duct system repairs and duct sealing must be done in accordance with Title 24 requirements; tapes and mastic must be labeled UL181 and cloth backed duct tape is not allowed.


PRACTICA CONSULTING

Duct testing can uncover potential problems in leakage and distribution.

Under the Title 24–2008 (effective in 2009) replacement air conditioning systems will also require refrigerant charge testing and air flow testing.

HERS verification. Duct sealing and testing is completed by the installing contractor and then it is field verified by a HERS rater. The HERS rater does not have to test every system, rather the HERS rater is allowed to randomly sample jobs to ensure quality. Typically the HERS rater tests one in seven jobs.

HIGH-RISE RESIDENTIAL BUILDINGS

Title 24 standards for HVAC duct systems in high-rise residential buildings are not as strict as the low-rise standards. Air leakage from the duct system in high-rise buildings often times is quite high. HVAC duct sealing and testing should always be considered for high-rise residential buildings. Following the low-rise installation guidelines and standards in high-rise buildings will typically achieve significant energy savings.

Considerations for Residents

Duct effectiveness may provide health benefits by reducing airborne pollutants such as excess moisture, outside pollution, unpleasant odors, and dust and other particulates from outdoors or unconditioned areas of the building. Effective duct design and installation also result in quieter operation, reduced energy costs and a more comfortable home.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Duct testing and sealing during construction is highly cost effective. It saves between 10% to 20% of the HVAC operating costs over the building's life, for a one-time cost of about $250 per unit. That cost may be offset by rebates available for Energy Star certification or utility program incentives.

Placing ducts in conditioned spaces can be very cost effective because it reduces distribution losses and minimizes HVAC system loads.

Appropriate duct sizing can also cut costs through reduced materials and labor and downsized equipment. Investing in the proper design and installation of ducted systems will result in better performance, energy savings and a more comfortable home

Increasing duct insulation above minimum code requirements can be done for a nominal cost when installing new ducts. Depending on the building and the duct layout, it may be prohibitively expensive as a retrofit option.

Resources

» **California Energy Commission** has information about HERS providers: www.energy.ca.gov/HERS

» **Energy Star** offers fact sheets on duct sealing and insulation, and more: www.energystar.gov

» **HERS** provider websites list duct testing companies: www.cheers.org, www.cbpca.org, and www.calcerts.com

» **Local utilities** may offer rebates for improving duct efficiency; check with the local utility agency or www.flexyourpower.org

Related Case Studies

» Sara Conner Court Apartments, p. 221

» Village Walk, p. 151

FINISHES & FURNISHINGS

FINISHES & FURNISHINGS

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FINISHES & FURNISHINGS

Creating a multifamily green building doesn't end with the design of the structure and systems. The finishes and furnishings that help transform a building shell into a home play an important—and often highly visible—role in determining how green and healthy that home will be.

Certain conventional finishes and furnishings may undermine a project's green goals. For example, cabinets made with particleboard or medium density fiberboard (MDF) containing urea-formaldehyde binders may continue to release formaldehyde, a carcinogen, into a home for years after installation. Using environmentally preferable finishes and furnishings can help ensure that a building is durable, resource efficient and healthy for workers and residents.

BENEFITS

This table lists the Guidelines' Finishes & Furnishings measures and their primary benefits. *(See the individual measures for details.)*

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
K1 Entryways	✓					✓	✓	
K2 Recycled paint					✓			✓
K3 Low/no-VOC paint and other coatings	✓						✓	
K4 Low-VOC adhesives and sealants	✓						✓	
K5 Environmentally preferable materials for interior finish	✓				✓		✓	✓
K6 Reduced formaldehyde in interior finishes	✓						✓	
K7 Durable cabinets	✓				✓	✓	✓	
K8 Environmentally preferable interior furniture	✓				✓	✓	✓	
L1 Environmentally preferable flooring					✓			✓
L2 Low-emitting flooring	✓						✓	
M1 Energy- and water-efficient appliances			✓	✓		✓	✓	✓
M2 Central laundry	✓		✓	✓	✓	✓	✓	✓
M3 Recycling and waste collection					✓	✓	✓	✓
M4 Lighting	✓		✓				✓	✓
M5 Elevators			✓			✓	✓	✓
M6 Outdoor play structures	✓	✓			✓		✓	

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate thebuilding, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to the building's operations and location.

CORE CONCEPTS

DESIGN PROCESS

Ideally, green finishes and furnishings should be specified early, as part of an integrated design process *(see the introduction to these Guidelines).* It is possible, however, to make incremental improvements to a conventional building that is already underway or to retrofit an existing building by including some green finishes and furnishings. For example, if the original design calls for vinyl flooring, it may be possible to substitute natural linoleum *(L1)* if there is funding for the added cost. Low-or no-VOC paints *(K3)* can readily be substituted for conventional VOC-compliant paints.

Some recommended measures in this section need to be planned for early in the design process, such as providing adequate space for recycling collection *(M3)* and including central laundry facilities *(M2).*

AVAILABILITY

Green and healthy finishes are now much more readily available than even a few years ago. All major paint manufacturers, for example, make low or zero-VOC paints *(K3).* There are many suppliers of linoleum and recycled-content carpet *(L1).* Other products, while generally available, may require more effort to obtain, such as cabinetry with no added formaldehyde *(K6, K7).*

COST

It is critical that operations and maintenance costs be taken into account when considering the costs of finishes and furnishings. Some conventional products cost less initially than environmentally preferable options, but are inferior in quality and will require frequent and costly maintenance, repair or replacement. Some of the measures in this section, such as energy-efficient appliances, lighting and elevators *(M1, M4, M5)* will also reduce energy costs, saving money for the building owner and residents year after year.

Many green finishes and furnishings are cost-competitive with conventional products and can be used in virtually any affordable multifamily housing project. These include low-VOC paints *(K3),* recycled-content carpet *(L1),* and entryways designed to reduce tracked-in pollutants *(K1).*

Certain materials, such as recycled glass tile and FSC-certified wood flooring *(L1),* may tend to cost more than conventional products, requiring a special commitment from the developer. But some of these more expensive green products may provide a marketing advantage—attractive green materials have a certain cachet among environmentally aware renters, homebuyers, and perhaps even funders.

INSTALLATION AND SCHEDULING

On any jobsite, whether it's a green or conventional project, it is important to follow safe and healthy practices such as providing proper ventilation when applying paint, adhesives and sealants. Carrying out an IAQ management plan *(A3)* for construction and preoccupancy phases is strongly recommended. This may affect scheduling. For example, flushing out interior spaces may require extra time in the construction schedule.

PRODUCT SUBSTITUTIONS

Be sure the entire design and construction team understands the project's green building goals and requirements so that design intentions aren't compromised by product substitutions. In bidding and construction documents, clearly spell out product specifications, and, where appropriate, provide product brand names and even contact information for local suppliers.

INSIDE STORY:
HEALTHY, DURABLE INTERIORS FOR AFFORDABLE HOUSING
First Community Housing, San Jose, CA

At First Community Housing, a San Jose–based nonprofit developer and manager of affordable housing, the commitment to good design extends well beyond what the eye can see.

INDOOR AIR QUALITY AND DURABILITY

"Indoor air quality is as important to us as energy efficiency," said Marty Keller, FCH's director of construction management, even though the case for energy efficiency is sometimes more clear-cut because "the savings are easy to see. You can't measure the improvements for IAQ."

Although the benefits may be harder to quantify, providing healthier homes is a core value for FCH. Low-VOC paints and adhesives, healthier carpets and low-emitting products approved by third-party organizations such as Green Seal are all standard practice at FCH.

Durability also ranks near the top of FCH's priorities. When evaluating a flooring material, for example, FCH looks at the floor's lifecycle cost over a projected building life of fifty-five years. FCH has found that "vinyl flooring lasts five years on average," Keller said, while "linoleum on average lasts fifteen years. So even though linoleum costs 50% more to put in, it lasts so much longer that the net annual cost is much lower."

SCHEDULING

Keller encourages developers to be alert during the course of construction for opportunities to upgrade to greener finishes. Even if vinyl flooring is initially specified, "Ask your contractor what's the last possible date to change from vinyl to linoleum without slowing progress of the job," he recommended. By that point, it may be possible to release some contingency money from the budget if you haven't encountered unexpected expenses such as undiscovered gas tanks or toxic chemicals in the soil. Contingency funds can be freed up to cover the extra upfront cost of linoleum, and the substitution can be made without disrupting the construction schedule.

TRANSFORMING THE MARKET

In many green product categories, including flooring and paints, Keller is seeing more demand, more competition and more supply. "Years ago low-VOC paint didn't last long and had a frightful premium. Now the premium has just about disappeared or disappeared altogether. For a lot of green building materials, the premium has gone away, and the durability has gone up substantially."

Keller concedes that there are still challenges when it comes to obtaining certain green materials. On two recent projects, FCH was able to get cabinets made with no urea formaldehyde. "But this [green cabinets] industry is in its infancy," Keller said. "The amount of product available for production housing is limited and it's still expensive."

Multifamily developers can play an important role in advancing the market for green building products. "Our suppliers know that when you get a call from First Community Housing, the inevitable question is: What have you got that's green? Even if we don't directly ask, we expect our vendors and suppliers to come to us with green products," Keller said.

For more information, visit www.firsthousing.org

MEASURE K1

ENTRYWAYS

Design Entryways to Reduce Tracked-In Contaminants

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 12 48 13: Entrance Floor Mats and Frames, **12 48 43:** Floor Mats

OLD: 12484: Floor Mats and Frames, **12485:** Entryway Track-off Systems

Recommendation

Minimize the amount of contaminants tracked inside by installing walk-off systems at the entryways of buildings and units.

Where possible, specify easily cleaned flooring with a hard surface for the building's entryways and the units' doorways. Provide features in the units' entryways for shoe removal and storage.

Description

An important way to improve indoor air quality (IAQ) is to reduce the amount of dust and particulates entering the building from foot traffic. Up to two-thirds of dust in homes is tracked in on occupants' shoes. The dust contains everything from soil and pesticides to abrasive sand, mold, road grime and bacteria. Once these particulates are inside the building, they can be difficult to get rid of, especially from surfaces such as carpet that readily trap and absorb large amounts of particulates and liquids.

Benefits

Proper entryway design reduces the amount of dust and toxins tracked into the building.

In common-area entryways that are maintained by a janitorial staff, good entryway design can reduce cleaning costs and prolong the life of flooring materials.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

All multifamily buildings can be designed for entryway pollutant control at the common entrances. Within units, including a feature for shoe removal and storage is easy in new buildings and feasible for many retrofit projects.

Design Details

In multifamily buildings, there are two opportunities to positively affect IAQ through entryway design: the common entry areas, such as lobbies, hallways, balconies, laundry rooms, community rooms and elevator areas; and the living units themselves. The IAQ and health implications are greatest in the living units, especially those occupied by children and elderly residents, and in other spaces where people spend a lot of time, such as work spaces in mixed-use buildings *(Planning & Design: AA4–Mixed-Use Developments).*

Here are strategies for good entryway design:

COMMON ENTRANCES

» Specify a three-component track-off entryway system that consists of:

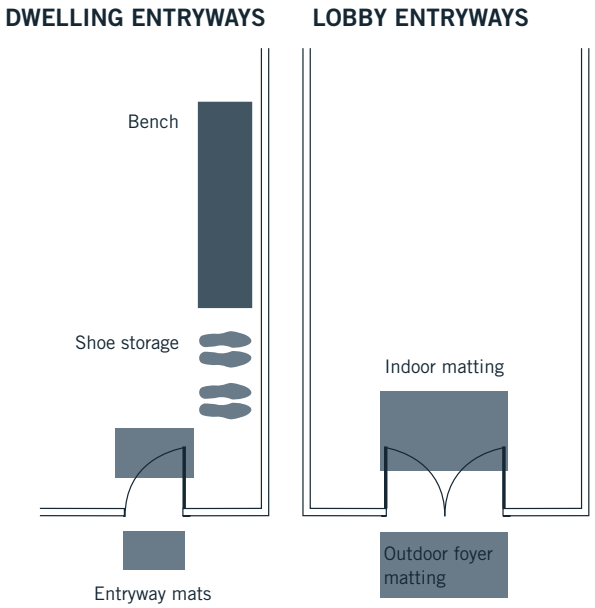
1. A permeable outdoor mat or grille system to collect loose dirt and water;
2. Indoor mats that brush or scrub shoe soles as people walk across them; and
3. A duster or finisher mat that removes remaining dirt and helps dry shoes.

» In buildings with large foyers or lobbies, the track-off system should extend at least 30 feet. In smaller buildings, aim for track-off systems that are as close to that length as possible.

» Specify a smooth-surface, waterproof flooring material that is easily cleaned and will collect any remaining contaminants from footprints (such as tile or stained concrete.

» Glazed tiles or other flooring may become slippery when wet. Use anti-slip products or methods where this is a concern.

» Avoid carpet at entryways because it is hard to clean and it traps dirt.



Entryways with walk-off mats reduce the amount of dust and toxins tracked into the building.

» Regularly clean indoor and outdoor entryway areas *(Operations & Maintenance: N1–Operations and Maintenance Procedures).*

» Pave walkways leading to entries and discourage foot traffic through landscaped areas.

» Avoid using pesticides and other chemicals near buildings *(Site: B1–Sustainable Landscaping).*

» Directly inside entryways, specify durable wall finishes that are easy to clean or touch up. Semi-gloss paint coupled with wainscoting, chair rails, baseboards and corner guards will reduce everyday wear-and-tear.

DWELLING UNITS

» Provide track-off mats at each unit's entryway. Choose recycled-content track-off products. A number of vendors now use recycled rubber and other natural materials for track-off products and doormats *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

» Avoid adhered carpeting at entryways. Choose easily cleaned flooring with a hard surface, such as hardwood, bamboo, concrete, ceramic tile or natural linoleum *(Finishes & Furnishings: L1–Environmentally Preferable Flooring).*

» Provide areas inside each unit near its entryways for removal and storage of outdoor shoes and wet outerwear. This may take the form of a tiled floor with a bench and shoe-storage cupboard, or a mudroom.

» Address proper cleaning practices in the residents' manual *(Operations & Maintenance: N1–Operations and Maintenance Procedures).*

Code Considerations

Work with local jurisdictions to design entryways that are accessible to all residents, and take into consideration potential changes in tenant types in the future *(Planning & Design: AA8–Adaptable Buildings).* Carefully design ramps and stair assemblies so that they meet accessibility requirements while also allowing for track-off systems. In units, features for shoe removal and storage should also meet accessibility requirements.

Considerations for Residents

Occupants will benefit from having cleaner entrances and fewer contaminants inside their homes.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Techniques for managing entryway contamination can be as simple as floor mats. Other strategies, including tile or hard surfaces for entryways, can cost more than carpeting, but have the potential to last much longer. A three-step grille system with mats and easy cleaning access will add some expense; such systems are often special-order items requiring additional design time.

Within units, dedicated mudrooms may be too expensive in urban areas or for affordable housing, but it costs little to include a feature for shoe removal and storage near the entryway.

Resources

» ***Environmental Building News*** has an article, "Keeping Pollutants Out: Entryway Design for Green Buildings" (Oct. 2001); fee to access: www.buildinggreen.com

Related Case Studies

» Crossroads, p. 234

MEASURE K2

RECYCLED PAINT

Use Recycled-Content Paint on Exterior Surfaces

KEY BENEFITS	
Health/IEQ	√ Material Efficiency
Site/Community	O&M
Energy Efficiency	Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 09 91 13: Exterior Painting

OLD: 09910: Exterior Paints

Recommendation

For outdoor painting, specify recycled-content latex paint.

Description

Some paint manufacturers make high quality, economical, recycled paint for use in place of standard latex paint. The recycled portion (ranging from 20% to 100%) comes from postconsumer or postindustrial stock, as well as paint recovered from household hazardous waste collection facilities.

Until recently, recycled paints have only been recommended for exterior uses because of their high levels of volatile organic compounds (VOCs). Currently, however, at least one manufacturer makes a recycled interior paint with less than 50 grams per liter of VOCs *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings).*

To make recycled paint, manufacturers typically filter the collected paint to remove solids, mix it with some new white paint to add coloring flexibility, adjust the pH and add pigments to achieve the desired shade. Although most recycled paint has at least 50% recycled content, other recycled percentages are available.

Recycled latex paint is available in a wide variety of colors, and is applied just like other paint.

Benefits

Recycled paint is often less expensive than new paint. It also reduces the need to use virgin resources to manufacture new paint.

According to the California Integrated Waste Management Board, "The average household stockpiles 1 to 3 gallons of waste paint per year, according to several studies. In California, unless latex paint is reused or recycled, it is considered a hazardous waste and must be disposed of in a Class I hazardous waste landfill."

Using recycled paint creates demand for what would otherwise be a waste product, and helps strengthen the infrastructure for collecting and recycling used paint.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to outdoor areas requiring painting or repainting.

For painting interior living spaces, choose recycled or nonrecycled interior paint with less than 50 grams per liter of VOCs *(Finishes & Furnishings: K3–Low/No-VOC Paints and Coatings).* For interior spaces that are isolated from living areas, such as garages and utility rooms, higher VOC recycled paints can be considered.

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.

Design Details

Recycled latex paint is applied like conventional paint. Due to the blended nature of the paint, it tends to come in a limited range of colors.

Code Considerations

Same as standard practice.

Considerations for Residents

No concern for exterior use.

Offgassing of VOCs is an indoor air quality concern. At least one manufacturer has developed a low-VOC recycled interior paint (< 50 gpl); more recycled interior paints may be available in the future.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Recycled paint is often less expensive than new paint of comparable quality.

PRACTICA CONSULTING

Paint being strained for recycling.

Resources

» **Build It Green Product Directory** has information about sourcing recycled paint: www.BuildItGreen.org

» **California Integrated Waste Management Board** has information about recycled paint and a list of manufacturers and sources: www.ciwmb.ca.gov/ConDemo/Paint

» ***Environmental Building News*** has articles on recycled paint, including "Recycled-Content Paint Standard Released" (Dec. 2006); fee to access: www.buildinggreen.com

» **Green Seal,** a nonprofit organization that sets standards for environmentally preferable products, has developed a standard for recycled-content latex paint: www.greenseal.org

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

MEASURE K3

LOW/NO-VOC PAINTS AND OTHER COATINGS

Specify Low and Zero-VOC Interior Paints, Stains and Other Coatings

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 09 91 23: Interior Painting

OLD: 09910: Interior Paints

Recommendation

Specify low or zero-VOC paints and other coatings for all interior applications.

Description

A coating is "a material which is applied to a surface in order to beautify, protect, or provide a barrier to such surface," as defined by South Coast Air Quality Management District (SCAQMD) Rule 1113. Common coatings are lacquers, paints, primers, sealants, shellacs, varnishes and wood preservatives.

The strong smell that paint and other coatings normally emit is from the evaporation of volatile organic compounds (VOCs). Offgassing of VOCs that occurs during painting and for a few days afterward can be substantial, affecting the health and comfort of painters and occupants.

Most, but not all, low- and no-VOC paints are water-based. The terms low-VOC and zero-VOC do not necessarily mean that the product is free of potentially toxic chemicals. See the sidebar on other coating chemicals of concern.

As an alternative to conventional paint, tinted gypsum plaster and natural clay plaster can be a less-toxic interior finish option.

Look for the VOC content of paints and other coatings on the product label or on the MSDS and technical data sheets and specifications. Choose products that do not exceed the VOC limits established by SCAQMD Rule 1113, Architectural Coatings (rule effective July 1, 2008), shown in the following table. Most suppliers now carry products that meet these VOC limits.

COATING CATEGORY	MAXIMUM VOC LIMIT (GRAMS OF VOC PER LITER OF COATING)
Clear Wood Finishes	275
Clear Brushing Lacquer	275
Fire-Proofing Exterior Coatings	350
Fire-Retardant Coatings	
Clear	650
Pigmented	350
Flat Coatings	50
Floor Coatings	50
Mastic Coatings	300
Multi-Color Coatings	250
Nonflat Coatings	50
Nonflat High Gloss	50
Primers, Sealers and Undercoaters	100
Quick-Dry Enamels	50
Quick-Dry Primers, Sealers and Undercoaters	100
Recycled Coatings	250
Roof Coatings	50
Aluminum-based	100
Primers (Bituminous)	350
Shellac	
Clear	730
Pigmented	550
Stains	100
Waterproofing Sealers	100
Concrete/Masonry	100
Wood Preservatives	
Below-Ground	350
Other	350

For a complete listing of VOC limits, see: www.aqmd.gov/rules/reg/reg11/r1113.pdf

Benefits

Low and zero-VOC coatings improve indoor air quality for workers and occupants. These products also reduce ground-level ozone, commonly known as smog.

Other Chemicals in Coatings

Although low-VOC and zero-VOC coatings can contain lower levels of potentially toxic chemicals, most coatings are not entirely free of toxins. Coatings will not have a list of ingredients on the label. Refer to the product's Material Safety Data Sheet (MSDS) for a listing of potentially toxic ingredients. An MSDS is required for all coatings and provides toxicity, flammability, safe use and hazards information. Manufacturers are required to provide MSDS upon request and most make them readily available on their websites.

Some third-party certification programs look beyond the VOCs regulated by the SCAQMD to additional hazardous and toxic chemicals. Look for products that meet California's Specification Section 01350 *(for information, see Structure: F1–Insulation),* Green Seal's Standard GS11, or Scientific Certification Systems' Indoor Advantage Gold *(see Resources).* Some of the chemicals screened by these programs include formaldehyde, ketones, phthalate esters, and aromatic hydrocarbons such as benzene. While these programs offer further restrictions and screening for potentially toxic chemicals, be aware that certified products may still contain toxic chemicals.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all new construction and as part of rehabilitation, unit turn-over and routine maintenance. Applicable to all interior surfaces except metals and plastics. *(See Finishes & Furnishings: K2–Recycled Paint for exterior paint recommendations.)*

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.

When possible, specify factory-applied sealers on metals.

Design Details

Proper paint and coating application is an important aspect of good indoor air quality (IAQ) construction practices. In addition to choosing low/no-VOC paints, stains and coatings, minimize potential IAQ concerns by specifying that materials be finished offsite whenever possible. Also allow sufficient ventilation and airing out of the areas during and after painting or coating to reduce exposure to VOCs *(Site: A3–Construction Environmental Quality).*

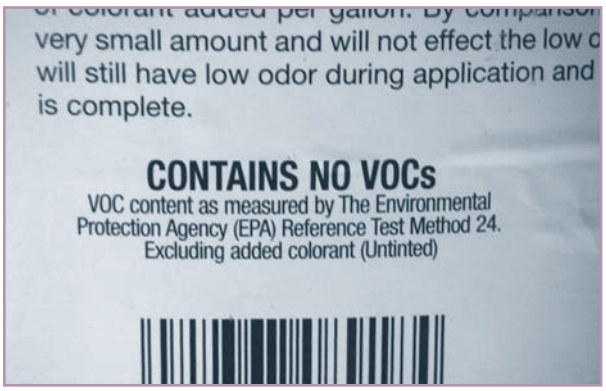
To improve durability and make cleaning easier in heavily used spaces such as corridors, restrooms and laundry facilities, use a semi-gloss or high-gloss paint.

VOC levels are generally reported for the base paint before the product is tinted. Most tints are synthetic and 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 volatiles than light colors. Some manufacturers only offer low-VOC paints with light and moderate tints.

Some professional contractors and suppliers may have a negative view of low-VOC products due to problems with first-generation products. Make sure they have tried the latest products, because low/no-VOC paints and coatings have been reformulated to improve performance. Performance issues such as spread, cover and drying time are related to the quality and type of paint, sealant or coating, not the product's VOC content.

Code Considerations

VOC limits are regulated by the U.S. Environmental Protection Agency nationally and the State of California locally. Most paints and coatings are labeled with language such as "Low-VOC Compliant" or "VOC Compliant." This simply means that the product meets California's VOC limits and is legal for sale in the state. It does not mean the product meets VOC levels recommended by the *Multifamily Green Building Guidelines.*



Look for the VOC content of paints and other coatings on the product label or on the MSDS.

Considerations for Residents

Many people, especially those with chemical sensitivities, can have adverse reactions to paints and coatings. Low- or zero-VOC coatings may or may not prevent these reactions.

Educate occupants and building maintenance staff about the benefits of low/no-VOC paints and coatings and encourage them to use these products *(Operations & Maintenance: N1–Operations and Maintenance Procedures).*

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Some zero-VOC paints are considered premium grade by manufacturers and cost the same as conventional premium-grade paints. However, more contractor-grade products are becoming available in low/no-VOC varieties; these are priced lower than premium paints. The incremental retail price of most low/no-VOC paints and coatings ranges from $0 to $4 per gallon, depending on brand, quantity and product line differences.

Paint quality may affect product or labor costs because it affects application, coverage, dry time, resistance to peeling and flaking and other characteristics. Check with professional installers to find the best quality low/no-VOC products.

Resources

- **Build It Green** has a fact sheet about paint, and the Green Product Directory has information about sourcing low/no-VOC paints and coatings: www.BuildItGreen.org/products
- ***Environmental Building News*** reviews paint and VOC issues in the article, "Paint the Room Green" (Feb. 1999); fee to access: www.buildinggreen.com
- **Green Seal** verifies VOC levels and certifies products that do not contain harmful solvents, formaldehyde and specific heavy metals: www.greenseal.org
- **Housing and Urban Development** has lead paint safety information: www.hud.gov/offices/lead; or download HUD's Lead Paint Safety guide: www.hud.gov/offices/lead/training/LBPguide.pdf
- **Scientific Certification Systems** (SCS) verifies product's VOC claims: www.scscertified.com
- **South Coast Air Quality Management District's** (SCAQMD) Rule 1113 can be downloaded from: www.aqmd.gov/rules/reg/reg11/r1113.pdf

Related Case Studies

- Carmen Avenue, p. 230
- Colony Park, p. 227
- Crossroads, p. 234
- First Community Housing, p. 161
- Oxford Plaza, p. 15
- Sara Conner Court Apartments, p. 221

LOW-VOC ADHESIVES AND SEALANTS

Specify Solvent-Free, Low-VOC Adhesives and Sealants

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 07 91 26: Joint Fillers, **07 92 00:** Joint Sealants

OLD: 07920: Joint Fillers, Calking, Joint Sealants, Sealants

Recommendation

Specify solvent-free construction adhesives and sealants that do not exceed the VOC limits in South Coast Air Quality Management District's (SCAQMD) Rule 1168.

Description

Many conventional construction adhesives and sealants are solvent-based and release significant amounts of volatile organic compounds (VOCs). When possible, choose installation methods that do not require adhesives. If adhesives must be used, choose those that have the least negative effect on indoor air quality.

There are many solvent-free, water-based construction adhesives with low- or no-VOC content that pass all relevant industry performance tests. *(For more information about low/no-VOC products and related indoor air quality issues, see Site A3–Construction Environmental Quality and Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings.)*

PRACTICA CONSULTING

On construction walk-throughs, check discarded sealant and adhesive containers to verify they are low VOC.

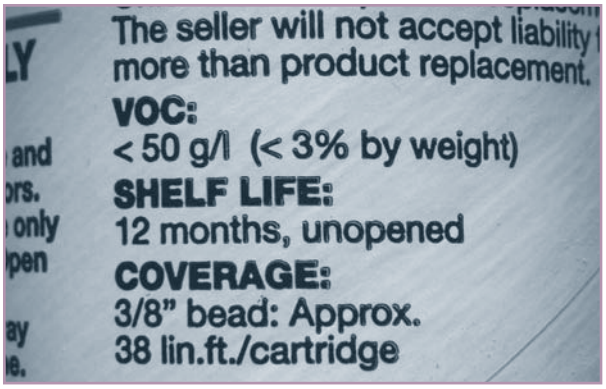
SCAQMD RULE 1168 VOC LIMITS

ADHESIVES	VOC LIMIT
Ceramic tile	65
Contact	80
Fiberglass	80
Metal to metal	30
Multipurpose construction	70
Rubber floor	60
Wood: structural member	140
Wood: flooring	100
Wood: all other	30
Welding: ABS (avoid)	325
Welding: CPVC (avoid)	490
Welding: plastic cement	250
Welding: PVC (avoid)	510
Plastic primer (avoid)	650
Special purpose contact	250
All other adhesives	50
SEALANTS	**VOC LIMIT**
Architectural porous primers (avoid)	775
Sealants and non porous primers	250
Other primers (avoid)	750
AEROSOL ADHESIVES (GS-36)	**VOC LIMIT**
General purpose mist spray	65%
General purpose web spray	55%
Special purpose aerosol adhesives	70%

VOC weight limit based on grams/liter of VOC minus water.
Percentage is by total weight.
GS=Green Seal standard

Benefits

Low/no-VOC adhesives improve indoor air quality for workers and occupants. These products also reduce ground-level ozone, commonly known as smog. Water-based adhesives clean up with water and soap, eliminating the need for toxic cleanup products such as paint thinner.



Low-VOC construction adhesives improve indoor air quality for workers and occupants and reduce smog.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Choose a low- or no-VOC adhesive product that meets industry performance standards and is appropriate to the material you are working with. Low/no-VOC polyurethane construction adhesives can be used on foam, wood, metal, fiberglass and most common building materials under most weather conditions. Low- and no-VOC adhesives are also available for carpeting, natural linoleum, tile and other building products.

Design Details

Choose low/no-VOC adhesives and sealants that meet the VOC limits in the 2007 South Coast Air Quality Management District (SCAQMD) Rule 1168, shown in the table above. Follow SCAQMD recommendations to avoid certain adhesives when possible.

To make implementation easier, include within the specifications the specific brand names of low/no-VOC products and locations of product retailers.

On construction walk-throughs, routinely check discarded sealant and adhesive containers and verify they are low-VOC. When adhesives are purchased in bulk, larger containers can often be returned to vendors for refill.

Many contractors are accustomed to using adhesives and sealants with high VOC content. Early discussion, training and product testing can alleviate contractors' concerns and ensure that the specified products are used.

Code Considerations

VOC limits are regulated by the U.S. Environmental Protection Agency nationally and the State of California locally. Most adhesives are labeled with language such as "Low-VOC Compliant" or "VOC Compliant." This simply means that the product meets California's VOC limits and is legal for sale in the state. It does not mean the product meets the VOC levels recommended by the *Multifamily Green Building Guidelines.* These Guidelines recommend meeting the SCAQMD standards for VOC content.

Considerations for Residents

Low- and no-VOC products protect indoor air quality.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Low and zero-VOC adhesives do not cost more than conventional products and are available through normal contractor suppliers.

Resources

» **Build It Green Product Directory** has information about sourcing low/no-VOC adhesives: www.BuildItGreen.org/products

» **Green Seal,** a third-party standards and certification organization, has environmental standards for commercial construction adhesives (GS-36): www.greenseal.org.

» **South Coast Air Quality Management District's** (SCAQMD) Rule 1168 for adhesives and sealants can be downloaded from: www.aqmd.gov/rules/reg/reg11/r1168.pdf

Related Case Studies

» Crossroads, p. 234

» First Community Housing, p. 161

» Oxford Plaza, p. 15

» Sara Conner Court Apartments, p. 221

ENVIRONMENTALLY PREFERABLE MATERIALS FOR INTERIOR FINISH

KEY BENEFITS	
√ Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 01 81 00: Sustainable Design Requirements, **Division 9:** Finishes

OLD: 01600: Product Requirements, **Division 9:** Finishes

Recommendation

Use environmentally preferable materials for interior finishes, including A) FSC-certified, B) reclaimed, C) rapidly renewable, D) recycled content or E) finger-jointed.

Each of these categories is described in separate sections below.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to cabinets, interior trim, shelving, doors, countertops and other interior finish materials. *(For interior furniture, see Finishes & Furnishings: K7.)*

Considerations for Residents

Environmentally preferable interior finish materials should have no direct effect on occupants. Be sure to check all products for potential odors, VOC emissions and maintenance needs to avoid indoor air quality problems. Some products, like recycled rubber flooring derived from tires, may emit unpleasant odors *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings, K6–Reduced Formaldehyde in Interior Finishes and L2–Low-Emitting Flooring).*

General Resources

See sections below for category-specific resources.

» **BuildingGreen** has listings of environmentally preferable materials and articles about criteria used to designate building products as green, including "Building Materials: What Makes a Product Green" (Feb. 2006); fee to access: www.buildinggreen.com

» **Build It Green** has fact sheets and other information about sourcing environmentally preferable materials, including the Green Product Directory: www.BuildItGreen.org

» **U.S. Environmental Protection Agency's** Environmentally Preferable Purchasing (EPP) website provides guidance on procuring green building products: www.epa.gov/epp

A. FSC-Certified Wood

Description

The Forest Stewardship Council (FSC) is a non-governmental organization that promotes standards for sustainable forestry certification worldwide and accredits forestry certifiers. FSC principles include management for biological diversity, long-term forest health and long-term economic well-being of local communities.

FSC tracks and monitors wood throughout the chain-of-custody—as it moves from harvesting to manufacturing and distribution and finally to the point of sale—to ensure that the customer is actually getting a certified sustainably harvested product.

FSC authorizes third-party certifying organizations to carry out certification. In the United States, these organizations are SmartWood and Scientific Certification Systems (SCS). These groups certify forest lands and chain-of-custody forest products based on FSC standards.

Benefits

FSC certification guarantees that forests are managed in a way that will assure the long-term availability of wood while protecting the health of forests and the natural resources they contain and support.

Application

Many interior finish products are available with FSC-certified wood content, including flooring, cabinetry and veneers *(Finishes & Furnishings: K7–Durable Cabinets and L1–Environmentally Preferable Flooring).*

Design Details

It is important to coordinate with suppliers in advance to ensure availability and secure the best pricing. In some markets, FSC-certified hardwoods (for cabinet faces and floors, for example) may be more readily available and cost competitive than FSC-certified softwoods.

(For more information about environmentally preferable wood products, see D4–Engineered Lumber and D5–FSC-Certified Wood for Framing Lumber; and Finishes & Furnishings: L1–Environmentally Preferable Flooring.)

Code Considerations

There are no code issues with certified wood.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

In general, FSC-certified hardwoods are easier to find and more cost competitive than FSC-certified softwoods. FSC softwood prices are generally higher than noncertified lumber, while FSC hardwoods are generally about the same price. *(For more information about FSC-certified wood costs, see Structure: D5–FSC-Certified Wood for Framing Lumber.)*

Resources

Also see General Resources, above.

- **Forest Certification Resource Center** provides information about forest product certification programs (including FSC) and a searchable database of certified forests and forest products: www.certifiedwood.org
- **Forest Stewardship Council** (FSC) has information about FSC certification and maintains online lists of FSC products and manufacturers: www.fsc.org
- **Rainforest Alliance's SmartWood program** provides FSC chain-of-custody certification services: www.smartwood.org
- **Scientific Certification Systems** provides FSC chain-of-custody certification services: www.aqmd.gov/rules/reg/reg11/r1168.pdf

B. Reclaimed Materials

Description

Reclaimed materials, also called salvaged materials, can be used in many residential building projects. These materials come from many sources, including deconstructed or renovated buildings. Common salvaged materials include timber, doors, sinks, toilets, fencing, bricks, tile, pipes, hardware and light fixtures. Reclaimed lumber is among the most widely available salvaged products, as studs, beams, flooring and trim.

Benefits

Not only does salvaging and reusing materials reduce waste sent to landfills, it is also better than recycling from an environmental standpoint. The collection, transportation and processing of recycled-content materials uses energy and generates pollution. Reusing building materials—even if lumber needs to be re-milled or doors have to be repaired and painted—typically generates less waste and pollution than recycling does.

Salvaged materials can be less expensive than new materials, and may be of higher quality. Salvaged timbers have tighter grains than some new wood, for example. Reclaimed materials can also help give a building a distinctive character.

Application

Most applicable to small developments because of limited supply of matching salvaged products. On small projects, doors, lumber, hardware and other materials can often be found with little effort. Reclaimed materials can be challenging to incorporate into a large project.

Design Details

Finding salvaged materials, especially for large projects, can be time consuming. Supply is inconsistent, which makes it difficult to plan for large quantities of materials. On small projects, however, using salvaged materials is often possible. There is a readily available supply of materials that can fit into small developments.

Salvaged timber can be used for nonstructural applications. The use of salvaged timber is rare in structural applications because of the challenge of locating salvaged timber that has been re-graded by a qualified wood grader.

Take care when choosing reclaimed materials. Certain reclaimed products may undermine other green building goals. Old toilets and single-pane windows, for example, don't meet current water or energy efficiency standards.

In addition to using reclaimed materials, another important waste reduction strategy is to "close the loop" by donating or recycling unneeded materials. In the Construction and Demolition Waste Management Plan *(Site: A2),* stipulate that appropriate surplus materials be resold or donated to salvage yards or nonprofit organizations. Also, some building products manufacturers will take back clean, unused scraps to be made into new products (for example, gypsum board, ceiling tile, carpet and fiber-cement products). Organizing materials on site will allow for quick separation of reusable materials for donation *(Structure: D3–Construction Material Efficiencies).*

Code Considerations

Salvaged or reclaimed lumber may not meet structural requirements for some applications. Some salvaged materials, such as single-pane windows, toilets that use more than 1.6 gallons per flush, and wood-burning fireplaces are not recommended and may not be allowed by state and local regulations.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Some reclaimed products are very inexpensive, costing much less than new materials. Doors, for example, are widely available and can be found in small matching sets from most salvage companies. Other products, like salvaged flooring, are in higher demand and may have a price premium.

Large quantities of matching reclaimed materials are difficult to find. Sourcing, installing and finishing certain reclaimed materials may increase labor costs.

Resources

Also see General Resources, above.

» **California Integrated Waste Management Board's** Recycled Content Products Directory includes sources for reclaimed materials: www.ciwmb.ca.gov/rcp

C. Rapidly Renewable Materials

Description

The depletion of finite raw materials and long-cycle renewable materials can be reduced using rapidly renewable materials. Rapidly renewable materials are plant- and animal-based agricultural products that take 10 years or less to grow or raise and harvest. These include bamboo, wool, cotton insulation, linoleum, cork, strawboard and other agrifibers.

Benefits

Buying products comprised of rapidly renewable materials helps to reduce the depletion of forests and other natural resources that take many years or decades to regenerate.

Application

Rapidly renewable materials can be used in many applications, including floors, countertops, cabinets and insulation.

Design Details

Use as you would traditional interior finish materials.

Code Considerations

There are no code considerations with rapidly renewable materials.


PRACTICA CONSULTING

Bamboo, a rapidly renewable resource, is often used for flooring and cabinetry.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Depending on the product, rapidly renewable materials may cost less, the same or more than conventional products.

Resources

See General Resources, above.

D. Recycled-Content Materials

Description

Recycled-content products are inherently more sustainable than virgin raw materials because they provide a market for products that have already been used in the same or another application. These products are often similarly priced, perform equally well and reduce the environmental impacts associated with the extraction and processing of virgin materials.

There are two types of recycled content, postindustrial (also called preconsumer), and postconsumer:

» **Postindustrial/preconsumer waste.** Many manufacturers use waste from industrial processes to make new products. For example, sawdust from lumber mills is used as a feedstock for other building products, such as medium density fiberboard (MDF), high density fiberboard (HDF) or particleboard. Reusing manufacturing waste often costs less than using virgin materials, and it makes good financial sense for most manufacturers.

  Specifying products with postindustrial recycled content typically does not help reduce waste going to landfills or help maintain municipal recycling programs. For these reasons, specify products with postindustrial recycled content only if postconsumer content is not available.

» **Postconsumer waste** is material recovered after a product's useful life has ended and the product is ready to be discarded. Recovery is typically done through curbside collection programs. Materials are then refined into feedstock for new products.

Benefits

Buying products with postconsumer recycled content helps the environment by reducing the need to extract and harvest raw materials and by reducing landfill deposits. Preconsumer recycled-content products are also more environmentally friendly than virgin materials because they incorporate a waste product that might otherwise not be reused.

Application

Recycled-content building materials and finishes. The following table lists building products that are commonly available with recycled content. Typical and highest achievable percentages of recycled content are shown.

BUILDING MATERIAL	COMMON RECYCLED %	HIGHEST ACHIEVABLE %
Flyash in concrete	15 PI	60 PI
Rubber flooring	65 PC	90 PC
Carpet – commercial	50 PC backing 25 PC face	100 PC backing 25 PC face
Carpet – residential	50 PC face	90 PC face
Ceramic tile	25 PC	55 PC
Steel framing	25 PC	60 PC
Exterior paint	50 PC	75 PC
Bathroom partitions	20 PI	75 PC
Wood fiber products (MDF, etc.)	85 PI	85 PC

PI = postindustrial; PC = postconsumer

Recycled-content furnishings and maintenance products. Continue to buy recycled products after the project is occupied. Encourage tenants and maintenance staff to purchase recycled products such as paper towels, garbage bags and furniture *(Finishes & Furnishings: K8–Environmentally Preferable Furniture and M6–Outdoor Play Structures).* Include information on products with high postconsumer recycled content in manuals and trainings (*Operations & Maintenance: N1)* and in educational signage *(Operations & Maintenance: N3).*

Design Details

Not all manufacturers supply the recycled-content percentages of products on their cutsheets. The best method for determining the recycled-content percentage and type (postindustrial or postconsumer) is a call to the manufacturer. Some third-party labeling programs, such as Scientific Certification Systems (SCS), provide information about a product's recycled content.

Code Considerations

Many municipalities have adopted ambitious waste reduction goals. Recycling and purchasing recycled products helps meet local goals by increasing the market for recycled products.

Cost and Cost Effectiveness

BENEFIT ★★★
COST $$ $

Most recycled-content products are competitive with or less expensive than comparable virgin products. However, some recycled-content products cost more. These are typically high-end finish materials, such as recycled glass tile. Mainstream products such as insulation *(Structure: F1–Insulation)* and carpeting *(Finishes & Furnishings: L1–Environmentally Preferable Flooring)* have very little or no cost difference.

To reduce or avoid disposal costs in the long term, choose products that the manufacturer will take back at the end of the product's life. Also consider donating scraps or extra material.

Resources

Also see General Resources, above.

» **California Integrated Waste Management Board's** Recycled Content Products Directory provides information about where to buy recycled-content materials: www.ciwmb.ca.gov/rcp

E. Finger-Jointed Wood

Description

Finger-jointed trim and casing consists of short pieces of clear wood glued together to create a finished paint-grade material.

Benefits

Finger-jointed casing and trim are common finish materials for applications where a painted finish is desired.

Application

Many building suppliers, home improvement centers and lumber stores stock finger-jointed casing and trim.

Design Details

Because finger-jointed trim and casing is comprised of different pieces of wood with different grains, it should only be installed in applications where materials will be painted.

Code Considerations

No special code considerations.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

The cost of finger-jointed trim is the same as or less than solid-wood trim.

Resources

See General Resources, above.

Related Case Studies

» Crossroads, p. 234

» First Community Housing, p. 161

MEASURE K6

REDUCED FORMALDEHYDE IN INTERIOR FINISHES

Reduce Formaldehyde Emissions in Interior Applications

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 01 60 00: Product Requirements, **Division 9:** Finishes

OLD: 01600: Product Requirements, **Division 9:** Finishes

Recommendation

Choose cabinets, interior trim, shelving, subflooring and other interior finish materials with reduced levels of formaldehyde emissions.

Description

Formaldehyde is classified as a known carcinogen by the State of California's Proposition 65 regulation and by the World Health Organization. At levels above 0.1 parts per million (ppm) of air, formaldehyde may also cause other health problems, including watery eyes, burning sensations in the eyes, nose and throat, nausea, coughing, chest tightness, wheezing, skin rashes and allergic reactions.

Two types of formaldehyde binders (or glues) are widely used in the building industry: urea and phenol. Manufacturers commonly use urea formaldehyde binders for interior-grade pressed wood products because of their low cost and light color.

Pressed wood products made with urea formaldehyde adhesives are often the most significant sources of formaldehyde in the home. Homes with a lot of new pressed wood products can have formaldehyde levels greater than 0.3 ppm. These products include particleboard (used for subflooring and shelving and in cabinets and furniture); hardwood plywood paneling (used for decorative wall covering and in cabinets and furniture); and medium density fiberboard (used for drawer fronts, cabinets and furniture tops). Medium density fiberboard contains a higher resin-to-wood ratio than any other pressed wood product and is generally recognized as being the highest formaldehyde-emitting pressed wood product.

The amount of urea formaldehyde emitted from products decreases over time but initial concentrations can be quite high and emissions persist for several years.

The most common alternatives to urea formaldehyde include phenol formaldehyde, methylene diphenyl isocyanate (MDI) and polyvinyl acetate (PVA). Additional alternatives have been or are being developed, including soy-based adhesives that are formaldehyde free.

Phenol formaldehyde and MDI binders are mostly used in structural grade applications such as exterior grade plywood, oriented strand board (OSB), I-joists and engineered wood beams *(Structure: D4–Engineered Lumber).* Phenol formaldehyde binders are typically used in exterior applications because they provide better moisture resistance compared to urea formaldehyde. Phenol formaldehyde is more stable than urea formaldehyde and offgasses more slowly and in lower quantities, and therefore has less of a negative effect on indoor air quality.

Polyvinyl acetate (PVA) binders are widely used for applying veneers on interior-grade composite wood products. Common carpenter's glue is also a PVA adhesive. PVA binders are not waterproof and are only applicable for interior applications. PVA is water-based, cleans up with soap and water, and is formaldehyde free.

There are a number of government and third-party formaldehyde emissions standards *(see Code Considerations).*

Benefits

Avoiding products made with urea formaldehyde binders or reducing formaldehyde emissions in other ways protects indoor air quality.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to interiors of residential and commercial areas.

Design Details

Specify pressed wood products and other materials that do not use urea formaldehyde binders. Whenever possible, select products that meet California's Air Resources Board's ATCM Phase 2 criteria *(see Code Considerations).*

Reduced-formaldehyde alternatives are available for all types of interior finish products including door cores, trim, shelving, cabinets, workstations, furniture, subflooring and sheathing. Exterior/structural grade plywood or OSB can be substituted for many interior applications including subflooring, sheathing and cabinets.

Agrifiber products such as strawboard do not use formaldehyde binders and can be used in many applications. Pressed wood materials are available,

PHASE 1 (P1) AND PHASE 2 (P2) FORMALDEHYDE EMISSION STANDARDS (PPM)*

EFFECTIVE DATE	HARDWOOD PLYWOOD (VENEER CORE)	HARDWOOD PLYWOOD (COMPOSITE CORE)	PARTICLE BOARD	MEDIUM DENSITY FIBER BOARD	THIN MEDIUM DENSITY FIBER BOARD
01/01/2009	P1: 0.08		P1: 0.18	P1: 0.21	P1: 0.21
07/01/2009		P1: 0.08			
01/01/2010	P2: 0.05				
01/01/2011			P2: 0.09	P2: 0.11	
01/01/2012					P2: 0.13
07/01/2012		P2: 0.05			

**Based on the large chamber test method (ASTM E1333-96) in parts per million (ppm). Table from Staff's Suggested ATCM Modifications (April 26, 2007), adopted by CA Air Resources Board*

including interior grade plywood, particleboard and MDF, that use urea formaldehyde–free binders. Finger-jointed or solid wood trim can be substituted for urea formaldehyde–based MDF trim *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

If particleboard or plywood with urea formaldehyde–based binders cannot be avoided, a low-VOC wood sealant applied to all six sides of cabinet materials will reduce formaldehyde emissions *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings).* Specify two coats for best results.

Code Considerations

In 2007, California's Air Resources Board adopted an airborne toxics control measure (ATCM) to reduce formaldehyde emissions from composite wood products including hardwood plywood, particleboard, medium density fiberboard, and finished products made with composite wood products.

Starting on January 1, 2009 the program will begin phasing in formaldehyde emissions standards for these products. Companies selling or manufacturing these products in California will be required to obtain third-party validation of compliance (there are no code compliance issues for purchasers or users of these products). The table above shows phase 1 and phase 2 compliance levels. Phase 1 brings California code in line with standards such as California's "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers," also known as Specification Section 01350 *(see Structure: F1–Insulation for information about Section 01350),* European E1 emissions criteria and SCS Indoor Advantage Gold. Phase 2 thresholds are more stringent.

Considerations for Residents

Reduced exposure to formaldehyde creates a healthier indoor environment.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Availability and cost range greatly. Most, but not all, options cost more initially than standard practice. Costs will come down as manufacturers begin meeting new code requirements.

Resources

- **Build It Green Product Directory** has information about sourcing products with reduced formaldehyde: www.BuildItGreen.org/products
- **California Air Resources Board** has information about formaldehyde: www.arb.ca.gov/research/indoor/formaldehyde.htm; the formaldehyde regulations can be downloaded from: www.arb.ca.gov/toxics/compwood/carb1.pdf
- **California Integrated Waste Management Board's** Section 01350 is described at: www.ciwmb.ca.gov/greenbuilding/Specs/Section01350
- **Healthy Building Network** has information about formaldehyde in building products: www.healthybuilding.net/formaldehyde/index.html
- **U.S. Environmental Protection Agency** provides information about formaldehyde: www.epa.gov/iaq/formalde.html

Related Case Studies

- Crossroads, p. 234
- First Community Housing, p. 161
- Pepperwood Apartments, p. 121
- Sara Conner Court Apartments, p. 221

MEASURE K7

DURABLE CABINETS

Specify Long-Lasting Cabinets

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 06 40 00: Architectural Woodwork, **12 36 00:** Countertops

OLD: 06400: Architectural Woodwork, **06415:** Countertops

Recommendation

Install, replace and refurbish kitchen, bathroom and other built-in cabinetry using durable materials and methods.

Description

Durability is an important environmental attribute. Durable products and materials require less maintenance and replacement, which reduces waste and long-term costs. Cabinets experience significant wear and tear, especially in the kitchen and bathroom where water damage can occur.

These features contribute to a cabinet's durability:

- All casework is built with exterior-grade plywood or MDF, assembled with adhesives, screws and bolts.
- Doors are solid hardwood.
- Full extension drawer slides have ball bearings.
- Cabinet joints use dowel, biscuit or dovetail joining methods.
- Hinges are stainless steel and attach to doors from two directions.
- Bases use I-beam construction to strengthen base cabinets.

Uncoated particleboard isn't recommended for kitchen or bathroom cabinets. It's prone to swelling when wet and can fall apart much more quickly than other materials.

Durable finishes extend the life of cabinets. Cabinet boxes are commonly made with particleboard, MDF or plywood faced with thin veneers of wood or melamine. Powder coating, which is highly durable, started as a metal finish, but now a low-temperature powder coating process is used on wood, including cabinets, boxes, shelving and more. Powder coating is low in VOC emissions and seals in formaldehyde emissions from pressed wood products *(Finishes & Furnishings: K6–Reduced Formaldehyde in Interior Finishes).*

Benefits

Durable cabinetry lasts longer and reduces replacement costs and construction waste.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all projects. This measure addresses the durability of cabinets. *(For information about associated health issues, see Finishes and Furnishings: K3–Low/No-VOC Paints and Other Coatings and K6–Reduced Formaldehyde in Interior Finishes. For information about selecting green materials, see Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish.)*

Design Details

Focus on these areas when specifying cabinets:

1. **Substrate.** Use MDF or particleboard that is fully laminated with melamine or a wood veneer that has been sealed. Particleboard with exposed surfaces will fail in just a few years. In high abuse installations, specify plywood boxes of 5/8 in. thickness or greater. For durable corner connections, use dovetail, biscuit or dowel methods, which further increase the cabinets' longevity.
2. **Face frames, doors and drawer fronts.** Use solid wood for the cabinet face frames, doors and drawer fronts to provide an attractive and durable exterior finish. At a minimum use fully laminated MDF.
3. **Hardware.** Use high quality adjustable hinges that are appropriate for the level of abuse anticipated. For example, hinges in senior housing complexes may not require the strength and rigidity of other occupant types. In high abuse situations, consider the difficulty of reattaching hinges to the substrate using existing screw holes. It is easier to rescrew hinges into plywood than into MDF or particleboard.
4. **Sealants and finishes.** Use water-based products with low VOCs *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings).* Avoid alkyd and oil-based stains and finishes. Water-based wood sealers and finishes perform as well as or better than oil-based finishes. If possible, have the cabinets finished

offsite to further reduce offgassing into the living space. Multiple coats add to durability because they provide better protection against water, scratches, impact and other wear and tear.

If particleboard or plywood with formaldehyde-based glues cannot be avoided, a low-VOC wood sealant applied to all six sides of cabinet materials will reduce formaldehyde emissions *(Finishes & Furnishings: K6–Reduced Formaldehyde in Interior Finishes).* Specify two coats for best results.

For a painted look, select powder coating *(see Description, above).*

5. **Installation.** Screw the cabinets together and to the wall. To make repair, replacement and salvage easier, avoid gluing them in place. If rodents or roaches are potential problems, install cabinets with tight backs, install escutcheons around plumbing and electrical penetrations, and caulk all cracks bigger than 1/16 in., such as between the wall and cabinets. This can help reduce common asthma triggers such as roach and mouse droppings, and reduce the need for chemical pesticides *(Structure: D2–Structural Pest and Rot Controls).*

Code Considerations

There are no code considerations regarding durable cabinets.

Considerations for Residents

Residents will appreciate the look, feel and quality of durable cabinetry. This, in turn, may increase the value of the homes.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

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.

Resources

» **ToolBase Services,** provided by the NAHB Research Center, publishes *The Rehab Guide, Kitchens & Baths (vol. 6),* with information about maintenance, repair and replacement of cabinets and hardware: www.toolbase.org (click on Design & Construction Guides)

Related Case Studies

» First Community Housing, p. 161

MEASURE K8

ENVIRONMENTALLY PREFERABLE INTERIOR FURNITURE

KEY BENEFITS	
√ Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: Division 12: Furnishings

OLD: Division 12: Furnishings

Recommendation

Specify durable interior furniture made from environmentally preferable materials such as FSC-certified or finger-jointed wood or reclaimed, rapidly renewable or recycled-content materials.

Choose low-emitting interior furnishings. Air out new furniture that is not low emitting to allow offgassing of formaldehyde and other VOCs.

Description

Many furniture products are made with materials that may be harmful to people, to the environment, or both. These products may require a lot of energy to produce, release pollutants during manufacturing or not be recyclable. Some products, such as the stuffing material and fabrics used in many couches, chairs and beds, may release formaldehyde or other volatile organic compounds (VOCs) for months.

Over the past few years the availability of environmentally preferable furniture for the commercial building sector has increased but the residential furniture industry still lags behind.

Benefits

Environmentally preferable furniture conserves natural resources. Durable hardware and furniture components extend the life of products, reducing waste and replacement costs. Furniture that emits zero or low levels of formaldehyde and other VOCs results in better indoor air quality.

For projects where a highly visible green image is desired, use alternative materials prominently in the furniture. Tables, chairs and doors made from salvaged or reclaimed materials, for example, can enhance a project's green image.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all projects. Furniture in multifamily buildings typically combines residential and commercial products. Residential furniture is found in units and in some recreational and common areas. Commercial furniture is generally used in lobbies, offices, main entry areas, hallways, clubhouses and shared laundry facilities.

For information about recycled-content site furnishings, including tables, benches and garbage and recycling bins, see Finishes & Furnishings: M6–Outdoor Play Structures. For information about kitchen and bathroom cabinets and other built-ins, see Finishes & Furnishings: K7–Durable Cabinets.

Design Details

Consider these issues when selecting environmentally preferable furniture:

FURNITURE MANUFACTURERS

Check a company's website or literature for details on their environmental practices. Look for these characteristics when comparing manufacturers:

- **Made in California:** California manufacturers are subject to the state's strict environmental regulations for emissions and waste disposal.
- **Efficient material use:** Reuses scraps and leftovers in the manufacturing process or recycles them elsewhere.
- **Recycled materials:** Promotes the recycled products industry by using recovered materials in their products *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*
- **Less packaging:** Minimizes packaging to reduce waste.

FIRST COMMUNITY HOUSING

Durable common area furniture.

» **Manufactured regionally:** Uses raw materials harvested close to the project and/or manufactures furniture close to the project.

MATERIALS

Select furniture made from environmentally preferable materials, including:

» **Wood products:** Use wood composites with no added formaldehyde, reclaimed wood or wood certified by the Forest Stewardship Council (FSC) *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish and K6–Reduced Formaldehyde in Interior Finishes).*

» **Rapidly renewable:** Use strawboard, bamboo or other agrifiber materials *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

» **Metals:** Use metal with recycled content, and factory-applied paints or coatings.

» **Plastics:** Avoid polyvinyl chloride (PVC). Use postconsumer recycled plastic or composite plastic products *(Finishes & Furnishings: M6–Outdoor Play Structures).*

» **Foams:** Avoid foams that use HCFCs as blowing agents *(H2–Air Conditioning with Non-HCFC Refrigerants).*

» **Fabrics:** Specify fabrics made from natural, renewable and biodegradable fibers and dyed or treated with low-toxicity, low-VOC dyes and chemicals.

» **Finishes:** Select products with low-VOC coatings, stains and paints *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings).*

» **Adhesives and glues:** Select low-VOC products with no added formaldehyde *(Finishes & Furnishings: K4–Low-VOC Adhesives and Sealants, and K6–Reduced Formaldehyde in Interior Finishes).*

» **Recyclability:** Select products that are easy to disassemble and recycle; consider using refurbished furniture *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

AIR OUT FURNITURE

Some conventional furniture can emit potentially unhealthy levels of formaldehyde and other VOCs. To reduce offgassing of VOCs into the building, air out furniture for a period (up to two weeks) before installing. If schedule constraints don't allow for airing-out time, then place even more emphasis on purchasing low-emissions furniture.

FLUSH OUT THE BUILDING

Furniture, carpet and other absorptive materials can absorb odors, VOCs and airborne contaminants from building materials and construction practices. Before installing furniture, perform a building flush-out to reduce this effect *(Site: A3–Construction Environmental Quality).*

DURABILITY

Buy durable furniture to reduce replacement costs and conserve resources.

Code Considerations

Most residential furniture does not meet fire code requirements for common areas. Refer to the California Technical Bulletin 133 Standards for information *(see Resources).*

Considerations for Residents

Using low-VOC or no-VOC products reduces indoor air pollution. Furnishing common areas (and in some cases residential units) with healthy, resource-conserving furniture demonstrates the owner's commitment to the health of the residents and the environment, and may foster a sense of pride among residents.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Some environmentally preferable furnishings cost more because they are made with special materials.

When purchasing furniture, in addition to first-cost considerations, consider quality, durability and service needs. Inferior products may require more frequent maintenance, repair, replacement and disposal, which can ultimately increase costs compared to better quality, more durable products.

Resources

» **California Integrated Waste Management Board** (CIWMB) lists furniture in their recycled-content product directory: www.ciwmb.ca.gov/RCP. CIWMB also has a Modular Office Furniture Specification: www.ciwmb.ca.gov/GreenBuilding/Specs/Furniture

» **California Technical Bulletin 133** describes flammability standards for common-area furniture: www.bhfti.ca.gov/industry/tb133.pdf

» **Oikos Green Building Source** lists green furniture manufacturers in the United States; many are located in California: www.oikos.com/green_products/category.php?category_id=562

Related Case Studies

» Crossroads, p. 234

» First Community Housing, p. 161

MEASURE L1

ENVIRONMENTALLY PREFERABLE FLOORING

Choose Flooring Materials That Are Healthier and More Sustainable

KEY BENEFITS			
Health/IEQ		√	Material Efficiency
Site/Community			O&M
Energy Efficiency			Resident Satisfaction
Water Efficiency		√	Climate Protection

NEW: 09 30 00: Tiling, **09 60 00:** Flooring

OLD: 09310: Ceramic Tile, **09600:** Flooring

Recommendation

Use environmentally preferable flooring materials, including A) FSC-certified wood, B) refinished flooring or reclaimed wood, C) rapidly renewable materials, D) recycled-content ceramic tile, E) exposed concrete or F) recycled-content, low-VOC carpet.

Each of these categories is described in separate sections below.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

See Finishes & Furnishings: L2–Low-Emitting Flooring for information about reducing VOC emissions from flooring and flooring adhesives.

Code Considerations

The same code considerations apply to environmentally preferable flooring as to any conventional flooring product.

General Resources

See sections below for category-specific resources.

» **BuildingGreen** has listings of environmentally preferable materials and articles about criteria used to designate building products as green, including "Building Materials: What Makes a Product Green" (Feb. 2006); fee to access: www.buildinggreen.com

» **Build It Green** has fact sheets and other information about sourcing environmentally preferable materials, including the Green Product Directory: www.BuildItGreen.org

» **U.S. Environmental Protection Agency's** Environmentally Preferable Purchasing (EPP) website provides guidance on procuring green building products: www.epa.gov/epp

A. FSC-Certified Wood

Description

Forest Stewardship Council (FSC)-certified wood flooring is independently certified to have come from sustainably managed forestry operations *(for information about FSC certification, see Structure: D5–FSC-Certified Wood for Framing Lumber and Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish)*.

Benefits

FSC certification assures that forests are managed in a way that protects the long-term availability of wood resources, the health of forest ecosystems and the sustainability of local economies.

Application

Use FSC-certified wood in place of conventional hardwood flooring.

Design Details

An increasing number of flooring suppliers offer FSC-certified solid and engineered flooring in a variety of domestic and exotic species. However, they may not be as widely available as conventional hardwood flooring, so it is important to coordinate with suppliers in advance to ensure availability and secure the best pricing.

For engineered wood flooring, ensure that the plywood or MDF backing is low emitting and made without formaldehyde-based adhesives *(Finishes & Furnishings: L2–Low-Emitting Flooring).* Also ensure that the backing is FSC certified or made of a rapidly renewable material.

For wood floor finishes, use water-based products with low levels of volatile organic compounds (VOCs). Avoid alkyd and oil-based stains and finishes. If possible, have the stain and finish factory-applied to limit exposure of jobsite workers and occupants *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings)*.

Considerations for Residents

Many people highly value the beauty of wood flooring, particularly when they know that the wood came from environmentally preferable sources.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Costs are wholesale from December 2007. FSC-certified hardwood flooring is increasingly cost competitive. Costs range from roughly $5.50 to $20 per square foot uninstalled. FSC-certified wood species that are not in high demand tend to be less expensive than more popular species.

Resources

Also see General Resources, above.

- **Forest Certification Resource Center** has a searchable database of certified forests and forest products: www.certifiedwood.org
- **Forest Stewardship Council** (FSC) has online lists of FSC products and manufacturers: www.fsc.org
- **Third-party certifiers:** Rainforest Alliance's SmartWood program (www.smartwood.org) and Scientific Certification Systems (www.scscertified.com) provide FSC chain-of-custody certification services.

B. Refinished Flooring or Reclaimed Wood Flooring

Description

Reclaimed wood flooring comes from sources such as old buildings and railroad ties. It can be finished to look like new wood or left with its natural blemishes. *(For more information about reclaimed wood, see Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish.)* For retrofit projects, refinishing existing flooring rather than replacing it is generally an environmentally preferably approach.

Benefits

Reclaimed wood flooring reduces resource consumption and landfill deposits. It is often very beautiful, even when marked with old nail holes or other signs of age. Some reclaimed wood flooring is made from very high quality old-growth hardwoods.

Refinishing existing flooring conserves natural resources and may save money.

Application

Use reclaimed wood in place of conventional hardwood flooring.

Design Details

There are many reclaimed hardwoods available for flooring, as well as some softwood species such as Douglas fir (note that softwood scratches and dents easily). When choosing reclaimed wood, be aware that—depending on the condition and location of the material—labor, refinishing, availability and storage can be expensive. *(See section above for information about wood floor finishes.)*

Considerations for Residents

Many people highly value the beauty of wood flooring, particularly when they know that the wood came from environmentally preferable sources.

Resources

See General Resources, above.

C. Rapidly Renewable Flooring

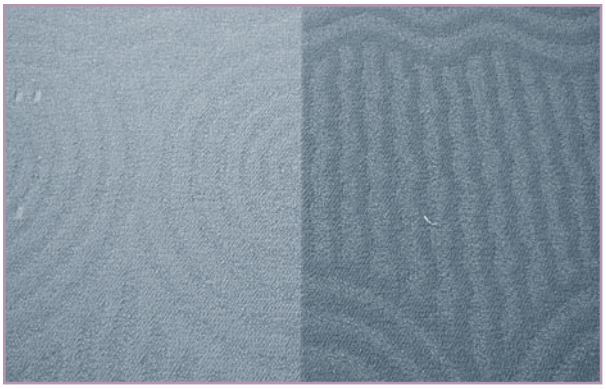
Description

Bamboo, natural linoleum and cork flooring are attractive, durable materials derived from rapidly renewable resources. Rapidly renewable resources are made from agricultural products that grow quickly and can be harvested on a relatively short cycle compared to slower-growing trees. In some cases, such as with bamboo or cork, the material is harvested without destroying the plant, allowing the plant to regenerate and be harvested repeatedly.

Bamboo floor manufacturing involves cutting bamboo stalks lengthwise into narrow strips and gluing these strips together either horizontally in layers, or vertically in strips.

Natural linoleum, which has been used for flooring for more than a century, is made from renewable biodegradable resources, including linseed oil from crushed flaxseed, pine rosin, cork and jute, and abundant nonrenewable resources, including limestone and clay. Many people mistakenly use the word linoleum to refer to vinyl flooring, which is made from petroleum.

Cork is harvested from the outer bark of the cork oak tree; the tree regenerates its bark within about ten years.



These carpet tiles contain recycled content and have low-VOC emissions. Carpet tiles reduce waste because worn sections can be selectively replaced.

Benefits

Rapidly renewable flooring materials reduce pressure to harvest forests. Bamboo is as durable as most hardwoods. Cork and linoleum are naturally fire and moisture resistant, sound absorbent and available in a variety of patterns and colors. Linoleum often lasts 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.

Application

Use in place of conventional hardwood, carpet or vinyl flooring. Cork can also be used as an underlayment for hard-surfaced flooring to reduce impact noise *(Structure: C1–Acoustics).*

Before choosing cork, the property or operations manager should discuss concerns with the product manufacturer's sales representative. Cork is best used where proper maintenance will be performed *(see Design Details).*

Natural linoleum can be installed wherever a durable surface is needed, including entryways *(Finishes & Furnishings: K1),* hallways, kitchens, common areas and laundry facilities.

Design Details

For bamboo and cork flooring, ensure that the plywood or MDF backing is low emitting and made without formaldehyde-based adhesives *(Finishes & Furnishings: L2–Low-Emitting Flooring).* Also ensure that the backing is FSC certified or made of a rapidly renewable material.

For cork flooring, choose glueless tongue-and-grove products for easy installation. Use low-VOC finishes. Although cork is resilient and durable, it may dent or scratch, particularly in high traffic areas, and some products may fade if exposed to direct sunlight. In multifamily buildings, cork is not advised in areas with high moisture content such as bathrooms and kitchens. Proper maintenance is required: vacuum or sweep the floor weekly; damp mop monthly with manufacturer-approved products and minimal water.

Linoleum installation is more complex than vinyl sheet or tile installation. Always use a manufacturer-certified installer who is trained in properly preparing the subfloor and cutting and gluing the linoleum. Linoleum must be installed on a smooth, dry surface. Do not allow contractors to use the same glues and methods for installing linoleum as they do for vinyl. Follow the manufacturer's recommendation for adhesives. Also use the manufacturer's low-VOC linoleum surface treatment. Waxing is not recommended as it introduces potentially harmful chemicals and requires periodic stripping and resealing. In high traffic areas, sealers can be applied to increase resilience.

Considerations for Residents

During the first week after installation, natural linoleum has a mild but unique odor that some occupants may not like. To clean linoleum floors, mop them with water or dry mop them with an electrostatic cloth mop that picks up dirt and dust. The latter does not require any chemicals or water, and the cloths are reusable.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Costs are wholesale from December 2007. Bamboo and cork flooring wholesale costs range between $4 and $9 per square foot uninstalled.

Linoleum costs between $3.00 and $5.50 per square foot uninstalled, depending on type and quantity. Linoleum takes longer to install than vinyl and requires a trained contractor for installation, which may increase cost, but lasts three times longer than vinyl. Generally, linoleum is selected for its health and environmental benefits, vibrant colors, and ease of repair rather than for its lifecycle cost benefits.

Resources

Also see General Resources, above.

» **Healthy Building Network** has information about the environmental and health hazards of vinyl: www.healthybuilding.net

» **U.S. Environmental Protection Agency's** Air Toxics website has information about vinyl chloride hazards: www.epa.gov/ttnatw01/hlthef/vinylchl.html

D. Recycled-Content Tiles

Description

Recycled-content ceramic tiles can contain up to 70% recycled glass or other recycled materials.

Benefits

Recycled-content products keep valuable resources out of the waste stream. Some recycled-content tile is very dense, which significantly reduces the amount of moisture and stains that are absorbed into the tile, making it more durable and easier to maintain. Although manufacturing ceramic tile is an energy-intensive process, there have been some energy efficiency improvements in firing techniques in recent years.

Ceramic tile has high thermal mass, which makes it a good option in conjunction with passive solar design *(Planning & Design: AA7).*

Application

Install recycled-content tiles wherever conventional tiles are specified.

Design Details

Ceramic tile is more durable than wood, linoleum and carpet but requires periodic maintenance, especially the grout. Grout may stain or trap dirt if not properly sealed. Ceramic tile is available in a wide range of colors, textures and patterns so the design possibilities are infinite.

Try to specify that your contractors do their tile cutting offsite or outdoors as much as possible.

Considerations for Residents

People with serious allergies or other chronic respiratory ailments may better tolerate ceramic tile products because they release few, if any, emissions. Ceramic tile is easier to keep clean than carpet.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Costs are wholesale from December 2007. Recycled-content tiles from standard tile manufacturers are typically available at little to no additional cost. Some specialty manufacturers make higher recycled-content tiles for a slight cost increase. Recycled-content ceramic tiles usually range from $10 to $20 per square foot. Recycled-content glass tiles can range from $3 to $40 per square foot, uninstalled.

Resources

See General Resources, above.

E. Exposed Concrete

Description

Concrete can be polished, scored with joints in various patterns, or stained with pigments to make an attractive finish floor.

Benefits

Using the slab as a finish floor eliminates the need to use other flooring materials. It is also durable and easy to clean. A concrete floor can provide thermal mass in a passive solar home *(Planning & Design: AA7)* and is well suited to a radiant-floor heating system *(Systems: H1).*

Application

For slab-on-grade applications, the finish must be designed and installed when the slab is being poured, and well protected throughout construction. Exposed concrete can also be used wherever a durable surface is needed, including entryways *(Finishes & Furnishings: K1),* hallways, kitchens, common areas and laundry facilities.

Design Details

Concrete can be made attractive with a variety of colors and stains, and sealed with a low-VOC, water-based sealant *(Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings).* The floor is hypoallergenic once the sealant has cured. Use wax to protect the sealant and provide a finished look.

Concrete may work in a living room or shared spaces but may be less ideal in rooms where warmth or cushioning is desired, such as bedrooms and kitchens. Area rugs can help to address this concern, although rugs may somewhat decrease the effectiveness of passive solar design or in-floor radiant hydronic heating.

Considerations for Residents

Concrete is easy to clean, moisture resistant, and long lasting. Concrete can become uncomfortably cold without insulation or radiant heat under it.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

For slab-on-grade applications, exposed concrete may be very economically feasible. Staining or painting concrete will add cost to concrete finishing but there will be no additional cost for carpeting or other finish flooring materials. Usually, a low-VOC sealer is all that is required for sealing and waterproofing the concrete.

Resources

See General Resources, above.

F. Recycled-Content, Low-VOC Carpet

Description

Recycled-content carpet is made from recycled plastic bottles, recycled nylon and wool, or recycled cotton. To protect indoor air quality, choose carpet products that have been tested and approved for low emissions by a reputable third-party organization.

Benefits

Carpeting accounts for 70% of floor coverings in the United States, but it has a relatively short life expectancy—approximately eight years—compared to other floor coverings. Every year in the United States, 2.5 million tons of carpeting goes to landfills.

Purchasing recycled-content carpet helps provide a market for recyclable materials. Recycled-content carpet made from soda bottles (PET plastic) is available in a rainbow of colors and has 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 comparable nonrecycled products. Some nylons can be processed back into carpet fiber, while others are ground up and used for backing materials.

Low-VOC carpets improve indoor air quality.

Application

High recycled-content, low-emitting 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.

Design Details

To reduce waste, choose a durable carpet with high recycled content. It should also meet or exceed the Carpet and Rug Institute's (CRI) Green Label Plus requirements for VOC emissions or have been tested for low emissions according to the testing protocols described in the State of California's Special Environmental Requirements Specification—Section 01350 *(Finishes & Furnishings: L2–Low-Emitting Flooring).* Use a physical attachment method or a low-VOC adhesive.

Carpet cushion. Depending on the kind of carpet used, carpet cushion (or underlayment) may be needed. Carpet cushion can improve the carpet's insulating properties, reduce wear from foot traffic and furniture, and prolong appearance. Carpet cushions made from bonded urethane, jute, synthetic fiber or rubber are available with a high recycled content. CRI labels low-VOC carpet cushions with the Green Label.

Common areas. Consider using commercial-grade carpet, which is much more durable than residential carpet. Carpets are available with 100% recycled backing, and some also have recycled-content face fiber. Consider the carpet's color and its effect on maintenance; light-colored carpet tends to show dirt more readily than darker colors. Select solution-dyed carpets rather than carpets dyed using other methods; solution-dyed carpets are more colorfast and hold up better to heavy-duty cleaning. Carpet tiles are also a good option; tiles can be selectively replaced, reducing costs and waste. If sheet roll carpet is used, specify carpet with recycled content in the fibers and backing.

In buildings housing seniors or residents with impaired mobility, glue down carpets to reduce tripping hazards. On stairs, carpet tends to wear quickly, so consider using a more durable material such as rubber treads.

Residential units. In addition to recycled synthetic carpets, carpet made from natural materials such as wool and cotton (recycled or virgin), or other plant fibers (including jute, seagrass, sisal, linen and coir) are also available. However, these may be more expensive or less durable than synthetic carpets. The main advantage of natural fibers is that they come from biodegradable, rapidly renewable resources. Make residents aware of specific maintenance techniques if used.

Installation and maintenance. Recycled carpets have the same installation and maintenance requirements as nonrecycled carpets. If carpeting must be glued down, use a low- or no-VOC adhesive *(Finishes & Furnishings: K4–Low-VOC Adhesives and Sealants).* Some carpet tile manufacturers utilize a factory-applied, low-toxic glue, which helps reduce VOC emissions on site.

Vacuum carpets regularly to ensure good indoor air quality. Use vacuums with HEPA filters.

Closing the loop. Many carpet manufacturers have programs for pickup, reuse or recycling of old carpet. Establish a protocol for recycling carpet. 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. Some manufacturers also offer carpet leasing as a way to promote recycling and possible reuse.

Considerations for Residents

Low-VOC carpets have fewer indoor air quality impacts than standard carpet products.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

In general, there is little to no premium for buying high recycled-content carpet. However, products geared to the custom or luxury market are often more expensive, whether or not they contain recycled content.

Using more durable commercial carpet reduces replacement costs. Warranties on commercial products can be twice that of residential carpet warranties. Carpet tiles may save money because damaged tiles can be selectively replaced, but this requires stocking spare tiles in case the product line is discontinued. Tiles may be twice the price of sheet carpeting.

Resources

Also see General Resources, above.

- **Carpet America Recovery Effort** (CARE), a voluntary industry/government initiative, seeks to keep carpets out of landfills: www.carpetrecovery.org
- **Carpet and Rug Institute** (CRI) sponsors the Green Label and Green Label Plus certification for carpets, cushioning and adhesives with low-VOC emissions: www.carpet-rug.com
- ***Environmental Building News*** has an article, "Making Carpet Environmentally Friendly" (June 2007); fee to access: www.buildinggreen.com
- **Scientific Certification Systems** certifies carpets and cushions for recycled content and other environmentally preferable features: www.scscertified.com
- **U.S. Environmental Protection Agency's** Comprehensive Procurement Guidelines have information on recycled-content carpet and underlay: www.epa.gov/cpg

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- First Community Housing, p. 161 and p. 209
- Sara Conner Court Apartments, p. 221

MEASURE L2

LOW-EMITTING FLOORING

Install Flooring That Offgasses Low Levels of VOCs

KEY BENEFITS

√ Health/IEQ	Material Efficiency
Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 09 30 00: Tiling, **09 60 00:** Flooring

OLD: 09310: Ceramic Tile, **096000:** Flooring

Recommendation

Use low-emitting flooring materials that meet California Section 01350 or CRI Green Label Plus emissions standards.

If flooring adhesives are used, choose low-VOC products.

Description

Certain flooring products offgas formaldehyde and other volatile organic compounds (VOCs) that can pollute indoor air. Low VOC alternatives exist for almost all flooring products.

Benefits

Low-emitting flooring products protect indoor air quality for construction workers and occupants.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all projects.

This measure covers indoor air quality issues related to flooring. For more information about flooring products, see Finishes & Furnishings: L1–Environmentally Preferable Flooring.

Design Details

For all types of flooring, specify flooring products tested and approved under California's "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small Scale Environmental Chambers," also known as Specification Section 01350 *(see Resources).* Whenever possible, select products that meet California's Air Resources Board's ATCM Phase 2 criteria, which have stricter formaldehyde standards than Section 01350 *(see Code Considerations in Finishes & Furnishings: K6-Reduced Formaldehyde in Interior Finishes for more information).*

When selecting carpeting, look for products that carry the Carpet and Rug Institute's (CRI) Green Label Plus logo.

Try to select flooring products that are factory finished or require no onsite finishing. If onsite finishing is required, use low-VOC products *(Finishes & Furnishings: K3-Low/No-VOC Paints and Other Coatings).* To further protect indoor air quality, encourage installers to saw and sand outside of the building as much as possible.

If flooring adhesives must be used, choose low-VOC products that meet the recommendations in *Finishes & Furnishings: K4-Low-VOC Adhesives and Sealants.*

FLOORING MATERIALS

» **Bamboo and engineered wood.** Choose products that emit low levels of formaldehyde and other VOCs. In 2007, California's Air Resources Board adopted an airborne toxics control measure (ATCM) to reduce formaldehyde emissions from composite wood products, including some flooring products *(see ATCM information above).*

» **Cork.** Choose factory-sealed cork flooring that doesn't have a polyvinyl chloride (PVC) backing or wear layer. If unsealed cork flooring is installed, use a low-VOC natural wax or low-VOC polyurethane sealer.

» **Ceramic tile, concrete and stone.** Ceramic tile, concrete and stone have minimal indoor air quality impacts. Opt for setting the tile with portland cement–based thin-set mortar and grout rather than organic mortars and epoxy grouts. Tile glazes do not offgas. Concrete floors do not offgas once cured and are easy to maintain with low- and no-VOC sealants and waxes. Natural stone has no VOC emissions. If the stone will be sealed, choose a low-VOC sealant *(Finishes & Furnishings: K4–Low-VOC Adhesives and Sealants).*

- **Rubber.** VOC emissions from rubber are generally low, but for indoor use avoid rubber flooring derived from tires. Rubber flooring can be installed without adhesives due to its inherent tacky property.
- **Carpet.** Synthetic carpeting and carpet padding can offgas high levels of VOCs for many years after installation. Choose carpets that have the CRI's Green Label Plus logo. Green Label Plus is equivalent to California's Specification Section 01350. Air out the carpet in a well-ventilated area before installation. Carpet made from natural materials such as wool, jute, seagrass, sisal, linen and coir tend to have much lower emissions than conventional synthetic carpet *(Finishes & Furnishings: L1-Environmentally Preferable Flooring).* Install carpet with carpet tacks rather than adhesives, or use low-VOC adhesives.

Code Considerations

The same code considerations apply to low-emitting flooring as to any conventional flooring product.

Considerations for Residents

Low-emitting flooring protects indoor air quality. Good indoor air quality provides a healthier living environment and may increase the value of the homes.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Most low-emitting flooring products typically do not cost more than conventional flooring products. CRI Green Label Plus carpeting will cost more than conventional residential carpet but is no more expensive than other high quality commercial carpet.

Resources

- **Build It Green Product Directory** has information about sourcing low-emitting flooring materials: www.BuildItGreen.org/products
- **California Integrated Waste Management Board's** Section 01350 is described at: www.ciwmb.ca.gov/greenbuilding/Specs/Section01350
- **Carpet and Rug Institute** (CRI) sponsors the Green Label and Green Label Plus certification for carpets, cushioning and adhesives with low-VOC emissions: www.carpet-rug.com
- **South Coast Air Quality Management District's** (SCAQMD) Rule 1168 for adhesives and sealants can be downloaded from: www.aqmd.gov/rules/reg/reg11/r1168.pdf

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- First Community Housing, p. 161
- Oxford Plaza, p. 15
- Sara Conner Court Apartments, p. 221

MEASURE M1

ENERGY- AND WATER-EFFICIENT APPLIANCES

Install Energy/Water-Efficient Refrigerators, Dishwashers and Clothes Washers

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: 11 31 00: Residential Appliances

OLD: 11451: Residential Appliances

Recommendation

Install Energy Star–qualified refrigerators and dishwashers in residential units.

Install clothes washers in residential units that meet CEE specifications.

Description

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 purchase the most energy-efficient products available. Energy Star sets standards for energy efficiency that roughly target the upper 20% 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 and clothes washers.

PHOTO COURTESY OF PNNL

Energy Star–qualified appliances are significantly more energy efficient than non-qualified appliances.

The Consortium for Energy Efficiency (CEE) provides a nationally recognized definition of "super efficiency" through the establishment of performance tiers. Their national Super-Efficient Home Appliances Initiative addresses residential refrigerators, dishwashers and clothes washers.

Benefits

Energy Star appliances save money, water and energy. Most of these products are superior in quality and performance to models that don't meet these standards. CEE-listed appliances are super efficient and can further save energy and water.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Install in place of standard home appliances. Consider centralizing laundry facilities to save more energy, and reduce first costs and maintenance costs *(Finishes & Furnishings: M2–Central Laundry)*.

Appliance replacement can be performed independently or as part of dwelling unit rehabilitation. For retrofits, evaluate the cost effectiveness of replacing appliances with higher efficiency models now rather than waiting until the appliance is at the end of its life.

If appliances will be donated, request Energy Star models. To help compensate the donating manufacturer, offer to promote the benefits of their Energy Star units as part of the project's public relations efforts.

Design Details

Specify refrigerators, dishwashers and clothes washers that meet or exceed Energy Star requirements.

REFRIGERATORS

Specify Energy Star–qualified refrigerators. These energy-efficient models have high efficiency compressors, more precise temperature controls and improved insulation. Larger models use more energy; for larger households choose refrigerator/freezers with a capacity less than 25 cubic feet and for smaller households choose models less than 20 cubic feet. Avoid through-the-door ice dispensers and side-by-side refrigerator/freezers, as these models use 10% to 30% more energy than comparable models without these features.

DISHWASHERS

Specify dishwashers that meet 2009 Energy Star energy requirements (energy factor ≥ 0.68 and maximum annual energy use of 325 kWh) and that use no more

than 5.8 gallons per cycle. These models 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. 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.

CLOTHES WASHERS AND DRYERS

Specify residential clothes washers that meet CEE Tier 2 or 3 criteria for energy and water efficiency (Tier 2: modified energy factor (MEF) ≥ 2.0 and WF ≤ 6.0; Tier 3: MEF ≥ 2.2 and WF ≤ 4.5). Tier 3 models are the most efficient products.

For central laundry facilities, choose commercial clothes washers that meet CEE Tier 1, 2 or 3 criteria (Tier 1: MEF ≥ 1.8, WF ≤ 7.5; Tier 2: MEF ≥ 2.0, WF ≤ 6.0; Tier 3: MEF ≥ 2.2, WF ≤ 4.5). *(See Finishes & Furnishings: M2–Central Laundry.)*

These models use 35% to 50% less water per load of laundry and 50% less energy. Cost savings are gained by improving moisture extraction from final rinses and matching hot water temperatures to specific loads. Higher water extraction reduces drying time significantly, saving energy.

Horizontal-axis (front-loading) models use premium motors and tumble laundry in a low volume of water. High performance top-loading models use a variety of sophisticated agitators and cycles to achieve water and energy savings. Commercial-grade horizontal-axis models are easier to service and maintain, thanks to front-mounted components that allow for service without moving the units.

For retrofits projects, replace older top-loading clothes washers, refrigerators made before 2001, and non-Energy Star dishwashers, especially if these appliances need repair.

Gas-fueled clothes dryers save considerable energy and money over electric units.

Code Considerations

Same as standard practice.

Considerations for Residents

Energy Star–qualified and CEE-rated appliances save money by reducing energy and water use. In addition, many of these appliances work better than their standard counterparts: refrigerators maintain more uniform temperatures; dishwashers heat water to the desired level consistently; and horizontal-axis washing machines are less abrasive to fabric, helping clothing last longer.

Special low-suds detergents (labeled high efficiency or HE) may be required for use in high efficiency washing machines. These detergents are used in smaller amounts than conventional detergents and cost less per load.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$ $ $

While some Energy Star and CEE appliances may cost more upfront, in general they all cost less to operate over time.

Energy Star criteria are developed to be cost effective for the national average cost of electricity, which is substantially lower than California rates.

Energy Star refrigerators are widely available from most major appliance suppliers. The premium for Energy Star refrigerators typically pays back in five years or less. They are available in all price and size ranges.

Qualifying dishwashers carry a small premium over non-qualifying dishwashers.

Horizontal-axis and advanced top-loading washing machines cost 50% to 60% more than standard washers but typically pay back the premium after 2,000 loads of laundry. If the cost of detergent is figured in, these units pay back even faster because low-water washing machines use much less detergent per wash.

Rebates are frequently available for qualifying appliances, and can offset a significant portion of any incremental cost increases. Check with local utilities for rebate offers. Clothes washers may be eligible for multiple rebates from electric and water utilities.

Resources

- **American Council for an Energy Efficient Economy** (ACEEE) provides information on energy-efficient products and practices: www.aceee.org
- **Consortium for Energy Efficiency** (CEE) provides information about their Super-Efficient Home Appliances Initiative and lists qualifying products: www.cee1.org
- **Energy Star** provides information about appliance efficiency and lists qualifying products: www.energystar.gov.
- **Flex Your Power** provides information about rebates and incentives from California utility companies: www.flexyourpower.org

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- Sara Conner Court Apartments, p. 221
- Village Walk, p. 15

MEASURE M2

CENTRAL LAUNDRY

Locate Clothes Washers and Dryers in Central Areas

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: Division 11: Equipment

OLD: Division 11: Equipment

Recommendation

Locate clothes washers and dryers in central areas instead of in individual units.

Choose commercial washing machines that meet the Consortium for Energy Efficiency's (CEE) Tier 1, 2 or 3 specifications, or the equivalent. Choose gas-fueled dryers.

Provide clotheslines adjacent to the laundry room whenever possible.

Description

Residents with clothes washers inside their units tend to wash smaller, less efficient loads more frequently than residents using a centralized laundry room.

According to a 2002 study by National Research Center Inc."Residents of apartments with in-unit laundry facilities used 3.3 times more water for laundry than residents in apartments utilizing common area laundry facilities" *(www.laundrywise.com).*

The cost of water—and the 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 water treatment costs rise.

High efficiency washers save more energy than conventional top-loading models *(Finishes & Furnishings: M1–Energy- and Water-Efficient Appliances).* Horizontal-axis models spin at higher speeds, improving water extraction and reducing drying time. High efficiency top-loading washers are also available.

Through its Super-Efficient Home Appliance Initiative, CEE has developed specifications for high efficiency clothes washers, including both horizontal-axis and high efficiency top-loading models. CEE has structured its specifications in three tiers, with Tier 3 being the most energy and water efficient (Tier 1: modified energy factor (MEF) ≥ 1.8, water factor (WF) ≤ 7.5; Tier 2: MEF ≥ 2.0, WF ≤ 6.0; Tier 3: MEF ≥ 2.2, WF ≤ 4.5). All three CEE tiers are more energy efficient than Energy Star specifications.

Gas-fueled dryers are substantially more energy efficient than electric dryers. Encourage the use of clotheslines by placing them in convenient locations and pricing dryer use to make line-drying attractive.

Benefits

A central laundry facility can reduce construction costs by $3,000 to $5,000 per unit (2007 costs).

Centralized laundry facilities save water and energy. Commercial-grade horizontal-axis models are easier to service and maintain, thanks to front-mounted components that allow for service without moving the units. Also, maintaining equipment in central laundry rooms is much less expensive per occupant than maintaining individual appliances. Both coin-operated and card systems are available that, when leased, are maintained by the leasing company (also known as route operators). Central systems, whether purchased or leased, can provide additional income to the property owner.

Gas-fueled clothes dryers save considerable energy and money over electric units. Clotheslines save even more energy and money.

Centralized laundry facilities can encourage social interaction among neighbors, if placed correctly and designed as attractive features instead of as an afterthought.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		Commercial

Centralized laundry facilities are most readily accepted by the residents of rental units. Although there is a perception that homeowners want in-unit laundry hook-ups, studies by the Multi-Housing Laundry Association *(see Resources)* show that given the choice of a well-designed, accessible common facility or in-unit hookups, residents prefer the centrally located facility. Central facilities eliminate the responsibility for and expense of maintaining the equipment, and free up space in the home.

Design Details

Placing laundry facilities no more than 250 feet from the dwelling units they serve improves their accessibility. In most cases, this means designing multiple, small laundry rooms instead of a large centralized one. Residents prefer smaller and closer facilities; these can usually be incorporated into a building's existing design (no new building or large room is needed). Avoid locating laundry rooms in noisy or uncomfortable areas, such as in mechanical rooms or near garbage bins.

These additional strategies will help centralized laundry work better for residents:

- Locate along major foot traffic corridors to encourage interaction and improve safety.
- Locate next to activity areas, such as workout rooms, swimming pools, community centers or other amenities.
- Ensure the rooms are well lit and have adequate visibility for security and safety, including, where feasible, a centrally monitored video security system. Daylight is important, and green plants and comfortable seating make the space more appealing.
- Keep the areas clean and the machines in good working order. Include a janitor's closet in or near the laundry rooms to make maintenance easier.
- Use semi-gloss or high-gloss paint on walls to make them easy to keep clean. Use durable, water-resistant flooring such as concrete.
- Place overflow pans under each washing machine to reduce potential damage if a unit overflows. Three-sided pans can slope toward a central floor drain; four-sided pans should have a drain connected to the plumbing waste line.
- Keep the cost of doing laundry affordable to occupants.
- Provide adequate ventilation to remove moisture (generally on a moisture sensor control) and appropriate HVAC controls to maintain a comfortable temperature.
- Provide a mix of top- and front-loading washers to accommodate residents' physical abilities. Some people may have trouble bending down to reach into a front-loading machine while people in wheelchairs may have difficulty reaching up to use a top-loading machine. Both types of washing machines are available that meet CEE specifications.

PRACTICA CONSULTING

Provide a mix of top- and front-loading washers to accommodate residents' physical abilities.

Code Considerations

Central laundry facilities often require airtight fire doors when they are located on every floor. For this reason, and to protect indoor air quality, take special care to properly exhaust all dryers to the outdoors. This will help to control moisture, hot air and lint. Plan adequate make-up air for the exhausted dryer air.

Considerations for Residents

High efficiency laundry machines save water and energy. They also save drying costs by reducing drying times. High efficiency washers use low-suds detergents, which reduce the amount of soap needed per wash, saving money. Some reports indicate that these units also wash clothes better than standard units, and prolong garment life.

If laundry facilities are well designed, residents are more likely to perceive them as an amenity rather than a hassle. Acceptance tends to be lower in middle and higher income communities; some education about the advantages of central laundry may be necessary. Focus on the time savings of completing all laundry quickly by using multiple machines and the value of removing the most likely source of water damage in the home—washing machine leaks.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

To estimate the cost savings, calculate the cost per square foot of the space used by the individual laundry closets, add the cost of wiring, plumbing a gas line for the dryer, installing a drain, exhausting the equipment, providing ventilation and maintaining the individual units. Then subtract the total cost of building and maintaining central facilities.

The combined construction, water and energy savings can offset the cost of high efficiency washers. Use dryers fueled by natural gas instead of electricity to further conserve energy and reduce operating costs. Check with your local utility for rebate details.

Resources

- **Consortium for Energy Efficiency** provides information about CEE's Tier 1, 2 and 3 specifications and a list of qualifying washers: www.cee1.org
- **Flex Your Power** provides a clearinghouse of rebates and incentives from water and gas and electric utilities across the state: www.fypower.org
- **Laundrywise,** a website developed by Multi-housing Laundry Association, provides information about central laundry facilities, including studies, statistics and a water savings calculator: www.laundrywise.com
- **Multi-housing Laundry Association** is a trade association of laundry service providers, manufacturers and affiliated companies: www.mla-online.com

Related Case Studies

- Carmen Avenue, p. 230
- Crossroads, p. 234
- Sara Conner Court Apartments, p. 221

RECYCLING AND WASTE COLLECTION

Make It Convenient for Residents and Commercial Tenants to Recycle

KEY BENEFITS

Health/IEQ	√ Material Efficiency
Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 11 80 00: Collection and Disposal Equipment

OLD: 12400: Furnishings and Accessories

Recommendation

Provide convenient facilities for recycling collection within each unit and easy access to the building's central recycling bins. Make recycling and garbage services equally easy to use.

Design multifamily buildings to accommodate food waste recycling now or in the future.

Description

Recycling should be as easy as throwing out garbage, but multifamily housing is rarely designed to facilitate this. Long walks to bins or poorly designed collection areas are common barriers to recycling. Residents may be unaware of recycling opportunities because they have little or no contact with the waste company. Often, the waste bill is paid directly by the property manager. Tenant turnover can make outreach a challenge. Thus, proper design of collection areas and consistent education is critical to making recycling easy, sanitary and useful for residents and commercial tenants.

Benefits

Recycling reduces the amount of material entering landfills and can save money for building owners through reduced disposal fees.

Recycling reduces greenhouse gas emissions both upstream during manufacturing and downstream at disposal. Materials made from recycled-content products generally have fewer energy inputs because of reduced needs for extraction of raw materials and associated transportation fuel energy *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

If landfilled material has organic content, like paper, cardboard or wood, it will break down and create methane, a potent greenhouse gas that is twenty times more effective at trapping heat in the atmosphere than carbon dioxide. Landfills are the largest contributor of methane in the United States.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily developments.

Design Details

Most residents and commercial tenants will recycle and most maintenance staff will implement recycling programs if it is made easy. Plan for recycling early in the design process.

It is imperative that developers discuss with City staff the various City requirements regarding the trash and recycling infrastructure as they relate to sewer drains, fire sprinklers, enclosures, stormwater, roofing and space requirements. In addition, City staff can advise which haulers are authorized to provide recycling and garbage services. It is crucial that a meeting between the approved hauler, city staff and developer occur prior to developing any design documents. Haulers can tell you their exact requirements in order to facilitate collection of recycling and trash.

Recycling infrastructure should include collection of mixed paper, cardboard, containers (metal, glass, plastic) and possibly food waste and other organic material. Use simple and clear signage. Recycling and food waste bins should be labeled and distinct from garbage bins.

SIZE OF CONTAINERS & ENCLOSURES

Garbage and recycling companies will provide carts, bins or both. The size and number of containers depend on the number of people or units in the project and the frequency of collection.

» For once-a-week collection (the norm), a rule of thumb is to provide ¼ cubic yard of capacity for every three residents. This can be a mix of garbage bins and recycling carts or bins, with about half the volume for garbage and half for recycling.

» Bin sizes vary, but the typical footprint is 7-feet wide and 4-feet deep. Most 64-gallon carts fit in a footprint that is 32x30 inches and 42-inches tall. Bins and

carts typically have hinged lids that must be raised. Take care when designing spaces for bins and carts since they can damage low ceilings. Also provide space to walk among the containers and shift them around—an area that is 150% of the sum of bin and cart footprints should be adequate.

» For mixed-use buildings, provide separate areas and/or bins for commercial and residential waste and recycling collection. If that's not possible, provide sufficient capacity to accommodate all uses *(Structure: C2–Mixed-Use Design Strategies).*

OUTSIDE THE BUILDING

Locate recycling containers near garbage bins so residents and commercial tenants can make one trip to dispose of recyclables and trash. Consider these issues:

» Locating containers in underground parking areas can pose serious difficulties for the collection company, such as requiring workers to roll containers outside. To avoid substantial fees, underground collection infrastructure needs to include enough overhead clearance or plans for how the containers will be moved to the building's exterior for collection. Some property owners have golf carts that link up to the bins and move them outside. Work with your hauler early on to avoid costly service fees.

» Each hauler has specific requirements for turn-around radius but generally it is sufficient to plan for 45 feet for a 90-degree turn and 90 feet for a 180-degree turn. A safety liability is created when trucks are forced to back out of a road or drive into traffic. Trucks need a minimum of 20 feet vertical clearance.

» Include curb cuts where the vehicles will enter and exit the complex.

In complexes with exterior parking lots, the typical practice is to provide walled enclosures for bins and carts. A well-designed enclosure will have:

SFDPW.MSTE.ORG

In buildings of three or more stories, recycling and trash chutes keep stairwells and elevators cleaner. Recycling chutes should be clearly labeled.

» Sufficient turning radius and vertical clearance to empty a bin;

» Sufficient space to move among bins and carts;

» Lever-style door handles that can be operated with full hands;

» Wall space for instructional signage;

» Smooth floor that can be swept or mopped;

» Wheel stops near walls to prevent damage to walls;

» Adequate lighting to read signs and sort materials;

» Properly enclosed or sealed containers to limit pests and theft; and

» A location where noise, odors and truck exhaust won't be a nuisance to residents.

INSIDE THE BUILDING AND UNITS

In all areas where residents will be emptying recyclables and trash, provide durable and easily cleanable surfaces, and keep the areas well maintained. Dirty or unsightly recycling and trash discourage people from using them and attract vermin.

» **Collection inside the units.** Try to provide a single disposal area for garbage and recyclables inside each residential unit. Provide at least one 18-inch bin for recycling, and preferably one bin for each type of recyclable material. Locate bins in an accessible place but shield them from view so they are not an eyesore.

» **Kitchen storage.** Small kitchens require creative storage solutions such as drawers, tilt-out bins or pull-out shelves. Some bins have lids that close automatically when a cabinet door is closed. Take advantage of underused spaces such as corner cabinets and under-sink storage. Consider offsetting sink plumbing to create more storage room. For corner cabinets, a spinning rack can be space efficient. Label or color-code bins, especially if they are not easily visible.

» **Chutes.** Developments of three or more stories often use chutes to convey garbage from each floor to a ground-floor trash room, where it lands in a metal bin. Chutes keep stairwells and elevators cleaner. Specify round chutes to avoid materials jamming and creating a back up. The bins in the trash room are either rolled to a pick-up point by maintenance staff or to the collection truck by the driver. Spills in collection rooms and near chutes are inevitable, so use durable, easy-to-clean wall and floor finishes in these areas.

Maximize recycling by providing two chutes, one for recyclables and the other for trash. Locate the trash and recycling chutes side by side for equal

STOPWASTE.ORG

Chutes empty into bins in the trash room. Round chutes help prvent materials from jamming.

accessibility. Clearly mark the recycling chute, "Recycling Only." In jurisdictions with single-stream recycling, all recyclables may be mixed together and easily handled with a single chute. In jurisdictions that require recyclables such as paper and plastic to be separated, the number of chutes may become unwieldy.

Consider installing sound insulation so that the chutes are not a nuisance *(Structure: C1–Acoustics).*

» **Common areas.** Place recycling and garbage containers in common areas such as mail rooms and laundry rooms. To discourage identify theft, recycling in mail areas should ideally be behind a wall with a slot for access. In laundry areas, large plastic detergent bottles and cardboard boxes require space for large carts (96 gallon) or a way for maintenance staff to keep empty carts nearby for exchange.

BULKY WASTE

Provide an area for large cardboard recycling and plan for maintenance staff to break down the cardboard and transport it to the trash room. Provide tenants with a list of local material drop-off facilities and stores that accept donations of household goods; the City recycling coordinator may have information handouts available for distribution.

COMPOST AND FOOD SCRAP COLLECTION

Food scrap collection programs keep food scraps and food-soiled paper out of landfills, where they break down and produce methane, a potent greenhouse gas. These programs turn food scraps into compost, a valuable resource used by farmers and landscapers to improve soil quality. In the future, most waste haulers will likely offer curbside food scrap collection service, but it is currently only offered in a few places. Plan ahead and include space for a separate food waste compost bin in the garbage and recycling enclosure.

If the multifamily development has a community garden *(Site: B1–Sustainable Landscaping),* encourage the garden coordinators to set up onsite composting. Some municipalities offer discounted pricing on compost bins.

Code Considerations

In California, state regulations require cities to divert 50% of waste from landfills. Many local municipalities have even higher standards, with some calling for 75% waste reduction by 2010 and zero waste by 2020.

Local policies and regulations may suggest or require that property owners provide space for tenants to recycle. Check local requirements. Some cities have ordinances about enclosing or reducing the visibility of garbage and recycling containers.

Considerations for Residents

A well-organized recycling program can improve residents' attitudes toward recycling. It's important to provide instruction to residents and staff on proper recycling procedures. Composting in a community garden fosters social interaction.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$ $ $

It is often less costly to recycle than to dispose of waste as trash. By providing well-planned space for recycling, the owner can enable tenants to keep disposal costs down.

Chute systems add cost, but increase participation in high-rise buildings and keep the building cleaner.

Resources

» **California Integrated Waste Management Board** has statewide resources on recycling and composting: www.ciwmb.ca.gov

» **StopWaste.Org** provides information on recycling, composting and more, including the publication, "Recycling Guidelines for Multifamily Housing Design": www.BuildGreenNow.org

Related Case Studies

» Avenue 64, p. 198

» Crossroads, p. 234

» First Community Housing, p. 209

AVENUE 64

PLANNING AHEAD FOR RECYCLING AND WASTE COLLECTION SAVES MONEY AND MAKES LIFE EASIER FOR RESIDENTS *Emeryville, CA*

At Avenue 64, a new community of 224 luxury apartment homes in Emeryville, the design team planned for recycling and waste collection from the outset of the design process.

"We met with the City, the service provider and the developer very early on," said architect Radziah Loh of McLarand Vasquez Emsiek & Partners. "This allowed us to get key information on the size and number of bins, the turnaround radius needed for the trucks, the number of pickups that would be needed, and other logistics that often don't get communicated until much later in the design process." The recycling and waste collection strategies described in the *Multifamily Green Building Guidelines* were also helpful during design, Loh said.

A well-designed recycling and waste management system provides multiple benefits, according to John Stevens, development director of BRE Properties, Inc., which owns and manages Avenue 64. "Recycling is the right thing to do for the environment, and it's good business," he said. "It lowers our operating costs by reducing our disposal fees, and our residents appreciate that we've made it convenient for them to recycle."

Avenue 64 is a podium-style structure, with four stories of residential units above on-grade parking, and two small retail spaces at ground level. Each floor has four central trash rooms, so that no tenant has to walk far to take out the trash and recycling. Each trash room has two separate chutes, one marked for mixed recyclables (plastic bottles, aluminum, tin and steel cans, glass bottles, paper and cardboard) and the other for garbage. The recyclable material collected at Avenue 64 represents "a significant amount of resources that are being put back into the economy instead of winding up in a landfill," Stevens said.

The chutes, which are made by Wilkinson Hi-Rise, feed into bins in four trash rooms in the garage. One key to the chutes, according to Loh, is to have a two-foot gap between the bottom of the chute and the bins so that materials can drop unimpeded into the bins. In the trash rooms on each floor, there is also a large area where tenants can leave cardboard boxes. The maintenance staff breaks down the boxes, a convenience for the tenants which results in more cardboard being recycled. On collection day, maintenance personnel use a golf cart to pull out the bins, which are hooked together to form a train that is brought to a staging area in the rear of the building to await pickup by the local service provider.

In large rental properties where there's regular turnover, it's particularly important to educate tenants about recycling. Avenue 64's property manager provides new tenants with educational materials from the City of Emeryville that explain the importance of recycling, and the recycling chutes have signs listing what can be recycled. The maintenance staff also checks the bins to help ensure that garbage and recyclables are winding up in the right place.

For more information: www.breavenue64.com

LIGHTING

Specify Low Mercury, High Efficacy Fluorescent Lamps

KEY BENEFITS	
√ Health/IEQ	√ Material Efficiency
Site/Community	O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: Division 26: Electrical

OLD: Division 16: Electrical

Recommendation

For retrofit projects, specify low mercury, high efficacy tubular and compact fluorescent lamps (CFLs) for general illumination. Use pin-based CFL fixtures instead of screw-in fixtures whenever possible.

Specify Energy Star–qualified exit signs to replace incandescent and compact fluorescent exit signs.

Description

For existing multifamily buildings, upgrading lighting is typically one of the easier and more cost effective energy efficiency measures. Although in the past fluorescent lighting suffered from a reputation of poor quality, 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. Some newer fluorescent lamps can be dimmed like traditional incandescent lamps. This gives more flexibility in designing for daylighting or providing a certain ambiance, especially in common areas.

Lighting retrofits involve replacing the ballasts and lamps of existing lighting fixtures with more energy-efficient products. Start first with areas where lights are likely to be on a lot, such as common areas and hallways, and then move to individual units.

For lighting retrofits where it may not be cost effective to replace the entire luminaire, specify compact fluorescent lamps as a replacement for incandescent lamps. If incandescent light fixtures cannot be replaced with pin-based CFLs, replace the lamps with screw-in CFLs. Install T8 linear fluorescent lamps with electronic ballasts as a replacement for T12 lamps with magnetic ballasts.

Also, consider new LED lighting technology for new and retrofit multifamily projects.

LIGHTING TERMINOLOGY

Here are some important terms to know when choosing energy-efficient lighting:

» **Lumen** indicates a lamp's light output. A 100-watt incandescent lamp, for example, produces about 1,750 lumens. When evaluating lamps, consider the lumen output, not the wattage, to determine the desired light level. Wattage indicates energy used, whereas lumen indicates light output.

» **Efficacy** (lumens per watt or LPW) indicates a lamp's efficiency. It is the ratio of light output in lumens to the electricity used.

» **Color rendering index (CRI)** measures how accurately colors appear under the lamp. For fluorescent lamps, a CRI greater than 80 is recommended.

» **Correlated color temperature (CCT)** classifies a light's color in degrees Kelvin. For fluorescent lamps, a CCT of approximately 2,700K creates an intimate environment for homes; 3,500K is friendly and inviting and good for common areas and offices; 5,000K is bright and alert and useful for seniors who see better with a bluer light.

LIGHTING TECHNOLOGY

Here's a brief summary of the lighting technologies discussed in this measure *(see Resources for more information).*

» **Tubular fluorescent lamps,** such as T5s and T8s, are commonly used in ceiling luminaires for kitchens, offices and common areas. The letter T indicates tubular, while the number after the T indicates the lamp's diameter in eighths of an inch. T8 lamps have largely replaced T12s in new construction, and are commonly used as an energy-efficient retrofit replacement for 40-watt T12 lamps. There are a variety of generations of T8 technologies, including the so-called Super T8, which is more efficient than the standard T8.

T5 lamps are readily available for undercabinet lighting. T1s are used in sign lighting and provide the brightest light for exit signs within California's required maximum of five watts per face.

» **Compact fluorescent lamps (CFLs)** use one-fourth the electricity of an incandescent lamp and last seven to ten years. They come in pin-based and screw-based configurations. Pin-based lamps only fit fixtures specifically designed to accommodate them. Screw-based lamps will fit most fixtures that typically take a conventional incandescent lamp.

» **Light emitting diodes (LEDs)** use a semiconductor device less than ¼ inch in size that converts electricity into light. The technology's strong suit is its durability and ability to create directional light using very little electricity. Manufacturers are now concentrating arrays of LEDs to function like incandescent or fluorescent lamps. LED residential lighting is a new technology not specifically listed in residential building codes that will undoubtedly become more prevalent in the coming years.

» **Photoluminescent** signs and markings glow in the dark to provide a reliable path to exits within a building or to identify fire extinguishers. The technology uses zero electricity, relying only on ambient light to charge the photoluminescent material, and is 100% reliable if installed correctly.

LAMP DISPOSAL AND MERCURY

All fluorescent lamps contain mercury, a toxic substance. Mercury is an essential component of fluorescent lights and one reason they are so efficient. No mercury is released when the lamps are intact or in use, but proper disposal is necessary.

In the last twenty years there has been a significant decrease in the amount of mercury used per lamp and the trend continues downward. Some manufacturers now offer fluorescent lamps (linear and CFL) that contain only a fraction of the mercury used in standard fluorescent lamps.

Just because a lamp is marketed as environmentally preferable or green doesn't mean it has low mercury content. To identify the lowest mercury content lamps, request mercury content data from vendors lamps. Also specify that the lamps pass the U.S. Environmental Protection Agency's (EPA) Toxicity Characteristic Leaching Procedure (TCLP) or the California Total Threshold Limit Concentration (TTLC); see sidebar.

All fluorescent lamps, tubes and ballasts must be recycled by a household hazardous waste disposal facility, a universal waste handler or an authorized recycling facility. As of February 2006, it is illegal in California to discard any fluorescent lamps or ballasts as nonhazardous solid waste (that is, as ordinary trash). *(For more information about lamp and ballast disposal, see Resources.)*

Benefits

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

High efficiency lighting saves money and energy and reduces associated greenhouse gas emissions.

When a pin-based CFL is spent, only the lamp needs replacement, not the ballast. Since the ballast typically lasts much longer than the lamp, this reduces overall replacement costs. In addition, using pin-based CFLs ensures that occupants don't circumvent the energy savings by replacing the CFLs with incandescent lamps.

TCLP AND TTLC COMPLIANT LAMPS

The U.S. EPA uses the Toxicity Characteristic Leaching Procedure (TCLP) to establish whether to classify a product as hazardous waste. TCLP-compliant fluorescent lamps don't necessarily have the lowest mercury content. TCLP merely indicates how much mercury might leach from the lamp if it were put in a landfill; it isn't an accurate indication of how much mercury is in the lamp. The amount of mercury leached from the lamp must be less than 0.2 mg/L to pass TCLP.

The State of California uses the Total Threshold Limit Concentration (TTLC) to determine if something is a hazardous waste. The procedure determines the total concentration of a toxic chemical in a sample. The sample must contain less than 20 mg of mercury per kg of total weight to pass TTLC

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

This measure applies to retrofit projects. For new construction, California's Building Energy Efficiency Standards (Title 24) address requirements for energy-efficient lighting.

Low mercury lamps can generally be specified wherever a fluorescent lamp is applicable. T8 lamps and CFLs can

CFL SAVINGS

According to Pacific Gas and Electric Company (PG&E), a household that replaces twelve incandescent lamps with equivalent CFLs could realize the following savings:

Cost savings: Up to $97 per year, or $914 over the products' lifetime.

Energy savings: Up to 595 kilowatt hours per year; 5,596 kilowatt hours over the products' lifetime.

Greenhouse gas reduction: Up to 312 pounds per year; 2,932 pounds over the products' lifetime—about as much carbon dioxide as the average passenger car produces in four months of driving.

be used in all rooms, garages and outdoor porch lighting. Pin-based CFL fixtures can be installed in any room and are available as ceiling fixtures, wall sconces and recessed cans.

LED exit signs are nearly standard practice today, and replace fluorescent and incandescent fixtures in all applications. Cold cathode fluorescent exit signs are as efficient as LEDs.

Design Details

FLUORESCENT LIGHTING

Use CFL or T8 fixtures instead of incandescent fixtures. Low mercury fluorescent lamps with flicker-free electronic ballasts and a high CRI are recommended in every fixture.

To ensure that residents will continue to use fluorescent lamps, use pin-based CFLs and fixtures rather than screw-in CFLs with a standard Edison base. Pin-based CFLs cannot be retrofitted with incandescent lamps; this increases the likelihood of long-term energy and cost savings.

For recessed cans, use Insulation Contact Air-Tight (ICAT) compact fluorescent models.

When specifying tubular fluorescent lighting, choose T8 instead of T12 lamps. Compared to T12s, T8s are more energy efficient, thinner and use an electronic ballast instead of a magnetic ballast.

CFL AND INCANDESCENT EQUIVALENCIES

INCANDESECENT LAMP WATTAGE	CFL WATTAGE	LIGHT OUTPUT
40 watt	9–11 watt	> 450 lumens
60 watt	13–15 watt	> 800 lumens
75 watt	18–20 watt	> 1,100 lumens
100 watt	23–25 watt	> 1,600 lumens

Look for the most light output (lumens) for the wattage of the CFL you purchase.
Source: www.pge.com/res/rebates/lighting/index.html

LEDS

Because of their directional output and durability, LEDs can be very effective in certain applications. In addition to exit signs, LED strip lights can be installed under cabinets, in hallways and along staircases. Waterproof outdoor fixtures are also available for gardens, walkways, garage exteriors and other outdoor applications *(Site: B3–Light Pollution Reduction).*

EXIT SIGNS

Energy Star exit signs consume 5 watts or less, whereas compact fluorescent exit signs use 15 watts and incandescents use 20 to 40 watts. Energy-efficient technologies for exit signs include cold cathode T1 fluorescents, LEDs and photoluminescent products.

While photoluminescent signs and tape consume no energy and are useful for various applications, they must be exposed to certain levels of artificial or natural light each day to illuminate effectively in the dark. Check with your local code official and follow manufacturer guidelines to ensure they receive enough light to be visible in an emergency.

LIGHTING CONTROLS

Lighting controls can significantly reduce lighting energy use, especially in common areas. Occupancy sensors (passive infrared, ultrasonic, or both) are a sure way to reduce energy use. Install them in closets and rooms that will only be occupied intermittently. Occupancy sensors in restrooms and bathrooms will also cut energy use, but be sure to position them so that they will sense the presence of someone in a toilet stall. Title 24 requires occupancy sensors in bathrooms to be manual-on-automatic-off.

Electronic dimmers may also help save energy. Some dimmers, however, are mechanical and only cut power to the lamp without reducing the overall power draw. Electronic dimmers will save about 40% of the energy when an incandescent lamp is dimmed by 50%. Do not use dimmers with CFLs unless the CFL is specifically designed for dimming. Dimmable CFLs cost significantly more than standard CFLs.

Photocells, which control electric lighting in response to daylight levels, can also save energy. They are typically used to shut off exterior lights during the daytime and automatically turn the lights at night. Photocells are also used in conjunction with daylighting design to provide high quality illumination indoors during daytime hours *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation)*.


KEMA

Wall occupancy sensor.

Code Considerations

Title 24–2008 requires that at least 50% of the total installed wattage in kitchens be high efficacy fluorescent lighting. With the exceptions noted below, all other interior and exterior residential hardwired lighting must be either high efficacy fluorescent lighting or use specific controls.

Exceptions include appliance lights (for example, a lamp in a range hood), lamps on dimmers, and lamps where the luminaire cannot accommodate a CFL (for example, small wall sconces and chandeliers).

Considerations for Residents

Thanks to improvements in fluorescent lamp technology, residents can now expect better interior lighting with more natural color rendition, at significantly lower operating costs. Electronic, flicker-free ballasts will also increase acceptance of fluorescent lighting inside a home. Energy and money savings from fluorescent lamps make them very attractive to residents.

Ensure that residents have adequate information about their home's lighting strategy. Consider keeping low mercury, high efficacy fluorescent lamps appropriate to the units onsite for sale to residents *(Operations & Maintenance: N1–Operations and Maintenance Procedures).*

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Costs are retail as of March 2007, courtesy of Bay Area LISC's publication, Guidelines for Preparing a Green Physical Needs Assessment (www.bayarealisc.org).

Prices of standard T8 lamps range from $1.89 to $1.99. Prices of low mercury T8s range from $2.99 to $5.99. Electronic T8 ballasts cost from $16.99 to $26.99, depending on whether it is a one- or two-lamp ballast.

Dimmable fluorescent lamps require dimming ballasts; expect the cost to be more than triple that of standard electronic ballasts.

Depending on the type of lamp, screw-based CFL prices range from $1.50 to $17.99; utility rebates are sometimes available that bring the price well below $1.00 per lamp. CFLs last eight to ten times longer than incandescent lamps and use one-fourth the electricity. Typical payback time is about three years, but can be substantially less depending on factors such as available rebates and the amount the lamp is used.

Prices for pin-based CFL fixtures with lamps ranged from $15 to $200 (the lamp itself costs roughly $7). Pin-based CFLs are more cost effective than screw-in CFLs; the ballast outlasts the lamps, and therefore only the lamp needs to be replaced, which saves money.

The installed cost of LED exit signs is about $180 per fixture. Payback may be from less than one year to four years depending on fixture cost and rebates.

Resources

» **Energy Star** has specific criteria for CFLs and exit signs, including longevity, light distribution performance and warranties: www.energystar.gov

» **Flex Your Power** provides information about rebates and incentives from California utility companies. California utilities provide rebates for some multifamily energy efficiency measures, including lighting upgrades for existing buildings only: www.flexyourpower.org

» **Inform** has fact sheets on mercury in lamps: www.informinc.org/fact_P3mercury_lamps.php

» **Pacific Gas & Electric Company** (PG&E), **Southern California Edison** (SCE) **and San Diego Gas and Electric Company** (SDG&E) offer education and resources on energy-efficient lighting at their energy education centers and online:

PG&E: www.pge.com/pec

SCE: www.sce.com/RebatesandSavings/EnergyCenters

SDG&E: www.sdge.com/esc

FLUORESCENT LAMP RECYCLING

» **California Integrated Waste Management Board** (CIWMB) provides information about fluorescent lamp and ballast disposal: www.ciwmb.ca.gov/wpie/fluoreslamps

» **Earth 911** lists locations nationwide where fluorescent lamps and ballasts may be taken for recycling: www.earth911.org

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

» Pepperwood Apartments, p. 121

» Sara Conner Court Apartments, p. 221

ELEVATORS

Specify Gearless Elevators; Use Biodegradable Lubricating Oils

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: **14 21 00:** Electrical Traction Elevators, **14 24 00:** Hydraulic Elevators

OLD: **14210:** Electrical Traction Elevators, **14240:** Hydraulic Elevators

Recommendation

Design the building to encourage the use of stairs instead of elevators.

Specify gearless AC elevators (also known as machine room-less elevators) instead of hydraulic elevators when appropriate.

If specifying hydraulic or geared traction elevators, use biodegradable lubricating oils instead of petroleum products.

Description

All buildings, and especially low- and mid-rise buildings, can be designed to encourage residents to use stairs. This may reduce elevator energy consumption and improve residents' health.

Elevators can account for up to 3% to 5% of building energy use. For multifamily applications, elevators are often mandatory for accessibility reasons. Typical elevator installations require significant space and can be costly to operate.

Hydraulic elevators, which "lift" the elevator, dominate the low-rise multifamily market because they are much cheaper than traction elevators. Geared AC traction elevators are common in mid-rise buildings.

Gearless AC traction elevators, which are commonly referred to as machine room-less elevators, dominate the high-rise markets. They are also becoming more widely available for low- and mid-rise buildings, although at a slight cost premium to hydraulic elevators. Gearless elevators use a motor and counterweights to pull belts over sheaves, and they don't use lubricating oils, which eliminates the need to store, dispose of or clean up hazardous waste. Compared to conventional geared elevators, gearless elevators use about 50% less energy.

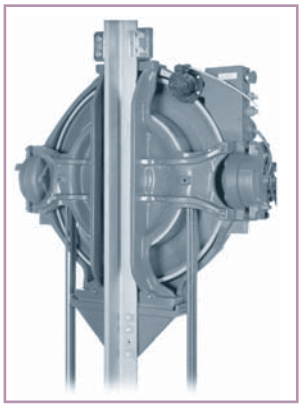
In some machine room-less models, the same shaft can accommodate two independent cabs installed one above the other. This doubles the number of cabs in the same space and increases passenger capacity while reducing energy use. Other energy-saving features may include permanent magnet motors as well as regenerative drive systems that capture energy generated by the elevator and return it to the building for reuse.

In applications where a hydraulic or geared traction elevator is installed, environmental impacts can be reduced by using plant-based, biodegradable lubricating oil. These fluids breakdown quickly and do not cause as much damage if they leak into the ground as petroleum-based oils.

Benefits

Making stairs convenient will encourage residents to use the elevator less, reducing the building's energy use.

Gearless elevators have several advantages over hydraulic and geared traction elevators. First, they are space efficient and easier to install because they typically do not require a mechanical room or special drilling. Second, they have much smaller motors, which can decrease energy use by up to 50%, cutting costs and associated greenhouse gas emissions. Finally, they do not require lubricating oils that can leak and cause groundwater contamination.


KONE ECODISC

A gearless elevator motor.

Because gearless elevators create less heat than other elevator systems, cooling systems may be almost unnecessary and energy use is decreased.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Gearless elevators are appropriate for most building types and sizes. However, gearless elevators in low-rise applications can cost more than conventional hydraulic elevators, making them most appropriate for applications of three stories or more.

For hydraulic elevators, lubricating oils that are plant-derived can be used in place of most petroleum-based products. Their soy-based grease comes from a renewable resource, is economical, nonpolluting and meets all industry needs for safety and performance.

Design Details

In low and mid-rise applications, encourage the use of stairs by making them attractive and more prominent in building lobbies. Where possible, place the elevator further into the lobby than the stair entrance. In high-rise applications, make elevators more convenient to use but consider design options that encourage the use of stairs.

Hydraulic and geared traction elevators have commonly accepted sizing and space standards. For machine room-less elevators, however, sizing and space requirements are not standardized; also, limitations on capacity, speed and cab interior may restrict applications in which these elevators can be used.

If using hydraulic or geared traction elevators, biodegradable lubricating oils require no special design considerations.

SMART ELEVATORS

Some elevator systems, known as smart elevators, use destination control software to manage passenger trips and reduce energy use. The software directs passengers to certain elevators based on the floor they wish to go to. Besides saving energy, smart elevators get passengers to their floors with fewer stops and can decrease passenger wait-time by as much as 30%.

ELEVATOR RETROFITS

- **Lighting:** Light-emitting diodes (LED) can be used in elevators for interior lights, call buttons, floor indicators and arrows. They reduce energy use and save on installation and maintenance costs compared to incandescent lights. Also consider installing sensors that turn the lights off when the elevator isn't in use.
- **Controller replacement.** Consider replacing elevator controllers that are more than ten years old with a more energy-efficient microprocessor-based controller. If an older traction elevator has a DC controller, replacing it with an AC unit will reduce heat generation and cut energy costs.

Code Considerations

Some interpretations of building codes may not allow for 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.

Considerations for Residents

Prominent stairways encourage walking, which is beneficial for residents' health. Gearless elevators produce a smoother ride than hydraulic elevators. They can operate faster than conventional hydraulic elevators, which may improve residents' satisfaction.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

Allowing room for a prominently located stairway may increase costs in constrained areas. However, the reduction in elevator use can help offset the cost.

For low-rise multifamily buildings, hydraulic elevators are the least expensive conveyance option in terms of upfront costs, but they are costly to operate relative to traction elevators. For mid-rise buildings (three to four stories and more), gearless elevators are competitive with hydraulic and geared elevators. Because gearless elevators have high travel speeds with less downtime, sometimes only one elevator is needed for a building rather than two. This can lead to a significant cost savings, as can upgrades such as regenerative elevator drives and destination control software (depending on the application and elevator usage).

Resources

- **American Council for an Energy-Efficient Economy** (ACEEE) published a white paper "Opportunities for Elevator Efficiency Improvements" (April 2005): www.aceee.org/buildings/coml_equp/elevators.pdf
- ***The BOMA Magazine*** has an article, "Protecting the Environment and Your Money: How Elevators are Going Green" (Sept./Oct. 2007): www.fmlink.com/ProfResources/Magazines/BOMA
- **Buildings.com** has an article, "Machine-Room-Less (MRL) Elevators" (May 2006): www.buildings.com/articles/detail.aspx?contentID=3076
- **Build It Green Product Directory** lists products that correspond with this measure: www.BuildItGreen.org/products
- ***Environmental Building News*** has an article, "The Elevator Revolution" (Aug. 2004); fee to access: www.buildinggreen.com

Related Case Studies

- Crossroads, p. 234

OUTDOOR PLAY STRUCTURES

Specify Healthy, Resource-Conserving Outdoor Play Structures

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
√ Site/Community	O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	Climate Protection

NEW: 11 68 00: Play Field Equipment and Structures

OLD: 02881: Playground Equipment and Structures

Recommendation

Specify outdoor play structures that are made from low-toxic, natural, recycled and/or recyclable materials.

Specify play structures that do not utilize wood treated with chromated copper arsenate (CCA).

Use recycled plastic lumber products for site furnishings.

Description

Play structures are typically made from wood, plastic, steel, aluminum or a combination of these materials. Some of these materials use a lot of energy to produce, or have other environmental problems associated with them. For instance, they may release pollutants during manufacturing, they may not be recyclable or they may pose health hazards.

CCA-treated wood, for example, used to be common for play structures. Studies have shown that disposing of CCA-treated wood poses significant environmental risks due to its arsenic and chromium content. Research also shows that play structures containing CCA-treated wood may be a health risk for children. As of December 31, 2003, the use of CCA-treated wood for playground products and most residential uses was phased out in the United States; however, companies were allowed to sell existing stock until depleted. Arsenic-free wood treatment methods, including alkaline copper quaternary (ACQ), copper azole (CA-B) and copper boron azole (CBA-A), have now replaced CCA.

Although manufacturers have phased CCA-treated wood out of production, some CCA-treated wood products may still be on the market. Check product literature and specifications carefully to ensure CCA-free products are used.

Many manufacturers keep valuable materials out of the waste stream by incorporating recycled materials into products designed for outdoor use, including recycled plastic lumber for play structures and site furnishings; recycled rubber playground surfacing made from old tires; and recycled plastic play structures, waste and recycling bins, benches, chairs, fencing, walkway bridges, bike racks, planters, and even park signs. *(For information about environmentally preferable interior furniture, see Finishes & Furnishings: K8.)*

Natural playgrounds can be an appealing, educational and environmentally responsible alternative to using manmade and possible toxic materials. Natural playgrounds are landscapes purposefully designed for having fun and learning about the natural world. They make the most of existing outdoor features, and often weave together natural elements in complex and exciting ways. They may incorporate plants, boulders, earth forms, sand and dirt, streams and other natural water features, pathways and environmental art.

Benefits

CCA-free wood is safer for children and the environment.

Recycled-content play structures and site furniture conserve resources and keep usable materials out of landfills. The California Integrated Waste Management Board, for example, reports that California recycles 75% of the 40.2 million waste tires it generates yearly; pour-in-place or tile playground surfacing material is one common application for these old tires.

Natural playgrounds promote imaginative play, strengthen children's connection to nature, and minimize the use of building materials.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all projects. Play structures may be found in both residential and nonresidential settings.

Design Details

Consider these issues when selecting environmentally preferable play structures:

PLAY STRUCTURE MANUFACTURERS

Look for these characteristics when comparing manufacturers:

» **Made in California:** California manufacturers are subject to the state's strict environmental regulations for emissions and waste disposal. Sourcing local products also reduces the product's carbon footprint.

» **Efficient material use:** Reuses scraps and leftovers in the manufacturing process or recycles them elsewhere.

» **Recycled materials:** Promotes the recycled products industry by using recovered materials in their products. The U.S. Environmental Protection Agency's Comprehensive Procurement Guidelines recommend recycled-content levels for many products, including park and recreation products *(see Resources).*

» **Less packaging:** Minimizes packaging to reduce waste.

MATERIALS

Select play structures made from environmentally preferable materials, including:

» **Wood products:** Avoid CCA-treated wood. Choose products made with reclaimed wood, FSC-certified wood *(Structure: D5–FSC-Certified Wood for Framing Lumber)* and wood composites with no added formaldehyde.

» **Wood alternatives:** Choose products made with strawboard or other agriboard materials. For outdoor applications where wood would normally be used, choose recycled plastic lumber instead where feasible.

» **Plastics:** Avoid polyvinyl chloride (PVC). Use plastic products with a high postconsumer recycled content.

» **Design for disassembly and recycling:** Select products that are easy to disassemble for reuse or recycling.

» **Durability:** Select products that are tough, reusable and upgradeable, or that contain reusable parts.

Code Considerations

As of December 31, 2003, CCA-treated wood products for most residential uses, including play structures, were phased out in the United States. However, companies were allowed to sell existing stocks until depleted.

Considerations for Residents

Environmentally preferable play structures and outdoor furniture may reduce people's exposure to arsenic and other toxic chemicals.

To keep repair and replacement costs in check and reduce waste, choose durable park furnishings and playground equipment.

Cost and Cost Effectiveness

BENEFIT	★★☆
COST	$$$

When purchasing park and playground furnishings, in addition to first-cost considerations, consider quality, durability and service needs. Less durable products may require more frequent maintenance, repair, replacement and disposal, which can ultimately increase costs. For example, recycled plastic lumber benches are more expensive than wood benches; however the plastic lumber products are easier to maintain and last longer.

Resources

» **Build It Green's** Green Product Directory offers fact sheets on recycled plastic lumber and other environmentally preferable materials: www.BuildItGreen.org

» **California Department of General Services'** Green California program has information about plastic lumber and treated wood in outdoor furnishings: www.green.ca.gov/EPP/furnisher

» **California Integrated Waste Management Board** (CIWMB) lists playground equipment in their Recycled Content Products Directory (click on the "Parks, Recreation and Sports" category): www.ciwmb.ca.gov/RCP

» **StopWaste.Org** has information about environmentally preferable purchasing including the fact sheet, "Recycled Content Park and Recreation Products in Alameda County," which has sample specifications and other purchasing resources for playground equipment, surfacing and parks furnishings: www.StopWaste.Org/EPP

Related Case Studies

» Carmen Avenue, p. 230

» Crossroads, p. 234

» Sara Conner Court Apartments, p. 221

OPERATIONS & MAINTENANCE

OPERATIONS & MAINTENANCE

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OPERATIONS & MAINTENANCE

To a certain extent, a building's environmental performance is a function of its location and design. But the day-to-day behaviors of the residents and property management staff also play a large role in reducing greenhouse gas emissions and maximizing the benefits of energy efficiency, durability and indoor environmental quality over the building's entire life.

Building operations and maintenance shouldn't be an afterthought to the development process, and it shouldn't be reduced to a checklist of cleaning procedures and replacement schedules. It's important that the people who live and work in green multifamily housing be given relevant information, regular encouragement and specific feedback so that they will be motivated not only to care for their homes, but also for the community and the global environment. There are three important components to fostering this motivation:

- Provide training and manuals to staff and residents so they have the information and resources necessary to properly operate and maintain the building *(N1).*
- Provide signs or other displays to demonstrate important green features and transit options to residents, staff, the public and the media *(N2, N3).*
- Install energy monitors in units and common areas to raise awareness about energy use and encourage conservation *(N4).*

BENEFITS

This table lists the Guidelines' Operations & Maintenance measures and their primary benefits. *(See the individual measures for details.)*

MEASURE	Health/IEQ	Site/Community	Energy Efficiency	Water Efficiency	Material Efficiency	O&M	Resident Satisfaction	Climate Protection
N1 Operations and maintenance procedures	✓	✓	✓	✓	✓	✓	✓	✓
N2 Transit options	✓	✓				✓	✓	✓
N3 Educational signage	✓	✓	✓	✓	✓	✓	✓	✓
N4 Energy monitors			✓			✓	✓	✓

EXPLANATION OF BENEFITS

Health/IEQ: Reduces indoor pollutants, promotes better indoor environmental quality, and/or provides opportunities for improved public health.

Site/Community: Protects land, water and air on and near site from pollution or other environmental damage, uses municipal infrastructure more efficiently by redeveloping building or site, and/or provides important and needed amenities for the surrounding community.

Energy Efficiency: Reduces building energy consumption.

Water Efficiency: Reduces water use in building and/or on site.

Material Efficiency: Reduces, reuses and/or recycles materials that might have otherwise ended up in landfills, reduces materials needed to construct or operate thebuilding, and/or uses materials produced in a way that minimizes environmental damage.

O&M: Increases building's durability, and/or reduces operating and maintenance expenses.

Resident Satisfaction: Saves residents money and/or improves residents' quality of life.

Climate Protection: Reduces greenhouse gas emissions related to building's operations and location.

CORE CONCEPTS

INTEGRATED DESIGN

Good operations and maintenance practices actually start not with the building manager but with the developer and the architect, and should be addressed early in the design process. Specifying high quality, durable, vandal-proof materials will make a project easier to maintain over time. Site and building designs that encourage community interaction will instill pride in residents and deter crime. *(For detailed recommendations on design strategies that provide the foundation for a well-maintained, durable project, see the Planning & Design section.)*

MAINTENANCE

To ensure that finishes and furnishings continue to provide health, durability and environmental benefits, they need to be properly maintained, using effective but low-toxic cleaning products and maintenance techniques. Teach staff and residents about appropriate maintenance procedures, and give residents some guidance on where to find and how to choose green, healthy furnishings *(N1).*

COST

Over the life of a building, O&M costs will greatly outweigh construction costs, so it makes sense to take steps to design a durable, energy-efficient, low-maintenance building. No matter how well designed, however, every building needs to be properly operated and maintained if it is to perform well year after year. Energy-efficient homes, for example, will only offer substantial long-term cost savings if occupants understand how they work. This is especially true for design strategies that people may be unfamiliar with, such as passive solar heating *(AA7).*

It does take time to develop manuals, signage and displays and to provide O&M training to staff and residents. While it's difficult to quantify the cost savings that result from these efforts, it is reasonable to assume they will contribute to a healthier, longer-lasting, more energy-efficient building.

MARKETING AND COMMUNITY RELATIONS

Educational displays and tours of the development can be an important marketing tool for developers. For affordable housing projects, these efforts can enhance a developer's reputation among stakeholders including community and political leaders and funders. For market-rate housing developers, displays and tours can attract positive media attention, which may help drive interest from potential tenants and buyers.

STREAMLINING A GREEN OPERATIONS & MAINTENANCE PROGRAM

First Community Housing, San Jose, CA

First Community Housing, a nonprofit affordable housing developer in San Jose, doesn't shy away from leading-edge green strategies such as photovoltaic systems, combined water heating and space heating systems, and cool roofs. But facilities personnel aren't always familiar with how to operate and maintain some of the more unique systems, said Marty Keller, FCH's director of construction management.

ACCESSIBLE, DETAILED O&M MANUALS

To familiarize maintenance staff with appropriate O&M procedures, FCH provides a detailed O&M manual that's modeled on a specification manual. "Any equipment that's specified has a companion section in the O&M manual that shows how to operate and maintain it in a green way, including how to dispose of it in a green way," said Keller.

FCH's projects always have a commissioning agent. "They play a critical role in ensuring good design review and good quality installation, and that systems are performing in the way intended," said Keller. FCH also pays the commissioning agent to help develop the O&M manual, including distilling information from the spec book into user-friendly language. "The maintenance staff has variable skill sets," Keller said. "You have to be able to bridge that in a fairly easy to understand and accessible way."

The O&M manual also addresses finishes such as carpet. Instead of sheet carpet, FCH typically installs carpet tiles because they can be individually replaced when worn, saving time, material and money. When the tiles are removed, Keller said, "We don't want people to put them in the dump. The manual tells them to call up the carpet company—they'll come and take it" for recycling.

Cleaning and maintenance chemicals are also covered. "We explain that it's a health issue for them," Keller said, "and we include a listing of chemicals that are environmentally preferable substitutes for what is commonly used." He acknowledged that getting staff to switch from familiar products requires some education, "and the new stuff has to perform. Painters in the old days had no use for healthier paint because it didn't perform. Now if it's healthier, as long as it performs, then we get acceptance."

TRAINING: IN PERSON & ON TAPE

At the end of every construction project, FCH holds a two-day training session for the maintenance staff. Part of the training includes having the various subcontractors teach staff how to operate and maintain equipment and systems. But Keller found that some of that training was wasted because of staff turnover. "Now we put that walk-through on video. We distill it down to a couple of hours of video and expect the maintenance staff to become familiar with it. It provides them with some assistance in addition to the O&M manual."

"We're proud of having set up the structure" for this green O&M program, Keller said, including "manuals, visual aids and tools that are easy to understand."

For more information, visit www.firsthousing.org

MEASURE N1

OPERATIONS AND MAINTENANCE PROCEDURES

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: **01 70 00:** Execution and Closeout Requirements, **01 91 13:** General Commissioning, **01 92 00:** Facility Operations, **01 93 00:** Facility Maintenance

OLD: **01300:** Administrative Requirements, **01700:** Execution Requirements, **01810:** General Commissioning Requirements

Recommendation

Provide tenants, homeowners and maintenance staff with training and manuals on building operations, cleaning and other maintenance practices.

Description

To maximize the benefits of energy efficiency, durability and indoor environmental quality, green buildings must be properly operated and maintained. Over the life of a building, operations and maintenance costs will greatly outweigh construction costs. Energy-efficient buildings can only offer substantial long-term cost savings if building staff and occupants understand how the systems work. This is especially true for strategies that people may be unfamiliar with, such as passive solar heating.

Materials used in green buildings sometimes require different maintenance procedures or cleaning products to prolong their life. Educating residents and staff on proper procedures will help extend product life and maintain healthier interiors.

Some conventional cleaning chemicals may be hazardous to residents' and workers' health or may create water or air pollution. Janitorial supplies such as paper towels, toilet tissue, garbage bags and cleaning tools consume natural resources when they're manufactured and may wind up in landfills after they're used. Environmentally preferable cleaning products and practices help safeguard the health of people and the environment.

Benefits

Green operations and maintenance (O&M) practices help ensure that buildings last longer, cost less to operate, and feel more comfortable. Benefits include reduced energy costs and fewer product replacements.

Green cleaning products help protect resident and worker health, and reduce pollution, resource consumption and waste. Environmentally preferable cleaning products and practices may benefit property managers by lowering liability risks as a result of using less toxic products. The property's marketability may also be enhanced because many residents appreciate living in a building that's maintained in a healthy, environmentally sound manner.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

All new residents should go through a basic training session that highlights the home's key green features and maintenance attributes. Along with the residency agreement, provide a manual with information that reinforces the training.

Provide training to maintenance staff and building operators on operations and maintenance procedures, including environmentally preferable cleaning practices. Provide a detailed O&M manual designed for easy reference. The manual will also be useful for quickly training new employees.

Tours and signs can help reinforce the preferred operations and maintenance practices *(Operations & Maintenance: N3–Educational Signage).*

For green tenant improvement guidelines for commercial tenants, see Structure: C2–Mixed-Use Design Strategies.

Design Details

DURING CONSTRUCTION

Add language in construction documents requiring the contractors to train the building staff upon completion of construction *(Structure: C3–Commissioning).* Also include language in construction documents to ensure that the subcontractors provide all necessary information for the manuals. Organize requirements by CSI division and incorporate them into the project specifications.

Clearly label all safety valves and controls for major building systems.

INFORMATION FOR RESIDENTS

Provide information to residents through a combination of manuals, trainings and signs. Ensure that all information is clearly communicated in the languages of the residents and is applicable to a range of learning abilities. Print the resident's manual double-sided and on recycled paper. At a minimum, the manual should include:

- A copy of the project's green building program certificate and/or checklist, if applicable.
- Product manuals for all installed appliances.
- Tips on how to save energy (for example, Flex Your Power fact sheets, California Multifamily Housing Consortium's newsletter, or similar publications).
- Cleaning and maintenance procedures for the green building materials.
- Information about environmentally preferable cleaning products and practices.
- Information on pollution reduction steps taken, such as low-VOC paints or integrated pest management. Encourage residents to embrace the same principles in their own purchases and activities.
- Information on detecting early signs of mold and steps to prevent, remediate or get help with mold.

Here are more details on the topics that should be covered in the resident's manual or in trainings or signage:

- **Energy efficiency:** Discuss how to operate appliances, thermostats and lighting to save energy. Where applicable, discuss methods to improve passive solar heating and cooling performance, such as furniture placement, paint colors and shading devices *(Planning & Design: AA7–Passive Solar Design).* Illustrate how window operation can influence natural ventilation *(Systems: H3–Advanced Ventilation Practices).* If applicable, explain how to read meters and control systems that give feedback to residents on energy use *(Systems: G3–Water Submetering and Operations & Maintenance: N4–Energy Monitors).*
- **Water conservation:** Provide information and signage on how to operate new fixtures, especially dual-flush toilets and waterless or low-water urinals *(Systems: G1–Water-Efficient Fixtures).*
- **Finishes:** Explain why the products were chosen, what makes them green, and how to maintain them to ensure their long life. Give out a resource list for finding green products and furniture *(Finishes & Furnishings: Section K).*
- **Indoor air quality:** Explain the steps that were taken to provide good indoor air quality. Discuss healthy maintenance practices, including using low-VOC consumer products and taking shoes off upon entering the home *(Finishes & Furnishings: K1–Entryways).*
- **Cleaning:** Encourage residents to use the least-toxic products for the appropriate cleaning task. Although there are no uniform standards for environmentally preferable residential consumer brands at this time, some manufacturers claim that their products are better for people and the environment. Encourage residents to read product labels carefully before buying and follow manufacturer's directions for use, storage and disposal.
- **Pest management.** Give tips for how to reduce the potential for ants, cockroaches and rodents, such as keeping kitchens clean, not letting dishes build up in the sink and storing dry foods in pest-proof containers.
- **Recycling:** Provide details on recycling in the building. Depending on the project, include information on collection facilities, recycling-chute operation, built-in recycling container maintenance, and storage of compostable materials between pick-ups to reduce pests *(Finishes & Furnishings: M3–Recycling and Waste Collection).*
- **Proper material disposal:** Provide information about where residents can donate, sell or recycle unwanted bulky items such as furniture and appliances. Include a comprehensive list of items accepted by each facility.
- **Community facilities:** Give an overview of community facilities that have green building features. For example, if central laundry areas have high efficiency washing machines, advise occupants on proper use and soap amounts per load *(Finishes & Furnishings: M1–Energy- and Water-Efficient Appliances and M2–Central Laundry).*
- **Natural surveillance:** Discuss design elements that help provide safety *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).* Provide information on how to report and remediate graffiti and vandalism.
- **Landscaping:** Provide information on the sustainable landscaping practices and explain maintenance practices that occupants should be aware of, such as integrated pest management instead of insecticides, drip irrigation systems, swales in parking lots, and so on *(Site: B1–Sustainable Landscaping).*
- **Alternative transportation:** Provide information about local public transit, and any onsite programs for residents such as free or reduced-cost transit passes or car-sharing programs. *(Operations & Maintenance: N2–Transit Options).*
- **Post-construction tour:** Allow future residents to tour the site during the last phase of construction to create a sense of ownership.

MAINTENANCE AND STAFF TRAINING

Provide training to all new staff members and regularly check compliance by keeping a record of training sessions. Consider incorporating an alarm system that alerts staff when maintenance is needed on building systems. Auto-reminders in a computer-based calendar or email program may be helpful.

Plan for staff turnover by instituting a training program that includes resource materials in multiple languages and that is appropriate for a range of learning levels. Consider video-recording training sessions so new employees can benefit from past training opportunities. A comprehensive manual that includes the following should be readily available to all employees:

» Operations and maintenance procedures and schedules for all areas, systems and finishes.

» Instructions for proper record keeping, including equipment maintenance and calibration records, commissioning reports, information about changes in the building's structure, equipment or uses.

» A list of required cleaning products for each green building material organized by CSI number (both new and old formats). Specify low-toxic and biodegradable products wherever possible. Include product names, ordering information and cleaning instructions; ideally, products should be available locally. Keep on hand an adequate inventory of the required cleaning products.

» Cut-sheets of everything in the building that may need replacement or repair in the future. Includes electrical boxes, switches, wall coatings (paint colors and brands), toilets, sinks, faucets, furniture, hardware, flooring, towel bars, replacement tile and more. Keep on hand an assortment of the most frequently replaced items.

» An extra set of plans for staff to refer to when working with service personnel.

» Information on proper disposal techniques for hazardous and nonhazardous waste.

» A vandalism management plan that specifies prompt removal of vandalism and graffiti *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).*

ENVIRONMENTALLY PREFERABLE CLEANING

Property managers should ensure that cleaning personnel—whether in-house or contracted services—are appropriately trained. Rather than developing a green cleaning program from scratch, consider following the cleaning guidelines and standards developed by organizations such as the U.S. Green Building Council's LEED for Existing Buildings Rating System (LEED-EB) and Green Seal *(see Resources.)* Here are some recommended best practices:

» Meet Green Seal's standards for glass, all-purpose, and washroom cleaners, and hard-floor and carpet care products. For other cleaning products, choose low- or zero-VOC products *(for information about VOCs, see Finishes & Furnishings: K3–Low/No-VOC Paints and Other Coatings and K4–Low-VOC Adhesives and Sealants).*

» Reduce the total number of stocked cleaning products by using multi-use cleaners in concentrated formulas. With concentrated cleaning chemicals, consider using automated dilution control equipment that properly measures and dispenses chemicals. These devices can reduce chemical consumption by 50%.

» Choose vacuum cleaners that meet the requirements of the Carpet & Rug Institute's Green Label program *(www.carpet-rug.org).*

» Choose recycled-content janitorial paper products (toilet tissue, paper towels, facial tissue) that meet or exceed the U.S. Environmental Protection Agency's Comprehensive Procurement Guides *(see Resources).*

» Consider using microfiber cloths for dusting and mopping. They can reduce the use of chemical cleaners and water.

» Be alert for signs of actual mold or signs that mold is likely to develop, such as condensation and wet spots. Address moisture problems as soon as possible, and perform regular building inspections, including the HVAC and plumbing systems.

Code Considerations

If you plan to use automated dilution control equipment for concentrated cleaning chemicals, check with local codes prior to installation. Many municipalities have "back flow" requirements for these devices because they may be permanently attached to water lines.

Considerations for Residents

By communicating about the building's green features and actively involving residents in taking care of their building, owners can help instill a sense of respect for the development. This can create a good relationship between occupants and owners, and increase the perception of safety by fostering community interaction *(Planning & Design: AA6–Design for Safety and Vandalism Deterrence).*

Green cleaning products and practices contribute to better indoor air quality, which may protect residents' health.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Developing, assembling and reproducing manuals can take time. Providing trainings to tenants and maintenance staff will be an additional task for property managers. However, once a system is in place, the process can be repeated for all new developments. Video records of trainings can save money on training over the long term. Cost savings from reduced operations and maintenance costs are hard to quantify but are possible with such a program.

Compiling materials to include in the manuals should be coordinated with the general contractor and architect before construction starts. These tasks generally don't cost anything but require perseverance to collect all paperwork.

In general, environmentally preferable cleaning products cost the same as their traditional counterparts. Recycled janitorial paper products are generally less expensive than their traditional counterparts. Property managers can also reduce costs by reducing overall consumption. For example, switching from multi-fold paper hand towels to paper dispensed from jumbo rolls can reduce consumption by 30%.

Resources

- **Bay Area LISC** publishes a free guidebook "Green Affordable Housing Operations & Maintenance Toolkit & Buyers Guide" that should be a starting point for any O&M manual; click on Resources then Publications: www.bayarealisc.org
- **Collaborative for High Performance Schools'** (CHPS) *Best Practices Manual, Volume IV* has extensive O&M guidelines and procedures that are applicable to all building types; available for free**:** www.chps.net
- **Green California,** a state website, provides information on environmentally preferable purchasing, cleaning products, lighting, paint, water efficient fixtures and more: www.green.ca.gov
- **Green Cleaning Network** is a nonprofit educational organization that promotes the use of environmentally preferable cleaners and processes: www.GreenCleaningNetwork.org
- **Green Seal** has standards for green cleaning products and lists approved products: www.greenseal.org
- **Local energy utilities** sometimes offer classes on energy-efficient building maintenance; contact your local utility.
- **National Association of Homebuilders'** *Green Home Building Guidelines* has recommendations and resource lists for O&M manuals:www.nahbgreen.org
- ***Pennsylvania Green Building Operations and Maintenance Manual*** has relevant information for maintaining any green building. This free manual was developed with Green Seal (see above): www.dgs.state.pa.us/dgs/lib/dgs/green_bldg/greenbuildingbook.pdf
- **StopWaste.Org** publishes free resources on environmentally preferable building maintenance and operations, including fact sheets and the in-depth guides, "A Resource Guide for Environmentally Preferable Products (EPP)" and "A Guide to Green Maintenance & Operations": www.StopWaste.Org/EPP
- **U.S. Environmental Protection Agency's** Comprehensive Procurement Guidelines (CPG) are available at: www.epa.gov/cpg
- **U.S. Green Building Council's** LEED Rating System publishes the *LEED for Existing Buildings Reference Guide v2.0;* fee to purchase: www.usgbc.org

Related Case Studies

- Carmen Avenue, p. 230
- Colony Park, p. 227
- First Community Housing, p. 209

MEASURE N2

TRANSIT OPTIONS

Provide Residents with Public Transit Information and Assistance

KEY BENEFITS

√ Health/IEQ	Material Efficiency
√ Site/Community	√ O&M
Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: N/A

OLD: N/A

Recommendation

Encourage use of public transit, carpooling or car sharing to reduce vehicle miles traveled.

Description

In the United States, transportation accounts for one-third of carbon dioxide (CO_2) emissions created by human activities, according to the Urban Land Institute's 2007 report, "Growing Cooler: The Evidence on Urban Development and Climate Change." According to the report, "Since 1980, the number of miles Americans drive has grown three times faster than the U.S. population, and almost twice as fast as vehicle registrations. Average automobile commute times in metropolitan areas have risen steadily over the decades, and many Americans now spend more time commuting than they do vacationing."

One of the most effective ways to reduce transportation-related CO_2 emissions is to provide people with convenient, appealing alternatives to driving by themselves in private cars *(Planning & Design: AA1–Infill Sites, AA2–Design for Walking and Bicycling, AA3–Alternative Transportation and AA4–Mixed-Use Developments).* Building owners and property managers can play a key role in encouraging residents to drive less. Effective actions include providing transit and carpooling information, offering free or discounted transit passes, and establishing a car share program on site or nearby.

Benefits

Reducing vehicle miles traveled decreases vehicle-related CO_2 emissions.

Building owners who provide transit information and assistance foster good relations with residents. Developments well served by public transit and other desirable transportation alternatives may be more marketable.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily projects.

Design Details

Provide an information board or transit kiosk with information on local travel options, including public transit routes, stops and schedules. Post the information in a place where people are likely to notice it, such as next to mailboxes. Bulletin boards where residents can post carpooling opportunities encourage ride-sharing and neighborliness.

Consider offering free or discounted public transportation passes to residents. Some counties, such as Santa Clara County, provide discounted bulk purchases of transit passes depending on the number of units and proximity to light rail or buses.

Consider offering a car-share program on site or helping set up one nearby *(Planning & Design: AA3–Alternative Transportation).*

Work with local jurisdictions to incorporate bus stops, bus shelters or other public transit options into your project *(Planning & Design: AA3–Alternative Transportation).*

When giving building tours to residents, neighbors and other community members, point out the transit information *(Operations & Maintenance: N3–Educational Signage).*

Code Considerations

When a development has good access to public transportation, some municipalities will reduce parking requirements *(Planning & Design: AA3–Alternative Transportation).*

FIRST COMMUNITY HOUSING

Free transit passes (Ecopasses) were developed for residents of an affordable housing development in the Bay Area.

Considerations for Residents

When transit alternatives are convenient and appealing, residents may save money and spend less time commuting (or at least be able to read, work or relax while commuting). Using public transit strengthens people's connection to the community and encourages walking, which fosters good health *(Planning & Design: AA2–Design for Walking and Bicycling).*

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Compared to the cost of adding parking or even building a new parking structure, the cost of providing transit information and assistance is extremely low.

Resources

» **American Public Transportation Association** (APTA) provides information about the benefits and importance of public transportation: www.publictransportation.org and links to all California transit agencies: www.apta.com/links/state_local/ca.cfm

» **Car-share companies** in California include: City CarShare (www.citycarshare.org), Flexcar (www.flexcar.com) and Zipcar (www.zipcar.com). Other companies and more information: www.carsharing.net

» **Urban Land Institute's** report, "Growing Cooler: Evidence on Urban Development and Climate Change," documents strategies for reducing vehicle miles traveled: www.uli.org

Related Case Studies

» Crossroads, p. 234

MEASURE N3

EDUCATIONAL SIGNAGE

Teach People about the Project's Green Features

KEY BENEFITS

√ Health/IEQ	√ Material Efficiency
√ Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
√ Water Efficiency	√ Climate Protection

NEW: **10 12 00:** Display Cases, **10 14 00:** Signage, **10 18 00:** Informational Kiosks,

OLD: **10101:** Visual Display Surfaces, **10125:** Display Cases **11900:** Exhibit Equipment, **12400:** Furnishings and Accessories

Recommendation

Provide instructional materials or signs to explain the project's green building components.

For projects with renewable energy generation, provide an educational display about the system in a publicly visible area.

Consider providing building tours if the infrastructure and funding is available.

Description

Signs and displays can be effective ways to demonstrate important green features and provide feedback on dynamic conditions such as energy generation and use. Audiences may include residents, maintenance staff, building operators, funders, the public and local news agencies.

Place permanent displays and signs in and around the building to highlight green building attributes. Brochures that enable self-guided tours can also be a good way to inform people about the project's environmental attributes and the maintenance and operating needs of the units. Also consider writing a case study or similar publication to communicate the project's successes and inform the design of other buildings.

Regularly scheduled tours may help promote the project and its green design elements.

Benefits

Signs, displays and tours provide opportunities to inform building residents and the public about the building's environmental design strategies and other beneficial features. By highlighting green building attributes, developers can convey a positive message to the community.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily projects. Even if a project includes only a few green building strategies, it is useful to make them known to residents and the public.

Design Details

SIGNS AND DISPLAYS

Many displays require little time to design and can be completed after construction. Displays with glazing that reveal the structure of walls or other building elements should be conceived of during the design phase.

There are companies that specialize in creating displays about green building materials. Displays may include material samples, along with descriptions of what makes each product green. Include information on maintenance and performance. Another option is to educate occupants and visitors about the building's green features through a web-based kiosk.

Possible locations for signs and displays include:

» **Common areas.** Hallways, lobbies and community centers are good locations for general displays about the project's goals and overall approach to green building.

» **Landscaped areas.** Highlight native species, drought-tolerant plantings and integrated pest management (IPM) *(Site: B1–Sustainable Landscaping).*

» **Parking lots or entrance walkways.** Point out features such as permeable surfaces, cool-site materials *(Site: A5–Cool Site),* recycled materials and FSC-certified trim *(Finishes & Furnishings: K5–Environmentally Preferable Materials for Interior Finish).*

» **Walls.** Have cutouts with vision glazing to showcase insulation materials, or display samples of alternative insulation *(Structure: F1–Insulation).*

» **Photovoltaics.** Interactive dynamic or static displays in the lobby showing the quantity of electricity generated on site can promote renewable energy and energy conservation *(Systems: I2–Photovoltaic Systems).*

Signs like this one, from the media tour of the Livermore Centex zero net energy home, highlight environmental attributes of materials.

TOURS

Tours can take place on a regular basis—perhaps bi-weekly or monthly when the project first opens, then at longer intervals as indicated by community interest and tenant turnover. Areas to highlight in tours include:

- Design elements of the buildings, such as orientation and placement on the site *(Planning & Design: AA7–Passive Solar Design, Daylighting and Natural Ventilation);*
- Landscaping design strategies *(Site: B1–Sustainable Landscaping);*
- Mechanical rooms with high efficiency equipment *(Systems section);*
- Rooftops, if the building has PV panels, a green roof or a cool roof *(Systems: I2–Photovoltaic Systems, Structure: E3–Vegetated Roofs and Site: A5–Cool Site);*
- Interior finishes that are durable, low VOC, or have no added formaldehyde *(Finishes & Furnishings section);* and
- Sustainable living practices including maintenance, cleaning products and furniture selection criteria *(Operations & Maintenance: N1–Operations and Maintenance Procedures and Finishes & Furnishings: K8–Environmentally Preferable Interior Furniture).*

Code Considerations

None.

Considerations for Residents

In multifamily developments with a high turnover of residents, signs and tours help educate new residents on how their homes were built and work. This, in turn, may increase the building's longevity as well as energy and water savings.

Residents may also benefit from a sense of pride that comes from having an environmentally responsible home and from having something positive to show visitors.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

Signs and exhibit display prices vary widely depending on complexity. They can range from a few hundred dollars for a simple sign to many thousands for interactive displays.

Resources

- **Oberlin College's Adam Joseph Lewis Center for Environmental Studies'** website has information about how the building's data monitoring and display systems provide real-time information about energy generation and use and many other building systems: www.oberlin.edu/ajlc/ajlcHome.html
- **Quality Attributes Software** produces GreenTouchscreen, a web-based kiosk with live building data, directories and 2D/3D animation: www.greentouchscreen.com
- **Real-time photovoltaic displays** are available from a number of companies, including: Heliotronics (www.sunviewer.net), Fat Spaniel (www.fatspaniel.com) and SolTrex (www.soltrex.com)

Related Case Studies

- Colony Park, p. 227
- Crossroads, p. 234

MEASURE N4

ENERGY MONITORS

Install Energy Usage Monitors to Conserve Energy

KEY BENEFITS

Health/IEQ	Material Efficiency
Site/Community	√ O&M
√ Energy Efficiency	√ Resident Satisfaction
Water Efficiency	√ Climate Protection

NEW: 26 27 13: Electricity Metering

OLD: 16490: Low-Voltage Distribution Components and Accessories

Recommendation

Install energy usage monitors as a conservation strategy in residential and commercial units and common areas.

Description

An energy usage monitor, sometimes called a watt meter or home energy monitor, provides data about electricity, natural gas or other fuel usage to the tenant. Depending on the capabilities of the particular system, it can provide information on the usage of specific appliances, overall household usage or both.

Energy usage monitors often use wireless technology, which simplifies installation and reduces system costs. Some energy monitors show real-time energy use, whereas others present summarized information. Some are computer-based and allow the tenant to view energy usage on a personal computer, while others have an in-unit wall display. These systems can also be linked to more comprehensive building monitoring products that show data for water use, photovoltaic electricity production and other building systems.

Energy monitors are different than utility-installed meters or submeters. However, some types of advanced utility meters (sometimes called smart meters) have features in common with energy monitors. In 2006, California's utilities began installing smart meters in some regions, but they are not yet available throughout the state.

If a residential or commercial unit has a utility-owned submeter, the utility company will bill that tenant directly for energy use. In California, multifamily building owners are not allowed to charge a tenant directly for electricity supplied by a major utility. Energy usage monitors, which are installed in addition to the utility's meters or submeters, cannot be used to bill tenants; instead, their purpose is to encourage conservation by making tenants aware of their energy use.

Studies show that occupants are more likely to reduce energy consumption when they have real-time feedback on the usage levels or costs. Systems can be installed in the homes, commercial units and common areas and can be connected to a base system accessible by building managers. The data encourages tenants and building staff to reduce energy use and, depending on how the system is set up, may allow building managers to see when and where tenants are using energy.

Benefits

An energy usage monitor allows tenants to be more aware of energy usage, and will likely encourage them to save energy by changing behaviors and using more efficient appliances.

Application

SIZE	√ Low Rise	√ Mid Rise	√ High Rise
TYPE	√ New Construction		√ Retrofit
USE	√ Residential		√ Commercial

Applicable to all multifamily projects.

Design Details

In general, energy usage monitors are simple and quick to install; installation is usually handled by the vendor.

Monitoring systems with built-in wireless transceivers can be mounted inside buildings within approximately 500 feet line-of-sight from each other and up to approximately 200 feet through walls, depending on the wall material.

Some viewing consoles have cords and are connected to a base system, but can simply sit on the counter or be moved for easy and frequent viewing.

Code Considerations

Most usage monitors strive to meet ANSI standards.

Considerations for Residents

Usage monitors grant residents access to energy use information, which tends to encourage energy conservation and reduce utility bills.

Cost and Cost Effectiveness

BENEFIT	★★★
COST	$$$

The cost of usage monitors is relatively low compared to the decrease in energy cost over time associated with their installation. The cost continues to decrease with ongoing innovations and increased market penetration.

Resources

» **Local utilities.** Contact your local utility provider for information about the availability of smart meters in your area. PG&E: www.pge.com/smartmeter; San Diego Gas & Electric: www.sdge.com/smartmeterv2/index.shtml; Southern California Edison: www.sce.com/PowerandEnvironment/smartconnect

» **Manufacturers.** There are numerous private manufacturers of energy usage monitors.

Related Case Studies

» Danco Communities, p. 220

KNOWLEDGE IS POWER: *Danco Communities, Arcata, CA*

THE POTENTIAL OF HOME ENERGY MONITORS

Sean Armstrong became sold on the benefits of energy monitors while a student at Humboldt State University in Arcata, where he lived in an off-the-grid demonstration house that was powered by solar electricity. An energy monitor gave instant feedback on the household's electricity use.

The energy monitor "was extremely successful for us," Armstrong said. By looking at the LCD display in the house, "we could see if one CFL [compact fluorescent light bulb] was left on."

Now a project manager with Danco Communities, a workforce housing developer, Armstrong is still a believer in the potential of energy monitors. But he cautioned that installing them in multifamily buildings brings certain challenges.

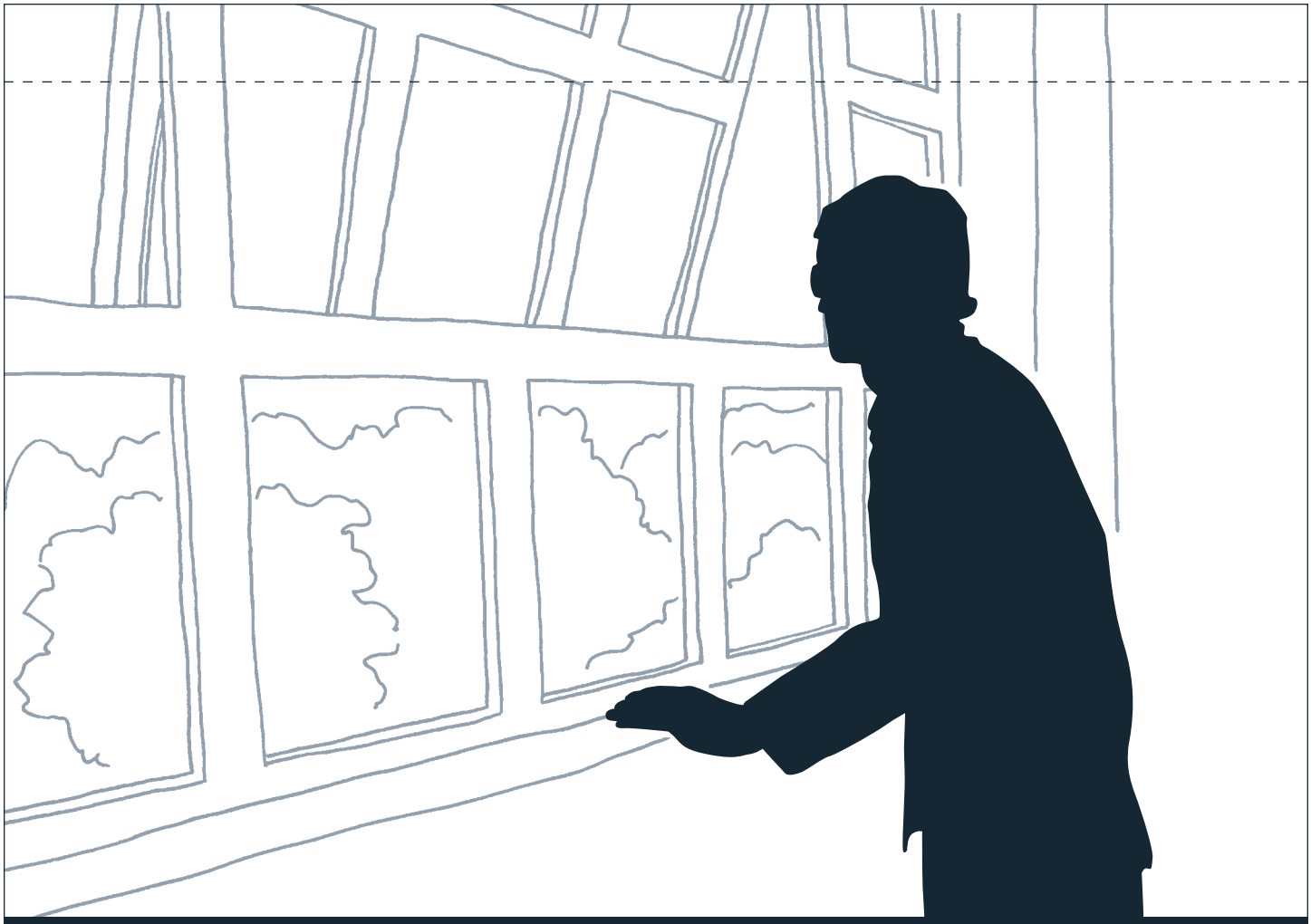
Some energy monitors are designed for commercial or industrial use and their LCD displays are more detailed than a typical resident needs, Armstrong said. And some devices that transmit data over the building's electrical wires don't work for multi-unit housing.

For a new 36-unit development in Arcata that has solar electric panels, solar hot water and other green features, Armstrong selected a brand of hardwired energy monitors. Unfortunately, he discovered after installation that this particular brand doesn't work for 240-volt applications. "It's frustrating," Armstrong said, "but we're going to replace them if we can get funding as a demonstration project."

But energy monitors on their own aren't enough to change behavior, Armstrong pointed out. He worked with Humboldt State students to develop signs that help residents respond appropriately to the data provided by the monitors.

Based on his own experience and a review of energy monitor research, Armstrong believes that the information provided by these devices and accompanying signage can motivate tenants to reduce their electricity use by at least 10%.

For more information: www.danco-group.com



CASE STUDIES

CASE STUDIES

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CASE STUDIES

SARA CONNER COURT APARTMENTS

SETTING A GREEN & BAY-FRIENDLY EXAMPLE *Hayward, CA*

Sara Conner Court Apartments is a 57-unit community of affordable rental homes. The project revitalizes a brownfield site in Hayward, California, previously occupied by a beverage processing plant, gas station and dry cleaner. Developed in partnership with the City of Hayward, this urban infill development is named in honor of the late Sara Conner, a community volunteer and longtime board member of the nonprofit affordable housing developer, Eden Housing.

One of Eden's goals for Sara Conner Court Apartments was to build an exemplary project that would inspire local development of quality homes for people with low incomes. The project team put considerable effort into creating a community that is not only safe, attractive and affordable, but also environmentally friendly and healthy.

LOCATION
Hayward, California

PARCEL SIZE/DENSITY
1.8 acres / 30 dwelling units per acre

BUILDING TYPE
2 and 3 story townhouse-style units above a concrete podium parking structure, and 3-story wood-frame apartments

TOTAL SQ. FT.
53,941 sq. ft. (net) units; 1,761 sq. ft. community area

TARGET POPULATION
Families with low incomes

NUMBER OF UNITS
57 one, two and three-bedroom rental units

COMPLETION DATE
August 2006

OWNER/DEVELOPER
Eden Housing, Inc., Hayward, CA

ARCHITECT
Pyatok Architects, Oakland, CA

LANDSCAPE ARCHITECT
Rich Seyfarth, Berkeley, CA

GENERAL CONTRACTOR
Segue Construction,
Point Richmond, CA

CONTACT FOR MORE INFO
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Hayward, CA 94544

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EMAIL klamont@edenhousing.org

GreenPointRATED
A PROGRAM OF BUILD IT GREEN

Green Building Features

Sara Conner Court doesn't have glamorous green features like solar electric systems or vegetated roofs. Instead, the team improved the project's environmental performance while maintaining its affordability by focusing on fundamental strategies such as solar orientation, daylighting, natural ventilation and durability.

LIVABLE COMMUNITIES

The four buildings are arranged around a spacious 8,500-square foot courtyard with areas for playing, relaxing, barbecuing and picnicking. The largest building has 30 two- and three-story townhouse-style units above a parking structure. Despite its size, the building doesn't feel out of scale thanks to bays and indentations that give the impression of six smaller buildings. The other three buildings are wood frame, stucco-clad structures with handicap-accessible flats on the ground floor and two-story townhouse-style apartments above.

The buildings and parking areas were kept compact to allow plenty of space for a courtyard, play area and landscaping. Other community amenities include a small grass lawn, attractively landscaped walkways, a community room, computer lab and central laundry facility. Each apartment has its own patio or deck.

The community is served by public transit and is located within walking distance of local elementary and middle schools, grocery stores, a low-cost medical clinic and other neighborhood services.

INSIDE TIP:

Weigh community, livability, density and open space benefits from the outset of the development process.

Compact housing developments can be good for the community and the environment because they typically use land and public infrastructure more efficiently than sprawling developments. But on urban lots it's not easy to create higher density housing that also allows adequate space for parking, outdoor recreation and landscaping. For Sara Conner Court Apartments, Eden chose to build many of the homes above a podium parking structure. Although the parking structure costs considerably more than surface parking, it preserves valued open space and contributes to a more livable community.

LOWER ENERGY USE & GREENHOUSE GAS EMISSIONS

The project was designed to be at least 15% more energy efficient than required by California's Title 24–2001 building energy standards. The apartments have no air conditioning; rather, they were designed for good natural ventilation, with operable windows at the front and back of each unit to provide cross breezes. The courtyard and breezeways ensure that each unit gets plenty of daylight and fresh air. The parking structure is open so that car exhaust is flushed out with fresh air rather than with energy-consuming exhaust fans.

GREEN at a GLANCE

Here are key green aspects of Sara Conner Court Apartments

PLANNING & DESIGN

- Urban infill; brownfield remediation
- Proximity to public transit, schools and neighborhood services
- Ample open space, natural ventilation and daylighting
- Community spaces include courtyard, play area, community room, computer lab

SITE

- 50% of jobsite waste reduced, reused or recycled
- Indoor air quality and hazardous waste plans followed during construction

STRUCTURE

- Drainage plane under siding to shed moisture
- Durable siding and 50-year roof
- Raised heel trusses

SYSTEMS

- High efficiency exterior and exit sign lighting
- Energy Star appliances in units
- No air conditioning
- Water-efficient toilets, faucets and showerheads
- Range hoods vented to the outside
- Sealed ducts for energy efficiency
- Central laundry facility with Energy Star clothes washers and gas-fueled dryers

FINISHES & FURNISHINGS

- Low-emissions carpet
- Exposed edges of cabinet boxes fully sealed to prevent formaldehyde outgassing
- Natural linoleum flooring
- Low VOC interior paints, adhesives and sealants
- Exterior wood trellises are weather-resistant cedar instead of pressure-treated lumber

The apartments' efficient gas-fueled hydronic heating systems allow the water heater to do double duty, providing hot water to the faucets as well as heating the apartment. Each apartment has its own gas meter, which costs more to install than a central meter but provides an incentive for the residents to keep their energy use—and related greenhouse gas emissions—in check. All heating ducts were fully sealed to improve the efficiency of the heating system and protect indoor air

INSIDE TIP:

Look for multiple benefits and stay ahead of the regulatory curve.

Eden was committed to exceeding the requirements of California's building energy code, known as Title 24, by at least 15%. During the design process, however, the team realized that the larger of the four buildings was coming in somewhat below that energy performance benchmark. They analyzed extra measures that would improve the design's energy performance while still being affordable. Increasing the insulation in the floor/roof assembly above the parking structure was one option, but the team opted instead for tighter sealing of the heating ducts. This saves energy and provides an added benefit of better indoor air quality. Also, even though the project was developed under Title 24–2001, Eden expected that the 2005 code update would require tighter duct sealing. They decided to stay ahead of the regulatory curve by choosing tighter duct sealing for this project.

HEALTHY MATERIALS AND PRACTICES

Carpets in living rooms and bedrooms bear the Carpet and Rug Institute's Green Label, an indication of lower chemical emissions. In addition, the carpets were installed with adhesives that have low levels of volatile organic compounds (VOCs). Exposed composite-wood materials in the kitchen cabinet boxes are fully sealed with a low VOC sealant to prevent the offgassing of formaldehyde. The entryway, kitchen and dining area flooring is natural linoleum instead of vinyl. The kitchen range hood's exhaust fans vent to the outside, and bathroom exhaust fans are on timers tied in to the light switch so that they stay on long enough to adequately vent the space.

INSIDE TIP:

Make sure the linoleum installer follows the manufacturer's specifications.

Natural linoleum is a high quality, eco-friendly product, but it is more complicated to install than vinyl sheet or tile. The installation went smoothly on this project, but on a previous project Eden had encountered installation problems related to the jobsite's moisture and temperature conditions. To avoid such problems, use an installer certified by the linoleum manufacturer, and make sure they understand and agree to follow the manufacturer's specifications.

Bay-Friendly Landscaping Practices

The project team, with guidance from StopWaste.Org's Bay-Friendly Landscaping program, designed an outdoor setting that's beautiful and environmentally sound. Here are some of the steps they took:

NURTURE THE SOIL

Healthy topsoil is alive with billions of microorganisms that play a vital role in protecting soil from erosion, feeding plants and reducing pollution. Unfortunately, conventional building practices often treat soil as if it were a lifeless medium—compacting it with construction equipment or removing it from the site altogether. By the time the landscapers arrive on the job, the topsoil may be totally gone or lifeless and hard as rock, and not surprisingly, what is then planted fails to thrive or dies.

Teresa Eade, senior program manager with Bay-Friendly Landscaping, applauds the Sara Conner Court team for their soil protection efforts. They removed topsoil before construction began and stockpiled it away from construction activities. Later it was respread in the site's planting areas, amended with compost and organic soil amendments to supplement missing nutrients, and aerated to a depth of 12 inches. "You can really tell the soil is healthy by how healthy the plants are," Eade says.

INSIDE TIP:

Amend the Soil with Compost

In Northern California, the standard material used to add organic matter to the soil is nitrolized sawdust, a byproduct of forest-products industries. Nitrolized sawdust can be unpredictable in the soil because it is not biologically stable, and in the short-term it negatively affects beneficial soil organisms. Compost, on the other hand, is stable in the soil and adds billions of beneficial soil organisms. Also, using compost closes the recycling loop by reusing organic matter that might otherwise have been landfilled. When buying compost, choose products that have been certified by a third party for quality. The U.S. Composting Council has a Seal of Testing Assurance (STA) program that provides third-party certification. The compost used at Sara Conner Court was an STA-certified compost from BFI Organics.

CONSERVE WATER AND PROTECT WATER QUALITY

The site is now beautifully landscaped with plants suited to the Bay Area's Mediterranean climate, characterized by a six-month dry season and cool rainy winters. Selected plants include trees such as pineapple guava, shrubs such as barberry, Oregon grape, quince and rosemary, and perennials such as fleabane, sedge and lavender.

A key element of the landscaping plan is hydrozoning, which simply means situating plants with similar water needs together so that they're watered by the same valve on the irrigation system. Turf demands a lot of water, so it's particularly important to zone any lawn areas separately from drought-tolerant plants. At Sara Conner Court, the turf is limited to a small lawn in front of the development and another next to the play area, and the turf is irrigated separately with a high efficiency irrigation system.

GREEN at a GLANCE

Continued from previous.

BAY-FRIENDLY LANDSCAPING

- Topsoil removed and stored during construction
- Soil tested and improved with organic amendments, STA-certified compost and recycled mulch
- No synthetic fertilizers used
- Shade trees moderate building temperature and reduce heat island effect
- Stormwater directed toward lawns, planting beds and bioswales to reduce flow of rainwater to storm drains
- Hydrozoning reduces water use
- Diverse plant palette of California natives and other drought-tolerant plants
- No species planted that are listed by Cal-IPC as invasive in SF Bay Area
- Turf minimized; grass clippings are grasscycled
- Grass-porous pavement in courtyard area minimizes impervious surfaces and provides fire lane
- Nursery pots returned to vendor for reuse
- All plant debris during construction and ongoing maintenance separated for recycling into compost
- Play structure and landscaping materials contain recycled content

All rainwater that runs off the parking areas and the buildings' roofs drains to the lawns, planting areas or bioswales. This allows the runoff to percolate into the soil, where organisms can break down contaminants such as motor oil into harmless components. It also recharges the groundwater, reduces the volume of water and can delay the flow of rainwater into the storm drain until after peak flows, which minimizes erosion of local creeks.

INSIDE TIP:

Nix the sidewalk lawn strips.

Avoid putting in lawn strips next to sidewalks. Turf needs be watered regularly but it is difficult to mow, fertilize or water narrow strips efficiently; much of the irrigation water will be wasted as overspray or runoff, damaging sidewalks and roads. At Sara Conner Court, attractive groundcover and other non-invasive, low-water plants line the sidewalks.

CREATE WILDLIFE HABITAT

On a visit in November 2006, five months after the landscaping was installed, Eade noticed abandoned hummingbird nests in the new trees. "That means the hummingbirds would have nested as soon as the trees were planted," she says. "And we saw a hummingbird still feeding on a Mexican sage. We also saw some beneficial insects attacking an aphid infestation."

INSIDE TIP:

Plan for diversity.

A diverse palette of plants creates a beautiful environment for people, attracts birds and means that the plants won't be as prone to pest problems, which in turn means that pesticide use can be minimized. If the plants are also drought tolerant and not invasive, water is also conserved and waste is prevented.

SARA CONNER COURT APARTMENTS

Financing

Green building features were designed into this project from the beginning.

SITE ACQUISITION COSTS . . . . . $1.9 million
Land . . . . . $1.8 million
Demolition $117,000
Off-site improvements $582,000
Acquisition financing and title costs $47,000
Subtotal . . . . . $2.6 million

DEVELOPMENT COSTS
Soft costs . . . . . $3.7 million
Hard costs (remediation & construction) . . . . . $12.7 million
Furnishings $65,000
Developer Fee . . . . . $1.4 million

TOTAL BUDGET . . . . . $20.5 million

FUNDING SOURCES
City of Hayward . . . . . $4.5 million
Redevelopment Agency of the City of Hayward . . . . . $1.75 million
Construction and permanent loans through Silicon Valley Bank . . . . $2.9 million
Enterprise Social Investment Corp. equity generated by the sale of low income housing tax credits . . . . . $11.5 million
StopWaste.org grant $55,000
Enterprise Foundation's Green Communities grant program $50,000

AVERAGE COST/SQ. FT. . . . . . $368/sq. ft.

AVERAGE COST/UNIT $359,650

AFFORDABILITY TARGETS
30% of median income . . . . . 6 units
40% of median income . . . . . 6 unit
50% of median income . . . . . 28 units
60% of median income . . . . . 16 units
Onsite property manager . . . . . 1 unit

This Case Study was written by StopWaste.org as part of its Multifamily Green Building Guidelines.

To obtain the Guidelines and many other waste-reduction and green building publications, visit **www.multifamilygreen.org** or call **510-891-6500**.

COLONY PARK

BUILDING GREEN DOWNTOWN *Anaheim, CA*

BROOKFIELD HOMES

In the mid 1980's

two warehouses were constructed near downtown Anaheim on the site of one of the last remaining orange groves in the city. The concrete tilt-up buildings were used for storage and shipping, but over time it became clear to city staff and others that the site, located in a residential neighborhood across the street from an elementary school, wasn't well suited for warehousing and trucking. Eventually the city rezoned the site, making it part of a redevelopment area now known as the Anaheim Colony Historic District.

On the 20-acre site where the warehouses once stood, Brookfield Homes is building Colony Park, a community of 339 townhomes and flats ranging in size from 1,073 to 2,060 square feet. Designed with ample open space, including a public and a private park, and located within walking distance of downtown, Colony Park is part of Anaheim's larger revitalization effort that is making it more appealing for people to own homes closer to where they work, shop and play.

Colony Park's two neighborhoods, Legacy and Harmony, are Brookfield Homes's fifth and sixth communities in Anaheim, and their first to be GreenPoint Rated. The homes have been designed to exceed Title 24 energy efficiency requirements by at least 16%.

LOCATION
Anaheim, California

PARCEL SIZE/DENSITY
20.39 acres;
16.6 dwelling units per acre

BUILDING TYPE
One to three-story condominium townhomes and flats, 1 to 4 bedrooms

TOTAL SQ. FT.
28,936 sq. ft.

TARGET POPULATION
556,308 (residential living square footage)

NUMBER OF UNITS
339 homes, including 34 affordable homes

COMPLETION DATE
2010 (models opened fall 2007)

OWNER/DEVELOPER
Brookfield Homes Southland, Costa Mesa, CA

ARCHITECT
Legacy at Colony Park: JZMK

Harmony at Colony Park: McLarand Vasquez Emsiek & Partners

LANDSCAPE ARCHITECT
The Collaborative West

CONTACT FOR MORE INFO
Cheryl Casanova, Brookfield Homes

TEL 714-427-6868
EMAIL CStump@brookfieldsouthland.com
WEB www.brookfieldsouthland.com

GreenPointRATED
A PROGRAM OF BUILD IT GREEN

Green Building Features

URBAN INFILL & RENEWAL

Choosing to develop a multifamily residential project on an infill site is one of the most sustainable strategies a developer can follow. The concrete tilt-up warehouses on the Colony Park site were torn down, but rather than hauling the concrete away to a waste management facility, Brookfield Homes crushed all 16,000 tons of it on site and reused it as aggregate base for the ground bed for the community's new streets.

At 16.6 dwelling units per acre, Colony Park provides a density appropriate to city living yet still retains ample outdoor space, including a private park and an open-air pavilion that serves as a community gathering place.

Thanks to Colony Park's location, residents have pedestrian and bicycle access to neighborhood services and downtown amenities, making it easier for them to reduce their car trips or do without a car altogether. Colony Park's open spaces and walkways, as well as an adjacent 1-acre public park, connect homeowners to their surrounding neighborhood.

To help calm traffic and make the neighborhood safer and more pleasant for walking and bicycling, Brookfield reduced the street widths by 10 to 20 feet in certain locations using bulbouts landscaped with trees. Individual homes are designed for safety, natural surveillance and neighborliness, with all main entrances prominent and visible from the street, and townhomes facing each other across open spaces, preserving a sense of privacy while still keeping front doors visible.

INSIDE TIP:

With infill projects, be prepared for a lengthier entitlement process.

Brookfield Homes has extensive experience with both urban infill developments and suburban greenfield projects. On the Colony Park project, Anaheim Redevelopment Agency provided invaluable assistance throughout the development process. "With infill, the entitlement process is longer," notes Brookfield's Cheryl Casanova. "There's a lot of community sensitivity, and we spend a lot time holding community meetings and negotiating to make sure everyone's happy." Despite the additional risk on the entitlement side, "it's definitely worth it in the end," Casanova says.

GREENPOINT RATED

Each home in Colony Park will have its own GreenPoint Rated certificate, giving home buyers assurance that they are getting a healthier, more environmentally responsible home. GreenPoint Rated, an independent third-party rating program run by Build It Green, grades homes on five categories—energy efficiency, resource conservation, indoor air quality, water conservation and community. Brookfield estimates that Colony Park's green building features increased the development's costs by roughly 3 to 5 percent, with an average cost per square foot of $87.91. But building green provides definite market advantages. "People are aware of [green building]," says Casanova. "The rating separates us from our competition."

GREEN at a GLANCE

Green aspects of Colony Park are listed here:

PLANNING & DESIGN

- Infill site within downtown redevelopment area
- Proximity to public transit
- Traffic-calming strategies installed
- Ample outdoor space for residents
- Designed for safety and natural surveillance

SITE

- 80% or more of construction & demolition waste diverted from landfill
- Construction IAQ management plan written and followed
- Two-week building flush-out prior to occupancy
- Landscaping mulched to depth of 2 inches or greater
- Smart irrigation controllers

STRUCTURE

- Minimum 25% recycled aggregate
- Engineered lumber for 90% or more of floor and ceiling joists
- 40-year manufacturer warranty on roofs

SYSTEMS

- Low-flow kitchen and bathroom faucets
- Water submetered for each residential unit
- Recirculating engineered plumbing operated on a sensor
- Ultra-quiet Energy Star bathroom fans with timer controls
- Range hoods vented to the outdoors
- Designed to exceed Title 24 by at least 16%

FINISHES & FURNISHINGS

- Low-VOC paint
- Energy Star–qualified refrigerators and dishwashers
- Built-in recycling center in each unit

OPERATIONS AND MAINTENANCE

- O&M manual for maintenance staff and residents
- Educational signage to explain project's green features

BROOKFIELD HOMES

BROOKFIELD HOMES

INSIDE TIP:

Transitioning from conventional to green building practices doesn't have to involve drastic changes.

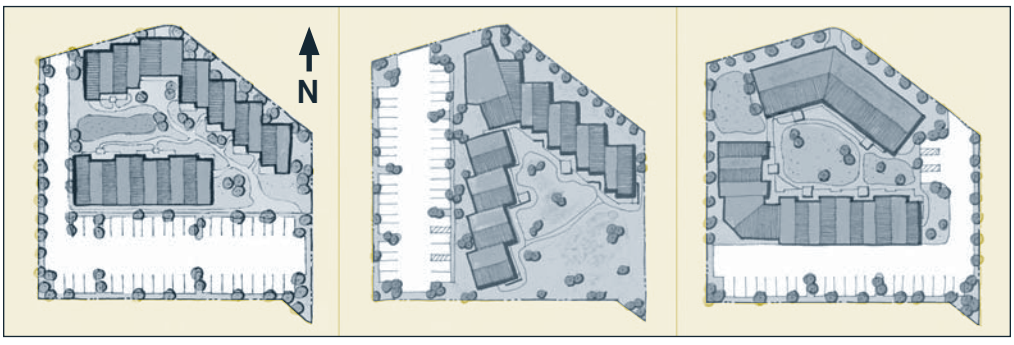
When the City of Anaheim and Build It Green approached Brookfield Homes about participating in GreenPoint Rated, they suggested starting with a project that would be coming on line in a few years. But after Brookfield staff reviewed the GreenPoint Rated checklist, they realized they were already following many green practices at their developments, thanks to the company's green building initiatives. "We said, let's take the checklist and see what happens for Colony Park," recalls Casanova. "Let's see how we fare on a project that's already underway. We were able to get many points for infill, location and transit access, and for other innovative things we already do, like tankless water heaters. So we made a few adjustments [to the original plans] and were able to be rated."

CARMEN AVENUE

ORIENTATION, ORIENTATION, ORIENTATION *Livermore, CA*

Downtown Livermore has gotten a little more affordable, thanks to a new 30-unit apartment complex on Carmen Avenue, a short walk from the new Civic Center library. Developed and managed by Allied Housing, Inc. and Affordable Housing Associates , the development is one of the first multifamily projects in California to be GreenPoint Rated. Key green features include jobsite waste recycling, passive solar design, natural ventilation, a photovoltaic system, low-toxicity finish materials, and excellent access for people with disabilities.

The project architect's mantra during design was "orientation, orientation, orientation." Once a project's location is determined, the design team needs to focus on getting the building orientation right to take advantage of solar access and prevailing winds, and to improve circulation patterns for residents.



KODAMA DISEÑO ARCHITECTS

Project architects analyzed multiple plans to optimize solar orientation, open space, views and access. The site plan on the far left was ultimately selected; it places the building on an east-west axis with parking hidden at the rear. .

LOCATION
Carmen Avenue, Livermore, California

PARCEL SIZE/DENSITY
1.04 acres;
30 dwelling units per acre

BUILDING TYPE
Two buildings (2 and 3 stories) with rental apartments

TOTAL SQ. FT.
28,936 sq. ft.

TARGET POPULATION
Low-income individuals and families, including people with special needs such as survivors of domestic violence and people with disabilities

NUMBER OF UNITS
30 total: Studios (2), 1-bedroom (5), 2-bedroom (16), 3-bedroom (7)

COMPLETION DATE
January 2008

OWNER/DEVELOPER
Allied Housing, Fremont, CA
Affordable Housing Associates, Berkeley, CA

ARCHITECT
Kodama Diseño Architects, San Francisco and Oakland, CA

GENERAL CONTRACTOR
Segue Construction,
Point Richmond, CA

CONTACT FOR MORE INFO
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Allied Housing, Inc.
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Fremont, CA 94538

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Eve Stewart, Senior Project Manager
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Berkeley, CA 94702

TEL 510-649-8500 ext. 21
EMAIL estewart@ahainc.org
WEB www.ahainc.org

GreenPointRATED
A PROGRAM OF BUILD IT GREEN

GREEN at a GLANCE

Key green aspects of Carmen Avenue are listed here.

PLANNING & DESIGN

- Urban infill site
- Proximity to public transit and neighborhood services
- Courtyard with areas for play, socializing and relaxing
- Parking in back puts emphasis on people, not cars
- Design for safety: All main entrances visible from street or from other apartments
- Orientation for passive solar design (all units face south), natural ventilation and community interaction
- Thermal mass to manage heat gain
- Design for affordability and accessibility

SITE

- Section 01505 C&D waste management plan
- Two-week flush-out of interior spaces prior to occupancy
- Recycled-content aggregate
- High efficiency irrigation; no plants that are invasive or require shearing
- Exterior lighting designed to reduce light pollution

STRUCTURE

- High-volume recycled flyash concrete
- Composition roof shingles with 40-year manufacturer's warranty
- Radiant roof barrier
- Low-e^2 double-glazed windows with vinyl frames

SYSTEMS

- Dual-flush toilets, faucet aerators and low-flow showerheads
- Combined water/space hydronic heating
- 32-kilowatt photovoltaic system
- Designed to exceed Title 24 by 15%
- Low-mercury fluorescent lighting

FINISHES & FURNISHINGS

- Low-VOC paint and adhesives
- Recycled-content exterior paint
- Natural linoleum and low-emission carpet
- Recycled plastic benches
- Central laundry
- Energy Star refrigerator and low-water dishwasher

OPERATIONS AND MAINTENANCE

- O&M manual for building staff

Green Building Features

LIVABLE, AFFORDABLE COMMUNITIES

A courtyard between the development's two buildings provides space for children to play and adults to socialize and relax. Parking is situated at the rear of the site to improve pedestrian access and better connect the homes with the neighborhood. The site is located on two bus lines and within a short walk of a grocery store and Livermore's Multi-Service Center, which offers an array of social services.

REDUCING ENERGY BILLS & TACKLING CLIMATE CHANGE

It gets hot in Livermore, with summer temperatures of 100°F and higher not uncommon. To create homes that would be affordable and comfortable, the developer and design team focused on passive solar design and natural ventilation. To reduce the need for air conditioning to the point where it is rarely needed, the design incorporates thermal mass, overhangs and energy-efficient windows to manage heat gain, and takes advantage of cool night air and consistent afternoon breezes.

Cutting the Cooling Loads

1. **BUILDING ORIENTATION** – Elongated along east-west axis
2. **GLAZING PLACEMENT** – Almost all glazing is on true south and true north facades
3. **GLAZING TYPE & WINDOWS** – Low-e^2 insulated glazing with vinyl windows
4. **ROOF INSULATION** – R-30 fiberglass insulation
5. **WALL INSULATION** – R-21 fiberglass insulation
6. **OVERHANGS & TREES** – Six-foot overhangs on the south facade of one building; three-foot overhangs on the south facade of the other building.
7. **FLOOR MASS** – Outdoor walkways are concrete deck; interior floors are not mass construction
8. **WALL MASS** – 5/8-inch gypboard on all walls and ceilings
9. **RADIANT BARRIER** – Yes
10. **ATTIC VENTING** – Ridge vent
11. **SEALING DETAILS** – Sill plate gasket, outlet gaskets, caulking, taping and more

Some of the passive design measures, like orienting the buildings along an east-west axis, took time to work out, but cost nothing extra to build. Other measures, like overhangs on the south facades, have a price tag, but will significantly reduce cooling loads and the tenant' energy bills. The table below shows how the design team approached the challenge of reducing the cooling loads, beginning with the building orientation.

INSIDE TIP:

Spend most of the design time and budget on low-tech solutions.

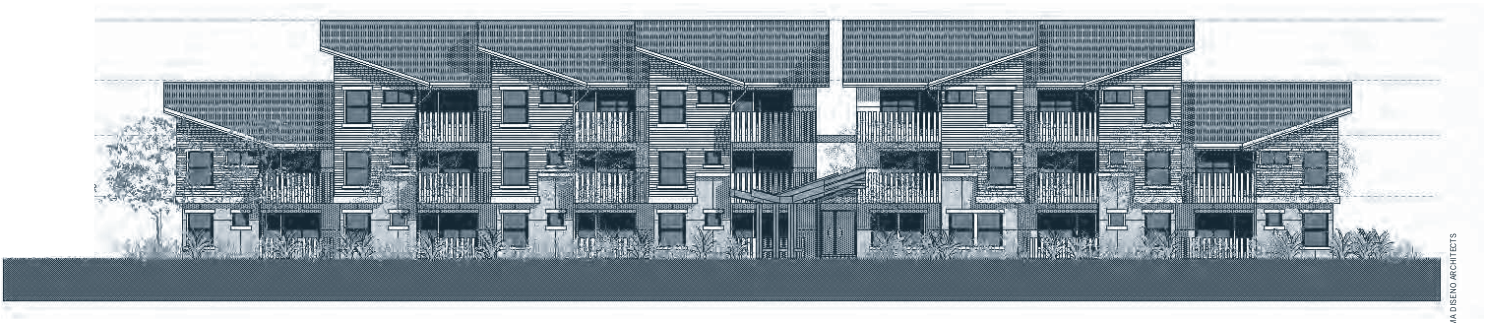
Start the design of HVAC and lighting by trying to minimize or even eliminate anything that uses power or requires regular maintenance. Passive features that use standard construction materials are sometimes less expensive upfront, and are always less expensive over time. At Carmen Avenue, passive features include the solar orientation; 5/8-inch gypboard throughout for thermal mass; exterior walkways to form south-facing overhangs; high-performance glazing; and high interior volumes for ventilation and daylighting. Only after maximizing the low-tech features should effort be spent on designing HVAC and lighting systems and controls.

To further reduce energy use, the apartments have combined water/space hydronic heating systems, Energy Star appliances, and low-mercury fluorescent lighting in the bedrooms, kitchens and bathrooms. All of the electricity use in the common areas will be met by a rooftop photovoltaic system.

INSIDE TIP:

Don't exclude good ideas early on just because they seem expensive.

The Carmen Avenue buildings were designed from the start with large open roof areas sloping towards true south at an ideal solar pitch to allow for the possibility of installing photovoltaics. Recognizing that nothing ever gets funded that isn't already in the design, the team designed the solar electric system before funding was found. Good ideas, even if they seem expensive, should be kept on the table at least until the end of design documents. You may find money for it, you may find a cheaper method, or you may find a good deal that you weren't aware of.



KODAMA DISEÑO ARCHITECTS

HEALTHY & ENVIRONMENTALLY PREFERABLE MATERIALS

The project team minimized jobsite waste by writing and implementing a Section 01505 construction and demolition (C&D) waste management plan. At least 65% to 75% of construction waste was diverted from landfills.

INSIDE TIP:

Successful C&D waste requires a team effort.

Many municipalities, as well as programs such as GreenPoint Rated, require that construction projects document that they have diverted high volumes of their waste from landfills. To make sure this process goes smoothly, develop a well-considered C&D waste management plan in advance. Also be sure to involve subcontractors in this planning process. Often subcontractors such as framers and drywall installers manage their own construction waste, so a documentation system needs to be in place to track their waste as well as any general waste created on site. Before the first scrap of wood is created, have a plan for how the subcontractors will handle and document waste, who your disposal company is, how they will be providing the documentation you need, and other logistics.

CARMEN AVENUE

This Case Study was written by StopWaste.org as part of its Multifamily Green Building Guidelines.

To obtain the Guidelines and many other waste-reduction and green building publications, visit **www.multifamilygreen.org** or call **510-891-6500**.

Construction materials were selected for durability, including a composite shingle roof with a 40-year manufacturer's warranty. Recycled-content materials include aggregate used as a road and foundation base, high-volume flyash concrete and exterior paint. Low toxicity materials include low-VOC paint, natural linoleum flooring, recycled-content carpet with Green Label Plus certification of low emissions, and sheet rubber flooring with Greenguard certification of low emissions.

INSIDE TIP:

Put green product sales representatives to work.

When making a case for lifecycle cost benefits or when managing the submittal process in construction, get product representatives to support you. Many sales reps have PowerPoint presentations, lifecycle cost analysis spreadsheets and studies that support the use of their products, and some will provide assistance with submittal review and even provide oversight of the installation. Linoleum flooring is a good example of a product that is widely recommended because of its durability and nontoxic nature, yet it requires a higher level of technical knowledge to install properly.

WATER CONSERVATION

The landscape was designed to use very little water. With the exception of a small grassy play area, the plants are drought tolerant and many are native. The irrigation system uses high efficiency bubblers and drip to deliver water more efficiently than pop-up sprayers. Low water-use dishwashers, dual-flush toilets, good quality faucet aerators and low-flow showerheads will also save water.

Financing

Green building features were designed into this project from the beginning.

SITE ACQUISITION COSTS . . . . . $1 million

DEVELOPMENT COSTS

Construction . . . . . $7.5 million
Soft costs . . . . . $5.5 million
Total . . . . . $13 million

MAJOR FUNDING SOURCES

City of Livermore . . . . . $2.9 million
County of Alameda . . . . . $1.45 million
State MHP . . . . . $2.45 million
4% tax credit . . . . . $5.3 million
Other . . . . . $0.9 million

AVERAGE COST/SQ. FT. . . . . . $449/sq. ft.

AVERAGE CONSTRUCTION COST/SQ. FT. . . . . . $259/sq. ft.

AVERAGE COST/UNIT $433,000

AFFORDABILITY TARGETS

Households making less than 50% of the area median income (AMI) . . . . . 29 units
Onsite property manager . . . . . 1 unit

CROSSROADS

A SHELTER AT THE INTERSECTION OF ENVIRONMENTAL RESPONSIBILITY AND SOCIAL JUSTICE *Oakland, CA*

On a nondescript section of Oakland's bustling International Boulevard, one building catches the eye from blocks away. A vivid yellow wall juts out at a sharp angle near the fourth-story roof line, signaling that this is no ordinary place. The facility, Crossroads, is Alameda County's newest and largest homeless shelter. With that yellow wall standing out like a beacon of hope, Crossroads' new building provides dignified temporary housing for homeless people seeking to regain their self-reliance.

Owned and run by the not-for-profit East Oakland Community Project (EOCP) and designed by Kodama Diseño Architects and Planners, the 125-bed facility may be the first green homeless shelter in the country. Crossroads was built from the ground up by general contractor Oliver and Company using environmentally responsible design principles and construction technologies. All the green strategies support EOCP's service mission, from solar electric panels that defray the high energy costs of operating a large, 24-hour residential facility, to nontoxic building materials and furnishings that contribute to healthier living spaces.

LOCATION
7515 International Boulevard, Oakland, CA

PARCEL SIZE
0.3 acres (13,492 sq. ft.)

BUILDING TYPE
Four-story building with dormitory housing; 17 parking spaces for employees including 3 spaces on parking lifts

TOTAL SQ. FT.
24,324 sq. ft.

TARGET POPULATION
People in need of transitional or emergency housing, including single men and women, families, and persons with HIV/AIDS

CAPACITY
125 residents; 47 part and full-time employees

COMPLETION DATE
January 2008

OWNER/DEVELOPER
East Oakland Community Project

ARCHITECT
Kodama Diseño Architects and Planners

GENERAL CONTRACTOR
Oliver and Company

PROJECT MANAGER
Jonathan Austin,
JSA Consulting Services

ORGANIZATIONAL/FUNDRAISING CONSULTANT
Natalia López

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Executive Director
East Oakland Community Project
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Oakland, CA 94621

TEL 510-532-3211
EMAIL eocp@eocp.net
EMAIL www.eocp.net

GREEN at a GLANCE

Key green aspects of Crossroads are listed here.

PLANNING & DESIGN

- Urban infill site
- Wide sidewalks with street trees as buffer from busy street
- Bicycle racks at entrance
- Parking lifts reduce size of parking area
- Proximity to public transit, neighborhood services, parks
- Onsite amenities include computer room with high speed Internet access, commercial kitchen, dining room, 2,288-square-foot courtyard with play structure and seating
- Anti-graffiti exterior paint
- Design for daylighting and natural ventilation
- Adaptable design
- Design for long-term affordability

SITE

- At least 75% of construction and demolition waste diverted from landfill disposal
- Limited landscaping: drought-tolerant species, no turf
- Light pollution reduction: outdoor lights shielded or Dark-Sky certified

STRUCTURE

- 35% flyash concrete
- Engineered wood I-joists
- Durable siding: fiber cement and stucco
- Fiberglass insulation with no added formaldehyde

SYSTEMS

- Water-efficient faucets and showerheads with flow rates below code requirements
- Commercial kitchen with external grease interceptor for keeping grease out of wastewater
- Radiant hydronic space heating (wall panels) with 85% efficient boilers
- No air conditioning
- Energy Star ceiling fans
- Bathroom fans vented to outdoors, controlled by humidistat or light switch
- Kitchen range exhaust vented to outdoors
- 30-kW photovoltaic system

Green Building Features

CONNECTING PEOPLE TO THE PLACES AND SERVICES THEY NEED

For 17 years, EOCP operated a 105-bed shelter out of a damp and dilapidated warehouse. The City of Oakland was paying nearly $23,000 a month to rent the space, and heating bills were through the roof. EOCP's executive director, Wendy Jackson, believed that the City deserved more value for what it was spending on rent and the shelter's residents deserved a more dignified setting for getting back on their feet. EOCP clients seem to agree. "The new environment is cleaner, warmer and better," said Clavell Coleman, who has lived in both buildings. "The other place was like it was waiting for a wrecking ball."

In the late 1990s, Jackson began planning and fundraising for a new state-of-the-art facility. When she first started talking about EOCP's vision for a new shelter that was durable, energy efficient and healthy, people would agree with her that homeless people need a decent place to live, "but they didn't see beyond that," Jackson said. "Back then it was not as big a deal to others as it was to me." In the ensuing years, however, Jackson has witnessed "a lifting up of national consciousness"—a recognition that green building can make all types of housing "a better place to be and more economically feasible to operate," she said.

At Crossroads, which opened in January 2008, single residents share dorm rooms in men's and women's wings. Five family rooms with private bathrooms occupy another wing. Crossroads also provides a respite dormitory for homeless people recently released from the hospital, and a bathroom designated for transgender individuals. Residents receive comprehensive support services to recover from homelessness, including case management, life skills training, health care connections, mental health and substance abuse counseling, housing referrals and career counseling.

The facility is built on an urban infill site well served by AC Transit bus lines, and the Coliseum BART station is a short bus ride away. Although the building fills most of the lot, the design team took care to provide appealing outdoor space for residents and employees, including a 2,288-square-foot courtyard with a play structure, tables, seating and plantings, and a fourth-floor roof deck adjacent to the staff's lounge.

Interior spaces were designed to be adaptable and multifunctional. The 1,509-square-foot dining room has movable partitions so the room can be used during the day for meetings, training and other activities. Administrative staff offices have partitioned workspaces instead of interior walls for easier and more affordable reconfiguration in the future.

REIGNING IN ENERGY COSTS AND GREENHOUSE GAS EMISSIONS

The old shelter's escalating energy bills were tough on EOCP's budget and frustrating for Jackson and her team because much of the money spent on energy didn't actually help keep residents or staff comfortable. Instead it was wasted by the building's inefficient heating system and lack of insulation. "Energy costs provided a strong financial impetus for going green," said Jonathan Austin, an affordable housing and homeless shelter consultant engaged by EOCP to help manage the development process.

In the new building, hydronic radiant wall panels served by boilers warm the building without blowing dust and other allergens the way that ducted forced-air systems do. No air conditioning was installed; given Oakland's mild coastal climate, operable windows and Energy Star–qualified ceiling fans will provide adequate cooling even on hot days. Good daylighting design eliminates the need for daytime electric lighting in many parts of the building, and is supplemented by energy-efficient, low-mercury fluorescent lighting.

On the roof, a 30-kilowatt (kW) photovoltaic system is expected to generate roughly 48,500 kilowatt-hours of electricity per year. This will offset 25% to 33% of the building's projected electricity load, reduce its greenhouse gas emissions and help keep energy expenses manageable for decades to come.

INSIDE TIP:

Seek out creative financing mechanisms for renewable energy systems.

There came a point in Crossroads' development process where Austin, EOCP's development consultant, nearly despaired of finding funding for a photovoltaic system. The roof had space for a 30-kW system—a large, costly system by a homeless shelter's standards, but too small to attract investors willing to help fund solar installations.

Third-party investment deals are gaining traction among nonprofit organizations unable to benefit directly from federal tax credits available to corporations and individuals who purchase solar electric systems. Under these agreements, an investor pays for some or all of the PV system in order to take advantage of the tax credits and depreciation benefits. The investor then sells the electricity generated by the system back to the nonprofit organization, usually at a fixed rate.

The problem, said Austin, is that "it's hard to find an investor willing to invest in a 30-kW system. Most investors want to fund larger systems. They're looking for 100-kilowatt systems or larger."

He was about to give up on finding a funding mechanism when he heard from the Nonprofit Solar Alliance, a project of the Northern California Land Trust that was set up in 2006 to help provide energy security to those who need it most. The alliance had put together a pilot project consisting of three land trust properties and a nonprofit group. With the addition of EOCP's project, they had an aggregated solar investment that attracted the interest of Enterprise Community Foundation. Enterprise invested $200,000 in a for-profit limited liability corporation created by the alliance. In return, Enterprise gets a five-year federal depreciation and a tax credit for each of the five solar installations.

EOCP and the other groups participating in the LLC had to come up with the balance of the funds to purchase their PV systems. With a California state rebate of $79,000 and a $72,000 offset from Enterprise, EOCP is only paying $99,000 for a $250,000 PV system. They expect to pay a very low rate of $0.06/kWh for electricity generated by the system for the next five years, after which they will own the system outright.

Now that the deal is done, Austin's only regret is that Crossroads couldn't accommodate a larger system. "If I could do it over again," he said, "I'd want to do a 50-kW or even a 100-kW system, but 30 kW is what will fit on this roof."

GREEN at a GLANCE

FINISHES & FURNISHINGS

- Walk-off mats at entryways
- 50% recycled exterior paint
- Low-VOC interior paint
- No-VOC linoleum adhesive; solvent-free, low-VOC sealants and caulking
- No-added formaldehyde cabinet boxes and counter substrates
- Durable and environmentally preferable furnishings, including locally made products, FSC-certified wood beds, recycled steel lockers, and common area furniture made with solvent-free adhesives
- Environmentally preferable, low-emitting flooring
- Energy and water-efficient refrigerators, dishwashers and clothes washers
- Central laundry facilities
- Recycling receptacles in offices and common areas; central collection on ground floor
- Fluorescent lighting with low-mercury lamps
- Energy-efficient gearless elevator
- Outdoor play structure and seating with recycled-content steel

OPERATIONS AND MAINTENANCE

- Transit information provided to residents
- Educational signage in lobby

HEALTHY SPACES SUPPORTING RECOVERY FROM HOMELESSNESS

For the Crossroads development team, building green meant more than saving money. It also meant supporting EOCP's mission of "helping homeless people transition to well-being." While the old shelter provided a roof over people's heads, that roof leaked, leading to mold growth in the building. The new facility, said Andrew Dibblay, an EOCP client who has lived in both buildings, "is warm and bright, with a happy atmosphere and a nice ambiance."

"I see people who have to get up and go," Jackson said, whether they're heading off in the morning to work or to get their children to school. "Here they're really able to get up and go." And residents who may have just gotten out of the hospital or are ill, "if they need to relax, here they can relax."

Interior spaces, including the lobby, dormitory rooms, offices, common facilities, bathrooms and corridors, are designed for good daylighting and natural ventilation, with high windows that reflect natural light off ceilings and operable windows that provide cross breezes. "It's bright, cheery and the air quality is good," said Jackson.

Flooring was chosen that is long lasting, easy to clean and low in emissions of potentially harmful chemicals. On the first floor, colored concrete was used (with an epoxy finish in the respite care and kitchen areas to meet code requirements). The other three floors have natural linoleum tile flooring, installed with a zero-VOC linoleum adhesive. EOCP evaluated the use of sheet linoleum, but chose linoleum tiles because they can be individually replaced and cost less per square foot for installation.

To protect indoor spaces from formaldehyde pollution, the design team chose no-added formaldehyde insulation, cabinet boxes and countertop substrates. Low-VOC construction adhesives, caulks and paints were used throughout the interiors.

FREEING UP RESOURCES BY CHOOSING PRODUCTS THAT LAST

When choosing building materials and interior finishes, "the emphasis was on anything that can make the building last longer," said Austin. "These guys are not developers," he noted of EOCP, and the staff needs to be able to focus its budget and resources on providing services, not maintaining or replacing short-lived products. "They need things that will last for the long term, 30 to 50 years, like steel and concrete."

Materials specifically chosen for their durability and low maintenance include aluminum (rather than vinyl) windows, polished concrete floors on the first floor, linoleum tiles on floors two through four, a roof with a 30-year warranty, ceramic tile walls and floors in bathroom showers, metal stairs, and fiber-cement and stucco exterior siding. An energy-efficient gearless traction elevator reduces the necessity of parts replacement and disposal and eliminates the need for an elevator machine room.

Although durability and low maintenance were priorities, Jackson emphasizes that "a green building does require that you be involved with the building," including learning how the systems work and making environmentally responsible choices every day. "This building is eco-friendly and it means we have to follow the rules of eco-friendly living." For Jackson, that includes recycling, setting up a composting program and even encouraging staff to fill reusable bottles with the shelter's filtered water rather buying their own bottled water to keep at their desks.

MULTIFAMILY GREEN BUILDING GUIDELINES
CASE STUDY

CROSSROADS

This Case Study was written by StopWaste.org as part of its Multifamily Green Building Guidelines.

To obtain the Guidelines and many other waste-reduction and green building publications, visit **www.multifamilygreen.org** or call **510-891-6500**

INSIDE TIP:

Make the effort to source more durable materials, even if they cost more upfront.

Some long-lived products have higher first costs but save money over time by reducing maintenance and replacement costs. Linoleum, for example, is more expensive than vinyl flooring but can last three times as long. To cover added upfront costs of certain durable materials, some affordable housing developers apply for grants, while others allocate money saved in one area to pay for pricier products.

For Crossroads' interiors, Austin took a different tack. He approached a number of green building suppliers for donations, and one—Forbo, the manufacturer of Marmoleum brand of linoleum—stepped up with a significant contribution, writing down a substantial amount of the flooring's cost.

Kodama Diseño designed the layout of the multicolored linoleum tiles. The green tiles, which were donated outright, were leftovers from a Martha Stewart project, a reminder that beautiful design belongs in everyone's home.

Financing

Green building features were designed into this project from the beginning.

SITE ACQUISITION COSTS $760,000

DEVELOPMENT COSTS

Construction. $7,463,000
Soft Costs $2,427,000
TOTAL COSTS $10,650,000

MAJOR FUNDING SOURCES

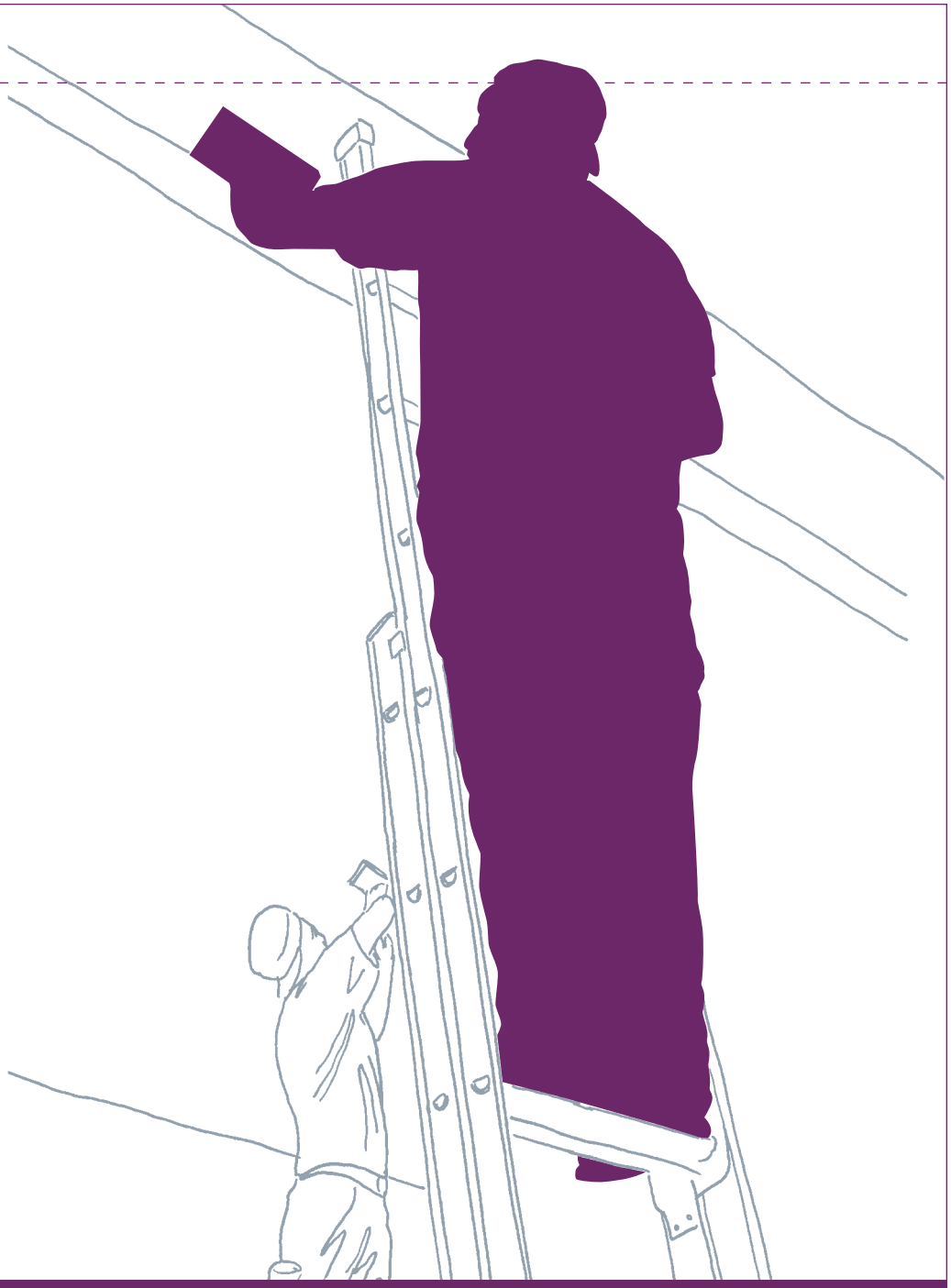
Washington Mutual Bank
(loan guaranteed by City of Oakland) $2,400,000
Alameda County $3,160,000
City of Oakland. $1,150,000
Affordable Housing Program
(Federal Home Loan Bank) $1,000,000
State of California (Emergency Housing
and Assistance Program) $1,000,000

Funding Sources Continued

US Dept of Housing and Urban Development
(HUD) Housing Opportunities
for Persons with AIDS $1,287,500
HEDCO Foundation. $350,000
Y & H Soda Foundation. $100,000
Nonprofit Solar Alliance $72,000
San Francisco Foundation $60,000
Stopwaste.Org $50,000
Washington Mutual Bank Foundation $25,000
Evelyn and Walter Haas Jr. Fund $25,000

AVERAGE COST/SQ. FT.. . . . . $438/sq. ft.

AVERAGE CONSTRUCTION COST/SQ. FT . . . . . $307/sq. ft



RESOURCES

RESOURCES

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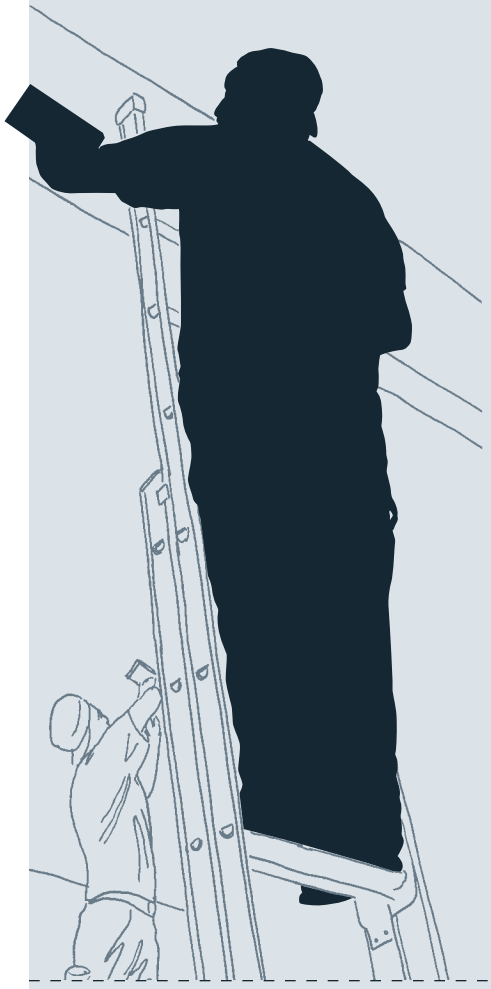
ENERGY

Energy Star
A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping consumers save money and protect the environment through energy-efficient products and practices. Provides information on energy-efficient appliances and building systems for consumers and businesses. www.energystar.gov

American Council for an Energy-Efficient Economy (ACEEE)
A nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. Provides information on energy-efficient appliances and building systems for consumers. www.aceee.org

Consortium for Energy Efficiency
A nonprofit public benefits corporation that develops initiatives to promote the manufacture and purchase of energy-efficient products and services. Provides information on efficiency standards, initiatives and incentives, and lists of qualifying appliances and systems. www.cee1.org

Consumer Energy Center (California Energy Commission)
Online information resource provided by the California Energy Commission. Provides information about energy resources and how to use them wisely at home, work and in vehicles. www.consumerenergycenter.org



California Solar Initiative
California has set a goal to create 3,000 megawatts of new solar-produced electricity by 2017. Provides information on incentives for installing solar electric systems. www.gosolarcalifornia.ca.gov

Database of State Incentives for Renewables & Efficiency (DSIRE)
An ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council (IREC), funded by the U.S. Department of Energy. Provides a comprehensive source of information on state, local, utility and federal incentives that promote renewable energy and energy efficiency. www.dsireusa.org

Flex Your Power
California's statewide energy efficiency marketing and outreach campaign. The organization is a partnership of California's utilities, residents, businesses, institutions, government agencies and nonprofit organizations working to save energy. Provides product guides and a listing of financial incentives and technical help for energy-efficient appliances, equipment, lighting and buildings. www.fypower.org

WATER

California Urban Water Conservation Council
A partnership of urban water agencies, public interest organizations, and private entities focused on increasing efficient water use statewide. Provides product and policy information on water conservation. www.cuwcc.org