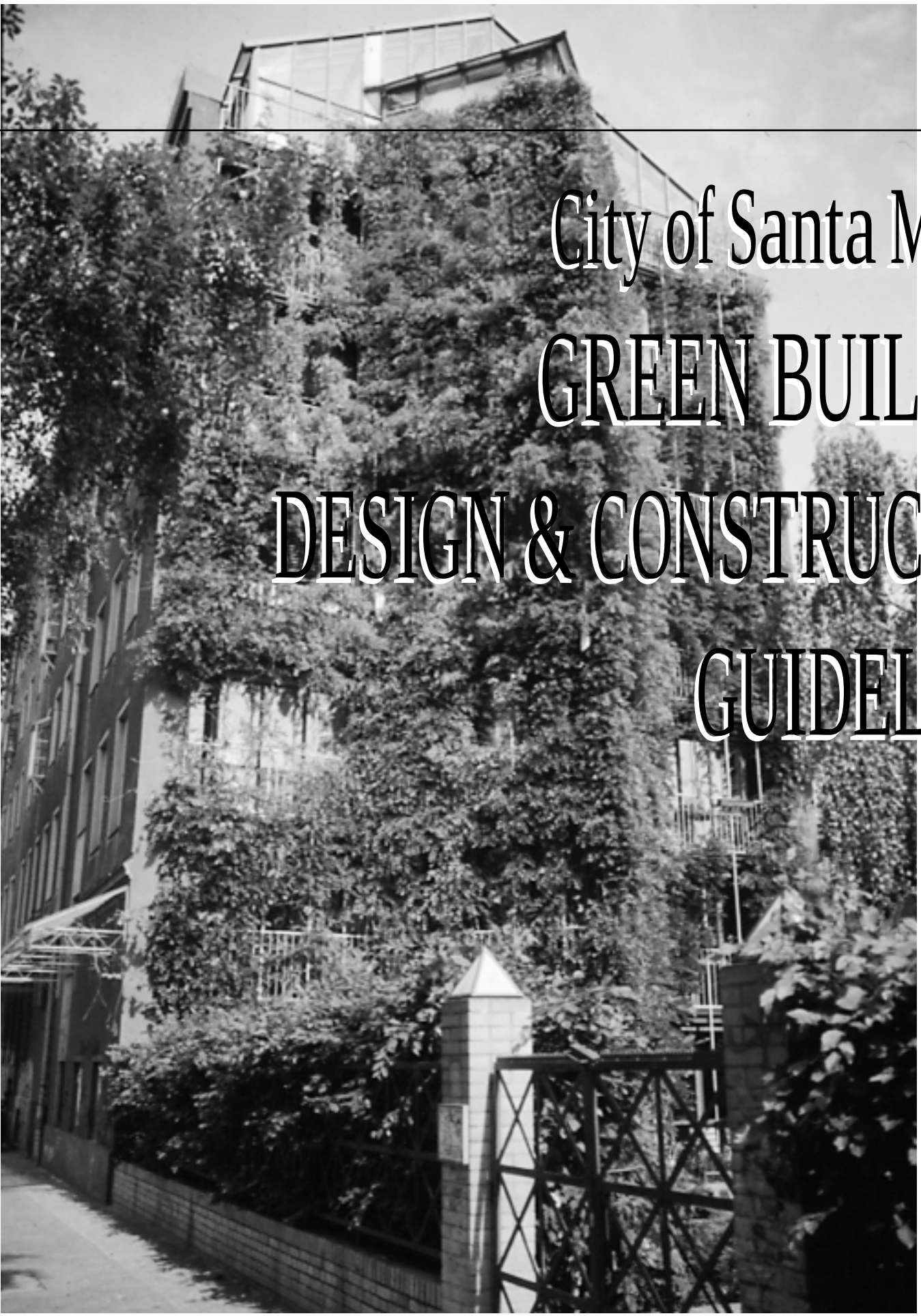

City of Santa Monica

GREEN BUILDING DESIGN & CONSTRUCTION GUIDELINES

APRIL 1999

Conserve Today.
Preserve Tomorrow.
Santa Monica
A Sustainable Community

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INTRODUCTION

Background

In September 1994 Santa Monica's city Council adopted the Santa Monica Sustainable City Program. This program was developed by the city's Task Force on the Environment as a way to create the basis for a more sustainable way of life -- one that safeguards and enhances local resources, prevents harm to the natural environment and human health, and strenghtens the community and local economy -- for the sake of current and future generations.

Conventional design and construction methods produce buildings that can negatively impact the environment as well as occupant health and productivity. These buildings are expensive to operate and contribute to excessive resource consumption, waste generation, and pollution. To help reduce these impacts and meet the goals of the Sustainable City Program, the Task Force recommended that the City adopt a set of guidelines to facilitate the development of "green" buildings in Santa Monica without forcing excessive costs or other burdens upon developers, building owners or occupants.

The Green Building Design and Construction Guidelines were developed over a three-year period by Sheltair Scientific Ltd., a sustainable design consultant team, with extensive input from the local design, construction and development community. The Guidelines include required and recommended practices that are intended to reduce life-cycle environmental impacts associated with the construction and operation of both commercial and municipal developments and major remodel projects in Santa Monica. They provide specific "green" design and construction strategies in the following areas: Building Site & Form, Landscaping, Transportation, Building Envelope and Space Planning, Building Materials, Water System, Electrical Systems, HVAC Systems, Control Systems, Construction Management, and Commissioning.

The Guidelines were developed for, and specifically apply to, the following building types: Institutional and Commercial Offices, Light Industrial Buildings, Commercial Retail Buildings, Multi-Family Residences, and Hotels & Motels. Recommended practices can apply to all buildings.

WHAT MAKES A BUILDING "GREEN"?

A "green" building places a high priority on health, environmental and resource conservation performance over its life-cycle. These new priorities expand and complement the classical building design concerns: economy, utility, durability, and delight. Green design emphasizes a number of new environmental, resource and occupant health concerns:

- Reduce human exposure to noxious materials.
- Conserve non-renewable energy and scarce materials.
- Minimize life-cycle ecological impact of energy and materials used.
- Use renewable energy and materials that are sustainably harvested.
- Protect and restore local air, water, soils, flora and fauna.
- Support pedestrians, bicycles, mass transit and other alternatives to fossil-fueled vehicles.

Most green buildings are high-quality buildings; they last longer, cost less to operate and maintain, and provide greater occupant satisfaction than standard developments. Sophisticated buyers and lessors prefer them, and are often willing to pay a premium for their advantages.

What surprises many people unfamiliar with this design movement is that good green buildings

often cost little or no more to build than conventional designs. Commitment to better performance, close teamwork throughout the design process, openness to new approaches, and information on how these are best applied are more important than a large construction budget.

WHY GREEN BUILDING DESIGN?

North Americans currently lead a material way of life that is unsustainable in ecological and resource terms over the next century – and buildings are major causes of this. The "ecological footprint" — the productive land area required for resource extraction and to assimilate pollution generated — of the average American exceeds three city blocks per person. For comparison, the average European requires two-thirds of this land area; the average Third World citizen one-twelfth. If all of the earth's population lived a Californian lifestyle, the equivalent of three planets would be required to maintain them.

Buildings are major contributors to this consumption and waste:

- Buildings consume ~40% of total annual U.S. energy use. Production of this energy emits ~100 million tons of carbon dioxide, the primary greenhouse gas driving climate change.
- Most existing air-conditioned buildings use chlorofluorocarbon refrigerants, which have been implicated in destruction of the ozone layer.
- American homes each use between 10,000 and 40,000 gallons of water per year.
- Construction of the average home creates ~2.5 tons of waste; demolition produces ~20 tons, of which most goes to landfills.

Buildings have impacts on health as well as the environment. It is estimated that half of all commercial buildings suffer from air quality problems, resulting in poorer health of workers and other occupants.

THE GREEN DESIGN PROCESS

The process of green building design and construction is fundamentally different from current standard practice. Time after time, successful green buildings result from a design process with four critical features.

Commitment to stringent health, ecological, and resource use performance targets by developers, designers and builders. Measurable targets challenge the design and construction team, and allow progress to be tracked and managed throughout development and beyond. Post-occupancy evaluations are often used to demonstrate performance of ambitious targets, to help market the project and to inform future efforts.

Close collaboration by multi-disciplinary teams, from the beginning of conceptual design, throughout design and construction. Health, resource and ecological issues inherently cross professional boundaries, requiring specialized information and skills. Typically, the design team is expanded to include new members, such as energy analysts, materials consultants or lighting designers and cost consultants; often, contractors, operating staff and prospective occupants are also included. The expanded design team provides fresh perspectives and approaches, and feedback on performance and cost. The design process becomes a continuous, sustained team effort from conceptual design through commissioning and occupancy.

Computer energy simulations assess energy conservation measures early and throughout the design process. The expanded design team collaborates early in conceptual design to generate many alternative concepts for building form, envelope and landscaping, focusing on minimizing peak energy loads, demand and consumption. Computer energy simulation is used to assess their effectiveness in energy conservation, and their construction costs. Typically, heating and cooling load reductions from better glazing, insulation, efficient lighting, daylighting and other measures allows smaller and less expensive HVAC equipment and systems, resulting in little or no increase in construction cost compared to conventional designs. Simulations are used to refine designs and ensure that energy-conservation and capital cost goals are met; and to demonstrate compliance with regulatory requirements.

Design alternatives are evaluated on the basis of reduced life-cycle cost, as well as capital cost. Design alternatives are aimed at minimizing the buildings' life-cycle cost – not just the lowest construction cost. Assessments include costs and environmental impacts of resource extraction; materials and assembly manufacture; construction; operation and maintenance in use; and eventual reuse, recycling or disposal. Computer energy simulation is one tool used to incorporate operational costs into the analysis; other computer tools (cited in the Recommended Practices that follow) are also available to help perform life-cycle cost analysis.

This process involves deeper analysis than is typical of traditional design practice, and requires more effort from design consultants. Design fees for this additional work typically reflect the increased work involved, but the investment is small compared to the environmental and cost impacts over the life of a typical building.

GREEN DESIGN STRATEGIES

This book has many Recommended Practices that can reduce the ecological and resource impacts of buildings, and enhance the health and satisfaction of their occupants. Several strategies surface repeatedly throughout these Practices.

Use less to do more. The most effective green design solutions meet several needs with a few elements. For example, a concrete floor may be simply finished with a colored sealant that reflects daylight for better illumination, and eliminates air pollutant emissions from floor coverings. The floor can also be used to store daytime heat and nighttime cold to provide occupant comfort. One carefully designed element serves as structure, and finished surface, distributes daylight, and stores heat and cold – saving materials, energy resources, capital and operating costs.

Careful combinations of design strategies are very effective. Buildings are complex systems of interacting elements. Intelligent green design considers the effects of one or more elements on the others, and on the building as a whole. For example, the need for mechanical and electrical systems is greatly affected by building form and envelope design. Synergistic strategies such as daylighting, solar load control, and natural cooling and ventilation using wind and stack effect can all work together to reduce lighting, heating and cooling loads – and the cost of equipment needed to meet them. Careful combination of several reinforcing strategies can save resources and money – both in construction and operation.

Build to adapt and to last. Buildings designed to adapt to changing uses over long useful lives

reduce life-cycle resource consumption. Long-lasting structural elements that provide generous service space and accommodate movable partitions can last centuries, instead of being demolished because they cannot adapt to unforeseen uses. Durable envelope assemblies improve comfort and reduce life-cycle maintenance and energy costs. Robust interior walls designed to be moved, and mechanical and electrical systems that make changes easy, save materials and money when tenant improvements or renovations occur.

Avoid creating problems, instead of fixing them after the fact. Preventing problems from the beginning makes practical and economic sense. For example, using low-toxicity building materials and installation practices is far more effective than diluting indoor air pollution from toxic sources with large quantities of ventilation air. Similarly, designing to minimize heating, cooling and lighting loads is far more profitable than installing more or larger mechanical and electrical equipment.

Take advantage of site conditions. Climate-responsive design rediscovers the powerful relationship of buildings to place. Buildings that respond to local topography, microclimate, vegetation and water resources are typically more comfortable and efficient than conventional designs that rely on technological fixes to ignore their surroundings. Santa Monica has excellent solar and wind resources for passive solar heating, natural cooling, ventilation and daylighting, but has few local water supplies, many of them recently polluted. Taking advantage of free natural resources, and conserving scarce high-priced commodities are two of the best ways to reduce costs and connect occupants to their surroundings.

"Performance" Ordinances in the Santa Monica Municipal Code

Two Santa Monica Municipal Code ordinances aim at higher environmental and resource performance of buildings than state or federal requirements. These performance-based ordinances require building projects to meet or exceed a performance target, but allow complete flexibility in the methods used. These targets have been set to reduce resource or environmental impacts, using cost-effective and well-proven design and construction strategies. Santa Monica's two building performance ordinances focus on reducing energy consumption and runoff of untreated stormwater.

This book sets out many Recommended Practices that offer different ways to satisfy and surpass these performance requirements. These Recommended Practices provide of techniques to respond to the unique opportunities and constraints of a specific project. While the SMMC performance ordinances do not require the use of any particular method, they require documents demonstrating that the design meets minimum performance targets.

Building Energy Conservation Ordinance

The City of Santa Monica requires lower annual energy consumption than California's 1999 Title 24 regulation. Santa Monica Municipal Code Ordinance # requires more stringent annual non-renewable energy budgets, summarized in the following table.

Building Occupancy	Annual Source Energy Conservation Target (relative to Title 24 energy budget)
Multi-family residences	25%
Hotels and motels	30%
Commercial and institutional offices	30%
Light industrial	30%
Retail	20%

These annual energy conservation targets are based on detailed computer energy simulations of archetypal buildings that comply with Santa Monica's zoning and building ordinances, and the 1998 Title 24 regulation. Computer model inputs and targets for Santa Monica were independently reviewed for accuracy and cost-effectiveness by respected architects, quantity surveyors and energy engineers familiar with construction practices in the City.

Santa Monica's building energy performance ordinance is based on California's Title 24 regulation, which is still applicable in the City. However, Santa Monica's ordinance requires use of computer simulations following Title 24's Performance Approach to demonstrate that non-residential buildings meet the energy conservation target.

Design teams of non-residential buildings are required to submit two reports to the City on energy performance of their designs:

1. A report summarizing preliminary computer energy analysis performed during conceptual design, as part of the development permit application; and

2. A report summarizing the final computer simulation demonstrating that the final design complies with the above targets, as part of the building permit application.

For residential buildings with more than two dwelling units, two methods can be used to demonstrate compliance with Santa Monica's Building Energy Conservation Ordinance:

1. computer energy simulations following the same requirements listed above for non-residential buildings; or

2. documentation submitted for the building permit following Title 24's Prescriptive Standards, and incorporating the following list of energy-conserving construction features:

- All windows and glass patio doors equipped with double-glazed, low-emissivity glazing, with center-of-glass U-value not more than 0.260 Btu/(hr.sq.ft. deg.F.), and Solar Heat Gain Coefficient not more than 0.375.

- The average efficacy of all fixed lighting fixtures installed within dwelling units not less than 40 lumens watt (typically T8 and compact fluorescent lamps).

- Space heating appliances with Annual Fuel Utilization Efficiency (AFUE) not less than 92%.

• Space cooling appliances (if installed) with Seasonal Energy Efficiency Ratio not less than 12.

These multi-family residential building energy conservation measures have been demonstrated to result in 25% reduction in annual source energy use.

Stormwater Management Performance Ordinance

The City of Santa Monica's Urban Runoff Reduction ordinance (SMMC 7.10.060) requires that new development and substantial remodels prepare and submit an Urban Runoff Mitigation Plan. The Ordinance and the Runoff Plan are designed to reduce the amount of polluted runoff that reaches our storm drain system and Santa Monica Bay. The Ordinance requires a 20% reduction in urban runoff from all new developments and substantial remodels within the City. The Ordinance also specifies guidelines for existing properties and sites under construction to reduce the level of contaminants carried by urban runoff into the Bay.

The most critical aspect of complying with the Ordinance is incorporating urban runoff reduction into the design of the project. The Urban Runoff Reduction Ordinance is a performance-based ordinance in that it requires a certain level of compliance, yet does not specifically prescribe specific methods that must be used to comply. These Guidelines help designers comply with the ordinance by highlighting some of the more cost-effective measures that have been used in the City of Santa Monica.

When submitting a project for first planning approval, every applicant is required to submit an Urban Runoff Mitigation Plan to the City's Engineering Division. The Plan must show that the projected urban runoff from the project will be reduced by at least 20%. To accomplish a 20% reduction in runoff the project should maximize the amount of permeable area and minimize the amount of runoff flowing toward impermeable areas. The Site & Form section of this document provides more detail.

How To Use These Guidelines

These Guidelines provide designers and builders with guidance on the ways that buildings can provide better health, ecological and resource performance effectively and economically. It is most helpful when decisions have the greatest effect: during the conceptual and schematic stages of design; during construction; and in commissioning.

Most chapters provide advice for conceptual and schematic stages of design. In these early stages, it is easy to explore, and accept or reject design strategies. The Construction Management and Commissioning chapters focus on later stages of development. Builders make many material and equipment choices during construction, and commissioning ensures that design intentions and performance targets are realized.

Each chapter also provides plain-language summaries of "Required Practices" - Santa Monica Municipal Code ordinances that have a significant effect on the environmental performance of buildings.

The Guidelines are tailored to introduce designers and builders to green design and construction strategies that may be unfamiliar, while avoiding information overload. To that end, information is presented in several ways, with details appropriate to early design, construction or commissioning.

Each of the following chapters is organized into five sections.

The Chapter Introduction discusses its environmental, resource or health objectives. It also provides an overview of general strategies with merit. The Required and Recommended Practices are put in context to explain the relation of each to the others – when to consider their use, which to use together, and which are most effective.

The Summary of Required and Recommended Practices lists "Required Practices" of the Santa Monica Municipal Code ordinances; and "Recommended Practices" in a table that shows their performance in several key design and construction issues. These issues include Environment, Ease of Use, Other Benefits, and Capital Cost.

Environment addresses environmental, health and resource-conservation performance of the practice used alone. "Low" is a slight but definite improvement, compared to current standard practice in Southern California. For example, less than a 5% improvement in energy consumption. "Moderate" is better – a 5% to 10% improvement. "High" is reserved for the most effective Practices – more than a 10% improvement.

Ease of Use indicates how easily a Practice can be implemented. A "High" rating means that competent professionals should have little or no extra difficulty in its use. "Moderate" implies that the designer or contractor may be required to learn some new techniques or take extra care the first time they apply the advice, but are unlikely to have major difficulties. "Low" indicates that special expertise will likely be required, and particular care and attention is needed to ensure the best results.

Other Benefits points out benefits other than reduced environmental, health or resource impacts. One example is the social and livability benefits of pedestrian amenities. Another is the enhanced marketability of buildings with operable windows used for natural cooling.

Capital Cost estimates the effect of the Practice on the total cost of construction, relative to current standard practice. "Low" indicates little or no extra cost – less than 1% of total project capital cost. "Moderate" means increased costs between 1 and 5%; "High" indicates a cost increase of greater than 5%.

The Required Practices explain how to comply with Santa Monica Municipal Code ordinances with particular influence on the environmental impacts of buildings, using plain language and illustrations. All building projects must comply with the Required Practices, whether they are new construction or substantial remodels.

The methods shown in the Required Practices are acceptable to building inspectors, plan checkers and governing City departments, as satisfying the particular SMMC ordinance. However, the Required Practice discussions should be considered as a supplement to the Municipal Code; the ordinance itself should be consulted, and form the basis for compliance decisions made by City staff.

The Recommended Practices present different ways to accomplish a given objective – a flexible 'toolbox' of technique. It is unlikely that all of the Recommended Practices would be used in any one project, though often several are best used together.

The information in a Recommended Practice provides details appropriate to early design, construction or commissioning. Discussions are brief, to make them easy to use for a busy – and time-starved – professional.

The Further Information section provides sources for more detailed information useful in later stages of design development and preparing contract documents. They offer resources beyond the scope of these Guidelines. These references will be useful to readers interested in gaining a deeper understanding of practice, theory and current research.

TABLE OF REQUIRED PRACTICES

Ordinance	Subtitle
SITING & FORM	
SFa SMMC 7.10.060	Submit an Urban Runoff Mitigation Plan to the Engineering Division
LANDSCAPE	
LAa SMMC 7.10.060	Minimize Stormwater Runoff to Impermeable Areas
LAb SMMC 9.04.10.04.110	Specify & Install Water-Efficient Irrigation Systems
LAc SMMC 9.04.10.04.110	Restrict the Use of Water Features & Fountains
TRANSPORTATION	
TRa SMMC 5.20.080 (c) (2)	Install Clarifiers or Oil/Water Separators on Drains from Service Bays & Parking Areas
TRb SMMC 9.04.10.08.050	Provide Secure & Accessible Bicycle Storage for Visitors & Occupants
TRc SMMC 9.04.10.08.050	Provide Facilities for Shared Vehicle Transportation
ENVELOPE & SPACE PLANNING	
ENa SMMC 9.04.10.02 150-151	Provide Space for Recycled Material Storage & Handling Systems
WATER SYSTEMS	
WSa SMMC 7.18	Specify & Install Water-Conserving Plumbing Fixtures & Fittings
WSb SMMC #	Reduce Hot Water Heat Loss with Insulation & Heat Traps
WSc SMMC #	Heat Swimming Pools & Preheat Process Hot Water with Unglazed Solar Collectors
WSd SMMC 5.20.080(c)(1)	Eliminate Lint from Sanitary Sewers in Professional Cleaning Facilities
WSe SMMC 5.20.080 (c)(1) & (c)(4)	Eliminate Grease from Sanitary Sewers in Food Preparation & Meat Retailing Facilities

WSf	SMMC 5.20.080 (c)(5)	Eliminate Silver from Sanitary Sewers in Photo-Finishing Facilities

CONSTRUCTION MANAGEMENT

CMa	New SMMC ordinance #	Prepare a Demolition & Site Protection Plan
CMb	New SMMC ordinance #	Salvage Reusable Materials & Separate Recyclables from Demolition
CMc	New SMMC ordinance #	Inventory, Mark & Protect Topsoil, Trees & Vegetation to be Retained
CMd	SMMC 7.10.070	Prepare a Stormwater Control Program for the Construction Site
CMe	New SMMC ordinance #	Recycle Construction Waste, & Designate a Site Waste-Management Person
CMf	SMMC 5.08.150 (b), 7.10.040	Provide Safe Storage, Worker Training & Spill Cleanup Procedures for Hazardous Materials

TABLE OF RECOMMENDED PRACTICES

		Environment	Ease of Use	Benefits	Capital Cost
SITING & FORM					
SF1	Use Narrow Floor Plates for Access to Daylight, Views & Natural Cooling	* * *	* *	* * *	**$$**
SF2	Locate & Orient the Building to Control Solar Cooling Loads	* * *	*	* *	**$**
SF3	Locate & Orient the Building for Passive Solar Heat in Winter	* * *	*	* *	**$**
SF4	Shape & Orient the Building for Exposure to Prevailing Winds	* * *	*	* * *	**$**
SF5	Shape the Building to Induce Buoyancy Airflow Into & Out of Interior Spaces	* * *	*	* * *	**$$**
SF6	Shape the Building for Solar Energy Collection	* * *	*	* *	**$$**
LANDSCAPE					
LA1	Locate Landscaping & Landscape Structures to Shade Buildings	* *	* * *	* * *	**$**
LA2	Use Landscape Design to Modify Wind Patterns & Enhance Building Ventilation	* *	* * *	* *	**$**
LA3	Apply Environmental Landscape Design Principles	* * *	* * *	* *	**$**
LA4	Incorporate Areas for Urban Agriculture & Rooftop/Balcony Gardens	* * *	* *	* *	**$$**
LA5	Provide Shelter & Habitat for Urban Wildlife Through Landscape Design	* * *	* * *	* *	**$**

		Environment	Ease of Use	Benefits	Capital Cost
LA6	Provide On-Site Composting Facilities	* *	* *	* * *	**$**
LA7	Use Recycled Landscape Products & Materials	* *	* * *	* * *	**$**
	TRANSPORTATION				
TR1	Match the Area & Type of Paved Surfaces to Their Use	* * *	* *	* *	**$$$**
TR2	Create a Safe & Comfortable Environment for Pedestrians	* *	* *	* * *	**$**
TR3	Provide Changing Rooms, Lockers & Showers for Cyclists and Joggers	* *	* *	* *	**$$**
TR4	Place Automobile Parking Fully or Partially Underground	*	* *	* * *	**$$$**
TR5	Share Parking Between Occupancies in Mixed-use Projects	*	*	44	**$**
TR6	Provide Convenient Parking & Charging Facilities for Electric Vehicles	*	*	*	**$**
	ENVELOPE & SPACE PLANNING				
EN1	Design Windows to Maximize Daylighting & Views	* * *	* *	* * *	**$$**
EN2	Shade Windows During Cooling Periods	* * *	* *	* *	**$$**
EN3	Use Roof Monitors for Daylighting Upper Floors	* * *	* *	* * *	**$$**
EN4	Design Windows to Maximize Natural Ventilation	* *	* *	* *	**$$$**

		Environment	Ease of Use	Benefits	Capital Cost
EN5	Shape & Plan the Interior to Enhance Daylight a& nd Natural Airflow Distribution	* *	* *	* * *	**$$**
EN6	Incorporate Thermal Mass Into Building Structure	* *	* *	* * *	**$**
EN7	Select Light Colors for Exterior Finishes	* *	* * *	* *	**$**
MATERIALS					
MA1	Restore & Incorporate Portions or Entire Existing Buildings in New Designs.	* * *	*	* *	**$$**
MA2	Specify Reuse of Salvaged Building & Landscape Materials	* * *	*	* *	**$**
MA3	Design with Panel, Precut & Engineered Construction Products to Minimize Waste	* *	* * *	*	**$**
MA4	Specify Durable Exterior & Interior Finishes.	* * *	* *	*	**$$$**
MA5	Design Interior Building Components for Future Disassembly, Reuse & Recycling	* *	* *	* * *	**$$**
MA6	Specify Wood from Sustainably Managed Sources	* * *	* *	* * *	**$**
MA7	Use Low-Emission Finishes & Interior Materials to Reduce Indoor & Environmental Pollution	* * *	* *	* *	**$$**
WATER SYSTEMS					
WS1	Specify & Install Water- & Energy-Conserving Appliances	* *	* *	* * *	**$$$**

		Environment	Ease of Use	Benefits	Capital Cost
WS2	Reuse Graywater for Outdoor Landscaping Irrigation	* * *	*	*	**$$**
WS3	Collect Rainwater for Outdoor Landscaping Irrigation	* * *	* * *	*	**$$**
WS4	Select High-Efficiency Service Hot Water Heaters & Boilers	* *	* * *	*	**$$**
WS5	Install Heat-Recovery Systems on Wastewater Plumbing	* *	* *	* *	**$**
WS6	Use Solar Collectors & Heat Storage for Service Hot Water Heating	* * *	* *	* *	**$$**
ELECTRICAL SYSTEMS					
ES1	Select Electrical Equipment for Reduced Energy Demand & Consumption	* * *	* * *	* *	**$$$**
ES2	Select Lighting Equipment for Reduced Energy Demand & Consumption	* * *	* *	* * *	**$**
ES3	Integrate Daylighting & Electric Lighting in Task-Oriented Spaces for Productivity & Comfort	* *	* *	* * *	**$$**
ES4	Integrate Daylighting & Electric Lighting in Gathering Spaces for Comfort & Efficiency	* * *	* *	* *	**$**
ES5	Maximize Impact in Sales Areas with Efficient Lighting Strategies	* * *	* *	* * *	**$**
ES6	Integrate Daylighting & Electric Lighting in High-Bay, Manufacturing & Color-Critical Areas	* * *	* * *	* *	**$$**

		Environment	Ease of Use	Benefits	Capital Cost
ES7	Incorporate Photovoltaic Electricity Systems into the Building Fabric	* * *	*	* *	**$$$**
ES8	Provide for Future Electric Vehicle Charging Stations	* *	* * *	*	**$**
HVAC SYSTEMS					
HS1	Eliminate Mechanical System Sources of Indoor Air Pollution	* * *	* * *	* * *	**$$**
HS2	Isolate & Exhaust Indoor Point Sources of Air Pollutants	* * *	* * *	* * *	**$$**
HS3	Separate Outdoor Air Intakes from Air Pollutant Sources	* * *	* *	* * *	**$**
HS4	Provide for Additional Outdoor Air Supply Quantities in Future	* *	* * *	* *	**$**
HS5	Filter or Treat Ventilation Air Supplies	*	* *	*	**$**
HS6	Provide Effective Ventilation Air Distribution	4	44	44	**$$**
HS7	Reduce or Eliminate Use of CFCs and HCFCs in Cooling Equipment	444	44	44	**$**
HS8	Select High-Efficiency Heating & Cooling Equipment to Reduce Energy Consumption & Demand	444	444	444	**$$**
CONTROL SYSTEMS					
CS1	Use Digital Electronic Control of Lighting & HVAC Systems for Energy & Demand Savings	444	44	44	**$$**

		Environment	Ease of Use	Benefits	Capital Cost
CS2	Incorporate Daylighting Controls in Architecturally Daylit Spaces	* * *	* *	* *	**$$**
CS3	Incorporate Occupancy Controls in Zones with Intermittent Use	* * *	* * *	*	**$$**
CS4	Use Variable-Speed Motor Controllers for Fans & Pumps with Modulating Flows	* *	* * *	* * * *	**$$**
CS5	Cool Building Mass at Night for Energy & Demand Savings	* * *	* * *	* *	**$**
	CONSTRUCTION MANAGEMENT				
CM1	Crush Waste Concrete & Masonry for Reuse	* * *	* * *	*	**$**
CM2	Use Material-Conserving Construction Practices	*	* * *	* *	**$**
CM3	Select Safe Materials for Use On-Site	* *	* *	* *	**$$**
CM4	Use Integrated Pest Management (IPM) to Minimize Pesticide Use in Construction	* * *	*	444	**$$**
CM5	Use Energy-Efficient Site Lighting & controls, & Low-Pollution Equipment	*	* * *	* *	**$$**
CM6	Isolate Construction in Occupied Buildings to Protect Occupants	* * *	* *	* *	**$**
CM7	Schedule Potential Air-Polluting Operations to Reduce Occupant & Worker Exposure	* *	* *	* * *	**$$**

		Environment	Ease of Use	Benefits	Capital Cost
CM8	Flush with Full Outdoor Air for Seven Days Prior to Occupancy to Protect Occupants	* *	* *	*	**$$**
CM9	Thoroughly Clean Interiors, Building Cavities & HVAC Systems Prior to Furniture Installation and Occupancy	* *	* * *	* * *	**$**
COMMISSIONING					
CO1	Prepare & Follow a Formal Commissioning Plan	* * *	* * *	* * *	**$$**
CO2	Pretest & Functionally Test All Equipment to be Commissioned & Correct Deficiencies	* *	* * *	*	**$**
CO3	Provide Operation & Maintenance Training or Staff	* * *	* *	* * *	**$$**
CO4	Provide a Complete Final Commissioning Report to the Owner & Building Management	* *	* *	* *	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low 4
Moderate 4 4
High 4 4 4

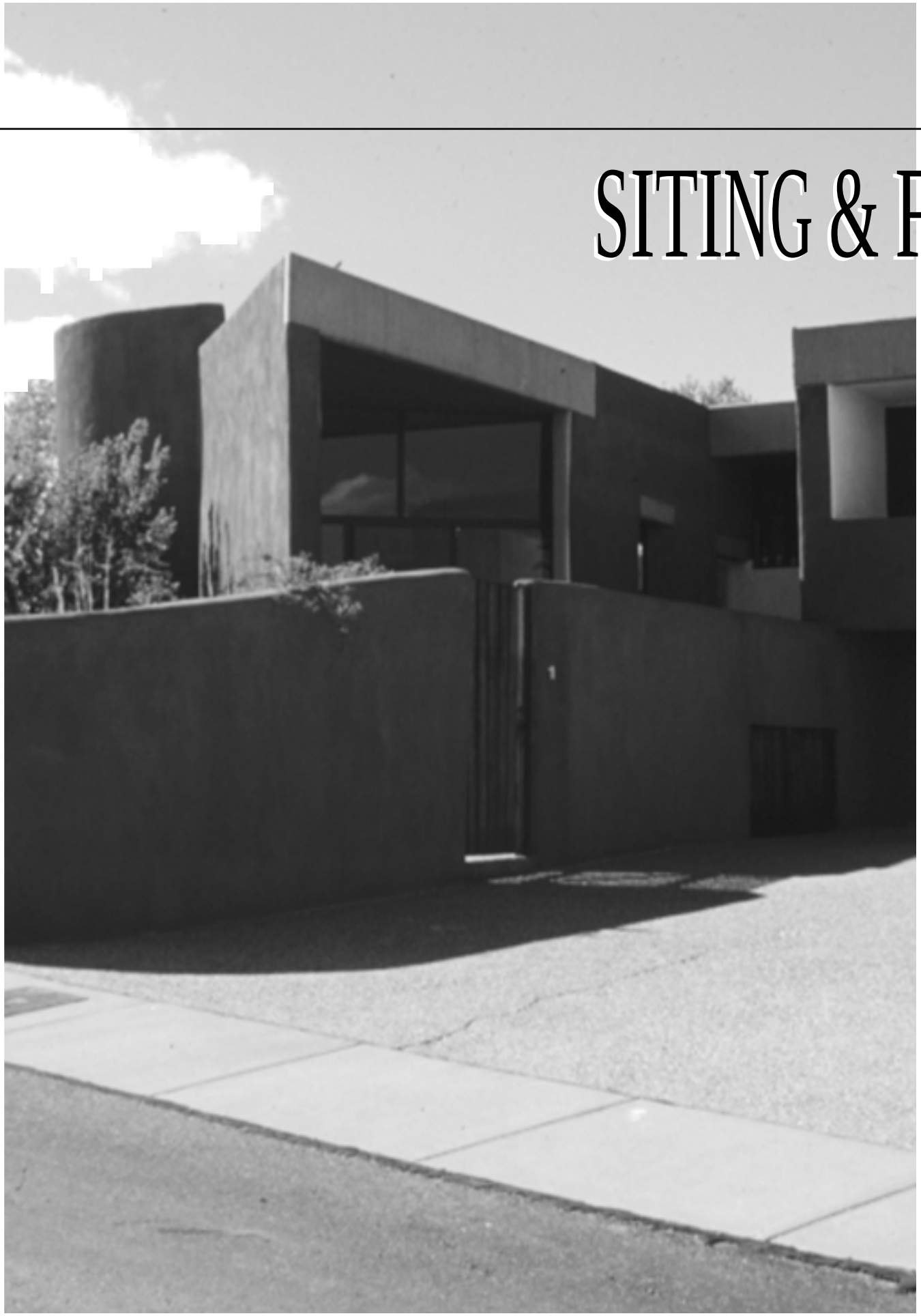
Ease of Use: how easily a given Practice can be implemented in design or construction.

Low 4
Moderate 4 4
High 4 4 4

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low 4
Moderate 4 4
High 4 4 4

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

SITING & FORM



SITING & FORM

Most of the location, orientation and massing decisions made in the early stages of design have a profound effect on the energy and environmental impacts of buildings. This is particularly the case for solar-responsive, daylighting and natural cooling design, where early decisions establish the potential for passive renewable energy use. Other environmental strategies, such as stormwater management, are also greatly influenced by site planning.

Solar-Responsive Design

There are many direct and indirect benefits of designing buildings that respond to the sun. However, approaches to shape and orientation differ depending on the purpose: Is the goal to minimize cooling loads, or to collect solar energy now or in the future? The challenge is to ensure that different portions of the building respond appropriately to these two very different goals, while integrating them into a functional and elegant whole.

Careful orientation and massing can minimize solar energy entering the building and greatly reduce cooling loads, especially for commercial and retail buildings with high internal loads. This translates into lower energy costs over the life of the building and less air pollution from electricity generation. Careful solar control can also reduce costs for mechanical cooling equipment often to the point of lower overall construction cost. Solar control to reduce cooling loads helps provide year-round comfort, more independence from energy price increases and less vulnerability to brownouts.

Many Santa Monica buildings require heating — especially building with low internal electrical loads, such as multi-unit residential.

Unlike solar control for cooling, using solar energy for service hot water (SHW) heating or electricity generation requires maximizing the exposure of collectors to the sun. This reduces the capital cost of these systems, which in the past has been relatively high. Those parts of the building that carry these systems should be shaped to collect solar energy efficiently.

In Santa Monica, solar hot water systems are cost-effective for many uses now. Photovoltaic electricity generation is currently expensive, but costs are dropping rapidly. "Building-integrated" photovoltaic (BIPV) systems, which incorporate collectors into the roof, walls and other building elements, are now entering the market, replacing conventional exterior finishes and reducing construction cost. Another trend is to use solar collectors as window shades — gaining two functions from the same elements. Ensuring that the building will be able to take advantage of free, renewable solar energy in the future, when capital costs will be lower, is a prudent strategy.

Daylighting Design

Building occupants place a premium on natural light and a view to the exterior. If carefully admitted and controlled, daylight enhances the visual quality of interior spaces, and offers many psychological benefits that are difficult and expensive to replicate with electrical lighting. Natural light has inherent variability and unique spectral qualities that reveal and highlight interiors. Providing naturally lit interiors has been shown to increase occupant satisfaction, lower absenteeism, and improve worker productivity and retail sales.

Daylighting design has a major impact on the form and orientation of buildings. First, the building and its openings — windows, skylights and roof monitors — must be oriented to allow light to enter interior spaces, without causing glare or visual discomfort. As well, design for daylighting can constrain the depth of buildings, to allow natural light in most occupied spaces. This limitation can be

greatly eased by the use of light distribution strategies, such as lightshelves and ceiling slopes, that extend the depth of daylit space.

A view to the outdoors is important for occupants' sense of well-being, since it provides cues on orientation, time of day and weather. Providing visual contact with the exterior from most interior areas attracts and retains tenants and staff — but also places limitations on building depth and interior partitions.

Natural Ventilation and Cooling

Natural, or passive, ventilation and cooling uses wind and the buoyancy of warm air to provide comfortable conditions within buildings during hot periods. When carefully combined with daylighting and thermal mass, natural ventilation can greatly reduce the cooling load in buildings, and minimize or eliminate the need for mechanical cooling in most circumstances in Santa Monica.

Natural ventilation and cooling offers many advantages over artificial air-conditioning. First, although all major manufacturers are introducing equipment that uses less damaging refrigerants, often with equal or better energy efficiencies than existing chlorofluorocarbon (CFC) equipment, many still use refrigerants that damage the ozone layer and are slated to be banned in the near future. Natural cooling eliminates this concern. Second, regardless of the refrigerant, mechanical cooling equipment consumes fossil fuels during use, with their associated operating and environmental costs. Third, there is growing market evidence that building occupants prefer natural ventilation over that provided by mechanical air-conditioning systems — providing an advantage when selling or leasing a building or attracting and retaining employees.

Santa Monica has ideal conditions for natural ventilation and cooling. The prevailing breezes are consistently on-shore from Santa Monica Bay, from the west-southwest and west throughout the year. These winds are most consistent when cooling requirements are high, when air temperatures are higher and the sun is most intense. As well, Santa Monica's street grid and lot orientation are at right angles to the prevailing on-shore winds, allowing the use of natural ventilation for most locations.

However, building form and orientation must be shaped to take advantage of natural cooling opportunities. First, the building must be located and shaped considering the prevailing wind. Air inlets are best placed in upwind exposures, where the pressure is highest. Air outlets are best placed in downwind, low-pressure exposures. Spaces with single-sided natural cooling must be narrow; cross-ventilation requires paths for air to move through one or more rooms in the building. Interior walls are best placed where they don't block airflow. As well, natural cooling is enhanced by tall spaces, that allow heated air to rise out of the occupied zone and out of the building. Finally, thermally massive floors and walls store the cold from night air in effective night ventilation strategies — which affects structural design.

Integrating Design Strategies

Many of these features — openings to the outdoors, high and narrow spaces, and interior wall placement — are the same as those of daylighting design. Combining these two strategies can reduce the cooling loads of Santa Monica buildings to the point where artificial air-conditioning is not necessary, and artificial light is required only as it gets dark. The result: much lower air pollution and consumption of non-renewable energy.

Most of the Recommended Practices in this chapter are aimed primarily at reducing energy consumption, but they also offer indoor environmental quality benefits. However, they only establish the potential for energy savings and its environmental benefits; these strategies must be coordinated with envelope, mechanical and electrical systems design and control strategies to ensure these savings are realized.

Solar-responsive, daylighting and natural cooling design offer significant environmental benefits, and they work best when combined. The most effective design strategy is a narrow floor plan, allowing most interior spaces a direct connection to the outdoors. Narrow spaces provide the opportunity for increased daylight, better views to the exterior and more potential for natural ventilation.

Stormwater Management

Pollution of Santa Monica Bay by stormwater runoff is one of the most pressing and difficult environmental problems in the Los Angeles basin. Building sites have a role to play in reducing the amount and contamination of stormwater runoff. The Santa Monica Municipal Code ordinance 7.10.060 requires that building developers submit an Urban Runoff Mitigation Plan, showing how the site will address this issue. The most effective approach is to limit the amount of impermeable surfaces on the site, since permeable surfaces both reduce peak stormwater runoff, and treat stormwater pollutants.

Runoff from parking areas and vehicle lanes in particular contain a wide variety of contaminants, including lead, asbestos, oil, grease and gasoline. Biological and mechanical methods of treating these contaminants, and reducing the amount of stormwater carrying them to the Bay, are summarized in

- SFa: SMMC 7.10.060: Submit an Urban Runoff Mitigation Plan to the Engineering Division
- TRa: SMMC 5.20.080: Install Clarifiers or Oil/Water Separators on Drains from Service Bays and Parking Areas
- LAa: SMMC 7.10.060: Minimize Stormwater Runoff to Impermeable Areas

SITING & FORM PRACTICES SUMMARY TABLE

Required Practices	Ordinance	Subtitle
SFa	SMMC 7.10.060	Submit an Urban Runoff Mitigation Plan to the Engineering Division

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
SF1 Use Narrow Floor Plates for Access to Daylight, Views & Natural Cooling	4 4 4	4 4	4 4 4	**$$**
SF2 Locate & Orient the Building to Control Solar Cooling Loads	4 4 4	4	4 4	**$**
SF3 Locate & Orient the Building for Passive Solar Heat in Winter	4 4 4	4	4 4	**$**
SF4 Shape & Orient the Building for Exposure to Prevailing Winds	4 4 4	4	4 4 4	**$**
SF5 Shape the Building to Induce Buoyancy Airflow Into & Out of Interior Spaces	4 4 4	4	4 4 4	**$$**
SF6 Shape the Building for Solar Energy Collection	4 4 4	4	4 4	**$$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low 4
Moderate 4 4
High 4 4 4

Ease of Use: how easily a given Practice can be implemented in design or construction.

Low 4
Moderate 4 4
High 4 4 4

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low 4
Moderate 4 4
High 4 4 4

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

SFa

REQUIRED PRACTICE
SMMC 7.10.060

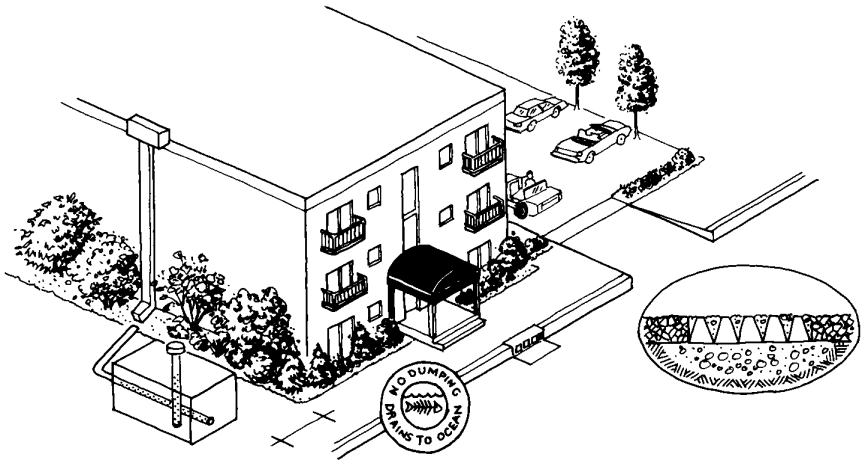
Environment 4 4 4
Most effective way to improve water quality in Santa Monica Bay

Ease of Use 4 4
Effort needed to incorporate features in design of project

Other Benefits 4 4 4
Aids in reducing peak runoff flow coming from project and impacting storm drain system.

Capital Cost
Varies with runoff mitigation measure used.

SUBMIT AN URBAN RUNOFF MITIGATION PLAN TO THE ENGINEERING DIVISION



The City of Santa Monica's Urban Runoff Pollution Control Ordinance requires that all new developments and substantial remodels (as defined by the Municipal Code) prepare an Urban Runoff Mitigation Plan. The purpose of this plan is to insure that each new development maximizes permeable surface area and minimizes the amount of runoff that is directed to impermeable areas. The Urban Runoff Mitigation Plan must be submitted to the City of Santa Monica, Engineering Division when an application for first planning approval is submitted. The Urban Runoff Mitigation Plan must show that the projected runoff will be reduced by at least 20%.

Following the design elements and principles in this book will help insure that the plan will meet the requirements outlined in the Urban Runoff Pollution Control Ordinance.

One or more of these elements must be implemented:

- Limit the impervious area of the total surface area. Calculate the imperviousness ratio as follows: Percentage of impervious area = Total impervious area/Total project size. Impervious areas include rooftops, impervious driveways, sidewalks, etc. Permeable pavements are excluded from the impervious calculation. If the percentage of permeable area is greater than 20%, then no additional measures are required.
- Incorporate structural Best Management Practices (BMPs) that are found to be beneficial to the prevention of stormwater pollution, i.e., oil/water separators, catch basin inserts, sand filters, detention basins, ponds, vaults, trenches, dry wells, roof downspout infiltration, porous pavement, grid pavers, grass swales and strips, etc.
- Design timing and application methods of irrigation systems to minimize the runoff of excess water into the storm drain system.
- Achieve long-term soil stabilization by permanent growth of native vegetation, including but not limited to native grass, sod, tree planting, shrubs, vines and /or other ground covering.

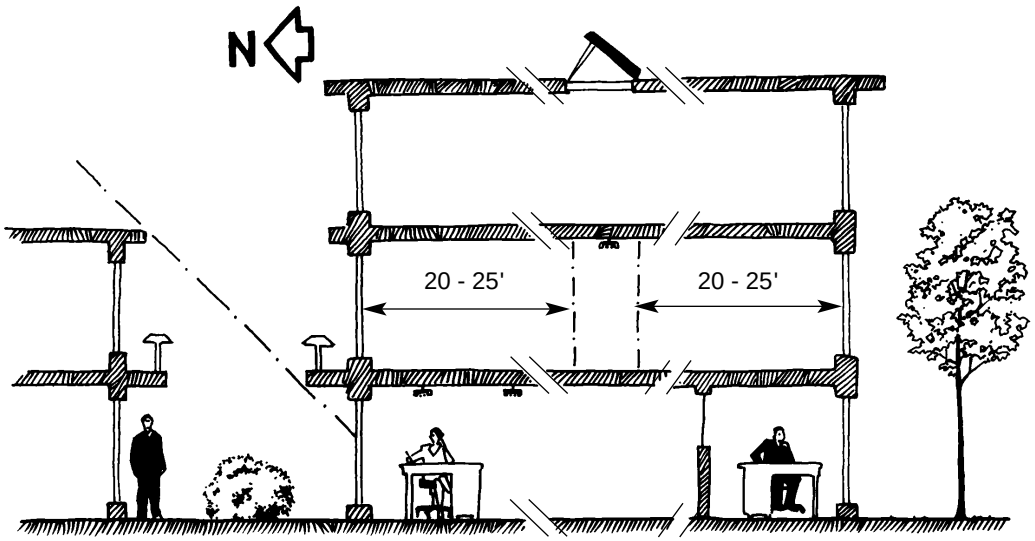
Further Information

- SMMC 7.10.060
- SMMC 5.20.080
- Tom Richman, et al 1997

Linked Practices

LAa
TRa
TR1
WS3
CMd

USE NARROW FLOOR PLATES FOR ACCESS TO DAYLIGHT, VIEWS & NATURAL COOLING



Floor plan depth is the most important single consideration that affects the potential for daylighting, exterior views and natural ventilation. Floor plans with relatively narrow wings, such as I-, H-, U-, or T-shaped plans, ensure that most interior spaces have good access to natural light and winds. Courtyards and atria can also be used to bring light and air to surrounding narrow spaces.

The area of interior space that can be daylit using windows depends on both building depth and floor-to-ceiling height. (Single-story buildings and the top floors of multi-storey buildings can be toplit using skylights, roof monitors or light wells.)

- Since useful daylight from typical windows can only reach 15 to 25 ft. into spaces with 8 or 9 ft. floor-to-ceiling heights, floor plans deeper than ~ 56 ft. (two rooms flanking a double-loaded corridor) will require constant electric lighting.
- Redirecting daylight with lightshelves, prismatic glazing and other reflective systems can extend naturally lit interior space to 30 to 35 ft. deep.

An occupant's view of the exterior depends on the distance from the window, the visible transmissivity of the glazing, and obstructions to light. To ensure good views for most occupants:

- Limit the maximum distance of workstations from the building exterior to 20 to 25 ft.
- Use atria and outdoor courtyards to increase the variety and number of views.

Further Information

- Brown, G.Z.1985
- Daniels, K. 1997
- Lam, W.M. 1977
- CIBSE, 1997
- Givoni, B. 1994

Linked Practices

EN1
EN2
EN4
EN5
CO2

Environment 444

Smaller peak electrical demand. Enhanced indoor lighting quality and potential for natural ventilation.

Ease of Use 44

Site and context dependent. May be difficult to comply with Floor Area Ratio requirements. Requires greater collaboration among design consultants. Airflows less predictable in complex buildings.

Other Benefits 444

Enhanced indoor lighting and operable windows provide occupants with greater comfort and a sense of control over indoor conditions.

Capital Cost $$

Site and context dependent. Initial cost should not significantly increase on sites where choice of orientation is possible. Potential reduction in HVAC equipment size.

SF1

A well-designed natural cooling strategy can be as effective as mechanical air-conditioning, but its potential is also greatly influenced by floor plan depth.

Narrow floor plans increase the potential for effective cross-ventilation: bringing outdoor air into one side of a space and exhausting it on an adjacent or opposite side. Cross-ventilation can move air effectively over deep floor plans, but air temperature increases and air quality drops as it moves across the room. The practical limit for the length of the airflow path is five times the ceiling height (~50 ft. for a ten ft. ceiling).

Single-sided ventilation, where only one exterior wall has operable windows or vents, is also possible but less effective, since air speed (with its cooling effect) is typically lower than in cross-ventilation situations.

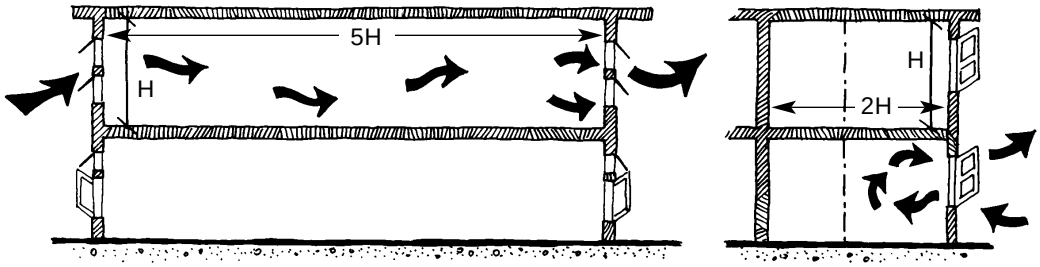
With a single operable window or vent, natural ventilation relies on wind turbulence and buoyancy, instead of the higher pressures available from wind. In single-sided ventilation, air flows in the bottom, is heated within the space, and flows out at the top of the same opening. The larger the height between the top and bottom, and the higher the temperature change, the greater the airflow.

Single-sided, single-opening natural ventilation is is effective to a depth of approximately two times the ceiling height. This implies a maximum room depth of approximately 18 to 20 ft., for 9 to 10 foot ceiling height with a window approximately five foot high.

Where separate high and low openings are used, warm air leaves through the upper vent, inducing inflow through the lower vent. In this situation, if the vertical separation between the openings is approximately 5 ft., ventilation is effective for up to 2.5 times the ceiling height. This gives a maximum room depth of 23 to 25 ft.

Cautions

- Energy savings from daylighting depend on skylights and windows and electric lighting controls that must be properly commissioned.
- Energy savings from natural cooling require that supplementary air-conditioning systems are turned off when windows are open.
- Unacceptable noise and indoor air pollution are possible when openings are close to major traffic routes. Traffic noise and pollution diminish significantly above the third floor.

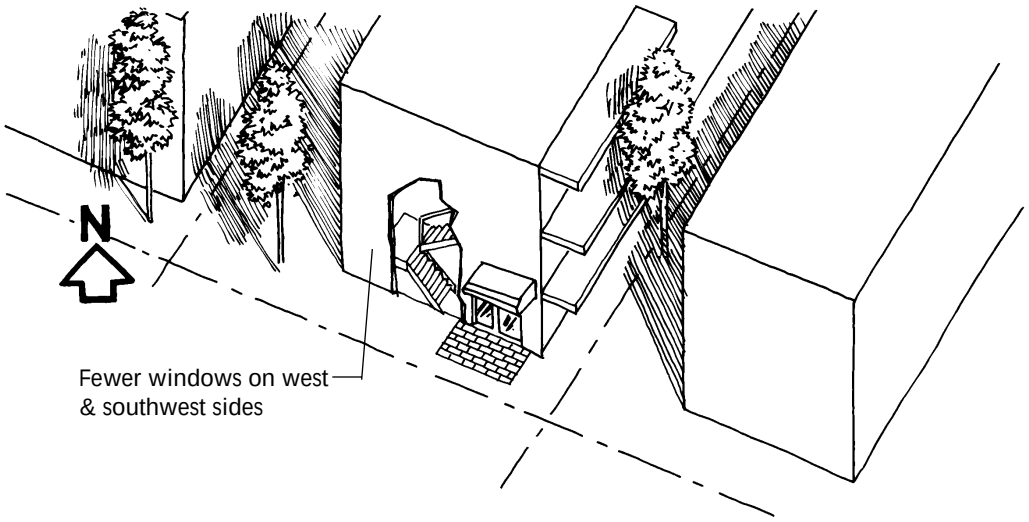


Flow-through ventilation

Single-sided ventilation

LOCATE & ORIENT THE BUILDING TO CONTROL SOLAR COOLING LOADS

SF2



Locate building requiring cooling in shade of other buildings

In Santa Monica, electric lighting and mechanical air-conditioning for cooling are the largest energy consumers in commercial buildings with high internal loads. Where site conditions permit, landscaping or other shade structures to reduce the amount of sun on the building is the most effective method of solar control. Peak solar cooling loads are greatest through southwest- and west-facing windows and walls; solar loads from windows and walls facing other directions are smaller and easier to control. It is important to evaluate the shading opportunities of existing and future buildings on neighboring lots.

Where site conditions permit:

- Locate the building toward the southwest, south, or west sides of the site to provide shade for lower floors from neighboring buildings.
- Orient the building with the short wall facing west or southwest for the least solar gain in the summer.
- Place service cores or opaque stairwells at the southwest or west ends to buffer interior spaces from afternoon solar gain.

Cautions

- Optimal location and orientation are difficult on many Santa Monica sites because of lot shape, size, the location of other buildings and orientation of the street grid.
- Shading the building for less solar heat gain must be weighed against potential benefits of using controlled sunlighting with light shelves, natural ventilation and solar energy collection.

Environment 444

Reduced cooling loads, energy use and air pollution.

Ease of Use 4

Site and context dependent. Limited opportunities on constricted sites.

Other Benefits 44

Increased thermal and visual comfort.

Capital Cost $

Context dependent. Changes in orientation or location may not increase cost. Reduced cooling loads result in reduced need for mechanical cooling and smaller air-conditioning equipment.

Further Information

- Brown, G.Z.1985
- Crowther, R.L. 1992

Linked Practices

EN1
EN2
EN4
EN5
SF5
LA1
LA2

SF3

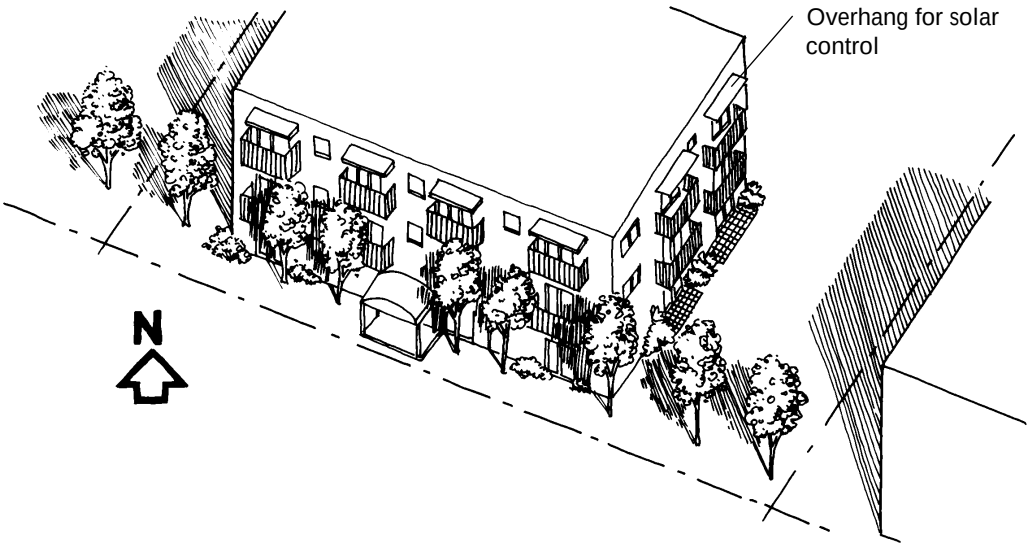
LOCATE & ORIENT BUILDINGS FOR PASSIVE SOLAR HEAT IN WINTER

Environment 444
Reduced heating loads, energy use and air pollution.

Ease of Use 4
Site and context dependent. Limited opportunities on constricted sites.

Other Benefits 44
Increased thermal comfort.

Capital Cost $
Context dependent. Changes in orientation or location may not increase cost. Reduced heating loads lead to reduced need for heating equipment.



Locate buildings requiring heating for exposure to sun

Although reducing cooling and electric lighting use are major concerns in Santa Monica, passive solar heating can be an effective strategy in many types of buildings, especially residential, hotels and others with low internal cooling loads. The high percentage of clear skies during winter allows the use of sunlight to reduce or even eliminate the need for supplemental heating.

Direct gain through south-facing windows, clerestory windows and roof monitors is the most common method of passive solar heating. These should have access to direct sunlight between 10 am and 2 pm from November to March and should be equipped with control devices to avoid overheating at other times.

Where site conditions permit:

- Locate the building toward the north and east parts of the site for greatest wall and roof exposure.
- Orient the building with the long side east-west for highest winter gains and lowest summer gains. Southeast or southwest orientation can capitalize on morning or afternoon solar gains respectively without major losses in performance.

Carefully analyze the building program to identify spaces and activities that benefit from passive solar heating. Locate spaces that require heating where they have direct access to winter sun and spaces that require cooling to face north or east.

Further Information

- Heschong, L. 1996
- Mazria, E. 979

Linked Practices

EN1
EN2
EN4
EN5
SF6
LA1
LA2

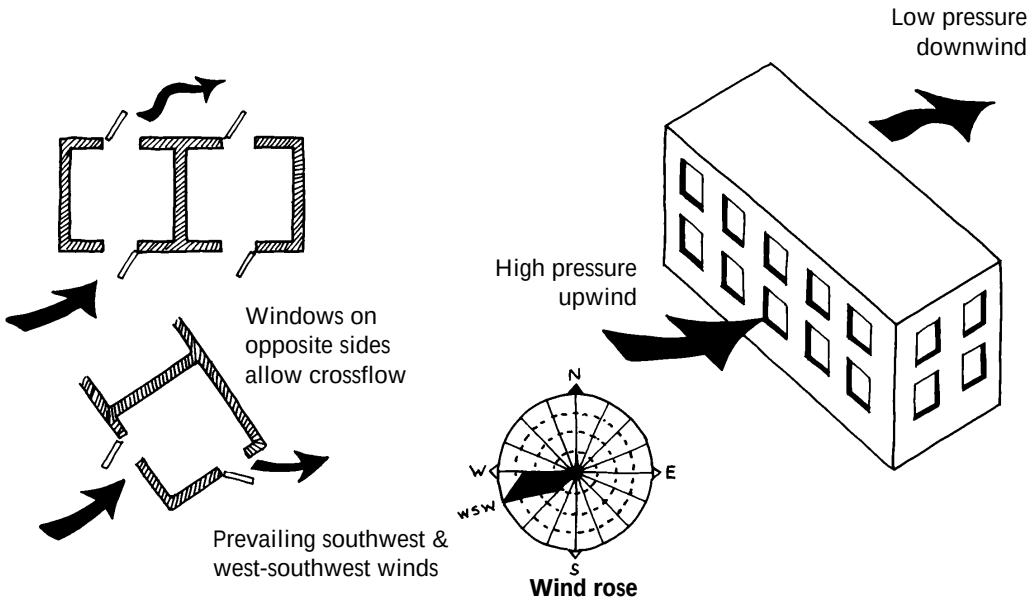
Use a sunpath diagram and shading masks, or simulation to assess potential shading on roof areas and vertical southeast, south and southwest facing surfaces.

Cautions

- Constrained urban sites make it more difficult to optimally locate buildings, and require greater care in building envelope design.
- Locating building at the northern edge of the site may require shaping/stepping the building to minimize shading of neighboring properties.
- Building form and orientation only establish the potential exposure to the sun. The area and location of windows must also be carefully planned.

SF4

SHAPE & ORIENT THE BUILDING FOR EXPOSURE TO PREVAILING WINDS



Two principles must be considered when planning to use natural ventilation as the primary means of cooling buildings:

- Wind induces high pressures on upwind faces, and low pressures on downwind faces; and
- Hot air rises due to buoyancy, or "stack effect" (see SF5).

Although wind-induced natural ventilation is typically the most powerful, the best effects are created by using the two in combination.

Wind-induced natural ventilation depends on pressure differences between air inlets and outlets, and especially on the strength and direction of the prevailing wind. Santa Monica has an excellent wind resource for natural cooling, with moderate on-shore breezes consistently coming from the west-southwest and the west.

To take advantage of pressure differences created by wind, air inlets should be placed in high-pressure areas that face upwind. Outlets should be placed in downwind, low-pressure areas. Precise orientation to the wind is not critical; even walls angled up to 30° to the wind create enough pressure to be useful for natural cooling. (See EN4 for details).

Use irregular, articulated building footprints to increase the exposure of walls to low- and high-pressure areas. This provides more opportunities to catch the wind from different directions in each space, and to cool and ventilate more interior spaces independently. Low- and high-

Environment 444

Reduced cooling loads and less dependence on mechanical ventilation.

Ease of Use 4

Context dependent. May not be possible on many Santa Monica sites. Requires greater collaboration among design consultants. Airflows and effectiveness require specialist analysis for complex buildings.

Other Benefits 444

Operable windows provide occupants with greater sense of control over indoor conditions.

Capital Cost $

Context dependent. Initial cost should not significantly increase on sites where choice of orientation is possible. Potential reduction in HVAC equipment size.

Further Information

- Allard, F. 1998
- Baker, N. et al 1993
- Givoni, B. 1991

Linked Practices

SF5
EN4
EN5
EN6
LA1
LA2

pressure areas can be created with articulations of the walls and roofs, using features such as bay windows, recesses and projections, roof monitors and clerestories. These shapes can allow designers to cross-ventilate even spaces with only one exterior wall.

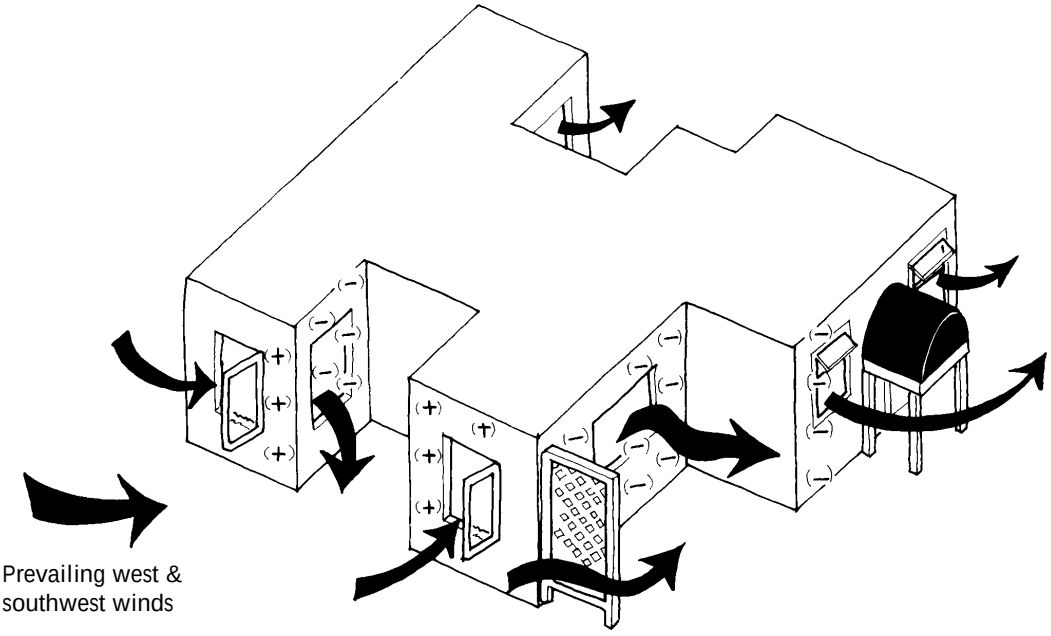
• If the shape and size of the lot allows it, orient the long face of the building southwest to create the greatest pressure difference between the windward and lee faces. This can allow cross-ventilation across the full depth of the building.

• Most lots in Santa Monica dictate that the long elevation of the building will face southeast, limiting the potential for cross-ventilation across the building. In these cases, use fins, recesses and projections along walls that face northwest and southeast. These irregularities create pressure differences along the elevation that can induce airflow into and out of correctly placed openings.

Cautions

• Effectiveness depends on the configuration of upwind obstructions.

• Orienting to the wind and increasing exposed wall and roof area also improves the potential for daylighting and view, but may increase solar gain. (See SF2).



Articulated walls create low & high pressure areas & allow crossflow

SF5

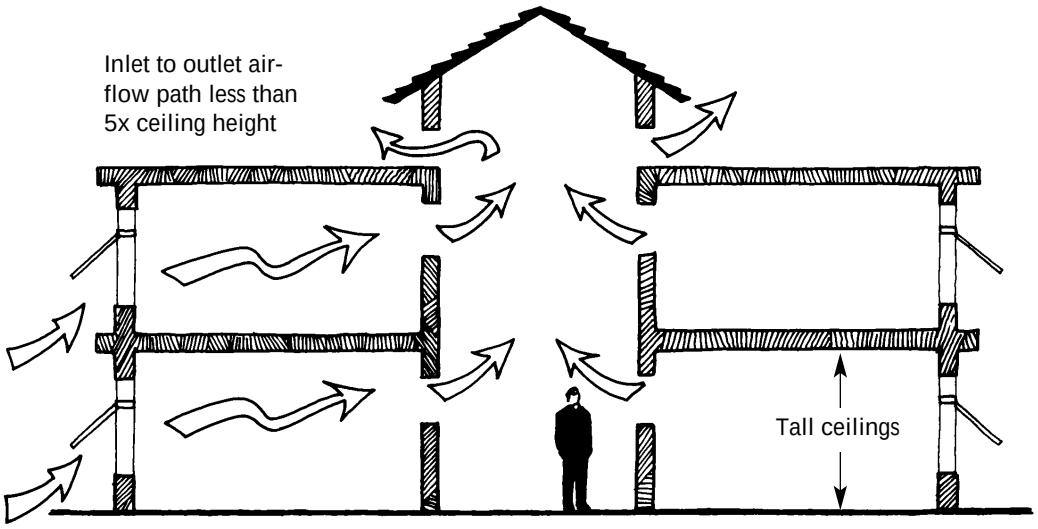
SHAPE THE BUILDING TO INDUCE BUOYANCY AIRFLOW INTO & OUT OF INTERIOR SPACES

Environment 444
Reduced peak electrical demand and annual cooling energy requirements.

Ease of Use 4
Requires greater collaboration among design consultants. Airflows and effectiveness require specialist analysis for complex buildings.

Other Benefits 444
Operable windows provide occupants with greater sense of control over indoor environmental conditions.

Capital Cost $$
Increased cost of shaping the building and including dedicated ventilation shafts may be offset by reduction in HVAC capacity.



Atria & roof monitors promote buoyancy airflow

Buoyancy, or "stack effect," can induce natural cooling and ventilation within a building, though typically it creates lower pressure differences than wind. Columns of warm air rise, and if allowed to exit from the top of a space, will draw air in at lower levels. Stack ventilation is especially useful for deep core spaces, spaces with only one exposed side, and with atria and courtyard designs.

Pressure differences due to buoyancy are directly proportional to both height and the temperature difference between incoming and outgoing air. As a result, there are two ways to increase buoyancy-driven flow: increasing the height of spaces, and heating air within the building.

In general, natural cooling should be examined on a whole-building basis to ensure airflow paths into, through and out of occupied zones and spaces, and to ensure safety in the event of fire. Room-by-room analysis is helpful when placing windows and openings, and to help place interior partitions.

- Use roof monitors, atria or tall chimneys to increase stack height, and thus buoyancy pressure differences. These features can be placed at the center of a building, creating cross-flows from the sides of the building; or at one end of the building, creating cross-flow from one side to the other.
- Limit the maximum depth of spaces from the air inlet to the stack outlet to less than five times the ceiling height (~45 to 50 ft.).

Further Information

- Allard, F. 1998
- Brown, G.Z. 1985
- CIBSE, 1997
- Daniels, K. 1997

Linked Practices

EN4
EN5
EN6
SF4
LA1
LA2

Examine possible ways of reinforcing the stack effect by installing:

• outlets in negative pressure areas due to winds. Outlets should be placed downwind of prevailing breezes to avoid overwhelming the stack effect, i.e., on east and south-east orientations.

• solar chimneys, where sunlight at high levels heats outgoing air above the occupied volume.

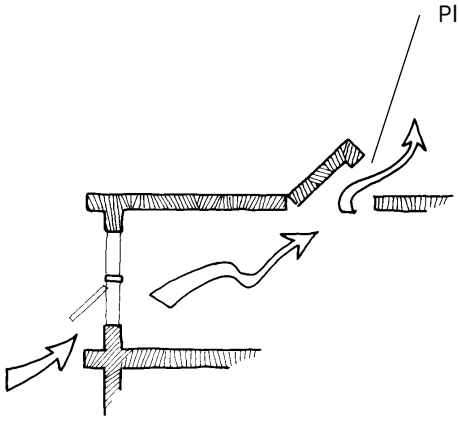
Cautions

• Airflow should be examined at low, mid and high heights within the building to ensure adequate ventilation under a variety of wind conditions.

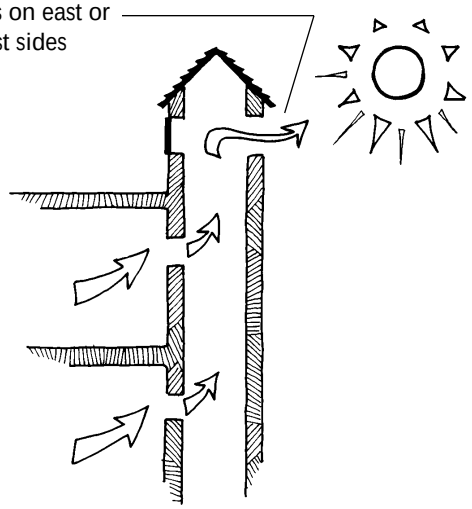
• Interior spaces should be arranged to ensure that dead-air pockets in occupied zones do not occur.

• Ventilation openings must be carefully sized, with smaller openings at lower floors, and larger openings at higher floors to provide equal ventilation rates.

• Smoke & fire implications of natural ventilation strategies must be carefully considered.



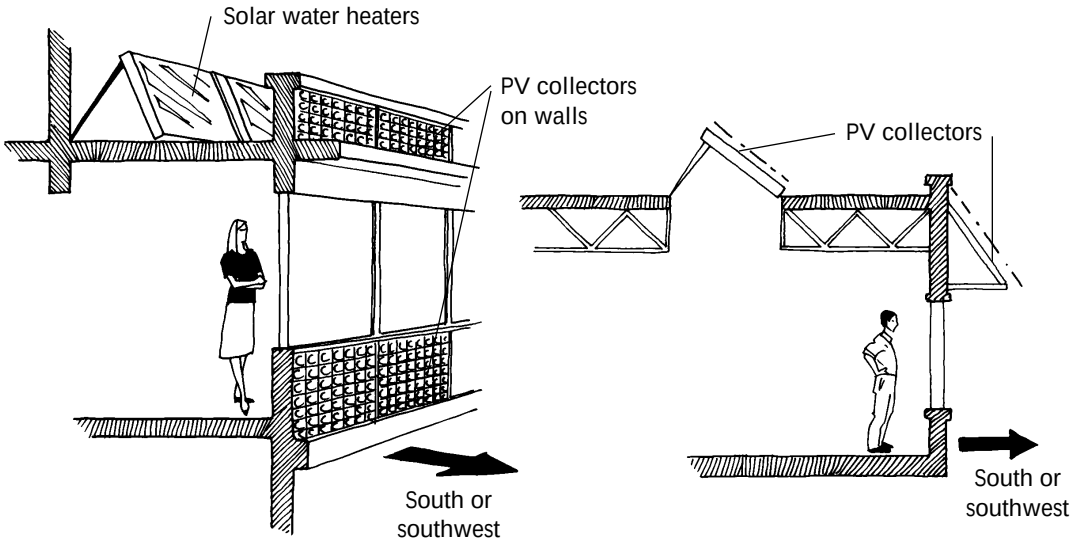
Roof monitor for outlet



Ventilation chimney for outlet

SF6

SHAPE THE BUILDING FOR SOLAR ENERGY COLLECTION



Environment 444
Potential for significant reductions in electrical and water heating costs.

Ease of Use 4
Close coordination is required among design consultants. Project managers should consider retaining a specialist in solar applications.

Other Benefits 44
Can be a marketing bonus.

Capital Cost $$
Varies with system type, and whether collectors are integrated into building envelope assemblies. PV costs are rapidly dropping; while currently expensive, costs are likely to be competitive in near future.

Solar energy collection systems transform buildings from energy consumers to energy producers.

Considering solar access when designing roofs, walls, windows and external shading devices intended for solar collection offers the best economics and esthetics. For the least collector area and lowest cost, building elements should be arranged to optimize tilt and orientation to the sun. If this is not possible, collector areas should be adjusted accordingly, and mounts designed with appearance in mind.

Traditional solar hot water and photovoltaic (PV) collectors are typically rectangular and designed for rack mounting. However, new PV products designed to be incorporated into wall and roof assemblies are now available:

- "solar shingles";
- panels designed to integrate into curtain walls; and
- etching techniques designed to be used as sunshades, with the designers' choice of shading factor.

Since these are intended to replace conventional weather surfaces, they can be more economical.

Collectors operate best with unobstructed access to the sun. Shading studies of the building are essential to ensure solar collection potential. Roof-mounted collectors are easiest to tilt optimally and are less likely to be shaded than collectors mounted on walls, though locations towards the top of walls can help.

Further Information

- Duffie, J.A. & Beckman,W.A. 1980
- Crowther, R.L.1992
- Daniels, K. 1997
- Mazria, E. 1979

Linked Practices

ES7
WSc
WS6

For maximum solar energy potential, collectors should:

- face south or, better, southwest; and
- be tilted at 34° from the horizontal (Santa Monica's latitude).

Orientation and tilt are forgiving; annual energy performance drops ~15% for collectors oriented up to 45° from due south; and by less than 10% if collectors are tilted 15° from the latitude angle, i.e., between 19° and 49°.

A rough rule of thumb will help designers in allocating solar water collector area during conceptual design: 1 sq.ft. of flat plate collector area with optimal slope and tilt provides slightly less than 1 U.S. gallon of hot water per day, on average over the year. (Collector area should be confirmed before finalizing form decisions, since performance will vary with the collectors selected.)

Areas required for solar electricity are typically much larger than for solar hot water. Currently available PV panels are unlikely to satisfy a building's total electricity consumption without covering the roof and all non-north elevations with panels and implementing extraordinary electricity conservation.

For PV collectors placed on walls, a narrow building oriented on a north-south axis with the majority of the panels on east and west walls generates the most power, especially in summer. East-west plans generate approximately 88% of the optimum; square plans approximately 75% relatively consistently throughout the year.

Tilting south-facing walls increases both the collection area exposed to the sun and annual electrical energy generated. A 20° tilt from vertical produces a 21% increase; 30° increases generation by 46%.

Cautions

- The best building forms for solar energy collection differ from those for controlling solar cooling loads.
- Integrating solar collection into building exteriors requires careful detailing, coordination between designers, site review and commissioning.
- Solar collectors require access for periodic cleaning for the best performance.

FURTHER INFORMATION

Allard, F. (ed.) 1998. *Natural Ventilation in Buildings: A Design Handbook*. James & James, London.
Exhaustive coverage of the theory and practice of natural ventilation in buildings, providing the fundamentals, prediction and diagnostic techniques as well as design guidelines, technical solutions and case studies.

Ander, G. 1995. *Daylighting Performance and Design*. John Wiley & Sons, New York.
Excellent quick reference and guide for design professional, providing current data and tables applicable to daylight design California conditions.

Baker, N., A. Fanchiotti,, and K. Steemers. (eds). 1993. *Daylighting in Architecture, A European Reference Book*. Commission of the European Communities, Directorate-General XII for Science Research and Development, James & James, London..
Comprehensive guide on daylighting design concepts, strategies and technologies, illustrated with numerous examples and case-studies.

Brown, G.Z.1985. *Sun, Wind and Light: Architectural Design Strategies*. John Wiley & Sons, New York.
Good introduction to form-generating potential of sun, wind and light in the earliest stages of building design with emphasis on reducing energy use. Covers design strategies, analysis techniques and strategies for supplementing passive systems.

CIBSE Project Task Group. 1997. *CIBSE Design and Applications Manual: Natural Ventilation in Non-Domestic Buildings*. Chartered Institute of Building Services Engineer (CIBSE), London.
Invaluable applications manual to enable design professionals to build an understanding of natural ventilation. Excellent overview of strategies, rules of thumb, detailed calculation methods and a range of European case-study buildings.

Crowther, R. L. 1992. *Ecological Architecture*. Butterworth Architecture, Boston.
Primer on ecological design, emphasizing the importance of holistic building design and its integration with natural systems. Case-studies by author and design guidelines for design, landscaping and planning.

Daniels, K. 1997. *The Technology of Ecological Building: Basic Principles and Measures, Examples and Ideas*. Trans. Elizabeth Schwage. Birkhauser, Boston.
Useful introduction to the technology of ecological building, offering detailed analysis of numerous European environmental case-study projects and emerging technologies.

Duffie, J.A., and Beckman, W.A.1980. *Solar Engineering of Thermal Processes*. John Wiley & Sons, New York.
Classic and fundamental text on solar thermal engineering. Emphasis on procedures and data for calculating solar resources and solar systems design that has direct application to photovoltaic applications.

Givoni, B., 1994. *Passive and Low Energy Cooling of Buildings*. Van Nostrand Reinhold, US.
Comprehensive coverage of passive and low energy cooling strategies for buildings with hot summers. Deals with both technical principles and practical guidance.

Heschong, L., 1996. *Renewable Energy, Chapter II: Sustainable Building Technical Manual* Public Technologies Inc., Washington DC.
Like the other section of the Sustainable Building Technical Manual, this offer concise, valuable overview of the topic. Chapter highlights design considerations for passive solar heating, cooling and thermal storage as well as active systems.

Lam, W., M.C., 1977. *Perception and Lighting as Formgivers for Architecture*. Van McGraw-Hill, New York.
Examines the nature of human needs and environmental objectives. It emphasizes how the process of perception can direct good luminous environments and how to integrate electric light to reinforce architectural concepts. Numerous case-studies illustrate the concepts and principles.

Lam, W., M.C., 1986. *Sunlighting as Formgiver for Architecture*. Van Nostrand Reinhold, New York.
Comprehensive coverage of the techniques for using natural lighting in buildings for energy savings and enhanced indoor lighting quality. Numerous case-studies illustrate the 'sunlighting' concepts and strategies.

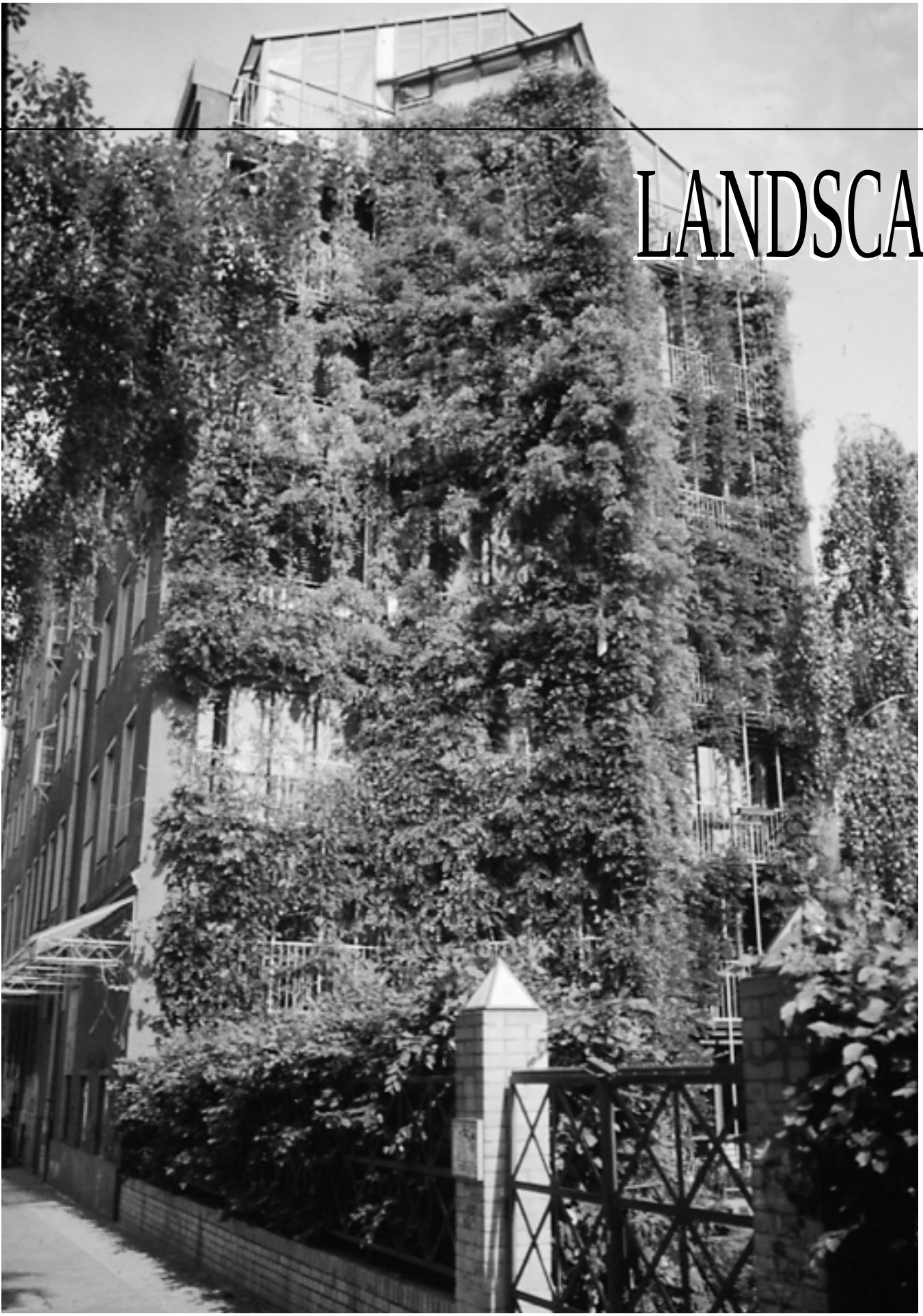
Mazria, E., 1979. *The Passive Solar Energy Book - Expanded Professional Edition*. Rodale Press, Emmaus, PA.
Clearly illustrated primer and resource on fundamental concepts, principles and strategies for passive solar design. Offers step by step process for designing and sizing passive solar buildings.

Richman, T., et al 1997. *Start at the Source: Residential Site Planning and Design Guidelines: Manual for Stormwater Quality Protection*, Bay Area Stormwater Management Agencies (San Francisco)
Brief, information-dense design guide to stormwater runoff reduction and treatment, oriented toward biological and landscaping methods. Many illustrations and diagrams.

Southern California Gas Company., (1995) *Daylight Harvesting* (Energy Resource Centre, 9240 East Firestone Boulevard, Downey, CA, 90241-5388, 800-427-6584)
Introductory primer providing brief descriptions of daylighting strategies and potential energy benefits of using daylight in Southern California.

Watson, D. and K. Labs 1983. *Climactic Building Design: Energy Efficient Building Principles and Practices*, McGraw-Hill Book Co., New York.
Useful introductory text illustrating ways to evaluate local climate and offering a wide range of building design strategies to take advantage of site environmental and climate conditions.

LANDSCAPING



LANDSCAPE

Lawns, ornamental shrubs and trees, often poorly adapted to difficult urban conditions, have for many years dominated urban landscape design. To survive, these landscapes require high levels of maintenance, irrigation, fertilizers, herbicides and pesticides. These not only increase the cost of ownership, but pollute stormwater runoff and provide little or no habitat for local wildlife.

Ecologically based landscape design can change this pattern. It considers a region's water flows, climate, open spaces, native vegetation, wildlife and existing urban development. Understanding the ecology of the region helps when working with the needs of a specific site design, including its solar access, wind patterns, topography, rainfall and drainage patterns, the preservation of existing vegetation and unique features of the site.

In recent years the City of Santa Monica has promoted a more environmentally responsive approach to landscape design, particularly in water conservation. Through the City requirement to use drought-resistant plants, restrict the amount of lawn and the use of efficient irrigation systems, water consumption has dropped significantly.

The Required Practices focus on landscape design that conserves water and improves water quality. Outdoor water use accounts for approximately 35% of overall water consumption in Greater Los Angeles, of which half is used to irrigate gardens and landscaping. Planting drought-tolerant vegetation, minimizing lawn areas and using drip irrigation can reduce water use in the garden by 50% to 70% and overall water consumption by 20% to 25%. By managing stormwater runoff through on-site surface water retention and reducing the area of impermeable paving, fewer pollutants enter Santa Monica Bay.

The Recommended Practices address a broader range of environmental benefits gained through landscape design. These include improving the microclimate around buildings to reduce cooling energy consumption and improve occupant comfort, reducing glare, enhancing the appeal of exterior spaces, providing habitat for urban wildlife and creating opportunities for local food production.

Controlling Solar Gain and Improving Ventilation

Controlling solar gain in a building through planting on south, southwest and southeast sides of buildings is a very effective way to reduce cooling loads. In Santa Monica, where southwest-oriented building facades have the greatest solar heat gain, planting shade trees regulates heat gain and reduces air-conditioning needs. Trees and other vegetation can also shade paved areas and provide a canopy for pedestrians.

In addition to controlling solar gain, landscaping and landscape structures can enhance a building's natural ventilation and cooling by influencing wind flow. This requires the landscape design to respond to prevailing wind patterns and local wind flow variations, and strategically locating trees, hedges and shrubs to direct winds toward ventilation inlets and create low-pressure areas at outlets. Dissipating turbulent, higher velocity winds in circulation areas around buildings can also be achieved by placing a multi-layered planting of large trees and shrubs with dense foliage at the base and corners of buildings.

Air Quality and Wildlife Habitat

Ecologically based landscape design can improve local air quality by absorbing carbon dioxide, producing oxygen and filtering particulates. Landscaped parks and streets provide a "green lung" for the

community. Building roofs and balconies can be deliberately designed to accommodate vegetation. Conventional roofs degrade air quality by replacing a site's original vegetative cover with an impervious surface that absorbs solar energy and contributes to the urban heat island effect. Planted roofs provide a living surface that cools and insulates the building, improves air quality and protects roof membranes from ultraviolet breakdown.

Landscape design can create important habitat for resident and migratory wildlife by providing food and shelter. Through mulching and composting green matter, ecologically-based landscaping can maintain and improve soil fertility, retain soil moisture, stimulate soil-based microbial activity and maintain the cycle of nutrients in the soil. In addition, the use of native and other ecologically appropriate plants reduces water consumption, maintenance requirements, and the use of pesticides and herbicides, and increases the area's suitability for wildlife.

Health Benefits of Ecological Landscaping

Finally, environmentally based landscape design practices can have direct financial and human health benefits. Capital and annual utility costs and regular maintenance requirements can be reduced, resulting in lower overall operating costs. Incorporating areas to grow food within developments encourages local food production and reduces monthly food expenses. It can provide occupants with a secure source of organically grown, fresh produce. Opportunities to garden provide personal health benefits that can improve the quality of life, particularly for older people with leisure time to enjoy gardening.

LANDSCAPE PRACTICES SUMMARY TABLE

Required Practices

	Ordinance	Subtitle
LAa	SMMC 7.10.060	Minimize Stormwater Runoff to Impermeable Areas
LAb	SMMC 9.04.10.04.110	Specify & Install Water-Efficient Irrigation Systems
LAc	SMMC 9.04.10.04.110	Restrict the Use of Water Features & Fountains

Recommended Practices	Environmental	Ease of Use	Benefits	Capital Cost
LA1 Locate Landscaping & Landscape Structures to Shade Buildings	✔✔	✔✔✔	✔✔✔	**$**
LA2 Use Landscape Design to Modify Wind Patterns & Enhance Building Ventilation	✔✔	✔✔✔	✔✔	**$**
LA3 Apply Environmental Landscape Design Principles	✔✔✔	✔✔✔	✔✔	**$**
LA4 Incorporate Areas for Urban Agriculture & Rooftop/Balcony Gardens	✔✔✔	✔✔	✔✔	**$$**
LA5 Provide Shelter & Habitat for Urban Wildlife Through Landscape Design	✔✔✔	✔✔✔	✔✔	**$**
LA6 Provide On-Site Composting Facilities	✔✔	✔✔	✔✔✔	**$**
LA7 Use Recycled Landscape Products & Materials	✔✔	✔✔✔	✔✔✔	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.
Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

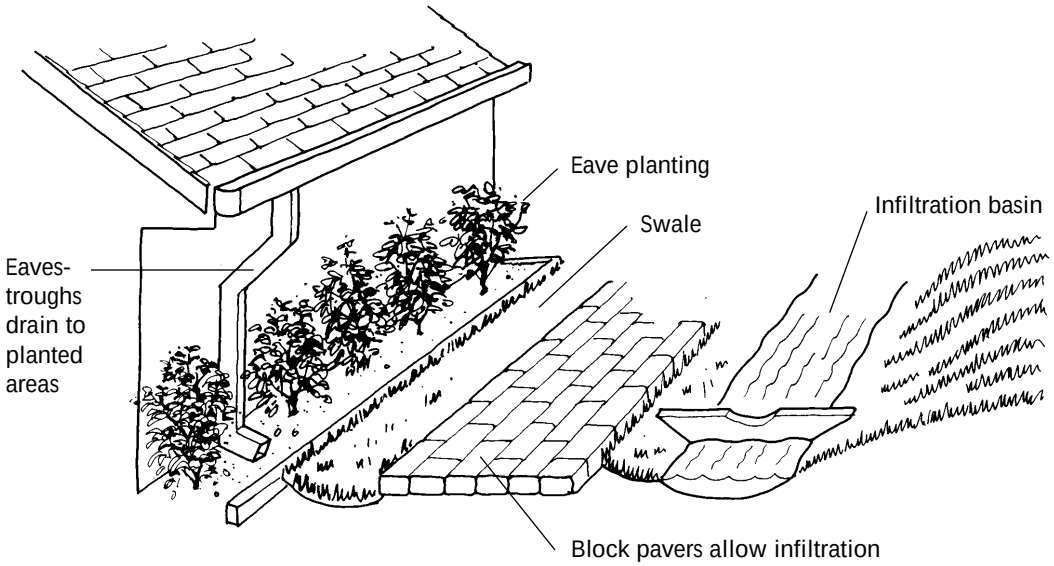
Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

MINIMIZE STORMWATER RUNOFF TO IMPERMEABLE AREAS

LAa

REQUIRED PRACTICE

SMMC 7.10.060



By diverting stormwater from impervious areas such as roofs and paths, and by reusing it whenever possible, urban runoff can be greatly reduced. This can be achieved by directing rain gutters to landscaped areas, drywells and infiltration basins where water can seep into the ground.

Placing landscaped areas directly below eaves allows roof runoff to percolate into the subsoil. Plants should be sturdy enough and provide a subsurface matrix of roots to tolerate heavy sheet flow runoff and periodic saturation.

Landscaped infiltration basins for stormwater retention should have flow directed toward them with curbs, berm, or similar structures, and slightly concave to retain surface water until it infiltrates.

Drywells (also known as "French drains") are particularly valuable for small sites, since they can supplement limited infiltration areas. These consist of a hole filled with open-graded aggregate, such as #2 or 3 stone, wrapped on the top and sides with filter fabric. Drywells should be at least 15 ft. from building foundations at the bottom of sloped landscaped areas, covered with at least 1 ft. of soil.

Manufactured sediment traps are available that intercept runoff from drainage areas, and slowly release it while trapping sediments.

Cautions

- A soils engineer should be consulted for soil suitability, and to size drywells.

Further Information

- SMMC 7.10.060
- SMMC 5.20.080
- Richman, T. & Associates, et al 1997

Linked Practices

SFa
TRa
TR1
WS3
CMd

Environment ✔✔✔

Very effective for reducing stormwater runoff pollution.

Ease of Use ✔✔✔

Very simple design measures can make a dramatic impact.

Other Benefits ✔

Capital Cost $

Very low capital cost.

LAb

REQUIRED PRACTICE
SMMC 9.04.10.04.110

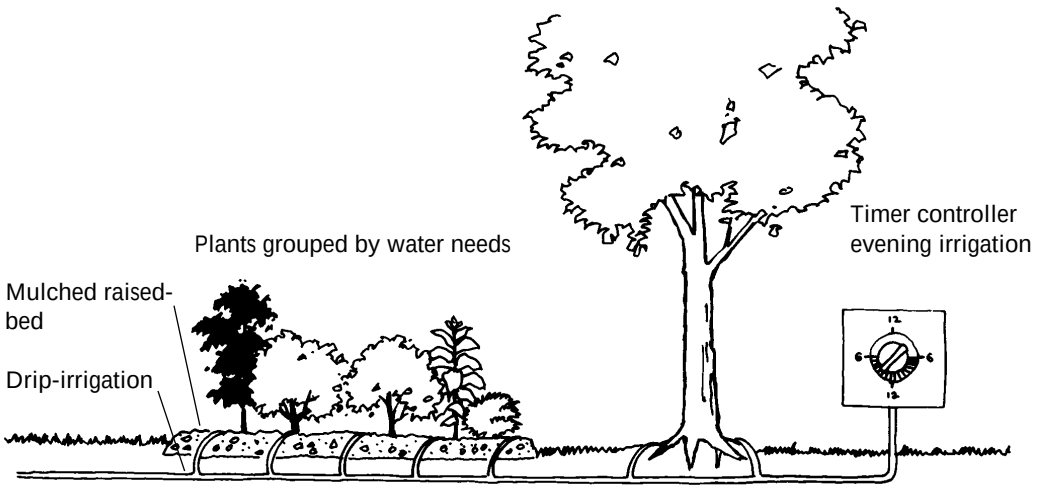
Environment ✔✔✔
Lowers garden water consumption dramatically.

Ease of Use ✔✔
Requires regular monitoring to ensure system is operating properly.

Other Benefits ✔✔
Plants grow better with drip irrigation. Reduces water costs.

Capital Cost $
Costs are competitive with conventional irrigation systems.

SPECIFY & INSTALL WATER-EFFICIENT IRRIGATION SYSTEMS



Water-efficient irrigation

Appropriate planting and efficient irrigation systems can reduce irrigation water use by 50% to 70% and overall water consumption by up to 25%.

- Group plants with similar water requirements on common zones to match precipitation heads and emitters.
- Use drip irrigation for trees, shrub beds and areas of groundcover to eliminate evaporation losses.
- Choose low-volume, low-angle sprinklers for lawn areas.
- Select heads that fit the size and shape of the areas to be watered.
- Program automatic controllers for night irrigation to reduce losses due to evaporation and wind drift.
- Select controllers with adjustable watering schedules and moisture sensors to account for seasonal variations, and calibrate them during commissioning.
- Where possible, use graywater for irrigation. Use barrels at the bottom of rainwater leaders for manual irrigation of trees and shrubs.
- Place 3 to 5 in. of mulch on planting beds each spring to minimize evaporation.

Cautions

- Ensure compost and mulch are regularly added to soil to enhance moisture retention.
- Limit lawn areas and select appropriate plants for site and climatic conditions.

Further Information

- SMMC 9.04.10.04.110
- Kourik, R. 1992
- Netafim Irrigation Inc.1998

Linked Practices

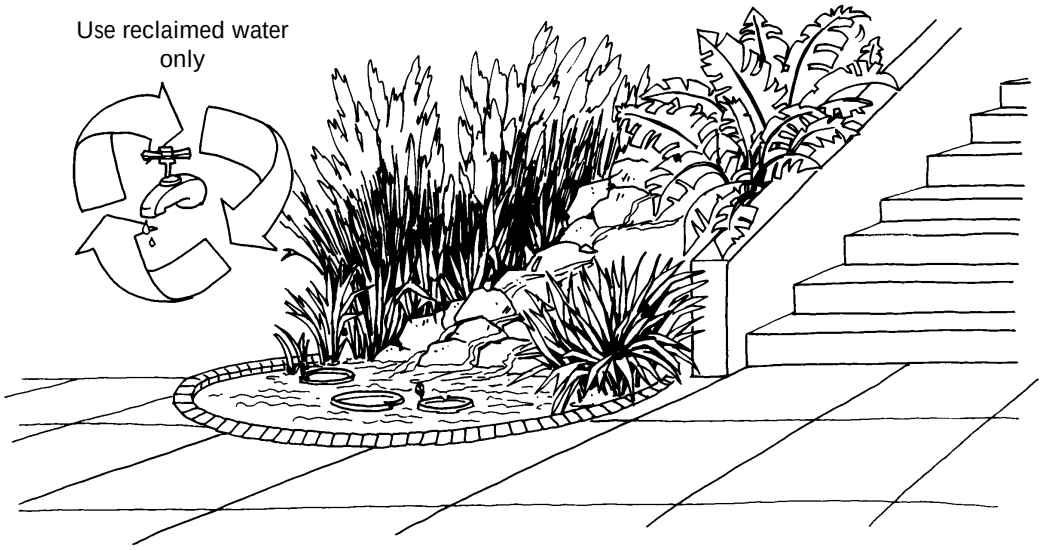
LA4
WS2
WS3

RESTRICT THE USE OF WATER FEATURES & FOUNTAINS

LAc

REQUIRED PRACTICE

SMMC 9.04.10.04.110



Environment Water-	✔
Ease of Use Water-	✔
Other Benefits Water-	✔
Capital Cost Water-	$

To be provided by City of Santa Monica

Further Information

- SMMC 9.04.10.04.110

Linked Practices

LA1

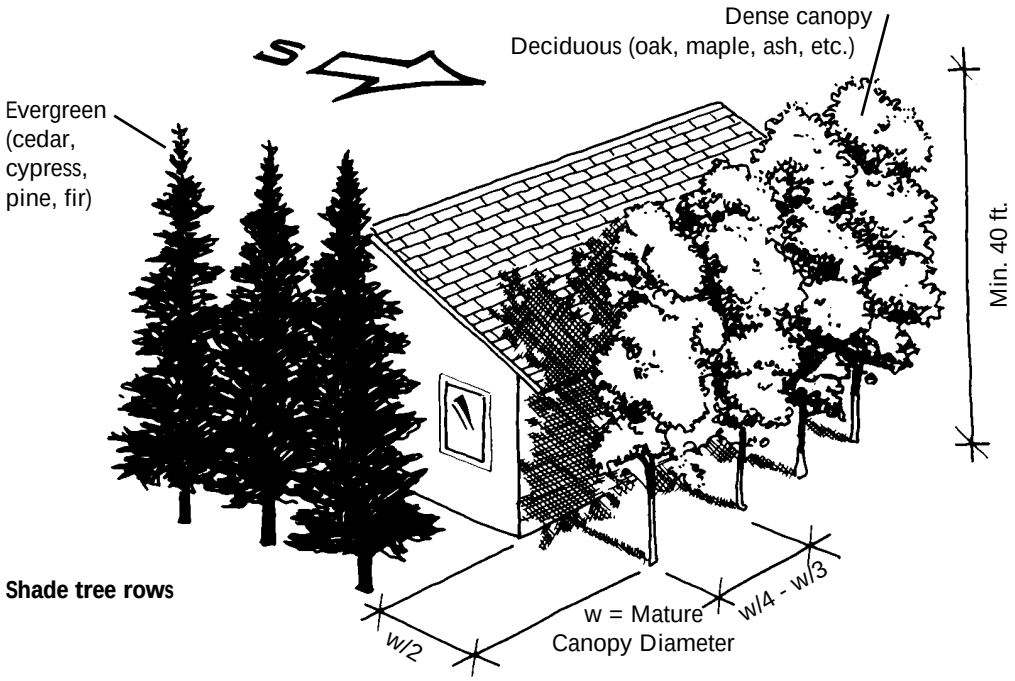
LOCATE LANDSCAPING & LANDSCAPE STRUCTURES TO SHADE BUILDINGS

Environment ✔✔
Reduces solar heat gain, energy consumption and pollution, and improves air quality.

Ease of Use ✔✔✔
Once established, landscaping provides passive, low-maintenance cooling.

Other Benefits ✔✔✔
Increases amenity for occupants and value of property.

Capital Cost $
Similar to conventional landscaping, with possible increased cost for additional shade plants.



Shade tree rows

For buildings with high cooling loads, landscaping can reduce solar heat gain, cooling energy and increase the attractiveness of outdoor spaces. Plants can reduce ambient air temperatures by up to 10°F and surface temperatures by 20°F.

- Plant trees with dense canopies and mature height of 40 ft. next to east and west building facades to shade windows and walls from low-angle sun.
- Plant trees with higher deciduous canopies along south and southwest sides of buildings, to provide summer shade while maintaining solar access in winter.
- Plant trees approximately half the width of the tree's mature canopy from the building and spaced at 1/4 to 1/3 the canopy width.

For greater shading and cooling, plant a multi-layered composition of shrubs and small trees with a minimum height of 10 ft. and width of 4 ft. next to building facades.

Two further shading techniques are to:

- Place vine-supporting trellises with tight lathing above windows and doors facing south, southwest and southeast.
- Mount vertical vine lattices 12 to 36 in. away from walls, to create a shaded, cool air pocket.

Cautions

- Adequate quality and quantity of soil is required to allow plants to grow to mature size.
- Drip irrigation systems are needed for dry periods.

Further Information

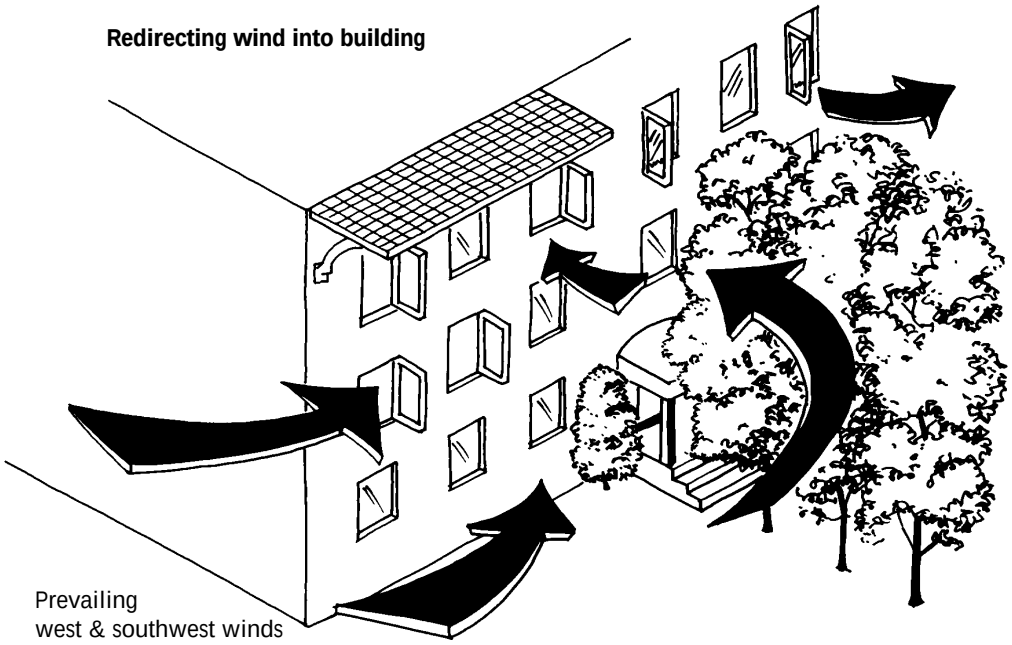
- Brown, R.D. & Gillespie, T.J., 1995
- Lam, W., 1986
- Lyle, J.T. 1994
- Marsh,W.M. 1991
- Moffat, A.S. & M. Schiler,1993

Linked Practices

EN1
EN2
SF2
SF3

USE LANDSCAPE DESIGN TO MODIFY WIND PATTERNS & ENHANCE BUILDING VENTILATION

LA2



There are two general categories of wind modification to enhance natural ventilation:

- Microclimate modification deflects local wind flow toward or away from building inlets and outlets through strategically placed vegetation and landscape structures, such as trellises and fences.
- Windbreaks moderate wind flows on a neighborhood or site scale. Trees are planted close together, across the path of prevailing winds to redirect and slow the wind.

Microclimate Modifications

To capture and direct airflow into a building, plant trees and shrubs with dense foliage adjacent to a building, immediately downwind of or above air inlets. Trellises with tightly spaced lathing can also be located to create a high-pressure area at inlets, enhancing inward flow.

Where ventilation outlets are located on the side of a building relative to the prevailing wind, plant trees and shrubs immediately upwind of air outlets to create a low-pressure area, enhancing outward flow.

Use a dense planting of trees, shrubs, and/or trellises with vines at the base of building facades to dissipate and redirect downdrafts away from building entrances, patios and sidewalks.

Dissipate high-velocity winds around the sides of buildings with multi-layered large trees and shrubs with dense foliage at building corners.

Further Information

- Allard, F. 1998
- Brown, G.Z., & Gillespie, T.J. 1985
- Brown, R. D., 1995
- Lyle, J.T., 1994

Linked Practices

SF3
SF4

Environment ✔✔

Assists in natural ventilation and cooling.

Ease of Use ✔✔✔

Low maintenance once established.

Other Benefits ✔✔

Trees and shrubs provide amenities for occupants and increase property value.

Capital Cost $

Similar to conventional landscape design.

LA2

Windbreaks

The effectiveness of a windbreak depends on its size, porosity, and orientation to prevailing winds. Windbreaks should be carefully considered in Santa Monica, since they can interfere with on-shore breezes, essential to natural cooling and ventilation strategies.

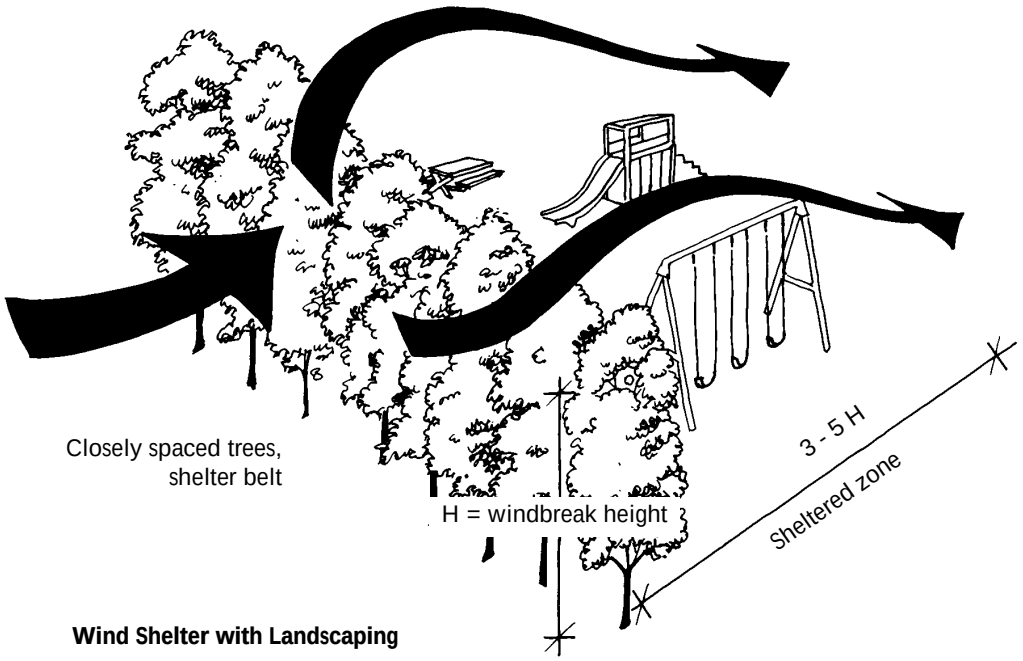
Where required, windbreaks should form a continuous barrier approximately 10 times longer than their proposed mature height. Their height should be ~15 ft. for every story of building height.

Windbreaks should be planted closer to the building than the mature height of the plants, respecting other site requirements. They should be oriented at angles to the prevailing wind to direct air toward inlets or away from outlets. When multiple windbreaks are used, consider planting in a funnel pattern to direct wind toward the building to increase wind flow where desired.

Windbreaks intended to dissipate wind for outdoor spaces should be set perpendicular to the prevailing winds. The depth of the protected area will be approximately five times the height of the windbreak. (A 10-ft. high hedge will effectively calm wind flow in the 50 ft. behind it). In this application the windbreak should allow 15% to 30% of the wind to pass through to minimize turbulence downwind.

Cautions

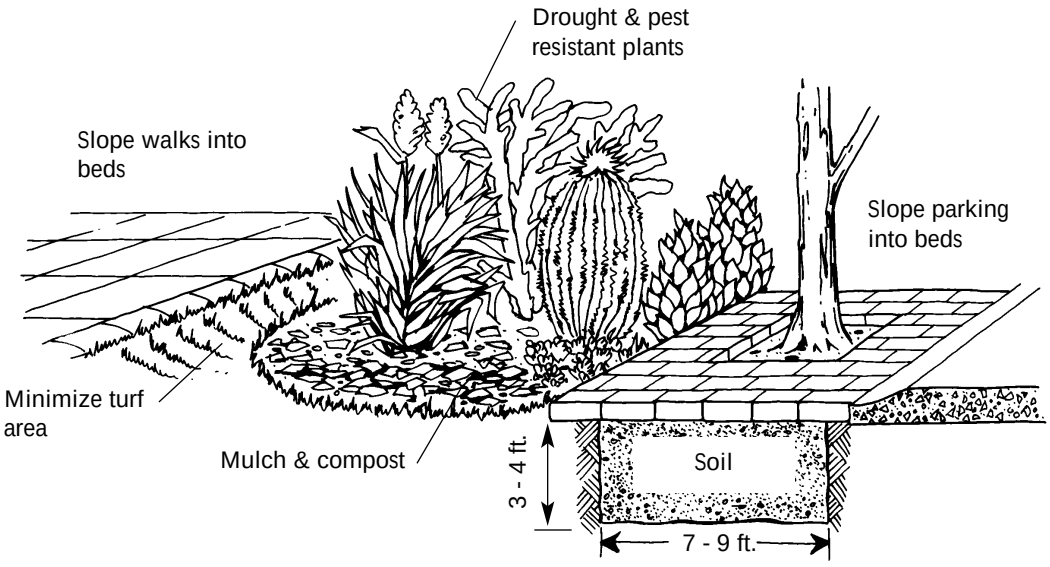
- Redirecting wind flow helps natural ventilation but is not a substitute for sensitive site planning and building orientation.
- Wind patterns in an urban context are complex and turbulent. Wind tunnel testing and computer models can help in planning effective wind modification.
- Both windbreaks and microclimate modifications require consideration at conceptual design to align proposed vegetation with air inlets and outlets.



Wind Shelter with Landscaping

APPLY ENVIRONMENTAL LANDSCAPE DESIGN PRINCIPLES

LA3



Environmental landscape design involves selecting slow-growing, drought-tolerant plants that require less water and maintenance, significantly reducing water consumption. Native California plants and well-adapted non-native plants can be combined in wildlife-friendly and visually attractive landscapes suited to difficult urban conditions.

Lawns require more water than other plants during dry periods and their use should be minimized. Currently the City of Santa Monica restricts lawn areas to a maximum of 20% of the landscaped area, but lower percentages are desirable. Drought-tolerant groundcovers should be considered as an alternative to lawn.

The following principles guide environmental landscape design.

1. Design the landscape based on a site's microclimate characteristics - exposure, wind, moisture, soil types and existing native vegetation. Southern exposures tend to be the hottest and driest, requiring the most drought-tolerant plant species. Northern exposures are cooler, require less water and offer more planting options. Exposed windy areas are drier than protected areas.

2. Test soils to determine their nutrient content, organic matter, and necessary soil amendments. Soils in urban environments commonly suffer from excessive compaction and depleted organic matter. To promote healthy plant growth, continuously mulch and compost whenever pos-

Environment ✔✔✔
Requires minimal water and provides wildlife habitat.

Ease of Use ✔✔✔
Low maintenance once established.

Other Benefits ✔✔
Enhances the diversity and attractiveness of the urban landscape.

Capital Cost $
Costs are competitive with or only slightly higher than conventional landscape design.

Further Information
- City of Fort Collins website, 1999
- City of Santa Barbara website, 1999
- Moffat, A.S. & M. Schiler, 1993
- U.S. Department of the Interior website, 1999

Linked Practices
LAb
LA4
LA5

LA3

sible. When planting in paved areas, provide a continuous soil trench with a minimum cross-sectional area of 3 sq. yd. to ensure an adequate volume of rooting medium.

3. A variety of drought-tolerant native and non-native trees, shrubs, groundcovers and perennials grow in the Santa Monica region. In most cases they can replace non-native ornamental plants to achieve the same objectives of color, texture, shade and seasonal interest. They have the added benefit of providing fruit and seeds for wildlife.

4. Add mulch and compost to soils at least once a year to continuously add nutrients to the soil. Mulching reduces water use by reducing evaporation and runoff by 75% to 90% over unmulched planting areas.

5. Install efficient drip irrigation systems that deliver water directly to the root zone in measured amounts to reduce water consumption by 50% to 70%. Use low-volume, low-angle, pop-up sprinkler heads for lawn areas. Use separate zones for lawn and planting areas to match watering requirements and provide longer duration watering cycles to encourage deeper rooting.

6. Utilize permeable paving and slope walkways toward landscaped areas wherever possible to encourage water infiltration and air exchange, and reduce the need for irrigation.

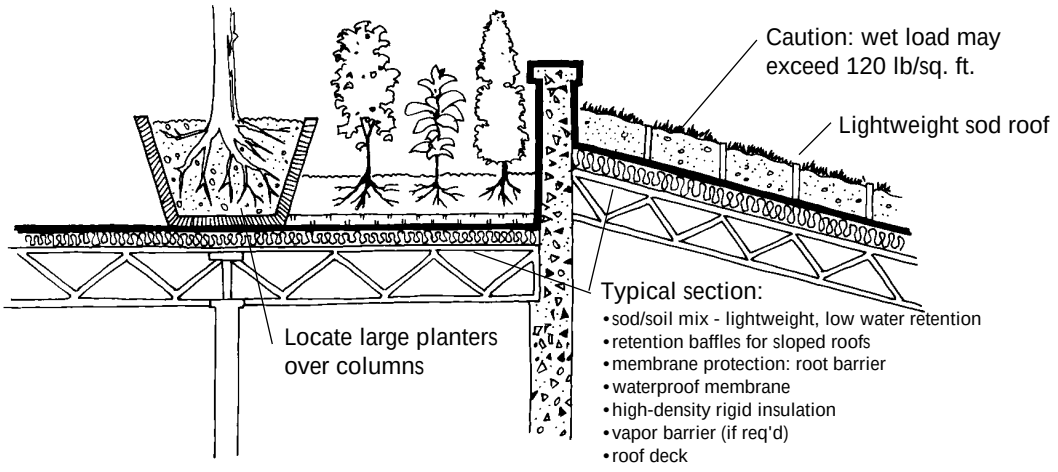
7. Avoid fertilizing and pruning during dry periods, as these activities stimulate vegetative growth and increase water needs.

Cautions

- Provide adequate quality and quantity of soil.
- Drip irrigation systems are essential for plants to become established.
- Expertise in environmental landscape design and maintenance is highly recommended.

INCORPORATE AREAS FOR URBAN AGRICULTURE & ROOFTOP / BALCONY GARDENS

LA4



Growing food in residential gardens provides locally grown produce that can reduce food expenses and the energy consumed in food transportation, and can enhance the quality of life for occupants. Using intensive gardening techniques, a 400 sq.ft. plot can provide one person with an annual supply of vegetables and fruit.

Gardens on balconies, terraces and roofs (which cover 25% to 100% of urban sites) can significantly enhance the city's environment, provide habitat for wildlife and opportunities for food and decorative gardens.

Moderately sloped and flat roofs can be planted with drought-tolerant perennial grasses and groundcovers that require minimal maintenance.

Recommended soil depths for landscaping are:

Groundcovers (including ornamental grasses) .....12 in.
Urban agriculture & flowers.....12 to 18 in.
Shrubs .....18 to 24 in.
Trees .....30 to 36 in.

• Dedicate areas for food production, including raised beds, in landscape designs.

• Include fruit- and nut-producing trees.

• Consider planters and roof vegetation in the structural design.

• To reduce structural requirements and costs, place planters over structural columns, walls and slab bands.

Cautions

• Soil depths, roof drainage and waterproof membranes must be considered during the structural design of buildings (wet weight of 1 cu. ft. of soil = ~120 lbs).

• Drip irrigation systems are essential for plants to become established.

Further Information

• Hough, M., 1995
• Jeavons, J. 1982
• Lyle, J.T. 1994

Linked Practices

LAb
LA5

Environment ✔✔✔

Provides local supply of food and reduces energy consumption associated with food transportation. Gardens and planters also filter local air pollutants, slow stormwater runoff, and provide urban wildlife habitat.

Ease of Use ✔✔

Gardens for food production require relatively intensive maintenance. Decorative gardens require limited maintenance once established.

Other Benefits ✔✔

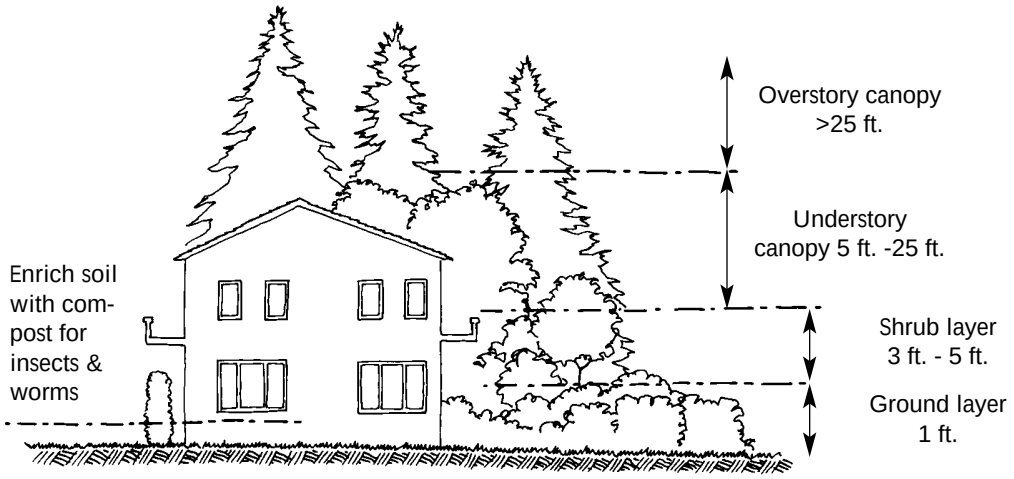
Provides opportunities for residents to garden and grow food.

Capital Cost $$

Structural considerations in the building may add to capital costs.

LA5

PROVIDE SHELTER & HABITAT FOR URBAN WILDLIFE THROUGH LANDSCAPE DESIGN



Landscape design can re-create habitat lost to urban development, and attract resident and migratory wildlife. In addition, connecting landscaping with neighborhood and regional open spaces creates a network of wildlife corridors. Design considerations include:

Food

- Select plants that produce native seeds, nuts and fruits for diverse food sources throughout the year.
- Ensure feeder siting is appropriate for desired birds. Check with local naturalists to determine species' requirements.
- Condition and/or amend soil through the regular addition of compost and mulch to sustain beneficial, soil-based insects and organisms.

Water

- Include bird baths for drinking and cleaning. Locate them in open areas and keep them shallow with gently sloping sides and rough surfaces for easy access and escape.

Cover and Shelter

- Combine plants to provide horizontal and vertical diversity, with upper-story tree canopies, middle-story shrubs and low groundcovers for refuge from predators and weather and nesting sites.
- Size and locate nest boxes for the requirements of desired birds. Hang boxes 5 ft. from tree limbs or in open areas on predator-proof metal or metal-clad wood posts.
- Design areas that can retain leaf litter, and fruit- and nut-drop to provide additional food and habitat, particularly for beneficial insects.

Cautions

- Encourage integrated pest management (IPM) practices to reduce pesticide, herbicide and chemical fertilizer use.
- Landscapes will appear more natural and less manicured than conventional designs.

Environment ✔✔✔

Reintroduces wildlife habitat and wildlife to the city.

Ease of Use ✔✔✔

Generally requires less maintenance than conventional landscaping.

Other Benefits ✔✔

Enhances opportunities for wildlife stewardship programs.

Capital Cost $

No significant cost increase over conventional landscape treatments.

Further Information

- Dramstad, W.E. et al, 1996
- Terres, J.K., 1994

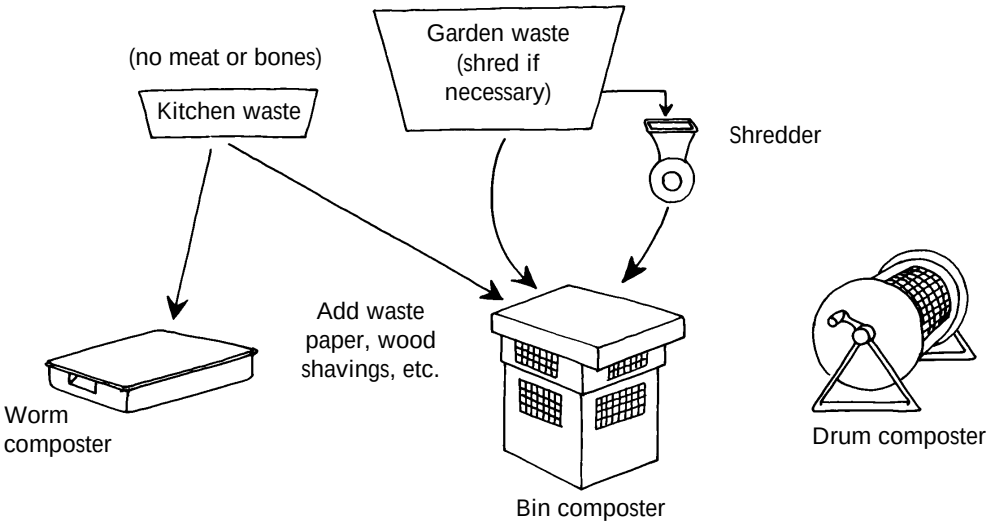
Linked Practices

LAb

CM4

LA6

PROVIDE ON-SITE COMPOSTING FACILITIES



On-site composting reduces the amount of organic waste deposited in landfills (approximately 15% to 25% of solid waste for a typical household). The City of Santa Monica encourages on-site composting, providing information and inexpensive single-chamber, plastic compost bins.

Compost bins are available in a variety of shapes and sizes:

- Tumbling composters are the most efficient, creating compost within 3 to 4 weeks.
- Single-chamber, wood or plastic compost bins are less expensive but also less efficient, requiring proper mixing and layering of green compost (vegetable and fruit scraps, plant clippings) and brown compost (dried leaves, shredded newspapers).
- Open compost piles should be avoided; they are the least efficient, attract vermin and require considerable space and maintenance.

For multi-family residential and commercial applications, worm composters are compact and can be stored indoors under countertops or in closets. They are particularly effective in breaking down food scraps, and produce little or no odor when properly maintained.

- Composters should have a minimum volume of 1 cu. yd. (except for smaller worm composters).
- Add vegetable kitchen waste to compost bin.
- Use shredders or clippers to mechanically break down garden waste prior to adding it to the compost bin.
- Provide clear instructions at all composter locations.

Cautions

- Requires education and occupant commitment to be effective.

Environment ✔✔

Reduces the amount of solid waste entering landfills; enhances soil quality.

Ease of Use ✔✔

Requires regular maintenance and dedicated space within a building or garden.

Other Benefits ✔✔✔

Provides local, high-quality organic soil amendment and reduces garbage collection fees.

Capital Cost $

Basic composting units can be purchased from the City of Santa Monica. The cost of more efficient, tumbling composters varies depending on size.

Further Information

- Moffat, A.S. & M. Schiler,1993
- Marinelli, J, 1992

Linked Practices

LA7

LA7

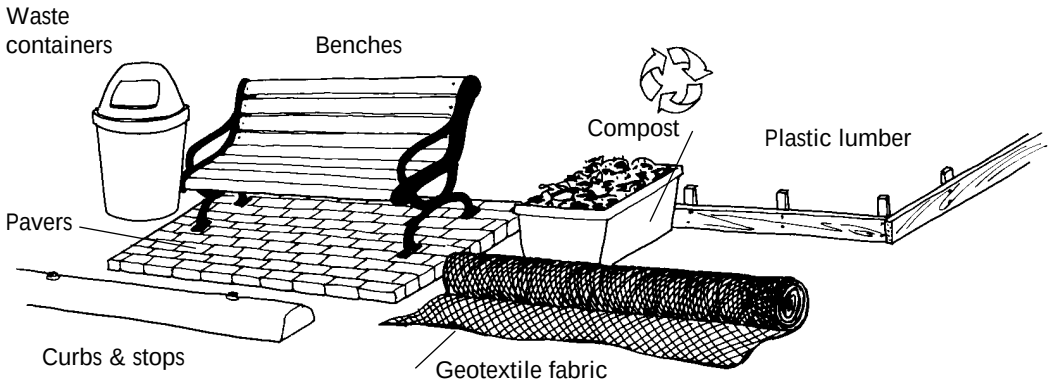
USE RECYCLED LANDSCAPE PRODUCTS & MATERIALS

Environment ✔✔
Recycles waste material, reduces the amount of waste entering landfills, and conserves natural resources.

Ease of Use ✔✔✔
Products do not typically require additional on-site finishing, are generally durable and require minimal maintenance.

Other Benefits ✔✔✔
Many products have a high resistance to vandalism.

Capital Cost $
In general there is no significant cost difference between recycled and non-recycled material.



A wide variety of products that have been manufactured using post-consumer and post-industrial, recycled materials are available for many landscape applications, reducing problems of solid waste disposal, energy used during manufacturing and the consumption of natural resources.

In many applications plastic lumber can be substituted for wood in decks, tables and fences. Other available recycled plastic or rubber products include benches, tree grates and tree protection fences, geotextile fabrics, compost bins, irrigation hoses, edging materials for plant beds, paving products and wheel stops for use in parking lots.

Recycled construction waste such as crushed concrete, stone and asphalt can be used as a sub-base under driveways, parking areas, patios and other hard-surface areas. Larger slabs of concrete can be used for retaining walls and pavers.

Reclaimed brick and stone can be used for patio paving and masonry garden walls.

Cautions

- There can be variations in the quality of product finishes.
- Some recycled products are not as strong as the equivalent non-recycled product.

Further Information

- AIA, 1998
- CIWMB website, 1999
- Loken, S. et al, 1994

Linked Practices

CMb
CMc
CM1
MA2

FURTHER INFORMATION

Allard, F. Ed. 1998. *Natural Ventilation in Buildings: A Design Handbook*. James & James, London.
Exhaustive coverage of the theory and practice of natural ventilation in buildings, providing the fundamentals, prediction and diagnostic techniques as well as design guidelines, technical solutions and case studies.

American Institute of Architects. 1998. *Environmental Resource Guide*. John Wiley & Sons, Washington, D.C. URL http://www.e-architect.com/
The reference work for architects and building specifiers on green products by generic type. Dense, but information packed; covers life-cycle environmental impacts of many building materials.

Barnett, D.L. 1995. *A Primer on Sustainable Building*. Rocky Mountain Institute, Snowmass, CO.
An excellent overview of issues and benefits of sustainable building.

Brown, G.Z. 1985. *Sun, Wind and Light: Architectural Design Strategies*. John Wiley & Sons, New York.
Good introduction to form-generating potential of sun, wind and light in the earliest stages of building design with emphasis on reducing energy use. Covers design strategies, analysis techniques and strategies for supplementing passive systems.

Brown, R.D. and T.J. Gillespie. 1995. *Microclimate Landscape Design: Creating Thermal Comfort and Energy Efficiency*. John Wiley & Sons, New York.
Presents the basic principles of microclimatology - how objects in the landscape affect climate to create microclimates. Explains how to use landscape design to modify microclimate, including radiation, wind, temperature, humidity and precipitation.

California Integrated Waste Management Board (CIWMB). (March 1999). *Recycled-Content Product Database*. [WWW document] URL http://www.ciwmb.ca.gov/rcp/
A database of sources for materials with recycled content, focusing on California and the U.S.

City of Fort Collins. (March 1999). *Xeriscape: a New Kind of Landscaping*. [WWW document] URL http://www.ci.fort-collins.co.us/utilities/water/conserv/xeriscap.htm
A summary of environmentally responsive landscaping resources, including a list of very low, low and moderate water consumption.

City of Santa Barbara. (March 1999). *Water Conservation Program: Landscaping*. [WWW document] URL http://ci.santa-barbara.ca.us/wresourc/bflandsc.htm
An excellent and visual orientation to water-conserving landscaping on the Southern California coast.

Dramstad, W. E., J.D. Olson,, and R.T Forman, 1996. *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*. Harvard University Graduate School of Design, Cambridge.

Presents and explains the principles of landscape ecology and provides numerous examples of how those principles can be applied in specific situations.

Hough, M. 1995. *Cities and Natural Process*. Routledge, London.
A good discussion of the processes that define the growth and operation of cities, and how, in understanding natural ecological process, cities can develop more balanced relationships with natural ecosystems.

Jeavons, J. 1982. *How to Grow More Vegetables*. Tenspeed Press, Berkeley, CA.
A concise discussion on how to maximize vegetable production in small, contained gardens.

Kourik, R. 1992. *Drip Irrigation For Every Landscape and All Climates*. Metamorphic Press, Santa Rosa.
One of the most thorough books available on design and construction of drip irrigation systems.

Lam, W. M. 1986. *Sunlighting as Formgiver for Architecture*. Van Nostrand Reinhold, New York.
Comprehensive coverage of the techniques for using natural lighting in buildings for energy savings and enhanced indoor lighting quality. Numerous case studies illustrate the "sunlighting" concepts and strategies.

Loken, S., W. Spurling,and C. Price. 1994. *GREBE (Guide to Resource Efficient Building Elements)*. Center for Resourceful Building Technology, Missoula, MT.
The original resource book on green building materials, and still one of the best. Updated regularly.

Lyle, J.T. 1994. *Regenerative Design for Sustainable Development*. John Wiley & Sons, New York.
One of the seminal books on the theory, design and construction of regenerative systems and the practical application of ecological design.

Marinelli, J. 1992. *The Naturally Elegant Home: Environmental Style*. Little Brown, Boston.
Provides useful examples of environmentally sensitive residential building and garden design.

Marsh, W. M. 1991. *Landscape Planning: Environmental Applications*. John Wiley & Sons, New York.
A definitive reference for landscape architects, planners and designers on the definition and application of environmental design principles to landscape and site planning.

Moffat, A.S., and M. Schiler. 1993. *Energy-Efficient and Environmental Landscaping*.
Appropriate Solutions Press, South Newfane, VT.
Good discussion on specific landscape design approaches for enhancing the energy efficiency of buildings.

Netafim Irrigation Inc. 1998. *Techline Design Manual*. Netafim Irrigation, Inc. Landscape Division.

Fresno, CA.
A technical primer for designing drip irrigation systems.

Richman, T. et al. 1997. *Start at the Source: Residential Site Planning and Design Guidelines: Manual for Stormwater Quality Protection*. Bay Area Stormwater Management Agencies San Francisco.
Brief, information-dense design guide to stormwater runoff reduction and treatment, oriented toward biological and landscaping methods. Many illustrations and diagrams.

Terres, J. K. 1994. *Songbirds in Your Garden*. Algonquin Books, Chapel Hill, NC.
Brief but information-filled guide to enhancing wild bird habitat with urban landscaping design.

U.S. Department of the Interior. (March 1999). *Water Wise Gardens of California*. [WWW document] URL http://209.21.0.235/waterwise_gardens/index.htm
Photos and contact information for tours of water-conserving gardens in Los Angeles region, including two in Santa Monica.

TRANSPORTATION

TRANSPORTATION

Transportation affects almost every aspect of resource use, air and water quality, and urban livability. Reducing the need for automobiles has major environmental benefits and is one of the most important urban planning strategies. Building designers and planners can help reduce automobile use in three ways:

- Integrate complementary occupancies within building projects.
- Encourage pedestrian, bicycle and transit use.
- Reduce the environmental impacts of parking facilities.

Complementary Building Occupancies

Separation of commercial, retail and residential areas; availability of efficient and reliable public transit; and the dangers of cycling and other human-powered transportation all affect the need for automobile commuting and storage. Parking spaces in mixed-use buildings and developments can often be shared between occupancies with differing schedules, reducing the area of impervious parking pavement, stormwater peak flows and pollution. As well, locating several complementary occupancies within a project – housing, services, retail, commercial and/or light industry – often eliminates the need for many automobile trips, encouraging more low-impact transportation modes, such as biking, walking and mass transit.

Pedestrian and Bicycle Amenities

Making streets safer and more attractive to pedestrians, providing bicycle facilities at destinations and creating safe, continuous bicycle paths also reduce the need for automobiles. Santa Monica is already a good example for many cities to follow.

Bicycling, walking and even in-line skating are alternatives to the car for shorter commuter distances, and for greater distances when combined with public transit. Building design strategies can encourage these options by providing secure bicycle parking, shower and changing facilities. These are a powerful complement to the network of safe bicycle-ways in Santa Monica's Bicycle Master Plan.

Encouraging pedestrian activity is not only a way to decrease automobile use, with its fossil fuel dependence, air and water pollution, it is also a way of bringing life to the streets and increasing the safety of the community. If people feel safe on the sidewalks, they also feel safe in the city. Buildings can improve the comfort and safety of pedestrians with appropriately scaled and detailed facades and views of the street for building occupants. If pedestrians are also provided with a choice of sun or shade, they are more likely to use these outdoor spaces. An attractive street generates places for social interaction, increasing the vitality of the neighborhood and providing improved commercial opportunities.

Development projects designed for pedestrians and cyclists are increasingly valued places to live, work and visit. Examples in Santa Monica are the Third Street Mall and Main Street in Ocean Park. Owners of buildings that enhance the quality of the neighborhood will benefit both directly and indirectly – increased pedestrian traffic is better for retail businesses, and people are attracted to vital areas, enhancing the market value of the buildings.

Reduce the Environmental Impacts of Parking Facilities

Urban runoff from paved surfaces carries with it pollutants such as fuel, oil, paint, heavy metals, pesticides, human and animal wastes, and trash. By reducing surface car parking areas, increasing the permeability of surfaces not used for car movement, and integrating natural landscaping into car parking areas, urban runoff can be naturally treated, groundwater supplies replenished and pollution entering

Santa Monica Bay reduced.

Trees and other vegetation adjacent to building or parking areas offer welcome shade and lower outdoor air temperatures in the summer, creating more comfortable transition spaces between indoors and outdoors for building users and visitors. Shading of parking areas and building surfaces reduces the amount of solar radiation reaching them, which significantly lowers building cooling loads and operating costs. Furthermore, natural landscaping within the city provides habitat for many plant and animal species, and green areas are more attractive to building users and pedestrians than hard landscapes and pavement.

TRANSPORTATION PRACTICES SUMMARY TABLE

Required Practices

	Ordinance	Subtitle
TRa	SMMC 5.20.080 (c) (2)	Install Clarifiers or Oil/Water Separators on Drains from Service Bays & Parking Areas
TRb	SMMC 9.04.10.08.050	Provide Secure & Accessible Bicycle Storage for Visitors & Occupants
TRc	SMMC 9.04.10.08.050	Provide Facilities for Shared Vehicle Transportation

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
TR1 Match the Area & Type of Paved Surfaces to Their Use	✔✔✔	✔✔	✔✔	**$$$**
TR2 Create a Safe & Comfortable Environment for Pedestrians	✔✔	✔✔	✔✔✔	**$**
TR3 Provide Changing Rooms, Lockers & Showers for Cyclists and Joggers	✔✔	✔✔	✔✔	**$$**
TR4 Place Automobile Parking Fully or Partially Underground	✔	✔✔	✔✔✔	**$$$**
TR5 Share Parking Between Occupancies in Mixed-use Projects	✔	✔	✔✔	**$**
TR6 Provide Convenient Parking & Charging Facilities for Electric Vehicles	✔	✔✔	✔	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.
Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

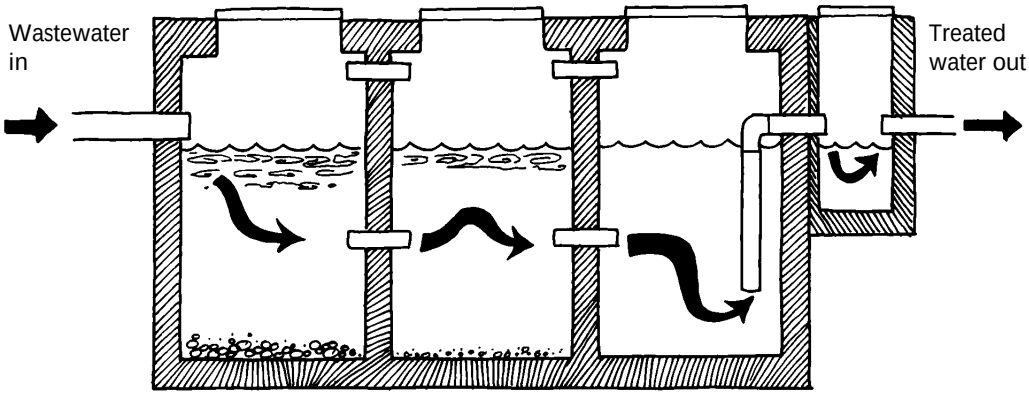
Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

INSTALL CLARIFIERS OR OIL/WATER SEPARATORS ON DRAINS FROM SERVICE BAYS & PARKING AREAS

TRa

REQUIRED PRACTICE

SMMC 5.20.080



Automotive repair facilities and paint shops, dealerships, gas stations, equipment degreasing areas, parking structures/areas, and other facilities generating wastewater with significant oil and grease content are required to pretreat these wastes before discharging to the city or storm drain systems. Pretreatment requires that a clarifier or oil/water separator be installed and maintained on site.

Clarifiers or oil/water separators for commercial/industrial processes must be sized on a case-by-case analysis of wastewater characteristics. Typically a minimum capacity of 750 gallons is required for small gas stations, auto repairs, and light commercial sites; 1500 gallon capacity for large-scale truck washing and steam cleaning facilities. The ultimate discharge must be directed to the sewer system. All units regardless of size shall be fitted with a standard final-stage sample box and spill-absorbent pillows.

Clarifiers or oil/water separators should be installed in all new and rebuilt parking structures or parking areas of newly built facilities. Oil/water separators installed for parking areas and garages will be sized according to10-minute peak flow guidelines. Ultimate discharge shall be to the city storm drain system.

In all cases a site plan and sizing proposal must be submitted to the Industrial Waste Section for initial approval. Plumbing hook-ups must be performed by state licensed plumbers under permit and inspection of the Building and Safety Division.

Cautions

- Clarifiers and oil/water separators cannot be used for the disposal of hazardous waste such as coolants, solvent, freon, hydraulic fluids, transformer oils, etc. (SMMC 5.20.040 and 5.20.050)
- Both clarifiers and oil/water separators must be periodically pumped and have maintenance contracts in order to keep discharges within limits. City inspections will ensure compliance.

Environment ✔✔✔
Most effective way to improve water quality in Santa Monica Bay

Ease of Use ✔✔✔
Straightforward

Other Benefits ✔
Few non-environmental benefits

Capital Cost $
Standard good design practice.

Further Information
- SMMC 5.20.040, .050, .080
- SMMC 7.10.060
- Tom Richman, et al, 1997
- Santa Monica Industrial Waste Section: (310) 458-8235
- Santa Monica Building and Safety Division: (310) 458-8355

Linked Practices
CMd
SFa
LAa
TRa
TR1
WS3

TRb

REQUIRED PRACTICE
SMMC 9.04.10.08.050

Environment ✔✔✔

Increased bicycle use translates directly into reduced automobile use, reduced congestion and improved urban air quality.

Ease of Use ✔✔✔

Many ways to integrate bicycle parking into a new or existing facility.

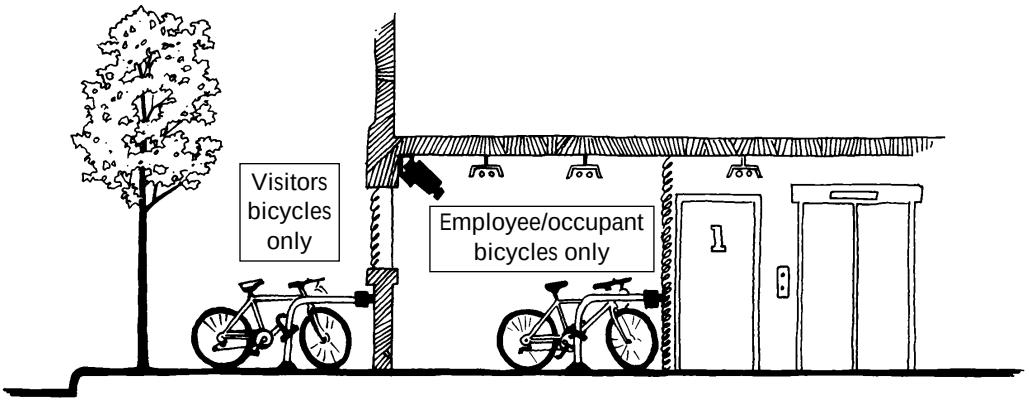
Other Benefits ✔✔

Cycling is anticipated to become increasingly important and such facilities are necessary to attract and retain qualified employees and tenants.

Capital Cost $

Site specific, depending on ease of integrating a secure enclosure. Potential reduction in automobile parking requirements.

PROVIDE SECURE & ACCESSIBLE BICYCLE STORAGE FOR VISITORS & OCCUPANTS



Santa Monica's Municipal Code requires short- and long-term bicycle parking for building visitors and occupants. The amount and type is regulated by Section 9.04.10.08.050. All new non-residential buildings or structures shall provide off-street bicycle parking as follows:

- A minimum of four bicycle parking spaces on-site;
- New buildings or structures over 15,000 sq.ft. shall provide bicycle parking at a rate of 5% of the automobile parking required by Section 9.04.10.08.040;
- In new buildings or structures over 50,000 sq.ft., 50% of the required bicycle parking shall be provided for long-term bicycle commuters. Long-term bicycle parking shall consist of either a "locker" with a fully enclosed lockable space accessible only to the owner/operator of the bicycle; attendant parking with a check-in system in which bicycles are accessible only to the attendant(s); or a locked room or office inside the building designated for the sole purpose of securing bicycles;
- All required outdoor bicycle parking shall be no further than one-half the distance from the furthest off-street auto parking space from a main entrance of the building being developed. Visitor bicycle parking requires public, visible and well-lit lock-up facilities near the building entrance, separate from automobile parking. If not immediately visible, conspicuous signage must be provided to show its location.

Further Information

- SMMC 9.04.10.08.050
- BFA Internet Resource Center 1999
- Cox, E. website 1998

Linked Practices

TR3

The entry door to long-term occupants' bicycle storage should be within sight of building or parking security, elevators or a main building entrance. Access should not require stairs.

- Storage rooms should have solid opaque walls with the entire interior space visible from the entrance, and be fitted with motion-activated, tamper-proof security lighting.
- Storage rooms should provide at least 6 ft. headroom. Bicycle stalls should be at least 6 ft. long for horizontal bicycle parking, 3 ft. if placed vertically.
- Bicycle racks should have two points of contact, to allow convenient locking for a variety of sizes and styles.
- Floors should have durable, easily maintained slip-free surfaces that can withstand wet or muddy tires.

Cautions

- Access, attractiveness and functionality of storage facilities are critical for their acceptance and use.

TRc

REQUIRED PRACTICE
SMMC 9.04.10.08.050

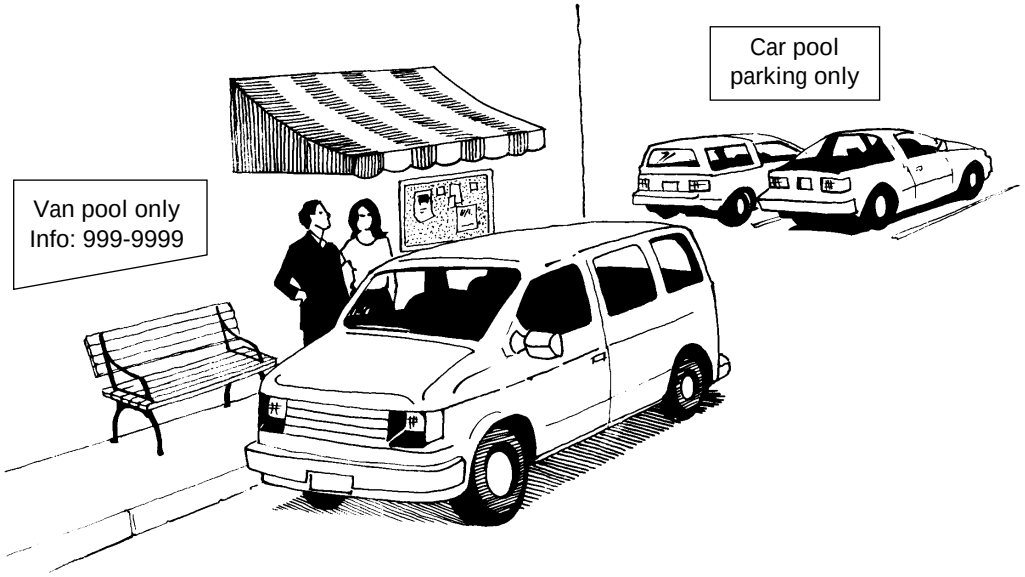
Environment ✔✔
Reduced personal automobile trips, reduced congestion and improved air quality.

Ease of Use ✔✔✔
Easily integrated into entrance and parking design.

Other Benefits ✔✔
More efficient use of site.

Capital Cost $
Labeling designated parking involves minimal cost. Cost of shelter may be minimal if integrated into the building design.

PROVIDE FACILITIES FOR SHARED VEHICLE TRANSPORTATION



A growing network of high-occupancy vehicle lanes, pool parking and employer incentives such as subsidized parking supports carpooling and vanpooling. Building design can encourage carpooling and vanpooling by giving priority to shared transportation, and by making waiting areas convenient and safe.

Car- and vanpool parking are regulated by Section 9.04.10.08.050 of Santa Monica's Municipal Code: 10% of parking spaces for new office and industrial buildings greater than 50,000 sq.ft. must be permanently reserved for vanpools or carpools. For other non-residential buildings greater than 50,000 sq.ft., the rate is 5%. Pool parking spaces must have at least 7 ft.-2 in. overhead clearance.

- Locate carpool and vanpool parking spaces closer to the building entrance than other automobile parking.
- Draw attention to the location of car- and vanpool parking and pick-up areas with prominent signage.
- Provide attractive and comfortable waiting areas to encourage car- and vanpool commuters. Provide amenities such as sunshades and rain canopies, seating and bulletin boards. Waiting areas are a natural location for public art.
- Ensure commuter safety with building lobbies that view waiting, pick-up and drop-off areas, occupied windows that overlook them, good lighting, and if necessary, prominent surveillance cameras. Eliminate potential hiding places for potential criminals.

Further Information

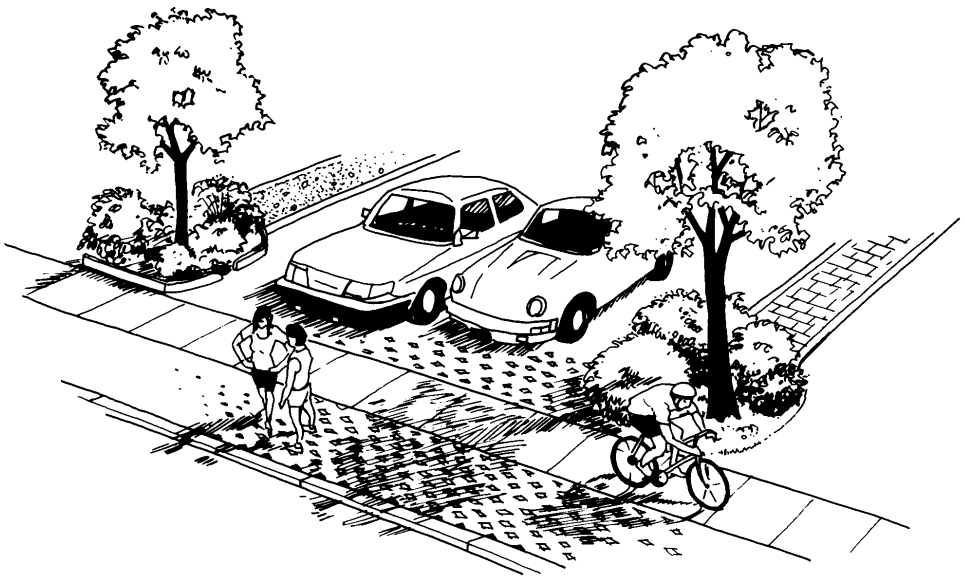
- SMMC 9.04.10.08.050
- Roseland, M. 1998

Linked Practices

TR1
TR2

TR1

MATCH THE AREA AND TYPE OF PAVED SURFACES TO THEIR USE



The area and type of paved surfaces can signal their use by cars, parking or pedestrians. Wherever traffic requirements allow it, install surfaces that encourage non-automobile traffic, and allow stormwater infiltration. Use impervious pavement (concrete and asphalt) only where regular car, bus or truck traffic is expected. Match the surface to the need:

- Porous asphalt, paver blocks or large aggregate concrete for parking and highly used bicycle and pedestrian areas
- Lattice blocks that permit grass growth for fire lanes and overflow parking
- Crushed stone or brick for lightly used pedestrian paths
- Recycled asphalt and recycled concrete where impervious surfaces are required

Provide “curb cuts” and slope hard landscaping features to allow water to flow to permeable surfaces and oil/water separators.

Integrate trees with a high, dense canopy into “parking groves”. These provide shade for parked vehicles, and are more attractive when cars are absent. Ensure parking groves do not provide hiding places, with landscaping that does not block sight lines.

Explore the feasibility of a common driveway or entrance with adjacent facilities.

Cautions

- Safe and visible circulation is critical. Do not compromise fire rescue access.
- “Parking groves” require careful planning for space efficiency and security.
- Ensure that pedestrian path's paving are accessible for disabled people.

Environment ✔✔✔

Peak stormwater flows increase with impervious area, such as standard concrete or asphalt paving.

Ease of Use ✔✔

Requires careful planning to provide safe and efficient parking.

Other Benefits ✔✔✔

Different surface finishes enhance appearance, inviting more pedestrian and bicycle traffic.

Capital Cost $$

Bricks and pavers have higher initial cost than poured-in-place concrete or asphalt. Less paving material overall translates into lower initial cost.

Further Information

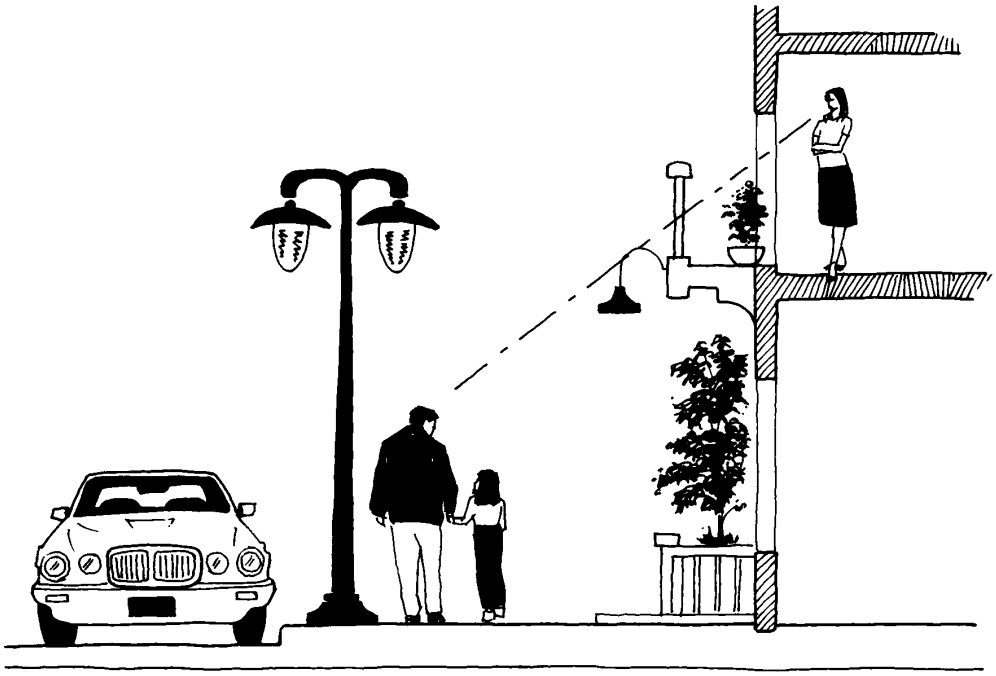
- Richman, T. et al 1997
- Hough, M. 1994
- Sorvig, K. 1996

Linked Practices

TRa
TR2

TR2

CREATE A SAFE AND COMFORTABLE ENVIRONMENT FOR PEDESTRIANS



Environment ✔✔
Indirect method of discouraging personal automobile use. Shading can help reduce building cooling load and increase durability of exterior finish materials.

Ease of Use ✔✔
Context dependent. Often easy to integrate into building form.

Other Benefits ✔✔✔
Creating safe comfortable streets stimulates pedestrian activity, making buildings more desirable. Potentially reduced property damage and vandalism.

Capital Cost $
Site and context dependent. If considered from the outset of design, costs can be minimal.

Streets and public spaces that encourage pedestrian activity are essential characteristics of livable, sustainable cities. Critical design issues include making streets and public spaces safe and comfortable, and distinguishing between public, semi-public and private spaces.

Streets well used by residents and locals who feel a sense of ownership tend to be safe streets. Secure streets are typically animated throughout the day and evening. To encourage this, provide a variety of uses on each site, design public boulevards to accommodate informal gatherings and activities, and include appropriate security lighting.

Street life and safety can be enhanced with facades that:

- are attractive, humanly scaled and accessible to pedestrians, provide a sense of enclosure, interest and variety;
- clearly signal transitions from public to semi-public to private space, using arches, gateways, thickened corners, etc.;
- orient occupied windows toward public spaces to provide "eyes on the street";
- vary ground level uses and activities that encourage sidewalk use throughout the day and not just during business hours; and
- avoid creating seldom-used, natural hiding spots that cannot be seen by passersby and building occupants.

Good lighting is critical for safe streets at night.

- Provide effective lighting onto sidewalks in

Further Information
- Gehl, J. 1987
- Hough, M. 1984
- IESNA, 1980
- Jacobs, J 1961
- Schumacher, T. 1986

Linked Practices
TRb
TRc
TR1
TR5

accordance with illuminance levels and cut-off angles as specified by IESNAs RP8.

• Provide adequate lighting to emphasize significant street features: walls, street signs, mailboxes and obstacles.

Creating comfortable outdoor areas to walk through or relax in is also important for a high quality street life. Flexible outdoor spaces offer a variety of uses and are more likely to be used year-round. Small spaces are more intimate and more easily shaded and made secure.

• Provide courtyard spaces and other contained outdoor areas to provide a choice of sheltered and sunlit outdoor spaces. Canopies, arcades and trellises are three options to protect pedestrians from the elements.

• Avoid trapping pollutants in spaces next to streets by using high tree canopies or plantings that promote air circulation.

• Provide wider areas next to sidewalks for shaded seating and small gatherings that do not obstruct pedestrian traffic.

The interface between buildings and public space is a critical feature of urban street life. Clear transitions allow easy movement and way-finding while avoiding extensive signage. While it is important to mark the transition from public to semi-public to private space, permeability between zones is also crucial.

• Design features such as stoops and entries to provide a zone of shared space neither totally private nor totally public.

• Share entrances between two or more suites, encouraging informal meetings of neighbors.

• In commercial areas, make the entrances visible using canopies, arcades, widened sidewalks, etc.

• Extend the street space into the building at main entrances. Stimulate interaction between public and private spaces with changes in height or level, plantings, stoops and bay windows. Second-storey shops, offices and residence entrances can further extend the public domain.

• Use the size of transition areas to regulate the intimacy and intensity of social activity.

• Ensure a visible and attractive connection with main paths in public or semi-public space, so that they are not hidden and unused. Give people a reason to enter the space.

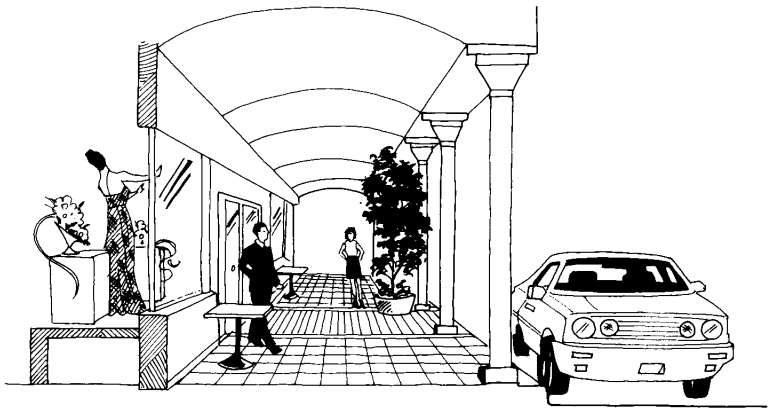
Cautions

• Simply directing windows toward public spaces is insufficient. Building occupants need a sense of ownership and responsibility for the street, which is provided by balancing several of these techniques.

• Ensure that sheltered areas are visible from the street, sidewalk and building.

• Avoid creating small dark, courtyards that winter sun never reaches.

• Heavy and massive arcades and other features can obscure retail visibility and affect pedestrian safety.



TR3

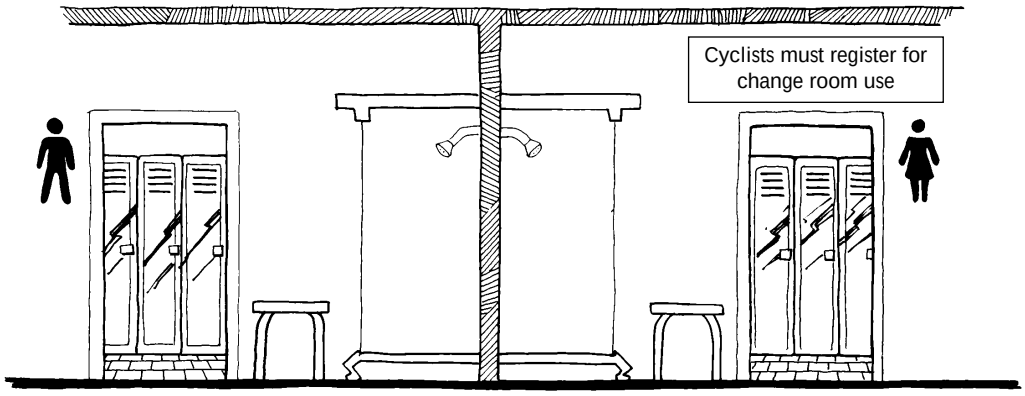
PROVIDE CHANGING ROOMS, LOCKERS & SHOWERS FOR CYCLISTS & JOGGERS

Environment ✔
Encourages alternatives to automobile commuting.

Ease of Use ✔✔
Dependent on project size and ability to integrate with other building amenities.

Other Benefits ✔✔
Changing and shower facilities for cyclists can serve other uses (e.g., lunchtime joggers).

Capital Cost $$
The incremental costs depend on size and nature of the building project, and ability to integrate with other amenities.



Although cyclists and joggers can change in washrooms and store a change of clothes in the workplace, dedicated facilities are more likely to encourage regular human-powered commuting. Health and environment amenities attract and retain qualified staff and employees — a market plus for buildings.

- For commercial and institutional facilities, provide changing rooms, lockers and showers for employees.
- Connect changing room, shower and locker facilities with bicycle storage, or with washroom facilities, exercise rooms or pools.
- Provide sufficient showers to avoid waits at peak times, and to accommodate growing use.
- Provide separate change/shower rooms for males and females. For very small buildings, a single lockable shower/dressing room for both genders could be provided.

Cautions

- Facilities must be accessible to building occupants, but not to the general public or visitors.
- Easiest for institutional or commercial development projects greater than 10,000 sq.ft.

Further Information

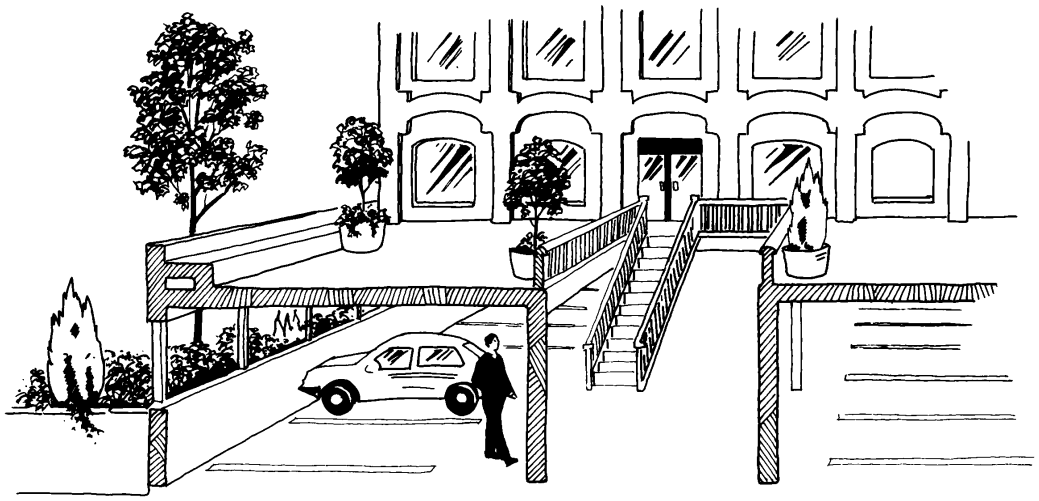
- Cox, E. 1998
- Roseland, M. 1998

Linked Practices

TRb
WSa

TR4

PLACE AUTOMOBILE PARKING FULLY OR PARTIALLY UNDERGROUND



Underground parking, either fully or partially below-grade, allows more intense use of street-level and above-grade areas, or more landscaped area. These enhance the urban life of Santa Monica and offer greater convenience and amenity for building users, as well as allowing for more leasable or salable floor area.

When planning underground parking areas:

- Provide visual links to the outdoors to provide a sense of direction.
- Introduce daylight, particularly near pedestrian entrances and exits.
- Make interiors logical, inherently guiding users to entrances and exits.
- Enhance security with good lighting throughout and by eliminating hiding places.
- Integrate long-term bicycle storage and changing facilities into the parking strategy.
- Design floor-to-floor heights of at least 8 ft. to permit different uses in future.

In very small sites with high land costs, robotic parking devices that allow more cars to be stored in a given volume are now available – with a high cost premium. These reduce circulation areas needed in standard parking lots, allowing more efficient space use.

Cautions

- Pay close attention to user safety issues, which are greater than with surface parking.
- Underground parking structures typically require more materials than equivalently sized above-grade structures.

Environment ✔

Allows use of above grade space over parking for landscaping or other uses.

Ease of Use ✔✔

Usually makes site and space planning easier on restricted urban sites.

Other Benefits ✔✔✔

Eliminating above-grade parking allows more interesting, varied and safe street activity.

Capital Cost $$$

Site and context dependent. If integrated into building design from the outset, increases in cost need not be significant.

Further Information

- Frankel, E.H. 1998
- Harriman, M.S. 1991

Linked Practices

TR2

TR5

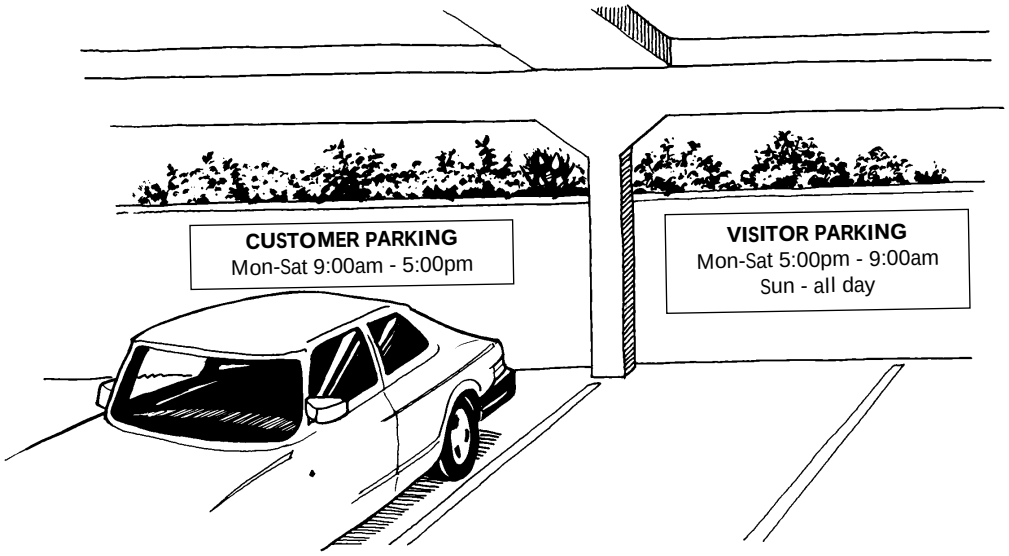
SHARE PARKING BETWEEN OCCUPANCIES IN MIXED-USE PROJECTS

Environment ✔
Creates opportunity for increased natural landscaping. Reduces automobile use indirectly.

Ease of Use ✔
Often requires negotiations between different building occupants, or with Planning officials.

Other Benefits ✔✔✔
Less space allocated for parking allows more flexibility in site planning.

Capital Cost $
Less initial site and construction work translates into lower capital costs.



Where compatible occupancies within mixed-use buildings and development projects allow sharing of parking stalls, impervious parking areas and "heat-island" effects can be reduced.

Mixing compatible and complementary occupancies within a development can reduce the number of car trips, because occupants are more likely to find it convenient to walk to nearby services. Mixes of residential with commercial or retail occupancies tend to be the most compatible.

Different occupancies often have parking demands that differ with the time of day or week. This allows sharing of parking spaces between occupancies, reducing the site area dedicated to car storage. Potential is often greatest for visitor parking, and for residential mixed with commercial or retail occupancies. If parking area can be reduced, there are more opportunities for natural landscaping and creative site planning.

Provide signage that clearly identifies when different users may use shared parking spaces.

Cautions

- Fewer on-site parking spaces can increase the potential for greater pressure on street parking. Reducing parking allowances should be reviewed with City Planning Department early in the design process.
- Sharing parking facilities requires cooperation between building occupancies and from planners.

Further Information

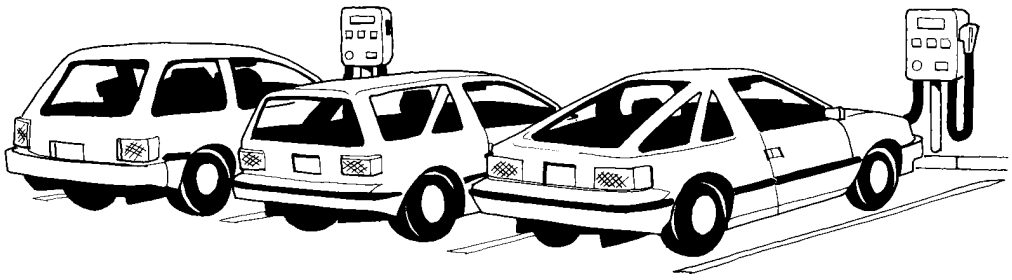
- Roseland, M.1998
- Woodhull, J. 1992

Linked Practices

TRa
TR1

PROVIDE CONVENIENT PARKING & CHARGING FACILITIES FOR ELECTRIC VEHICLES

TR6



While currently rare, increased numbers of electric vehicles (EV) in the future will require facilities – and lack of charging stations will slow their market penetration. Charging stations are much more cost-effective when many users share them, and their use is spread throughout the day or week. Unfortunately, at the moment there is no single standard for EV charging stations; but preparations in new construction can make future installation much easier, and encourage more widespread use.

Locate EV parking in a conspicuous and preferred location, close to a main building entrance and the EV charging station electrical panel. Provide one EV parking stall for every 20 on-site parking stalls, and space for one charging station for every two EV parking stalls.

Provide:

- a plinth for the charging stations, equipped with conduit to the electrical panel.
- curb stops and bollards that provide access space to the charging stations.
- signage reserving the parking stalls for EVs.

Cautions

- Short wiring runs from the electrical panel to the charging station reduces energy waste and wiring cost.
- There is currently no widely accepted standard for EV charging stations. The type(s) of charging station to install should be discussed with the client and occupants.

Further Information

- California Energy Commission website 1999
- California Electrical Code, Chapter 6, Article 625
- California Building Code, Section 1202

Linked Practices

ES8

Environmental ✔

Environmental benefit depends on numbers of electrical vehicles used in future.

Ease of Use ✔✔

Easy to provide for future, but lack of charging station standards makes current selection difficult.

Other Benefits ✔

Marketing benefit in future.

Capital Cost $

Very small costs to prepare for future charging station installation.

FURTHER INFORMATION

Bicycle Federation of America. (April 1999). *Internet Resource Centre*. [WWW document] URL http://www.bikefed.org
Comprehensive coverage of a host of policy, planning and design guidelines supporting bicycle use.

California Electrical Code, Chapter 6, Article 625. (April 1999). *Electric Vehicle Charging System Equipment*. [WWW Document] URL http://www.energy.ca.gov/afvs/ev/ev_building_codes.html
New section of the California Electrical Code applying to electric vehicle charging stations.

California Energy Commission. (March 1999). *Electric Vehicles (EVs) in California*. [WWW Document] URL http://www.energy.ca.gov/afvs/ev/index.html
The CECs Web site contains general information on EVs, lists of EVs for sale and lease, summaries of state programs, listings of incentives, a photo gallery and Web links for the EV industry.

Cox, E. (April 1999). *Long Term Bike Parking*. [WWW Document] URL http://www.jps.net/cbc/longbikepark.html
Useful overview of design considerations for long-term bicycle storage offering essential and optional features for caged facilities, bike rooms, bike lockers and shower & clothes locker rooms.

Frankel, E. H. 1998. *"Robotic Park"*, Architectural Record.

Gehl, J. 1987. *Life Between Buildings: Using Public Space*. Trans. Jo Koch. Van Nostrand Reinhold, New York.

Harriman, M. S. 1991. *"Stacking the Decks"*, Architecture. Vol. 80 No. 12.
Short article describing alternative approaches of integrating parking garages in the city's edge and downtown. Three case studies are discussed: Seaport Village, San Diego,CA, and Northpark Town Center and Riverwood, both in Atlanta, GA.

Hough, M. 1984. "Climate." *City Form and Natural Process: Towards a New Urban Vernacular*. Van Nostrand Reinhold, New York.
Excellent examination of natural process and cities, covering natural resources of climate, water, plants, wildlife as balanced natural systems and their modification and transformation by cities.

IESNA. 1980. RP-8 Roadway Lighting, Chapter *4, Pedestrian Walkway and Bikeway Lighting Design*. Illuminating Engineering Society of North America, New York.
Professional standard providing the basis for the design of fixed lighting for roadways, bikeways and pedestrian paths.

Jacobs, J. 1961. *The Death and Life of Great American Cities*. New York: Random House.
Offers alternative principles for city planning, emphasizing how the sidewalks can be designed to promote social and economic vitality to cities and their streets.

Richman, T. et al. 1997. *Start at the Source: Residential Site Planning and Design Guidelines: Manual for Stormwater Quality Protection*. Bay Area Stormwater Management Agencies, San Francisco
Brief, information-dense design guide to stormwater runoff reduction and treatment, oriented toward biological and landscaping methods. Many illustrations and diagrams.

Roseland, M. 1998. *Toward Sustainable Communities: Resources for Citizens and their Governments*. New Society Publishers, Stony Creek, CT..
Valuable introductory primer on community-scale sustainability issues and strategies.

Schumacher, T. 1986 "*Buildings and Streets: Notes on Configuration and Use."* On Streets. Ed. Stanford Anderson. MIT Press, Cambridge:

Sorvig, K. 1996. *Sustainable Building Technical Manual.* Public Technologies Inc., Washington DC.
Like the other sections of the Sustainable Building Technical Manual, the Site Materials and Equipment (Chapter 7), offers a concise, valuable overview of the topic. Chapter highlights design considerations for soils amendments, plant materials and management, paving materials and materials for site construction and furnishings.

Woodhull, J. 1992. "*How Alternative Forms of Development Can Reduce Traffic Congestion."* Sustainable Cities; Concepts and Strategies for Eco-City Development, Ed. Bob Walter et al., Eco-Home Media, Los Angeles.
Offers alternative approaches to traffic planning concentrating on "access" rather than mobility. Covers densification, parking, development patterns and offers solutions for pedestrian-friendly, transit-oriented traditional neighborhood development.

ENVELOPE & SPACE PLANNING

ENVELOPE & SPACE PLANNING

On urban sites where optimal orientation and massing are difficult, the building envelope provides the greatest opportunity to conserve energy. In Santa Monica, the envelope should maximize daylight, natural ventilation and views to the exterior, and control solar heat gain and traffic noise. The building envelope may also be designed to integrate systems for collecting solar energy and rainwater.

Windows significantly affect building energy performance. The design of windows is critical in providing effective daylighting, solar control, ventilation, noise control and views to the exterior.

The most critical practices are EN1, EN2 and EN3, which control the entry of daylight and natural ventilation into a building, and their interior distribution. Addressing these issues early as a multi-disciplinary team offers the best opportunity to develop solutions that resolve these energy and environmental performance issues while reducing envelope and whole building costs.

Daylighting Design

Daylight offers the twin advantages of creating a high-quality work environment while reducing energy use for lighting. While building form establishes the daylighting potential of interior spaces, the distribution of windows and their light transmission characteristics determines the amount of daylight entering the building. Roof monitors and other forms of top-lighting, such as skylights and sawtooth roofs, are particularly applicable to Santa Monica because the majority of buildings are low-rise.

Solar Control

Effective solar control is an essential part of window design in Santa Monica. For commercial buildings with high internal electrical loads, such as offices or retail occupancies, reducing cooling loads and glare problems from windows, skylights and roof monitors is a very effective energy conservation strategy. For buildings and spaces with low internal electrical loads, passive solar heating by admitting sun when heat is required must be balanced with blocking mid-day summer sun. Solar control is best accomplished with high-performance glazing or exterior solar controls such as overhangs or awnings, rather than with internal blinds. The design issue is to control solar gain without compromising daylighting or exterior views.

Natural Ventilation

Natural ventilation can reduce the energy required to cool buildings by reducing or eliminating the need for chillers, fans and pumps. The type and placement of operable windows or dedicated air inlets and outlets is critical in directing air into and out of the building so they provide both ventilation and cooling of interior surfaces.

Noise Control

Open windows that admit air into the building also admit exterior noise and pollutants. Natural ventilation relies on continuous air paths within ventilated spaces and can also conflict with acoustic requirements. Interior acoustic conditions can be improved by controlling excess internally generated noise at its source and minimizing noise from outdoors.

It is difficult to satisfy all of these performance requirements, many of which are conflicting. However, they can be resolved by designing different parts of the window for different need: for example, separating ventilation from daylighting by using dedicated vents or separating view from daylighting by using lightshelves.

Space Planning and Interior Finishes

Interior space planning and finish materials significantly affect the distribution and effectiveness of

daylighting, natural ventilation and passive solar gains. The design of the interior must ensure that light and air reach the largest area possible, requiring careful design of interior spaces and partitioning. The color and shape of interior surfaces has a major impact on the distribution and quality of daylight. Their design must be carefully coordinated with that of the windows and skylights.

Thermal Mass

Thermal mass can moderate indoor temperatures by dampening temperature swings. This minimizes the need for mechanical cooling and also stores solar heat to reduce winter heating needs. Moderate surrounding surface temperatures also contribute to the comfort of occupants. The amount and distribution of thermal mass and its exposure to sunlight and airflow dictates its effectiveness in moderating internal temperatures.

Recycling Facilities

In addition to shaping building interiors to maximize the use of daylighting, ventilation and passive solar gains, other environmental strategies affect interior space planning. The Santa Monica Sustainable City Program has a goal of reducing solid waste to 50% of 1990 levels by the year 2000, according to State law.

Providing a recycling area is required by Santa Monica Municipal Code for multi-family and commercial buildings. Making the recycling area convenient, keeping it clean and well managed, and providing on-site education for users about waste separation and recycling can make the difference between minimal compliance with the law and a successful recycling effort.

ENVELOPE & SPACE PLANNING PRACTICES SUMMARY TABLE

Required Practices

	Ordinance	Subtitle
ENa	SMMC 9.04.10.02 150-151	Provide Space for Recycled Material Storage & Handling Systems

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
EN1 Design Windows to Maximize Daylighting & Views	✔✔✔	✔✔	✔✔✔	**$$**
EN2 Shade Windows During Cooling Periods	✔✔✔	✔✔	✔✔	**$$**
EN3 Use Roof Monitors for Daylighting Upper Floors	✔✔✔	✔✔	✔✔✔	**$$**
EN4 Design Windows to Maximize Natural Ventilation	✔✔	✔✔	✔✔	**$$$**
EN5 Shape & Plan the Interior to Enhance Daylight a& nd Natural Airflow Distribution	✔✔	✔✔	✔✔✔	**$$**
EN6 Incorporate Thermal Mass Into Building Structure	✔✔	✔✔	✔✔✔	**$**
EN7 Select Light Colors for Exterior Finishes	✔✔	✔✔✔	✔✔	**$**

Legend

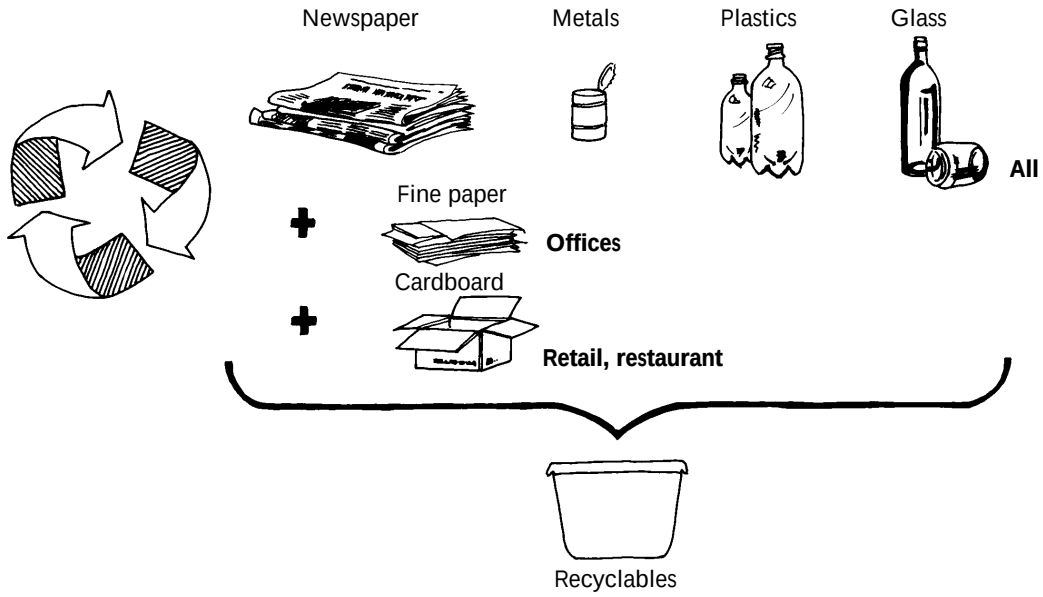
Environment: how well a Practice addresses environmental, health and resource-conservation issues.
Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

PROVIDE SPACE FOR RECYCLED MATERIAL STORAGE & HANDLING SYSTEMS



Provide space for recyclables storage near a convenient loading area.. These spaces must be at grade or have a lift to allow roll-in and roll-out of wheeled bins.

Recyclables storage and handling area must be adequate for the recyclables flow from the occupancy, assuming a 100% recovery rate over a typical period between pickups. Assume that there will be a minimum of four recyclables: paper, metals, plastics and glass.

A refuse and recycling room or outdoor enclosure must comply with the requirements of the zoning district and the following minimum design standards:

Non-Residential Development.

- Floor area less than 1000 sq.ft.: in refuse and recycling room four feet in width, 4 ft. in length, and 6 ft. in height, or an equivalent space in a centralized area; or an outdoor enclosure with the same dimensions.
- Floor area between 1000 and 5000 sq.ft: in refuse and recycling room 5 ft. in width, 9 ft. in length, and 8 ft. in height, or equivalent space in a centralized area; or an outdoor enclosure with the same dimensions.
- Floor area more than 5000 but no more than 10,000 sq.ft.: in refuse and recycling room 9 ft. 6 in. in width, 13 ft. feet,6 in. in length, and 8 ft. in height in a centralized area; or an outdoor enclosure with the same dimensions.
- Floor area more than 10,000 sq.ft. but no more than 20,000 sq.ft.: a 248 sq.ft. refuse and

Further Information

- SMMC 9.04.10
- Solid Waste Management Division (310) 458-2223

Linked Practices

LA6

Environment ✔✔

Convenient recycling facilities reduce the waste stream to landfill. Baling reduces handling and storage requirements.

Ease of Use ✔✔✔

Providing recycling space is not difficult for most multi-family and commercial buildings. Baling facilities requires additional space and equipment.

Other Benefits ✔✔

Sends a positive message to occupants about waste reduction. Contracted handling services produce employment.

Capital Cost $

Adds minimal cost to construction.

recycling room; or an outdoor enclosure with 8 ft. high walls.

The following features are also required:

- Bins in enclosed areas require exhaust ventilation.
- Food and beverage container storage areas should include durable flooring materials suitable for wheeled bins, wash-down, a hose-bibb and a floor drain.
- Offices should have a white paper area separate from other paper waste.
- Retail occupancies and restaurants should provide for cardboard, bottle and can collection.
- Provide a small, well-lit bulletin board in the recycling area for posting of solid waste reduction and recycling information.

Materials recyclable in the Los Angeles region include:

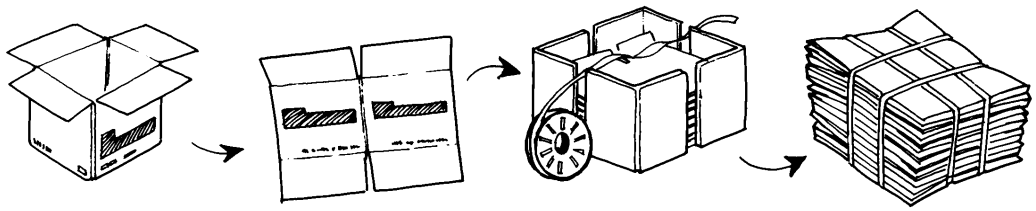
- fine paper
- waste paper
- cardboard
- metals
- plastics
- glass
- garden waste

Building operators should be trained to provide guidance for building occupants and ensure regular emptying and cleaning of the area. Recyclables separation instructions should be posted in universal symbols and several languages.

For retail and office projects over 30,000 sq.ft. provide space, truck access, mechanical and electrical connections for paper and cardboard baling equipment. Balers reduce volume by several times and ease handling of large materials quantities. They also increase the value of the recyclable material to the buyer.

Cautions

- Garden waste should include only grass and shrub cuttings, branches, leaves and similar waste. Food waste should be individually managed due to problems with odor, rodents and flies.
- Baling facilities must be compatible with local recyclables collection services, state and local laws.
- A trained operator is required for correct separation and safe operation of baling equipment.

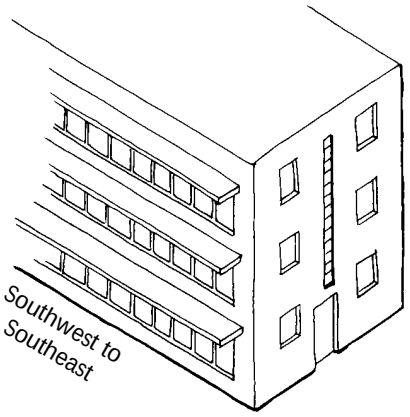


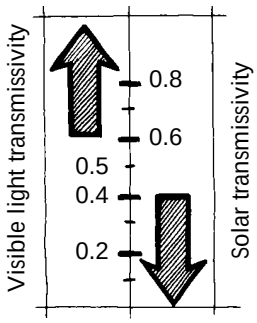
Cardboard baling

EN1

DESIGN WINDOWS TO MAXIMIZE DAYLIGHTING & VIEWS

Window design responds to facade exposure





Ideal glass selection has high visible light transmission but low solar heat transmission. (Note: selective glazing need not appear tinted or reflective)

Window design is the most important building envelope consideration for energy conservation. In Santa Monica, their design should maximize daylighting, views to the exterior and ventilation, while minimizing traffic noise and solar heat gain during cooling periods. Since these considerations vary with building orientation and surroundings, window design will vary from one facade to another. Also, it is important to distinguish between glazing strategies for cooling-load dominated buildings and those providing passive solar gains to offset winter heating requirements.

For cooling-load dominated buildings:

- Increase window area and glazing visible transmissivity on north- and northeast-facing walls to admit more daylight.
- Limit the amount of glazing on west and southwest orientations where mid-afternoon summer sun is difficult to shade effectively with fixed fins or overhangs.

The choice of glazing is critical in ensuring good daylighting. A wide range of glazings is available offering both good admission of daylight and low heat gain.

- Avoid heavily tinted or reflective glasses that reduce solar heat gain but also reduce daylight and exterior views.
- Specify high-performance low-emissivity glazing with visible transmissivity greater than 0.6 and solar transmissivity less than 0.4. This can reduce annual operating energy by 20% compared to a Title 24 compliant building. A further 20% reduction can be achieved if high-performance glazing is combined with daylight controls.

Lightshelves are particularly suited to the predominantly clear sky conditions enjoyed in Santa Monica. Lightshelves reflect sunlight and daylight toward the ceiling, even out light distribution, and shade view windows. The reflected light can significantly reduce electrical lighting needs and associated cooling loads within

Further Information

- Ander, G. 1995
- Baker, et al, 1993
- Brown, 1985
- Lam, W.M. 1986

Linked Practices

EN2
EN4
EN5
CS2

Environment ✔✔✔

Potential for significant reductions in electrical light and cooling energy use.

Ease of Use ✔✔

Few difficulties with alternate glazing choices. Lightshelves require careful analysis and design.

Other Benefits ✔✔✔

Improved occupant views and comfort.

Capital Cost $$

Cost of high-performance glazing and lightshelves offset by reduced HVAC equipment size.

deep plan buildings.

Use a combination of exterior and interior shelves on southeast, south and southwest orientations:

• Exterior shelves sized and shaped to reflect the majority of direct sunlight provide shade for the view window beneath. The best daylight penetration typically results from using light-colored, sloped external shelves.

• Interior shelves sized and shaped to redistribute the light and increase illumination deeper in the building interior.

Use interior shelves on north orientations to improve light distribution in spaces with high floor-to-ceiling dimensions.

Integrate lightshelves and ceiling design:

• Combine lightshelves with flat, light-colored ceilings free of obstructions for better light penetration.

• Slope the ceiling down from the window side to enhance light distribution,and reduce contrast and glare.

Visual contact with the outdoors provides occupants with cues about orientation, time of day and weather, and is important for their sense of well-being.

• Maximize the "information content" of views. Include skyline, upright middle objects (trees, buildings) and horizontal foreground objects (streets, lawns). Tall vertical windows typically provide the best range of views.

• Select glazing with visible transmissivity greater than 0.6 to avoid distortion.

Many of the performance criteria above apply equally to passive-solar heated buildings. The primary additional requirements for window design are that:

• The glazing used to admit winter solar gains has high solar transmission (>0.8) and high thermal resistance (R-value >2.0 sq.ft.hour/Btu).

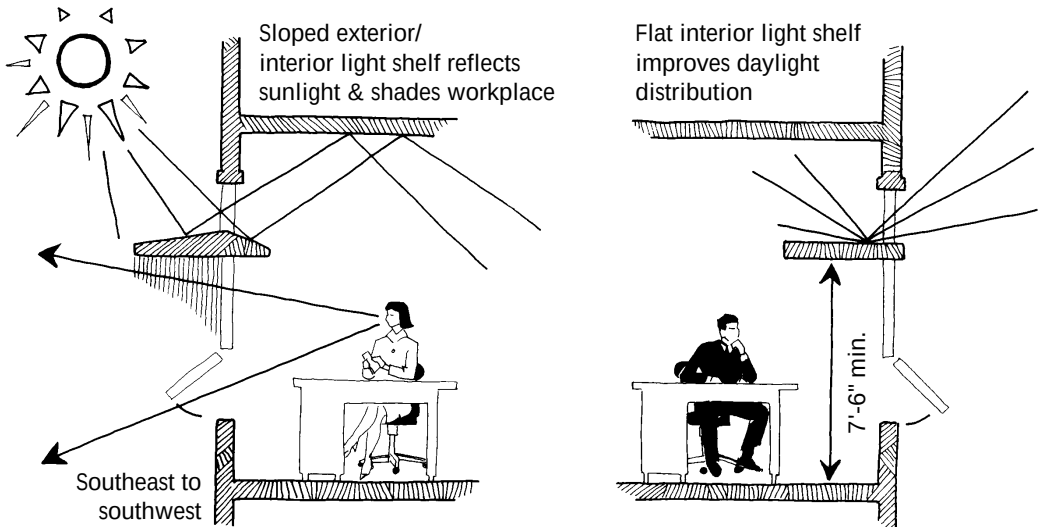
• The window area and distribution used to admit winter solar gains are carefully matched to the thermal mass.

• An effective solar control strategy is incorporated to minimize excess gains during cooling periods.

Cautions

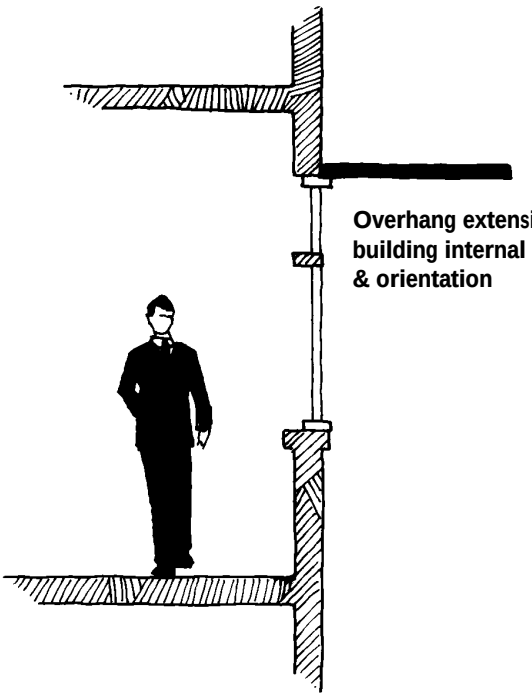
• Use computer energy simulation to evaluate trade-offs between daylight transmission and solar control.

• Avoid reflecting coatings or films since they reduce daylighting opportunities, and may cause glare problems and increased cooling loads for adjacent buildings.



SHADE WINDOWS DURING COOLING PERIODS

EN2



Solar control is a critical requirement for both cooling-load dominated and passively solar-heated buildings. High-performance glazing systems can significantly reduce solar heat gain while still admitting daylight. Exterior shading devices can further reduce solar heat gain, control glare and permit a wider choice of glazing options. The crucial design issue is to achieve a balance between solar control and daylighting.

Awnings and overhangs are the most effective means of solar control since they prevent sunlight from striking the windows. Movable systems are adjustable according to season, but are more prone to failure or misuse. Fixed overhangs are more dependable, but their design must account for daily and seasonal variation of the sun's path.

A properly sized overhang on southwest and southeast oriented windows can reduce energy use by up to 6%. A further 20% can be gained by combining overhangs with daylight controls.

There are no simple rules of thumb for appropriately sizing overhangs. Each project should be evaluated depending on its relative cooling and heating needs.

- Design overhangs appropriately for window size and orientation. The effectiveness of fixed horizontal overhangs on south-facing windows depends on the projection from the window plane and distance above the window.
- Extend the overhang beyond the sides of the window to prevent solar gain from the side.

Environment ✔✔✔

Most effective means of controlling solar heat gain, while maximizing daylighting.

Ease of Use ✔✔

Relatively straightforward. Additional design time to size overhangs and examine impacts on daylighting.

Other Benefits ✔✔

Improved occupant comfort.

Capital Cost $$

Increase in cost offset by reduction in cooling equipment.

Further Information

- Brown, G.Z. 1985
- Crowther, R.L. 1992
- Daniels,K. 1997
- Watson, D & Labs, K. 1983

Linked Practices

SF2
EN4
TR3
CS2

EN2

• Use slatted or louvered shades to allow more daylight to enter, while shading windows from direct sunlight. Tightly spaced louvers near the window shade high summer sun, and loosely spaced louvers further away shade low winter sun.

• Reduce solar heat gain by recessing windows into the wall. The reduction depends on the size of the window and tends to be modest for recesses less than 6 in. Deeper recesses provide additional shade and control glare, but may reduce daylighting.

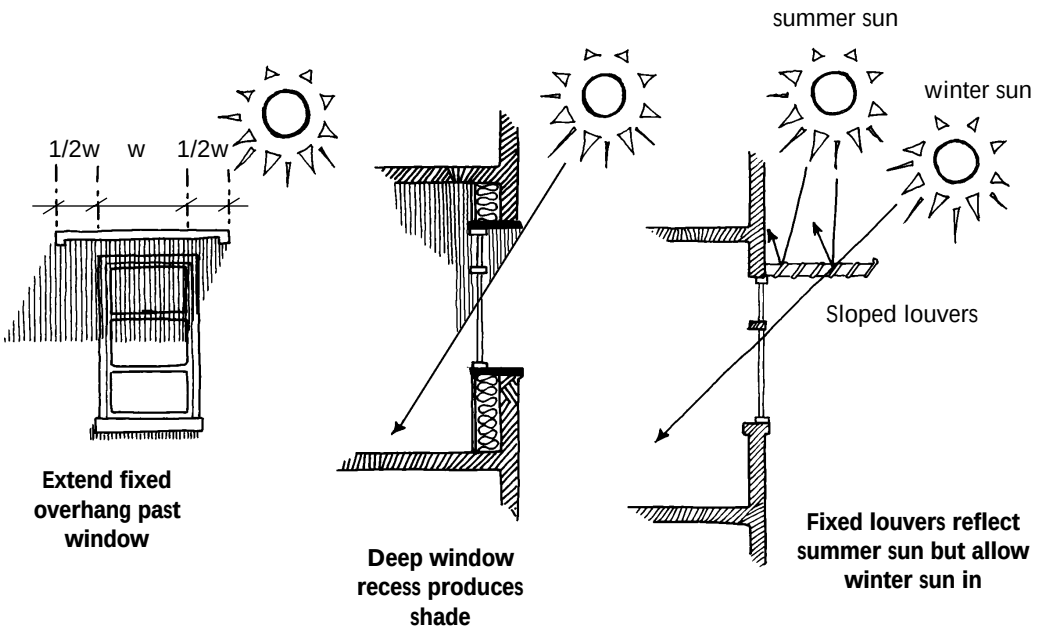
Vertical fins at right angles from windows on southwest and southeast orientations are typically not effective in Santa Monica. Designs should be carefully evaluated using shading studies to ensure effective shading is provided without compromising daylight.

Cautions

• Carefully examine possible reductions in daylighting caused by fixed overhangs or fins.

• Peak cooling and heating loads trail summer and winter solstices by up to a month.

• Shading devices should not block openings for natural ventilation.



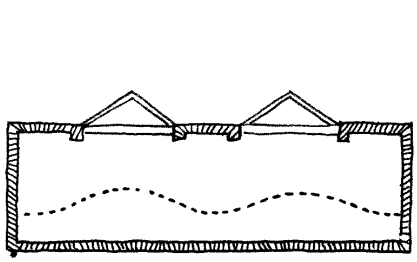
Extend fixed overhang past window

Deep window recess produces shade

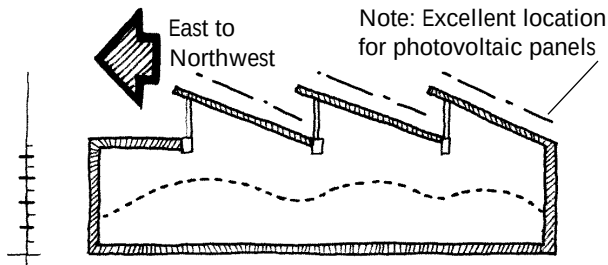
Fixed louvers reflect summer sun but allow winter sun in

EN3

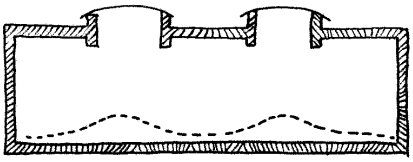
USE ROOF MONITORS FOR DAYLIGHTING UPPER FLOORS



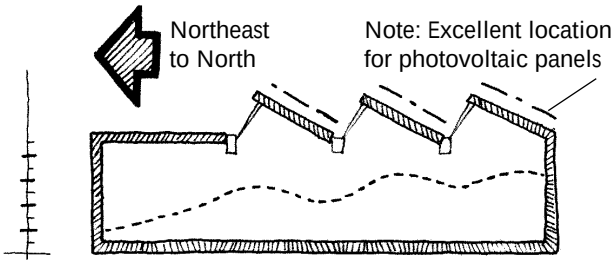
Splayed short-well skylights have better light distribution



Roof monitor



Deep well skylights illuminate best directly below



"Sawtooth" roof

Roof monitors and other forms of top-lighting, such as skylights, roof monitors and sawtooth roofs, are particularly applicable to Santa Monica because the majority of buildings are low-rise. In addition to daylighting, operable roof monitors provide excellent opportunities for natural ventilation while avoiding traffic noise problems.

Top-lighting provides interior light that is significantly different from that provided by windows:

- It can provide relatively uniform light distribution throughout a space.
- It is often easy to integrate with electric lighting because light originates from the ceiling in both cases.

Roof monitors can be designed to admit daylight and sunlight, although sunlight is difficult to control and best avoided:

- Make the roof aperture between 4% to 8% of the floor area.
- Shape the roof monitor to admit only daylight from the north.
- Consider integrating photovoltaic collectors on south-facing sides of the monitor.
- Splay the walls and use matte white reflecting surfaces around the monitor to improve light distribution and reduce glare.
- If a view of the sky is not critical, use diffusing glass to give better distribution of light.

Cautions

- Avoid using horizontal skylights, which result in excessive solar gains in summer.
- Brighter sky visible through skylights can cause glare problems.

Environment ✔✔✔

Potential for significant reductions in electrical light and cooling energy use.

Ease of Use ✔✔

Few difficulties.

Other Benefits ✔✔✔

More comfortable and desirable working conditions.

Capital Cost $$

Cost of roof monitors offset by reduced HVAC equipment size.

Further Information

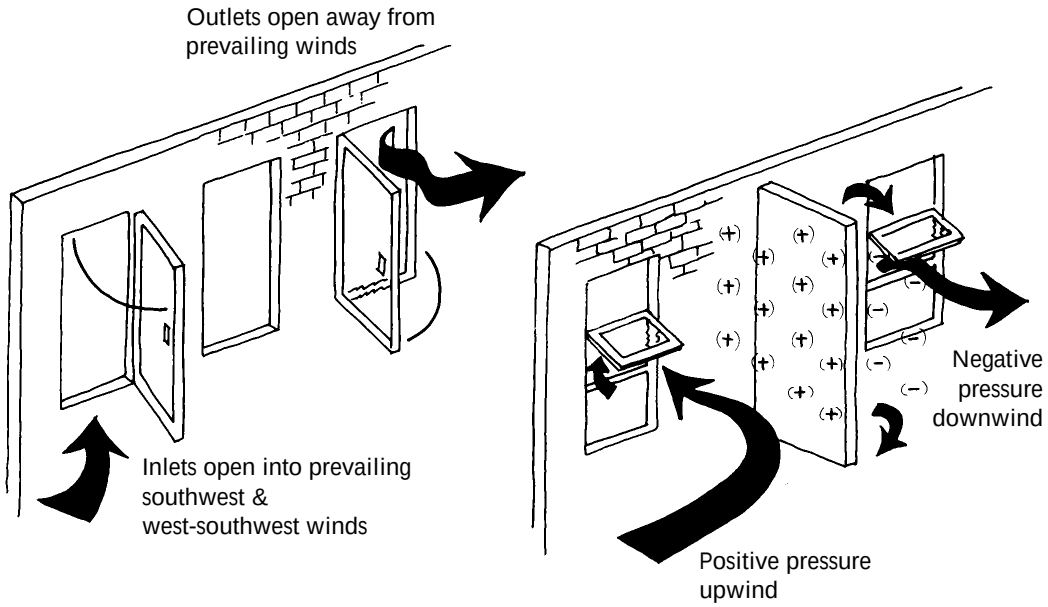
- Robbins, C.L. 1986

Linked Practices

EN5
CO1
CO2
CS2

EN4

DESIGN WINDOWS TO MAXIMIZE NATURAL VENTILATION



Environment ✔✔
Site, context and occupant dependent. Cooling equipment can be downsized or eliminated if occupants will accept occasionally higher temperatures.

Ease of Use ✔✔
Airflows and effectiveness less predictable in complex buildings.

Other Benefits ✔✔
Operable windows provide occupants with greater control over indoor conditions.

Capital Cost $$
Site and context dependent. Potentially smaller HVAC equipment.

Windows should be designed to admit natural ventilation. The most important design issue is whether the windows provide single-sided or cross-ventilation to interior spaces.

The amount of air that flows through a window (ventilation capacity) depends on the area and vertical distribution of openings. These depend on the way the window opens.

Horizontal pivot windows offer the highest ventilation capacity:

- For single-sided ventilation, place them as high as possible to exhaust warm air at ceiling level.
- Air entering through the upper opening is directed toward ceiling, making night-time cooling more effective.

Center vertical pivot windows have less ventilation capacity than horizontal pivot windows, but can act as wind scoops when wind direction is parallel to the building face.

Casement windows offer the same advantages as vertical pivot windows but are susceptible to gusts. If using casements to channel wind:

- Open into prevailing winds when used as inlets.
- Open away from prevailing winds when used as outlets.

If not part of the window design itself, incorporate fins, overhangs or articulation to create high and low wind pressure areas, and to channel incoming air.

Further Information
- CIBSE, 1997
- Crowther, R.L. 1992
- Givoni, B. 1994

Linked Practices
SF1
EN5
CS1

• Use vertical fins to improve natural ventilation of rooms with only one exterior wall. Provide two separate operable windows on upwind and downwind sides of fins, for inlet and outlet.

• Articulate the building facade (e.g., with bay windows) to create localized pressure differences. Place windows on adjacent or opposite faces of the protrusion as inlets and outlets.

Noise is a common irritant in the workplace and can be caused by sound transmission paths through windows. It is typically most severe on the first three floors of urban buildings, or near major streets. Windows on affected exposures of the first three floors should have a Sound Transmission Class (STC) of 35 or better. Sound leaks through cracks normally establish window noise ratings regardless of glazing.

• Block direct path of sound travel. Sound transmission through an "open" window can be reduced by 25%. by specifying the opening to redirect noise.

Often windows required for view and daylighting are not in appropriate locations for effective natural ventilation. Here, it may be appropriate to incorporate operable vents specifically located and designed to admit controlled amounts of ventilation air.

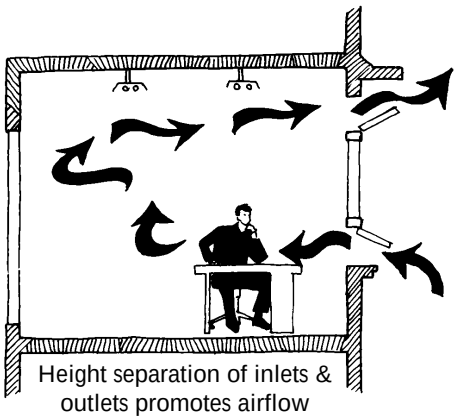
Cautions

• Vertical fins used to redirect winds may restrict views. Transparent fins function as well, but are expensive.

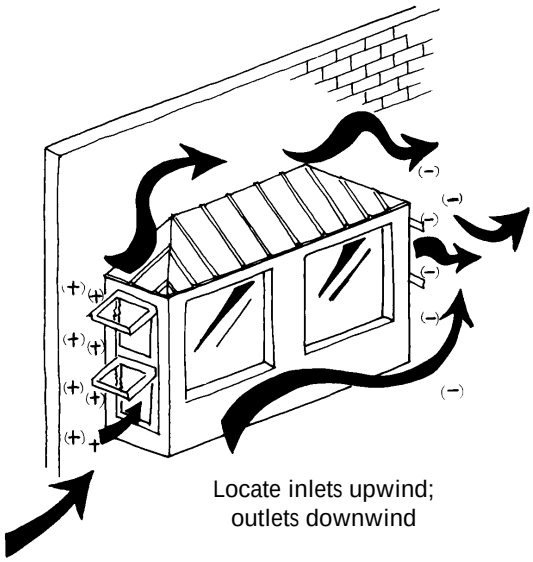
• Carefully consider the effects of adjacent buildings on site wind flow patterns. Complex locations and buildings may require model wind tunnel testing.

• If operable windows are used for ventilation, window sensors should be used to shut down the mechanical cooling system, if any.

• Consider maintenance and cleaning of operable windows and the use of blinds.



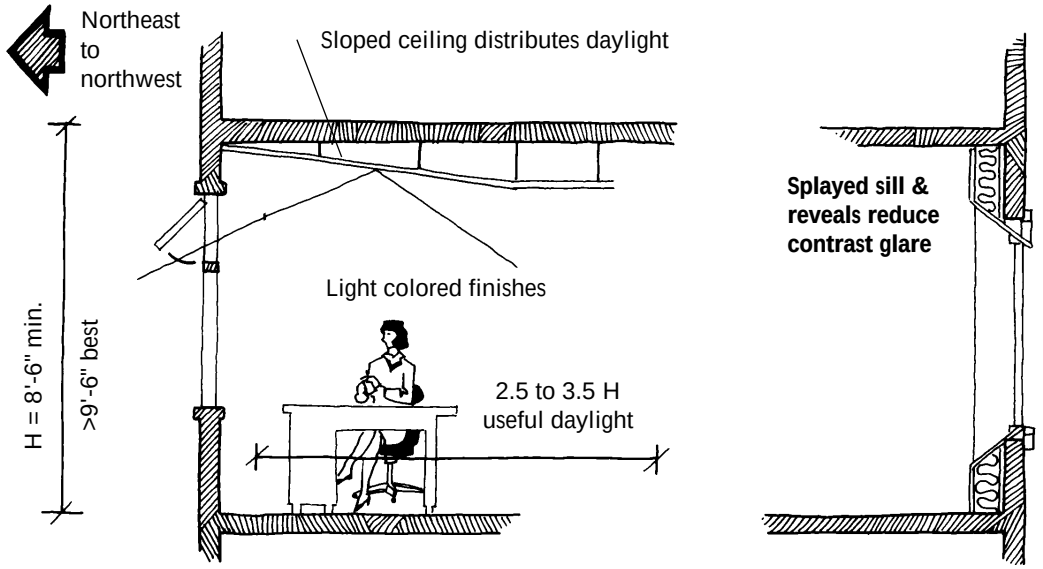
Height separation of inlets & outlets promotes airflow



Locate inlets upwind; outlets downwind

EN5

SHAPE & PLAN THE INTERIOR TO ENHANCE DAYLIGHT & NATURAL AIRFLOW DISTRIBUTION



Environment ✔✔
Reduced peak electric demand and cooling equipment size.

Ease of Use ✔✔
May require more careful interior planning. Airflows and effectiveness less predictable in complex buildings.

Other Benefits ✔✔✔
Enhanced indoor quality and occupant satisfaction due to individual control.

Capital Cost $$
Depends on program requirements for security. Lighter interior finishes need not cost more.

The layout and shape of the interior determine the effectiveness of daylighting and natural ventilation.

The depth of daylight distribution is a function of window height relative to the working plane. Increased ceiling height gives more flexibility, allowing devices such as lightshelves to bounce light deeper into the interior.

- Design ceiling heights 9 ft. 6 in. or greater to permit the use of taller windows.
- Separate the window into upper and lower portions, to independently control daylight, natural ventilation and view.
- Use light colors on interior surfaces, especially walls and ceilings, to increase the daylight that reaches areas remote from windows.
- Use splayed, light-colored window sills and reveals to reduce contrast and glare.
- Align interior partitions perpendicular to windows to avoid blocking daylight.
- Shape the ceiling and use secondary reflecting surfaces to further diffuse daylight.

Cross-ventilation depends on a continuous air-flow path. Open-plan layouts are ideal, but where spaces are subdivided, rooms must be designed to allow air-flow in and out, between rooms and through occupied areas.

- Locate larger spaces on the windward side of the building. This provides improved air distribution in all linked interior spaces.
- Use false ceilings above corridors and

Further Information

- Allard, F. 1998
- Baker, N. et al, 1993
- Brown, G.Z. 1985
- CIBSE, 1997
- Lam, W.M. 1986

Linked Practices

EN1
EN4
SF1
CS2

passageways to create breezeways for airflow between rooms on either side of the passage.

• Use operable transom windows in walls to permit a free flow of air and daylight.

• Use high ceilings to allow heated air to rise out of occupied zones.

Noise within the building from occupants, HVAC equipment and plumbing is a common irritant and is usually caused by poor sound isolation in floors and walls, or by poor equipment selection.

The integrity of acoustical partitioning can be achieved by:

• Extending partitions above the suspended ceiling.

• Eliminating holes for ducts, pipes, conduits, cables, etc., and sealing around necessary ones.

• Minimizing sound transmission through air ducts passing through the partition with baffles & duct liners.

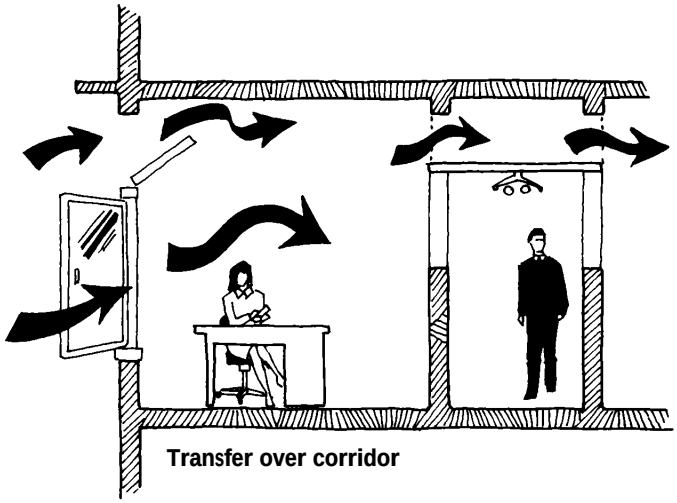
• Isolating piping from the structure.

Cautions

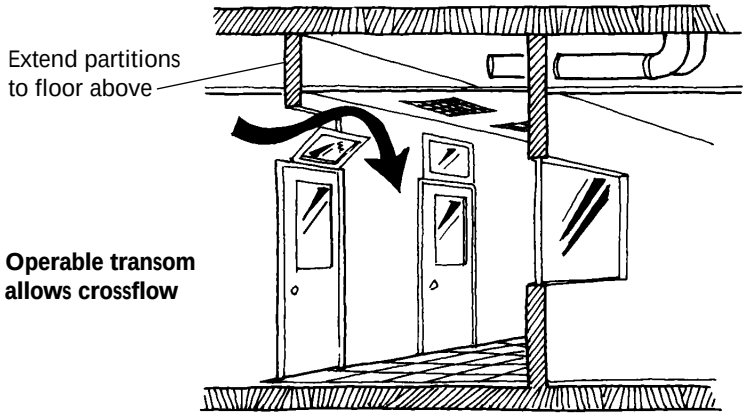
• Avoid creating stagnant zones with little airflow.

• Continuous air paths can reduce acoustic privacy.

• Although changing airflow direction can lead to more even distribution, the air tends to slow down and lose some of its cooling effect.



Transfer over corridor



Operable transom allows crossflow

EN6

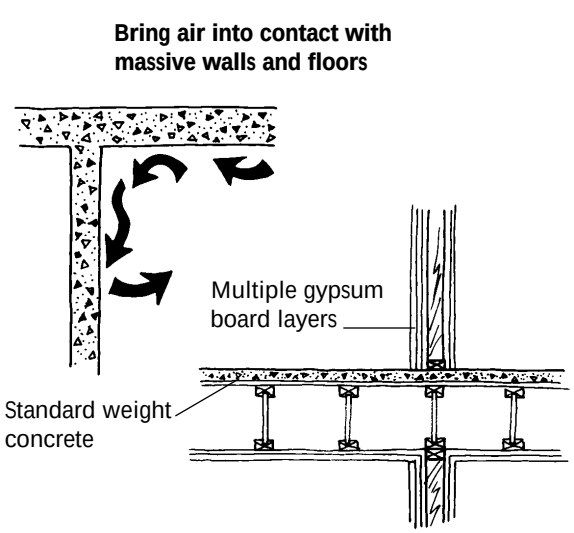
INCORPORATE THERMAL MASS INTO BUILDING STRUCTURE

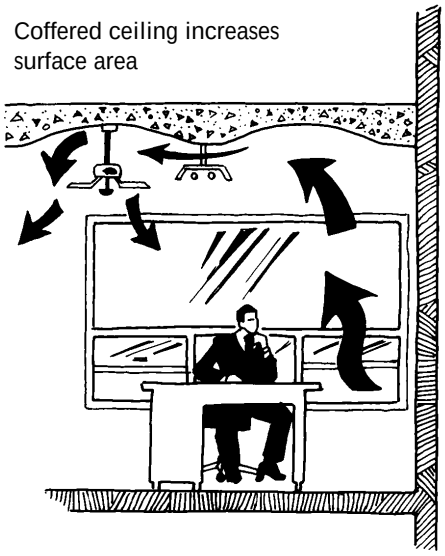
Environment ✔✔
Reduced peak electrical demand and cooling equipment size.

Ease of Use ✔✔
Careful design needed to resolve conflicts with acoustic and electrical lighting design.

Other Benefits ✔✔✔
Greater comfort in summer through lower surrounding surface temperatures.

Capital Cost $
Few or no additional costs if mass is inherent in building. Exposing thermal mass can reduce finishing material costs.





Thermal mass can moderate the temperature of occupied spaces, minimize the need for mechanical cooling and reduce winter heating requirements, but to do so it must be "coupled" to heat sources and some means of distribution such as the air handling system. Although greater mass in a building means that more heat can be stored, practical issues limit the useful amount.

Providing dedicated thermal mass is expensive with the possible exception of multiple layers of gypsum board and high-density concrete topping on wood floor systems. The most cost-effective method usually is to take advantage of thermal mass in the building structure.

In most commercial buildings, poured concrete or cellular precast slabs and shear walls are the largest thermal mass.

- There is little performance increase beyond 4 in. thickness. A 3-in. slab provides 95% of the performance of a 4 -in. slab.
- High-density concrete provides more thermal mass than low-density concrete. In multi-unit wood building construction, the thin concrete layer often placed on wood subfloors for fire retardancy and acoustic separation can be made from high-density concrete.
- Improving airflow across the surface is usually the most cost-effective means of using thermal mass.

The amount of heat transferred to and from walls and floor slabs can be increased by maximizing the exposed surface area.

- The corrugated profile of steel decking sections used in concrete composite floors can

Further Information
- Heschong, L. 1996
- Ogden, R. et al. 1998

Linked Practices
EN4
EN5

increase surface area by 15% to 50%. Use coffered ceilings or waffle slabs to increase surface area, but also provide smooth reflective surfaces for daylight distribution.

• Expose the underside of floor slabs to the inhabited spaces.

• Use operable windows and HVAC diffusers that direct airflow toward massive elements at night to lower their temperature.

Suspended ceilings create an insulating barrier. If a suspended ceiling must be used for acoustic control or to hide lights, ducts or wiring, provide "thermal transparency" in the ceiling:

• Use perforated or open-grid ceiling tile. Even 15% open area can allow significant air circulation.

• Limit the area of massive elements covered.

If mechanical ventilation is used:

• Use ceiling-mounted fans to assist air movement and mixing with air being introduced through open windows.

• Pass air beneath raised floors over an exposed floor slab. The cool air can then be introduced to the room through floor-mounted diffusers to provide displacement ventilation.

For passive solar heating, either "direct" or "indirect" thermal storage:

• Use concrete, adobe, tile, brick, stone or masonry floors. Here, the thermal mass must be exposed directly to winter sunlight.

• Use double gypsum board throughout the spaces "thermally linked" to south facing windows or clerestories. This diffuse thermal mass approach depends on inter-reflected sunlight and convection currents to transfer the solar heat gain to the wall surfaces.

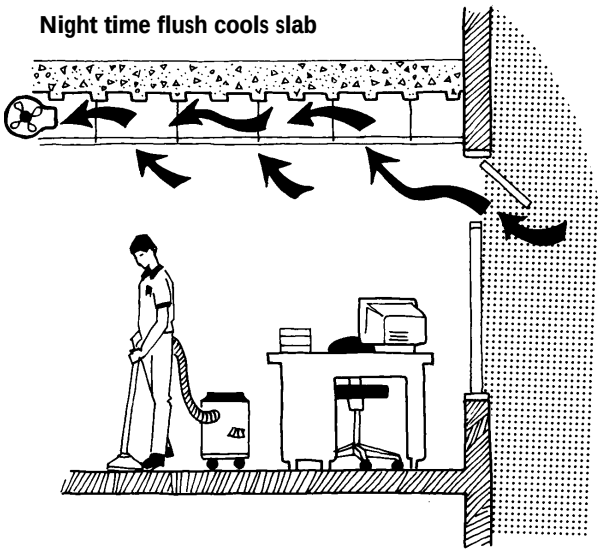
Cautions

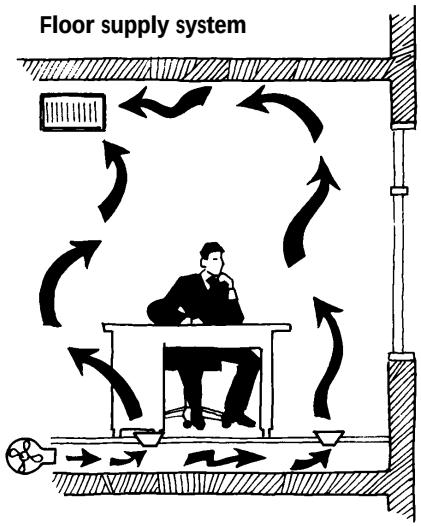
• Exposed hard surfaces reflect sound. Pay attention to noise distribution.

• Additional thermal mass, such as high-density concrete topping, will alter structural and seismic loads. Consult with structural engineer.

• If night ventilation is automatically controlled, use simple systems. If manually controlled, make them foolproof.

• If cooling loads are low, thermal mass benefits are limited.





EN7

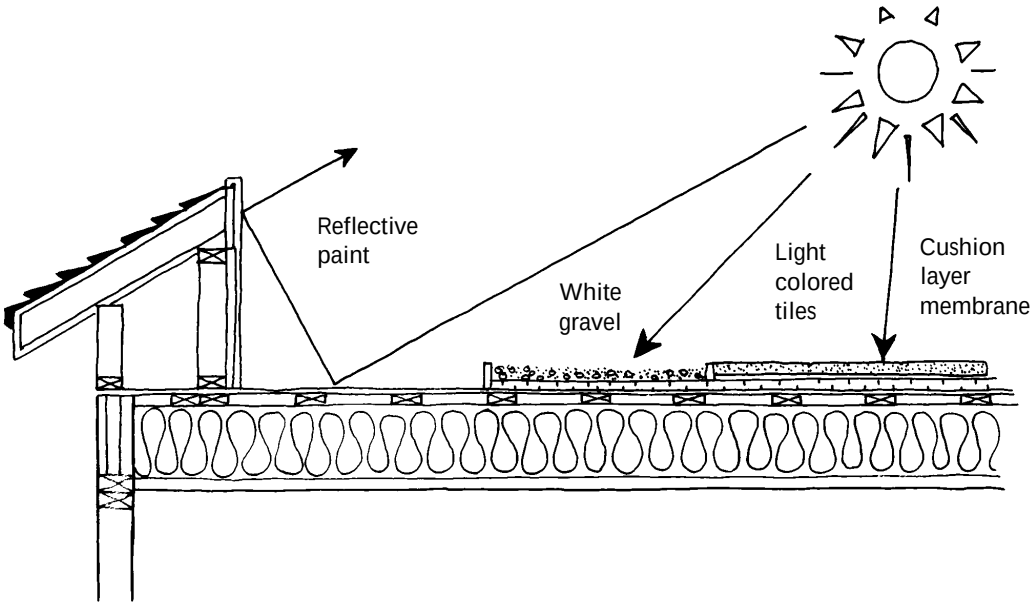
SELECT LIGHT COLORS FOR EXTERIOR FINISHES

Environment ✔✔
Reduced cooling load.

Ease of Use ✔✔✔
Few problems.

Other Benefits ✔✔
Less thermal stress on building envelope increases life of finish materials.

Capital Cost $
Light colored surface treatments do not need to increase cost.



Solar heat gains conducted through roofs can considerably increase cooling loads. Improving roof insulation or increasing the roof reflectivity can reduce solar gains.

Increasing the roof reflectivity to 0.7 or more can reduce solar heat gains by 80% compared to typical dark roofs. This can be achieved by a variety of techniques, such as covering the exterior surface of the roof with white gravel ballast, light-colored tiles or reflective paint.

Solar gains through roofs can also be reduced using reflective foil radiant barriers located in attic spaces of cavity roof systems, e.g., gable roofs. They are proven effective at lowering cooling demand, and can be retrofitted above thermal insulation and below the ventilated cavity.

Cautions

- Light colors on roofs are difficult to maintain in urban areas.
- Structural loading design must account for ballast.
- If using gravel ballast, fit gravel stops around rainwater drains and the roof perimeter.
- Reflective foil radiant barriers can raise attic air temperature and roofing surface temperature dramatically, so an attic fan is usually an important complement.

Further Information

- Crowther, R.L. 1992
- Dubin, F.S. and Long, C.G. 1978
- Givoni, B. 1998

Linked Practices

FURTHER INFORMATION

Ander, G. 1995. *Daylighting Performance and Design*, John Wiley & Sons, New York.
Excellent quick reference and guide for design professional, providing current data and tables applicable to daylight design in California conditions.

Allard, F. (ed.) 1998 *Natural Ventilation in Buildings: A Design Handbook*, James & James, London.
Exhaustive coverage of the theory and practice of natural ventilation in buildings, providing the fundamentals, prediction and diagnostic techniques as well as design guidelines, technical solutions and case studies.

Baker, N., A. Fanchiotti, and K. Steemers, (eds). 1993 *Daylighting in Architecture: A European Reference Book*. Commission of the European Communities, Directorate-General XII for Science Research and Development, James & James, London.
Comprehensive guide on daylighting design concepts, strategies and technologies, illustrated with numerous examples and case studies.

Brown, G.Z. 1985. *Sun, Wind and Light: Architectural Design Strategies*. John Wiley & Sons, New York.
Good introduction to form-generating potential of sun, wind and light in the earliest stages of building design with emphasis on reducing energy use. Covers design strategies, analysis techniques and strategies for supplementing passive systems.

CIBSE Project Task Group. 1997. *CIBSE Design and Applications Manual: Natural Ventilation in Non-Domestic Buildings*. Chartered Institute of Building Services Engineer (CIBSE), London.
Invaluable applications manual to enable design professionals to build an understanding of natural ventilation. Excellent overview of strategies, rules of thumb, detailed calculation methods and a range of European case-study buildings.

Crowther, R., L., 1992. *Ecological Architecture*. Butterworth Architecture, Boston.
Primer on ecological design, emphasizing the importance of holistic building design and its integration with natural systems. Case-studies by author and design guidelines for design, landscaping and planning.

Daniels, K. 1997. *The Technology of Ecological Building: Basic Principles and Measures, Examples and Ideas*. Trans. Elizabeth Schwager. Birkhauser, Boston.
Useful introduction to the technology of ecological building, offering detailed analysis of numerous European environmental case-study projects and emerging technologies.

Dubin, F..S., and Chalmers G. L. Jr. 1978. *Energy Conservation Standards for Building Design, Construction and Operation*. McGraw-Hill, New York.
Dated but useful guide offering an in-depth discussion of the relationship between mass, color, orientation, insulation and solar gain.

Givoni, B. 1994. *Passive and Low Energy Cooling of Buildings*. Van Nostrand Reinhold, New York.
Comprehensive coverage of passive and low energy cooling strategies for buildings with hot summers. Deals with both technical principles and practical guidance.

Givoni, B. 1998. *Climate Considerations in Building and Urban Design*. Van Nostrand Reinhold, New York.
Comprehensive and current reference on building climatology, providing solutions to site, planning and design issues

Heschong, L. 1996. Sustainable Building Technical Manual. Public Technologies Inc., Washington D.C.
Like other sections of the Sustainable Building Technical Manual, Renewable Energy (Chapter 12) offers a concise, valuable overview of the topic. Chapter highlights design considerations for passive solar heating, cooling and thermal storage as well as active systems.

Lam, W..M. 1986. *Sunlighting as Formgiver for Architecture*. Van Nostrand Reinhold, New York.
Comprehensive coverage of the techniques for using natural lighting in buildings for energy savings and enhanced indoor lighting quality. Numerous case studies illustrate the "sunlighting" concepts and strategies.

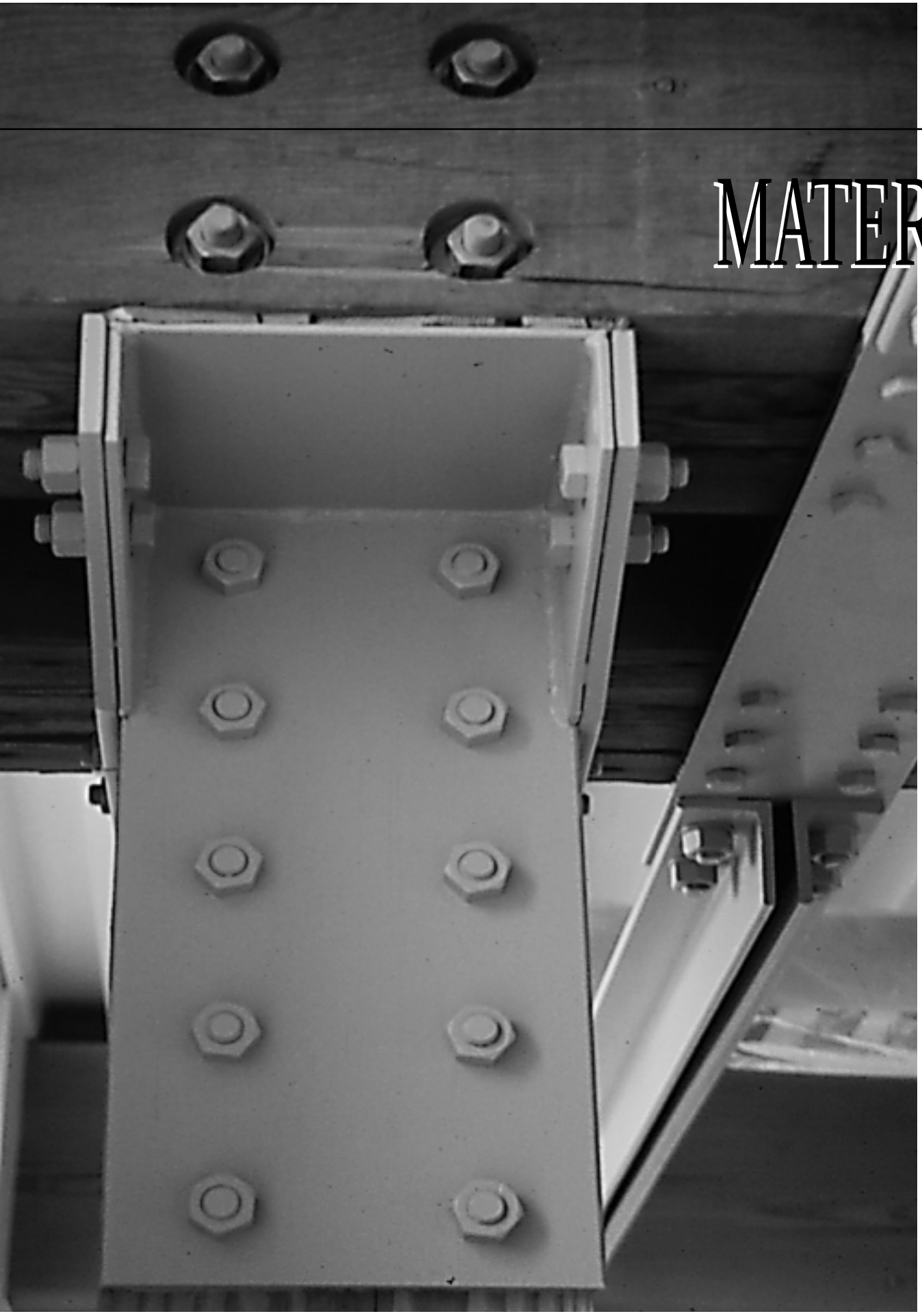
Mazria, E. 1979. *The Passive Solar Energy Book: Expanded Professional Edition*. Rodale Press, Emmaus, PA.
Clearly illustrated primer and resource on fundamental concepts of passive solar design containing step-by-step process for designing and sizing passive solar buildings.

Ogden, R.,C, Kendrick., & M. Gorgolewski. 1998. "*Use of Thermal Storage to Provide Passive Cooling in Steel Framed Buildings*". Proceedings: Green Building Challenge 1998, Vancouver, BC.
Technical paper reporting on current UK research on the effective use of thermal mass in commercial buildings, comparing alternative structural systems and suspended ceiling designs.

Robbins, C.L. 1986. *Daylighting: Design and Analysis*. Van Nostrand Reinhold, New York.
Thorough and detailed coverage of basic and advanced daylighting concepts, methods of analyzing both quantitative and qualitative performance and the integration of daylight and electric lighting. Useful tables and design data.

Watson, D.and Labs, K. 1983. *Climatic Building Design: Energy Efficient Building Principles and Practices*, McGraw-Hill, New York.
Useful introductory text illustrating ways to evaluate local climate and offering a wide range of building design strategies to take advantage of site environmental and climate conditions.

MATERIALS



MATERIALS

Building materials form a large part of the overall environmental burden of buildings:

- Raw materials extraction damages ecosystems, consumes energy and degrades water quality.
- Manufacturing produces waste and pollution, including toxic waste.
- Many materials, once installed, release toxic gases, affecting occupant health.
- Material cleaning and maintenance often causes health risks and toxic waste.
- Eventual disposal wastes recoverable resources, consumes landfill space and often degrades groundwater.

However, not all materials are equal. "Green materials" used in building are carefully selected for low consumption of scarce raw materials; low pollution in their production, delivery, use and disposal; long life; low maintenance; and their suitability for salvage or recycling.

Salvaging Buildings and Products

One of the most effective means of reducing new materials use is remodeling or adaptive reuse of all or parts of existing buildings. When feasible, this is often a better environmental option than demolition and recycling, and helps preserve the history of the neighborhood. However, the energy consumption of existing buildings should be carefully considered when assessing the environmental merits of a project. Major renovations are the best time to incorporate envelope upgrades such as improving insulation, installing high-performance windows and sealing air leakage.

In some projects, valuable materials salvaged from demolition can be used in the new design, avoiding the waste and pollution of new production. If there are no salvageable materials available from the site, they can be purchased directly from building demolition sales, from salvage contractors and used materials dealers.

Environmental Issues of Materials Choices

The importance of materials choices is increasingly recognized in green building design and construction, as well as in all types of purchasing. "Green purchasing" received national attention in 1998 through Executive Order 13101, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition", one of a series of presidential orders bringing environmentally-responsible practices to government. The order mandates that greener materials will be preferred in all federal purchasing, and defines how to perform life-cycle assessments to determine materials' environmental impacts.

Life-cycle assessment of construction materials and assemblies is complex and time-consuming. Fortunately there are now several programs that rate products for their environmental performance and award "environmental labels" to those with merit. These certification programs can be of great aid to concerned designers and specifiers.

A complete life-cycle assessment of a material includes consideration of:

- resource extraction
- manufacturing and transportation
- installation
- operation and maintenance
- salvage, recycling and disposal

Recycled-Content Products

Many new and established construction products made with reprocessed waste materials are now available. Products with recycled content are "industry ready", generally of equal or better quality, and usu-

ally require no special handling. Some products, such as outdoor lumber made with waste plastics and composite panels made with mineral waste and plastic, are uniquely suited to some applications, and have new uses that are still being explored.

It is important to obtain information from manufacturers verifying that the recycled content listed for a product is actually material that would otherwise have been discarded. Materials containing post-consumer waste or recovered materials have the greatest recycling merit. In-plant recycling, though it increases the efficiency of manufacturing, does not have the same environmental benefits since it does not close the consumer/manufacturer waste loop.

Healthy Products

Many building products contain chemicals that evaporate or "offgas" for several days or weeks after installation. If large quantities of these products are used inside a building, or products with particularly strong emissions are used, they pollute the indoor air. Other products readily trap dust and odors and release them over time. Building materials can also support growth of molds and bacteria, particularly if they become damp, potentially causing allergic reactions, respiratory problems and persistent odors - symptoms of "sick-building syndrome".

Recently, several lawsuits with large damage awards have been won by building occupants suffering from health problems linked to chemicals offgassed from building materials, setting legal precedents across North America. This is prompting many insurance companies to examine their policies and their clients' design and construction methods. Following a rigorous selection procedure for construction materials, aimed at minimizing occupant chemical exposure, is an effective way to reduce health risks – and exposure to liability by building developers, designers, contractors and operators.

The most common "unhealthy materials" associated with health problems in buildings are pesticides, engineered wood products and furniture containing formaldehyde glue, new carpets, plastic and rubber flooring, new paint, mineral and glass fiber insulation, and glues and caulking used for interior construction. Most other sick building problems are related to moisture problems, faulty heating and air-conditioning equipment and extraordinary pollution sources.

Healthier materials have minimal chemical emissions, dust release and cleaning or maintenance procedures requiring toxic chemicals. They help to make healthy buildings and are better for the environment and the safety of those who make and install them.

Healthy building practice extends well beyond the building design; it requires building occupants to select and use safe maintenance chemicals, restrict smoking and other pollution sources, and reduce waste.

Local Economy

A healthy community has a healthy local economy; building construction can aid by using local products and services where they are available. A locally based economy can be more sustainably managed than one based on imported materials and exported goods and services. Local materials, such as stone, tile, brick and timber, also give a building a quality of "place", or belonging in the region.

As well, local materials substantially reduce the energy and environmental impacts of transporting materials long distances.

Product Leases

One recent trend in building product selection is to lease the use of a product from the manufacturer instead of purchasing it, similar to the way furniture and office equipment are leased. The lease method has been recently applied to carpet, office partition systems, air-conditioning equipment and lighting. The principle of the lease is that many organizations do not want to own and maintain these items, they only want the services provided by them. If users can pay a monthly fee and eliminate their role in maintenance, they can save on capital costs and concentrate on their own business.

An environmental lease is one in which the supplier provides the product and the installation, arranges for maintenance as required, and removes and recycles the product when its service life has ended. A lease that holds the manufacturer responsible for recycling provides an incentive for them to make recyclable products and operate recycling facilities.

MATERIALS PRACTICES SUMMARY TABLE

Required Practices

Ordinance	Subtitle
MAa SMMC #	Require Recycling of Demolition & Construction Waste in Construction Contracts
MAb SMMC #	Specify Recycled Products per EPA Purchasing Guidelines

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
MA1 Restore & Incorporate Portions or Entire Existing Buildings in New Designs.	✔✔✔	✔	✔✔	**$$**
MA2 Specify Reuse of Salvaged Building & Landscape Materials	✔✔✔	✔	✔✔	**$**
MA3 Design with Panel, Precut & Engineered Construction Products to Minimize Waste	✔✔	✔✔✔	✔	**$**
MA4 Specify Durable Exterior & Interior Finishes.	✔✔✔	✔✔	✔	**$$$**
MA5 Design Interior Building Components for Future Disassembly, Reuse & Recycling	✔✔	✔✔	✔✔✔	**$$**
MA6 Specify Wood from Sustainably Managed Sources	✔✔✔	✔✔	✔✔✔	**$**
MA7 Use Low-Emission Finishes & Interior Materials to Reduce Indoor & Environmental Pollution	✔✔✔	✔✔	✔✔	**$$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

MAa

REQUIRED PRACTICE

SMMC

REQUIRE RECYCLING OF DEMOLITION & CONSTRUCTION WASTE IN CONSTRUCTION CONTRACTS

Environment ✔✔
Increases construction and demolition waste recycling and reduces solid waste volumes.

Ease of Use ✔✔
Contract clauses and on-site verification are a small additional management effort.

Other Benefits ✔
Supports jobs in recycling industries.

Capital Cost $
Inexperienced contractors may charge more at first for recycling. Experienced contractors typically have found disposal cost savings, and charge no more for recycling.

SECTION 01505 - PROJECT WASTE MANAGEMENT
PART 1 - GENERAL

1.1 WASTE MANAGEMENT GOALS FOR THE PROJECT

.1 The Owner has established that this Project shall generate the least amount of waste possible and that processes shall be employed that ensure the generation of as little waste as possible. These shall include prevention of damage due to mishandling, improper storage, contamination, inadequate protection or other factors as well as minimizing over packaging and poor quantity estimating,

.2 Of the inevitable waste that is generated, the waste materials designated in this specification shall be salvaged for reuse and or recycling. Waste disposal in landfills or incinerators shall be minimized. On new construction...

For full sample specification, see Appendix A

Municipal ordinances, regional incentives and even disposal cost savings stimulate recycling of construction and demolition waste. However, specific demolition salvage and waste recycling instructions for the contractor must be included in the construction contract and verified onsite by project management.

The contract or specification should require that the contractor tracks salvage, recycling and landfill shipments and keeps disposal receipts. The project architect or manager should review these, and recycling and disposal reports submitted to the City's Solid Waste Division.

Where buildings already exist on a development site, require an initial site inspection with the architect or project manager to identify materials for salvage and reuse or for recycling. Set specific targets for salvage and reuse, and for recycling. The numbers below are rough guidance:

- Structural metals – at least 70% salvaged for reuse after inspection, balance recycled.
- Architectural metalwork – at least 70% salvaged for reuse, balance recycled.
- Structural, large-dimension timbers (6x6 and larger) – at least 60% of timbers in good condition salvaged for reuse after inspection and regrading.
- Interior millwork (doors, stairs, trim, paneling, etc.) – at least 40% of material in good condition salvaged for reuse.
- Hardwood floors – at least 70% of material in good condition salvaged for reuse.

Further Information

- SMMC #
- LA SRCRD. 1998 (1), (2), (3)
- Construction Materials Recycling Assn. Of So. Cal.
- Triangle J Council of Govts. 1995
- Metropolitan Portland website. 1999

Linked Practices

LA7
CMa
CMb
CMc
CMe
CM1

• Plumbing fixtures – at least 60% of fixtures with heritage merit salvaged for reuse (except toilets using greater than 2.0 gal. per flush).

• Brick – at least 30% salvaged for reuse. (Note: brick is not accepted for crushing.

• Framing lumber – at least 25% of 2x8 and larger salvaged for reuse after inspection if quality is good.

• Lighting fixtures and air registers – at least 60% of items still in common use salvaged for reuse, balance recycled for materials.

In 1997, Morley Construction compared costs for recycling demolition and construction waste for a project in Santa Monica. Reduced disposal costs produced a significant overall saving on the project, even after paying extra labor to manage and separate waste on the site.

Cautions

• Contract progress payment claims should be dependent on recycling and salvage performance. Include a penalty for poor performance.

• The only acceptable evidence of recycling is scale tickets and receipts.

MAb

REQUIRED PRACTICE

SMMC

Environment ✔✔

Materials with recycled content help significantly to reduce solid waste from consumers and industry.

Ease of Use ✔✔✔

Little effort required to locate materials with recycled content. No extra effort is required to use them on a jobsite.

Other Benefits ✔✔✔

Supports industries leading in resource conservation and more environmentally sustainable employment.

Capital Cost $

The majority of materials with recycled content cost the same as materials of similar quality and performance without recycled content.

SPECIFY RECYCLED PRODUCTS PER EPA PURCHASING GUIDELINES

EPA RECYCLING GUIDELINES, BUILDING PRODUCTS

Product	Total Recovered Materials	Notes
Insulation, rock wool	75%	From mineral slag (smelting waste)
Insulation, fiberglass	>20%	From waste glass cullett (consumer containers)
Insulation, cellulose	75%	From newsprint
Insulation, plastic fiber batt	100%	From PET soda bottles
Carpet, polyester face fiber	>25%	From PET soda bottles
Concrete, fly ash	>15%	Coal ash as a proportion of cement in mix
Concrete, ground slag	>25%	Furnace slag as a proportion of cement in mix
Latex paint, reprocessed	20 – 100%	Consolidated or reprocessed. Colors limited.
Gypsum board	>10%	Recycled gypsum and face paper
Rubber or plastic patio block	>90%	Tire rubber and waste plastic
Rubber or plastic floor tiles	>80%	Commercial tile. Tire rubber and waste plastic
Structural fiber board	100%	Wood, paper or agricultural waste fiber
Laminated paper board	100%	Post-consumer paper
Shower or restroom dividers, steel	>20%	
Shower or restroom dividers, plastic	20 – 100%	Post-consumer plastic
Hydraulic landscape mulch	100%	Wood fiber and paper waste
Compost	100%	Leaves, grass, clippings (yard waste only)

Specify at least four major construction materials with post-consumer recycled content meeting EPA recycled content guidelines. (A "major" material covers more than half of a surface such as a parking area, the floors, roofs or walls, or serves a structural, partitioning or finishing function throughout large portions of the building.)

Typical building products available with recycled content in the Los Angeles region include:

- recycled asphalt
- plastic lumber
- cellulose insulation
- geo-textile fabric
- gypsum board
- plastic insulation
- fiberglass insulation
- rubber tile and mats
- fly-ash concrete
- carpet and carpet pad
- aluminum and steel products
- acoustical tile
- ceramic tile containing glass
- roofing tile and siding, cement/paper
- mineral-filled and plastic composite panels
- remanufactured wood products (e.g. flooring made from salvaged timber)

Not all materials available on the market meet EPA guidelines; the specifier should ensure that supplied materials are as specified.

Cautions

- Require disclosure by manufacturer of "post-consumer", "recovered waste" or "industrial waste" content.
- Avoid materials that must be shipped long distances. These defeat the environmental advantage of materials with recycled content by using excessive transportation energy.
- Special orders of materials not widely used may require long procurement lead times. Inquire about availability and scheduling before specifying.

Further Information

- SMMC #
- US EPA website 1999 (1) (2)
- LA SRCRD. 1998 (3)
- Environmental Building News Product Catalog
- Harris, B.J. 1999
- Mumma. T., ed. 1998

Linked Practices

CM2
CM3

RESTORE & INCORPORATE PORTIONS OR ENTIRE EXISTING BUILDINGS IN NEW DESIGNS

MA1

Where existing buildings meet the following criteria, retain as much as possible of existing building structures and incorporate them into the new development. Suitable buildings:

- can be economically brought up to current seismic, other life safety and fire code standards.
- are placed appropriately on the site.
- have floor-to-floor height and floor plan suitable for proposed uses.
- if they contain asbestos, lead, underground storage tanks and other environmental hazards, can be economically abated.
- have special historic significance or architectural merit.

When considering renovations of existing buildings, examine their annual energy consumption. Older wall and roof assemblies, windows and skylights often require upgrading to match the thermal performance of new buildings.

Typically, mechanical systems older than 8 to 10 years are much less efficient than modern equipment; replacement improves energy performance and reduces maintenance. Buildings with heritage value were often well designed for natural ventilation, cooling and solar control.

Retaining architectural features with particular merit – unique facades, millwork, fixtures, etc. – preserves historic context, reduces the environmental and resource impacts of new construction and often greatly enhances market value.

Cautions

- Identifying and abating asbestos and lead paint may be necessary for pre-1975 buildings before remodeling or demolition. OSHA rules and guidance from the EPA and local health authorities generally determine the necessary actions.

Further Information

- Alevantis, L.E. website 1996.
- California Dept. of Health Services website. 1999

Linked Practices

SF1
SF2
SF3
SF4
SF5
SF6

Environment ✔✔✔

Greatest potential to reduce demand for new materials and solid waste of all resource conservation strategies.

Ease of Use ✔

Almost always challenging in design, engineering and construction; careful site investigation can help avoid surprises.

Other Benefits ✔✔

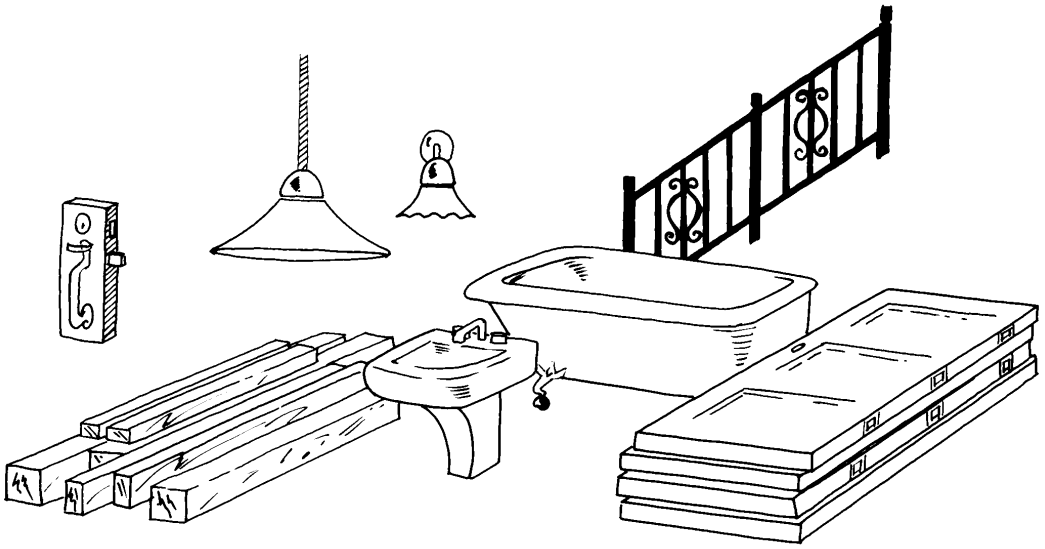
Preserves neighborhoods, streetscapes and local history.

Capital Cost $$

In the best cases, redevelopment of existing buildings reduces or equals new construction cost. Extensive reconstruction or major abatement of environmental hazards can greatly raise costs.

MA2

SPECIFY REUSE OF SALVAGED BUILDING & LANDSCAPE MATERIALS



Environment ✔✔✔
After salvaging whole buildings, salvaging materials is the next best way to reduce resource use and solid waste.

Ease of Use ✔
Extra effort is required to find materials, and they often require cleaning, repair, or modification for use. Construction scheduling may be affected.

Other Benefits ✔✔
Many salvaged materials have historic merit, or qualities that cannot be found in new materials.

Capital Cost $
Can save 50% to 90% of new material cost. More time is required to find, prepare and install them; however, in many cases there is still an overall cost saving.

Many salvaged building and landscape materials can be reused: brick, regraded and re-sawn wood, hardware, doors, plumbing fixtures, metalwork, and plants. However, use of salvaged materials typically requires finding them early, and planning from the start of conceptual design and through construction.

From both environmental and heritage perspectives, materials salvaged from buildings already existing on the site are preferable; less transportation is required, and historic continuity is preserved.

If there is little worthwhile on-site material, demolition sales and stockpiles of regional demolition and salvage contractors and suppliers should be surveyed to establish what and how much is available. Internet recycling information services and materials exchanges are useful resources. Once a decision is made, contract to reserve and store the materials until required for construction.

Specifying use of salvaged materials in contract documents is the best way to preserve valuable materials during deconstruction, and to ensure salvaged materials are purchased from suppliers.

Cautions

- Significant time and effort by both designers and contractors is needed to locate and use salvaged materials.
- Materials must be inspected and their quality verified before purchase; structural timbers in particular must be regraded.
- Plumbing and lighting fixtures must be checked to verify that they meet current codes.
- Some salvaged materials require extra labor to install and finish.

Further Information

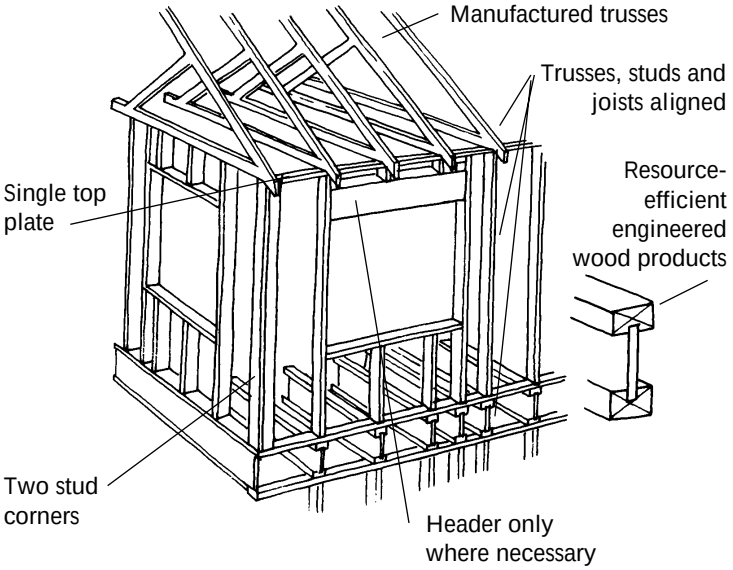
- ADPSR West Coast. 1998
- California Integrated Waste Management Board website. 1999
- California EPA CalMax website, 1999
- Los Angeles SRCRD (2), (3), (4)

Linked Practices

MA1
CMa
CMb
CMc
CM1

DESIGN WITH PANEL, PRECUT & ENGINEERED CONSTRUCTION PRODUCTS TO MINIMIZE WASTE

MA3



Building material conservation starts with building design. For example, all common construction materials come in standard sizes. Lumber is available in 2 ft. steps for length. Steel is available in common lengths up to about 20 ft. Virtually all wood panel materials and rigid insulation boards are made in 4 by 8 ft. sheets. Gypsum board is also readily available in sheet lengths of 9 to 15 ft.. Designing with common, modular dimensions and specifying building systems that precisely fit the module is a first step in materials conservation.

Modular design for wood frame construction is usually based on a 2 ft. grid; steel frame construction commonly uses a 5 ft. grid. Pre-cast concrete products, such as beams and hollow planks, are usually made in standard dimensions that the design must be precisely adapted to. Pre-manufactured building panels often have waste reduction merit, especially where many repeated elements are used. The panel manufacturer can purchase and cut material precisely, and recycle waste efficiently. Panel construction can save substantial amounts of wood while making better buildings because the inherent strength and insulating value of panels can be exploited.

Optimum Value Engineering is the practice of building frame structures with carefully aligned framing using engineered wood products such as "I" section wood joists and trusses. This provides optimum strength using the minimum amount of materials. The National Association of Home Builders has built research houses that demonstrate that this type of construction can save more than $1 per square foot in framing material costs.

Cautions

- Consult the structural engineer, building contractor and assembly manufacturers early to determine the most effective and efficient construction method for complex designs.
- Seismic design will often determine which systems are most resource-efficient in Santa Monica.

Environment ✔✔
Helps substantially to reduce resource use and construction waste.

Ease of Use ✔✔✔
Requires significant extra effort only for very complex designs.

Other Benefits ✔

Capital Cost $
Reduces material and waste disposal costs. Optimum Value Engineering typically costs the same or less than typical framed systems due to reduced material cost.

Further Information

- Edminster, A, 1998
- Energy Efficient Building Assoc. website, 1999
- Lstiburek, J., 1997
- Mumma. T., ed., 1998
- Structural Insulated Panel Assn.
- Wood Truss Council of America

Linked Practices

CM2

MA4

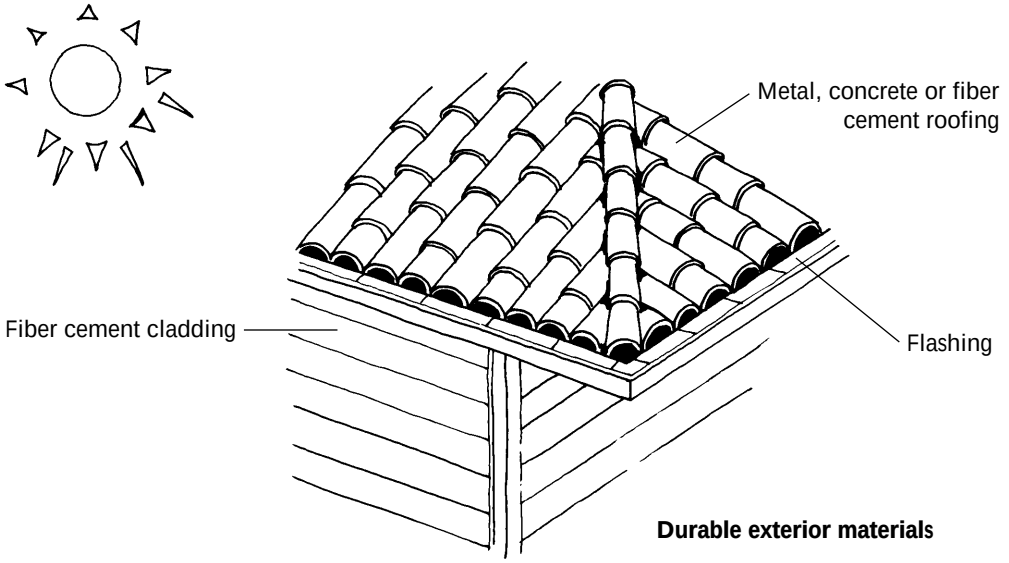
SPECIFY DURABLE EXTERIOR & INTERIOR FINISHES

Environment ✔✔✔
Very effective way to reduce waste.

Ease of Use ✔✔
Durable materials must be architecturally appropriate and suitable for space uses.

Other Benefits ✔
Materials with a long service life are typically low-maintenance and reduce operation costs.

Capital Cost $$$
Durable materials often costs more initially, but labor costs are typically unaffected, for significant reductions in life-cycle cost.



Durable exterior materials

Much of the waste that goes to landfill is building materials discarded due to short service lives. Roofing and floor coverings make up the majority of this waste category. Specifying highly durable, ultraviolet- and weather-resistant cladding and roofing, durable floor finishes and releasable (those installed with removable adhesive) carpet systems can substantially reduce long-term waste.

Roofing and claddings made from metals, ceramic, glass and concrete composites are the most weather-resistant, having a service life several times that of asphalt and plastic materials.

In Santa Monica's coastal climate, wood exposed to the sun and weather will deteriorate due to ultraviolet exposure; moist, salt air and slow drying during cool weather. Adequate flashing and protective coatings are necessary. Cladding materials, such as wood-cement composites, are more resistant to ultraviolet and moisture damage. They are also resource-efficient since they contain wood and paper waste.

Hard flooring made from ceramics or concrete, and durable resilient flooring of commercial rubber and linseed oil linoleum have several times the service life of vinyl flooring or carpets, and typically fewer indoor air quality concerns.

To reduce waste and cleaning problems, carpet use should be minimized in areas where sound control and comfort are less important. This is especially important in high-traffic areas, such as corridors. Releasable carpet systems can

Further Information
- Lippiatt, B., 1998
- American Institute of Architects,1998
- American Society for Testing of Materials, 1993

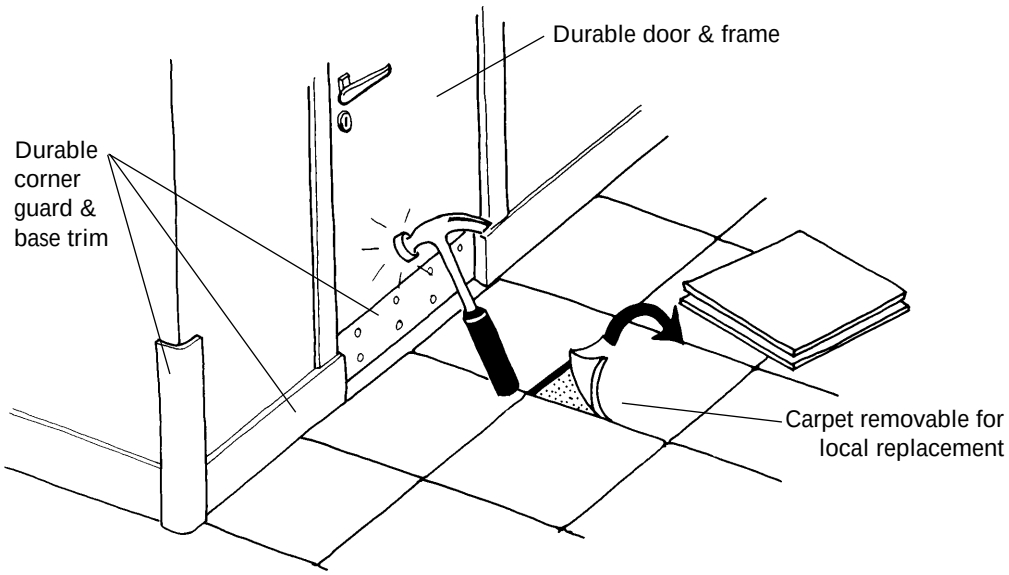
Linked Practices
LA7
MA7
CM2
CM3

be lifted and moved from low-wear to high-wear areas, extending life several years beyond that of glued-down carpets. Several manufacturers now offer leases for carpet use, and are responsible for repairing and recycling the product. This reduces initial cost, and gives manufacturers incentives to recycle materials.

Durable wall finishes in heavy use areas, such as public corridors, lobbies, stairs and washrooms, also reduce maintenance and replacement. Sturdy doors, tile or concrete and damage-resistant millwork are good choices. Corner shields and guards at floor level and wear layers on walls can protect vulnerable areas.

Cautions

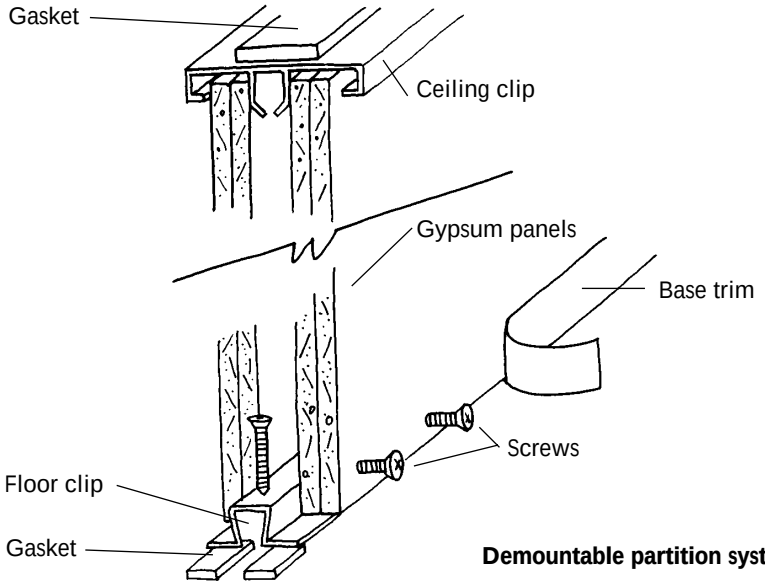
- Some roofing applications, such as flat roofs, have very limited options for durable alternatives.
- Discarded carpet is a very large part of the solid waste stream going to landfill from building material replacements. Recycling options are currently limited.
- Durable materials initially cost more, but save the building owner and tenant over the long term. These benefits should be emphasized in marketing.



Releasable Carpet & Durable Interior Finishes

MA5

DESIGN INTERIOR BUILDING COMPONENTS FOR FUTURE DISASSEMBLY, REUSE & RECYCLING



Demountable partition system

Environment ✔✔
Can be valuable in reducing future waste, but is highly dependent on future users.

Ease of Use ✔✔
Planning for space flexibility requires extra effort. It is often difficult to anticipate future needs in commercial buildings. Interior design with demountable components requires no extra effort.

Other Benefits ✔✔✔
Flexible interiors speed changes to tenancies, producing less interruption of operations and less construction disturbance.

Capital Cost $$
Initial costs are typically higher, but life-cycle costs are lower.

Interiors change often over the life of a building, particularly office and retail occupancies. Each "tenant improvement" wastes a great deal of material unless the initial design eases disassembly, reuse and recyclability.

In commercial applications, consider demountable partition systems that can be moved as interior uses change.

Specify fixtures and equipment that can be repaired or salvaged to minimize waste. Design should consider how repairs or removal will occur, and allow access for these purposes.

Specify materials and methods with high potential for recyclability, e.g. those which can be separated into recyclable components such as single metals, plastics, gypsum and glass. Wherever possible, avoid composite products that make this separation difficult or impossible.

To ease future disassembly, use bolt and nut fasteners before screws; screws before nails; nails before strippable adhesives, and strippable adhesives before permanent glues such as contact cement or epoxy. Use standard fasteners easily found in future; trim can be used to hide fasteners for a cleaner look.

Cautions

- Structural systems for commercial buildings should allow flexible interior space planning. Consider structural systems requiring the fewest fixed shear walls and braces projecting into occupied spaces.
- Building operator's manuals and tenant information should highlight and explain demountable partition systems, or they may be treated as if they are permanent.

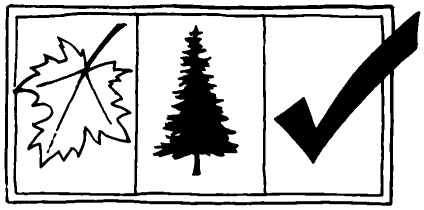
Further Information

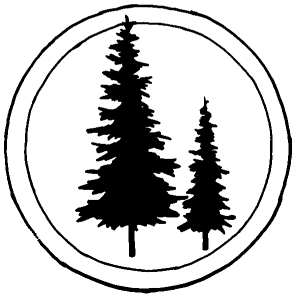
- McGraw Hill Construction Information Group website. 1999
- Modular Building Institute website. 1999
- ReSources Network website. 1999

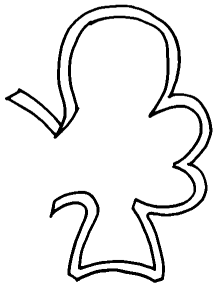
Linked Practices

MA3
MA4
CM2

SPECIFY WOOD FROM SUSTAINABLY MANAGED SOURCES







Forest depletion, soil loss, fishery and habitat damage caused by poor logging practice affects forested areas around the globe. Sustainably managed forests use better practices such as selective logging, watershed protection, replanting and thinning.

Independent, third-party agents are now operating certification programs for sustainably harvested wood products. Certified framing lumber, timbers, exterior decking, exterior-grade plywood and structural strand board (OSB) are all available, though some typical framing products used in California, such as #2 Douglas fir, are not. The price premium for certified Douglas fir framing lumber was about 40% in 1998, because only the higher grade #1 was available. Other certified products have little or no premium because the quality is similar. Certified #2 hemlock/fir framing lumber is available for about the same price as the typical #2 Douglas fir.

Resawn and regraded wood from timbers salvaged from demolition is another environmentally preferable option to virgin timber. In some cases reclaimed wood costs less than virgin timber, and salvaged wood quality is typically superior.

Cautions

- Do not specify any tropical woods unless they are from a reputable, certified sustainable supplier. Some woods, such as ebony, rosewood and Honduras mahogany, should be avoided altogether.
- More certified products are becoming available continually, so check suppliers and information sources regularly.

Further Information

- Edminster, A. 1998
- Certified Forest Products Council website. 1999
- Environmental Building News
- Rainforest Alliance, Smart Wood Program website. 1999.
- TreeTalk Inc. 1999

Linked Practices

MA2
MA3
MA4
CM2

Environment ✔✔✔

Promotes better forest management, effectively preserving habitats and ensuring better future supplies.

Ease of Use ✔✔

Currently requires extra effort to locate sustainably managed wood.

Other Benefits ✔✔✔

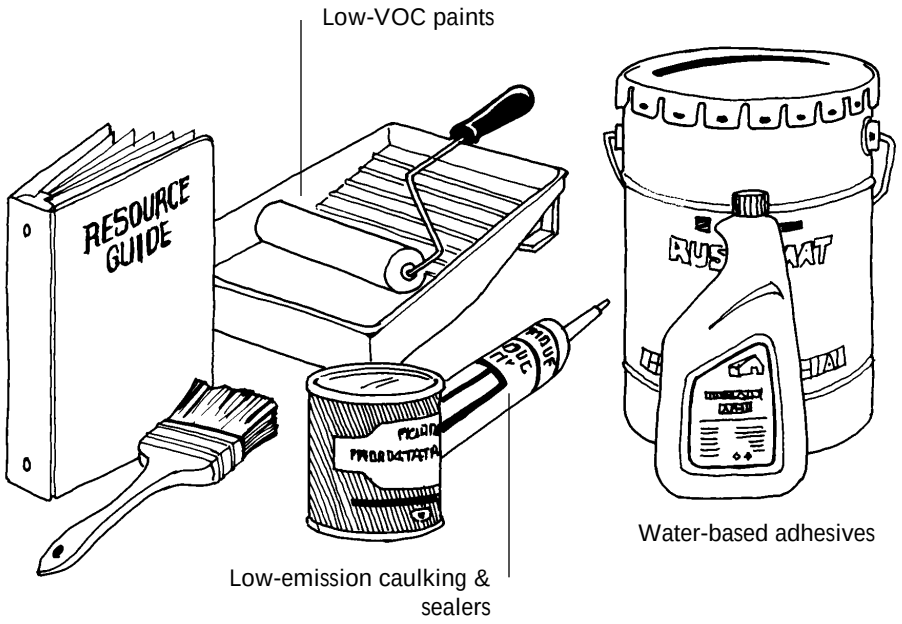
Promotes green business and forest stewardship education.

Capital Cost $

Costs slightly more than wood non-certified lumber. Some salvaged and alternate materials cost less.

MA7

USE LOW-EMISSION FINISHES & INTERIOR MATERIALS TO REDUCE INDOOR & ENVIRONMENTAL POLLUTION



Environment ✔✔✔

Improves health and satisfaction of occupants.

Ease of Use ✔✔

Rating programs and emissions testing make many healthy materials selections simple; others require use of a specialized healthy building consultant. Some products may be difficult to find or require special ordering.

Other Benefits ✔✔

Safer for workers to handle and install. Reduces designer, contractor, owner and manager liability.

Capital Cost $$

Many healthy materials cost no more than standard materials. However, some do, and the selection procedure adds costs.

Healthy buildings are largely a result of healthy materials choices. Minimize use of high-emission carpet, paints, adhesives, ceiling tiles, wood composite products, acoustic materials and insulation materials. Choose low-emission materials by a recognized selection procedure, such as low-toxicity rated products, or a pick list of low-emission materials by "generic type" i.e. by product category.

Some of the most important healthy materials to select are those which are "applied wet", such as paints, sealers, adhesives and caulking, and those used in large quantities, such as floor coverings, ceiling coverings, wall panel systems and furniture. Safer "wet products" are generally those that contain the least amount of volatile organic compounds (VOCs) which evaporate and pollute indoor air. Many low emission paints and adhesives are now available or are required for use in Southern California under air quality legislation by the SCAQMD (Southern California Air Quality Management District). These are much safer for people and the environment than the solvent-based products they replace.

Healthy floor, ceiling and wall coverings are also those that release the least dust and do not support microbial growth. Hard and resilient floor coverings, such as linoleum and tile, have inherent health advantages over carpet, since they do not trap dust and contaminants. Where carpet is

Further Information

- Alevantis, L.E. website, 1996.
- Hal Levin & Assoc., Indoor Air Bulletin
- Cutter Information Corp. IEQ Strategies

Linked Practices

MAb
MA2
MA4
HS1
HS2
HS4
HS5

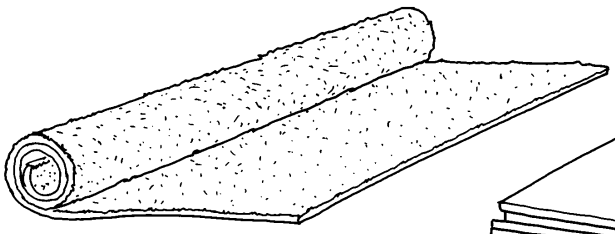
necessary, select products that minimize chemical emissions and have high recycled content. Some furniture manufacturers have designed their systems using chemically safe wood fiberboard made with formaldehyde-free glue, low-odor plastic foams and upholstery fabrics to minimize volatile emissions.

"Generic" healthier materials are generally those which are hard, non-porous and made from metals, glass, ceramics, solid woods, stone and cement, or are designed to release minimal gases and dusts:

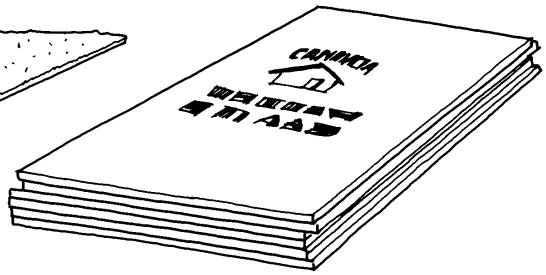
- paints and adhesives formulated to "zero VOCs" or "low VOCs" standards.
- insulations containing no glass or mineral fiber, which are totally contained by a permanent barrier when installed, or made from plastics formulated for low chemical emissions and fire resistance.
- carpets tested to comply with low-emission carpet rating standards. Carpet with factory-installed dry adhesive is safer than field-applied wet adhesive.
- engineered wood products containing no supplementary adhesive, or those using formaldehyde-free or other low-emission adhesives meeting HUD or European E1 standards.

Cautions

- Materials are only a part of the healthy building picture. Healthy mechanical systems and maintenance practices are also necessary.
- Materials covering the largest surfaces are the most critical for safe selection. Be cautious about carpet, rubber flooring and particleboard which may have very prolonged emissions.
- Some materials have volatile emissions for a short period but are safe after the curing period.
- Pre-selecting and specifying as many healthy materials as possible is essential so that construction is not delayed by ordering and delivery problems.



Low-emission carpet



Formaldehyde-free panel products

FURTHER INFORMATION

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Resources and information on green and healthy buildings. Many California material sources.

Alevantis, L.E. 1996. *Guidelines for Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials*. California Department of Health Services, Berkeley CA.. URL http://www.cal-iaq.org/iaq
Advice for architects and builders on construction materials selection and flushout.

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The reference work for architects and building specifiers on green products by generic type. Dense, but information packed; covers life-cycle environmental impacts of many building materials.

American Society for Testing of Materials, Dean, E. B. (March 1999). *Life Cycle Cost Bibliography (1993). E 917-93, 1994 Annual Book of ASTM Standards, Vol. 04.07* [WWW Document] URL http://akao.larc.nasa.gov/dfc/biblio/lccb.html
Standard practice for measuring life-cycle costs of buildings and building systems.

California Department of Health Services. (March 1999). *Indoor Air Quality Info Sheet - Asbestos in the Home and Workplace*. [WWW Document] URL http://www.cal-iaq.org/asb9809.html
Information and advice for occupants and remodelers.

California Environmental Protection Agency, Integrated Waste Management Board. (April 1999). *CalMax: Materials Exchange for Business Reuse and Recycling*. [WWW Document] URL http://www.ciwmb.ca.gov/calMAX/search.asp
A n excellent resource for designers and contractors seeking recycled materials, or wishing to dispose of salvaged materials. Features a web-based recycled materials exchange, connecting recyclers and users. Searchable database, allowing selection by region and material type wanted. Information resources, case studies, regulations, listings of recycling contractors and much more.

California Integrated Waste Management Board (CIWMB). 1998. *Construction and Demolition Recyclers, Processors and Receivers List*., 8800 Cal Center Dr., Sacramento, CA 95826-3200 URL http://www.ciwmb.ca.gov
The state clearinghouse for recyclers. Extensive listing of sources for recycled materials.

Certified Forest Products Council. (April 1999). *Certified Forest Products Database*. [WWW Document] URL http://www.certifiedwood.org
14780 SW Osprey Dr., Suite 285, Beaverton, OR 97007. (503) 590-6600
Industry information on suppliers and standards.

Construction Materials Recycling Association of Southern California. (818) 548-8996 (Kelly M. Ingalls) e-mail: kmibldg@earthlink.net
A newly formed industry association, beginning a newsletter.

Cutter Information Corp. IEQ (Indoor Environmental Quality) Strategies. 37 Broadway, Suite 1, Arlington, MA. 02174-5552. (781) 648-8700 or (800) 964-5125. URL http://cutter.com
Cutter produces several technical, professional newsletters, directories, monographs etc. for the building industry, environmental and management sectors. IEQ Strategies is their indoor air newsletter.

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Information and conferences.

Energy Outreach Center. (March 1999). *Reusable Building Materials Exchange*. [WWW Document] URL http://www.rbme.com
Electronic listings of what's available and what's wanted, unfortunately limited to Washington state. Useful for locating salvaged materials.

Environmental Building News. 28 Birge St., Brattleboro, VT 05301. (802) 257-7304 URL http://www.ebuild.com
The leading green building professional journal. Excellent articles, book reviews and resources.

Mumma. T., ed. 1998.*Guide to Resource Efficient Building Elements (GREBE)*. Center for Resourceful Building Technology, Box 100, Missoula MT 59806 (406) 549-7678. http://www.montana.com/crbt
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A newsletter for architects and building professionals on indoor air quality. W

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A database (for Mac or Windows) of recycled content products by category.

The Journal of Light Construction. 932 West Main St., Richmond, VT 05477. (802) 434-4747. URL http://www.jlconline.com
Provides construction information to builders, remodelers, contractors, architects, and others in the construction industry about home building, remodeling, restoration, estimating, etc.

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Development software for material life cycle cost assessment.

LA Solid Resources Citywide Recycling Division, (SRCRD) (1). 1998. *City of Los Angeles Solid Resources Management Specification*. (213) 847-1444.
A recommended recycling specification for contractors doing demolition, site clearing and construction.

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A list of waste receivers and services in the LA region.

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Recycled products suppliers in the LA region, by category.

LA SRCRD (4). 1997. *Wood You Recycle?*. (213) 847-1444.
A guide to wood re-use and recycling in the Los Angeles area.

Lstiburek, J. 1997. *Builder's Guide*. Building Science Corp., 70 Main St., Westford MA 01886. (978) 589-5100.
Building science-based construction methods and details for durable, resource-efficient buildings.

Metropolitan Portland Construction and Demolition Waste Information Program. (March 1999) *Construction Site Recycling*. [WWW Document] URL
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5 Bleecker St., New York, NY 10012 (212) 677-1900
A listing program by an independent forest stewardship organization.

ReSources Network. (April 1999). *Wall Products Directory*. [WWW Document] URL
http://www.resources.com/wdw/walls.htm
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1511 K St., Suite.600, Washington,. D.C.20005. (202) 347-7800.
Industry information on suppliers and technical features.

McGraw Hill Construction Information Group. (April 1999). *Sweet's System Online Building Product Information, Division 10 – Specialties*. [WWW Document] URL
http://www.sweets.com/sdff10.html
Architectural product information on demountable partitions.

TreeTalk Inc. (April 1999). *Woods of the World*. [WWW Document] URL
http://www.woodweb.com/~treetalk/home_woodweb.html
Box 426, Burlington, VT 05402. (802) 865-1111.
The comprehensive database on CD ROM with photos.

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A model specification for construction waste reduction.

U.S. Environmental Protection Agency. (1). (April 1999). *Environmentally Preferable Purchasing: EPA Guidelines*. [WWW Document] URL: http://www.epa.gov/opptintr/epp
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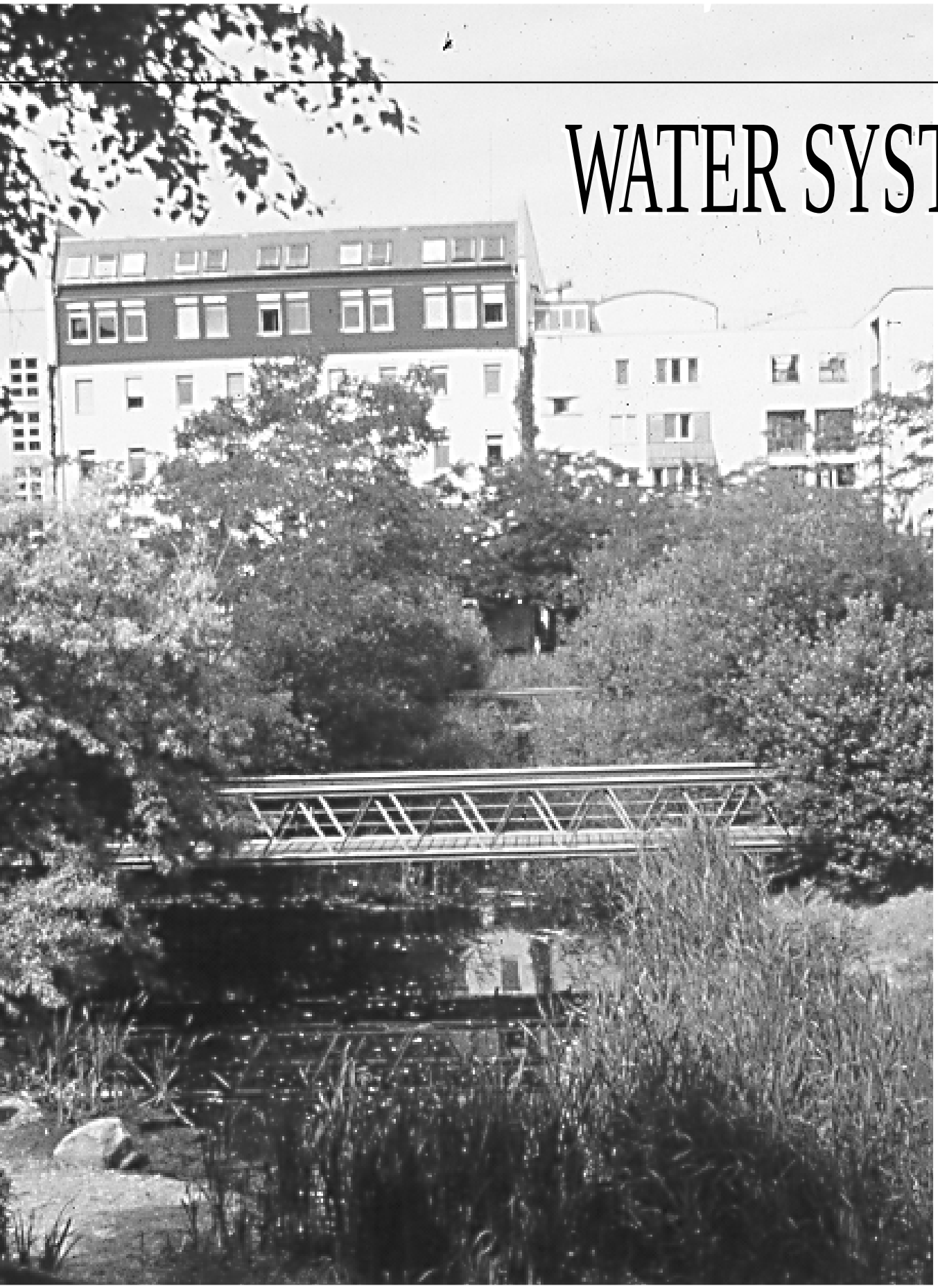
A case study of Santa Monica's municipal green purchasing program.

Wood Truss Council of America. 5937 Meadowwood Dr,. Ste. 14, Madison, WI 53711-4125.
(608) 274-4849
Industry association and information center, with many practical publications.

WATER SYSTEMS



WATER SYSTEMS

Development in Southern California has always been limited by the scarcity of clean, fresh water. In the 1970s and 1980s, responses to drought conditions made the Los Angeles region a leader in water conservation, without constraining economic growth and with little inconvenience to residents. Recently, however, several relatively wet years have reduced public concern - and conservation efforts.

Periods of drought are a certainty in the future, and their severity and duration are predicted to increase, due to climate change caused by human activity. Continued economic and population growth will put additional pressure on finite water supplies.

Why Conserve Water?

Conservation of potable water reduces the need for new supplies and treatment plants, avoiding large capital and operating costs - and their associated taxes. Environmental benefits of water conservation in urban areas such as Santa Monica include less pollution from water and sewage treatment and improved habitat quality in Santa Monica Bay, as well as avoiding the negative impacts of new dam and pipeline construction.

There are other reasons to reduce potable water consumption, notably the need to reduce the energy used to heat water. Heating water is the largest energy consumer in multiple-dwelling buildings in California, and the third-largest energy consumer in all U.S. commercial buildings. It constitutes a large portion of the energy budget for hotels and motels, restaurants and schools. In any building, using less energy translates directly into lower operating costs for building owners and tenants, increased profits for businesses and lower taxes for municipalities.

Most water in California buildings is heated using natural gas, which produces carbon dioxide, the most important contributor to global warming. But carbon dioxide is not the only air emission from water boilers and heaters. Air pollutants from poorly maintained natural gas water heaters and boilers include carbon monoxide, nitrogen oxides, and formaldehyde, as well as other trace pollutants. While electric water heaters do not directly produce air emissions, the generation of electricity used produces these same pollutants, and sulfur oxides as well. All of these contaminants are major contributors to degraded air quality throughout the Los Angeles basin - and have been shown to seriously affect indoor air quality in many buildings.

Direct benefits of water-conserving features to real estate developers include greater appeal to two broad and influential market segments: the environmentally conscious buyer or lessor, and businesses and retirees seeking low building operations and maintenance costs. Buildings with water-conservation features in combination with other "green" design measures have a distinct market advantage over less ecologically responsible buildings, selling and leasing more quickly, and often with a price premium.

Design Strategies

Water conservation in buildings and their sites is both practical and inexpensive, especially when rebates and incentives offered by the City, state and federal governments are considered. However, as in many strategies to reduce ecological impacts, water and water heating energy conservation should be considered early in design, monitored during construction and properly commissioned to ensure their proper installation and operation.

Water-Conserving Fixtures and Appliances

Reducing demand for water is the most effective and economical strategy, and the one to implement

first. The easiest and most inexpensive method is to use state-of-the-art water-conserving fixtures, fittings and appliances. Second- and third-generation water-conserving fixtures are much improved over earlier efforts, reducing or eliminating operation and maintenance problems. Efficient fixture costs are competitive, and the City of Santa Monica's Bay Saver program subsidizes their use.

Graywater Systems

After water-conserving plumbing fixtures, installation of a graywater system to provide irrigation allows a second use of water drained from baths, showers, bathroom sinks and washing machines. This is an effective way to reduce the use of treated potable water. Graywater collection and irrigation systems must be considered early in the design process, since they will affect landscaping design and the size and placement of mechanical spaces. This is especially true for gravity-flow graywater systems, since they must be higher than the irrigation systems they service.

Water-Heating Energy Conservation

Reducing the amount of hot water used also reduces the energy required to heat that water. Water heating energy can be further conserved with little extra cost by insulating piping, recovering waste heat from graywater, and by specifying highly efficient boilers and hot water heaters. Many advances have been made in water heating technology in recent years, including sealed combustion chambers, electronic ignitions and direct-vent condensing boilers. Capital costs for efficient heaters can be greatly reduced by taking advantage of the Federal Environmental Protection Agency Energy Star program.

In Southern California, solar water heating can eliminate the need to use non-renewable energy. Low-temperature unglazed solar water heaters are one of the most inexpensive and well-proven renewable energy technologies, and are very well suited for swimming pools and spas, as well as domestic water preheat and process water systems. Glazed flat-plate collectors can provide the higher temperatures required by service water, and can be very attractive when integrated with the envelope design. Low-interest loans and tax rebates provided by the federal government, and grants and loans from California's Energy Technologies Advancement Program (ETAP) for solar equipment can help to reduce capital costs of solar systems.

Designs incorporating efficient conventional and solar water heaters or graywater systems should be followed up with testing and commissioning before occupancy, to ensure that they operate as intended, and that building operators are well trained in their use and maintenance. Lack of proper testing, commissioning and training is one of the most common reasons for unsatisfactory performance. However, if systems are installed and operating correctly from the beginning, they typically provide years of service, saving water, energy and money.

WATER SYSTEMS PRACTICES SUMMARY TABLE

Required Practices

	Ordinance	Subtitle
WSa	SMMC 7.18	Specify & Install Water-Conserving Plumbing Fixtures & Fittings
WSb	SMMC #	Reduce Hot Water Heat Loss with Insulation & Heat Traps
WSc	SMMC #	Heat Swimming Pools & Preheat Process Hot Water with Unglazed Solar Collectors
WSd	SMMC 5.20.080(c)(1)	Eliminate Lint from Sanitary Sewers in Professional Cleaning Facilities
WSe	SMMC 5.20.080 (c)(1) & (c)(4)	Eliminate Grease from Sanitary Sewers in Food Preparation & Meat Retailing Facilities
WSf	SMMC 5.20.080 (c)(5)	Eliminate Silver from Sanitary Sewers in Photo-Finishing Facilities

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
WS1 Specify & Install Water- & Energy-Conserving Appliances	✔✔	✔✔	✔✔✔	**$$$**
WS2 Reuse Graywater for Outdoor Landscaping Irrigation	✔✔✔	✔	✔	**$$**
WS3 Collect Rainwater for Outdoor Landscaping Irrigation	✔✔✔	✔✔✔	✔	**$$**
WS4 Select High-Efficiency Service Hot Water Heaters & Boilers	✔✔	✔✔✔	✔	**$$**
WS5 Install Heat-Recovery Systems on Wastewater Plumbing	✔✔	✔✔	✔✔	**$**
WS6 Use Solar Collectors & Heat Storage for Service Hot Water Heating	✔✔✔	✔✔	✔✔	**$$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

WSa

REQUIRED PRACTICE
SMMC 7.18:

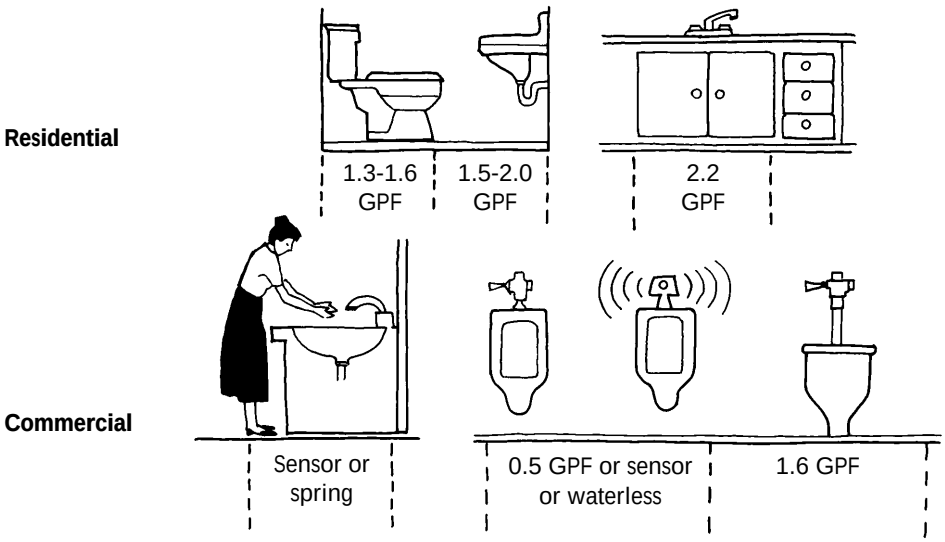
Environment ✔
Water-

Ease of Use ✔
Water-

Other Benefits ✔
Water-

Capital Cost $
Water-

SPECIFY & INSTALL WATER-CONSERVING PLUMBING FIXTURES & FITTINGS



Text, issue icons & explanations and illustration notes to be completed by City Staff.
Further Information and Linked practices completed.

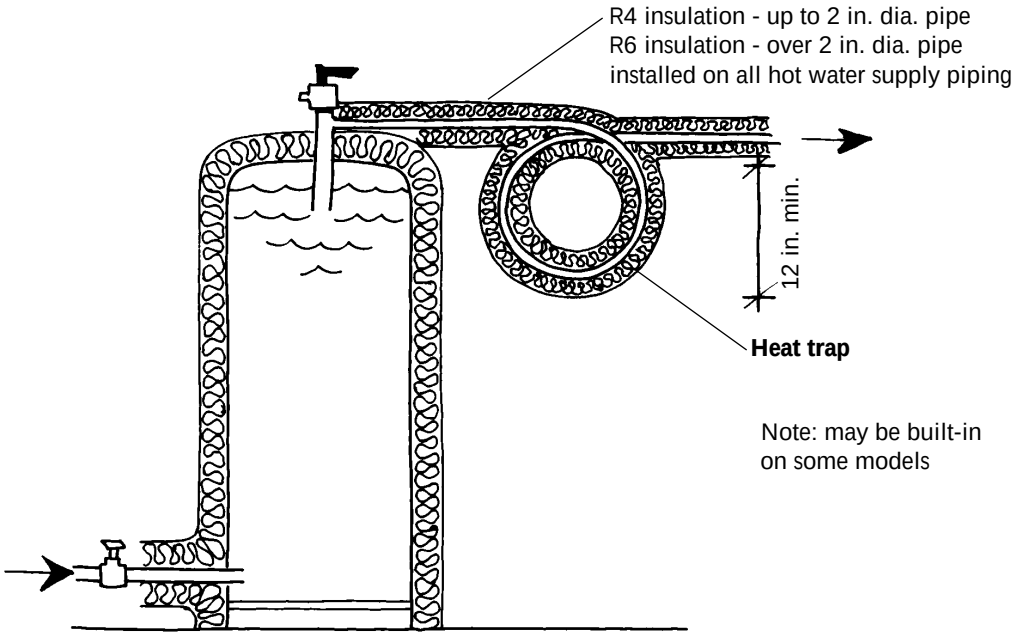
Further Information

SMMC 7.18
IAPMO 1997

Linked Practices

WSb
WSc
WS1
WS2
WS6

REDUCE HOT WATER HEAT LOSS WITH INSULATION & HEAT TRAPS



About 15% of typical domestic water-heating energy is wasted by distribution piping systems. Insulation and heat traps are easy and inexpensive ways to greatly reduce these losses.

Insulate all hot water distribution and recirculating system piping to R-4 (for piping 2 in. or less in diameter) and to R-6 (for larger piping), from the heater to the end-use fixtures, rather than just the first few feet as required by Title 24. This can greatly reduce energy wasted by these systems - especially recirculating systems. Insulation also reduces the time occupants must wait for hot water at the fixture with non-recirculating systems.

Installing heat traps on the inlets and outlets of non-circulating hot water heaters and tanks reduces buoyancy-induced flow of hot water through the piping, where it loses heat to the building interior. These simple pipe loops reduce unintended hot water circulation at a trivial capital cost, for typical paybacks of less than a year. (Heat traps are already built into many high-efficiency water heaters, and addition of external traps is redundant.)

Wrapping storage tanks with additional flexible insulation also offers significant energy savings at very minor cost. Insulation should be foil-faced and taped.

Cautions

- Increased pipe insulation thickness can actually be counterproductive; do not exceed recommended R-values.

Further Information

SMMC #
ASHRAE Standard 90.1-1989
ASHRAE Standard 90.2-1993

Linked Practices

WS4
WS5

Environment ✔✔

Reduced fossil fuel energy consumption translates directly into less air pollution.

Ease of Use ✔✔✔

Heat traps and insulation require no maintenance, and are familiar to most mechanical contractors.

Other Benefits ✔

Better pipe insulation can reduce water-heating requirements.

Capital Cost $$

Very rapid payback periods.

WSc

REQUIRED PRACTICE

SMMC

Environment ✔✔✔

Solar water heat replaces fossil fuel energy for water heating, resulting in less air pollution.

Ease of Use ✔✔

Contractors licensed for solar water installations should be employed.

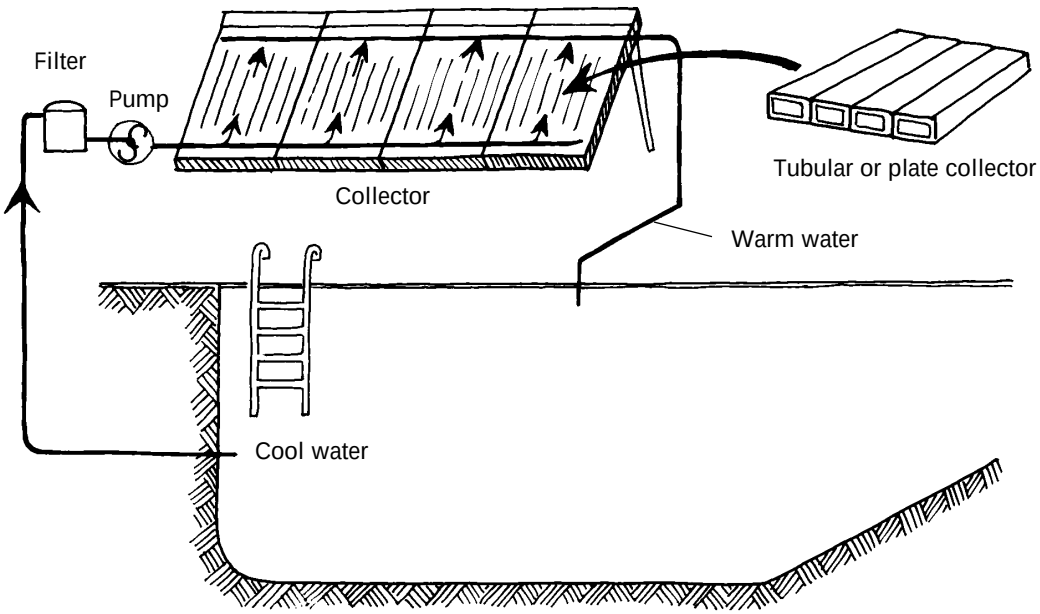
Other Benefits ✔✔

Solar water heating can reduce or eliminate conventional water-heating equipment.

Capital Cost $

By taking advantage of grants and loans, capital costs and paybacks – already in the two- to five-year range – are greatly reduced.

HEAT SWIMMING POOLS & PREHEAT PROCESS HOT WATER WITH UNGLAZED SOLAR COLLECTORS



Low-temperature solar water heating is a mature technology with excellent potential in Santa Monica, especially for pool and spa water heating and preheating of process water used for laundries, car washes, etc.

Unglazed solar collectors economically provide low-temperature water heating (75° to 95 ° F. range). These collectors are inexpensive, unobtrusive when integrated into building design, and simple to install. The systems have a fast payback period - from two to five years, depending upon the cost of the energy displaced.

Unglazed collectors can greatly reduce non-renewable energy consumption when preheating water before the final water temperature rise by downsized electrical or fossil fuel water heaters. This is especially useful for process water requirements, such as laundries, car washes, or commercial dishwashers and hot water space heating applications.

Preheat applications often require storage tanks, which should be considered in both space allocation and structural design.

Cautions

- Solar systems should be commissioned to ensure energy savings.
- For space heating or process water heating, large water storage volumes may affect structural requirements.
- Equipment and systems should be certified by the Solar Rating Certification Corporation (SRCC) and other national certification agencies.

Further Information

- SMMC #
- Duffie, J.A. and Beckman, W.A., 1980
- FSEC, 1997
- U.S. DOE / NREL website, 1999

Linked Practices

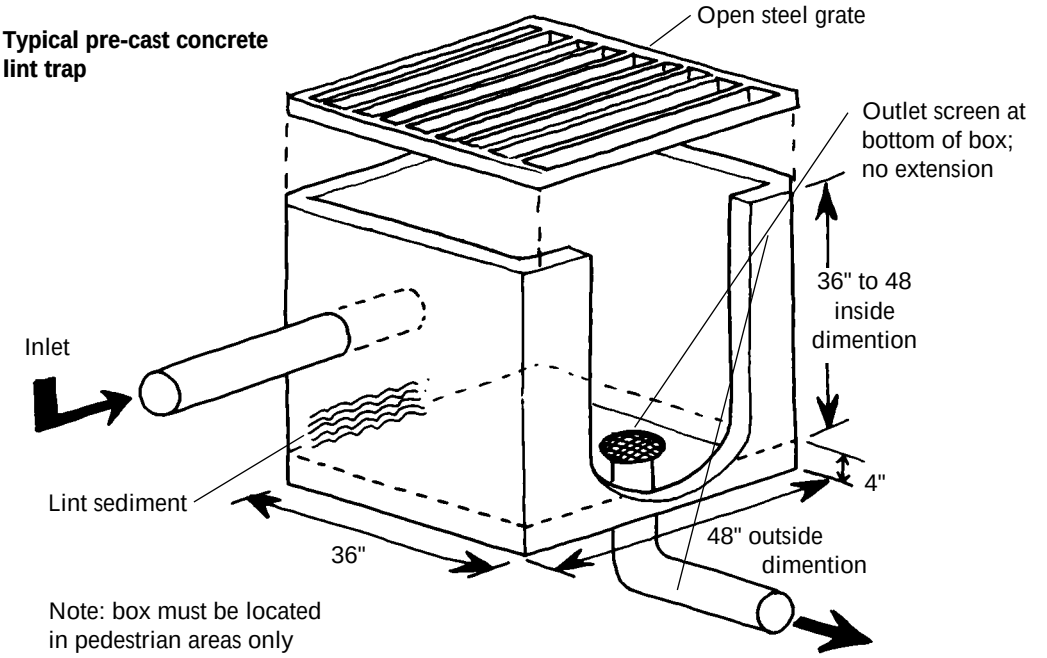
SF3
SF6
LA1
LA2
WSa
WSb
WS1
WS4
WS5
WS6

ELIMINATE LINT FROM SANITARY SEWERS IN PROFESSIONAL CLEANING FACILITIES

WSd

REQUIRED PRACTICE
SMMC 5.20.080(C)(1)

Typical pre-cast concrete lint trap



Note: box must be located in pedestrian areas only

Install lint traps and filters on drains from equipment and work areas, or rough-in plumbing for these in potential professional cleaning tenancies: dry cleaners, laundromats and carpet cleaners.

All commercial laundry facilities, laundromats, and dry cleaners with laundry facilities are required to install a lint trap or settling pits for discharge from washing machines. They are prohibited to discharge wastewater with a temperature greater than 104° Fahrenheit. The pH of wastewater discharged must be no greater than 11.0 or less than 5.5.

Dry-cleaning facilities are strictly prohibited from discharging wastewater from their dry cleaning operations. Separator water cannot be discharged to the sewer system or added to the boiler. Separator water can be treated onsite by filtration/evaporation methods, or untreated wastewater can be hauled offsite by licensed disposal companies for treatment. To treat separator water on site, approved equipment is available commercially; for information, the Industrial Waste Section should be contacted at (310) 458-8235.

Cautions

- Lint traps or settling pits should be periodically maintained and serviced. Receipts indicating when lint traps or settling pits were last serviced should be kept on file.
- Equipment to treat separator water should be maintained and serviced periodically.

Environment ✔✔
Reduces pollution of sanitary sewers and Santa Monica Bay.

Ease of Use ✔✔✔
Straightforward to install lint traps and settling pits.

Other Benefits ✔
Lint traps also act as floor drains, reducing risk of flood damage.

Capital Cost $
Required for all commercial laundry facilities.

Further Information
- SMMC 5.20.080 (c) (1)
- Industrial Waste Section (310) 458-8235

Linked Practices
WS1
WS4
WS6

WSe

REQUIRED PRACTICE
SMMC 5.20.080(C)(1) & (C)(4)

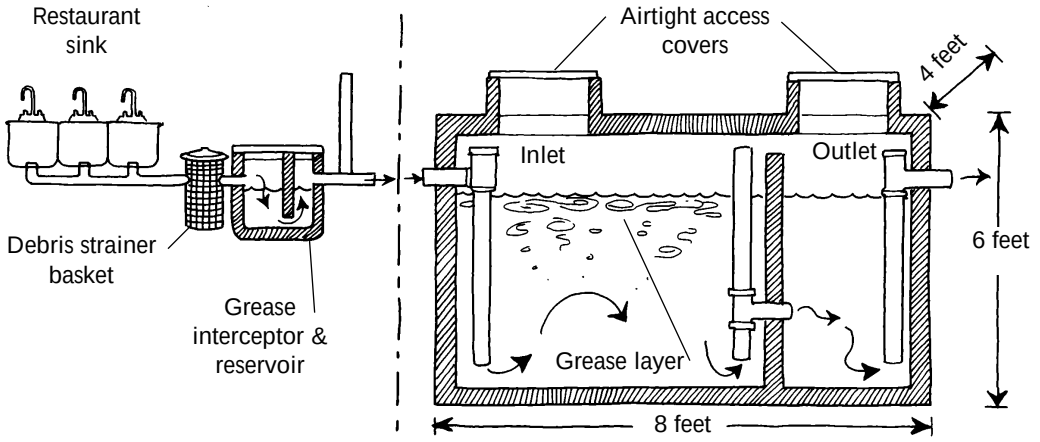
Environment ✔✔
Reduces pollution of sanitary sewers and Santa Monica Bay.

Ease of Use ✔✔
Straightforward to install grease interceptors, traps and mat washdown areas.

Other Benefits ✔
Reduces grease blockages of sanitary sewer system.

Capital Cost $
Required for all commercial food-preparation and meat retailing facilities.

ELIMINATE GREASE FROM SANITARY SEWERS IN FOOD PREPARATION & MEAT RETAILING FACILITIES



Restaurant grease interceptor

All restaurants, caterers, school cafeterias and other commercial cooking facilities must avoid causing grease blockages in the municipal sewer system.

In commercial food preparation and meat retailing tenancies, install:

- grease interceptors
- sink strainers on drains
- washdown areas for kitchen mats

Grease interceptors must drain to the sanitary sewer system, and receive wastewater from all contributory sources, such as pot sinks, dishwashers, floor drains and mat washing area drains. If these are not installed in the base building, rough-in plumbing for their future installation should be provided. As well, garbage disposal units installed in sink drains are prohibited for these tenancies.

All new or rebuilt facilities are required to install a grease interceptor to pretreat sewered grease. All units regardless of size shall be fitted with a standard final-stage sample box. Interceptors must be sized for at least a 30 minute peak wastewater flow detention time from all contributory sources. Variance from the above requirements will be permitted only for good cause. In cases where variance is granted, a grease trap will be required in place of an interceptor. Traps shall have a rated flow capacity sufficient for the same 30-minute flow outlined above. Contributing sources shall be the same with possible exceptions made for dishwasher flows.

Further Information

- SMMC 5.20.080 (c)(1) and (c)(4)
- Building & Safety Department (310) 458-8355
- Industrial Waste Section (310) 458-8235

Linked Practices

All new, and rebuilt, as well as existing kitchen facilities, must dedicate a specific area for the washing of floor mats and related equipment, bermed to ensure wastewater is not discharged to the storm drain system but to a grease interceptor discharging to the sanitary sewer. Outdoor wash-down area drains must be protected from rain water intrusion.

Cautions

- All grease interceptors must be installed by a state-certified plumber under permit and inspection of the Building and Safety Department, at (310) 458-8355. Site plans must have the prior approval of the Industrial Waste Section, at (310) 458-8235.
- All garbage disposal units must be eliminated.
- For grease interceptors and traps to function properly they must be serviced and maintained by a qualified contractor. For a list of qualified contractors, contact Industrial Waste Section.

WSf

REQUIRED PRACTICE
SMMC 5.20.080(C)(5)

Environment ✔✔✔
Reduces pollution of sanitary sewers and Santa Monica Bay. Reclaims valuable silver.

Ease of Use ✔✔
Straightforward to install.

Other Benefits ✔

Capital Cost $
Required for all photo-finishing facilities.

ELIMINATE SILVER FROM SANITARY SEWERS IN PHOTO-FINISHING FACILITIES

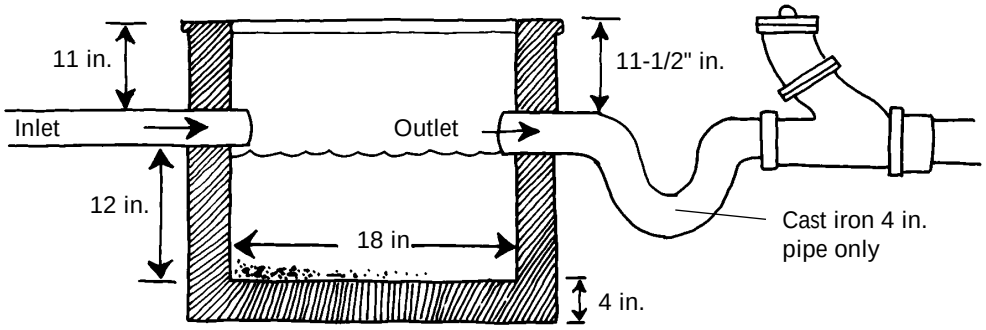


Photo-finisher sediment trap

Install silver recovery units and sampling boxes on drains, or rough-in plumbing for their future installation, in potential photo-finishing tenancies, including commercial and residential photo-finishing facilities, medical or dental offices with x-ray processors, and other facilities generating wastewater with a high content of silver. These pretreatment devices include:

- clarifiers for organic pollutants such as inks, dyes or acids such as enchants
- de-silvering devices for photo-developing wastestreams containing greater than 5 mg/liter silver in accordance with I.W.W.C.O. Section 5.20.050
- sample boxes whenever deemed necessary by the Industrial Waste Section, which will specify the type, size, placement, and connection of these devices.

Cautions

- All silver recovery units must be periodically maintained and serviced by a licensed company.
- Under no circumstances should waste fixer solution be discharged to floor drains, sinks, toilets, or any type of discharge pipe directly to the sewer system without treatment.
- All sample boxes must be installed by a state-certified plumber under permit and inspection of the Building and Safety Department at (310) 458-8355. Site plans must have the prior approval of the Industrial Waste Section, at (310) 458-8235.

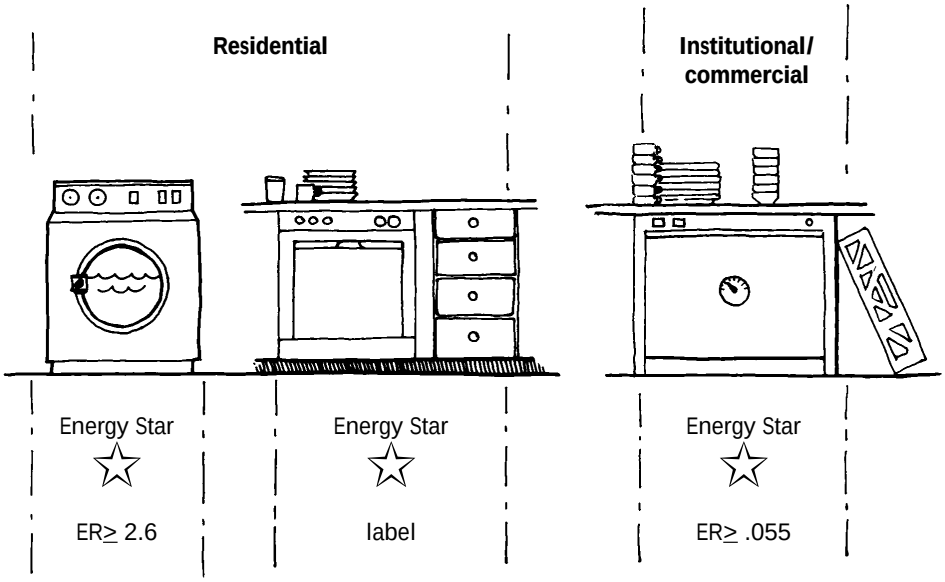
Further Information

- SMMC 5.20.080(c)(5)
- Building & Safety Department (310) 458-8355
- Industrial Waste Section (310) 458-8235

Linked Practices

WS1

SPECIFY & INSTALL WATER- & ENERGY-CONSERVING APPLIANCES



Energy Star clothes washers are now readily available in a wide range of capacities: they clean clothes as well or better than standard washers, accommodate bulkier loads, and are gentler to clothes since they do not use central agitators. Initial costs are currently higher; but the payback as a result of reduced energy and water costs is typically between two and three years.

In residential buildings, specify that all washing machines will be Energy Star compliant, with an Energy Rating (ER) of 2.6 or greater, for more than a 20% reduction in water and energy costs.

Energy Star dishwashers also use less hot water to clean - up to 40% less. Advanced designs automatically sense the condition of the dishes, and adjust water temperature and cycle duration to optimize both cleanliness and water consumption. Built-in booster water heaters assure sterilization when desired.

In non-restaurant commercial and institutional applications, specify that all dishwashers will be Energy Star compliant, with an ER of 0.55 or greater, for more than a 20% reduction in water and energy costs.

Cautions

- Appliance technology is evolving rapidly; monitor product performance and price improvements.
- Match clotheswasher capacity with the expected use; many horizontal-axis washers take smaller loads than standard washers.

Further Information

- US DOE, Energy Star Appliances, 1999

Linked Practices

WSa
WSc
WSd
WS2
WS4
ES6

Environment ✔✔

Water-efficient appliances save both water and water-heating energy.

Ease of Use ✔✔

Most major manufacturers now make water-efficient appliances, but distributors carrying a full range or the most efficient products may be more difficult to find.

Other Benefits ✔✔✔

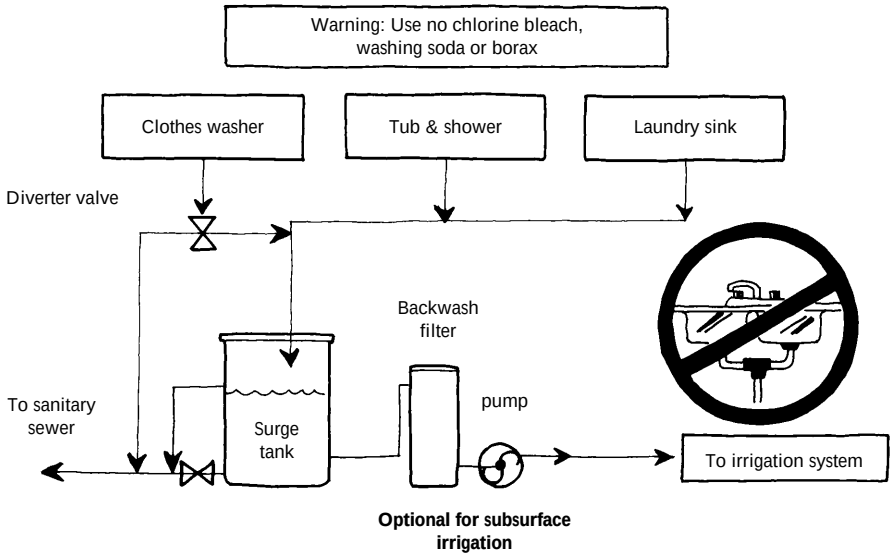
Efficient appliances are typically high quality: a marketing plus, especially for residential projects.

Capital Cost $ $$

Costs are rapidly dropping, and Southern California Edison offers rebates where electric heaters are installed.

WS2

REUSE GRAYWATER FOR OUTDOOR LANDSCAPING IRRIGATION



Environment ✔✔✔

Landscaping irrigation is one of the highest water consumers in urban California.

Ease of Use ✔

Graywater systems are currently new to many plumbing designers and contractors, especially in commercial applications.

Other Benefits ✔

Capital Cost $$

Unit costs drop with larger flows and landscaped areas.

Specify and install wastewater plumbing piping to capture "graywater" - drain water from baths, showers, laundry and bathroom sinks - for subsurface irrigation of outdoor landscaping. Graywater piping should be labeled to distinguish it from other sanitary piping.

A simple non-pumped gravity system is appropriate if leaching chambers or box troughs can be located downhill from the building, and maintenance staff is available for regular inspections and filter changes.

Where maintenance staff are not expected, pumped systems equipped with automatically backwashed sand filters are most appropriate, though more expensive. These systems, unlike other graywater systems, can be used for drip irrigation of lawns and require minimal service.

- Ensure graywater will not be exposed on the ground surface, even after prolonged rain.
- Ensure occupants are made aware of neglected maintenance or filter changes by obvious signals such as a visible overflow.
- Post permanent signage above sinks to ensure occupants use appropriate cleansers and soaps.

Cautions

- Regular inspection and maintenance are essential for non-automatic systems. Post permanent documentation of maintenance procedures in the building.
- Maintenance of automatic systems should be handled by a service contract with firms specializing in graywater systems.
- Mini leachfields designed according to the California Plumbing Code have poor irrigation performance. See Ludwig's publications for details.

Further Information

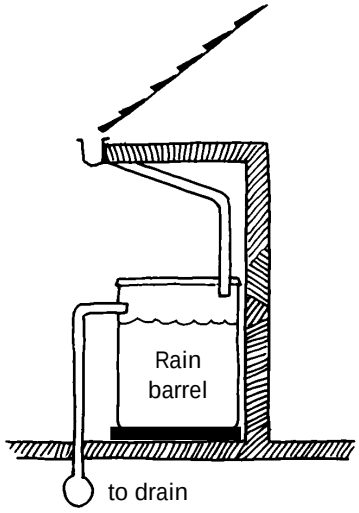
- CA Dept. of Water Resources, 1994
- CA Plumbing Code, Appendix G, Graywater Code
- Ludwig, A. 1995 (1)
- Ludwig, A. 1995 (2)
- City of Malibu, 1995

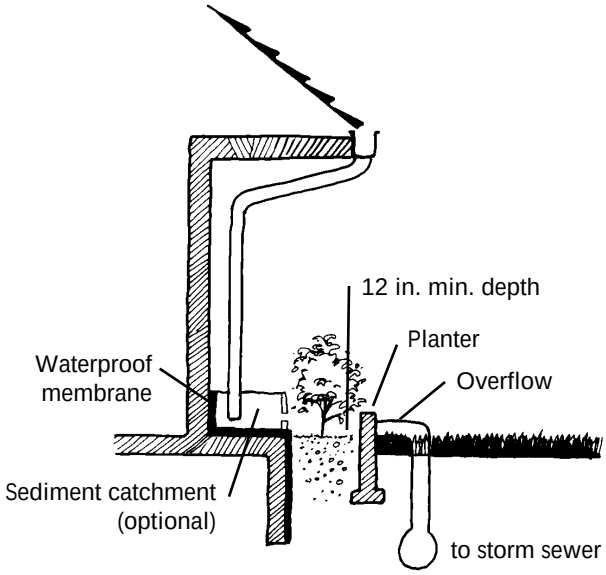
Linked Practices

WS3
WS5
LAb

WS3

COLLECT RAINWATER FOR OUTDOOR LANDSCAPING IRRIGATION





Collect rainwater with rainbarrels at each rainwater leader or downspout. The collected rain displaces potable water otherwise wasted for irrigation.

Most roofing materials are suitable for rainwater collection, except for redwood, cedar or treated wood shingles and shakes, which may contaminate water and soil by leaching toxic materials when wet. Food-producing gardens should not be watered with rainwater from roofs with these materials or asphalt shingles.

Manufactured rainbarrels are widely available in sizes that range from 36 to 75 gallons. Rainbarrels are also easily made from commercial plastic barrels; recycled food-grade PVC barrels are often available free. The larger the container, the more potable water will be saved, but it is rarely economic to store sufficient water for an entire summer.

Rainbarrels should incorporate a "roof washer" or "first flush" device, to avoid storing water contaminated with bird droppings and dust. They should also incorporate an inlet screen and an overflow outlet. Overflow and drain valves should include hose couplings, and discharge at least 6 ft. from foundations.

Cautions

- Ensure that "flat" roofs have sufficient slope to drain completely, without long-term ponding.
- Avoid using rainwater collected from asphalt roofing, cedar or treated shingles for food gardens.
- Ensure that rainbarrels include first-flush devices to avoid water contamination.

Environment ✔✔✔
Landscaping irrigation is one of the highest water consumers in urban California.

Ease of Use ✔✔✔
Rainbarrels are easy to install and to maintain.

Other Benefits ✔
Rainwater provides plants with fewer chemical pollutants than treated potable water.

Capital Cost $$
Purchased rainbarrels are a modest capital cost.

Further Information
- CA Dept of Water Resources, 1981
- Texas Water Development Board,1995

Linked Practices
LAa
LAb
WS2

WS4

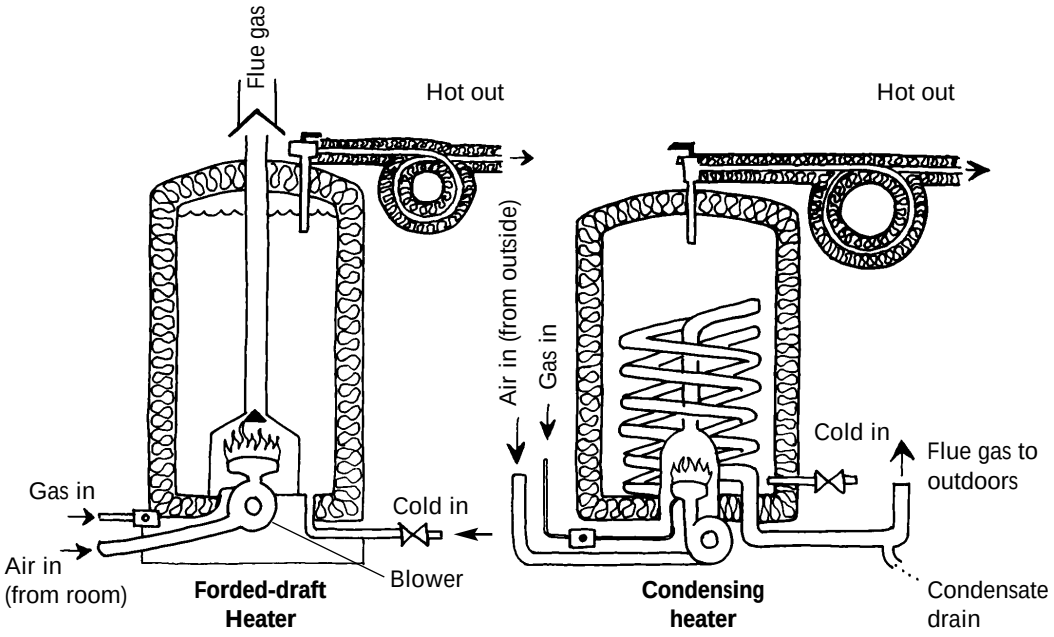
SELECT HIGH-EFFICIENCY SERVICE HOT WATER HEATERS & BOILERS

Environment ✔✔
Reduced fossil fuel energy consumption translates directly into less air pollution.

Ease of Use ✔✔✔
High-efficiency equipment is widely available.

Other Benefits ✔
Condensing boilers and heaters and powered burners offer greater flexibility in vent routing compared to atmospherically fired equipment.

Capital Cost $ $
Taking advantage of loans and incentives reduces capital costs significantly.



Specify Energy Star compliant boilers and service water heaters, with higher efficiencies than the legally required minimum.

Small, mid-efficiency atmospherically vented service water heaters and boilers equipped with vent dampers, powered burners, more insulation and often intermittent ignitions have Energy Factors (EF) ranging from 0.62 to 0.70, at a small premium over standard equipment.

Direct-vent, sealed-combustion and condensing water heaters and boilers have the best EFs - up to 0.86, though at a capital cost premium. Paybacks are typically attractive, and these units provide greater flexibility in vent location, and minimize the risk of indoor air quality problems.

Energy Star compliant gas service water heaters must use less than 242 therms/year; electric units less than 4700 kWh/year, verified by independent testing. Energy Star boilers must have Annual Fuel Utilization Factors of 85% or greater.

The Environmental Protection Agency's Energy Star program offers attractive loans to contractors and homeowners for these purchases.

Cautions

- Compare capital costs and internal rate of return of alternate equipment options where capital costs are tightly constrained.
- Ensure that proposed substitutions for specified equipment also comply with efficiency requirements, and are certified by the Energy Star program.

Further Information

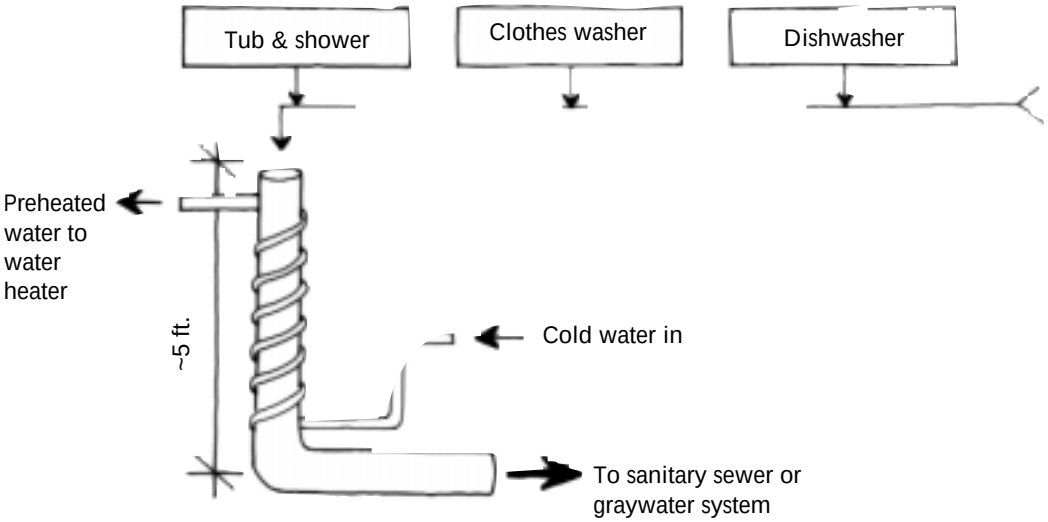
- ASHRAE Systems & Equipment Handbook, 1996
- U.S. Environmental Protection Agency website, 1999

Linked Practices

HS8

INSTALL HEAT-RECOVERY SYSTEMS ON WASTEWATER PLUMBING

WS5



Install graywater heat-recovery equipment in residential projects, commercial or institutional buildings with multiple showers, and industrial applications with large, continuous flows of hot water, such as clothes washers. Manufactured products are available and well proven.

Graywater heat-recovery equipment can save up to 60% of water-heating energy where hot water drain flow occurs at the same time as hot water supply flow - such as multiple showers or industrial process water systems. Systems serving fixtures on upper floors, where 60 in. of vertical drain pipe is replaced by proprietary graywater heat-recovery devices, need no pump and little or no maintenance. For below-grade applications, systems with demand-operated pumps are available; these need occasional service, and are best installed in a mechanical room for regular maintenance access.

Where there is less simultaneous hot water drain and supply flow (i.e., predominantly baths, sinks, laundries, etc.), graywater heat-recovery systems with heat storage add heat to the water supply to the hot water tank. These require more space, and regular inspection and cleaning.

Cautions

- Systems with pumps and storage require regular maintenance, and should be located in mechanical rooms or other service areas.

Further Information

- Energy Source Builder Newsletter #49

Linked Practices

WS2

Environment ✔✔

Reduced fossil fuel energy consumption translates directly into less air pollution.

Ease of Use ✔✔

Graywater heat-recovery equipment is not yet widely available.

Other Benefits ✔✔

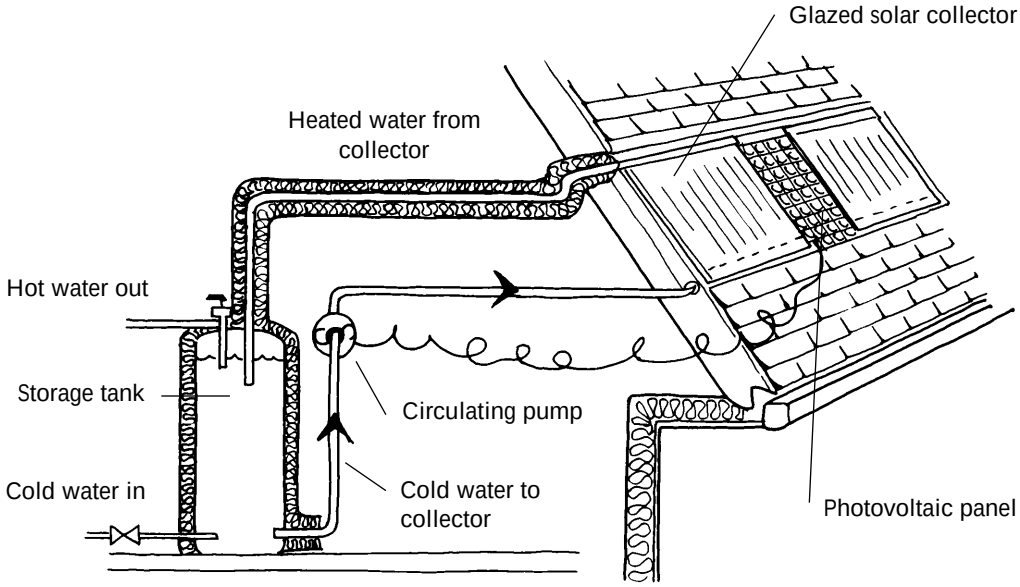
Graywater heat-recovery can reduce water-heating equipment requirements.

Capital Cost $

Paybacks are very rapid, from six months for simple gravity systems to two to three years for pumped systems.

WS6

USE SOLAR COLLECTORS & HEAT STORAGE FOR SERVICE HOT WATER HEATING



Environment ✔✔✔
Solar water heat replaces fossil fuel energy consumption for water heating, resulting in less air pollution.

Ease of Use ✔✔
Contractors licensed for solar water installations should be employed.

Other Benefits ✔✔
Solar water heating can reduce or eliminate conventional water-heating equipment.

Capital Cost $$
By taking advantage of grants and loans, capital costs and paybacks are greatly reduced.

Service and space heating water in the 120°F to 160°F range can be provided by flat-plate solar collectors (which incorporate glazed insulated boxes) or evacuated tube systems, which are even better insulated, with more efficient absorbers.

Both technologies are well developed, and can offset 50% to 70% of the heating load, with simple paybacks of three to fifteen years, depending upon the displaced fuel. The potential to offset peak generation is high when replacing or supplementing electric heat.

Medium- and high-temperature solar water-heating systems require annual maintenance and inspection for most efficient operation and energy cost savings.

Capital costs can be reduced with low-interest loans from the Federal Million Solar Roofs program, or with loans and grants available under the California Energy Technologies Advancement Program (ETAP).

Cautions

- For space heating or process water heating, large water storage volumes will affect structural requirements.
- The Solar Rating Certification Corporation (SRCC) or another national certification agency should certify equipment and systems.
- Solar systems should be properly commissioned to ensure energy savings.

Further Information

- Duffie, J.A. and Beckman, W.A., 1980
- Florida Solar Energy Center, 1997

Linked Practices

SF6
LA1
LA2
WSa
WSb
WSc
WS1
WS2
WS3
WS4
WS5

FURTHER INFORMATION

ASHRAE. 1997. *ASHRAE Fundamentals Handbook*.

ASHRAE. 1996. *ASHRAE Systems and Equipment Handbook*.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) publish a new Handbook of their series every year. The Handbooks have become the authoritative North American references for mechanical engineers on HVAC data, calculations, system design and equipment selection. These two Handbooks are the most valuable for building HVAC design.

ASHRAE. 1989. *ASHRAE/IES Standard 90.1-1989: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.*

ASHRAE. 1993. *ASHRAE/IES Standard 90.2-1993: Energy Efficient Design of New Low-Rise Residential Buildings.*

ASHRAE Standards 90.1 and 90.2 are very useful guides to energy-efficient water and HVAC system design for commercial and multi-family residential buildings, similar to Title 24's Nonresidential and Residential Manuals, but briefer, and covering U.S. and Canadian sites. They focus mostly on envelope, water, mechanical and electrical systems, leaving building form design to architects.

California Department of Water Resources. 1981. *Captured Rainfall: Small-scale Water Supply Systems*. P.O. Box 388, Sacramento, CA 95802.

A dated but still useful guide to rainwater catchment systems in California. Includes nomographs for catchment and cistern sizing.

California Department of Water Resources. 1994. *Graywater Guide: Using Graywater in Your Home Landscape*. California Department of Water Resources, Water Conservation Office, P.O. Box 942836, Sacramento, CA 94236-0001. (916) 643-1097.

"Prepared to help homeowners and landscape and plumbing contractors understand California's graywater standards, and to help them design, install, and maintain graywater systems."

California Plumbing Code. Title 24, Part 5: *California Administrative Code, Appendix J: Graywater Systems for Single Family Dwellings*. March 8, 1994.

California Plumbing Code. Title 24, Part 5: *California Administrative Code, Appendix G: Graywater Systems*. March 18, 1997.

The California Plumbing Code has recently been amended to address graywater system applications in commercial and multi-family residential, as well as single-family dwellings.

City of Malibu, Department of Environment, Building and Safety. 1995. *Graywater Handbooks*. 23555 Civic Center Way, Malibu, CA 90265

"Focuses on the design, construction, installation, operation, and maintenance of graywater systems for the City of Malibu, California."

City of Santa Monica Bay Saver Program. 1997. *Bay Saver Fixture Rebate Program Documentation*.. 300 N. Sepulveda Blvd., Suite 2035, El Segundo, CA 90245.

The City of Santa Monica offers incentives to upgrade to water-efficient fixtures, and several publications on water conservation.

Duffie, J.A., and W.A. Beckman. 1980. *Solar Engineering of Thermal Processes*. John Wiley & Sons, New York.
Dated but still fundamental text on solar thermal engineering. Emphasis on procedures and data for calculating solar resources and solar systems design that has direct application to photovoltaic applications.

Energy Source Builder Newsletter #49. (March 1999). Device Recovers Waste Energy From Drain Water. [WWW Document] URL http://oikos.com/esb/49/gfx.html

Florida Solar Energy Center (FSEC). 1997. *Thermal Performance Ratings*, FSEC-GP-14-81. Florida Solar Energy Center, Cocoa, FL.

Florida Solar Energy Center (FSEC). 1997. *Thermal Performance Ratings (Pool Collectors)*, FSEC-GP-16-81. Florida Solar Energy Center, 1679 Clearlake Road, Cocoa, FL 32922. (407) 638-1000. URL http://www.fsec.ucf.edu/
The Florida Solar Energy Center (FSEC) is a global authority on solar water heating, and publishes many useful publications. These two publications summarize FSEC's performance testing.

International Association of Plumbing and Mechanical Officials (IAPMO). 1997. *Directory of Water-conserving Plumbing Product*s. IAPMO, 20001 Walnut Drive South, Walnut, CA 91789-2825. (909) 595-8449. URL: http://www.iapmo.org
A comprehensive directory of all types of water-efficient plumbing products.

Ludwig, Art. 1995 (1). *Create an Oasis with Graywater*. Oasis Design, 5 San Marcos Trout Club, Santa Barbara, CA 93105-9726. (805) 967-3222.

Ludwig, Art. 1995 (2). *Oasis Building Professional's Graywater Guide: the Guide to Professional Installation of Graywater System*s. Oasis Design, Santa Barbara.
The Oasis Guides are excellent: brief, yet comprehensive, current and oriented to building professionals in Southern California.

Texas Water Development Board & Center for Maximum Potential Building Systems. 1995. *Texas Guide to Rainwater Harvesting*. Center for Maximum Potential Building Systems, 8604 F.M. 969, Austin, TX 78724. (512) 928-4786.
A good guide to design of rainwater catchment systems for irrigation and other uses.

U.S. Department of Energy. (March 1999). *Energy Star Program Home Page*. [WWW Document] URL http://www.energystar.gov/

U.S. Department of Energy. (March 1999). *Energy Star Appliances*. [WWW Document] URL http://www.energystar.gov/products/appliances.html

U.S. Department of Energy. (March 1999). *Energy Star Appliances – Find Products: Clothes Washers, Dishwashers; Refrigerators; Room Air Conditioners*. [WWW Document] URL http://www.energystar.gov/products/product-finder.html
The U.S. Department of Energy and the Environmental Protection Agency jointly sponsor the Energy Star program, which certifies water- and energy-efficient equipment and appliances. Its

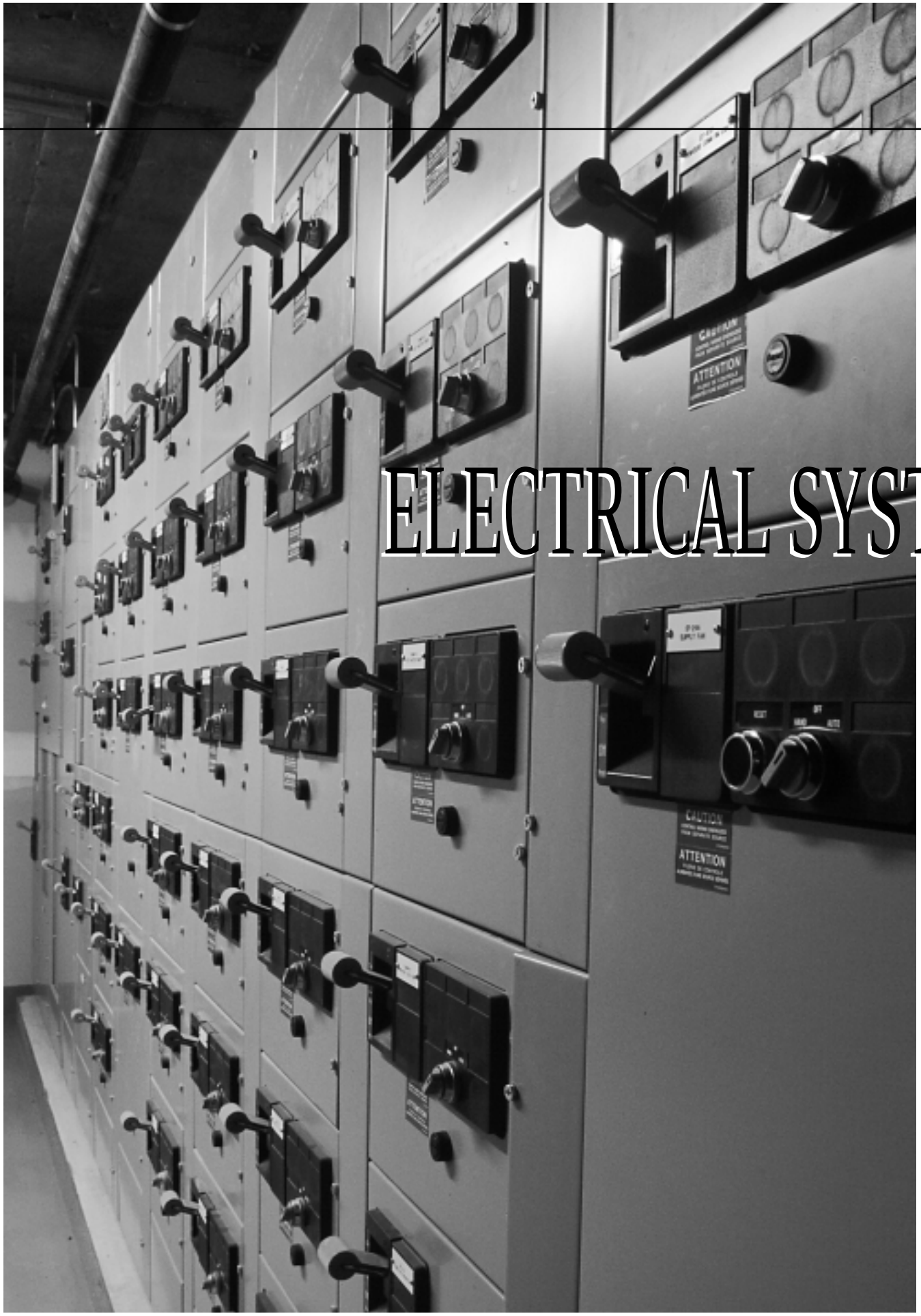
website lists many information resources, among them easily searchable databases of manufacturers, model numbers and efficiencies of Energy Star labeled water heaters, appliances, boilers and HVAC equipment. Mostly oriented to residential / small commercial equipment and appliances.

U.S. Department of Energy National Renewable Energy Laboratory. (March 1999). *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors*. [WWW Document] URL http://rredc.nrel.gov/solar/pubs/redbook/

U.S. Department of Energy National Renewable Energy Laboratory. (March 1999). *30-Year Average of Monthly Solar Radiation, 1961-1990, WBAN 23174 Los Angeles, CA.*. [WWW Document] URL http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum2/23174.txt
The National Renewable Energy Laboratory's database of solar energy and weather data is the reference standard.

U.S. Environmental Protection Agency. (March 1999). *Energy Star Boiler Program - The Virtual Home: Boilers carrying the ENERGY STAR logo*. [WWW Document] URL http://hes.lbl.gov/hes/es-prod-boiler.html

US Environmental Protection Agency. (March 1999). *Energy Star Boiler Program - The Virtual Home: The ACEEE List of Most Efficient Water Heaters*. [WWW Document] URL http://hes.lbl.gov/hes/ACEEE/water.html
Listings of Energy Star certified water heating equipment.



ELECTRICAL SYSTEMS

ELECTRICAL SYSTEMS

In a typical commercial building, electricity accounts for 60% to 95% of the total energy consumption. The use of electricity has few ecological drawbacks on the building site. However, electricity generation for California buildings has huge environmental impacts. It is one of the largest consumers of fossil fuels, releasing carbon dioxide (the major greenhouse gas) and regional air pollutants – nitrogen oxides, sulfur oxides, ozone and particulates. As well, a significant proportion of California's electricity is generated by nuclear reactors, which create radioactive waste with few indisputably safe options for long-term disposal.

Only 7% of California's current electricity supply is renewable, mostly from wind turbines, microhydro and solar thermal generators, and photovoltaic collectors. As deregulation proceeds, consumer choice is expanding. By purchasing "green power", users can encourage investment in new renewable electricity generation. However, these choices typically have a cost premium, wind turbines and PV collectors take time to build, and there is no guarantee that building occupants will sign "green power" contracts.

The most effective strategy to limit the environmental damage – and operating cost – of electricity use of buildings is to reduce their power demand and electrical consumption.

A building's electrical demand and consumption is greatly influenced by architectural and mechanical design decisions. The most cost-effective, enduring and foolproof steps to reduce electricity use in Santa Monica are outlined in the Site and Form, Envelope and Landscaping chapters:

- Control solar cooling loads.
- Use sunlight for passive solar heating
- Use natural cooling and ventilation.
- Incorporate daylighting.

Relying solely on efficient equipment and lighting technologies without these architectural strategies typically costs more to build and to operate over the lifetime of the building. Designing a building that needs smaller transformers, little or no mechanical cooling and less electric lighting power is the best way to reduce energy demand and consumption, and capital and operating costs.

Efficient Equipment and Life-Cycle Cost Assessment

Climate-responsive design can reduce the size and amount of electrical lighting, heating and cooling equipment. The capital savings can then be applied to purchasing more efficient electrical equipment, such as transformers and motors. Life-cycle cost assessment is especially valuable when selecting equipment with large capital costs and long operational lives. New computer tools, such as CITCEM or MotorMaster, make it easy for designers to optimize equipment choices with life-cycle cost assessment, for both initial and long-term savings. Both of these tools are available for free download via the Internet; the Further Information section at the end of this chapter gives their addresses.

For less costly or long-lived equipment such as motors under 10 horsepower, the advantages of premium quality and efficiency are clear. The payback period is very short, maintenance costs are lower, and life-cycle assessment is typically unnecessary.

Fixture and Lamp Selection

Federal and state regulations have encouraged the move away from less efficient lighting technologies. In response, manufacturers are producing increasingly efficient equipment, and the range of choice is

now very large and expanding rapidly. Keeping current is difficult for non-specialists and retaining a lighting design specialist can often pay for itself in reduced design time and lighting system cost – in both daylit and non-daylit designs.

Whether a lighting specialist or an electrical engineer does the design, the quality of light should be the primary consideration, with energy consumption an important secondary consideration. Quality issues include light distribution, contrast and glare. Good designers will meet these needs while minimizing the number of fixtures required, electrical demand, energy consumption, and capital and operating costs.

Integrating Daylighting with Electric Lighting

However well designed and efficient lighting equipment may be, the highest quality and most efficient light source is daylight. It offers the most accurate color rendering, and is welcomed as the best light source by most people.

During daylight hours, good lighting design looks first to natural lighting, and then to electric lighting as a supplement. Indirect, efficient electric lighting design uses the same surfaces to distribute light as does daylighting, and aims to make their lighting quality indistinguishable.

The best lighting will be different for every task and in each design. Where tasks require higher illumination, or drama is desired for esthetic reasons, the most energy-efficient strategy is to supplement general area lighting with direct lighting only in the desired areas.

Even the best lighting design can fail unless controls are considered and located with the final space use and furniture placement in mind, and carefully commissioned.

Photovoltaic Electricity Generation

While the initial cost of photovoltaic (PV) electricity generation is currently high relative to purchased power, a small but growing number of building purchasers and tenants consider this a valuable feature – a visible commitment to renewable energy, and a marketing benefit.

According to a study by the Sacramento Municipal Utility District, a four-kilowatt net-metered system (requiring no batteries) installed on a customer site would save $50 per month, for less than $24,000 capital cost. Prices for customer-installed PV collectors and electrical systems are projected to drop by 9% per year.

Customer-owned PV systems are rapidly becoming more economic for several reasons:

- Growing mass production is being reflected in quickly falling costs.
- PV collectors are increasingly integrated with building claddings, roofs and canopies, replacing traditional finishes and their costs.
- New codes, regulations and rates allow small systems to connect to the utility grid, eliminating the cost of batteries.
- Federal and state tax benefits and financial incentives are increasing in value and availability.

Few building developers are currently aware of these benefits. Besides strictly monetary advantages, many companies are reaping marketing rewards for PVs' visible commitment toward green goals. Forward-thinking designers are raising PV installation issues with their clients, and considering them carefully.

While design of most commercial buildings in Santa Monica strives to reduce building cooling loads by rejecting solar radiation, photovoltaics require unshaded access to the solar resource to perform optimally. This can be resolved by using PV collectors as window shades, or by locating collectors on roofs or south-facing walls. If PV collectors are not installed initially, forethought in envelope and electrical design can greatly ease future PV installation, as costs drop.

Electric Vehicle Charging Stations

With the State of California requiring that low-pollution vehicles form a significant proportion of new automobiles sales, electric vehicles (EVs) will soon become a common sight on Santa Monica streets, freeways and parking lots. However, scarcity of charging stations is likely to limit their widespread acceptance — and sales of buildings to EV owners. However, there is still no universal standard for EV charging stations, which presents a dilemma for designers and builders. While standards are being established, developers can anticipate future charging station installation by providing conduit, electrical panels and other equipment to make their future installation easier and cheaper. Anticipating the future needs of occupants (and their vehicles) is part and parcel of the thinking that underlies green building design.

ELECTRICAL SYSTEMS PRACTICES SUMMARY TABLE

Recommended Practices	Environmental	Ease of Use	Benefits	Capital Cost
ES1 Select Electrical Equipment for Reduced Energy Demand & Consumption	✔✔✔	✔✔✔	✔✔	**$$$**
ES2 Select Lighting Equipment for Reduced Energy Demand & Consumption	✔✔✔	✔✔	✔✔✔	**$**
ES3 Integrate Daylighting & Electric Lighting in Task-Oriented Spaces for Productivity & Comfort	✔✔	✔✔	✔✔✔	**$$**
ES4 Integrate Daylighting & Electric Lighting in Gathering Spaces for Comfort & Efficiency	✔✔✔	✔✔	✔✔	**$**
ES5 Maximize Impact in Sales Areas with Efficient Lighting Strategies	✔✔✔	✔✔	✔✔✔	**$**
ES6 Integrate Daylighting & Electric Lighting in High-Bay, Manufacturing & Color-Critical Areas	✔✔✔	✔✔✔	✔✔	**$$**
ES7 Incorporate Photovoltaic Electricity Systems into the Building Fabric	✔✔✔	✔	✔✔	**$$$**
ES8 Provide for Future Electric Vehicle Charging Stations	✔✔	✔✔✔	✔	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.
Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

ES1

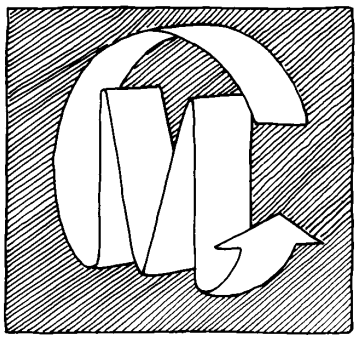
SELECT ELECTRICAL EQUIPMENT FOR REDUCED ENERGY DEMAND & CONSUMPTION

Environment ✔✔✔
Reduces energy consumption and air pollutant emissions.

Ease of Use ✔✔✔
Requires life-cycle analysis for specifications, but easy-to-use software is readily available.

Other Benefits ✔✔
Reduced operating costs.

Capital Cost $$$
High-efficiency motors and transformers have a capital cost premium, but typically a fast payback.



MotorMaster

Energy Star

Thoughtful selection of transformers and motors can greatly reduce electricity consumption.

Small efficiency improvements are very effective. Typical efficiencies range from 95% to 99%; a 1% improvement can reduce waste by one-half. When selecting transformers, consider load factor; with high load variation, transformers are mostly lightly loaded, and should be selected for low core losses. With higher load factors, transformers with low winding losses save more.

Specify transformers for lowest life cycle cost, not just capital cost. The EPA's Commercial and Industrial Transformer Cost Evaluation Model (CITCEM) and Distribution Transformer Cost Evaluation Model (DTCEM) software can be freely downloaded to aid life-cycle analysis. While capital cost premiums are quite high (20% to 50%), payback periods range from one to four years.

Select motors under 10 horsepower to be 5% more efficient than EPACT requirements; or designated as "Premium Efficiency" by the Consortium for Energy Efficiency. Larger motors should be selected for lowest life-cycle cost, which typically favors very high efficiencies. (Motor capital and life-cycle cost analysis is straightforward with software such as MotorMaster.) With capital cost premiums ranging from 0% to 30%, payback time varies from zero to three years.

Cautions

- Consider power harmonics when selecting transformers.
- Ensure motors over 10 horsepower serving varying loads are suitable for variable-speed drives.

Further Information

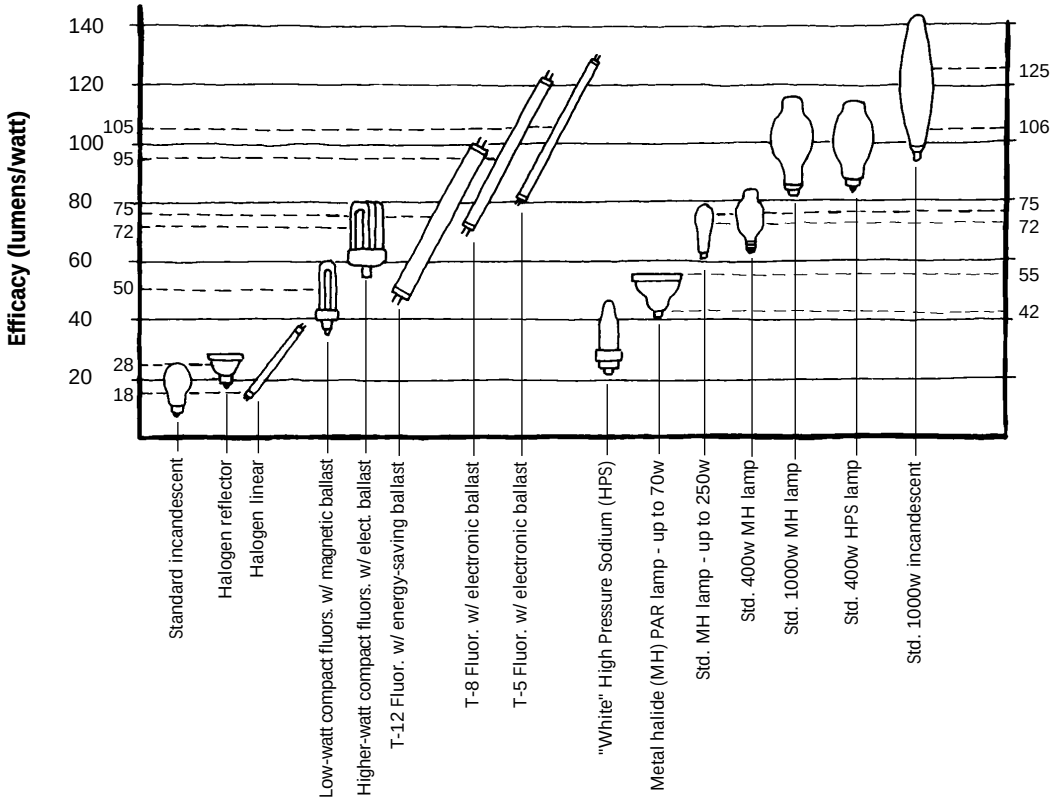
- CEE Premium-efficiency Motors web site
- EPA Energy Star Transformers: CITCEM & DTCEM web site
- Motormaster web site

Linked Practices

CS4

SELECT LIGHTING EQUIPMENT FOR REDUCED ENERGY DEMAND & CONSUMPTION

ES2



Lamp and fixture choices should optimize light distribution and fixture spacing. This not only reduces capital cost and energy consumption, it can also improve space esthetics and atmosphere.

T5 lamps are an energy-efficient choice for general lighting in new designs; they are shorter and 40% smaller in diameter than a T8. These lamps allow fixtures with a very slim profile. However, T5s are not a retrofit lamp; fixtures must be designed specifically for use with T5 lamps and with a light distribution that matches design needs. T8s rewired to share ballasts are often an economical retrofit option.

Select electronic ballasts for fluorescent lamps, and use their ability to adjust light output to optimize capital and operating cost. High ballast-factor ballasts can produce up to 128% of the normal light output without sacrificing lamp life. Although there is an increase in power consumption on a per-lamp basis, careful design can reduce the number of lamps or fixtures required.

Metal halide lamps are a good choice for efficient ambient lighting of high-ceiling spaces. High-pressure sodium (HPS) lamps also serve well, for areas where color rendition is less critical.

The use of compact fluorescent lamps with

Further Information

- Audin. L. et al 1994
- Eley, C. 1993
- Rea, M.S.1993
- Northwest Lighting website 1999
- Southern California Edison website 1999
- CREST inter.Light website 1999

Linked Practices

CS1
CS2
CS3

Environment ✔✔✔

Lighting has large potential for overall energy conservation.

Ease of Use ✔✔

Simple lamp replacement strategies are not always appropriate; determining the best design for the project requires more time.

Other Benefits ✔✔✔

Many energy-saving strategies also result in longer lamp life and lower maintenance costs. Can improve occupant comfort, satisfaction and productivity.

Capital Cost $

Efficient design will typically provide capital and energy savings.

dimmers is a viable option in many applications. Screw-base lamps are now available that can be used with most inexpensive incandescent dimmers.

Mercury content of lamps is another environmental concern. Fluorescent lamps with reduced mercury content, and mercury- and lead-free HPS lamps are now available with no reduction in lumen output in a wide range of wattages. Specify these lamps whenever possible.

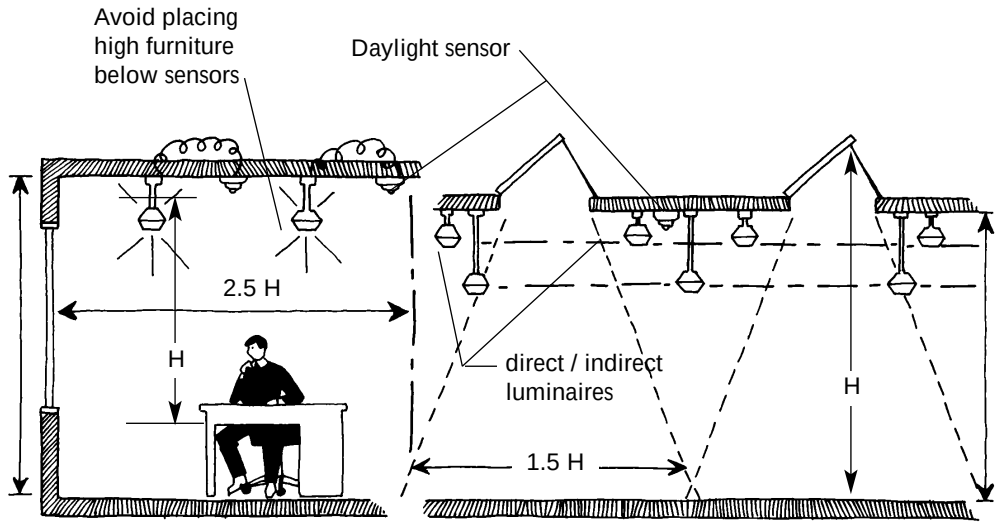
Light-emitting diode (LED) exit signs are currently one of the most efficient technologies, with less than two watts per face power draw.

Cautions

- Technology is rapidly changing. Lighting consultants can help with energy-efficient design.
- Lamp and fixture selection and installation should include earthquake protection.

INTEGRATE DAYLIGHTING & ELECTRIC LIGHTING IN TASK-ORIENTED SPACES FOR PRODUCTIVITY & COMFORT

ES3



For greatest comfort in task-oriented spaces such as offices, distribute daylight and most electric light indirectly – bounced from the ceiling and walls. Reflective surfaces should be light in color, preferably white.

Indirect luminaires are available with wall or ceiling mounts. Choose fixtures for high efficiency and wide light distribution to minimize the number needed. T5 or T8 lamps with electronic ballasts are good options. Efficient lighting power densities typically range from 0.6 to 1.2 W/sq.ft.

Consider space use and color quality to determine lamp color temperature. For a cool ambiance, select lamps with a correlated color temperature (CCT) of 4100°K; for a warmer atmosphere, select 3100°K or lower. 3500°K is a common neutral.

Lay out lighting control zones to supplement daylight variation throughout the day; and coordinate them with HVAC zones and controls for greatest economy. Typically, the maximum width of window daylit zones is 2.5 times the window height. Toplit daylit zones are seldom wider than 1.5 times floor-to-ceiling height (depending on skylight and well dimensions).

Cautions

- Consider power quality and compatibility with dimming ballasts.
- Requires careful luminaire and sensor selection, placement and commissioning.
- Indirect-only lighting system can seem bland; a small direct component adds "sparkle".

Environment ✔✔

Daylighting energy savings range from 10% to 75%.

Ease of Use ✔✔

Some extra effort is required to properly select and lay out an indirect system in a space with windows and skylights.

Other Benefits ✔✔✔

Dramatically improves occupant comfort and often productivity. Lower operating cost.

Capital Cost $$

Indirect or direct/indirect luminaires may cost more to install than a traditional recessed system, but typically less on a life-cycle basis.

Further Information

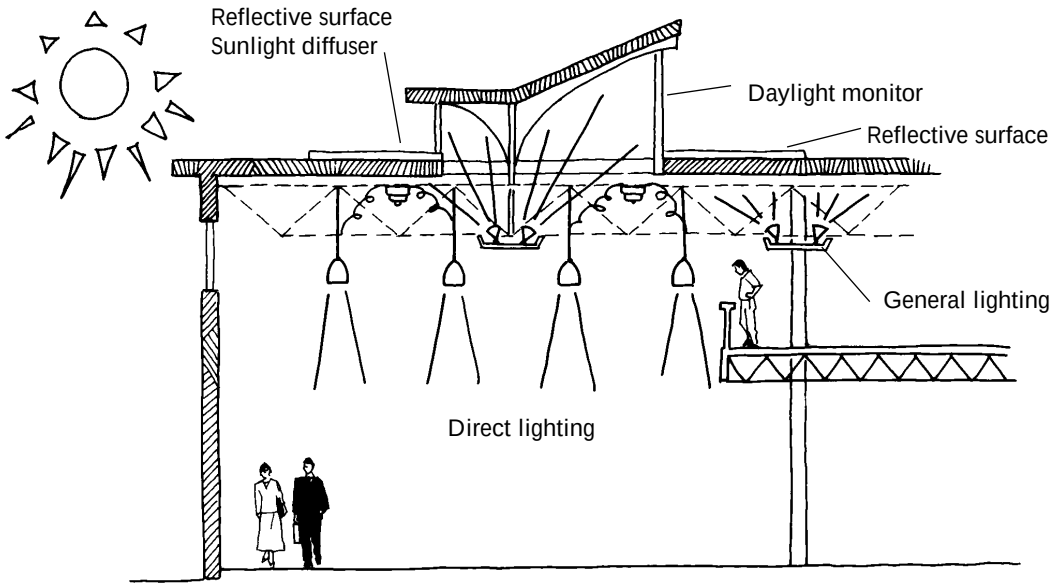
- Ander, G. 1995
- Benjamin, H. 1981
- Rea, M.S. 1993
- Rocky Mountain Institute, 1993

Linked Practices

SF1
EN1
EN3
EN5
CS1
CS2

ES4

INTEGRATE DAYLIGHTING & ELECTRIC LIGHTING IN GATHERING SPACES FOR COMFORT & EFFICIENCY



Environment ✔✔✔
Significant lighting energy savings when coupled with an appropriate control system.

Ease of Use ✔✔
Requires thoughtful light fixture placement.

Other Benefits ✔✔
Improves occupant comfort and reduces operating costs.

Capital Cost $
Specialty fixtures are not necessarily required.

Large spaces, such as lobbies, atria, reading areas, convention facilities, athletic spaces and gymnasiums, can make excellent use of daylight admitted high in the space. This gives more uniform illumination across the floor plane, and allows lower walls to be free of windows if desired.

Supplement daylight by integrating electric fixtures and lamps with wide distribution patterns. Metal halides or T5 / T8 fluorescents with electronic ballasts are good options. If the space is large enough, a design that uses both wide and narrow distribution direct luminaires can provide general ambient lighting as well as a focused atmosphere, with lighting power densities from 0.3 to 1.0 W/sq.ft.

Lay out lighting control zones that allow photosensors to be effectively located, and keep manually switched areas small. Zones sidelit by windows should lie parallel to the windows, with a maximum width typically 2.5 times the window height, with no obstructions. For toplit zones, examine the natural lighting level contours to shape and size zones with similar levels, and supplement dark areas. Coordinate lighting zones with HVAC control zones for economy. During commissioning, zones and sensor coverage should be adjusted.

Cautions

- Consider power quality and compatibility with dimming ballasts.
- Requires careful luminaire and sensor selection, placement and commissioning.

Further Information

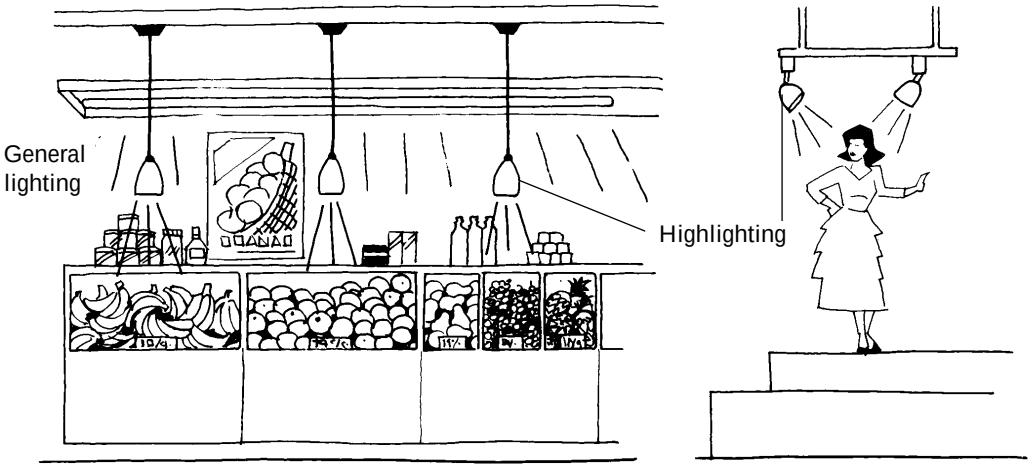
- Ander, G. 1995
- Bednar, M.J. 1986
- Benjamin. H. 1981
- Lam, W.. 1977, 1986
- Rea, M.S. 1993

Linked Practices

SF1
EN1
EN3
EN5
CS1
CS2

MAXIMIZE IMPACT IN SALES AREAS WITH EFFICIENT LIGHTING STRATEGIES

ES5



Retail lighting should create the right contrast to attract potential customers — not simply blast merchandise with light. Contrast can be effectively created by:

- using colored objects and lighting to create dramatic contrast with "color difference".
- using a low level wash for general illumination, with a few high-impact highlights for drama and contrast.

Color difference uses ambient light of one color temperature (e.g., ~4100°K, relatively cool), and highlighting with another color (3000°K, warm), or vice versa. Drama can be created using colored light.

General illumination can be provided with linear or compact fluorescent washes. Adjustable metal halide, white high-pressure sodium or halogen highlights can provide focus on displays.

Energy-efficient choices for highlighting include:

- adjustable metal halide spot PAR lamps or white high-pressure sodium lamps in trackheads or recessed cans.
- long-life (5,000+ hr.) halogen lamps.
- fiber optics to provide pinpointed light without UV or IR damage to the merchandise

Energy-efficient choices for surface washing are:

- compact fluorescent lamps.
- linear fluorescent lamps.
- metal halide flood PAR lamps.

Energy-efficient lighting power densities typically will range from 1.5 to 3.5 W/sq.ft., depending on the merchandise.

Cautions:

- Careful design is required to create the right effect for the type of merchandise.
- High light levels can harm food, clothing and painted objects.

Environment ✔✔✔

Merchandising areas are typically overlit, resulting in high electricity use.

Ease of Use ✔✔

Requires thoughtful light fixture selection and placement.

Other Benefits ✔✔✔

Impact on sales can be significant.

Capital Cost $

Special luminaires are not required.

Further Information

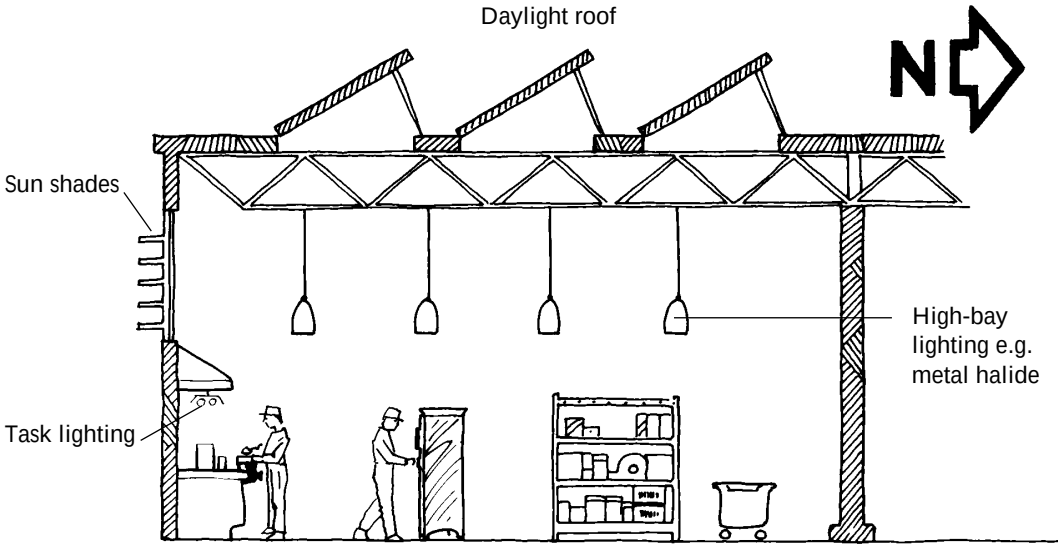
- Ander, G. 1995
- Kellogg-Smith, F. & Bertolone, F.J. 1986
- Rea, M.S. 1993

Linked Practices

SF1
TR2
ES2
CS1

ES6

INTEGRATE DAYLIGHTING & ELECTRIC LIGHTING IN HIGH-BAY, MANUFACTURING & COLOR-CRITICAL AREAS



Daylight is unmatched for color rendering, and safety and productivity of manual tasks. To supplement it efficiently, use electric light with similar distribution. For even ambient light distribution, introduce light high in a space with light-colored upper surfaces. Locate fixtures just above work areas for task illumination.

Lighting levels should respond to visual tasks. Efficient lighting power densities (LPD) range from 0.75 to 1.5 W/sq.ft., though select areas with task- and color-critical work may range from 2.0 to 2.5 W/sq.ft.

High-bay, metal halide (MH) lamps supplement natural light efficiently. Newer 360-watt lamps provide the same output as standard 400-watt MH lamps. High-output 400-watt lamps can provide 10% more lumens. Both have a 20,000-hour life.

Newer MH lamps eliminate the color shift problems of older lamps. When color quality is important, choose lamps with improved color stability, or use high color rendering index (CRI) T8 or T5 fluorescents.

Metal halide and high-pressure sodium (HPS) lamp output can be dimmed using photocell controls and high/low ballasts, to respond to daylight. Occupancy sensors can also switch high/low ballasts for areas with intermittent occupancy, such as aisles.

Cautions

- Consider power quality and lamp/ballast compatibility when using dimming ballasts.
- Control glare from direct sunlight.
- Requires careful luminaire and sensor selection, placement and commissioning.

Environment ✔✔✔

Significant energy savings when coupled with energy-saving controls.

Ease of Use ✔✔✔

Requires little or no extra effort if daylighting entry and distribution are considered early in conceptual design.

Other Benefits ✔✔

The combination of daylight and electric light increases comfort and productivity.

Capital Cost $$

High-intensity discharge lighting control systems are not yet widespread; but capital costs are falling.

Further Information

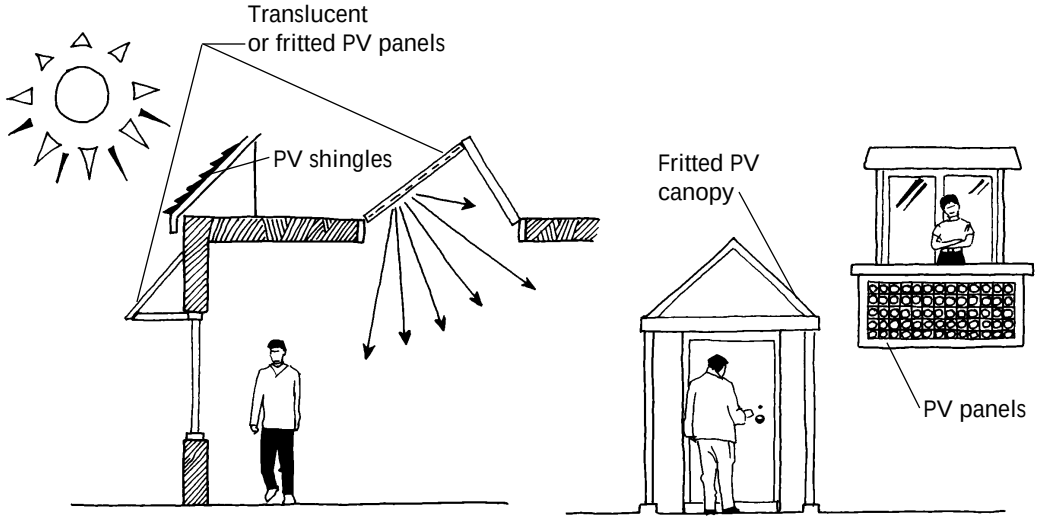
- Ander, G. 1995
- Bednar, M.J. 1986
- Lam, W. 1977, 1986
- Rea, M. 1993

Linked Practices

SF1
EN1
EN3
EN5
CS1
CS2

INCORPORATE PHOTOVOLTAIC ELECTRICITY SYSTEMS INTO THE BUILDING FABRIC

ES7



Photovoltaic (PV) collectors can be integrated into the building envelope as "building-integrated photovoltaics" (BIPV), or mounted on separate dedicated supports ("stand-off arrays").

BIPV collectors integrate weather protection and solar electricity generation for greater economy, since they integrate collector support structures, and displace conventional building materials.As well, they are typically more visually appealing, avoiding the clutter of support structures.

BIPV systems are available for roofing, curtain walls, skylights, roof monitors, awnings, lightshelves and semi-transparent glazing.

Stand-off PV arrays are suited for both new and retrofit applications, but do not save the cost of displaced finish materials.

For the greatest annual energy generation in Santa Monica, orient collectors southwest with a slope equal to the latitude (~35°) from horizontal). Vertical wall-mounted collectors facing southwest outperform collectors facing south on an annual energy basis. Morning fogs and clouds in Santa Monica reduce sunlight availability on southeast and east orientations. Horizontally mounted collectors yield an average of ~124.2 kWh/sq.ft./year. (All figures include reductions in solar radiation by typical cloud cover.)

Photovoltaic arrays generate direct current (DC) electricity. An inverter is required for alternating current (AC) devices, or to connect to the utility grid. Stand-alone PV systems with battery storage are much more expensive than grid-connected systems and, since charging batteries generate hydrogen gas, can be hazardous. In Santa

Environment ✔✔✔

Photovoltaics displace conventional electrical energy generation, resulting in fewer pollutant emissions.

Ease of Use ✔

Requires specialist designers and installers, and building operator training.

Other Benefits ✔✔

Reduced electrical transmission losses, and peak demand charges. Battery systems can provide backup power during grid failure.

Capital Cost $$$

Federal and state grants, tax credits and accelerated depreciation can reduce capital costs and payback time.

Further Information

- Solar Design Associates & NREL. 1997
- Humm, O. & Toggweiler, P. 1993
- Strong, S. 1987

Linked Practices

SF6
ES1
ES2
HS8

Average Annual Solar Radiation in Santa Monica, kWh/(sq.ft.-year)

Orientation	Array Slope = 20 degrees	Array Slope = 35 degrees	Array Slope = 50 degrees	Array Slope = Vertical
South	135.2	135.9	130.1	87.3
SW	140.7	140.6	134.8	96.5
SE	121.7	121.5	116.5	83.4
W	130.4	125.8	118.4	87.3
E	112.8	108.7	102.4	75.5

NOTE: To estimate annual energy from a PV array, multiply value by 0.14 for crystalline silicon PV, and 0.05 for amorphous silicon PV.

Monica these are recommended only for emergency power applications.

Grid-connected BIPV systems are cost-effective on a life-cycle basis in Los Angeles today. For example, in Santa Monica PV atrium glazing can have a payback period of less than 10 years when the savings of displaced exterior finish materials are considered.

Other electrical components, such as inverters and wiring, should be specified to minimize energy losses. AC systems allow for smaller wire sizes, a wider range of UL rated safety equipment, and lower costs.

Inverters come in two general categories: stand-alone, for battery storage systems; or utility-interactive, for connection to the utility grid. Modern solid-state utility-interactive inverters are available complete with safety disconnects, automatic transfer switches, maximum power point tracking and other features for code-approved installation.

Key considerations when selecting inverters are:

- sizing for peak loads and high surge currents of induction loads;
- power quality (output should be a true sine wave);
- high conversion efficiency (>90%);
- low standby power consumption; and
- staged or dedicated inverters for higher operating efficiency.

Ventilation to keep PV collector temperatures low is important for maximum power output. Custom designs can integrate with building HVAC systems to collect heat from PV collectors to preheat outdoor air.

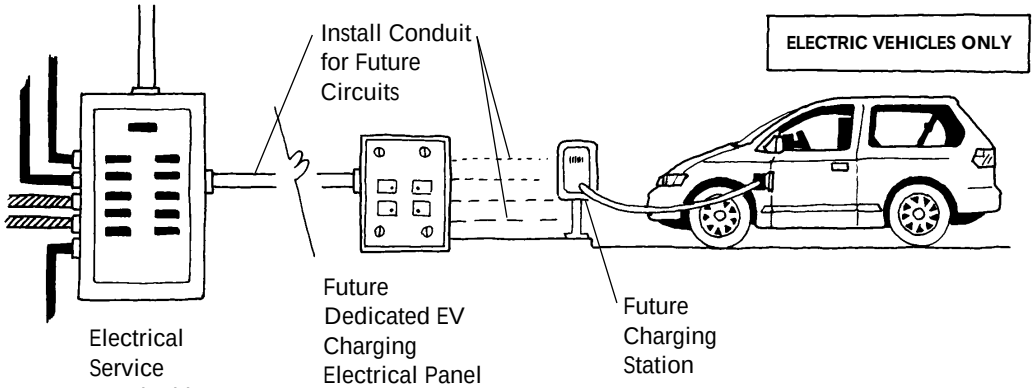
Low-interest loans are available from the Federal Million Solar Roofs program; both loans and grants are available from the California Energy Technologies Advancement Program (ETAP). Tax credits and accelerated depreciation are available to improve economic viability.

Cautions

- Equipment and systems should be certified by the Solar Rating Certification Corporation (SRCC) and other nationally-recognized electrical certification agencies.
- Codes and regulations governing building-integrated photovoltaics are under development.
- System design and installation should be performed by licensed specialists, and properly commissioned.
- Multiple trades may be involved for system maintenance/replacement, requiring extra coordination.
- System sizing should account for slight output degradation over time, typically 1% to 2% per year.
- Photovoltaic modules must be clean for best performance; easy access must be considered.

PROVIDE FOR FUTURE ELECTRIC VEHICLE CHARGING STATIONS

ES8



Prepare for future installation of electric vehicle (EV) charging stations for 1 of every 20 on-site parking stalls, by providing sufficient panel space, installing conduit, and for ventilation and lighting.

Currently, there are several different EV charger types: inductive paddles and others with plug connectors. Until these standards are resolved, it is difficult to know which type to install. However, they have similar electrical and mechanical requirements, and preparing for their future installation during construction is much simpler and cheaper than adding them later.

New California Electric Code and California Building Code sections govern EV charging station installation. Non-commercial chargers require either a dedicated 40A-240V ground-fault circuit interrupter (GFCI) circuit for a 3-to 8-hour charge; or a 15A-120V GFCI circuit for a 10- to 15-hour charge. (120V charging stations are far less convenient for users because of the long charge time.) Charger and lighting electrical panels should be located as close as possible to anticipated charging stations for lowest cabling costs. Install conduit for future cables. Anticipated charging stations should also have sufficient space for a charger, its base and protective wheel stops.

Chargers in garages require interlocked ventilation to reduce explosion hazards during charging.

Cautions

- Hydrogen gas is extremely explosive, and generous ventilation must be provided in enclosed spaces.

Further Information

- CEC website 1999
- California Electrical Code, chapter 6, Article 625
- California Building Code, Section 1202

Linked Practices

TR6

Environment ✔✔

Charging stations are needed to encourage use of electric vehicles.

Ease of Use ✔✔✔

Requires some research, but little special expertise.

Other Benefits ✔

Marketing benefit.

Capital Cost $

Major cost component is larger size of building electrical service; otherwise costs are minor.

FURTHER INFORMATION

Ander, G. 1995. *Daylighting Performance and Design*. John Wiley & Sons, New York.
An excellent quick reference and study for the busy professional. Up-to-date, many tables, and oriented toward California conditions, it is useful for any location.

Audin, L., D. Houghton, M. Shepard, and W. Hawthorne. *1994 Lighting Technology Atlas*. E Source Inc., Boulder, CO.
E Source continues to be one of the most comprehensive sources of objective and succinct technology and equipment reviews.

Bednar, Michael J., 1986. *The New Atrium*. McGraw-Hill, New York.
Overview of daylighting and other design issues of atriums.

Benjamin. H. 1981. *Daylight in Architecture*. McGraw-Hill, New York.
Good introduction to daylighting issues and concepts. Discusses daylight as related to other environmental and architectural concerns. Contains basic sketches, photos and case studies.

Brown, G.Z. 1985. *Sun, Wind and Light: Architectural Design Strategies*., John Wiley & Sons, New York.
Architecturally illustrated text focuses on climactic site resources and suggests design strategies. Reference tables are included.

California Energy Commission. *Electric Vehicles EVs in California*. (March 1999) [WWW document] URL http://www.energy.ca.gov/afvs/ev/index.html
The CECs' website contains general information on EVs, lists of EVs for sale and lease, summaries of state programs and incentives, a photo gallery and Web links for the EV industry.

Center for Renewable Energy and Sustainable Technology (CREST). *Inter.Light – The Lighting Source for Lighting Specifiers*. .(March 1999). [WWW document] URL http://www.lightsearch.com/
Inter.light is a searchable database of lighting resources, including lamps, luminaires, ballasts, controls, components, software and applications.

Consortium for Energy Efficiency (CEE). *CEE Fact Sheet – Premium-Efficiency Motors Initiative*. (March 1999). [WWW document] URL http://www.ceeformt.org/ceetoday/ceefacts/index.htm
The CEE has several certification programs that set efficiency targets for lamps and other equipment.. It is a non-profit corporation supported by the U.S. EPA and DOE.

Duffie, J A., and Beckman, W. A. 1980. *Solar Engineering of Thermal Processes*. John Wiley & Sons, New York.
The bible of solar thermal engineering, Duffie and Beckman's procedures and data for calculating solar resources has direct application to photovoltaic applications as well.

Eley, C. 1993 *Advanced Lighting Guidelines:1993 Revision 1*. Electric Power Research Institute, Palo Alto, CA.
An excellent handbook for all components of lighting, from lamps to luminaires to controls. Provides basic as well as technically detailed information. Includes diagrams, tables and charts.

Environmental Protection Agency (EPA). *Energy Star Labelled Transformers – Technical Resources Software: DTCEM & CITCEM* . [WWW document] (March 1999). URL http://www.epa.gov/appdstar/transform/resources.html
The U.S. DOE and the EPA jointly sponsor the Energy Star program, which certifies and labels efficient lighting and HVAC equipment, as well as appliances. Its website lists many information resources, mostly oriented to residential / small commercial applications.

Home Power Magazine. P.O. Box 520, Ashland, OR 97520. Available online at http://www.homepower.com
An excellent bi-monthly magazine, offering hands-on experience on photovoltaic and wind energy generation. While mostly oriented toward off-grid, single-family residential applications, it has a good balance of theory and practical experience, and information valuable for commercial/institutional projects. Back issues are available on-line and in CD-ROM format.

Humm, O. and Toggweiler, P. 1993. *Photovoltaics in Architecture*. Birkhauser Verlag, Boston.
An excellent introduction to integrating photovoltaics into buildings' roofs and walls. Includes brief technical discussion, construction details for a variety of wall and roof systems, and 45 case studies with photographs.

Kellogg-Smith, F. and Bertolone, F J. 1986 *Bringing Interiors to Light*, Whitney Library of Design, New York.
An application-specific lighting analysis and discussion of lighting design. Complete with case studies, diagrams and photographs.

Lam, W.M. 1977. *Perception and Lighting as Formgivers for Architecture*. McGraw-Hill, New York.
Lam, W.M. 1986 *Sunlighting as Formgiver for Architecture*. Van Nostrand Reinhold, New York.
Lam's two books are excellent introductions to the use of architectural form to enhance daylighting. Controls and fixture technology have increased efficiencies since these books were written. Case studies global in scope, and excellent photographs.

Lawrence Berkeley Laboratory. *Radiance Synthetic Imaging System*. (March 1999). [WWW document] URL http://radsite.lbl.gov/radiance/HOME.html
Radiance is an advanced lighting simulation and rendering software package by LBL, available for free download via the Internet. It predicts illumination, visual quality and appearance of design spaces for interior and exterior spaces considering electric lighting, daylight and interreflection. Requires a high level of computer literacy.

Lawrence Berkeley Laboratory. *SUPERLITE 2.*. [WWW document] (March 1999). URL http://eande.lbl.gov/BTP/WDG/SUPERLITE/superlite2.html
Simple DOS-based daylighting and electric lighting analysis program, available for free download

via the Internet. Superlite calculates interior illuminance levels in complex building spaces. . Less demanding than Radiance in computer hardware, it outputs a formatted text file with interior point-by-point illuminance levels; but not visual images.

Lighting Analysts, Inc. *Lighting Analysts Home Page – AGI32*. [WWW document] (March 1999). URL http://www.Lighting Analysts.com
AGI32 is a three-dimensional lighting analysis program for Windows-based computers. Capable of predicting exterior and interior light levels in spaces of almost any shape, including slopes, vaults and domes, AGI32 also comes with a luminaire library and creates graphic renderings.

Lighting Technologies Inc. *Lighting Technologies Home Page - Lumen Micro Software*. [WWW document] (March 1999). URL http://www.lighting-technologies.com/
Lumen Micro, a Windows interface light modeling program with an extensive luminaire library, uses a CAD interface, and can import Autocad and other CAD program files for geometry input/custom export. An add-on package creates high-resolution graphic renderings.

Northwest Energy Efficiency Alliance. *Northwest Lighting Home Page*. (October 1998). [WWW Document] URL http://www.northwestlighting.com
An extensive collection of lighting case studies, research, technology and specifiers reports covering almost all aspects of efficient lighting. Includes a large products database. The renowned Lighting Design Lab in Seattle, WA is a co-sponsor and maintains the database.

Rea, M.S., (ed). 1993. *Lighting Handbook: Reference and Application, 8th edition*. Illuminating Engineering Society of North America, New York.
The bible of illuminating engineering. This reference tome provides both basic and highly technical information for general and application-specific lighting inquiries.

Rocky Mountain Institute (RMI). 1993. *Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design*. RMI, Snowmass, CO.
Documents 8 buildings where energy-efficient designs have paid for themselves not only in reduced energy costs, but in higher worker productivity (as high as 16%), lower absenteeism, fewer errors, better quality, and increased retail sales.

Solar Design Associates and National Renewable Energy Laboratory. 1997. *Photovoltaics in the Built Environment: A Design Guide for Architects and Engineers*. DOE/GO-10097-436. Produced for U.S. Department of Energy.
An excellent guide to incorporating photovoltaic energy generation into commercial and institutional buildings.

Southern California Edison: Customer Technologies Applications Center (CTAC), 6090 Irwindale Ave., Irwindale, CA 91702. (800) 336-2822
CTAC is an excellent resource for Southern California designers and builders. Offering extensive information resources, samples of many lighting products and technologies, and training courses,

CTAC can help developers and designers take advantage of the many SCE rebates and programs.

Southern California Edison. *SCE, Saving Money" & "SCE, New Construction Incentives*. (March 1999) [WWW Documents] URL http://www.sce.com/savesca/index_sv.htm and, http://www.scebiz.com/solutionscc/programs/newconst.htm
WWW-based information on building energy saving and current utility incentives offering to builders by SCE.

Southern California Gas Company: Energy Resource Center, ML ERC 1, 9240 E. Firestone Blvd., Downey, California, 90241-5388. (800) 427-6584.
The Energy Resource Center acts as a clearinghouse for energy and environmental information, with a conference center showcasing the latest energy technologies. The ERC holds energy- and money-saving seminars and workshops on subjects ranging from boiler heat-recovery systems to the phaseout of CFCs. The building itself, selected as "Energy Star" by the U.S. EPA as a model for future building designs. About 80% of the building is made of reused or recycled materials, and it exceeds California Title 24 energy requirements by 45%.

Strong, S.J. 1987. *The Solar Electric House*. Rodale Press, Emmaus, PA.
An excellent reference on incorporating photovoltaic energy generation into building design. While oriented toward single-family dwellings, most of the information is directly applicable to commercial and institutional buildings.

U.S. Department of Energy. *Million Solar Roofs*. (March, 1999) [WWW document] URL http://www.eren.doe.gov/millionroofs/millionroofs.html

U.S. Department of Energy. *The Borrower's Guide to Financing Solar Energy Systems: A Federal Overview*. (March, 1999) [WWW document] URL http://www/eren.doe.gov/millionroofs/025104m_Borrowers_Guide.pdf
The U.S. DOE's Million Solar Roofs initiative is encouraging PV technology by addressing regulatory barriers, increasing general awareness, and with fiscal incentives. DOE administers the "Federal Investment Tax Credit for Solar Energy on Commercial Property" and "Accelerated Depreciation for Solar Energy on Commercial Property" programs, and operates the National Database of State Incentives for Renewable Energy DSIRE.

U.S. Department of Energy. *The Motor Challenge Program: What's New in Software: MotorMaster+ 3.0*. (March, 1999) [WWW document] URL http://wwwmotor.doe.gov/mcssoft.html

Offers a free CD with MotorMaster software, a database and program calculating life-cycle energy and cost savings, a comprehensive product database, and selection help for energy-efficient motors.

U.S. Navy. *NAVY Whole Building Design Guide: Building Integrated Photovoltaic*. (March, 1999) [WWW document] URL http://www.psic.org/navy-wbdg/bipv-rp/bipv-rp.htm
Part of the U.S. Navy's Whole Building Design Guide, the Building Integrated Photovoltaics chapter is a good overview of the issues, with a review of fundamentals and design recommendations.

HVAC SYSTEMS

HVAC SYSTEMS

Heating, ventilating and air-conditioning (HVAC) systems can play several roles to reduce the environmental impact of buildings. The primary function of HVAC systems is to provide healthy and comfortable interior conditions for occupants; well-designed, efficient systems do this with minimal non-renewable energy and air and water pollutant emissions. Cooling equipment that avoids chlorofluorocarbons and hydrochlorofluorocarbons (CFCs and HCFCs) eliminates a major cause of damage to the ozone layer.

However, even the best HVAC equipment and systems cannot compensate for a building design with inherently high cooling and heating needs. The greatest opportunities to conserve non-renewable energy are through architectural design that controls solar gain, while taking advantage of passive heating, daylighting, natural ventilation and cooling opportunities. The critical factors in mechanical systems' energy consumption – and capital cost – are reducing the cooling and heating loads they must handle.

Indoor Air Quality

Indoor air quality is a central concern for mechanical designers and contractors, requiring careful design, installation and site review for good results. The first step is to reduce contaminant sources through careful material selection practices, as recommended in the Materials and Construction Management chapters. Conditioning large amounts of outdoor air to deal with indoor pollutants that could have been avoided is a waste of energy – and money.

Bio-contaminants – microbial diseases, fungi and molds – are some of the most potentially dangerous indoor air pollutants. These typically grow best in warm, dark, moist environments, which have a ready source of nutrients such as dust and dirt. Standing water in contact with ventilation air supplied to occupied spaces can harbor these organisms. Of particular concern is legionella, which can be fatal to exposed occupants. Potential legionella sources include cooling tower drift, direct evaporative coolers, and standing water in coil drain pans or in humidifiers.

Combustion equipment for heating, such as furnaces and boilers, is another potential source of indoor air pollutants, such as carbon monoxide and nitrogen oxides. Natural gas and propane equipment, if operating properly, emit little carbon monoxide; their major air emissions are carbon dioxide and water vapor. However, they still emit trace pollutants, including sulfur oxides, polyaromatic hydrocarbons and nitrogen oxides, which have been shown to affect health with chronic, low-level exposures. Designers can reduce or eliminate occupant exposure to combustion products by isolating combustion chambers from occupied spaces, providing excess combustion air under all operating circumstances, and ensuring that equipment operators have complete manuals and training in maintenance procedures to keep the equipment properly tuned.

Man-made mineral fibers (MMMFs) are another potential indoor air pollutant from mechanical systems, causing nasal, throat and eye irritation. These typically come from damaged fibrous duct liners used to reduce noise, or from insulation and ceiling tiles exposed in air return plenums. These fibrous materials can become greater hazards if they become damp, as they form an ideal growth medium for bio-contaminants – especially since they tend to trap and retain dust.

Some indoor air pollutants are difficult to eliminate. In these cases, isolation and local exhaust helps control occupant exposure. This strategy works best with photocopiers and laser printers, storage areas for toxics such as cleaners and pesticides, areas for gluing and solvent use, and other local "point sources."

A crucial element in pollutant source control is ensuring that outdoor air intakes do not bring pollutants into the building. Santa Monica has some of the best outdoor air quality in the entire Los Angeles basin, largely due to steady on-shore winds, so treatment of outdoor air is usually necessary only near local sources of air pollution. However, the location of outdoor air intakes and operable windows must be carefully separated from building pollution sources such as cooling towers, combustion appliance vents, vehicle exhausts, plumbing vents and air exhausted from buildings.

Once pollutant source controls are addressed, efficiently filtering supply air and providing generous amounts of outdoor air will help ensure indoor air quality. An HVAC system that is capable of providing more outdoor air than the minimums required by ASHRAE standards helps ensure flexibility and occupant health in future, as building uses and furnishings change.

These efforts can aid the marketability of buildings, with growing awareness and concern about indoor air quality by buyers and lessors. They can also reduce the liability exposure of building developers, designers, builders and managers.

Energy-Efficient HVAC Equipment

Climate-responsive building design reduces heating and cooling loads, and thus the size of HVAC systems and equipment. The cost of smaller equipment often more than offsets the cost of envelope and electrical upgrades aimed at saving energy. Selection of more efficient HVAC equipment can further conserve non-renewable energy, and reduce air pollution from electricity generation and on-site combustion. The efficiency of heating and cooling equipment has improved significantly since the introduction of minimum efficiency regulations such as Title 24 and federal requirements. As demand for better equipment has increased, the cost of energy-efficient HVAC equipment has dropped. However, equipment that exceeds regulated minimums often bears a capital cost premium. This can be balanced by other factors which reduce capital and life-cycle cost, and enhance marketability of the building.:

- Smaller heating and cooling loads allow smaller, less expensive HVAC equipment and ductwork.
- Reduced energy costs can pay for HVAC equipment investment within two to three years.
- High-efficiency equipment tends to be of higher quality, with longer service lives and warranties.

Cooling Equipment and Ozone Layer Protection

Chlorofluorocarbon refrigerant production has been banned in most nations, and its use is declining as recycled CFC costs continue to rise dramatically. Hydrochlorofluorocarbon refrigerants are currently permitted, but new production is scheduled to end in 2010, within the lifetime of most of the smaller HVAC equipment typical in Santa Monica buildings. HCFC costs are likely to rise quickly when production ends, just as CFC costs have.

CFC-free chillers, air conditioners and heat pumps are now in widespread use, with excellent efficiencies, and capital costs comparable to those before the end of CFC production. However, HCFC-free equipment is currently not available in a full range of equipment sizes and models. Building design for the long term must consider how HCFC equipment will be replaced in future.

HVAC SYSTEMS PRACTICES SUMMARY TABLE

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
HS1 Eliminate Mechanical System Sources of Indoor Air Pollution	✔✔✔	✔✔✔	✔✔✔	**$$**
HS2 Isolate & Exhaust Indoor Point Sources of Air Pollutants	✔✔✔	✔✔✔	✔✔✔	**$$**
HS3 Separate Outdoor Air Intakes from Air Pollutant Sources	✔✔✔	✔✔	✔✔✔	**$**
HS4 Provide for Additional Outdoor Air Supply Quantities in Future	✔✔	✔✔✔	✔✔	**$**
HS5 Filter or Treat Ventilation Air Supplies	✔	✔✔	✔	**$**
HS6 Provide Effective Ventilation Air Distribution	✔	✔✔	✔✔	**$$**
HS7 Reduce or Eliminate Use of CFCs and HCFCs in Cooling Equipment	✔✔✔	✔✔	✔✔	**$**
HS8 Select High-Efficiency Heating & Cooling Equipment to Reduce Energy Consumption & Demand	✔✔✔	✔✔✔	✔✔✔	**$$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

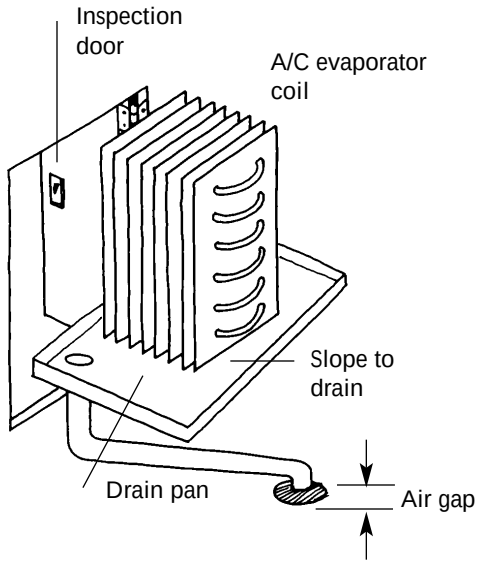
Low ✔
Moderate ✔✔
High ✔✔✔

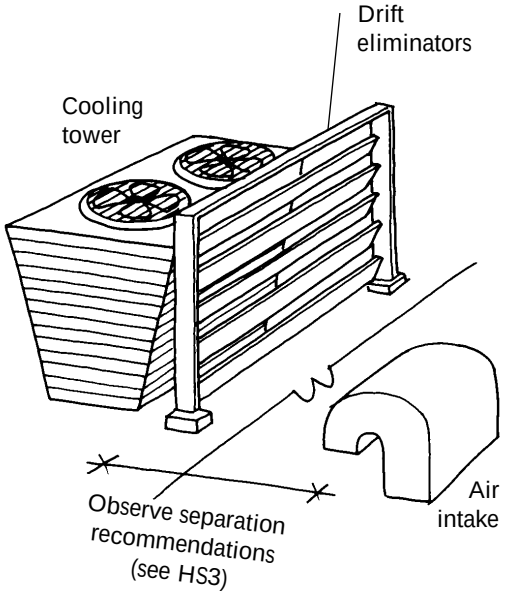
Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

ELIMINATE MECHANICAL SYSTEM SOURCES OF INDOOR AIR POLLUTION

HS1





There are three main sources of potential indoor air pollution from heating, ventilating and air-conditioning systems: standing water, man-made mineral fibers and combustion products.

Standing Water

Eliminate the potential for standing water in ducts and HVAC equipment. Pay particular attention to coils, drain pans, humidifiers and cooling towers.

Coil drain pans should have:

- a generous slope to a drain equipped with a trap and a trap primer.
- traps deep enough to ensure that water will not be drawn back into the pan.
- an air gap between the pipe end for inspection.
- sufficient space for continuously sloped drain piping, avoiding high pockets.

Humidifier and cooling coils should be located so that moisture droplets and condensation will not accumulate on duct surfaces. Avoid placing duct liners or other absorbent materials within 10 duct diameters downstream.

Cooling towers should be located distant from outdoor air intakes, and specified with drift eliminators with water treatment facilities convenient to the tower. Post logs at each tower, detailing treatment and inspection dates and the amount and type of chemicals added. Treatment schedules should reflect manufacturer requirements and local water quality.

Provide access hatches and prominent identification signs that make inspection and cleaning of cooling coils, drain pans and humidifiers simple. Hatches should allow easy cleaning of equipment and downstream ducts. Post a log at

Further Information

- ASHRAE Standard 62-1989
- ASHRAE, Practical Control of Indoor Air Problems, 1987
- ASHRAE, Engineering Solutions to Indoor Air Problems, 1988
- National Academy Press, 1981

Linked Practices

HS2
HS3
HS4
HS5
CM6
CM9

Environment ✔✔✔

Important for occupant health.

Ease of Use ✔✔✔

Requires little extra effort, except for closer coordination and inspection during and after construction.

Other Benefits ✔✔✔

Increases occupant satisfaction and comfort.

Capital Cost $$

Ducted return systems are more expensive than plenum return; all others have small or no capital cost premium.

each, identifying dates and observations of inspections and cleanings.

Designers, contractors and commissioning agents should ensure that field installations do not compromise drain slopes or hide inspection hatches and signage.

HVAC system operation manuals and operator training should specify a frequent and regular inspection schedule, with cleaning of potentially wet areas.

Man-Made Mineral Fibers

MMMF sources in HVAC systems include insulation within packaged equipment, duct liners installed for noise control, and damaged ceiling tiles and fibrous insulation in contact with return air.

In ducts and equipment, liners, silencers and equipment insulation should include a tough waterproof membrane installed on the air side, and exposed seams should be protected from fraying.

Return air plenums with fibrous ceiling tiles or exposed fiberglass and rock wool insulation should be avoided if possible; standard filters do not remove all damaging fibers from the air stream. Ducted return air systems or returns directly from conditioned spaces are preferable.

If a return plenum with exposed mineral fiber is unavoidable, ensure that it is continually under negative pressure. Obstructions to plenum airflow can positively pressurize portions of a plenum, resulting in intermittent puffs of air contaminated with MMMFs and dust. Site review and commissioning should look for obstructions to plenum airflow, and measure relative pressures between plenums and occupied areas.

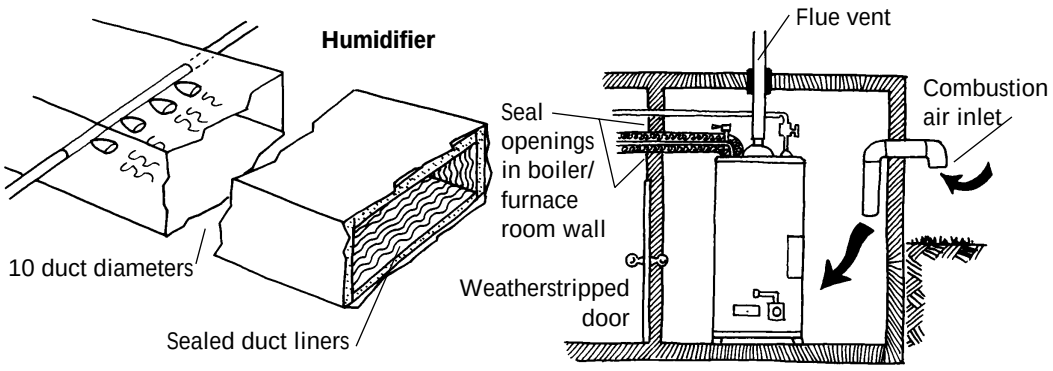
Backdrafting and Spillage of Combustion Products

Boilers and furnaces located within a building are vulnerable to backdrafting and spillage of combustion products, especially with high exhaust rates and static pressures. To avoid occupant exposure:

- Provide generous amounts of combustion air, with low-static pressure loss supplies.
- Isolate the combustion chamber from occupied spaces, using sealed combustion chambers, forced or induced draft equipment, or by sealing equipment rooms.
- Consider the effect of building exhausts on combustion equipment venting. Provide adequate make-up air for exhausts, especially those with large flows and static pressures.

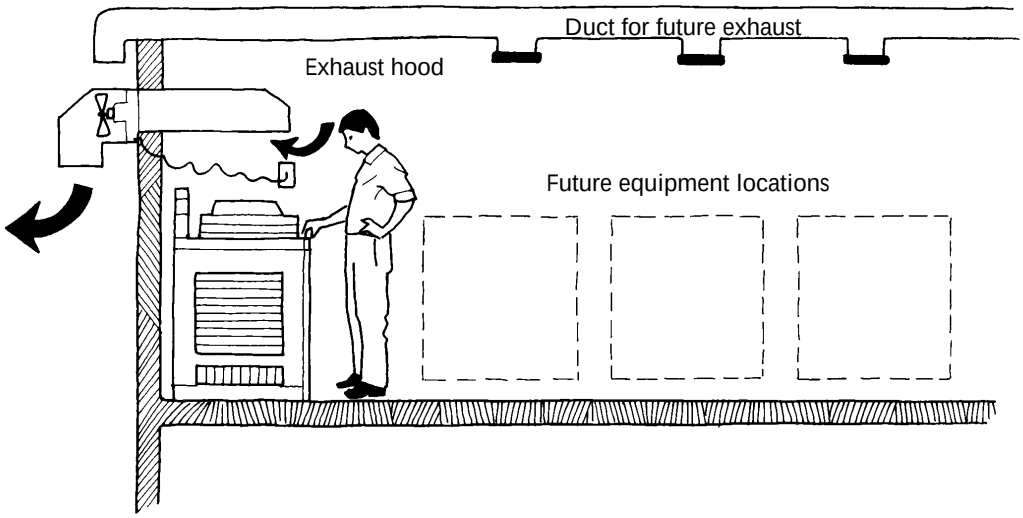
Cautions

- Building owners and contractors should be made aware of the potential health hazards of exposed mineral fibers in return air plenums if return ducts are eliminated as a cost-reduction measure.



HS2

ISOLATE & EXHAUST INDOOR POINT SOURCES OF AIR POLLUTANTS



Building occupants often need equipment or materials that can be sources of indoor air pollution. These include high-capacity photocopiers, laser printers, blueprint and film processing machines, gluing or painting areas, and toxic cleaning products.

To reduce occupant exposure to indoor air pollutants:

- Isolate the source from occupied spaces.
- Provide a local exhaust to the outdoors.

Ideally, each floor and suite should have a local exhaust capability. If the source location is known, install an exhaust inlet as close as possible, behind and above the source. If the location is not established, provide for future installations by installing:

- a capped exhaust duct inlet in each suite or floor, or
- equipment spaces that lead to an appropriate location for an exhaust outlet.

For intermittent sources, such as blueprint or film machines, control the exhaust with a labeled switch located near the equipment. Exhausts for continuous sources (including high-capacity laser printers and photocopiers) should be scheduled to start an hour before and after occupied periods.

Point source locations change as interior layouts change. Ideally, pollutant sources should be located in an unoccupied room. If this is not possible, locate point sources far from occupied areas, preferably in a niche or cabinet that limits pollutant dispersion and aids exhaust effectiveness.

Further Information

- ASHRAE Fundamentals Handbook, 1997
- ASHRAE Systems & Equipment Handbook, 1996
- ASHRAE Standard 62-1989
- ASHRAE, Practical Control of Indoor Air Problems, 1987

Linked Practices

HS1
HS3
HS4
HS5
CM6
CM9

Environment ✔✔✔

Reduces occupant exposure to indoor air pollutants.

Ease of Use ✔✔

Requires no special skills or knowledge.

Other Benefits ✔✔✔

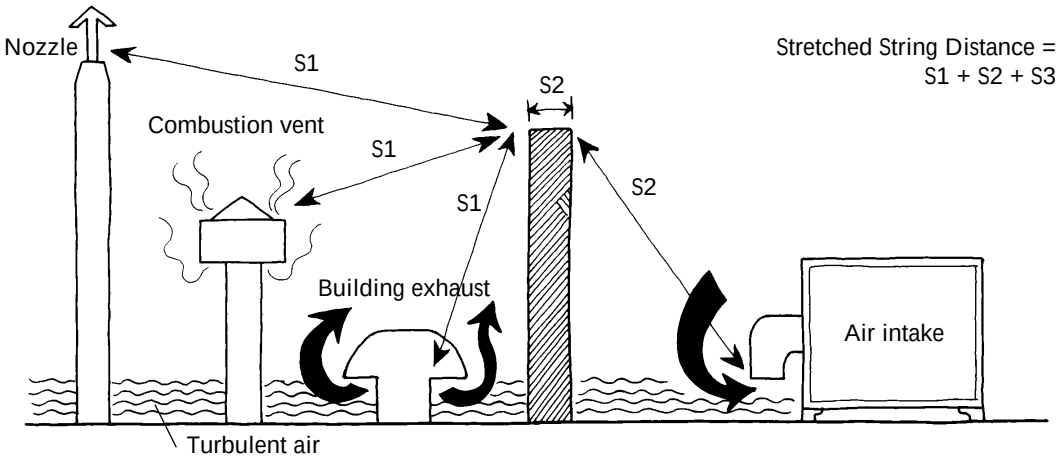
Increases occupant satisfaction and comfort.

Capital Cost $$

Will require installation of general exhaust for some spaces where it is not yet general practice.

HS3

SEPARATE OUTDOOR AIR INTAKES FROM AIR POLLUTANT SOURCES



Environment ✔✔✔
Critical to minimize occupant health risks; reduces exposure of neighbors to building air pollution.

Ease of Use ✔✔
Requires no special skills or knowledge.

Other Benefits ✔✔✔
Increases occupant satisfaction and comfort.

Capital Cost $
No additional capital cost with effective coordination and site review.

Outdoor air intakes located near pollutant sources are a common cause of indoor air quality problems, often affecting occupant health. Intakes and operable windows should be located as far as possible from potential pollutant releases.

Generic recommendations for "stretched string" separation distances between pollutant sources and outdoor air intakes or the property line are summarized in the accompanying table. (**"**Stretched string" distance is measured from the closest point of the pollutant source to the closest point of the outdoor air intake, window or door opening, or the property line, along a path as if a string were stretched between them.**)**

Minimize the risk of drawing contaminated air from building vents and exhausts into air intakes:

• Extend combustion equipment vent outlets on roofs above the turbulent air boundary.

• Exhausts with significant contaminants, toxic fumes or gases should be directed vertically to ensure their plumes are carried away from the roof and turbulent wake downwind of the building.

• Avoid locating intakes in semi-enclosed areas with exhausts, vents, cooling towers or evaporative coolers.

Be careful to avoid locating outdoor air intakes where they may capture air from automobiles and trucks, especially where vehicles may be idling while stopped, such as loading bays, passenger drop-off zones and parking areas, or near roads with heavy traffic.

Cautions

• Separation distance recommendations are generic. Review site conditions carefully, and perform a separation analysis per ASHRAE Fundamentals 1997, Chapter 15 where any uncertainty exists.

• Plumbers often locate plumbing vents without noting air intake locations.

Further Information

• ASHRAE Standard 62-1989
• ASHRAE Fundamentals Handbook, 1997
• ASHRAE, Practical Control of Indoor Air Problems, 1987
• ASHRAE, Engineering Solutions to Indoor Air Problems, 1988

Linked Practices

EN3
HS2
LA2

Recommended Separation Distances of Ventilation Outside-Air Intakes & Pollutant Sources

Pollutant Source	Distance from Outdoor air Intake (ft)	Distance from Property line (ft)	Notes
Property Line	3	-	
Garage entry, loading areas, or drive-in queue	25	-	Note 1
Driveway or street	10	-	Note 1
Limited access highway	25	-	Note 1
Mantles or ledges (sloped less than 1:1 and more than 6 inches wide)	3	-	
Landscaped grade	6 (8)	-	Note 2
Roof or grade	1.5	-	
Air exhausted or vented from spaces without unusual contaminants: e.g. offices, conference rooms, class-rooms, lobbies, retails paces, coffee stations, storage & air handling or elevator machine equipment rooms, individual dwelling units including hotel rooms, and electrical.telephone closets	5	0	Note 1 Note 3
Air exhausted or vented from spaces that may have mild contaminant intensity: eg: copy or printer rooms, dining areas and break rooms, kitchenettes or dining areas with ovens or other cooking of floor dispensing capability such as steam tables, cafeterias, laundry rooms, locker rooms, residential kitchens, limited access toilet rooms, and residential bathrooms.	9	5	Note 3 Note 4
Air exhausted or vented from locations with signifi-cant contaminant intensity: Public toilet rooms, health care facility bathrooms, janitor's closets, commercial kitchens, laboratories general exhaust, dry-cleaning establishments general exhaust, indoor swimming pools, diazo printing rooms, etc.	13	10	Note 3 Note 4
Gravity and plumbing vents	19	10	
Air drawn or vented from locations with noxious or toxic fumes or gases: Natural gas and propane appli-ance vents, paint spray booths, garages, tunnels, kitchen hood exhaust, laboratory filtered fume hood exhaust, chemical storage rooms, refrigerating machinery rooms and soiled laundry storage, etc.	18	10	Note 5
Effluent or exhaust air having a high concentration of dangerous particles, bio-aerosols, or gases: eg: fuel-burning appliance vents (other than natural gas and propane), uncleaned fume hood exhaust, evaporative condenser and cooling tower outlets.	26	15	Note 6

Note 1: Per UMC 317.6 minimm separation of ventilation outside air for heating from exhaust outlets, appliance vents, plumbing vents is 10 feet unless outlet is 3 feet above outside air inlet; and for horizontal intakes abutting sidewalk, streets, alleys or driveways. Larger distances may be necessary if intake is above likely location of vehicles.

Note 2: Soil, lawn or plants within 1.5 ft horizontally from intaek. UMC 405.2 requires 8 feet above grade for health facilities.

Note 3: Assumes 500 fpm exhaust velocity directed away from outdoor air intake.

Note 4: 0 ft separation from property line if property line abuts a street or public way and outlet is at least 10 ft above grade.

Note 5: Assumes 500 fpm vent exit velocity directed vertically up.

Note 6: Assumes 750 fpm exhaust velocity directed vertically up, and that exhaust is located above or at same level as intake.

Source: Proposed ASHRAE Standard 62R (1997)

HS4

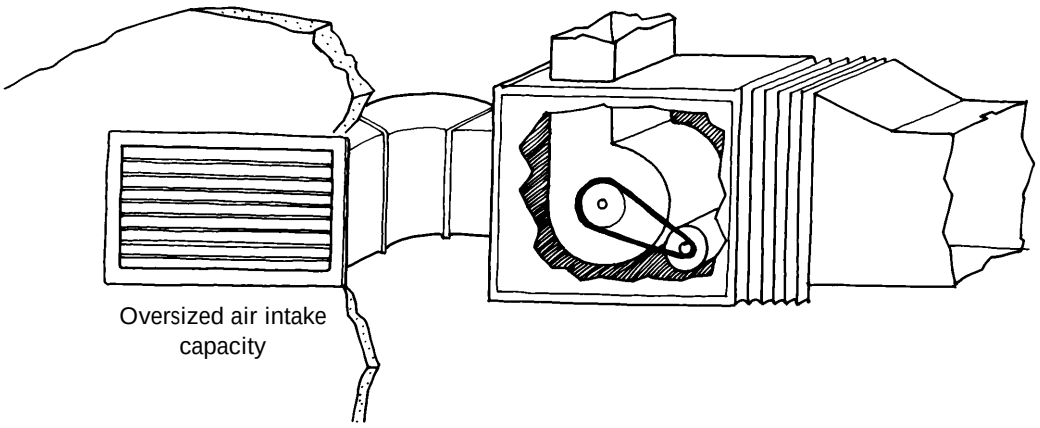
PROVIDE FOR ADDITIONAL OUTDOOR AIR SUPPLY QUANTITIES IN FUTURE

Environment ✔✔
Allows night ventilation strategies.

Ease of Use ✔✔✔
Requires no special skills or knowledge.

Other Benefits ✔✔
Provides flexibility for future changes in ventilation needs.

Capital Cost $
May require more equipment room, duct or shaft space.



ASHRAE Standard 62-1989 Table 2 sets minimum outdoor air supply rates for different occupancies, intended to ensure that the majority of occupants express no dissatisfaction with odors or experience sensory irritation. They are not intended to establish ventilation rates that ensure occupant health. The ASHRAE Standard 62-1989 outdoor air supply rates should be considered as minimum outdoor air rates supplied by mechanical systems.

Design supply air systems to allow the future supply of 150% of the outdoor air supply required by ASHRAE Standard 62-1989 Table 2. Wherever possible, provide additional outdoor air capacity in the supply air system to allow for future changes of occupancy, pollutant sources not known during design, and individuals with environmental sensitivities. Size outdoor air intake louvers and ductwork for this additional capacity, and provide space for future addition of coils, drain pans and equipment to condition this amount of air.

If air-side economizers are specified, this capacity is already inherent in the design. With the ability to provide large quantities of outdoor air, night ventilation can be used to precool building mass. This can have significant energy benefits.

Caution

- Additional space in equipment rooms for intakes and coils may be required.

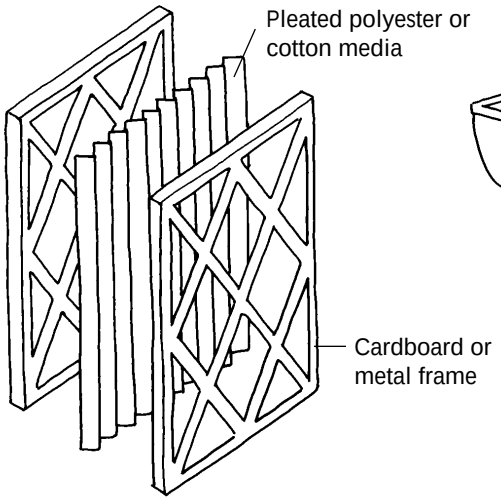
Further Information

- ASHRAE Standard 62-1989
- ASHRAE Fundamentals Handbook, 1997
- ASHRAE Systems & Equipment Handbook, 1996

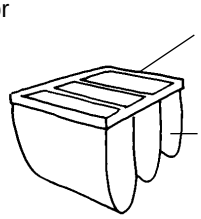
Linked Practices

EN4
HS2
LA2
CS1
CS5

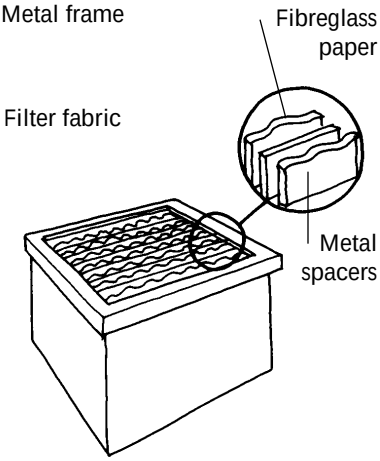
FILTER OR TREAT VENTILATION AIR SUPPLIES



Pleated panel filter



Bag filter



Box filter

Efficient filtration of ventilation air supplied to occupied spaces (and treatment when toxic compounds are present) can help greatly to ensure occupant health.

Particulate filters or air cleaners with a minimum efficiency of 30%* are recommended for mechanically supplied ventilation air to most occupied spaces, especially if it includes return air from spaces without unusual contaminant sources. These include residential rooms (except bathrooms or kitchens), offices, retail spaces, conference rooms, classrooms, lobbies, hotel or motel rooms, etc.

Air recirculated from dusty spaces or spaces containing mild contaminants requires 95% dust spot efficiency filtration* and often gas-phase air cleaning to remove odors and pollutants. Such spaces include dedicated copy and printer rooms, dining areas, break rooms, kitchens or other areas with cooking or food-dispensing equipment, cafeterias, laundry rooms, locker rooms, bathrooms and toilet rooms closed to the general public.

Air from spaces with more severe contaminants should not be recirculated, but should be equipped with exhausts and kept under negative pressure. In Santa Monica, outdoor air filtration or treatment is typically unnecessary unless there are nearby air pollution sources, such as loading bays, traffic, etc.

*Filter efficiencies should be rated according to ASHRAE Standard 52.1 Atmospheric Dust Spot Method.

Caution

• Unitary equipment may require supplementary filters to meet these efficiencies, and must be specified with appropriate static pressures.

Environment ✔
Healthier for building occupants, but few or no benefits to outdoor environment.

Ease of Use ✔✔
Straightforward.

Other Benefits ✔
Cleaner buildings require less cleaning and maintenance.

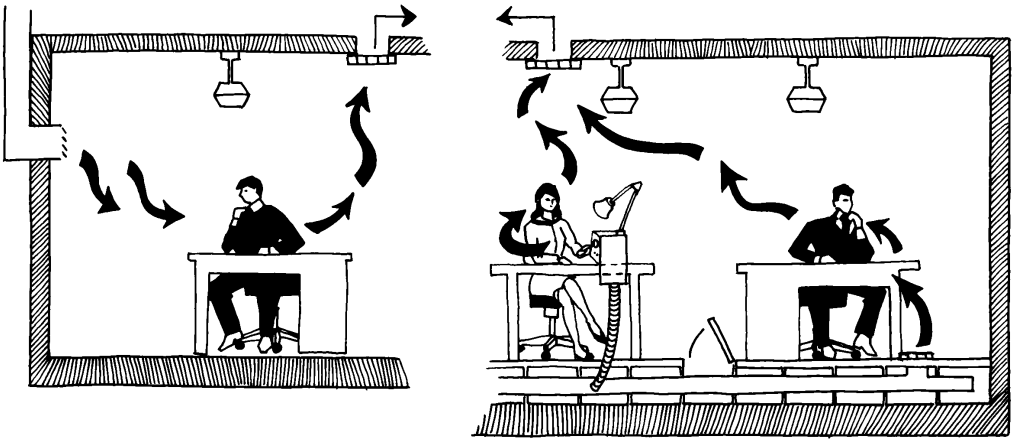
Capital Cost $
Very slightly more expensive than less efficient filters.

Further Information
- ASHRAE Standard 62-1989
- ASHRAE Standard 52.1-1992

Linked Practices
HS1
HS2
HS3
HS4

HS6

PROVIDE EFFECTIVE VENTILATION AIR DISTRIBUTION



Environment ✔
Effective ventilation air distribution can reduce supply air volumes, and the energy required to condition and move it.

Ease of Use ✔✔
Requires more design effort than standard air distribution practice.

Other Benefits ✔✔
Increases occupants satisfaction and comfort

Capital Cost $$
Depends on system used. Displacement ventilation can reduce ductwork; personal environmental modules are typically expensive.

Introduce ventilation air supplies, with a high proportion of outdoor air, directly to the occupied volumes of spaces, and place return air intakes as high in the spaces as possible. This has several advantages:

- Occupants breathe cleaner air.
- Smaller supply air quantities reduce energy consumption.

This strategy, known as "displacement ventilation", can use conventional supply registers located low in the occupied zone, or supply air distributed via a raised floor plenum. To ensure comfort and avoid drafts, the cool supply air must be carefully distributed with low velocities, and supply grilles provided with volume controllers for use by occupants. Return air temperatures are typically higher, due to lower supply air volumes.

Another method of concentrating fresh supply air in the occupied zone is the use of "personal environmental modules" at each workstation. Typically used only for offices, these have a small supply register in a desktop module complete with a lamp. Airflow is controlled by each user, and the registers are connected to a plenum or ductwork located below a raised floor.

Cautions

- Careful placement and selection of supply air diffusers and temperatures is critical to ensure comfort.
- Provision must be made to periodically clean raised-floor supply air plenums, considering that the plenum is also used for wire and cables.

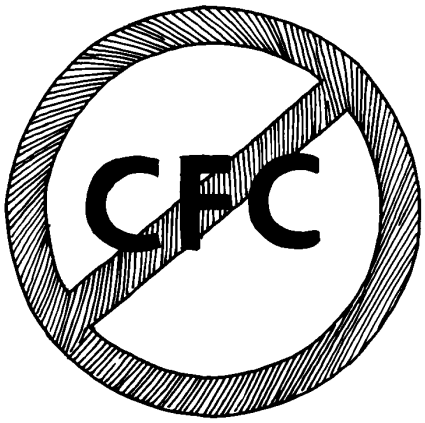
Further Information

- ASHRAE Standard 62-1989
- ASHRAE Fundamentals Handbook, 1997
- ASHRAE Systems & Equipment Handbook, 1996

Linked Practices

HS5

REDUCE OR ELIMINATE USE OF CFCS & HCFCS IN COOLING EQUIPMENT



Now banned

Being phased out

In retrofit projects with existing air-conditioning and refrigerating equipment, conduct a life-cycle cost analysis to assess replacement with equipment using chlorine-free refrigerants. The analysis should consider rising CFC/HCFC costs, maintenance and energy operating costs. It is often cheaper to replace older chillers with new HFC 134a equipment, both on a life-cycle and a first-cost basis. CFC air conditioners and heat pumps more than eight years old (midway through typical service lives) are often cost-effectively replaced by new equipment using HCFC or non-chlorinated refrigerants.

For new equipment, the choice of air conditioners and heat pumps using non-chlorinated refrigerants is currently limited. Non-HCFC equipment is preferable, if it meets capacity, efficiency and other criteria, since HCFC equipment is likely to be replaced or retrofitted in future as R-22 (the principal HCFC refrigerant) production ends.

If CFC or HCFC equipment is used:

- Provide sufficient space around equipment, into and out of the building for future replacement.
- Provide isolation valves at all inlets, outlets, gauges, etc. to reduce fugitive emissions.
- Install high-efficiency purges on chillers.
- Ensure that operations and maintenance manuals include equipment documentation complete with start-up and shut-down procedures, and logs that record refrigerant charge types, amounts and dates.

Caution

- Ensure that equipment rooms with CFC refrigerants are equipped with refrigerant release alarms.

Further Information

- ASHRAE Guideline 3-1990

Linked Practices

HS8

Environment ✔✔✔

Ozone layer depletion is a critical environmental issue, and building air-conditioning equipment is a major contributor.

Ease of Use ✔✔

Relatively simple for chillers; selection of smaller packaged equipment using non-chlorinated refrigerants is currently limited.

Other Benefits ✔✔

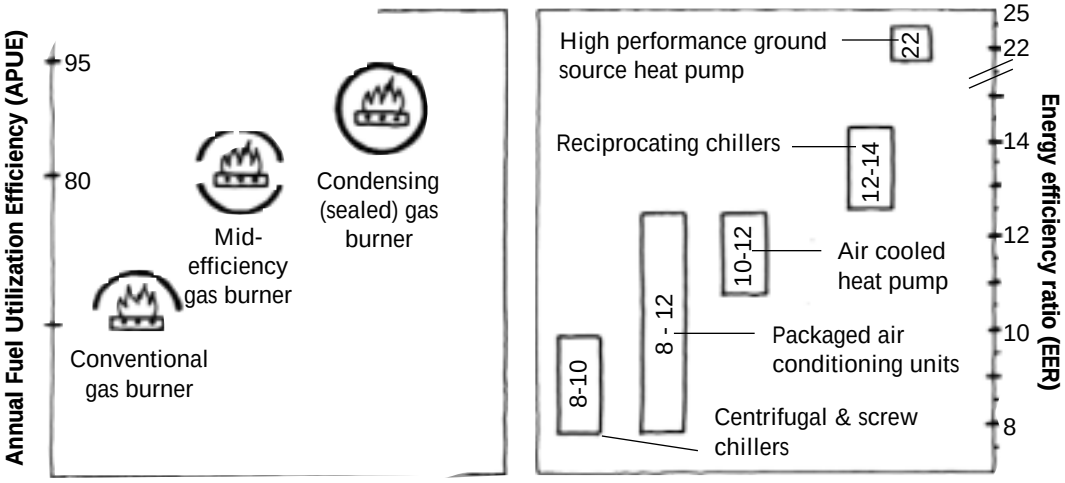
Specifying equipment using non-chlorinated refrigerants avoids cost of later replacement or retrofit, increasing value for prospective tenants and purchasers.

Capital Cost $

Little or no capital cost premium; replacement in building retrofit projects is often cheaper than modifying existing CFC chillers.

HS8

SELECT HIGH-EFFICIENCY HEATING & COOLING EQUIPMENT TO REDUCE ENERGY CONSUMPTION & DEMAND



Energy efficient burners and small air conditioners

While Title 24 has mandatory requirements for HVAC equipment efficiency, including furnaces, boilers, air-conditioners, heat pumps and chillers, these can easily be bettered with thoughtful selections.

- For packaged air conditioners and heat pumps, specify equipment complying with the Consortium for Energy Efficiency's minimum efficiency standards (reprinted in Appendix D).
- For boilers, specify Energy Star compliant equipment, which requires 85% Annual Fuel Utilization Efficiency (AFUE) or better.
- For furnaces, specify Energy Star compliant equipment, which requires 90% AFUE or better.
- For all other equipment, perform a life-cycle cost analysis as a basis for specifications.

Life-cycle cost analyzes consider capital, operating and maintenance costs over the life-time of the building. The National Institute of Standards and Technology provides a free computer program, "Building Life-Cycle Cost" (or "BLCC"), that helps with these analyzes, and a guide for estimating energy costs and discount rates, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis".

Air Conditioners and Heat Pumps

High-efficiency air conditioners and heat pumps are now widely available. Better packaged air conditioners have cooling Seasonal Energy Efficiency Ratios (SEERs) ranging from 12 to 15 (Energy Efficiency Ratios [EER] of 10.6 to 11.7). Air-cooled heat pumps have SEERs ranging from 11 to 12 (EERs of 7.8 to 12) and Heating Season Performance Factors (HSPF) of 6.8 to 7

Environment ✔✔✔

Reduces non-renewable energy consumption, demand and associated air pollutant emissions.

Ease of Use ✔✔✔

Selecting higher efficiency equipment is straightforward. Condensing boilers and furnaces are easier to vent due to lower space requirements.

Other Benefits ✔✔✔

Forced-draft and sealed-combustion boilers and furnaces reduce the risk of occupant exposure to carbon monoxide and other indoor air pollutants.

Capital Cost $$

Capital costs are approximately 5% to 20% higher than standard efficiency equipment. Ground-source heat pump systems are even higher but have lower life-cycle costs.

Further Information

- ARI Product Performance Ratings website, 1998
- CEC Appliance Efficiency Database website, 1998
- Consortium for Energy Efficiency: CEE Fact Sheets website, 1999
- Kreider, J.F., 1994
- U.S. DOE: Energy Star Heating & Cooling website, 1999
- U.S. Federal Energy Management Program: BLCC website, 1998

Linked Practices

HS3

(Coefficient of Performance [COP] of 3.2 to 3.5). Better water-source heat pumps have EERs of 12 to 15.8 and COPs of 4.1 to 5.3.

Ground-source heat pumps have much higher efficiencies, with EERs ranging from 15.8 to 22 and COPs of 3.3 to 4.1. Life-cycle costs are typically lower than for conventional equipment, but capital costs are high, since the wells or trenches required for the heat sink have a large cost premium. Reducing heat sink costs is the focus of many installations; new approaches include high-conductivity well grouts, "slinky" coil piping, and incorporating piping into poured foundation pilings. If trenches will be dug for other reasons, it is often very cost-effective to also use them for heat-sink piping.

Southern California Edison provides financial assistance for the purchase of high-efficiency heat pumps that replace electric resistance heaters and air conditioners in all-electric residential renovations.

Water Chillers

Chillers rarely operate at full-load conditions, so manufacturers' part-load performance data is important in their selection. Building simulation programs such as DOE 2 make the calculation of energy consumption considering part-load operation relatively simple; bin-method analyzes can also be used.

Centrifugal chillers with 150 to 1500 tons of cooling capacity are now available with full-load efficiencies ranging from 0.50 to 0.66 kW/ton (EERs up to 9.8). Reciprocating chillers have full-load efficiencies that range from 0.78 to 0.85 kW/ton (EERs up to 14.3 and Integrated Part Load Values to 17.4). Screw chillers range from 0.62 to 0.75 kW/ton (EERs to 9.8).

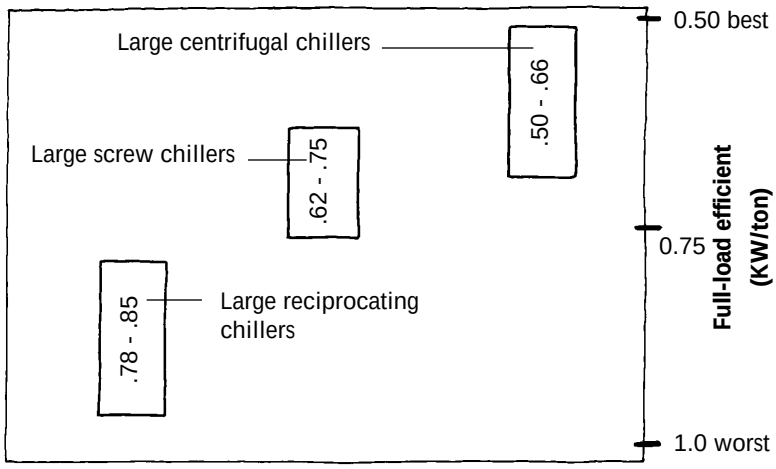
Cost premiums for energy-efficient chillers are typically about 6% — quickly paid back with reduced energy costs.

CFC- and HCFC-free chillers are now widely available. In retrofits, manufacturers should be consulted to examine retrofit versus replacement costs. Often replacement is less expensive even on a first-cost basis.

Boilers and Furnaces

Even in Santa Monica, high furnace and boiler efficiency are as critical as cooling equipment efficiency. Forced- or induced-draft boilers and furnaces with intermittent ignitions tend to have 80% to 86% AFUE. Condensing units that recover combustion gas heat typically have AFUEs of 88% to 97%, but larger sizes often required for commercial applications are available only from a few manufacturers.

When comparing efficiencies of larger gas boilers (greater than 300,000 Btu/hr. capacity), ratings should comply with ANSI Standard Z21.13-91 for a true comparison.



Energy efficient large chillers

FURTHER INFORMATION

ASHRAE. 1997. ASHRAE Fundamentals Handbook.

ASHRAE. 1996. ASHRAE Systems and Equipment Handbook.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) publish a new Handbook of their series every year. The Handbooks have become the authoritative North American references for mechanical engineers on HVAC data, calculations, system design and equipment selection. These two Handbooks are the most valuable for building HVAC design.

ASHRAE. 1992. ASHRAE Standard 52.1-1992: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

ASHRAE. 1989. ASHRAE Standard 62-1989: Ventilation for Acceptable Indoor Air Quality.

ASHRAE. 1989. ASHRAE/IES Standard 90.1-1989: Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.

ASHRAE. 1993. ASHRAE/IES Standard 90.2-1993: Energy Efficient Design of New Low-rise Residential Buildings.

ASHRAE, 1990. ASHRAE Guideline 3-1990: Reducing Emissions of Fully Halogenated Chlorofluorocarbons in Refrigeration and Air-Conditioning Equipment and Applications.

ASHRAE also creates and maintains a number of Standards and Guidelines for HVAC design and installation. Created by consensus of researchers, engineers and equipment manufacturers, ASHRAE Standards define what is typically considered "good practice". ASHRAE Standard 62 defines procedures for setting ventilation air supply rates depending on pollutant source strength; but due to their complexity and lack of emission rate data, Standard 62's Table 2 is most often used by engineers for outdoor air supply rates, appropriate to different occupancies.

ASHRAE Standards 90.1 and 90.2 are very useful guides to energy-efficient HVAC system design for commercial and multi-family residential buildings, similar to Title 24's Nonresidential and Residential Manuals, but briefer, and covering US and Canadian sites. They focus mostly on envelope, mechanical and electrical systems, leaving building form design to architects.

ASHRAE Guidelines encapsulate current research and good practice, for issues where there is yet insufficient information or consensus to form a Standard. Guideline 3 summarizes ways to reduce refrigerant emissions, and to plan for future replacement of CFC and HCFC refrigerants.

ASHRAE. 1987. Practical Control of Indoor Air Problems.

ASHRAE. 1988. Engineering Solutions to Indoor Air Problems.

Symposium proceedings, with articles covering many of the issues of indoor air quality, oriented toward engineering solutions.

Air-conditioning and Refrigeration Institute. (March 1999). *Product Performance Ratings*. [WWW Document] URL http://www.ari.org/directories/

ARI maintains an invaluable database of cooling and refrigeration equipment, with efficiencies, which is available for free download via the Internet. Invaluable in comparing alternative manufacturers and product lines, it allows easy and fast comparison of HVAC equipment by type, cooling or heating capacity, efficiency, or combinations of several parameters.

California Energy Commission. 1998. Title 24 Residential Manual.
California Energy Commission. 1998. Title 24 Non-residential Manual.
Indispensable references for energy-efficient building, electrical and HVAC design in California, these Manuals do a creditable job of taking a very complex subject (and a complicated regulation) and making it digestible for humans. Much of the material is applicable almost anywhere, not just to California buildings.

California Energy Commission. (March 1999). *California Energy Commission Appliance Efficiency Database*. [WWW Document] URL http://www.energy.ca.gov/efficiency/appliances/
The CEC maintains a database of HVAC and refrigerating equipment with efficiencies that comply with California standards, available via the Internet. Covering central and room air conditioners, heat pumps, central gas furnaces, refrigerators, freezers and wine chillers, it is oriented toward residential and small commercial equipment. It is most useful for its listing of Energy Efficiency Ratios (EERs) and Seasonal Energy Efficiency Ratios (SEERs) – which are often hard to find otherwise.

Consortium for Energy Efficiency. (March 1999). *CEE - Consortium for Energy Efficiency Home Page*. [WWW Document] URL http://www.ceeformt.org/index.htm
Consortium for Energy Efficiency. (March 1999). *CEE Fact Sheets*. [WWW Document] URL http://www.ceeformt.org/ceetoday/ceefacts/index.htm
The CEE is a non-profit corporation with members that include electric and gas utilities, public interest groups, and state research and development organizations and energy offices. Supported by the U.S. Environmental Protection Agency (EPA) and the Department of Energy (DOE), it's purpose is to encourage the free market toward greater use of energy-efficient equipment and appliances.
The CEE has several certification programs that set efficiency targets for equipment and appliances. It has excellent brief summaries on their air conditioners and heat pumps and residential gas heating.

Hydronics Institute. 1996. *I-B-R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial) January 1, 1996 Edition.* Berkeley Heights, N.J.
The Hydronics Institute sets standards for efficiency testing, and maintains a listing of boiler and hydronic heating equipment. The I-B-R ratings contain the most comprehensive listing of boiler efficiency ratings available.

Kreider, J.F.. 1994. *Heating and Cooling of Buildings: Design for Efficiency*. McGraw-Hill, New York.
Of the few books specializing in energy-efficient HVAC system design, this one stands out .

National Academy Press, 1981. *Indoor Pollutants*. Washington D.C.
One of the most comprehensive compilations of indoor air pollutants, their health effects, measurement and monitoring. Excellent and comprehensive background on indoor air quality problems, but weak on design responses.

Southern California Edison: Customer Technologies Applications Center (CTAC), 6090 Irwindale Ave., Irwindale, CA. 91702, (800) 336-2822

CTAC is an excellent resource for Southern California designers and builders. Offering extensive information resources, samples of many lighting products and technologies, and training courses, CTAC can also help developers and designers take advantage of the many rebates and programs offered by Southern California Edison.

Southern California Gas Company: Energy Resource Center, ML ERC 1, 9240 E. Firestone Blvd., Downey, CA 90241-538. (800) 427-6584.

The Energy Resource Center is a 45,000-square-foot facility that acts as a clearinghouse for energy and environmental information, with a conference center showcasing the latest energy technologies. The ERC holds energy- and money-saving seminars and workshops on subjects ranging from boiler heat-recovery systems to the phaseout of CFCs.

The building itself, selected as "Energy Star" by the U.S. Environmental Protection Agency and a model for future building designs. About 80% of the building is made of reused or recycled materials, and it exceeds California Title 24 energy requirements by 45%.

U.S. Federal Energy Management Program. (March 1999). BLCC 4.6-98 (Building Life Cycle Cost). [WWW Document] http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html#blcc

The Building Life Cycle Cost (BLCC) program by the National Institute of Standards and Technology calculates capital, operating and maintenance costs over the lifetime of the building. Also provides a guide for estimating energy costs and discount rates, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis". Available for free download, BLCC is straightforward to use, and the reference provides credible escalation rates.

U.S. Department of Energy. (March 1999). *Energy Star Program Home Page*. [WWW Document] URL http://www.energystar.gov/

U.S. Department of Energy. (March 1999). *Energy Star Heating and Cooling*. [WWW Document] URL http://www.epa.gov/hvac.html

U.S. Environmental Protection Agency. February 1999). *Energy Star Program, List of Most Efficient Furnaces and Boilers*. [WWW Document] URL http://eande.lbl.gov/cbs/VH/ACEEE/furnace.html

The US Department of Energy and the Environmental Protection Agency jointly sponsor the Energy Star program, which certifies and labels efficient HVAC equipment and appliances. Its website lists many information resources, among them manufacturers, model numbers and efficiencies of Energy Star labeled boilers, furnaces, air conditioners, heat pumps and appliances. Mostly oriented to residential / small commercial buildings and equipment.

CONTROL SYSTEMS

CONTROL SYSTEMS

Ideally, green buildings have simple lighting equipment and minimal HVAC systems since their form, structure and envelope inherently provide comfort. Most modern urban buildings, with their site and program constraints, require more extensive electrical and mechanical systems with automatic control.

The best control strategy allows occupants to directly manipulate simple and understandable building features, such as windows or shades. Controls should provide immediate feedback on their effects, but should not require occupant attention for safe, healthy indoor conditions, low energy consumption and operating costs. Occupants should be able to control their own surroundings, but automatic building controls must ensure the building operates efficiently regardless of occupant behavior.

Direct Digital Control Systems

Direct digital control (DDC) allows precise, flexible management of electrical and mechanical systems, and allows monitoring and management of energy consumption and demand. Rapid advances in computer technology have provided improved digital control systems at moderate cost. Many of the Recommended Practices of this chapter are technically and economically feasible because of these advances.

Larger climate-responsive buildings are often best served by a digital control system that tunes and adjusts electrical and mechanical systems to supplement natural light and cooling. Digital controls can easily respond to occupancy and schedule changes throughout the life of the building.

Daylighting controls can allow the electric lighting energy to be reduced by as much as 80%. Properly designed, they are essentially unnoticeable, and provide occupants with the ability to adjust space lighting to their own needs. Reduced lighting power translates into lower cooling loads, smaller HVAC equipment and reduced energy consumption.

Digital control coupled with occupancy sensors for lighting and HVAC systems ensure that if lighting or space conditioning are not needed, they are not used. This helps to reduce the energy consumption and equipment needs of a building, and offset control costs.

Similarly, variable-speed motor controllers ensure that energy is not wasted providing air or water flows that are unnecessary for comfort. Speed controller costs are falling quickly, and are now economic in much smaller applications than before.

HVAC Control Strategies

DDC systems also allow optimal HVAC control strategies that were difficult or expensive to do with older pneumatic controls. One example is load-shifting to periods of low utility demand. Correctly programmed energy management controls can substantially reduce energy costs, by operating HVAC equipment during periods of lower gas or electricity demand charges.

Night cooling in particular uses the building structure for thermal storage, allowing HVAC equipment to operate more efficiently when outdoor temperatures are cooler and demand charges lower. As well, operating costs are reduced, since high-demand fans and pumps are used less during peak demand periods.

Requirements for Best Controls Performance

However, DDC systems have some disadvantages. Poorly designed systems can be inaccessible or incomprehensible to occupants. DDC systems require careful design to allow occupants simple,

understandable local control without disturbing safe and economical electrical and mechanical system operations.

Design efforts to control solar gain, natural lighting, ventilation and cooling will be wasted unless the systems are set up and commissioned properly from the start. Proper testing, commissioning and documentation are essential for efficient operations, preventive maintenance and occupant satisfaction.

To use digital control systems to their full potential requires trained building operators motivated to provide healthy, comfortable indoor conditions and efficient operations. This has led to a trend towards professional building management by "building service companies", staffed by controls technicians, often operating many buildings from a remote central location.

Older digital control systems have suffered from incompatibilities between different manufacturers, limiting design and operator flexibility and greatly complicating building operator training. Recently there has been much progress on "interoperability" - integrating building controls, sensors, and actuators with security, communications and computer local area networks (LANs). Two protocols have been established that allow equipment from many different vendors to communicate and work together: Lonworks; and BACNet, sponsored by the American Society of Heating, Refrigerating and Air-Conditioning Engineers. These will greatly ease the task of controls integration in new designs and in future retrofits.

CONTROL SYSTEMS PRACTICES SUMMARY TABLE

Recommended Practices	Environmental	Ease of Use	Benefits	Capital Cost
CS1 Use Digital Electronic Control of Lighting & HVAC Systems for Energy & Demand Savings	✔✔✔	✔✔	✔✔	**$$**
CS2 Incorporate Daylighting Controls in Architecturally Daylit Spaces	✔✔✔	✔✔	✔✔	**$$**
CS3 Incorporate Occupancy Controls in Zones with Intermittent Use	✔✔✔	✔✔✔	✔	**$$**
CS4 Use Variable-Speed Motor Controllers for Fans & Pumps with Modulating Flows	✔✔	✔✔✔	✔✔✔	**$$**
CS5 Cool Building Mass at Night for Energy & Demand Savings	✔✔✔	✔✔✔	✔✔	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

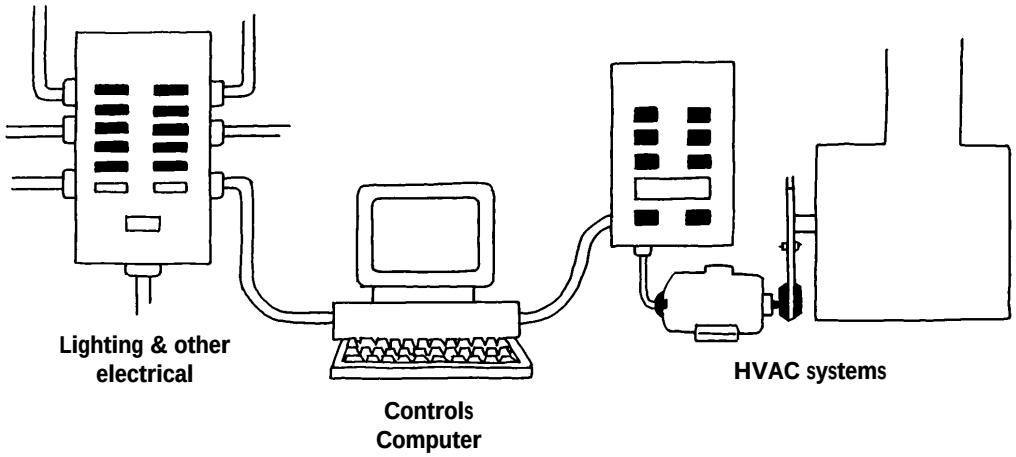
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

USE DIGITAL ELECTRONIC CONTROL OF LIGHTING AND HVAC SYSTEMS FOR ENERGY & DEMAND SAVINGS

CS1



Tremendous advances in computer technology are reflected in the sophistication and falling costs of Direct Digital Control (DDC) systems for buildings. DDC systems are now affordable for all but the smallest and simplest of buildings, and allow much finer control and energy savings than pneumatic controls. Besides flexible control of lighting and HVAC systems, DDC can also integrate fire and intruder alarms, security and access systems and local and wide area computer networks.

Even in retrofit situations with existing pneumatic controls, it is usually worth examining the use of zone or central digital controllers. Continued use of pneumatic actuators and sensors is sometimes cost-effective, but requires periodic compressor maintenance and more ongoing attention to calibration and adjustment.

Central DDC systems are typically too expensive for buildings with 10 or fewer HVAC or lighting zones, unless they collect renewable energy using photovoltaic arrays. However, even in these smaller buildings, digital controls and equipment should be specified that:

- offer optimal start and stop controls for HVAC plant equipment.
- provide occupant-accessible local overrides for temporary off-schedule use.
- have BACNet-compatible sensors, actuators and controllers.

Often DDC zone controllers are suitable and economic for small applications with fewer than 16 inputs and outputs.

For larger and more complex buildings, cen-

Environment ✔✔✔

Good controls systems ensure equipment operates as intended, and allows optimal operation in future.

Ease of Use ✔✔

Requires close collaboration between engineers, contractors and commissioning agent.

Other Benefits ✔✔

Allows better control over comfort conditions, reducing occupant complaints and increasing satisfaction.

Capital Cost $$

Capital costs for DDC systems are falling rapidly, and are now typically lower than pneumatic controls.

Further Information

- BCBC website, 1999

Linked Practices

LAb
WSc
WS6
ES3
ES4
ES6
ES7
CO1
CO2
CO3
CO4

tral controllers or centrally supervised zone controllers connected with a network offer the most flexibility and potential for energy savings. These systems should:

- provide a graphic interface for building operators that shows:
- floor plans of all areas of the building, locating all controlled equipment.
- schematic drawings of each controlled device, with on/off status, current sensor readings, setpoints, operator positions, control constants, and a link that shows the operating control program code.
- graphic trend logs of inputs, outputs and control points selected by the operator.
- graphs and tables of building energy and demand history for all fuel types.
- have BACNet-compatible sensors, actuators, controllers and communications.
- use optimal start and temperature-predictor programs for cooling and heating plant equipment.
- offer provide storage for at least 12 months of hourly trend-logging of flows, temperatures, pressures and other important data for all plant equipment.
- secure dial-up modem access for remote monitoring, supervision and trouble-shooting by building service companies contracted by the owner

A good sample specification and protocol for control point names and equipment control algorithms can be found at the British Columbia Buildings Corporation website (see Further Information).

DDC systems capabilities should be considered when designing mechanical and electrical systems. Often, savings can result from using control software to supplement equipment limitations. For example, the traditional rule-of-thumb has been to select control valves with linear process output / control input relationships. Intelligent DDC programming can automatically compensate for non-linear valves, reducing costs. Similarly, programs that use the fast dynamic response of DDC systems can optimally control pump and fan flows, so pressure drops are lower under non-peak loads. This saves energy, and can often reduce the number and size of motors, especially when variable-speed motor controllers are used.

Where natural ventilation and cooling strategies are supplemented by mechanical systems, their control must be carefully thought through. Sensors for windows and air inlets and outlets should signal their opening by occupants, and lockout or reduce mechanically supplied cooling and ventilation. Automatic systems intended to close windows and air openings must ensure that occupants are not endangered.

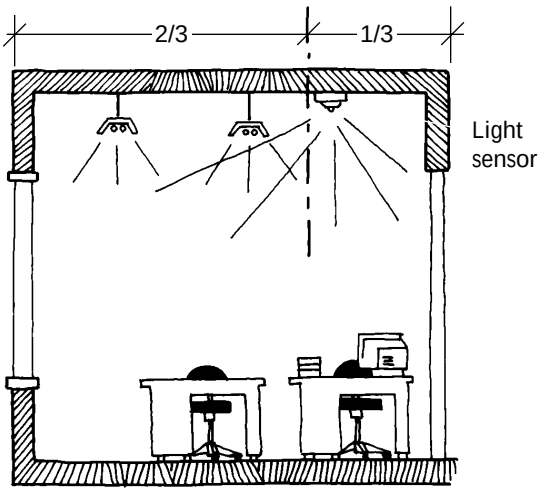
Good design documentation for each controlled device should include schematic drawings, listings of control points, expected operating readings and acceptable range, and sequences of operation. Field review and commissioning should check to ensure compliance with documented design intentions, and any changes made should be recorded for future reference by building operators.

Cautions

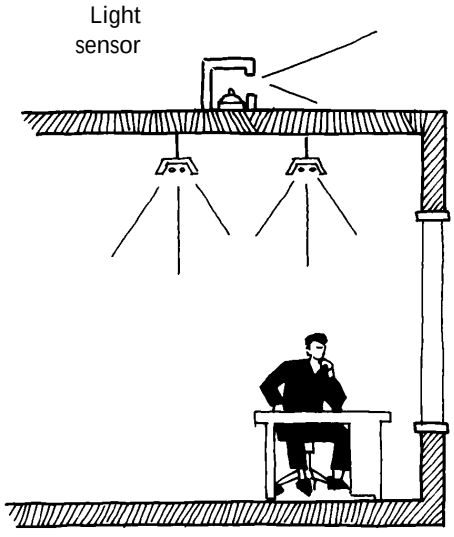
- Good communications and documentation are essential to a trouble-free control system.
- Sensors, actuators and controllers must be carefully commissioned.
- Building operators must be trained in control system use.

INCORPORATE DAYLIGHTING CONTROLS TO ACHIEVE SAVINGS IN ARCHITECTURALLY DAYLIT SPACES

CS2



Closed loop



Open loop

An effective control system is essential for daylighting and electric lighting for energy savings and occupant satisfaction. For workspaces, continuous dimming is the least obtrusive. This allows changes to the electric lighting output to be unnoticeable to occupants. On/off or multi-step strategies can be distracting and may result in occupant complaints or tampering with the sensors; these are best suited for storage areas or other intermittently occupied areas.

A photosensor should be assigned to each lighting zone. There are two main types of daylight controls, "closed loop" and "open loop". In a closed-loop system the sensor is located in the controlled space. This type of system is best for classrooms, open offices, concourses, lobbies, malls, factories and other large open areas. In an open loop system the photosensor is located outside the space(s) it controls, and is not affected by the electric light contribution. This type of system is appropriate for a series of small offices or rooms all with the same sky exposure, outdoor lighting, atria, and other daylighting features.

Cautions

- Requires time-out and sensitivity adjustments after 100-hour burn-in of fluorescent lamps, with room furnishings in place and HVAC systems operating.
- Proper commissioning is critical for energy savings and occupant satisfaction.
- Sensors must be periodically calibrated and tested to ensure long-term energy savings.

Further Information

- Ander, G., 1995
- BCBC website, 1999

Linked Practices

ES3
ES4
ES6
CO1.
CO2
CO3

Environment ✔✔✔

20% – 50% electrical energy savings are typical, along with peak load reductions.

Ease of Use ✔✔

Proper adjustment of the photosensor is required after occupancy.

Other Benefits ✔✔

Closed-loop systems provides lumen-maintenance. Often, smaller mechanical cooling equipment is needed.

Capital Cost $$

Capital costs for dimming ballasts are dropping more rapidly than controls. However, photoelectric control is still a capital cost premium, paid back rapidly by energy and demand savings.

CS3

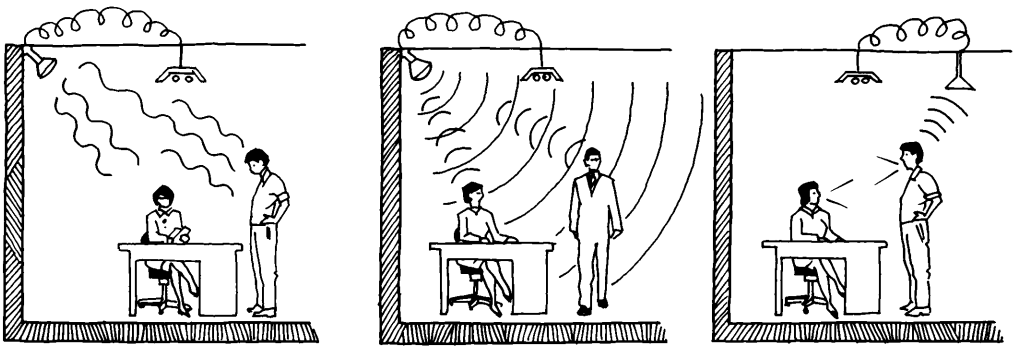
INCORPORATE OCCUPANCY CONTROLS IN ZONES WITH INTERMITTENT USE

Environment ✔✔✔
Can save up to 80% of lighting energy.

Ease of Use ✔✔✔
Technology is rapidly improving, addressing false-on and false-off conditions of early controllers.

Other Benefits ✔
HVAC energy savings due to lower amount heat from lighting.

Capital Cost $$
Capital cost is low for large zones of 2,000+ sq. ft.; moderate for smaller zones.



Occupancy Sensor Technologies

Use occupancy sensors to control lighting, heating and cooling according to motion detected within an intermittently occupied area. Occupancy sensors can save up to 80% of the lighting and HVAC energy when properly applied. There are three basic sensor technologies: infrared, ultrasonic, and acoustic.

Infrared (IR) technology senses body heat. IR requires a straight "line-of-sight" in order to operate properly. IR is ideal for small offices and other regularly shaped rooms as well as high spaces (auditoriums, open classrooms, large open offices with low or no partitions, factories and other large work facilities).

Ultrasonic (US) technology emits a high-frequency sound that reflects off room surfaces. US sensors have good sensitivity and range where small motions must be detected. They suit irregularly shaped spaces and room obstructions such as medium to high partitions, large furniture or structural columns. Due to the high sensitivity associated with US, air currents or other small movements produced by the ventilation system or motion in adjacent spaces may trigger false-on conditions, requiring attentive calibration.

Ultrasonic sensors are available in a variety of frequencies; be sure to note any other ultrasonic emitting equipment on the job and specify a distinct frequency for each controller. Check that sensor frequency does not overlap hearing-aid frequency.

Acoustic or audible sensors rely on voices,

Further Information

- CANMET Advanced Technologies website – Occupancy Sensors, 1999
- NLPIP, 1992.

Linked Practices

CO1.
CO2
CO3
CO4

machinery sounds, keyboard tapping and other typical daily noises. Background noise, such as a constant hum, and low-level noise are ignored. This technology works well in areas with high partitions or other obstructions, or high air movement within the space during unoccupied periods, such as kitchens and large washrooms.

Dual or triple technology sensors are available, as are intelligent sensors that self-adjust to occupancy data collected in a prescribed "learning period". These sensors also reduce false-on and -off conditions. However, they must still be properly located, adjusted and calibrated in commissioning, and regularly maintained.

Sensors have a field of view. Take care in locating the mounting position to cover the occupied area of interest according to the manufacturer's recommendations; the correct position will vary with the sensor's coverage pattern. Over-coverage can result in false-on signals; under-coverage can result in false-off.

Two commissioning adjustments are critical for energy savings and occupant satisfaction:

- time-out – how long equipment will remain on after last detection of motion. This will vary with the space use, and should be adjusted after occupancy.
- sensitivity – how small a change in infrared heat, movement or noise is required to trigger the sensor. Adjustment is important to prevent false-on and false-off signals.

These should be adjusted after lamps and sensors are installed, room furnishings are in place, fluorescent lamps have burned-in for 100 hours, and HVAC systems are operating.

Important options available include:

- manual-on/automatic-off with manual-off option – requires occupant to physically turn the equipment on initially. Equipment and be turned off either automatically or manually.
- lights-out warning – an audible or visible (lights flicker) indicator that lights will be turning off in one minute (time should be adjustable).
- coverage mask – to allow certain areas to be deleted from the coverage of the sensor, to prevent false-on.
- combined daylight sensor and control.

Cautions

- It is hard to predict "dead spots" (areas where sensor cannot detect) without knowing furniture location.
- Commissioning is critical for proper operation and energy savings.
- System must be periodically maintained and tested.
- Hours of fluorescent lamp life will be reduced (up to 40%), but calendar lamp life will be extended.
- Occupant education is often required, especially during "learning period" of intelligent sensors.

CS4

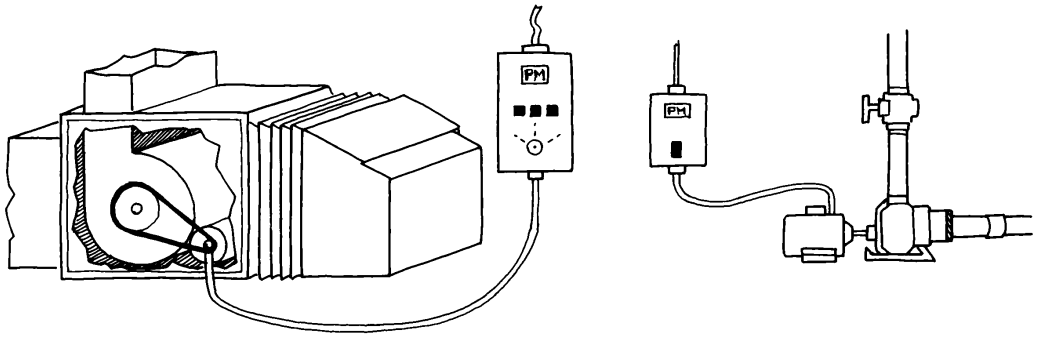
USE VARIABLE SPEED MOTOR CONTROLLERS FOR FANS & PUMPS WITH MODULATING FLOWS

Environment ✔✔
20% – 50% fan, pump and compressor electrical savings are typical.

Ease of Use ✔✔✔
Consult manufacturers for help in VFD selection. Requires proper commissioning.

Other Benefits ✔✔✔
Soft-start allows significant reductions in peak demand charges. Precise and rapid control response.

Capital Cost $$
VFD replaces starter otherwise required. Capital cost premium of 20% to 40%, with payback periods of months to up to three years.



Variable-speed motor controls

Where air or liquid flows must be controlled to vary by 30% or more, they are good candidates for variable-speed control instead of 2-way control valves or dampers. These increase static pressure of the fluid loop to reduce flow, wasting pump or fan energy. The larger and more varied the flow, the greater the energy savings available.

It is now economic to use variable-speed motor controllers for most fans, pumps and compressors of 10 horsepower or more with variable flow and high operating hours.

For many HVAC applications, variable frequency drive (VFD) speed controllers are a good choice. They offer precise flow control, quick response, soft-start capabilities and high power factors, and are efficient over a wide range of speeds. VFDs can be retrofitted to existing motors, though motors are best selected specifically for use with VFDs.

Be sure to select a controller suited to the load; constant torque loads, such as constant pressure and positive displacement pumps, and some compressors may require oversized drives and motors to ensure sufficient cooling under low speeds.

Cautions:

- Pumps operated in parallel should all run at the same speed.
- Ensure current rating of controller exceeds the total current rating of controlled motors under overload conditions.
- Ensure that VFD presents low harmonic distortion to the electrical distribution system.

Further Information

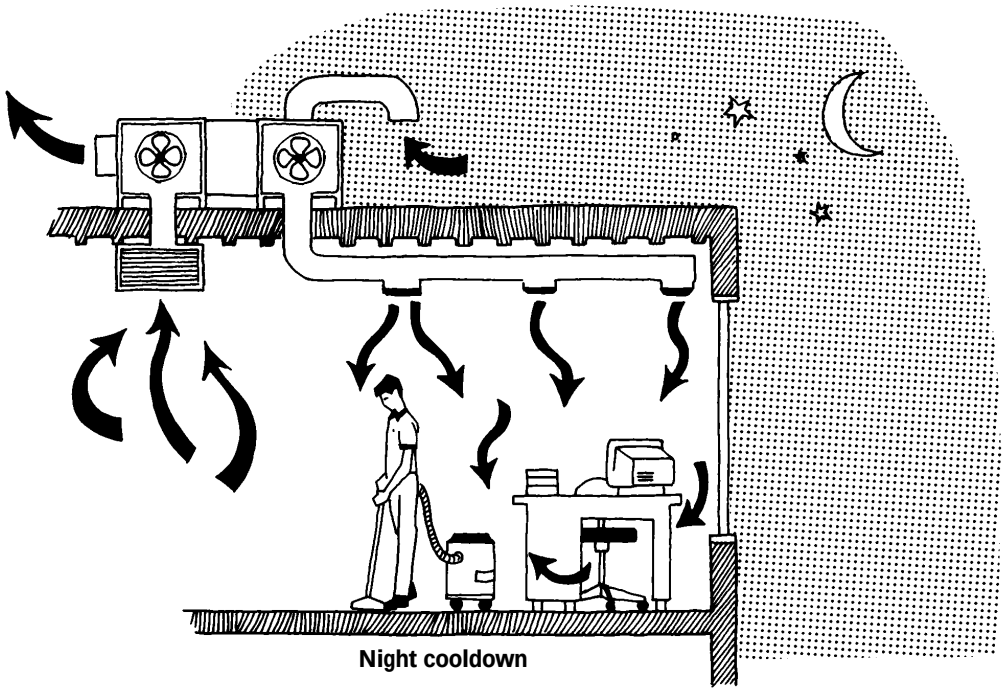
- BCBC website, 1999
- Gladstone, J.W., 1996
- Kreider, J.F., 1994
- Levenhagen, J.I.. & W.D. Bevirt, 1992
- Swenson, S.D. & D.H. Spethman, 1993

Linked Practices

ES1
CO1 .
CO2
CO3
CO4

CS5

COOL BUILDING MASS AT NIGHT FOR ENERGY & DEMAND SAVINGS



Night cooldown

For buildings and spaces that are not occupied at night, such as offices and retail businesses, control the HVAC systems to cool the building mass late at night, when outdoor temperatures are cooler and demand charges are lower. Night cooling can save up to 50% of cooling energy and reduce peak demand by up to 40%, compared to standard night temperature setback strategies.

Night cooling can be done with either air or water cooling systems. For air systems, late night and early morning outdoor air temperatures in Santa Monica allow use of the economizer cycle for much of the year, greatly reducing compressor run-time and energy. Similarly, for water systems, the chiller can be bypassed to use water from the cooling tower. For greatest demand cost savings, ensure that the HVAC systems start before the onset of higher demand charges.

The major drawback of night cooling is the potential for cold space temperatures at the beginning of the occupied period. Stopping night cooling an hour before occupancy typically ensures comfortable conditions for early arrivals. If a few late-night occupants are expected, ensure local systems are in place, with temperature controls for occupants that provide comfort for small occupied areas.

Cautions

- Not suitable for buildings with high occupancy between midnight and dawn.

Environment ✔✔✔

40% – 50% cooling energy savings are typical.

Ease of Use ✔✔✔

For spaces where night occupancy is low, this is a simple control algorithm change.

Other Benefits ✔✔

Often reduces peak demand costs.

Capital Cost $

No extra equipment is needed except a time-clock for non-DDC systems.

Further Information

- Braun, J.E., 1990
- Kreider, J.F.., 1994
- ASHRAE Systems & Equipment Handbook, 1996

Linked Practices

EN6
HS4
HS5
HS6
CO1
CO2
CO3
C04

FURTHER INFORMATION

Ander, G. 1995. *Daylighting Performance and Design*. John Wiley & Sons, New York.
An excellent quick reference and study for the busy professional. Up to date, with plenty of tables, and oriented toward California conditions, it is useful for any location.

ASHRAE. 1997. *ASHRAE Fundamentals Handbook*.
ASHRAE. 1996. *ASHRAE Systems and Equipment Handbook*.
The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) publish a new Handbook of their series every year. The Handbooks have become the authoritative North American references for mechanical engineers on HVAC data, calculations, system design and equipment selection. These two Handbooks are the most valuable for building HVAC design.

ASHRAE. 1987. *Practical Control of Indoor Air Problems*.
ASHRAE. 1988. *Engineering Solutions to Indoor Air Problems*.
Symposium proceedings, with articles covering many of the issues of indoor air quality, oriented toward engineering solutions.

Audin, L., D. Houghton, M. Shepard, and W. Hawthorne. 1994. *Lighting Technology Atlas*. E Source Inc., Boulder, CO.
E Source continues to be one of the most comprehensive sources of objective and succinct technology and equipment reviews.

British Columbia Buildings Corporation (BCBC). (March 1999). BCBC Client Comfort Control System (CCS) – Design Manual. [WWW Document] URL http://www.bcbc.bc.ca/internet/ccs/0/0%5F1.html
Specification used by the British Columbia Buildings Corporation (Crown corporation operating B.C. government facilities) for their own development and operations. On-line sample specification for direct digital control systems, covering hardware, programmability, operator interface, and communications. Has a comprehensive control points naming convention. (MS Word document is also available for free download.)

California Energy Commission. 1998. *Title 24 Residential Manual*.
California Energy Commission. 1998. *Title 24 Non-residential Manual*.
Indispensable references for energy-efficient building, electrical and HVAC design in California, these Manuals do a creditable job of taking a very complex subject (and a complicated regulation) and making it digestible for humans. Much of the material is applicable almost anywhere, not just to California buildings.

Canadian Centre for Mineral and Energy Technology (CANMET) and Enermodal Engineering, Ltd. (March 1999). *Advanced Technologies for Commercial Buildings*. [WWW Document] URL http://www.advancedbuildings.org/index.html
Canadian Centre for Mineral and Energy Technology (CANMET) and Enermodal Engineering, Ltd. (March 1999). *Advanced Technologies for Commercial Buildings – Occupancy Sensors*. [WWW Document] URL http://www.advancedbuildings.org/occsen.html

An extensive compendium of summaries of state-of-the-art energy and environmental building technologies, sponsored by CANMET and Gas Technology Canada.

Gladstone, J.W. and W.D. Bevirt. 1996. *HVAC Testing, Adjusting, and Balancing Manual*. McGraw Hill, New York.
Sponsored by the National Environmental Balancing Bureau, this covers the latest Testing, Adjusting and Balancing (TAB) techniques, equations, and calculations. Chapters on system balancing, controls, clean rooms, sound vibration, temperature control verification, and more.

Kreider, J.F., (1994) *Heating and Cooling of Buildings: Design for Efficiency*. McGraw-Hill, New York.
Of the few books specializing in energy-efficient HVAC system design, this one stands out .

Levenhagen, J.I. and D.H. Spethmann. 1992. *HVAC Controls and Systems*. McGraw Hill, New York
Covers all aspects of commercial controls, including pneumatic, electric, and electronic controls. Thorough review of controls hardware and applications, including supervisory systems, maintenance and operations, and total facility approach.

National Lighting Product Information Program (NLPIP). (April, 1999). *National Lighting Product Information Program Online*. [WWW document] URL http://www.lrc.rpi.edu/NLPIP/index.html
Objective in-depth information about lighting technologies, such as dimming electronic ballasts and occupancy sensors. Each report contains product performance and NLPIP test data by manufacturer catalog number, and explains key performance characteristics and considerations.

Southern California Edison: Customer Technologies Applications Center (CTAC), 6090 Irwindale Ave., Irwindale, CA. 91702, (800) 336-2822
CTAC is an excellent resource for designers and builders. Offering extensive information resources, samples of many controls products and technologies, and training courses, CTAC can also help developers and designers take advantage of the many rebates and programs offered by SCE.

Southern California Gas Company: Energy Resource Center, ML ERC 1, 9240 E. Firestone Blvd., Downey, CA 90241-538. (800) 427-6584.
The Energy Resource Center is a 45,000-square-foot facility that acts as a clearinghouse for energy and environmental information, with a conference center showcasing the latest energy technologies. The ERC holds energy- and money-saving seminars and workshops on energy efficiency and controls. The building itself, selected as an "Energy Star" by the U.S. Environmental Protection Agency and a model for future building designs. About 80% of the building is made of reused or recycled materials, and it exceeds California Title 24 energy requirements by 45%.

Swenson, S.D. 1993. *HVAC Controls and Control Systems, 1st edition*. Prentice Hall Career & Technology, New York.
Written from a practical viewpoint, with special emphasis on applications. Valuable for both the designer and the field technician.

CONSTRUCTION MANAGEMENT

CONSTRUCTION MANAGEMENT

Reducing the environmental impact of the construction process begins with managing necessary demolition responsibly. Many materials can be salvaged for reuse or collected for recycling, often by specialized waste receivers. These services can actually save money for the contractor or owner, because transportation costs and dumping fees are reduced and some items are worth cash.

Protecting the site from undue damage to soils, vegetation and air quality and preventing stormwater contamination during excavation and construction is the second part of responsible construction.

The third part is ensuring that construction waste is minimized, recyclables are recovered and toxic releases on site are minimized.

The final part is ensuring that building occupants are protected from construction-related health hazards during renovations, or during first occupancy after completion.

Demolition Planning

Surveying the demolition site for salvageable and recyclable materials, and hazardous wastes requiring special handling, is a necessary step in responsible demolition. A salvage survey can be done at the same time as a site environmental survey, where contaminated soils, asbestos or other hazards may be present. The general contractor, owner or architect can specify the removal of all reusable and recyclable materials in the demolition contract, require on-site separation and materials processing where practical and cost effective, and turn materials over to an appropriate receiver.

Preserving large shrubs and ornamental and shade trees on construction sites also saves money otherwise spent for new plant materials, helps to protect neighbors' privacy and maintain important qualities of the neighborhood.

Recycling Waste from Building Demolition

Solid waste disposal is one of the key environmental problems affecting all America's major urban areas. In Los Angeles, construction waste makes up 15% to 25% of the total solid waste stream. The Santa Monica Sustainable City Program has a goal of reducing solid waste to 50% of 1990 levels by the year 2000, according to state law, and construction and demolition waste diversion is an important part of that effort.

Solid waste recycling measures were initiated in Los Angeles in the 1960s, and were accelerated by the state solid waste Bill 939 in 1990. The 1994 Northridge earthquake created huge quantities of demolition waste in the region as damaged buildings were demolished. This galvanized cities and entrepreneurs into action, and produced expanded services including concrete and masonry crushing and many new receiving programs for separated and mixed loads of recyclable demolition materials. A strong building product recycling industry is now operating in the Los Angeles region, which greatly aids environmentally conscious designers and contractors.

Salvaging reusable construction materials such as doors, beams, woodwork, plumbing fixtures, bricks and ornamental metals not only reduces landfill, but creates jobs and serves a strong market for historical components. After salvaging reusable materials, separating recyclable metals and concrete, masonry and pavement waste for processing are the next most valuable steps. Utilizing all appropriate steps for salvage, separation and recycling of demolition waste substantially reduces solid waste volume to landfills, and usually saves the contractor money in dumping fees.

Reducing and Recycling Construction Waste

Unlike demolition waste, as much as 80% of waste generated during construction is reusable or recyclable since it is relatively clean and therefore marketable. Recyclers purchase metal scrap from structural steel, piping, concrete reinforcement and sheet metal work. Corrugated cardboard and gypsum are highly recyclable if uncontaminated, and will also be picked up by buyers. A great deal of wood scrap can be reused on site, while excess is accepted as fuel or fiber by many businesses. The main wastes that are difficult to recycle are plastics, mineral and glass fiber insulation, roofing and containers for paints, adhesives and caulking.

Construction and demolition waste recycling is most effective if it is included in the construction contract specifications, because many key steps in successful recycling programs, such as separation, occur on the construction site.

Minimizing the Handling and Release of Toxics on the Construction Site

Construction sites are sources of many toxic substances, such as paints, solvents, wood preservatives, pesticides, adhesives and sealants. Even with careful management, some of these substances are released into air, soil and water, and many are hazardous to workers. For these reasons, the best choice is to avoid their use as much as possible by using low-toxicity substitutes and low VOC (volatile organic compound) materials. Many new materials and methods are now available that are less toxic and safer for workers. See the Materials chapter for more detail on safe materials.

Many other activities on site will also release toxic pollutants. For example, trucks and machinery use fuels, hydraulic fluids and coolants that can leak if equipment breaks down, or may be spilled on site. Planned maintenance and worker training must be employed to minimize release of these toxic materials.

Two of the Santa Monica Sustainable City Program Goals are to minimize the levels of pollutants entering the air, soil and water; and to reduce the use of hazardous materials by 15% from 1995 levels by the year 2000.

Using low-pollution construction equipment such as electric motor-driven equipment and propane-powered engines also helps to reduce pollution on the jobsite.

Minimizing Energy and Water Use During Construction

Energy-efficiency and water-conservation measures are generally applied only to finished buildings, but some steps can also be taken during construction. Using high-efficiency sources and automatic controls can reduce electricity used for temporary and security lighting. Water use for washing, irrigation and dust control on site can also be reduced by conservation and recycling.

Minimizing Storm Water Pollution and Protecting Soils and Vegetation During Demolition and Construction

Santa Monica's Urban Runoff Reduction Ordinance requires every applicant to submit an Urban Runoff Mitigation Plan for the building site to the City's Engineering Division during the permit process. The purpose is to prevent runoff from entering the stormwater system and polluting Santa Monica Bay. The construction period is particularly important because disturbed soil, concrete fines, fertilizer, oils and other wastes from construction are produced. On-site collection and settling of storm water, prohibition of equipment washdowns, and prevention of soil loss and toxics release from the construction site are necessary to minimize water pollution.

Existing vegetation can also be protected and reused after construction in some cases, reducing the need for new plant materials and preserving existing landscapes.

One of the Santa Monica Sustainable City Program Goals is to reduce dry weather stormwater discharges to the ocean by 60% from 1995 levels by the year 2000.

Protecting Building Occupants from Health Risks During Construction

Workplace safety regulations protect the health of construction workers, but an adequate degree of protection should also be provided for occupants of buildings undergoing remodeling or renovations. Dust and vapors from construction areas are easily transported into occupied zones by air currents, people moving between zones, and by ventilating and air-conditioning systems.

Many health safety experts now recommend that airtight barriers be placed around construction zones in occupied buildings, particularly those, such as elementary schools and health care facilities, with highly vulnerable populations. Another step is providing independent ventilation of the construction zone to maintain negative air pressure relative to occupied areas. Finally, scheduling unavoidably dusty and high-emission operations during unoccupied hours allows clean-up and curing to occur before occupants return, which helps to avoid health risks and liability.

Protecting Building Occupants from Health Risks During Early Occupancy

Indoor air quality is often poorest in buildings immediately after construction is complete; however few regulations exist to protect building occupants during this period. Liquid finishes such as paints, sealers and adhesives release volatile gases during curing that cling to carpets, gypsum board and other porous surfaces and are then released over time. Dusty operations, such as finishing gypsum board, installing insulation and ceiling tile, and sanding or grinding hard floor surfaces leave large residues of nuisance or hazardous dust that accumulate on interior finishes, in ceiling cavities and ducts, to be released later into the occupied zone.

A proactive approach that minimizes occupant exposure to health hazards through careful construction procedures will go far toward reducing complaints and limiting owner and contractor liability.

CONSTRUCTION MANAGEMENT PRACTICES SUMMARY TABLE

Required Practices

Ordinance	Subtitle
CMa New SMMC ordinance #	Prepare a Demolition & Site Protection Plan
CMb New SMMC ordinance #	Salvage Reusable Materials & Separate Recyclables from Demolition
CMc New SMMC ordinance #	Inventory, Mark & Protect Topsoil, Trees & Vegetation to be Retained
CMd SMMC 7.10.070	Prepare a Stormwater Control Program for the Construction Site
CMe New SMMC ordinance #	Recycle Construction Waste, & Designate a Site Waste-Management Person
CMf SMMC 5.08.150 (b), 7.10.040	Provide Safe Storage, Worker Training & Spill Cleanup Procedures for Hazardous Materials

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

Recommended Practices	Environmental	Ease of Use	Benefits	Capital Cost
CM1 Crush Waste Concrete & Masonry for Reuse	✔✔✔	✔✔✔	✔	$
CM2 Use Material-Conserving Construction Practices	✔	✔✔✔	✔✔	$
CM3 Select Safe Materials for Use On-Site	✔✔	✔✔	✔✔	$$
CM4 Use Integrated Pest Management (IPM) to Minimize Pesticide Use in Construction	✔✔✔	✔	✔✔✔	$$
CM5 Use Energy-Efficient Site Lighting & controls, & Low-Pollution Equipment	✔	✔✔✔	✔✔	$$
CM6 Isolate Construction in Occupied Buildings to Protect Occupants	✔✔✔	✔✔	✔✔	$
CM7 Schedule Potential Air-Polluting Operations to Reduce Occupant & Worker Exposure	✔✔	✔✔	✔✔✔	$$
CM8 Flush with Full Outdoor Air for Seven Days Prior to Occupancy to Protect Occupants	✔✔	✔✔	✔	$$
CM9 Thoroughly Clean Interiors, Building Cavities & HVAC Systems Prior to Furniture Installation and Occupancy	✔✔	✔✔✔	✔✔✔	$

CMa

REQUIRED PRACTICE

SMMC

Environment ✔✔

Ideally only those materials that are not salvageable or recyclable should go to landfills

Ease of Use ✔✔✔

Requires little extra effort. Demolition contractors will typically survey a building before bidding.

Other Benefits ✔✔

May uncover important information about the site that will save money and assist design.

Capital Cost $

Not time-consuming or expensive. Value of reduced landfill fees or sale of salvage items often outweighs planning and salvage cost.

PREPARE A DEMOLITION & SITE PROTECTION PLAN

Prepare a demolition plan that maximizes salvage and recycling of building and landscape materials. Specify the expected recovery rate for each material type in the demolition contract.

Where an environmental audit for hazardous materials and contaminated soil is required, this stage must be done first. Next audit the building and site with a person experienced in materials recovery to identify salvageable and recyclable materials that can be removed without exposure to asbestos, lead and other hazardous materials.

Schedule the removal of reusable and recyclable materials prior to demolition to maximize the recovery rate. Often insufficient time is allowed, resulting in wasted materials and higher landfill fees.

Plan to protect soils, vegetation and watersheds during demolition and excavation.

See Appendix A for solid waste recovery specifications.

Cautions

- Asbestos, lead, contaminated soils or other environmental hazards of older buildings may severely restrict feasibility of salvage.
- All equipment which may contain mercury, lead, PCBs, radioactive or other hazardous substances should be properly disposed by a licensed hazardous waste contractor. This includes fluorescent lamps and ballasts, thermostats, pipe flashings, transformers and smoke alarms.
- Economics and scheduling of construction may restrict time allowed for salvage.
- Liability on site typically restricts salvage to insured contractors.

Further Information

- SMMC #
- LA Solid Resources Citywide Recycling Division, 1998
- Triangle J Council of Govts, 1997

Linked Practices

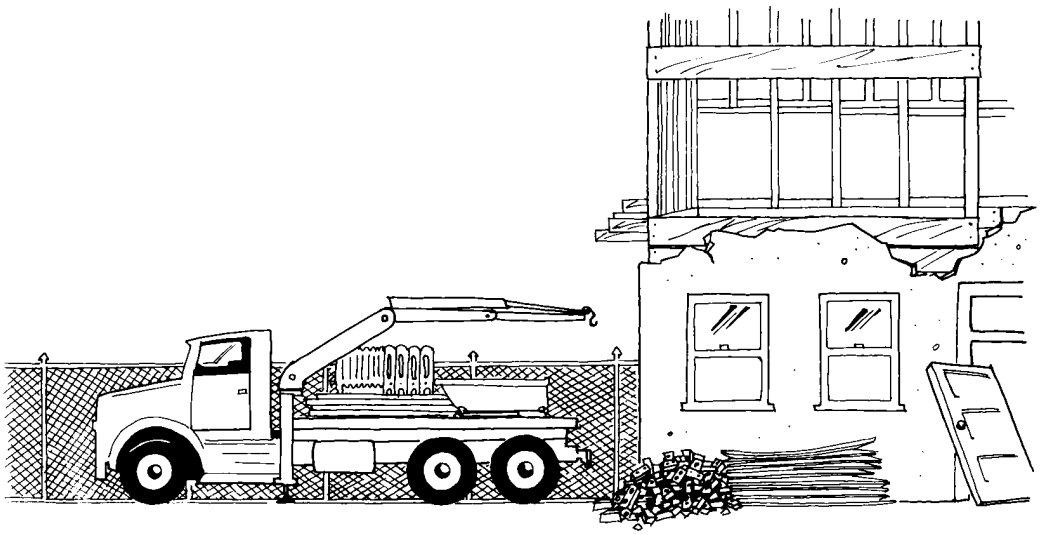
MAa
MA1
MA2
MA6

SALVAGE REUSABLE MATERIALS & SEPARATE RECYCLABLES FROM DEMOLITION

CMb

REQUIRED PRACTICE

SMMC



Salvage and recycling during demolition typically make bottom-line dollar sense. Salvage and sale of metals, valuable historic materials and reusable fixtures can actually produce a small income from demolition; and separating recyclable materials reduces the volume, weight and cost of landfill dumping.

Salvage reusable historic materials, such as:

- quality sawn or laminated timber
- architectural metalwork
- fine millwork - doors, stair parts, hardwood flooring and trim
- antique tubs and basins
- art glasswork and light fixtures

Salvage reusable materials in good condition, such as:

- clay brick and decorative masonry
- mechanical items - tanks, fans, pumps, pipe, modern heating and cooling equipment
- electrical items - newer lighting, motors, and cable
- newer windows and doors
- construction lumber and sheet materials

Separate for recycling all materials that are accepted for recycling in the Los Angeles region: metals, wood waste, clean fill, etc.

Cautions

- Care is required to prevent damage to reusable items and contamination of recyclables.
- Liability on site typically restricts salvage to insured contractors.
- Additional time may be required for salvage and separation compared to landfill disposal.

Environment ✔✔✔

Demolition recycling can dramatically reduce landfill volumes.

Ease of Use ✔✔

Many salvage contractors combine their operations with demolition.

Other Benefits ✔✔

Salvage and recycling produce jobs and support markets for historic materials.

Capital Cost $

Cost savings are typical with even minor amounts of salvage and recycling. Crushing concrete and masonry reduces dumping fees. Metals and historic materials produce a small income.

Further Information

- SMMC #
- California EPA CalMax website, 1999
- CIWMB, 1998
- City of Santa Monica, 1998
- LA SRCRD, 1997
- LA SRCRD, 1998
- Metropolitan Portland website, 1999

Linked Practices

MAa
MA1
MA2
MA6

CMc

REQUIRED PRACTICE

SMMC

Environment ✔✔✔

Minimizes disturbances to shade, habitat and storm water. Uses less water, fertilizer and pest treatment than new materials.

Ease of Use ✔✔

Can be difficult and may complicate construction on small sites. Soil preservation is generally not difficult.

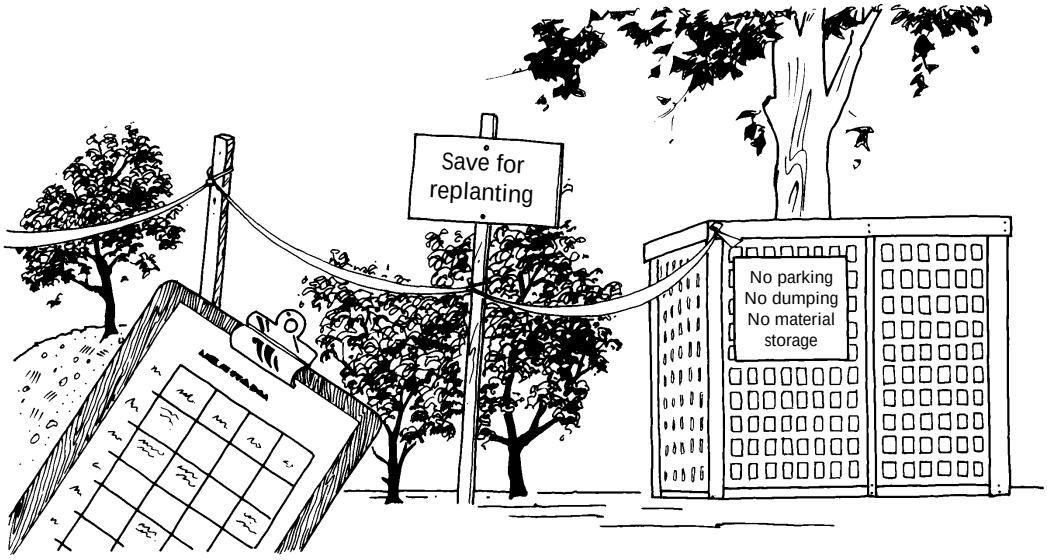
Other Benefits ✔✔✔

Provides continuity in the neighborhood during construction and reduces disturbance to neighbors.

Capital Cost $

Very little cost for preserving materials and soils. Some savings for new plants and soils.

INVENTORY, MARK & PROTECT TOPSOIL, TREES & VEGETATION TO BE RETAINED



Inventory site vegetation before demolition, clearly mark significant trees and shrubs to be retained with flagging tape and signage, and carefully locate temporary buildings and parking to avoid damage to vegetation and topsoil. Prepare a site plan showing the sizes and locations of vegetation to be removed, retained and salvaged, including plants located on adjacent public rights-of-way. The plan should be submitted as part of the application for a demolition permit. (If no demolition permit is required, submit the plan with the application for development permit.) When considering which plants to retain, consider their size, character, condition and location.

Mature trees give a site special qualities that take decades to replace if lost. Protection of the root zones of saved trees is particularly important. Tree protection should extend to at least the full perimeter of the tree canopy (the "drip line"). Allow no temporary buildings, materials storage or vehicle wheels within this zone.

Tree enclosures must be substantial and highly visible. In addition to fences, wheel stops at the drip line should be used around trees near delivery areas and heavy equipment operation. Protective fences for shrubs should be at least 3 ft. high to discourage climbing. Locate storage areas, trailers and vehicle access to protect existing vegetation and reduce soil compaction. Block

Further Information

- SMMC #
- U.S. Green Building Council & Public Technology Inc, 1997

Linked Practices

MA2
LA2
LA3
LA6
LA7

unauthorized vehicle access with physical barriers, and clearly limit and mark on-site parking for construction vehicles.

Remove and stockpile topsoil, and where suitable, strip groundcover and shrubs for reuse after construction. Shrubs can be carefully removed and stored with their roots covered with mulch or loose soil. Often, shrubs not suitable for reuse onsite can be donated or sold for use elsewhere. Topsoil should be carefully excavated, avoiding clay and large rocks, and piled where it will not be contaminated during demolition or construction. It can be screened or moved off site if necessary. If there is sufficient turf in good condition on site, it can be cut with a machine and piled for reuse.

Some large trees in the construction zone can be moved if they are unique, but this requires special equipment and will be expensive. Ensure that stored plants are watered during demolition and construction by designating a person responsible. Plants stored with roots under mulch require more water than when they are established in deep soil.

Cautions

- Consult a professional arborist with local experience to assess suitability and condition of existing vegetation, and for instructions on relocation, care and savings from preserving existing vegetation.
- Larger shrubs require careful excavation of roots, usually by hand methods, though a small excavator can be used to dig a perimeter trench.
- Specify exact procedures for boxing and storing trees and shrubs.

CMd

REQUIRED PRACTICE
SMMC 7.10.070

Environment ✔✔✔

Very effective in reducing runoff and pollution to storm drains.

Ease of Use ✔✔

Measures must be implemented before rain events to ensure effectiveness and ease of implementation.

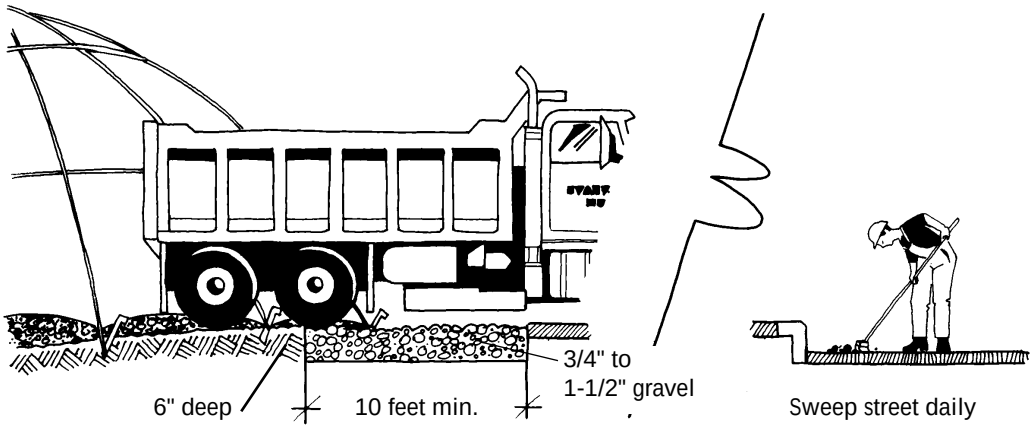
Other Benefits ✔✔

Reducing dust and sediment from leaving the site also helps comply with air regulations. Reduces complaints from neighbors.

Capital Cost $

Measures implemented prior to rain events are more effective and cost less than cleaning up sediment as it leaves the site.

PREPARE A STORMWATER CONTROL PLAN FOR THE CONSTRUCTION SITE



Wheel cleaning strip **Alternative**

Runoff from construction sites can contain significant pollution including sediment, concrete fines, lubricants and fuels, solvents, fertilizers, pesticides and many other contaminants which, if allowed to enter storm drains, will pollute Santa Monica Bay. Mitigation steps must be taken to ensure that no runoff leaves the site during the dry season and that stormwater contamination during rain events is minimized.

All construction projects in the City of Santa Monica must follow specific construction Best Management Practices, or BMPs. BMPs ensure that hazardous materials and pollutants stay onsite and don't get washed or dumped into the storm drain system. The BMPs in the list below are required by City Ordinance. BMPs must be put into practice at the time of demolition of an existing structure, or at the start of new construction, and will remain in place until a certificate of occupancy has been issued. In addition, depending on the size of the project, there may be state requirements above and beyond those of the City of Santa Monica. Check with the Engineering Division to determine if state regulations apply to the project.

- Runoff, sediment and construction waste from construction sites and parking areas shall not leave the site.
- Any sediments or other materials that are tracked onto adjacent streets or properties shall be

Further Information

- SMMC 7.10.070
- City of Santa Monica Stormwater & Wastewater website, 1999
- Friends of the San Francisco Estuary, 1995
- Richman, T. et al, 1997
- U.S. Green Building Council & Public Technology Inc., 1997

Linked Practices

SFa
LAa
TRa
TR1
WS3

removed the same day.

• On an emergency basis only, plastic covering may be utilized to prevent erosion of an otherwise unprotected area, along with runoff devices to intercept and safely convey the runoff.

• Excavated soil shall be located on the site in a manner that eliminates the possibility of sediments running into the street or adjoining properties. Soil piles shall be covered until the soil is either used or removed.

• No washing of vehicles shall be allowed adjacent to a construction site. No runoff from washing vehicles on a construction site is allowed to leave the site.

• Drainage controls shall be utilized as needed, depending on the extent of proposed grading and topography of the site.

Typical techniques used to contain runoff are swales, diversion ditches,and stormwater treatment devices such as dry wells, sediment control ponds (on large sites) and several proprietary fixtures. Where storm water is collected on site it can be recycled for dust control and irrigation.

Stabilizing excavated material, stockpiled soil and fill to prevent wind loss and erosion by storms is essential to stormwater protection. It is far easier and more economical to prevent stormwater contamination at the source than to attempt to capture and clean it later.

On some sites a wheel-cleaning strip of coarse gravel where trucks leave the site will help control soil loss and reduce the amount deposited on streets. A strip the full width of the site access road and at least 12 ft. long is generally adequate. The strip should be graded to slope into the site, and should be made from 3/4“ to 1-1/2” rock (“drain rock” material). After construction, the rock may be used for non-critical drainage, landscaping or fill uses.

Cautions

• Arrangements must be made for washdown of concrete and excavation equipment offsite where sediment capture facilities exist.

• Straw bales, often used as a sediment barrier, are not very effective.

• Oversized rock (over 3 in.) should not be used in a wheel-cleaning strip due to possible road hazards from becoming stuck between dual truck wheels.

CMe

REQUIRED PRACTICE

SMMC

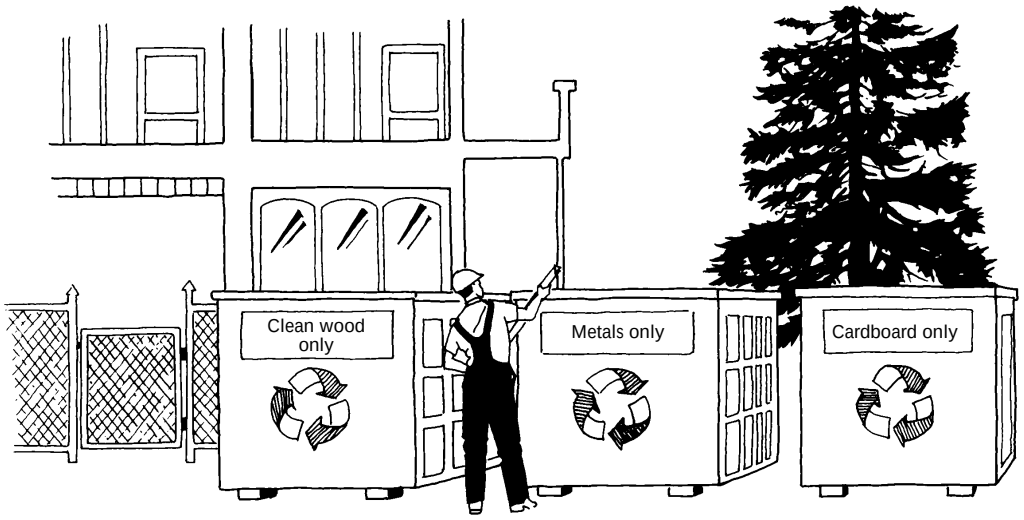
Environment ✔✔✔
Separation and recycling is an effective step for reducing construction waste.

Ease of Use ✔✔
Separation and recycling requires some effort, and may be an additional responsibility on site.

Other Benefits ✔✔
Construction waste separation and recycling is a growing industry that supports business and jobs.

Capital Cost $
Separation of metals, wood waste, drywall and cardboard can save 20% to 40% of disposal costs and produce revenue from sale of valuable materials.

RECYCLE CONSTRUCTION WASTE, & DESIGNATE A SITE WASTE-MANAGEMENT PERSON



Provide separated bins for all recyclables, where space allows, and train all site personnel to use them, for greatest resource recovery at least cost. Where there is insufficient space on site, recycling companies will receive mixed loads and separate and recycle for a fee.

Clean and properly separated waste is essential for recycling. Label the intended content of bins with clear signage, in several languages or universal symbols. Workers need to understand that contaminated bins will either be charged a separation fee, or will be charged as landfill waste.

Identify one person responsible for site waste management and allot sufficient time for this purpose; or hire a person specifically for the task for large projects. Train this person not only to recognize and handle recyclables correctly, but to instruct others to do so.

Collect and compile solid waste receipts and weigh tickets for periodic reporting to the City Solid Waste Division. See Appendix A for a sample waste recycling specification.

Cautions

- Contract clauses and site review are necessary to ensure compliance with recycling steps.
- It is best for the architect or project manager to verify recycling on-site by asking for trucking and recycling receipts.
- Pay special attention to subcontractors or trades who are only onsite periodically. Instruct them on recycling procedures before they start work.

Further Information

- CIWMB, 1998
- California EPA CalMax website, 1999
- City of Santa Monica, 1998
- Energy Outreach Center website, 1999

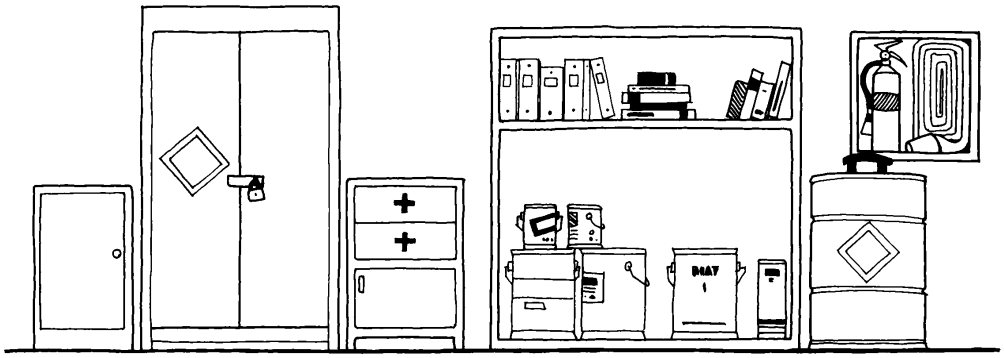
Linked Practices

MAa
MAb
MA2
MA6

PROVIDE SAFE STORAGE, WORKER TRAINING & SPILL CLEAN-UP PROCEDURES FOR HAZARDOUS MATERIALS

CMf

REQUIRED PRACTICE
SMMC 5.08.150 (B)
& 7.10.040



Store necessary hazardous materials in a secure and weatherproof location, such as a construction trailer, or a steel cabinet with a strong lock. Provide worker training in handling procedures to HMIS (Hazardous Materials Information System) and Occupational Health & Safety (OSHA) standards, and issue hazardous products only to trained, authorized persons. Collect all residue materials and contaminated containers in a well-marked, secure and weatherproof location, and deliver them to an approved hazardous material receiving facility.

Provide spill-cleaning equipment, such as absorbent materials, protective clothing and respirators, and train construction workers in clean-up procedures to prevent toxic waste from entering soil and drains. Even the safest paints and adhesives meeting "Zero VOC's" designation should not be washed down sanitary or storm drains.

Repair equipment fluid leaks immediately (e.g. fuel, engine oil, gear oil, coolants, and hydraulic fluid).

Cautions

- HMIS and OSHA information and rules are designed to protect workers. They may not adequately protect the site from pollution. Training is required for handling and safe disposal to minimize pollutant release.
- Carefully selecting safer procedures and materials is the best prevention.

Further Information

- SMMC 5.08.150 (b)
- SMMC 7.10.040

Linked Practices

MA7

Environment ✔✔✔

Spill prevention is, by far, the best environmental protection against hazardous material contamination.

Ease of Use ✔✔

Many safe handling procedures are already required to protect workers. Extending these to protect the environment needs little effort.

Other Benefits ✔✔

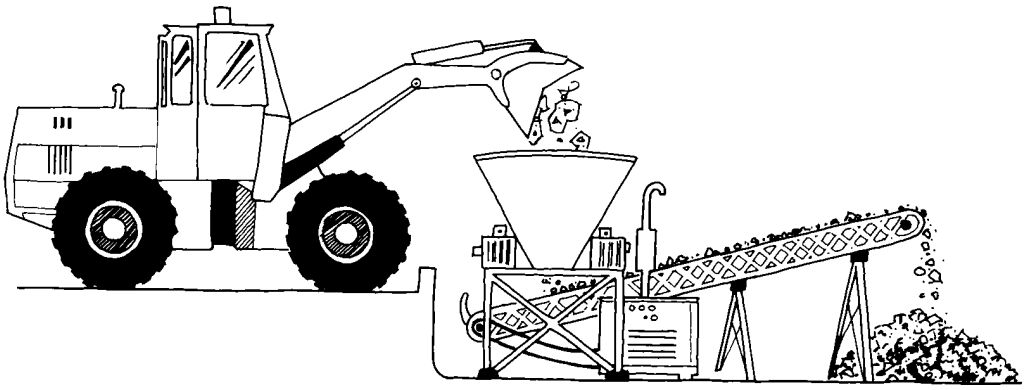
Increased workplace environmental standards and training often enhance jobsite morale and productivity.

Capital Cost $

There may be slight increases in management and equipment costs for procedures and training that exceed minimum requirements.

CM1

CRUSH WASTE CONCRETE & MASONRY FOR REUSE



Environment ✔✔✔
Reduced trucking fuel use and pollution, and reduced shipments to landfill.

Ease of Use ✔✔✔
Separating waste concrete and masonry for pickup requires little effort.

Other Benefits ✔
Construction waste separation and recycling is a growing industry that supports business and jobs.

Capital Cost $
On-site crushing, where possible, can save 15% to 30% compared to disposal. Off-site crushing and reuse saves on costs of new material.

Crush waste concrete, asphalt and acceptable masonry for use as granular fill and aggregate, or contract with a company that will accept these materials for recycling.

This is best done on site for demolition of buildings and sitework on large sites, or where truck access to the site is a problem, since it reduces the volume of materials needing to be trucked.

On smaller sites, contract with a company that will truck materials to a facility with a crusher. Clay brick and clay tile is generally not accepted.

The project engineer and soils consultant must verify specifications of crushed materials to be reused.

Cautions

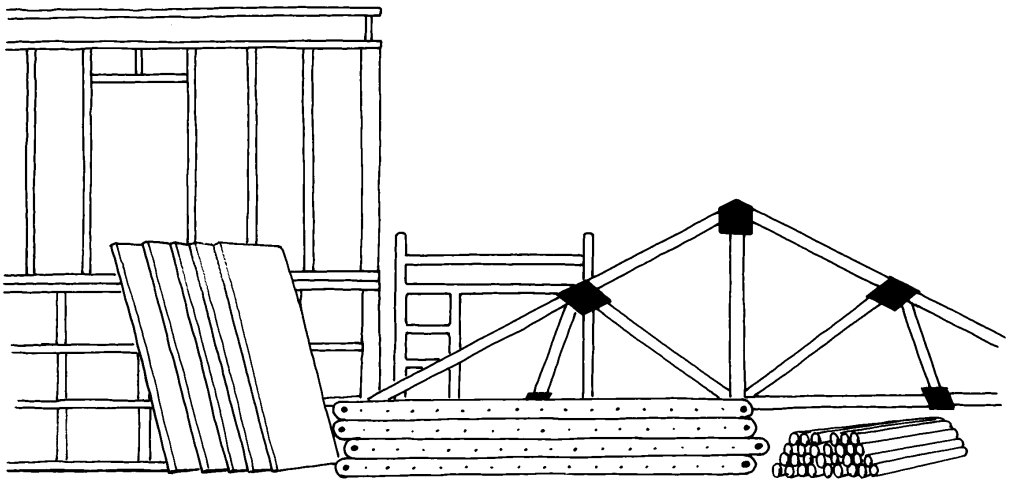
• Crushers take space and are very noisy and dusty. They are usually appropriate only on large sites where they can be isolated from close neighbors. Few sites in Santa Monica allow for on-site crushing. There is usually a delivery and minimum set-up cost, as well as an operating cost. Compare the cost of trucking to a crusher site for each project.

Further Information
• California Integrated Waste Management Board (CIWMB), (1998)
• City of Santa Monica, (1998)

Linked Practices
MA2
LA7

USE MATERIAL-CONSERVING CONSTRUCTION PRACTICES

CM2



Purchase pre-engineered or factory-cut material whenever possible, so that the manufacturer is responsible for optimizing materials use and recycling waste. Examples are factory trusses, laminated and other engineered wood products, sheet metal cladding and roofing, 9-ft. gypsum board, pre-cut headers, pre-assembled joist bridging, etc.

Use reusable and recyclable forming materials, such as steel forms or standard wood systems. Rent scaffold and staging materials, posts and bracing, fencing and hoarding, or purchase material of construction-grade lumber for reuse within the project where appropriate.

Cautions

- Cost of waste should be factored into any decision to purchase material. Precisely cut material may cost slightly more but it saves installation labor, waste handling and disposal costs.
- Construction-grade lumber stripped from other uses must be verified by project engineer and building inspector before reuse.

Environment ✔

Reducing waste at source has a modest effect on the amount of construction waste.

Ease of Use ✔✔✔

Many waste-reduction steps are already standard practice on well-run construction sites.

Other Benefits ✔✔

Rental of equipment and purchase of precisely cut and reusable materials creates employment both on and off site.

Capital Cost $

Reducing waste is always a part of good financial management. Reusable materials reduce capital and disposal cost.
Pre-cut materials reduce construction time.

Further Information

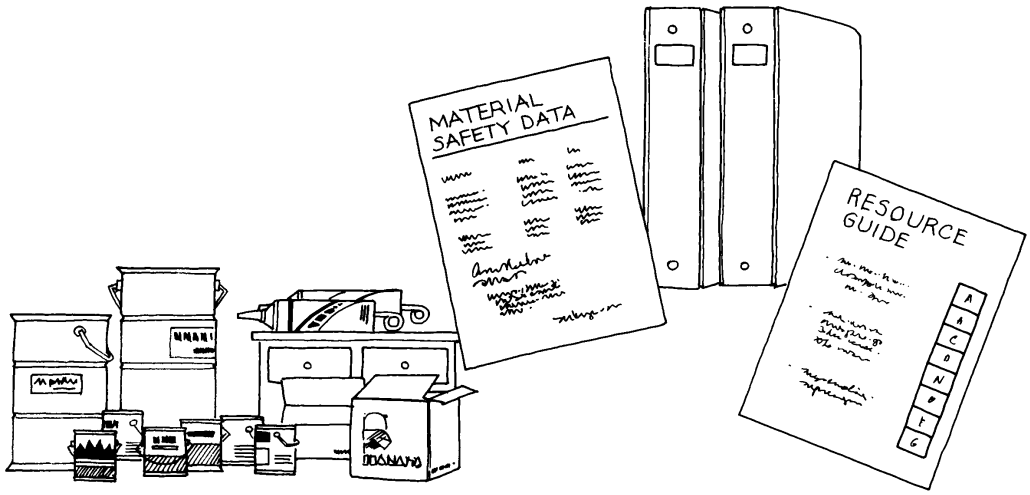
- Edminster, A. & Yassa, S., 1998
- Mumma. T. ed., 1998
- Lstiburek, J., 1997
- Canadian Home Builders Assoc., 1999
- Journal of Light Construction website, 1999

Linked Practices

MA1
MA2
MA3
MA5
MA6

CM3

SELECT SAFE MATERIALS FOR USE ON SITE



Environment ✔✔
Better for the environment and safer to handle. Produce less toxic waste in production and disposal.

Ease of Use ✔✔
Many products are readily available and are applied in the same way as more toxic ones. A few, such as insulation and sealers, may be more difficult to find and require different handling.

Other Benefits ✔✔
Increased demand for safer products encourages manufacturers to develop alternatives that are better for the user and the environment.

Capital Cost $$
Some low-toxicity construction products cost more than their traditional equivalents, but the cost difference is shrinking as markets grow.

Select materials that are safe to handle, avoiding caustics, heavy metals, hazardous solvents and hazardous fibers. Select construction products and methods that minimize long-term release of volatiles and trapped dust (see Materials chapter).

Safe materials specified in the contract usually do not exhaustively cover every product used on site. Use Hazardous Materials Information System (HMIS) guidance and safe materials selection guides to provide the safest workplace feasible, and to minimize impact on the completed building.

Locating some safer products and small additional costs for purchase may make this approach slightly more costly than a conventional approach. However, legislation such as the Southern California Air Quality Act is making products such as zero VOCs paints and adhesives readily available at little or no additional cost.

See Appendix B for sample safe materials specification.

Cautions

- Contract specifications should list specific low-toxicity materials, and should also indicate a selection standard for items not specified in the contract.

Further Information

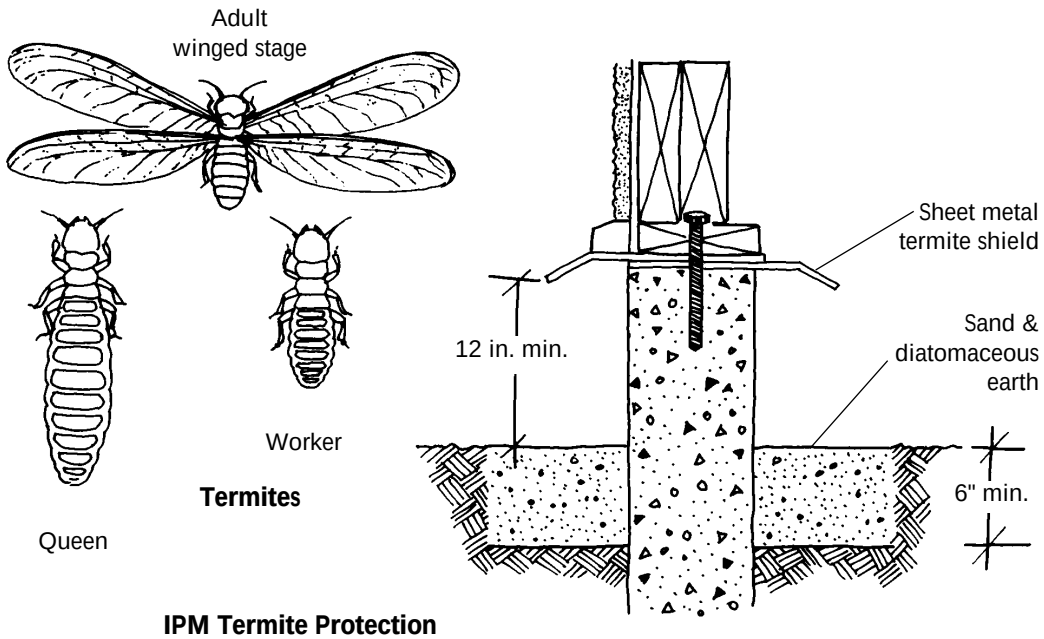
- ADPSR West Coast, 1998
- Alevantis, L.E., 1996
- UCSD Environmental Health & Safety Office website, 1999
- U.S. OSHA website, 1999

Linked Practices

MAb
MA4
MA7

USE INTEGRATED PEST MANAGEMENT (IPM) TO MINIMIZE PESTICIDE USE IN CONSTRUCTION

CM4



IPM Termite Protection

Pesticides used to safeguard an unprotected building over its life can be a major source of toxic release. Instead, use mechanical insect controls such as concrete, sand barriers and sheet metal foundation shields wherever possible, instead of toxic wood treatments, fumigation and residual pesticides in perimeter soils. Use termite-resistant outdoor lumber substitutes such as recycled plastic lumber and fiber-cement products.

Provide maximum allowable clearance of wood materials from soils, and build inspection openings into all concealed foundation spaces. (Most termites must build tubes to reach wood that is more than about 12 in. above ground in exposed locations.)

Use pest-resistant landscape materials and naturally pest-repellent plants. These steps often cost more than spraying at the outset, but are non-toxic, semi-permanent, reliable solutions, which pesticides alone are not.

Cautions

- Pest control details should be verified by a specialist in IPM practices.
- The contract should specify limitations on chemical pesticide spraying acceptable to building authorities and the owner.

Environment ✔✔✔

Minimizing pesticide use in buildings is the most effective way to reduce toxic releases from this source.

Ease of Use ✔

It is more difficult to design for pest control than to use conventional pesticides.

Other Benefits ✔✔✔

Integrated Pest Management reduces risk to workers and occupants and protects soil and air. Structural termite control is longer lasting than chemical treatment.

Capital Cost $$

Building for pest control typically costs more, but costs less to maintain.

Further Information

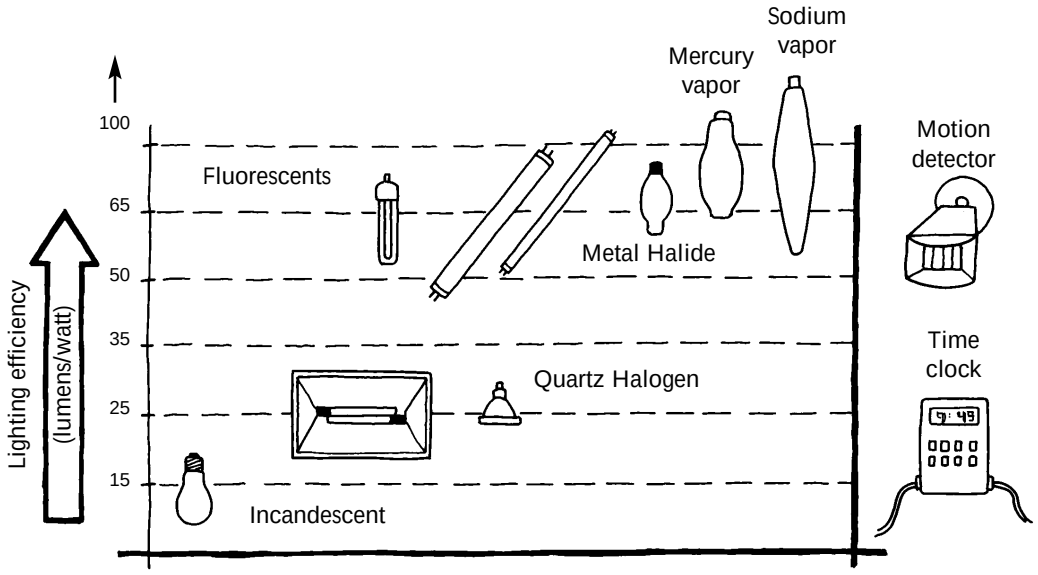
- Bio Integral Resource Center, 1996
- Lopez, A. 1996
- National Coalition Against the Misuse of Pesticides website, 1999

Linked Practices

LA3
MA4

CM5

USE ENERGY-EFFICIENT SITE LIGHTING & CONTROLS & LOW-POLLUTION EQUIPMENT



Environment ✔

Energy-efficient construction site lighting saves energy. Low-pollution vehicles and equipment protect local air quality.

Ease of Use ✔✔✔

Energy-efficient lighting and controls are readily available and easily understood by trades. Most electric equipment and vehicles are readily available.

Other Benefits ✔✔

Efficient lamps typically require less frequent maintenance and replacement. Electric equipment is quieter and requires less maintenance.

Capital Cost $$

Efficient and low-polluting equipment may initially cost more, but payback through lower operating and maintenance costs is typically rapid.

Use high-efficiency security lighting and motion sensor controls on construction sites according to energy conservation standards. Outdoor lighting should average 65 lumens per watt, and designed so that only lighting necessary for security, such as at site gates and trailers, operates through the night using light-sensitive controls. Control other site security lighting using motion detectors.

Use efficient work lighting, exceeding 40 lumens per watt, such as T5 or T8 fluorescent lamps with electronic ballasts and low mercury content for general work area lighting. Metal halide lamps are one energy-efficient choice for high-bay overhead installations, or high-pressure sodium lamps if color rendition is not critical. Minimize use of quartz/halogen and conventional incandescent lamps; compact fluorescent lamps are a better choice.

High-efficiency lighting pays back quickly with reduced operation and maintenance/replacement costs.

Use low-emission construction equipment such as electric compressors, hoists and forklifts. Use electric vehicles or propane-powered engines where engines are necessary.

Cautions

- Motion detectors must be carefully placed and tested for best security, and to avoid disturbing neighbors.

Further Information

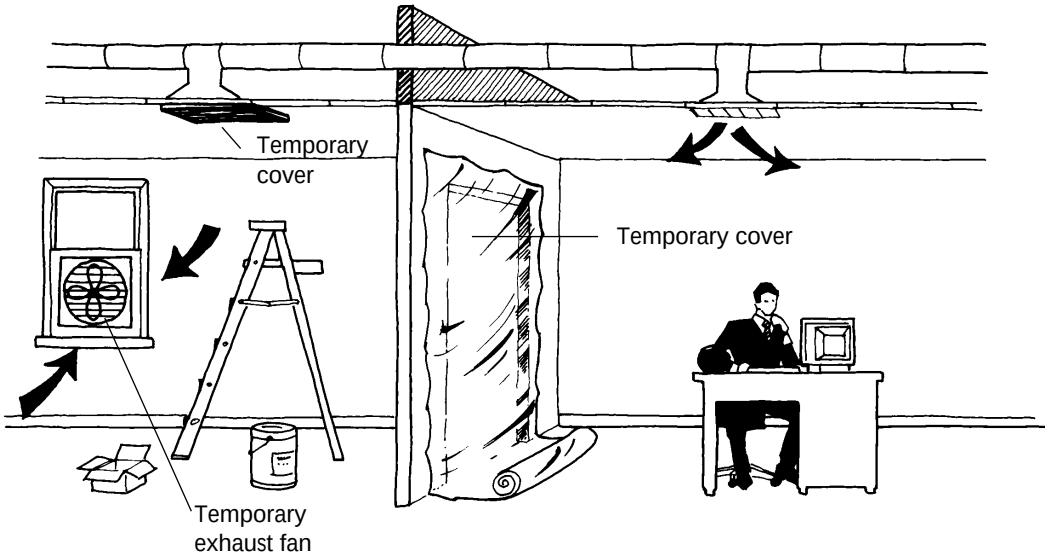
- CREST inter.Light website, 1999
- Eley, C., 1993
- Northwest Energy Efficiency Alliance website, 1999
- Rea, M. 1993
- Southern California Edison website, 1999

Linked Practices

ES1
ES2

ISOLATE CONSTRUCTION IN OCCUPIED BUILDINGS TO PROTECT OCCUPANTS

CM6



Isolate construction zones in occupied buildings using airtight barriers and separate ventilation systems.

Barriers can be made from heavy tarpaulins, plastic sheet (6 mil min.) or solid panels; all joints should be securely taped and tarpaulins and plastic protected from damage. Provide temporary "airlock" type double doors between occupied and construction zones if passage is necessary.

Where possible, seal all HVAC supply and return points in the construction zone (consult a mechanical specialist). Provide separate construction zone ventilation with temporary fans and ducts that always maintain lower pressures in construction zones relative to occupied areas. Portable high-volume exhaust fans, with flex-duct to the outdoors, are especially useful where finishes, solvents, adhesives and other toxic materials are used or dust is generated.

Some construction isolation is generally part of good management practice. Being thorough has excellent returns in terms of both occupant satisfaction — and avoidance of liability.

Cautions

• Take care when sealing HVAC systems serving both construction and occupied zones to ensure they work properly during and after construction.

Environment ✔✔✔

Isolating the construction zone helps greatly to protect occupants.

Ease of Use ✔✔

May require substantial effort to isolate the construction zone.

Other Benefits ✔✔

Building occupants are more satisfied if protected from dust, odors and noise. Less cleaning of the interior is required after construction.

Capital Cost $

Small additional costs for secure, airtight barriers and HVAC isolation and fans over minimal "tarping" measures.

Further Information

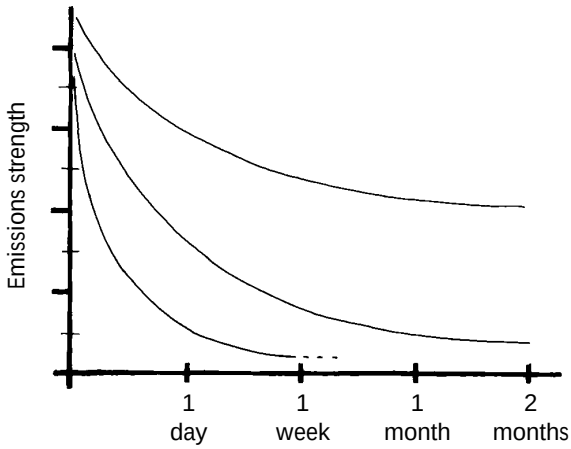
• Cutter Information Corp. newsletter
• Hal Levin and Assoc. 1999
• U.S. EPA, 1991
• U.S. EPA, 1997
• U.S.Green Building Council & Public Technology Inc., 1997

Linked Practices

MA7
HS1

CM7

SCHEDULE POTENTIAL INDOOR AIR-POLLUTING OPERATIONS TO REDUCE OCCUPANT & WORKER EXPOSURE



Environment ✔✔

Scheduling painting, adhesive and sanding operations for unoccupied hours reduces occupant exposure, even if the construction area is isolated.

Ease of Use ✔✔

Highly dependent on building use and flexibility of schedule, contractors and trades.

Other Benefits ✔✔✔

Occupants of buildings being remodeled are more satisfied if protected from dust, odors and noise.

Capital Cost $$

Modest additional cost for scheduling some work off hours and during holidays; widely variable with the specific situation.

If possible, schedule the following types of remodeling work for times when the building is unoccupied:

- dusty operations, such as interior demolition, sanding and ceiling tile removal
- operations releasing volatile chemicals, such as gluing, applying paints and finishes, and caulking
- operations releasing fibers, such as installing or removing insulation

Operations releasing volatiles should be planned to allow as much curing time as possible before occupants return. For example, work done on Friday evening before a long weekend provides an effective curing period for many liquid finishes if ventilation is adequate. Work done at night, but completed just before opening hours in the morning, may not protect occupants at all, but rather expose them to peak levels of air pollutants.

Schedule installation of high-emission interior wet products such as adhesives, paints and caulking as early as possible to allow curing time before installing adsorptive materials and furniture and prior to occupancy. Provide excess ventilation during application and for two to five days after to reduce residual vapors from volatile products. Dust clean-up requires far less time than volatiles curing. Exposure to dust may be minimal only one hour after dusty operations if air exhaust, filtration and clean-up are effective.

Delay installation of adsorptive materials such as carpet, porous ceiling tile, fabric, fabric-covered panels and upholstered furniture. This minimizes the amount of pollutants remaining in the space, which these materials adsorb and later re-emit.

Cautions

- Volatiles exposure may still be high several days after application of some products.
- On some types of projects, scheduling is very tight and there is little room to shift these operations.
- Careful attention to safe materials selection can reduce exposure.

Further Information

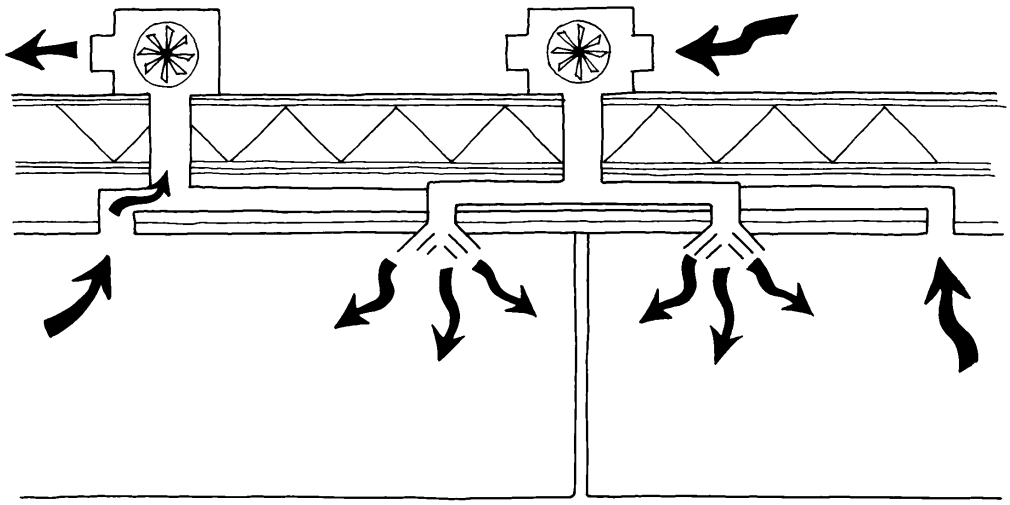
- Cutter Information Corp.newsletter
- Hal Levin & Associates, 1999
- U.S. EPA, 1991
- U.S. EPA, 1997
- U.S. Green Building Council & Public Technology Inc., 1997

Linked Practices

MA4
MA7
HS5

FLUSH WITH FULL OUTDOOR AIR FOR SEVEN DAYS PRIOR TO OCCUPANCY TO PROTECT OCCUPANTS

CM8



When possible, flush newly built spaces with full outdoor air for seven days prior to occupancy, after final paint touch-up and floor-covering installation. Use the full air capacity of the HVAC system or at least 2.5 ACH (air changes per hour), provided by temporary fans if necessary. If possible, do the flush-out before furniture installation, to avoid pollutants being adsorbed into furniture and released later.

There is a small construction management and electricity cost for a flush-out. However, it is an important step for protecting the health of occupants and reducing complaints during the critical early occupancy period. It helps to avoid sick time, disability leave and potential lawsuits.

If the buildings' HVAC system is used, replace or clean filters after the flush, and prior to occupancy.

Cautions

- HVAC systems with minimal outdoor air capacity often require supplemental temporary fans; most with "economizer" capacity can provide 2.5 ACH.
- If the occupant is on a very tight moving schedule, the extra time before moving in may be costly. Benefits and potential consequences should be considered carefully.
- A flush-out will have minimal effect on materials with prolonged emissions, such as rubber flooring, carpet backing and wood products with formaldehyde glue.

Environment ✔✔

A flush-out is moderately effective for reducing indoor air pollution from final painting and adhesive installation. It is less effective for new carpet and furniture.

Ease of Use ✔✔

Scheduling flexibility for the move-in date is necessary to complete a flush-out. Highly dependent on the specific project.

Other Benefits ✔

The flush-out period may also be used for final testing of systems, cleaning and checking.

Capital Cost $$

There is a small cost for scheduling a flush-out.

Further Information

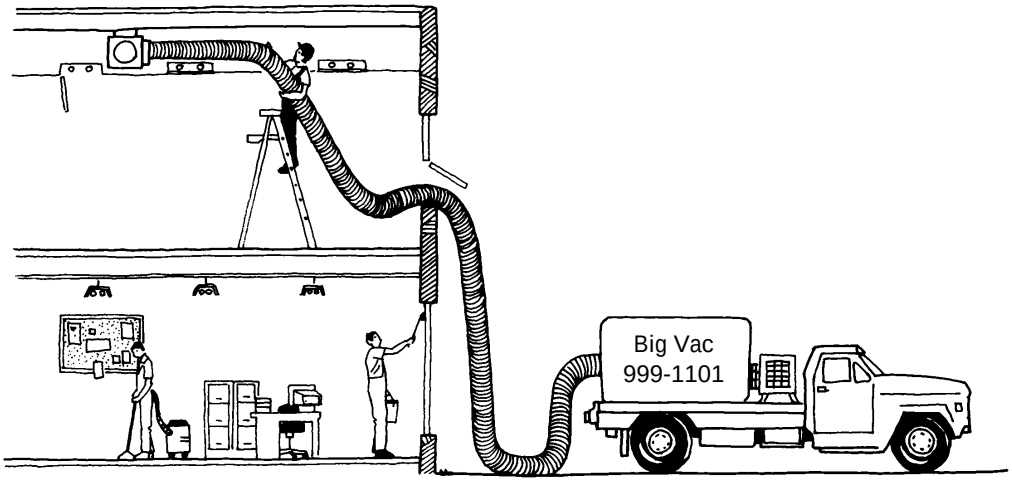
- Cutter Information Corp. newsletter
- Hal Levin & Associates, 1999

Linked Practices

HS4
HS5

CM9

THOROUGHLY CLEAN INTERIORS, BUILDING CAVITIES & HVAC SYSTEMS PRIOR TO FURNITURE INSTALLATION & OCCUPANCY



Environment ✔✔
Cleaning construction dust and debris from all surfaces, especially HVAC ducts and return air plenums, is important for ensuring indoor air quality.

Ease of Use ✔✔✔
Most of these steps are already a part of good construction practice.

Other Benefits ✔✔✔
Moving is always difficult. Taking possession of a clean building improves occupant satisfaction and reduces complaints.

Capital Cost $
There may be additional costs for cleaning and duct vacuuming beyond typical clean-up practice; however, careful contractors already do a thorough final cleanup

Prior to furniture installation and occupancy, thoroughly clean interiors, including cavities affected by construction, such as ceiling plenums.

After cleaning of interiors and prior to occupancy, vacuum HVAC ducts using compressed air or other mechanical means to dislodge debris and replace the air filters used during construction.

Ensure that cleaners used are selected for low toxicity and odor and do not emit toxic air pollutants, or they may prompt complaints. The health purposes of the final cleaning should be emphasized to cleaning staff.

Coordinating the final cleaning with the building or construction area flush-out recommended in CM8 will reduce impact on the construction schedule.

Clean or replace building HVAC system filters as part of the cleaning procedure prior to occupancy.

Cautions

- Cleaning steps must be specified in contract documents.
- If furniture installation cannot be delayed, require taped drop cloths on all exposed furniture during final construction and clean-up.
- Ensure that low-toxicity cleaning products are specified in the contract.

Further Information

- City of Santa Monica Environmental Purchasing website, 1999
- U.S. EPA, 1991
- U.S. Green Building Council & Public Technology Inc., 1997

Linked Practices

HS1
HS5

FURTHER INFORMATION

ADPSR West Coast. 1998. *Architectural Resource Guide*. P.O. Box 9126, Berkeley CA. (510) 273-2428
Resources and information on green and healthy buildings. Many California material sources.

Alevantis, L.E. 1996. *Guidelines for Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials*. California Department of Health Services, Berkeley CA.. URL http://www.cal-iaq.org/iaq
Advice for architects and builders on construction materials selection and flushout.

Bio Integral Resource Center. 1996. *The IPM Practitioner and Common Sense Pest Control*. PO Box 7414, Berkeley, CA 94707. (415) 524-2567
Guide to integrated pest management, useful for residential, commercial and institutional applications.

California Environmental Protection Agency, Integrated Waste Management Board. (April 1999). *CalMax: Materials Exchange for Business Reuse and Recycling*. [WWW Document] URL http://www.ciwmb.ca.gov/calMAX/search.asp
A n excellent resource for designers and contractors seeking recycled materials, or wishing to dispose of salvaged materials. Features a web-based recycled materials exchange, connecting recyclers and users. Searchable database, allowing selection by region and material type wanted. Information resources, case studies, regulations, listings of recycling contractors and much more.

California Integrated Waste Management Board (CIWMB). 1998. *Construction and Demolition Recyclers, Processors and Receivers List*., 8800 Cal Center Dr. Sacramento, CA 95826-3200 URL http://www.ciwmb.ca.gov
The state clearing house for recyclers. Extensive listing of sources for recycled materials.

Canadian Home Builders Association. 1999 (in press). *Builders Manual*. 150 Laurier Ave. W., Ste. 200, Ottawa, Ontario,. Canada, K1P 5J4. URL http://www.chba.ca
Wood frame construction details durability, resource- and energy-efficiency. The builder's guide for the Canadian R-2000 energy-efficient residential buildings program.

City of Santa Monica. 1998. *Construction and Demolition Waste Recycling Guide*. Environmental Programs Div. (310) 458-8972.
Summarizes local resources for C & D waste reduction.

City of Santa Monica. (March 1999). *Stormwater and Wastewater* [WWW Document] URL http://www.ci.santa-monica.ca.us/environment/policy/bay/
Access to Santa Monica's stormwater program information.

City of Santa Monica. (March 1999). *The City of Santa Monica's Environmental Purchasing*. US EPA742-R-98-001 [WWW document] URL http://www.epa.gov/opptintr/epp
A case study of Santa Monica's municipal green purchasing program, including low toxicity product selection.

Construction Materials Recycling Association of Southern California. (818) 548-8996 (Kelly M. Ingalls) e-mail: kmibldg@earthlink.net
A newly formed industry association, beginning a newsletter.

Center for Renewable Energy and Sustainable Technology (CREST). (March 1999). *inter.Light – The Lighting Source for Lighting Specifiers*. [WWW document] URL http://www.lightsearch.com/
CREST "...produces educational multimedia CD-ROMs and operates Solstice, an Internet service for the sustainable energy field." It is one of the premier centers for energy-efficient building information on the World Wide Web. Inter.light is a searchable database of lighting resources, including lamps, luminaires, ballasts, controls, components, software and applications. Each section is further divided into searchable details.

Cutter Information Corp. **IEQ (Indoor Environmental Quality) Strategies**. 37 Broadway, Suite 1, Arlington, MA 02174-5552. (781) 648-8700 or (800) 964-5125. URL http://cutter.com
A technical, professional newsletter for indoor air specialists.

Edminster, A. and Yassa, Sami. 1998. *Efficient Wood Use in Residential Construction*. Natural Resources Defense Council Publications Dept., 40 W. 20th St. New York, NY 10011-4211 (212) 727-2700.
An excellent, practical guide to resource-efficient wood construction.

Eley, C. 1993. *Advanced Lighting Guidelines:1993 (Revision 1)*. Electric Power Research Institute, Palo Alto.
An excellent handbook for all components of lighting, from lamps to luminaires to controls. Provides basic as well as technically detailed information. Includes diagrams, tables and charts.

Energy Outreach Center. (March 1999). *Reusable Building Materials Exchange*. [WWW Document] URL http://www.rbme.com
Electronic listings of what's available and what's wanted, unfortunately limited to Washington state. Useful for locating salvaged materials.

Friends of the San Francisco Estuary. (April 1999). *Erosion and Sediment Control Field Manual, and Manual of Standards for Erosion and Sediment Control Measures*. [WWW Document] URL http://www.abag.ca.gov/bayarea/sfep/
Erosion and Sediment Control Handbook: provides all of the information needed to select and design erosion control measures for construction sites.
Manual of Standards: covers control measures for urban or developing areas, with emphasis on control of construction erosion. Includes legal guidelines and technical standards, with sample specifications for controlling water quality impacts.
Both available from Friends of the San Francisco Estuary website.

Hal Levin and Associates. 1999. Indoor Air Bulletin. P.O. Box 8446, Santa Cruz, CA, 95061-8446. (408) 426-6624.

A newsletter for architects and building professionals on indoor air quality. Written in an accessible style.

Journal of Light Construction. (March 1999). *The Journal of Light Construction* [WWW Document] URL http://www.jlconline.com
932 West Main St. Richmond, VT 05477. (802) 434-4747
Provides construction information to builders, remodelers, contractors, architects and others in the construction industry about resource efficient home building.

LA Solid Resources Citywide Recycling Division, (SRCRD). 1998. *City of Los Angeles Solid Resources Management Specification*. (213) 847-1444.
A recommended recycling specification for contractors doing demolition, site clearing and construction.

LA SRCRD. 1998. *Construction and Demolition Waste Recycling Guid*e. (213) 847-1444
A list of waste receivers and services in the LA region.

LA SRCRD. 1997. *Wood You Recycle?*. (213) 847-1444
A guide to wood re-use and recycling in the Los Angeles area.

Lopez, A. 1996. *Natural Pest Control : Alternatives to Chemicals for the Home and Garden*. Chelsea Green, Sebastopol, CA.
A guide to non-toxic pest control in buildings and gardens.

Lstiburek, J. 1997. *Builder's Guide*. Building Science Corp., 70 Main St., Westford MA 01886. (978) 589-5100.
Building science-based construction methods and details for durable, resource-efficient buildings.

Metropolitan Portland Construction and Demolition Waste Information Program. (March 1999) *Construction Site Recycling*. [WWW Document] URL http://www.multnomah.lib.or.us/metro/rem/rwp/constrcy.html
Information resources and case studies on waste reduction and recycling.

Mumma. T., ed. 1998.*Guide to Resource Efficient Building Elements (GREBE)*. Center for Resourceful Building Technology, Box 100, Missoula MT 59806 (406) 549-7678. http://www.montana.com/crbt
The "original" resource book on resource-efficient building systems. Updated regularly.

National Coalition Against the Misuse of Pesticides (NCAMP). (March 1999). *NCAMP Home Page* [WWW Document] URL http://www.ncamp.org
NCAMP, 530 7th St. SE, Washington DC 20003
NCAMP also produces a newsletter called Pesticides and You.

Northwest Energy Efficiency Alliance. (April 1999). *Northwest Lighting Home Page*. [WWW Document] URL http://www.northwestlighting.com
An extensive collection of lighting case studies, research, technology & specifiers reports covering almost all aspects of efficient lighting. Includes a large products database. The renowned Lighting Design Lab in Seattle, Washington is a cosponsor and updater.

Northwest Energy Efficiency Alliance. *Northwest Lighting Home Page*. (October 1998). [WWW Document] URL http://www.northwestlighting.com
An extensive collection of lighting case studies, research, technology and specifiers reports covering almost all aspects of efficient lighting. Includes a large products database. The renowned Lighting Design Lab in Seattle, WA is a co-sponsor and maintains the database.

Rea, M.S., ed. 1993. *Lighting Handbook: Reference and Application, 8th Edition*. Illuminating Engineering Society of North America, New York.
The bible of illuminating engineering. This reference tome provides both basic and highly technical information for general and application-specific lighting inquiries.

Richman, T., et al. 1997. *Start at the Source: Residential Site Planning and Design Guidelines: Manual for Stormwater Quality Protection*. Bay Area Stormwater Management Agencies, San Francisco.
Brief, information-dense design guide to stormwater runoff reduction and treatment, oriented toward biological and landscaping methods. Many illustrations and diagrams.

Smart Growth Network. (March, 1999) *Riverdale Case Study*. [WWW Document] URL http://www.smartgrowth.org/casestudies/casestudy_index.html
Index of many case studies of demolition waste recycling; especially interesting is the Riverdale experience.

Southern California Edison: Customer Technologies Applications Center (CTAC), 6090 Irwindale Ave., Irwindale, CA 91702. (800) 336-2822.
CTAC is an excellent resource for Southern California designers and builders. Offering extensive information resources, samples of many lighting products and technologies, and training courses, CTAC can also help developers and designers take advantage of the many rebates and programs offered by Southern California Edison.

Triangle J Council of Govts. April 1999). *Waste Spec*. P.O. Box 12276, Research Triangle Park, NC 27709 (919) 549-0551 URL http://www.thcog.dst.nc.us/TJCOG
A model specification for construction waste reduction.

U.S. EPA, Office of Air and Radiation. 1997. *A Guide to Indoor Air Quality*. U.S. Environmental Protection Agency, Indoor Air Division, Washington, DC, (202) 233-9030.
One of several free publications on indoor environment.

U.S. EPA, Office of Air and Radiation. 1991. *Indoor Air Quality: A Guide for Building Owners and Managers*. U.S. Environmental Protection Agency, Indoor Air Division, Washington, DC, (202) 233-9030.
A workbook for analyzing and solving indoor air problems.

U.S. EPA. **California Lead Abatement Program Hotline**. (510) 450-2453
Telephone hot line for lead problems in buildings. Asbestos information also available.

U.S. Green Building Council & Public Technology Inc. 1997. *Green Buildings Technical Manual*. (PTI) 1301 Pennsylvania Avenue, N.W. Suite 800 Washington, D.C. 20004. http://www.pti.nw.dc.us (800) 852-4934.
A guide for local governments, building design professionals and managers on many aspects of green design, construction and management.

U.S. Occupational Safety and Health Administration (US OSHA). (March 1999). *Construction*. [WWW Document] URL http://www.osha.gov
Extensive U.S. government site, with many publications and resources on occupational health and construction. Includes authoritative summary sheets for chemicals and other jobsite hazards and links to MSDS data sheets.

University of California San Diego Environmental Health & Safety Office. (March 1999). *WWW Health & Safety Resources*. [WWW Document] URL http://www-ehs.ucsd.edu/wwwlinks.html
A large collection of health and safety information available online.

COMMISSIONING

BUILDING COMMISSIONING

Any building project is complex, from the first design concept through to the final stages of construction and occupancy. Some buildings, such as those with unusual electrical or air-conditioning systems, or those with special "green features", may require extra attention to be sure that they operate as designed. Ensuring that all features and systems are built and function as intended is called building commissioning.

Commissioning buildings usually covers air conditioning, electrical, communications, security and fire management systems and their controls. It may also include other systems and components, particularly if they are unusual or complex. Commissioning begins by documenting design intent for future reference. This is followed by testing components when they arrive on the jobsite, and again after they are fully installed. Adjusting (balancing) of air and water distribution systems to deliver services as designed, and checking and adjusting controls systems to ensure energy savings and environmental conditions is the next phase. Providing maintenance training and manuals for building staff is usually the last step of commissioning.

Along with drawings and equipment manuals, a final commissioning report is also submitted to the owners. A complete commissioning report contains all records of the commissioning procedures, testing results, deficiency notices and records of satisfactory corrections of deficiencies. In rare cases, commissioning may also extend to testing the building and systems several months or a year after occupancy.

System commissioning is primarily done by a mechanical consultant with special experience and training, ideally hired by and responsible directly to the project owner and often independent of the mechanical design firm and contractor. A special commissioning coordinator may be responsible for whole building commissioning for very complex projects such as health care facilities. The architect typically oversees the completion of commissioning.

Commissioning is a relatively new procedure that includes what was formerly referred to as "testing, adjusting and balancing" but it goes several steps further. Commissioning has been found to be very valuable, particularly with complex mechanical and electrical systems, to ensure that they operate as intended, and to realize energy savings and a quality building environment - which are often the reasons more complex systems are installed. When special building features are installed to generate renewable energy generation, recycle waste or reduce other environmental impacts, commissioning is often necessary to ensure optimum performance.

Rationale

Two of the Santa Monica Sustainable City Program goals are to increase the use of conservation techniques and practices, and to reduce non-renewable energy use by 15% by year 2000. Many of today's buildings contain highly sophisticated conservation and environmental control technologies which, in order to function correctly, require careful supervision of installations, testing and calibration, and instruction of building operators.

The purposes of commissioning are to ensure:

- performance of contractual obligations;
- quality of construction and correct operation of all functions;
- environmental quality and energy-efficient operation as designed; and
- that complete as-built information and operating and maintenance information are passed on

to owners and operating staff.

The degree of commissioning should be appropriate to the complexity of the project and its systems, the owners' needs for assurances, and the budget and time available. HVAC commissioning costs from 1% to 4% of the value of the mechanical contract. In 1996 whole building commissioning for an office building cost $0.20 to $0.40 / sq.ft.depending on the degree of the process and complexity of the systems.

Which Buildings Need Commissioning?

Formal commissioning is recommended for buildings with complex and digitally-controlled HVAC systems, or those with renewable energy, on-site water treatment systems, daylighting or occupancy sensor lighting controls, natural ventilation systems integrated with HVAC systems, or other unusual technologies. Commissioning is usually not used for projects with very little mechanical or electrical complexity, such as typical residential projects.

Commissioning also serves an important construction quality-control function for all building types, and helps consultants track the progress of contracts.

Commissioning should be done for:

- both new construction and major retrofits;
- medium or large energy management control systems (systems with more than 50 control points);
- unusually complex mechanical or electrical systems;
- on-site renewable energy generation systems, such as solar hot water heaters or photovoltaic arrays; and
- innovative water-conservation strategies, such as graywater irrigation systems or composting toilets.

COMMISSIONING PRACTICES SUMMARY TABLE

Recommended Practices	Environment	Ease of Use	Benefits	Capital Cost
C01 Prepare & Follow a Formal Commissioning Plan	✔✔✔	✔✔✔	✔✔✔	**$$**
C02 Pretest & Functionally Test All Equipment to be Commissioned & Correct Deficiencies	✔✔	✔✔✔	✔	**$**
C03 Provide Operation & Maintenance Training or Staff	✔✔✔	✔✔	✔✔✔	**$$**
C04 Provide a Complete Final Commissioning Report to the Owner & Building Management	✔✔	✔✔	✔✔	**$**

Legend

Environment: how well a Practice addresses environmental, health and resource-conservation issues.

Low ✔
Moderate ✔✔
High ✔✔✔

Ease of Use: how easily a given Practice can be implemented in design or construction.

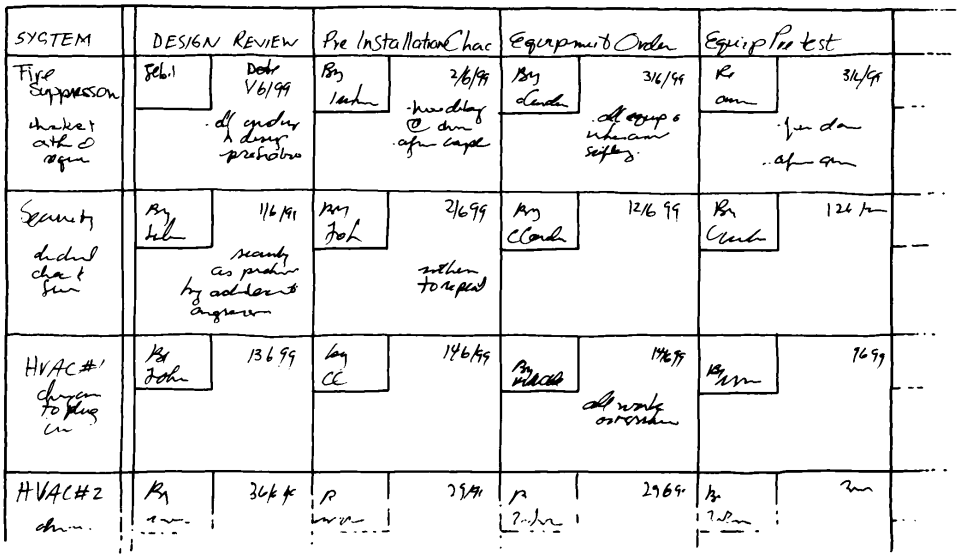
Low ✔
Moderate ✔✔
High ✔✔✔

Benefits: benefits of a Practice besides reduced environmental, health or resource impacts, eg. social and livability benefits of pedestrian amenities.
Low ✔
Moderate ✔✔
High ✔✔✔

Capital Cost: the effect of a Practice on total construction cost, relative to current standard Southern California practice.
Low **$**
Moderate **$$**
High **$$$**

C01

PREPARE & FOLLOW A FORMAL COMMISSIONING PLAN



Commissioning is often confused with basic operational testing and adjustment such as HVAC balancing. Commissioning is actually a comprehensive and coordinated program to ensure that the building performs as designed, and to optimize its operation for greatest energy conservation and occupant satisfaction.

A plan is essential for successful commissioning:

- Decide the degree of commissioning required early in the design process.
- Assign responsibility for commissioning, also early in the process.
- Define commissioning requirements clearly in specification documents for all systems that require it.
- Instruct the contractor to coordinate and delegate commissioning duties among subcontractors.
- Assign the commissioning coordinator or consultant (if involved) the coordination of all documents and commissioning work.

Cautions

- The difference between commissioning, and traditional "testing, adjusting and balancing" must be emphasized to contractors during the bidding process, so that they understand that more testing and verification will be required than has been standard practice.
- A commissioning consultant is recommended for buildings with complex mechanical or electrical systems, especially large telecommunications, bio-medical or computer systems, or where precise environmental control is necessary.

Further Information

- ASHRAE , 1996
- Natural Resources Canada, 1995
- U.S. DOE FEMP, 1998
- U.S. DOE/PECI, 1998

Linked Practices

WSc
WS2
WS6
ES7
ES8
HS1
HS6
HS8
CS1
CS2
CS3

Environment ✔✔✔

A commissioning plan will help to achieve the energy-conservation or building environment objectives in complex buildings.

Ease of Use ✔✔✔

A commissioning plan is a small piece of work on a large project where many coordination steps are already required.

Other Benefits ✔✔✔

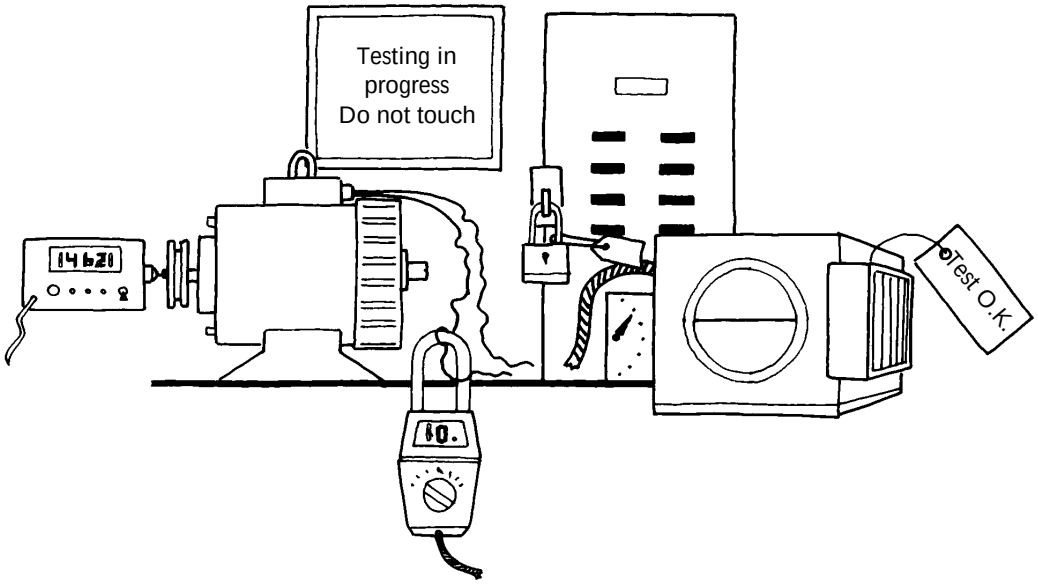
A commissioning plan is a very valuable tool for construction management to assure quality control. The plan is also useful to the architect, engineers and owners for assessing contract compliance.

Capital Cost $$

Following a complete mechanical commissioning plan typically adds about 1% to 4% to the total cost of the mechanical contract.

C02

PRETEST & FUNCTIONALLY TEST ALL EQUIPMENT TO BE COMMISSIONED AND CORRECT DEFICIENCIES



Environment ✔✔
Pretesting is an important part of assuring that mechanical and electrical systems deliver the energy and environmental benefits expected.

Ease of Use ✔✔✔
Pretesting requires a modest additional effort over minimum installation practices.

Other Benefits ✔
Pretesting can help to coordinate mechanical, electrical and controls installations.

Capital Cost $
There is a small additional cost for pretesting that exceeds minimum standards. If defects are corrected before the installation is complete, savings can be large.

Inspect and pretest all major equipment before installation is complete, to discover serious defects that may affect the commissioning and occupancy schedule. Finalize testing once installation is substantially complete, but before full start-up.

Testing should include proper operation of:

- all motors;
- all major controls, servos and actuators;
- pumps; and
- other electrical and mechanical devices.
- PV and water solar collectors

Check for correct voltage, starting and operating current, shaft speed, pressure, correct rotation, full travel and positive closure of dampers and valves, etc. Check electrical controls for response to sensors.

All pressure vessels and piping should be pressure- and leak-tested just prior to completion of installation to determine any defects in joints, welds, etc. Ensure that each pretest and test is fully documented, and the records given to the commissioning coordinator.

Caution

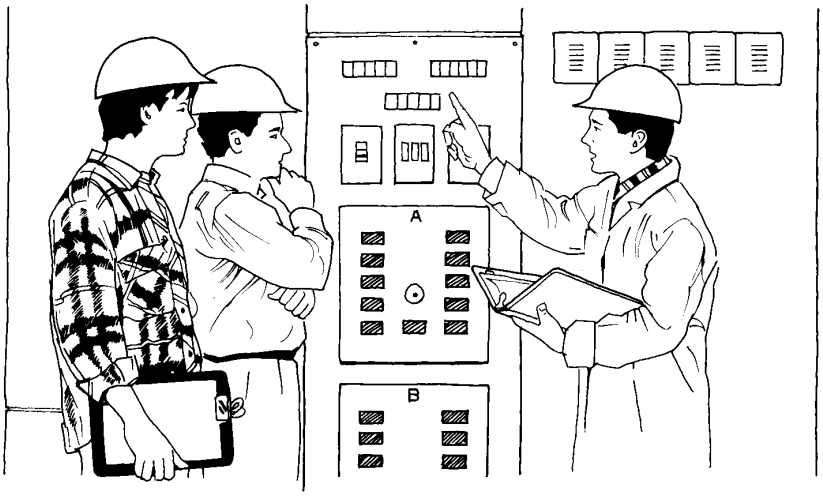
- Ensure lock-out and tagging procedures are rigorously followed for motors and electrical circuits during testing to maintain safety.

Further Information

- U.S. Dept. of Commerce & GSA , 1992
- National Environmental Balancing Bureau 1993
- F. Rubinstein,D. Avery, J. Jennings, 1997

Linked Practices

PROVIDE OPERATION & MAINTENANCE TRAINING FOR STAFF



Convene an on-site meeting, or series of meetings as necessary, to hand over the completed building to the owner, and to train operations staff. Participants should include:

- major consultants' inspection personnel involved in mechanical, energy and electrical systems;
- a representative of the general contractor;
- the lead electrical and mechanical technicians; and
- all main operations, maintenance and building management staff, on behalf of the owner.

A minimal procedure is generally adequate for simple and modestly sized multi-unit residential or commercial projects (less than ~20,000 sq.ft.). A full training program should be undertaken for larger buildings, or those with complex electrical and mechanical systems, advanced natural ventilation and renewable energy systems, innovative water systems, or special environmental control requirements.

Describe and walk through all mechanical, electrical, renewable energy and non-typical water systems, demonstrating start-up, adjustment and shutdown procedures, and all routine maintenance procedures. Ensure that operations staff is fully aware of maintenance requirements and intervals.

Turn over operations and maintenance procedures, documentation of design intentions, as-built drawings, equipment manuals, and all equipment manufacturers' data at these meetings..

Provide contact information of designers, contractors and maintenance services to building management staff.

Caution

- The degree of training will depend on the complexity and size of the building.

Further Information

- ASHRAE, 1996
- Natural Resources Canada, 1995
- U.S. DOE FEMP, 1998
- U.S. DOE / PECI, 1998

Linked Practices

WSc
WS2
WS6
ES7
HS5
CS1
CS2
CS2
CS3
CS4
CO4

Environment ✔✔✔

Building operation often affects energy conservation and environmental quality more than the building design itself. Successful turnover of building with complex systems is critical to success.

Ease of Use ✔✔

Requires communications skills and additional effort by design consultants.

Other Benefits ✔✔✔

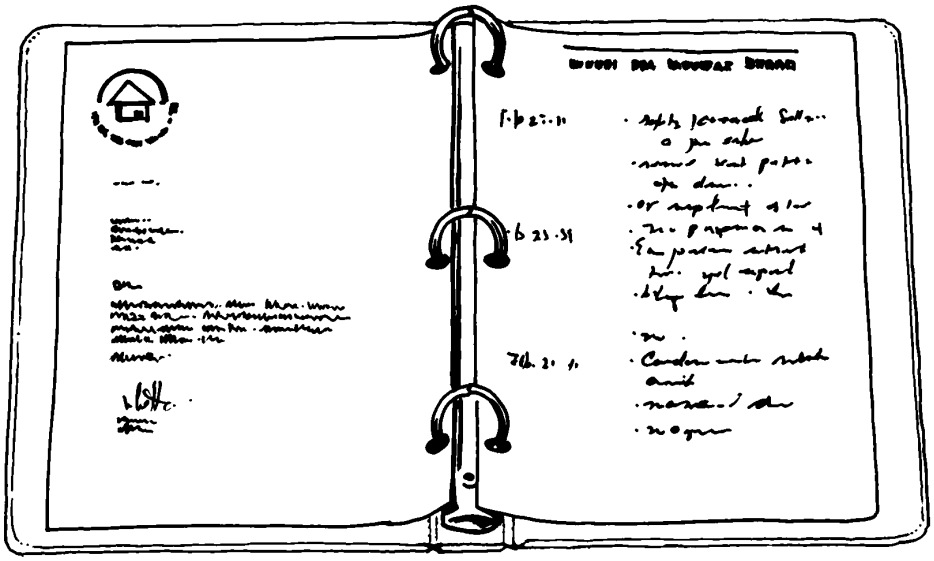
Helps owners and staff to understand their building better, and to anticipate problems and maintenance needs.

Capital Cost $$

Consultants must budget time for training sessions. Building owners must also pay staff for training time. This money is well spent, however, and can prevent costly misunderstandings, mistakes and down-time later.

C04

PROVIDE A COMPLETE FINAL COMMISSIONING REPORT TO THE OWNER & BUILDING MANAGEMENT



Environment ✔✔
Important for successful operation and maintenance, and to achieve energy conservation and environmental goals.

Ease of Use ✔✔
Requires significant effort for consultants to assemble all this information and turn it over in a useful form.

Other Benefits ✔✔
The commissioning report can be used to train new operations and maintenance staff in future.

Capital Cost $
There should be only a small cost for the consultant to assemble this information if there has been a commissioning procedure. The cost may be higher if there has been only limited commissioning.

Provide a final commissioning report documenting design intent, construction and test results. It should include:

- occupancy and schedule assumptions
- heating and cooling load calculations
- summaries of intended operation sequences
- as-built and equipment shop drawings
- schematic drawings of all mechanical, electrical and control systems
- equipment manuals;
- equipment operating procedures (normal and emergency)
- balancing reports
- air and water design conditions
- maintenance procedures and schedules
- control program software documents
- 24-hour telephone contacts for emergency service companies

Include an annotated source code for all control system programs in both hard copy and electronic form, complete with control point listings with set points and anticipated operating range. Ensure that all deficiencies and their successful correction are clearly documented.

Cautions

- It is easy for this step to be overlooked in the rush to occupy the building and complete construction.
- Documentation should be written in simple, plain language, understandable by non-technical people.

Further Information

- ASHRAE, 1996
- Natural Resources Canada, 1995
- U.S. DOE FEMP, 1998
- U.S. DOE / PECI, 1998

Linked Practices

WSc
WS2
WS6
ES7
HS5
CS1
CS2
CS2
CS3
CS4
CO4

FURTHER INFORMATION

ASHRAE, 1996. *Guideline 1: The HVAC Commissioning Process*. Publications Dept. ASHRAE ,1791 Tullie Circle N.E., Atlanta, GA 30329. (404) 636-8400. URL http://www.ashrae.org
A brief guide to the commissioning of HVAC systems, covering main points, but with little detail.

National Environmental Balancing Bureau (NEBB). 1993. *Procedural Standards for Building Systems Commissioning*, 1385 Piccard Drive, Rockville, MD 20850. (301) 977-3698.
More detailed procedures and checklists for HVAC system commissioning..

Natural Resources Canada, Energy Efficiency Division. 1995. *Commissioning Specifications, C-2000 Program*. Natural Resources Canada, C-2000 Program, 7th Floor, 580 Booth St., Ottawa, Ontario, Canada K1A 0E4.
Oriented toward construction, rather than design. Many portions of guide specifications are applicable to California projects, especially those with complex DDC systems.

Portland Energy Conservation Inc. (PECI). (March 1999). *PECI Commissioning Resources*. [WWW document] URL: http://www.peci.org/cxguides.html
921 Washington St., Suite 312, Portland OR 97205. (503) 248-4636.
An excellent resource. Portland Energy Conservation Inc. has lead the drive for building commissioning, and its website lists case studies, information resources, Web links and references.

Rubinstein, F., D. Avery, and J. Jennings. (Lawrence Berkeley Labs.). (November 1997). *On the Calibration and Commissioning of Lighting Controls*, Proceedings, Right Light 4 Conference, Copenhagen Denmark. Available from Lawrence Berkeley Labs as LBNL-41010 L-207. URL http://www.lbl.gov
Summarizes lessons learned from several projects commissioning daylighting and occupancy sensor lighting controls.

U.S. Department of Commerce & General Services Administration. 1992. *HVAC Functional Inspection and Testing Guide* NTIS: (800) 553-6847.

U.S. Department of Energy Federal Energy Management Program (DOE/FEMP) & U.S. General Services Administration (GSA). 1998. *Building Commissioning Guide, V. 2.2*.. FEMP, 1000 Independence Ave. SW, Washington D.C. 20585.
Takes a broad approach, with sufficient detail for developers, design teams and contractors to use it for their own building commissioning programs. Covers commissioning from programming through occupant acceptance. Available for free download at Energy Efficiency and Renewable Energy (EREN) website: URL: http://www.eren.doe.gov/femp/techassist/bldgcomgd.html

U.S. Department of Energy & Portland Energy Conservation Inc. (PECI). 1998. *Model Commissioning Plan and Guide Commissioning Specifications*, V. 2.05. NTIS: # DE 97004564. (800) 553-6847.
Comprehensive commissioning plan format and guide technical specification for contract preparation. Covers both design and construction, and sample test procedures. Available for free down-

APPENDIX A
MATERIALS

GUIDE CONSTRUCTION WASTE MANAGEMENT SPECIFICATIONS

Adapted from Los Angeles Solid Resources Management Specification, LA SRCRD, by Kelly M. Ingalls
and Greater Vancouver Regional District Solid Waste Management Specification, by Susan Morris Specifications

DISCLAIMER: THE HEALTH AND SAFETY OF WORKERS AND THE PUBLIC ARE THE FIRST PRIORITY IN ANY CONSTRUCTION OR DEMOLITION PROJECT. PROJECT OWNERS ARE RESPONSIBLE FOR COMPLYING WITH ALL APPLICABLE CODES AND STATUTORY OR REGULATORY REQUIREMENTS. THIS SPECIFICATION IS NOT INTENDED TO CONSTITUTE OR RENDER ENGINEERING, ARCHITECTURAL, LEGAL OR OTHER PROFESSIONAL SERVICES OR ADVICE, NOR SHOULD IT BE A SUBSTITUTE FOR SUCH SERVICES OR ADVICE FROM AN EXPERIENCED PROFESSIONAL DIRECTED TO THE SPECIFIC DESIGN SITUATION. WHILE THE INFORMATION IN THE SPECIFICATION IS BELIEVED TO BE ACCURATE, THE AUTHORS SHALL NOT BE LIABLE FOR DAMAGES ARISING FROM ERRORS OR OMISSIONS IN THIS SPECIFICATION.

SECTION 01505 - PROJECT WASTE MANAGEMENT

PART 1 - GENERAL

1.1 WASTE MANAGEMENT GOALS FOR THE PROJECT

.1 The Owner has established that this Project shall generate the least amount of waste possible and that processes shall be employed that ensure the generation of as little waste as possible. These shall include prevention of damage due to mishandling, improper storage, contamination, inadequate protection or other factors as well as minimizing over packaging and poor quantity estimating,

.2 Of the inevitable waste that is generated, the waste materials designated in this specification shall be salvaged for reuse and or recycling. Waste disposal in landfills or incinerators shall be minimized. On new construction projects this means careful recycling of job site waste, on demolition projects this also means careful removal for salvage.

1.2 RELATED SECTIONS

.1 Section 02050 - Demolition / Dismantling / Salvage

.2 Section 02200 - Earthwork

.3 Section 02870 - Site Furnishings

.4 Section 02900 - Landscaping

.5 Section 03100 - Concrete Formwork

.6 Section 03300 - Cast-In-Place Concrete

.7 Section 05100 & 05400 - Metal Framing

.8 Section 06100 - Rough Carpentry

.9 Section 06200 - Finish Carpentry Cabinets, Countertops

.10 Section 06300 - Wood Treatment

.11 Section 07200 - Building Insulation

.12 Section 08800 - Glazing / Windows

.13 Section 09250 - Gypsum Board

.14 Section 09300 - Tile Work

.15 Section 09550 - Wood Flooring

.16 Section 09650 - Resilient Flooring

.17 Section 09680 - Carpet

.18 Section 09900 - Painting

1.3 CODE OF PRACTICE

.1 In addition to other requirements specified herein it is a requirement for the Work of this project that the Contractor comply with the Los Angeles Solid Resources Consolidated Recycling Division recommendations outlined in publication entitled "Construction and Demolition Waste Recycling Guide" available from the SRCRD, Telephone: (213) 847-1444.

1.4 WASTE MANAGEMENT PLAN

.1 Waste Management Plan: The Contractor shall submit to the City of Santa Monica Solid Waste Division a Waste Management Plan pursuant to new SMMC #. Attached is a sample format together with sample waste generation rates to aid the Contractor in formulating the Plan. The Contractor may use this form or provide a custom form containing the same information. The Plan shall contain the following:

.1 Analysis of the proposed job site waste to be generated, including the types of recyclable and waste materials generated (by volume or weight). In the case of demolition, a list of each item proposed to be salvaged during the course of the project should also be prepared (refer to the Waste Recycling Guide and directory of service providers. This list is not necessarily complete. The Contractor may use any of these or other licensed service providers).

.2 Alternatives to Landfilling: Contractor shall designate responsibility for preparing a list of each material proposed to be salvaged, reused, or recycled during the course of the Project

.3 List of compulsory materials to be recycled, shall include, at minimum, the following designated materials:

.1 Old corrugated cardboard.

.2 Clean dimensional wood, palette wood.

.3 Concrete/Brick/Concrete Block/Asphalt.

.4 Scrap Metal.

.5 Drywall.

.6 Landclearing debris.

.7 Paint (return to hazardous waste depot).

.4 List of optional materials to be salvaged (demolition projects only)

.1 Dimensioned lumber and heavy timbers.

.2 Wood siding.

.3 Structural steel.

.4 Wood paneling, molding, trim and wainscoting.

.5 Heritage architectural elements such as mantle pieces, columns, etc.

.6 Cabinets and casework.

.7 Insulation, where suitable.

.8 Brick and block.

.9 Electric equipment and light fixtures.

.10 Plumbing fixtures and brass.

.11 Windows, doors and frames with historic value.

.12 Hardwood flooring.

.5 Meetings: Contractor shall conduct Project Waste Management meetings. Meetings shall include subcontractors affected by the Waste Management Plan. At a minimum, waste management goals and issues shall be discussed at the following meetings:

.1 Pre-bid meeting.

.2 Pre-construction meeting.

.3 Regular job-site meetings.

.6 Materials Handling Procedures: prevent contamination of materials to be recycled and salvaged, and handle materials consistent with requirements for acceptance by designated waste-disposal facilities. Where space permits, source separation is recommended. Where materials must be co-mingled they must be taken to a processing facility for separation off site.

.7 Transportation: The Contractor may engage a hauling subcontractor or self haul or make each subcontractor responsible for their own waste. In any case compliance with these requirements is mandatory.

.8 If requested, submit to the Consultant and/or Owner way-bills, invoices and other documentation confirming that all materials have been hauled to the required locations. Way bills may be requested by the building authority.

1.5 WASTE MANAGEMENT PLAN IMPLEMENTATION:

.1 Manager: The Contractor shall designate an on-site party (or parties) responsible for instructing workers and overseeing and recording results of the Waste Management Plan for the project.

.2 Distribution: The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foreman, each Subcontractor, the Owner, and the Consultant.

.3 Instruction: The Contractor shall provide on-site instruction of appropriate separation, handling, and recycling to be used by all parties at the appropriate stages of the Project. On demolition projects the Contractor shall provide on-site instructions for salvage and requirements for reusing salvaged materials within the project, either in new construction or in a renovation.

.4 Separation facilities: The Contractor shall lay out and label a specific area to facilitate separation of materials for recycling and salvage. Recycling and waste bin areas are to be kept neat and clean and clearly marked in order to avoid contamination of materials. The requirement for separation will only be waived if the Contractor can demonstrate to the Owner/Consultant that there is insufficient room to accommodate it. If this is the case the materials must be sent to a processing off-site facility for separation, salvage and recycling.

.5 Hazardous wastes: Hazardous wastes shall be separated, stored, and disposed of in accordance with the requirements of the authorities having jurisdiction, including Federal, State, County and City agencies.

.6 Application for Progress Payments: The Contractor shall submit with each Application for Progress Payment a summary of waste materials, recycled, salvaged and disposed of by the Project using the form appended to this specification or a form generated by the Contractor containing the same information. Failure to submit this information shall render the Application for Payment incomplete and shall delay Progress Payment. The Summary shall contain the following information:

The amount (in cubic yards or tons) of material landfilled from the Project, the identity of the landfill or inert fill site and/or transfer station. For each material recycled or salvaged from the Project, include the amount (in cubic yards or tons or in the case of salvaged items state quantities by number of items) and the destination (i.e. the material recovery facility, transfer station, landfill, or used building materials yard).

END OF SECTION 01505

CONSTRUCTION PROJECTS - TYPICAL WASTE GENERATION RATES

	Residential Multi-unit Construction		Institutional Low-rise Construction		Commercial Low-rise Construction		Residential Low-rise Construction	
Material	cu.yd./ 1,000 sq.ft.	tons/ 1,000 sq.ft.	cu.yd./ 1,000 sq.ft.	tons/ 1,000 sq.ft.	cu.yd./ 1,000 sq.ft.	tons/ 1,000 sq.ft.	cu.yd./ 1,000 sq.ft.	tonnes/ 1,000 sq.ft.
wood	3.3	0.40	7.0	0.86	5.6	0.68	6.0	0.73
drywall	3.6	0.92	0.9	0.22	0.2	0.05	1.1	0.27
metal	0.2	0.09	0.4	0.21	—	—	—	—
concrete/ asphalt	1.7	1.79	0.7	0.99	—	—	0.04	0.05
corrugated cardboard	—	—	—	—	7.1	0.14	2.4	0.05
other	5.6	1.54	0.2	0.54	1.0	0.27	0.5	0.14
Total	14.4	4.74	9.2	2.82	13.9	1.14	10.04	1.24

Explanatory note:
Waste generation rates vary depending on project type and size, subtrade efficiency, accurate material estimation, on-site materials storage procedures and product packaging.

Estimate the volumes or quantities of materials generated on the site by multiplying the floor area of your project with the generation rates listed for the different materials.

WASTE MANAGEMENT PLAN - CONSTRUCTION & DEMOLITION PROJECTS

Name of Company	Contact Person	Telephone No.

Project Site/Location	Project Type * Construction * Demolition	Project Size (in square feet)

	Pre-Project	Project Updates For period: to:	
Material	**Estimated Generation**	**Recycled/Salvage/Disposed**	**Facility**
Total			

Signature	Title	Date

Explanatory note:

Column 1 - "Material" — enter materials targeted for recycling and/or salvage and include a category for waste materials requiring disposal

Column 2 - "Estimated Generation" — enter estimated volumes (cu.yd.) or quantities (metric tonnes) of recyclable and waste materials generated and state number of salvageable items

Column 3 - "Recycled/Salvaged/Disposed" — enter volumes (cu.yd.) or quantities (metric tonnes) of materials recycled and disposed and state number of items salvaged

Column 4 - "Facility" – enter end-destination of recycled, salvaged and disposed materials.

PRACTICAL TIPS FOR DEMOLITION SALVAGE & RECYCLING

Demolishing buildings generates huge volumes of waste. The practice of tearing apart a building and putting all materials in a truck for disposal is usually cost prohibitive. Dismantling, salvaging and separating recyclable materials has become the cost-effective, competitive method for handling waste.

Tips

1. Modifying an existing building for new use preserves the greatest amount of building materials and provides the greatest overall savings.

2. Identify salvagers through this guide or find them listed in the Yellow Pages under "Demolition Contractors," "Salvage-Merchandise" or "Building Materials - Used."

3. Plan the project so that materials are moved systematically to prevent them from becoming mixed or destroyed by weather and requiring disposal.

4. Schedule sufficient time for salvage and recycling. The more time that is allowed, the greater the potential to divert waste and save money.

5. Re-use the components of the demolished structure in the new project. Start with common dimensional lumber such as 2x4s and 2x6s.

Following are a Portland remodeler's specific guidelines for salvaging and recycling:

Appliances - Store for reuse on project; donate or sell usable units; recycle unusable units with metal recycler.

Cabinets - Store reusable doors, drawers and trim for reuse on project; donate or sell usable units; recycle unusable cabinets with wood, hardware with metal.

Doors - Salvage reusable doors; recycle damaged doors with wood, hardware with metal.

Electrical - Scrap wire to electrician; recycle remainder with metal.

Framing - Reuse lumber when possible; recycle remainder with wood.

Heating - Recycle ducts and trimming with metal.

Insulation - Reuse clean scraps for chinking windows or filling around tubs; dispose of remainder.

Millwork - Remove casings and moldings for reuse; recycle unusable items with wood.

Paint - Reuse leftover paint as primer; dispose of unusable paint at hazardous waste facility.

Plumbing - Remove fixtures for reuse; donate or sell usable fixtures; recycle metal.

Siding - Reuse siding in good condition; recycle damaged wood siding.

Vinyl flooring - Flooring and/or adhesives may contain asbestos fibers. Before removal, call State Asbestos Hotline.

Windows - Salvage for reuse; remove and recycle glass; recycle wood and aluminum frames. Vinyl frames are not recyclable.

Wood flooring - Salvage for reuse; recycle damaged flooring with wood.

NON-RECYCLABLE CONSTRUCTION & DEMOLITION DEBRIS

Call the City Solid Waste Division for disposal information for materials marked with an asterisk (*).

- Any asbestos-containing materials such as older pipe insulation, asphalt floor tiles and old linoleum *
- Asphalt roofing and roofing felt
- Creosote treated timbers such as railroad ties and telephone poles
- Dry paint chips and completely dried out paint
- Empty barrels or empty paint buckets, cans, and caulking tubes *
- Fiberglass insulation
- Isocyanate and urea-formaldehyde foam insulation
- Plastic Laminate scrap and other composite/plastic interior finish material scrap
- Petroleum contaminated soils *
- Plaster from lath and plaster walls
- Pressure treated lumber*
- Vinyl siding and vinyl window frames
- Waxed corrugated cardboard
- Worn-out or dirty plastic drop-cloths and tarps

Suggested Materials Selection Practices for LifeCycle and Health

Most of the material production, installation, maintenance, durability and recycling issues are essentially about reducing resource use and waste, while the materials health issues are about protecting the health of trades persons and building users. In practice, the main criteria for green materials selection can therefore be simplified by placing them into two categories; resource efficiency and health. The information required and selection methods are different for each category, and conflicts will be encountered, but many choices are not compromises; there are many resource efficient choices that are also healthy ones.

Resource Efficient Materials

Since the purpose of choosing resource efficient materials is to reduce resource use and waste, it is important to prioritize materials on the basis of how much moves through the building over time. The high turnover materials in most commercial and residential buildings are floorcoverings, wallcoverings, furnishings, acoustic dividers and partition systems, roofing and cladding.

REPAIR & REPLACEMENT CYCLES FOR TYPICAL BUILDING MATERIALS

ITEM	REPAIR (Yrs.)	TOTAL REPLACEMENT (Yrs.)
Flat roof BUR membrane	10	20
Pitched roof, premium asphalt shingles	10	20
Pitched roof, cement composite shingles	20	50
Pitched roof, coated steel sheet	Usually not reqd	30 (as coating deteriorates)
Aluminum cladding, coated	Usually not reqd.	60 (as coating deteriorates)
Brick cladding	25 (repointing etc)	75 +
Conventional stucco (depends on detailing)	15	40
Acrylic stucco (depends on detailing)	20	?
Interior gypsum board	3 to 10	25
Interior concrete or block	10 to 20	75 +
Metal or vinyl windows	10 to 20	40 (tech. improvements dictate)
Clad wood windows	10 to 15	25 to 50
Solid wood interior doors	4 to 8	40
Metal doors (highly dependent on use)	5 to 15	25
Terrazzo (highly dependent on use)	10 to 15	60 +
Ceramic floors (highly dependent on use)	10 to 15	40 +
Resilient floors (dependent on type and use)	4 to 8	15
Vinyl composition tile	8 to 15	20
Hardwood floors (dependent on type and use)	5-10	40 +
Carpet (dependent on type and use)	3 to 8	5 to 15

MATERIALS OPTIONS, SELECTION CRITERIA

This section describes some resource efficient and healthy materials options for each of eight CSI divisions. The materials discussed are generic, i.e. they are product classes which may be made by several manufacturers. This is obviously not a comprehensive listing of all materials for a given use, nor is it an exhaustive list of materials that may have some special "green merit". It is merely a list of some examples of the type of resource efficient and healthy options which are available. Please refer to the resource guides and to manufacturers and dealers for specific information, and be aware that the variations between specific products may be very large.

DIV. 3 CONCRETE

Making portland cement, for concrete, requires much gas and oil energy, and produces a great deal of carbon dioxide, a greenhouse gas. Because concrete is such a high mass material, and such large quantities are used in buildings, it is very important to consider resource conservation choices.

Resource efficient options

Fly ash concrete is available in many regions as an alternative to conventional mixes. Fly ash is a waste material from coal burning power plants. It can be used to replace up to about 30% of the portland cement in conventional mixes. It is also mixed with ground blast furnace slag (GGBF), a waste from metal smelting. Fly ash produces a superior concrete with excellent finishing characteristics, however only some types of ash are appropriate for certain applications, and the proportions are restricted. Seek technical advice and refer to ASTM Standards.

Recycled aggregates and lightweight aggregates are available for some concrete applications. Recycled aggregate may contain crushed concrete and other masonry waste, or it may contain crushed glass. Lightweight concrete is made with expanded volcanic materials such as pumice and perlite in place of part of the usual stone aggregate. These materials place less load on structures (particularly when used on wood or lightweight steel floors), and provide some thermal insulation value.

Anti corrosion agents such as epoxy coating extend the life of steel reinforcement, especially for applications near salt environments. These have been found to extend the life of slabs substantially, avoiding repair and replacement costs.

Using low waste formwork is a final step in resource conservation. Systems such as modular steel forms, slipforms, preformed blocks and others can substantially reduce waste material from concrete forming.

Low pollution options

Indoor air pollution emissions from concrete in use are very low, and concrete is often confined to foundations and concealed structure where exposure to building air is minimal. The two exceptions are some concrete additives and some form release agents. Concrete additives such as water reducers or superplasticizers should be specified with caution because these may produce some odors and a risk of skin and bronchial irritation when fresh. Form release agents are sometimes made from diesel oil, or other odorous petroleum oils that will produce emissions in use. Wax or mineral or vegetable oil based products are available substitutes. This is most important for interior uses of concrete.

DIV. 4 MASONRY

Masonry and tile products are made from concrete, clay and various types of lightweight aggregates. Most masonry products are installed with mortar made from portland cement, sand and lime.

Resource efficient options

Lightweight concrete blocks and bricks are available, made with expanded agggregates such as pumice to reduce weight and add insulating value. Some brick and block products are available with waste and recycled contents, such as sewage sludge and ash from incinerators and coal burning plants. Hollow blocks are available with waste wood fiber and other recycled content. Native stone or lightweight cultured

stone made from cement and recycled aggregates are appropriate for some uses.

Glass block is available with recycled glass content.

Low pollution options

Air pollution is a minimal problem with masonry products. If sealers are needed to repel water, a low-volatile content, water-dispersed product is safer than a solvent based variety.

DIV. 5 METALS

Steel is highly recyclable and scrap is valuable. Aluminum is arguably the most recyclable material used in buildings. Stainless steel and brass products are alloyed metals and are recyclable if carefully separated by type. Copper is a highly valued recyclable.

Metal plating is also common in building products, especially in architectural metals, door hardware and office systems and furniture. Chromium, cadmium, brass and nickel plating is often done by small electroplating plants which may have a poor record of pollution control. Emissions such as hexavalent chromium and cadmium and acid wastes are very environmentally toxic. Alternatives such as plastic polymer coatings, especially "powder coatings" have important advantages. See Div 15, Furniture below. Galvanized metals are zinc coated, usually by large steel mills, a process which is energy intensive, but relatively low in toxic emissions.

Resource efficient options

·Steel is available from US sources with verified recycled content of 30% or greater. Some steel products such as galvanized studs, cladding and roofing panels and tube assemblies may verifiably come from electric "mini-mill" processes where recycled content claims of 40% or more are justifiable. Some specialty steel products, such as nails, are produced by manufacturers who have made an extraordinary effort to ensure recycled content, and to reclaim waste from their zinc plating process.

Aluminum from American sources typically has a verifiable recycled content between 20 and 30%, usually from consumer product containers.

Salvaged steel and aluminum beam and bar sections are also widely available from scrap dealers. These may be appropriate for both structural and non-structural uses if verified by a structural engineer. Architectural metalwork such as antique iron and brass, lighting fixtures and door hardware are also readily available from building salvagers.

Low pollution options

Air pollution is a minimal problem with metal products. The only exception is those that may require polishing, cleaning or repainting in place. See the Finishes Section below.

DIV. 6 WOOD & PLASTIC WOODS

Wood & plastic woods used in construction and interior finishing are primarily domestic species. Woods used in furniture, doors and specialty millwork are often imported tropical varieties. Appropriate forest management and wood salvage are keys to more sustainable wood sources in most cases. It is also possible to find processed woods and wood substitutes that have the interest and properties of fine woods without depleting threatened species. Many are available with certification by independent authorities. These are covered further in the Furnishings Section below.

Nearly all plastics are made from non-renewable petroleum feedstocks. The only exceptions are a few plastic products made from vegetable oils and plant starch which are relatively benign processes. Plastic production from petroleum may involve very hazardous substances such as vinyl chloride (VCM) used to make PVC. Plastics are sometimes used in building systems as claddings and panels, but the

majority of plastics are used as interior finishes. These uses are discussed below in Div. 9, Finishes.

Resource efficient options

Wood resource efficiency is one important factor in wood selection. Engineered wood products and value-added products, such as 'I" joists, oriented strand board, laminated veneer lumber, finger jointed lumber, open web wood joists and trusses, stressed skin wood panel and wood / steel joists, make better use of low grade fiber, small diameter trees and fast growing, less-utilized tree species. Certified, sustainablly-harvested forest products from domestic wood producers is now available for some products. Databases and websites are available listing these producers. Certification of tropical wood products is even more advanced. See the Finishes Section for more information.

Salvaged timber and wood products are available from operators who disassemble old buildings and bridges and then clean, grade and often resaw the timber. These can be used for structural purposes (after grading by a qualified person) or for interior finishing.

Structural sheathing is also available made from pressed post-consumer newsprint. This material not only uses a recycled product, but it adds substantial insulating value and acoustic absorbtion to the wall or roof. In some circumstances, non-structural insulating sheathing, such as wood fiber or glass fiber boards, can also be used with steel strap and bracket shear braces. These eliminate most of the structural sheathing requirements for walls altogether.

Low pollution options

Indoor air pollution emissions from some engineered wood products are substantial due to the glues used in the manufacturing process. Those made with exterior type glues (phenolic resins) and polyurea or isocyanurate adhesives (MDI based) have the least emissions.

DIV. 7 THERMAL INSULATION & MOISTURE PROTECTION

Depending on climate, building form and orientation, occupancy and use, thermal insulation can be an important factor in the energy performance of buildings. Generally, in practice, the insulation value required by Title 24 State Energy Code is used. However higher insulation values through designing larger cavities, or by using higher performance materials may occasionally be cost effective. Because this is dependent on so many factors, it is best to use computer energy simulation to decide where to insulate and how much, if the project or renovation is large enough to justify it. Once the desired insulation value has been determined, it remains to choose a resource efficient and healthy material.

Resource efficient options

Mineral fiber insulation (rockwool) is made primarily from mineral waste and mill slag. It is available in loose fill form, batts and rigid boards, and can be used for most applications, including outdoor and below ground locations.

Glass fiber insulation is now available with 40% or more, post consumer recycled glass content from cullett (waste glass from recycling). It is available in loosefill, batt and rigid boards.

Cellulose thermal insulations and acoustic sprayed coatings contain at least 70% post consumer paper waste. These are available only in loose fill form. Walls can be insulated using the "blown in batt" system installed with a high-pressure blower and a containment screen. If installed to density specifications, it will not settle after application. Horizontal spaces are filled with a low-pressure blower. Some systems use a small amount of moisture to encourage stabilization. Sprayed cellulose systems are designed for acoustic and fire retardancy (often for metal structures) and may contain mineral fiber.

Foamed polystyrene insulation is available with post consumer recycled contents from recycled fast food containers and hot drink cups. Expanded types are made with a steam process and a non-CFC gas. Extruded types are higher performance and are now made with HCFCs, which have far less ozone depleting potential than the CFCs used previously. New extruded products containing no HCFC's are now becoming available.

Urethane foams are high performance insulations available as rigid boards or sprayed-in-place systems. These also were once made with CFCs and are now made with HCFCs. One manufacturer has developed a sprayed-in-place system expanded with harmless CO2 (Icynene).

Vermiculite and perlite are naturally occuring minerals that can be used in insulating plaster mixes, and in loose fill applications such as filling cores of masonry walls.

A "spray-in-place" foamed silicate insulation, made from sodium silicate and magnesium oxychloride, is available for use where fire retardency and material safety are critical. This is used for cavity fill applications and some surface uses, but it is very moist when applied and can take several days to dry.

Reflective film radiant insulations can be used effectively to reduce the "radiant component" of energy transfer, such as excess heat gain from the sun. They can be particularly useful for reducing cooling loads in commercial buildings in sunny climates. These are made from aluminum foil and metallized plastics and are usually installed in a roof cavity with an adjacent air space.

Low pollution options

All common thermal insulations have some potential health risk and will require care in handling. They must be applied in such a way that they can be completely contained or isolated and cannot enter the building or air handling system. Thorough clean up after handling is also critical. Mineral fibers and glass fibers are now recognized as possible carcinogens and must be handled with respirators and protective clothing. Cellulose fiber is relatively safe, but it contains contains borates and sulfates as fire retardants and stabilizers which are highly irritating, so that installers and building occupants must also be protected. This is even more important for sprayable cellulose insulations that contain mineral fiber. Vermiculite and perlite dust are also hazardous to inhale and must be handled with caution. These natural mineral products must be certified asbestos-free.

All plastic insulations release some gases such as styrene, and are flammable, producing toxic gases when burning. Codes require a non-combustible covering over them, and may not allow them at all in some uses. These are primarily useful for exterior applications. Cutting with a hot wire releases toxic gases and should be avoided on building sites.

Cladding & Roofing

Cladding and roofing are very important for building longevity. The materials should be appropriate for the climate and application, and the best quality material allowable within the budget should be chosen. After durability, the second most important factor is recyclability.

Resource efficient options

Metal panels such as galvanized steel and enamelled or anodized aluminum are appropriate for pitched roofs and cladding. They have the merit of using very little material, and they are durable and recyclable

Composite shingles, tiles, and panels made from a variety of fiber reinforced cement products (some coated with plastics, enamels or thin metals) are also available for pitched roofs and cladding. These have the merit of durability, and some contain recycled content. Though they are not recyclable, these are a good choice for durability and resource efficiency.

Stucco is a resource efficient and durable finish where it is protected from moisture damage by good detailing. Acrylic modified stucco is less massive and can be installed on exterior insulation board, adding to thermal performance.

Where shingles are chosen for roofing, higher quality asphalt shingles and fiberglass matrix shingles are a moderately durable option. Some may be available with recycled content.

For flat roofs, torch-on, or cold process built-up roofing has some important advantages. It is fairly durable and repairable, and

though recycling systems are not in place, it is relatively easy to remove. An inverted roof design using a ballasted insulation layer over the membrane has advantages because the membrane is better protected from weather and damage. Flat and shallow pitched roofs can also be prepared with drainage mats and topsoil to grow grass if the structure allows. This "green roof" helps to control rainwater runoff and adds insulation value to the building. It also provides habitat for birds, butterflies etc.

Low pollution options

Roofing, due to its location, is usually not an important contributor to indoor air pollution. However hot mopped asphalt roofing releases extremely high levels of air pollutants during installation and may be restricted in some urban areas due to smog contributions. It is also a health risk to installers.

Sealants

Sealants are used in small quantities and are therefore not very important resource efficiency concerns. However they are important health concerns, because many are solvent based and toxic.

Resource efficient options

The sealant with the best service life will always be the best choice, regardless of material type, considering the high labour cost of replacement and the potential for costly building damage.

Low pollution options

Generally sealants used outside the building are not much of an indoor air pollution concern. Those used indoors in any quantity, such as caulking for door and window installation, should be carefully selected using health evaluations from material safety data sheets. Acrylics, silicones, and siliconized acrylics are typically the safest to handle and have the lowest solvent content. Quantities of solvent based products, such as common "acoustic caulking", butyls and urethanes, should be avoided indoors.

DIV. 9 FINISHES

Interior finishes are the most important materials category for reducing indoor air pollution load. They are often the most important products from a resource conservation perspective also, because they are the ones that experience the most wear, and are replaced regularly during renovations. Because office interiors are altered so often, there is not always a good argument for the most durable finishes. In some cases it is better to emphasize low toxicity, recycled content and reuseability/recyclability.

Gypsum

Gypsum products are the most common interior panels used due to their fire retardancy and low cost. However limitations on dumping gypsum in landfills may apply in some areas. Gypsum recyclers, where available, will receive clean gypsum waste from construction and possibly demolition.

Resource efficient options

Some gypsum board manufacturers can verify at least 10 to 15% recycled content. Gypsum is highly recyclable if not contaminated with paint, adhesives etc., and the paper facing can be made with recycled paper. One recent innovation in gypsum products is the fibergypsum process. This board, now available in the US, has no paper facing but contains recycled wood and paper fiber, and perlite inside the board. It is very strong and scratch-resistant, and should be considered for high wear areas such as commercial and institutional buildings.

Low pollution options

Gypsum products themselves are minor sources of indoor air pollutants, though the paper facing and any adhesives can be sources. Gypsum surfaces are also potent "sinks", i.e. they absorb odors and then release them. In the construction phase it is the installation adhesives, sealers, paints and caulkings that are the main concerns. See these sections below.

Wood & plastic

Wood and plastic, engineered and composite panels are important components of interiors. They can offer resource efficient design, and they can have recycled content. However the adhesives and sealers used in manufacture and installation are indoor air pollution sources.

Resource efficient options

Hardboards are durable and resource efficient. These are made with wood fiber pressed and heated to form panels. No adhesive is usually needed because the natural lignin in wood binds the fibers. They are reuseable if installed so that they can be easily removed. One US company now has a process for fiberizing wood demolition waste so that it can be used in hardboard products.

Particleboard and MDF (medium density fiberboard) panels are pressed from sawdust and small chips and fibers bound with glue. They can use low-grade woods and sawmill waste in their manufacture. These are resource efficient products, but must be chosen carefully for low pollution potential. See the health discussion below.

Low-density fiberboards made from paper and wood fiber are also resource efficient. Most processes use no glue. They are used as acoustic panels, underlayment, tackboards etc. They are available made from 100% recycled newsprint. They are not now being recycled.

Veneered wood panels, such as oriented strand board with hardwood facing, are resource effcient choices for interior finishing work. These are used for cabinets and millwork and can offer woodgrain surfaces while conserving wood. If installed for easy removal, these have good reuse potential.

Recycled plastic panels made from consumer product waste are available for interior uses such as toilet partitions and functional work tops. These have a good reuse potential.

Some vegetable oil based plastics are available in both flexible and rigid types. They can be colored and filled with minerals, metal shavings, or other plastic waste and wood fiber giving them a large range of texture and color possibilities. If installed for easy removal, these also have good reuse potential.

Fiber reinforced cement boards made with recycled fiber are a resource efficient choice. They are very durable products and can be used as substrates for tile and decorative finishes. In some installations they can have good reuse potential if designed for easy removal.

Low pollution options

Engineered wood products made with exterior glue (phenol formaldehyde) have very little formaldehyde emissions. Products which have been stabilized by ammonia treatment or other methods are also low emission. One manufacturer offers "formaldehyde free" products made with isocyanurate adhesive which are the lowest in air pollution emissions of all glue-bonded boards. The HUD low formaldehyde emissions standard label should be on these products. Those products which meet the more rigorous European E1 standard are even lower in emissions. The cement based and vegetable oil plastic composites are generally very low in pollution potential.

High pressure laminates are surface materials made by laminating paper and colorants together with melamine (phenolic) resin. They are a relatively resource efficient use of plastics because a very small quantity of materials suffices to produce a durable surface.

Resource efficient options

There are no manufacturers known at this time with substantial recycled content in their products. There are some who have made impor-

tant process improvements, such as waste-to-energy and heat recovery systems which exceed industry norms. Their products may have a small resource efficiency advantage over others.

Low pollution options

These products are low emission due to the high temperature curing process and the inherent chemical stability of the materials. However the dust from cutting and the emissions from glues used for installation can be quite important. This work should ideally be done in a shop off the premises, and the adhesives chosen for safe handling characteristics. See the Adhesives section below.

Ceramics & terrazzo

Ceramics and terrazzo are among the most durable and low emission interior finishes. Glazed or sealed products do not adsorb odors and pollutants, are easily cleaned and resist abrasion and wear. Though they are costly to buy and install, their life cycle cost is among the lowest of all finishes for some applications, due to their long life and minimal maintenance. The only important air pollution factors are the setting method, the grout and any sealers required to protect unglazed surfaces.

Resource efficient options

Using local or regionally manufactured ceramics reduces the high transportation cost.

Some tile is available with recycled content (up to 70%), such as scrap glass and feldspar waste from mining. These have important resource efficiency merit. Some manufacturers also have added heat recovery, water recovery and clay mine restoration measures to their operation which exceed industry norms.

Tile packaging is also an important item. Look for manufacturers that use simple systems with recycled contents, such as cardboard.

Terrazzo made with cement and crushed stone is also resource efficient.

Low pollution options

Cement mortars, usually modified with acrylic additives, are the safest to handle for tile setting. These also have the best performance for most applications. All plastic adhesives contain some solvents and will contribute to indoor air pollution. Where adhesives and caulkings must be used, such as for cove bases and flexible joints, a low solvent content product such as an acrylic can be chosen. Cement based, cellulose based and acrylic modified grouts are very safe and low emission. Glazed tile and high-fired tile usually do not require sealers. If a porous tile is chosen, the safest sealers are the low-volatile, acrylic or water-dispersed silicone types. Sealers containing hazardous solvents will contribute to indoor air pollution.

Wood flooring

Wood flooring can be used in offices, reception areas, stairs and meeting rooms. There are many resource efficient types of wood flooring, including salvaged, laminated and veneered products. The most important air quality issues are the installation method and the finish.

Resource efficient options

Salvaged solid wood flooring is widely available. These are high quality materials available for a very modest cost, however the installation is more expensive than for new material due to the extra labor for fitting and refinishing. It also requires sanding and refinishing on site.

Among new wood flooring materials there is now a wide range of veneered and laminated products which have a plywood or MDF core with a hardwood surface. These are usually prefinished at the factory with a very durable, low-maintenance finish. These are a resource efficient choice, but are less repairable than solid wood.

Domestic hardwoods such as oak, maple, birch and ash, and imported species such as Australian eucalyptus and Scandinavian beech are some varieties which are most likely to be from sustainable sources. Tropical hardwoods should be carefully researched using the wood publications and databases listed in the Resources Section of the Materials Chapter.

A steel track system using wedges to hold the flooring in place, or a "floating system", using edge gluing where necessary makes wood floors easy to remove. A nail down system is also salvageable, but with some loss of material. A glue down system is probably the least salvageable, but it is required for parquets.

Low pollution options

The factory prefinished products have substantial air quality benefits because no sanding and finishing is done on site. If sanding is done on the premises, the area must be carefully isolated, including sealing off the doors and HVAC system, and using temporary fans. Final cleanup with a high performance HEPA filter vacuum is recommended. For finishing on site, the water dispersed urethanes (actually urethane/acrylic blends), with low-volatile content have the least emissions of common finishes. Those with "crosslinker" additives are the most durable. Hardening oils, solvent varnishes and acid cured varnishes have prolonged emissions of pollutants. If edge gluing is required, white carpenters or woodworkers glue is a low toxicity product. If glue-down methods are required, such as for parquet, a low-volatile flooring adhesive can be used.

Resilient flooring

Resilient floorings, such as vinyl, rubber, linoleum and cork have merit for their easy maintenance, and some types are very durable. Some materials have renewable contents, and others have recycled content. In terms of air quality, there are important distinctions between material types, installation methods and maintenance products.

Resource efficient options

True linoleum is made with renewable materials (linseed oil, cork, wood dust and jute), as are cork products. Linoleum is extremely durable.

Recycled rubber tile and sheet goods are also available made with waste tires. These are good, resource efficient choices for heavy traffic and utility areas.

Vinyls are also easily maintained and durable. Some may soon be available with recycled plastic contents.

Low pollution options

All resilient flooring products produce some air pollutant emissions; so do their setting and maintenance products. Some manufacturers can provide comparative emissions data that will aid in selection. In some applications, interlocked rubber tiles and heavy linoleum can be laid without adhesive. If adhesive is required, see the Adhesives section below. Linoleum has a mild antiseptic effect that reduces sour odors from urine and food spills, making it a good choice for kitchens, cafeterias and washrooms.

Maintenance products are also significant pollution sources. Flooring with sealed "low maintenance" surfaces should be preferred, both for reducing maintenance costs and the use of cleaners and waxes.

Carpet & underpad

Carpet and underpad are among the most important interior products to consider for resource efficiency and pollution potential. They are high maintenance and high turnover materials with known air pollutant emissions. Fortunately several products are now available with recycled content, and with inherent lower pollution potential and lower maintenance requirements.

Resource efficient options

Polyester and nylon blended carpet is available with recycled content from PET soft drink containers. These have similar properties to other polyesters.

Wool carpet is also available in commercial, high density, low pile lines. The wool face fiber is a renewable material with inherent fire resistance and good durability for light commercial uses.

Releasable carpet tile and roll carpet systems can be moved from low wear areas to high to extend the life of the floor. They are also easily removed and replaced during renovation. The lowest maintenance carpets are typically the low pile, dense loop and needlepunch types which trap the least soil and show wear the least.

Carpet recycling is an industry priority today due to the large quantity sent to landfills, where it will not easily decompose. The major obstacles are recyclability of the face fiber itself, the added colorants, and separation of the different materials in the product. Carpets made from fewer materials will require less separation for recycling. Fully recyclable carpets are just now becoming available.

Carpet pad is made from sponge plastics and rubber, as well as woven and non-woven textile fibers. Rubber pad made from recycled tire rubber is a resource efficient choice. It is a dense and durable product with a very long life expectancy. Fibrous pad is also available in commercial grades made from recycled synthetic and natural fiber from textile mill waste.

Low pollution options

The way carpet is constructed is one important factor in the air pollutant emissions from the product. The vast majority of carpet is made by pressing the face fiber into a polypropylene mat, and then gluing it in place with a synthetic latex resin. The synthetic latex is a source of air pollution, including 4 PC (4 Phenylcyclohexene), an irritant which is implicated in several cases of sick building syndrome. One method of low emission carpet construction is to eliminate the latex bond through "fusion bonding". This type of carpet has a sponge plastic backing into which the face fiber has been heat welded. It is a good choice for low indoor pollution potential. Needle punched carpets which are very low pile and mass are also made without latex. Among all other latex bonded carpets, including wool products, there is wide variability in emissions. A few manufacturers have made a great effort to provide a low emission product, and some of these can provide full test results, listing VOC emissions at different time periods.

Airing out new carpet has often been recommended as a pollution reduction measure, but the evidence is not strong for the effectiveness of this method. Though this will help for some of the short term volatile contents, and will reduce odors picked up (adsorbed) in manufacturing and storage, other carpet contents are semi-volatile and will produce emissions for many months.

Finished concrete flooring

Finished concrete flooring is an integral system of slab and finish, produced by adding colorants and sealers to the topping concrete either before or after it cures. The concrete is often stamped with tile patterns and grid lines that also control cracking. It is a durable and low maintenance finish.

Resource efficient options

Finished concrete may be appropriate for areas that would otherwise be tile or terrazzo. Systems with integral color added to the entire topping layer are more resistant to damage, and less likely to require re-coloring, than systems which are dyed after placing the concrete. Proper sealing and waxing will ensure a long service life.

Low pollution options

Finished concrete is inherently low emission. The choice of sealers is the main concern. Water- dispersed, acrylic sealers and waxes meeting low volatiles standards are the safest.

Painting

Painting is only a moderate resource use item since so little material is actually used. It is, however, an important indoor air pollution and toxic waste consideration. Fortunately volatile emissions from liquid coatings such as paint tend to be short term, i.e. they decline to a very small fraction of the wet emission rate within a few days or weeks. The most toxic emissions from paints and coatings are usually evaporating solvents and a wide variety of volatiles released by oxidation. These volatiles are produced not only by solvent-based paints, but also water-based formulations. In fact water based paints may contain up to 12% solvents, though some new formulations contain very little. Today it is not necessary to use paint containing hazardous solvents for most interior applications. Water borne acrylics are clearly preferable to alkyds (solvent based oil paints) for handling safety, and they are highly durable and produce no solvent waste.

Resource efficient options

Several companies in the US are now providing recycled paints made by mixing remainders and returned products together by color. These are generally good-quality acrylic latex paints, suitable for moderate duty interior use; however, the color range is quite limited.

For exterior use, or some industrial applications, it may be necessary to use solvent-based paints. Where solvent paint is required, the painters should be required to recycle solvent. Building managers should eventually dispose of remainder paints that have been saved for touchup and renovations. These paints can be sent for recycling, either through municipal programs or through paint suppliers.

Low pollution options

The first priority with paint selection is to avoid products that contain lead, mercury, hexavalent chromium and cadmium. Though regulations have nearly eliminated many toxic components from consumer paint lines, industrial and commercial paints may still contain them. Check the MSDS's first, because all of these toxic contents must be disclosed. The next priority is to select those paints with the least volatile emissions. These are exclusively water dispersed acrylic and latex products. Those that meet California and New Jersey "zero VOC" standards have the least emissions. Those which meet listing programs such as Green Cross, the Canadian Environmental Choice Program or the German Blue Angel Program may also be low emission, though the standards may not be as rigorous as the "zero VOC" standard.

Adhesives for construction and flooring uses are also hazardous waste and indoor air pollution concerns, similar to paints above. Similar low pollution selection can be done. There are a few US companies providing lines of low VOC adhesives, sold as environmentally safe, "zero VOC's" or "low toxicity".

Ceiling tile

Ceiling tile is the most common ceiling finish in commercial and public buildings. Due to its large area, its potential for disturbance during renovation, and its contact with HVAC systems, it is an important product to consider for air quality and resource efficiency.

Resource efficient options

Tile is made from wood fiber, including recycled material, and often mineral fiber with added clay or gypsum fillers for fire retardancy. It is then painted. Some manufacturers list tile with recycled content, though none with post-consumer contents are known at this time. Tile is reuseable and paintable, and should last many years if not handled excessively.

Low pollution options

All tile collects dust and adsorbs odors. Tile with mineral fiber contents may also begin to shed hazardous fiber if disturbed, or as it deteriorates. Both problems are a particular concern where the ceiling is used for a return plenum to carry air back to HVAC air handlers. If this type of return system is used, the tile should be checked for damage and the plenum space occasionally cleaned with a high performance vacuum. If possible, in new and renovation design, HVAC returns should be ducted instead of risking contamination by debris in suspended ceilings.

WARNING: OLDER BUILDINGS BUILT OR LAST RENOVATED PRIOR TO 1976 MAY CONTAIN ASBESTOS INSULATIONS AND LEAD PAINT PRODUCTS. THESE ARE SERIOUS HAZARDS TO OCCUPANTS AND TRADESPERSONS DURING RENOVATION OR DEMOLITION. THESE MATERIALS ARE ALSO HAZARDOUS AS THEY DETERIORATE. A professional specialist should be engaged to identify and manage these hazards where they occur. Your regional EPA office or State Department of Health Services can provide advice and listings of qualified consultants.

DIV. 10 SPECIALTIES

There are several panel systems for office partitions and non-structural interior uses which allow changes to floor plans without major demolition and waste. Though these cost more than lightweight steel framing and gypsum panels built on-site, they are reusable and allow rapid changes to be made with minimal disruption. They also have many recyclable components when they are no longer useful. Usually referred to as "demountable systems", these have steel or aluminum track at the top and bottom, holding gypsum panels which lock into place. Door modules, glass, different surface finishes and several other options are available. The manufacturers claim typically less than 10% materials waste when relocating them. Used systems can be purchased, and matching components traded between departments or buildings, or stored for future use. These have important resource efficiency merits.

DIV. 12 FURNISHINGS

Though not a part of buildings, furnishings are an important resource efficiency and indoor air quality consideration for organizations. They represent a major cost and maintenance component for interiors, and are key to workplace satisfaction and comfort.

Resource efficient options

The most resource efficient option for furniture is to repair any good quality items currently owned by the organization. Good quality used office furniture can also be purchased from office furniture suppliers which exist in every city. A few large office furniture manufacturers and several resale operators also now offer reconditioned furniture as a purchase or lease option. These are usually classic, durable lines that have been bought back or returned from leases, and have been re-covered, re-finished and serviced.

Steel glass and solid wood furniture has significant resource efficiency and recyclability merits. It also has minimal indoor pollution potential.

Metal coating systems and wood finishes are important environmental issues with furniture. "Powder coated" metal finishes are an environmentally friendly substitute for painting and plating, using dry powder polymers applied to the metal and then fused with heat. Powder coated finishes are harder than many paints, and can actually rival plating for durability. For woods, factory applied and cured coatings such as urethanes have minimal emissions, and the manufacturing plants minimize dust release and recycles solvent.

Tropical hardwoods are common in office furniture, both as solid components and veneers. It is well known that rare and prized woods such as rosewood, teak and ebony are now in short supply, and substantial forest destruction takes place to extract them. Tropical hardwoods can be researched using the wood guides listed in the Resources Section of the Materials Chapter. Some conscientious office furniture manufacturers are already using these guides, and are offering substitute woods that enhance forest based economies of producer nations.

Another wood option is manufactured or synthetic hardwood. These are typically northern hardwoods dyed and machined to create beautiful and unique wood finishes. Several are listed in the databases and publications in the Further Resources section of the Materials chapter.

Upholstery foams used in chairs are generally high-density urethane products. These were once manufactured with ozone depleting CFC's, but are now made with safer HCFC's. Chairs should carry labels certifying that the foams are non-CFC. HCFC's are also due to be

phased out from upholstery foam before year 2000.

Low pollution options

The main air pollution potential from furniture is due to glue-bonded wood products, soft plastics, fabric treatments and finishes. Some office furniture manufacturers have done emission testing on their systems and can provide the data. Fabric coverings, foam fillings and fabric-covered acoustic panels are also dust collectors and adsorb odors. Where these are in use they can be cleaned regularly to minimize the problem.

CHECKLISTS

Resource Efficiency Checklist

Does it contain a low-grade waste, upgraded to a valuable product?

Is the material from a verifiably well-managed renewable source?

Is the packaging appropriate, and returnable or recyclable?

Is it regionally appropriate, and from regional sources?

Is it manufactured with a verifiable low-energy and low-pollution process?

Is installation simple, and minimize waste and release of toxic pollutants?

Is it likely to be more durable in the application than other competing products?

Is little maintenance required in its use? Do maintenance products and procedures minimize waste and indoor pollution?

Is it salvageable or recoverable for reuse or recycling after its service life?

Is the resource value conserved by recycling?

Lifecycle cost analysis

What is the annual cost?

What is the potential avoided future cost (i.e. major maintenance and replacement)?

What is the potential future environmental cost (i.e. removal and disposal)?

Where will a replacement come from?

Low Pollution Potential Checklist

Will the construction area be isolated or unoccupied?

Have existing renovation hazards, such as asbestos, other mineral fibers, or lead paint been identified and safely dealt with?

Have the floor coverings, wall coverings, furnishings and other interior products been selected for low VOC emissions in installation and use?

Have interior engineered wood products been chosen for low formaldehyde emissions?

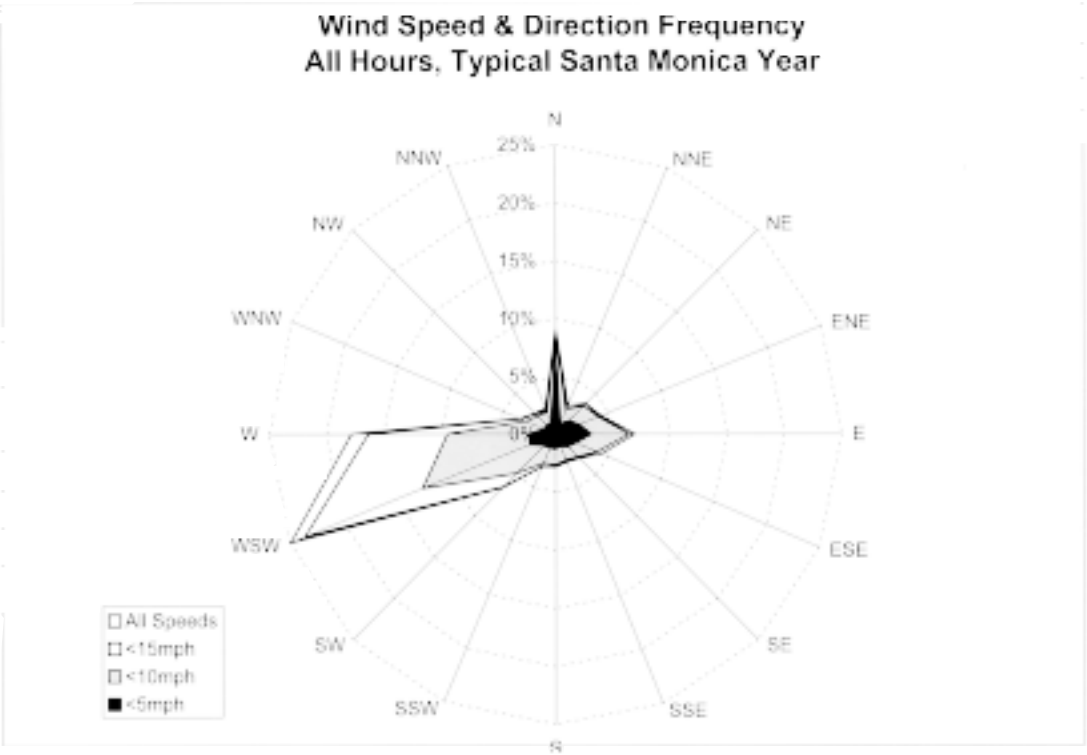
Have paints been chosen which meet “low VOC” or “zero VOC” standards?

Have interior adhesives and caulkings been minimized and selected for low VOC emissions?

Have the ceilings, insulations and acoustic panels been designed for low mineral fiber risk?

Has cleaning of the building area and HVAC equipment been done after construction?

APPENDIX B
SANTA MONICA WEATHER



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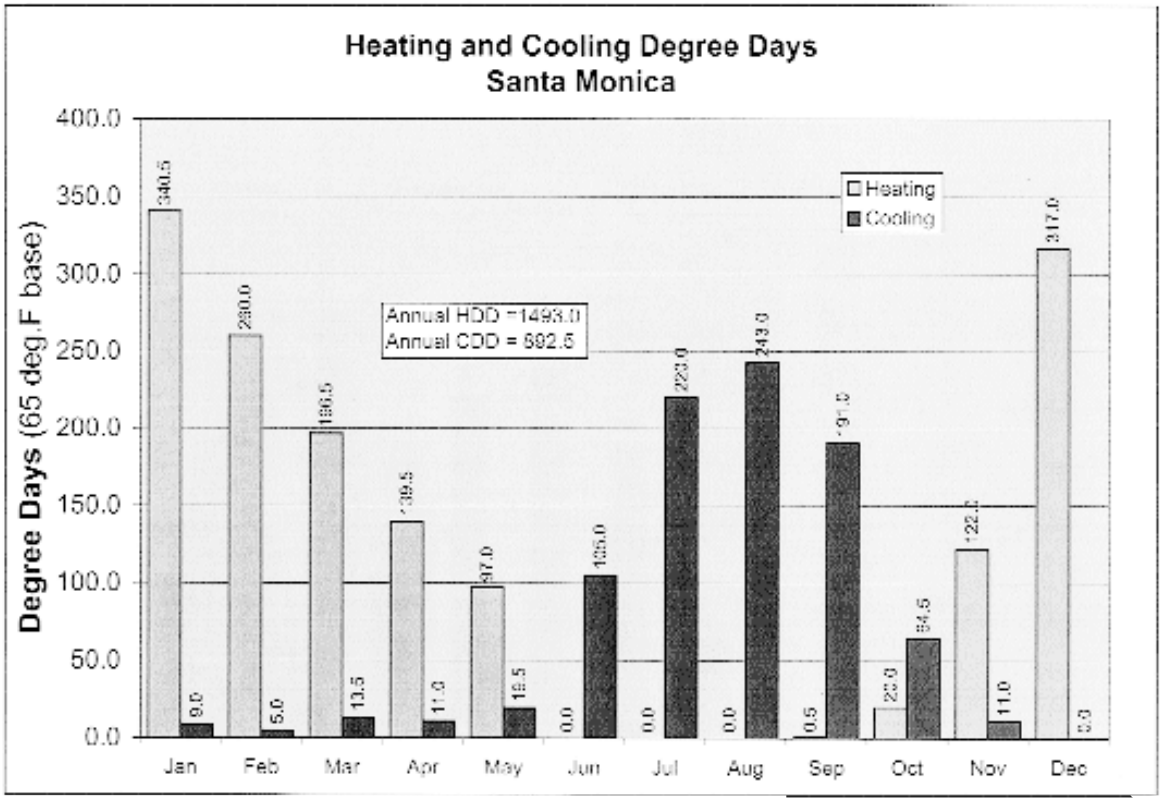
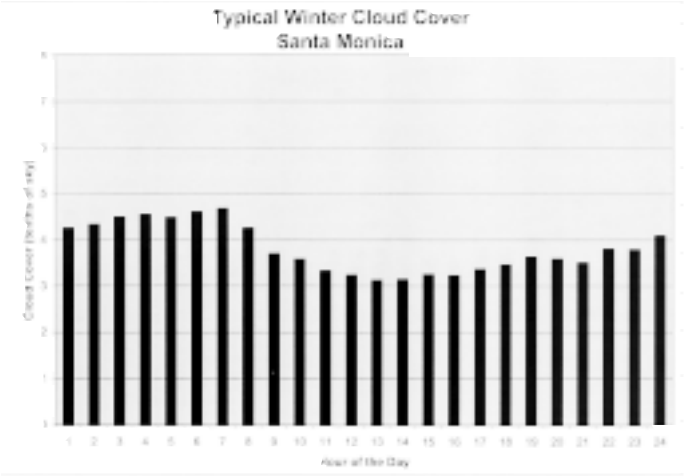
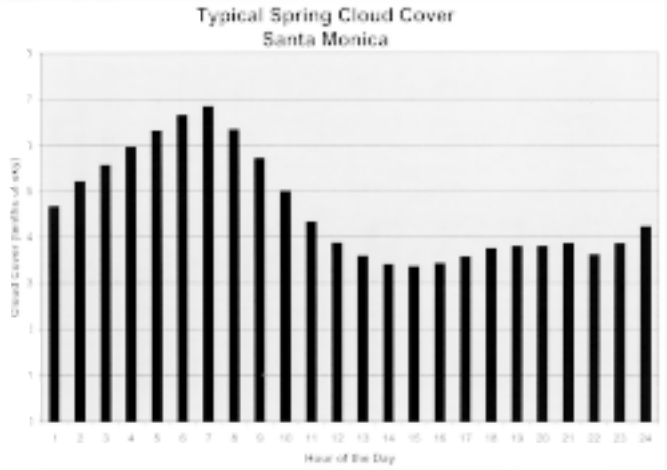


AVERAGE CLOUD COVER





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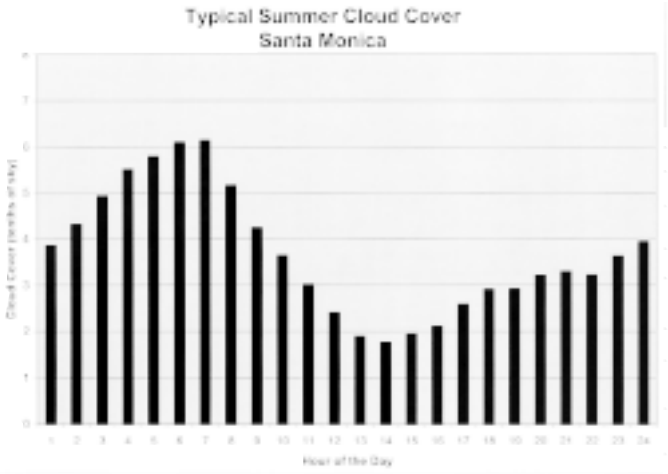
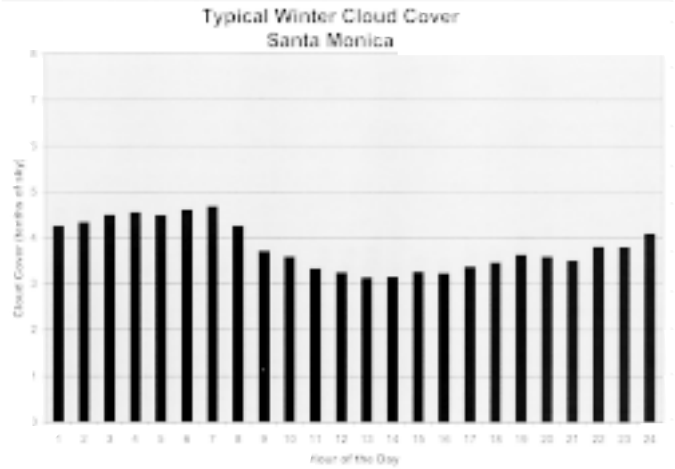
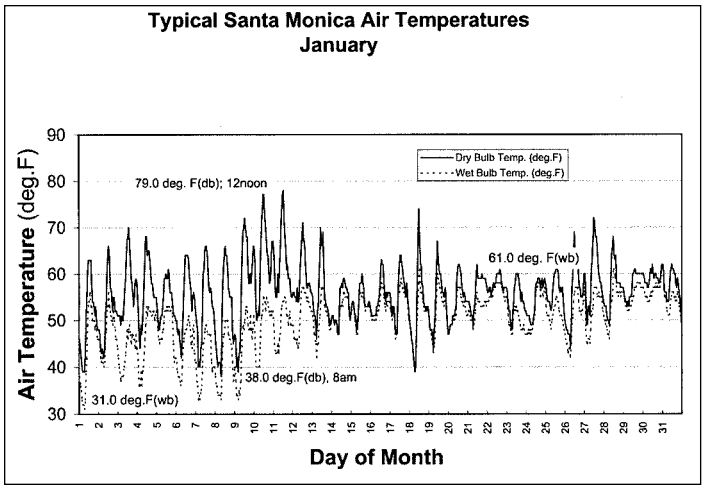
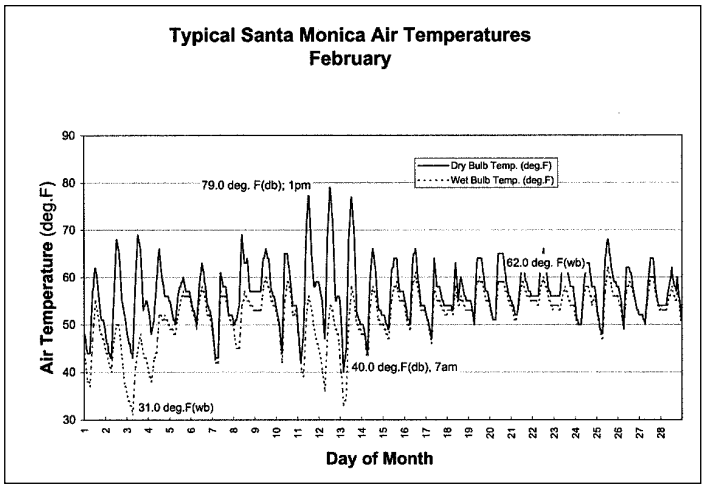




TYPICAL SANTA MONICA AIR TEMPERATURES





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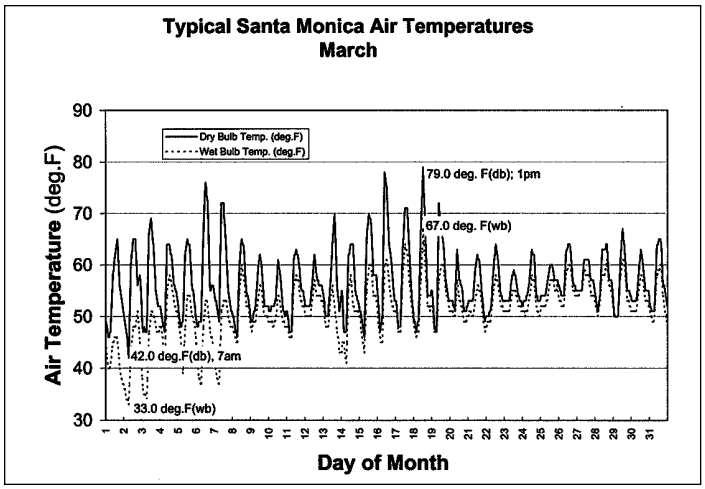

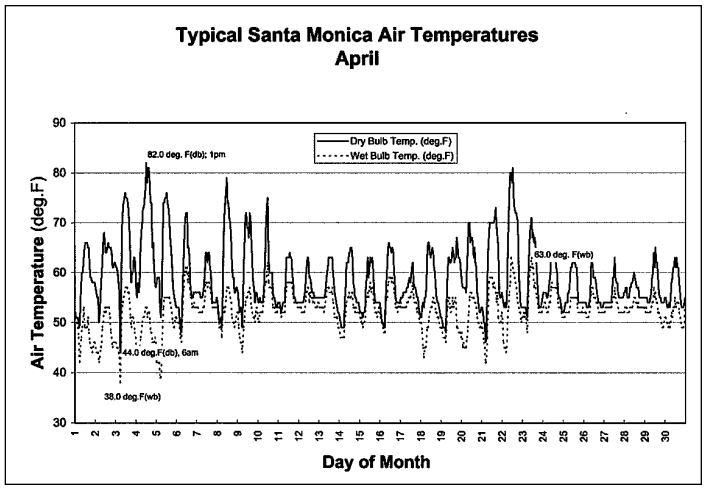

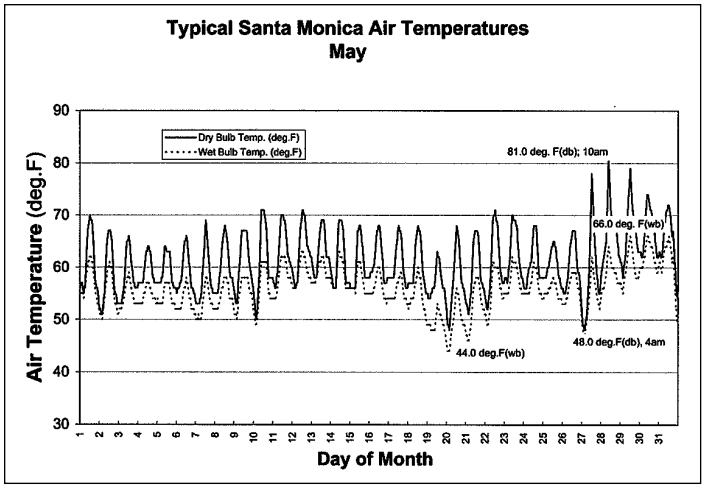

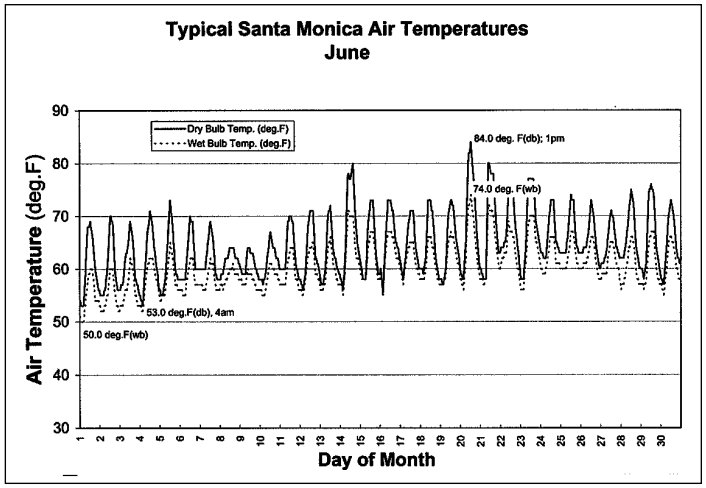

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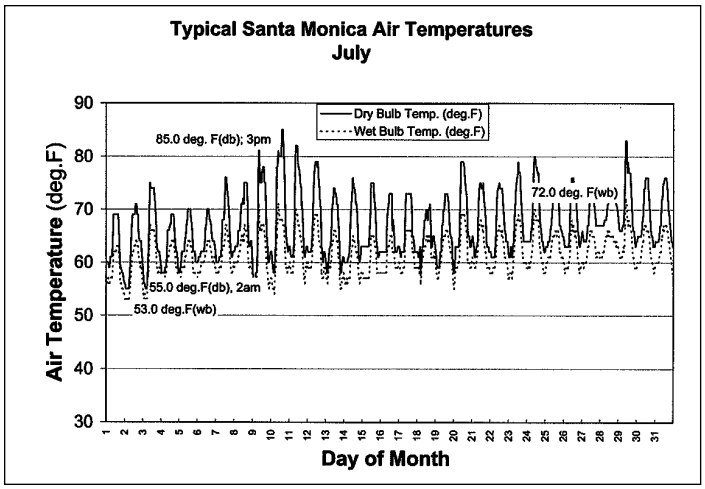

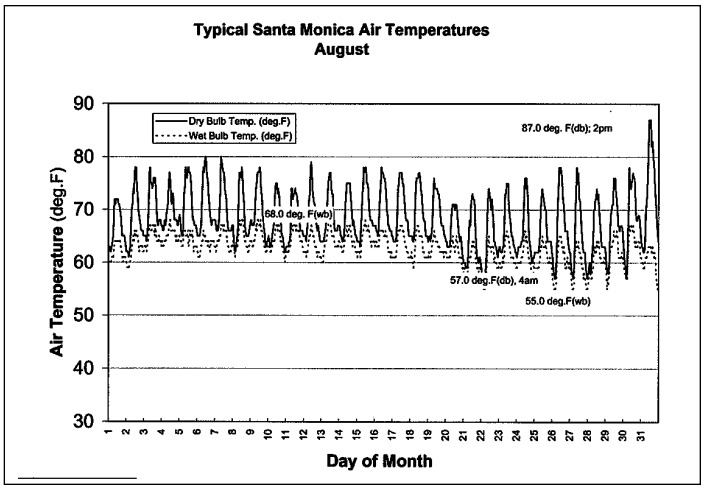

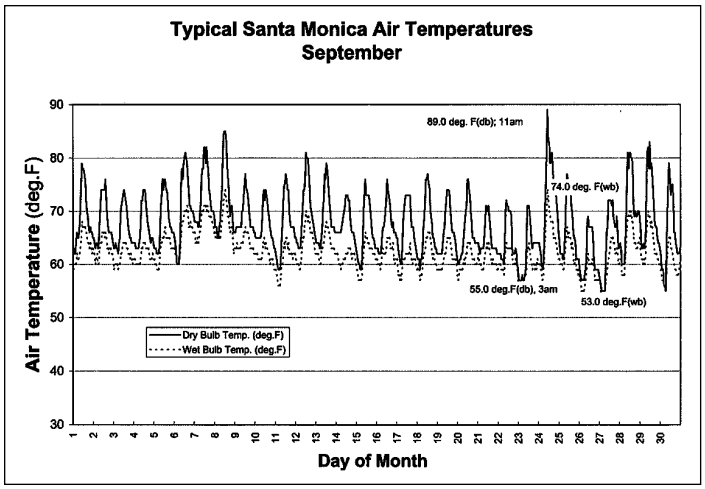

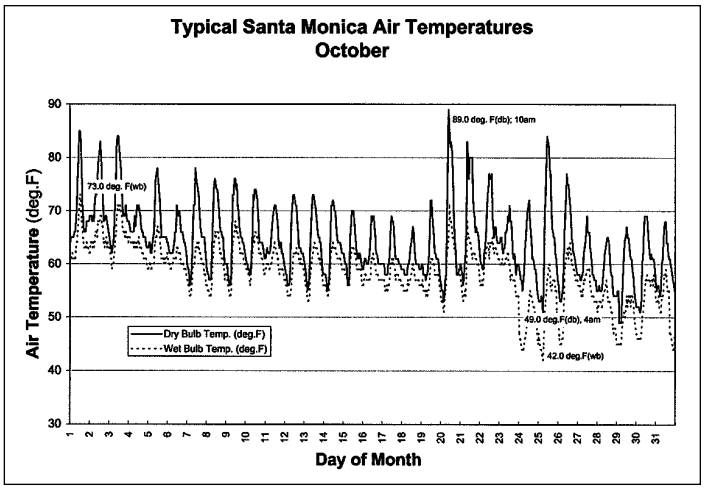

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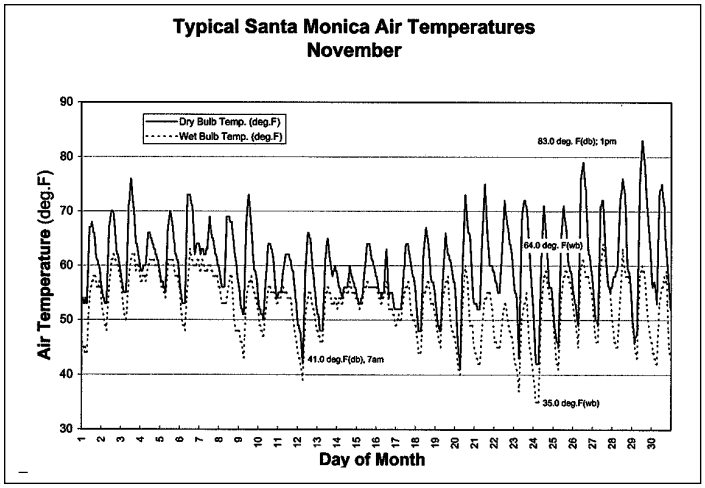

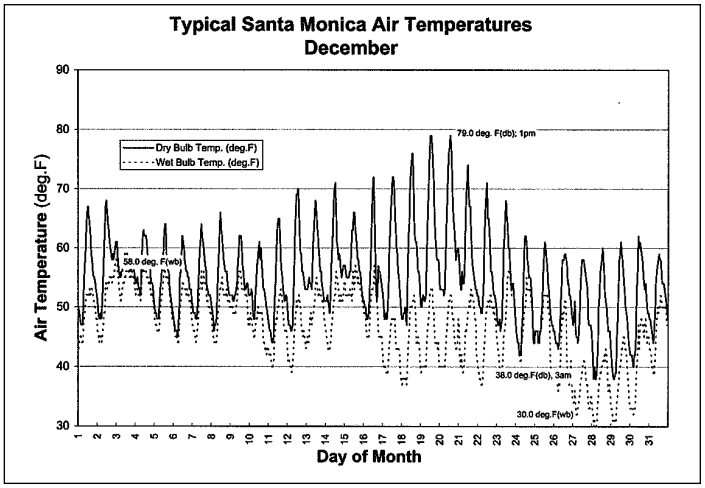

APPENDIX C
HVAC SYSTEMS

CEE FACT SHEET

HIGH-EFFICIENCY RESIDENTIAL CENTRAL AIR CONDITIONING AND HEAT PUMPS

Overview: The primary goals of this initiative are to increase the adoption and proper installation of high-efficiency residential central air conditioning and heat pumps. To achieve this goal, CEE has teamed with several of its utility partners nationwide to create common high-efficiency specifications for systems that promise greater efficiency and financial savings.

About this Market: The energy savings potential of the residential air conditioning market is significant. Central air conditioners and heat pumps rank third in residential energy use behind space and water heating. It is responsible for over 14 percent of U.S. electricity consumption and costs consumers $11.3 billion annually in energy expenditures.

Over 40 percent of all existing homes now have central air conditioning. These numbers are increasing rapidly: four out of five new homes built today are built with central air conditioners.

Initiative Background: Since 1994, CEE has worked with its utility partners nationwide to promote the adoption of common efficiency targets* that are 20 percent or more higher than government minimum standards and to encourage the manufacture and use of more efficient centralized air conditioning and heat pump systems through education and rebate programs.

This initiative also promotes proper sizing and system installation through utility education programs and installation evaluations. Such measures can reduce system efficiency losses by 10-30 percent. CEE is exploring additional opportunities to increase proper equipment installation.

*A complete listing of CEE efficiency tiers is attached.

Accomplishments: Thanks to our work with CEE utility partners, this initiative has helped increase the availability of energy-efficient single-package and split-air conditioning systems with capacities of up to 65,000 Btu/hr. In fact, in 1996 approximately 19 percent of residential central air conditioners and heat pumps sold in the U.S. met or exceeded CEE's minimum efficiency tier— up from 8.5 percent in 1992.

Additionally, the variety of high-efficiency products now available has grown to 32 percent—up from 11 percent when the program began.

Expected Energy Savings: This program consists of four efficiency tiers for cooling and heating performance. Equipment meeting these efficiency levels saves an average of 515 kWhs or $41 annually. Consumers living in warmer climates have the potential for even greater savings.

Environmental Benefits: The energy saved through this program will help reduce the production of

carbon dioxide, sulfur dioxide, and nitrogen oxide—air pollutants often associated with global warming, smog and acid rain.

Utility Participants: Twelve utilities serving over 13 million customers, or over 15 percent of the U.S./residential marketplace, have contributed to the success of this program. Current participants include: Atlantic Electric, Florida Power & Light, Interstate Power Company, Long Island Lighting Company, Northern States Power, Pacific Gas & Electric, Pacific Power & Light, Sacramento Municipal Utility District, Southern California Edison, Southern Maryland Electric Cooperative, the Tennessee Valley Authority, and Waverly Light & Power.

Consortium for Energy Efficiency
Energy Efficiency Levels for
Residential Central Air Conditioner and Heat Pump Initiative

	Cooling Performance		Heating Performance
Tier	**SEER**	**EER ****	**HSPF**
1	12	10.5	7.0
2	13	11	8.0
3	14	12	8.5
Advanced	15 & above	12.5 above	9.0 & above

** EER data are not widely available on all models. Therefore use of this specification, while encouraged to promote continued improvement in demand performance, is at the discretion of participating utilities until such time as certified EER information is available for most potentially qualifying models.

Other CEE Energy-Saving Initiatives
Dry Type Transformers
High-Efficiency Clothes Washers
High-Efficiency Commercial Central Air Conditioners and Heat Pumps
High-Efficiency Commercial Washers
Premium-Efficiency Motors
Residential and Small Commercial Lighting
Residential High-Efficiency Gas Heating
Super-Efficient, Apartment Sized-Refrigerators
Super-Efficient Household Appliances

# # #

CEE FACT SHEET

HIGH-EFFICIENCY COMMERCIAL CENTRAL AIR CONDITIONING AND HEAT PUMPS

Overview: The goal of this initiative is to encourage the widespread use of high-efficiency unitary (single-packaged and split-system) central air conditioning and heat pump equipment that is commonly used in commercial buildings. The initiative's success stems from the efforts of several key utility partners who voluntarily adopt and promote common energy-efficiency specifications, or tiers, that are feasible but not yet widely used.

CEE currently has two efficiency tiers available for adoption. Tier 1 specifies levels of high-efficiency for commercial equipment that are significantly greater than the federal standard. Tier 2 specifies equipment efficiency levels that achieve *even greater* energy savings. The use of these tiers is promoted through utility education and rebate programs.

About this Market: The energy-savings potential of the commercial air conditioning market is significant. There are nearly 5 million commercial buildings in the United States. In 1992 alone, these buildings consumed 2.6 quadrillion Btu's totaling of electricity, or 17% of all residential electricity use. It is one of the highest electricity consumers in the U.S., and is exceeded only by lighting.

Accomplishments: Our partners have increased the availability and purchase of energy efficient unitary, or packaged, air conditioning and heat pump systems. Overall, equipment availability has quadrupled since CEE began this initiative in 1992. Today, 37% of all available units now meet or exceed CEE's efficiency specifications.

Additionally, by promoting high efficiency standards to their customers, CEE's participating utility partners have helped pave the way for higher industry standards. The majority of CEE's Tier 1 efficiency levels are expected to be adopted as industry standards over the next few years. These revisions are likely to result in upgraded federal standards as well.

Expected Energy Savings: On average, CEE's Tier 1 efficiency specifications for unitary commercial air conditioners are at least 13 percent higher than the federal standard. CEE's Tier 2 specifications are generally 10 percent more efficient than the Tier 1 specs. For an average-sized building, the energy savings potential is about 1,712 kilowatt-hours per year (kWh/yr.), or $137 in annual energy expenditures. For a complete outline of our current specifications, see the attached tables.

Consumer Benefits: The energy saved through this program will help reduce the production of carbon dioxide, sulfur dioxide, and nitrogen oxide—air pollutants often associated with global warming, smog and acid rain.

Utility Participants: Twelve utilities serving over 2.5 million customers and equaling 20 percent of the U.S./commercial marketplace have contributed to the success of this program. Current participants include: Palo Alto Utilities, Florida Light & Power, Long Island Light, New England Electric System (NEES), Northern States Power – Minnesota, Pacific Gas & Electric, San Diego Gas & Electric, Sacramento Municipal Utility District (SMUD), Southern California Edison, Waverly Light & Power, Wisconsin Power & Light, and Wisconsin Public Service.

Other CEE Energy-Saving Initiatives
Commercial and Industrial Transformers
High-Efficiency Clothes Washers
High-Efficiency Commercial Washers
High-Efficiency Residential Central Air Conditioners and Heat Pumps
High-Efficiency Residential Gas Heating
Premium-Efficiency Motors
Residential and Small Commercial Lighting
Super-Efficient, Apartment Sized-Refrigerators
Super-Efficient Household Appliances

# # #

Consortium for Energy Efficiency
HIGH EFFICIENCY COMMERCIAL AIR CONDITIONING (HECAC) AND HEAT PUMP INITIATIVE

HECAC TIER I AND TIER II

Minimum Equipment Efficiencies for *Unitary Commercial Air Conditioners*				
Equipment Type	**Size Category**	**Sub-Category**	**Tier I Efficiency**	**Tier II Efficiency**
Air Conditioners, Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	12.0 SEER	13.0 SEER
		Single Package	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	10.3 EER 10.6 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and ≤240,000 Btu/h	Split System and Single Package	9.7 EER 9.9 IPLV	10.8 EER 11.2 IPLV
	>240,000 Btu/h	Split System and Single Package	9.5 EER 9.7 IPLV	10.0 EER 10.4 IPLV
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	Split System and Single Package	12.1 EER 11.2 IPLV	14.0 EER
	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	11.5 EER 10.6 IPLV	14.0 EER
	≥135,000 Btu/h	Split System and Single Package	11.0 EER 10.3 IPLV	14.0 EER

Minimum Equipment Efficiencies for *Heat Pumps*				
Equipment Type	**Size Category**	**Sub-Category**	**Tier I Efficiency**	**Tier II Efficiency**
Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	12.0 SEER	13.0 SEER
		Single Package	11.0 SEER	13.0 SEER
	≥65,000 Btu/h and <135,000 Btu/h	Split System and Single Package	10.1 EER 10.4 IPLV	11.0 EER 11.4 IPLV
	≥135,000 Btu/h and ≤240,000 Btu/h	Split System and Single Package	9.3 EER 9.5 IPLV	10.8 EER 11.2 IPLV
	>240,000 Btu/h	Split System and Single Package	9.0 EER 9.2 IPLV	10.0 EER 10.4 IPLV
Air Cooled, (Heating Mode)	<65,000 Btu/h	Split System	7.0 HSPF	8.0 HSPF
		Single Package	6.8 HSPF	7.5 HSPF
	≥65,000 Btu/h and <135,000 Btu/h	47°F db/43°wb Outdoor Air	3.2 COP	3.4 COP
		17°F db/15°Fwb Outdoor Air	2.2 COP	2.4 COP
	≥135,000 Btu/h	47°F db/43°wb Outdoor Air	3.1 COP	3.3 COP
		17°F db/15°Fwb Outdoor Air	2.0 COP	2.2 COP
Water Source (Cooling Mode)	<135,000 Btu/h	85° Entering Water	12.0 EER	14.0 EER
Water Source (Heating Mode)	<135,000 Btu/h	70° Entering Water	4.1 COP	4.6 COP

Revised 2/5/98.

EPA United States Environmental Protection Agency

United States Department of Energy

ENERGY STAR® - labeled products

Boiler Products

revised 12/2/98

Manufacturer Name (Trade Name)	Product Family Name	AFUE Rating	Model Series
Axeman-Anderson Co.	Axeman-Anderson Boilers	85.3-88.1	Olympia I Series (including those used in the Centaurus hot water heating system and the outdoor heating module system) : Models OL-91, OL-119, GL-91
Axeman-Anderson Co.	Axeman-Anderson Boilers	86.0-86.1	PO-2 Series: Model 74POD-2, 87POD-2 (Damper, Light Oil)
Axeman-Anderson Co.	Axeman-Anderson Boilers	85.0-88.7	NPO Series: 74NPO, 87NPO, 108NPO, 128NPO; 74NPO-U, 87NPO-U, 108NPO-U, 128NPO-U
Axeman-Anderson Co.	Axeman-Anderson Boilers	85.1-86.7	Vesta Series: PVT models 105B, 119B, 119H-189H
Buderus Hydronic Systems	Buderus	86.2-86.3	G115-21, 28, 34
Buderus Hydronic Systems	Buderus	85	G124x-18, 25, 32 II/DI
Buderus Hydronic Systems	Buderus	86.1	G205-34, 42, 50, 58, 66
Burnham	LE Series	87	LE-1, LEDV-1
Burnham	VT Series	86	V73WR-V76WR
Burnham	Revolution	87-88	RV3, RV4, RV5, RV6, RV7
Crown Boiler Co.	Cast Iron, Oil-Fired, Wet Base Hot Water Boilers	85.0-86.4	Bahama Series: Models BD-74, BD-91, BD-111, BD-151, BD-147, BD-178
Crown Boiler Co.	Cast Iron, Three Pass "Scotch Marine" Oil-Fired Hot Water Boilers	86.1-87.6	Freeport Series: Boiler Number CT-3, CT-4, CT-5, CT-6, CT-7, and CT-8
Dunkirk Radiator Corp.	Quantum Leap Series	95	QL-50, -75, -100
Dunkirk Radiator Corp.	EV Series	87.4-87.6	Models DPFO-3-9 3T-8T, and models ending in UDES or DES
Dunkirk Radiator Corp.	Empire Series	85.1-86.4	Models 3E.60, 3E.75, 3E.75C, 4E.90, 4E1.25, 4E1.25C, 4E1.50, 4E1.50C, 5E1.20, 5E1.20C

Dunkirk Radiator Corp.	Quantum-90	90	Q-90-50, -75, 100
Dunkirk Radiator Corp.	Ultimate Products	87.4-87.6	All models beginning with PFO-3-9-/PFO-3T-8T and all models ending with UDES
Energy Kinetics	System 2000	86.2-87.5	EK-1, EK-1-DV
Energy Kinetics	System 2000	85-87	EK-2, EK-2-DV
Glowcore	Series A		
Monitor Products, Inc.	MZ-Wall Hung Condensing Boiler	95	MZ 40C, MZ 25S, MZ 25C
Peerless	Gas Fired Boiler	85	PDE-03, PDE-04, PDE-05
Peerless	Oil Fired Boiser	85	WBV-03, WBV-04, EC/ECT-03, EC/ECT-04, EC/ECT-05
Slant/Fin Corporation	Prodigy 21 Boilers	85.8-86.3	KC45, KC90
Slant/Fin Corporation	Liberty	86	L-30H, L-40H, L-50H
Slant/Fin Corporation	Concept 21	85-85.6	CB-45, CB-90, CB-135, CB-180
Slant/Fin Corporation	XL-2000	83.56-85.05	XL-20, XL-30, XL-40, XL-50
Utica Boilers	Star Fire III	86	SFH 365, 4100, 5125, 6150
Utica Boilers	BC-Series	86	BC-3D, BC-4D
Utica Boilers	USC-Series	87	USC-3, USC-4, USC-5
Weil-McLain	Gold Oil Boilers	85.0-85.9	Model WGO-2 through GO-7, WTGO-3 through WTGO-7
Weil-McLain	Gold Gas Boilers	87.0-87.5	Model GV 3-6
Weil-McLain	Wall-Mounted High-Efficiency Gas Boilers	85.3-85.5	Model AHE-45 and AHE-60

* AFUE (Annual Fuel Utilization Efficiency) is a measure of unit efficiency. The higher the value the more efficient the furnace. Units must have a AFUE rating of 85% or higher to qualify for the ENERGY STAR logo

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EPA United States Environmental Protection Agency

United States Department of Energy

ENERGY STAR® - labeled products

Furnace Products

revised 12/2/98

Manufacturer Name (Trade Name)	Product Family Name	AFUE Rating	Model Series
Adams Manufacturing	Condensing Oil Furnace	95	AHEO Series Oil Furnaces
Adams Manufacturing	Condensing Oil Furnace	95	ASHEO Series Oil Furnaces
Air-Ease	Ultra SX 90	90	All models beginning with GUK or GCK
Air-Ease	Ultra SX 93	93	All models beginning with GU 93
Air-Ease	Ultra SX 95	95	All models beginning with GU 95
Amana Refrigeration	Air Command 90	93.3-95.3	All models beginning with GUC
Amana Refrigeration	Air Command 90	91.5-94	All models beginning with GCC
Amana Refrigeration	Air Command 90	93.2-94.4	All models beginning with GDC
Amana Refrigeration	Air Command 90	93.6-95.6	All models beginning with GUD
Amana Refrigeration	Air Command 90	93.6-94.0	All models beginning with GCD
Amana Refrigeration	GSC	93-94	All models beginning with GSC
Amana Refrigeration	Air Command 95	95.3-96.9	All models beginning with GUX
American Standard	Freedom 90	90-92.6	Models with AUY ,ADY, AUC, ADC, AUX ,ADX
Armstrong Air	Ultra SX 90	90	All models beginning with GUK or GCK
Armstrong Air	Ultra SX 93	93	All models beginning with GU 93
Armstrong Air	Ultra SX 95	95	All models beginning with GU 95
Carrier (Bryant, Day&Night, Payne)	Plus 90i	94-96	All models beginning with 355MAV
Carrier (Bryant, Day&Night, Payne)	Plus 90	92	All models beginning with 350MAV
Carrier (Bryant, Day&Night, Payne)	Condensing Furnace	90	All models beginning with 345MAV
Carrier (Bryant, Day&Night, Payne)	Condensing Furnace	91	All models beginning with 340MAV
Carrier (Payne)	Condensing Furnace	92	All models beginning with 490AAV

Carrier Corporation (Carrier)	Infinity	94-96.6	All models beginning with 58MVP
Carrier Corporation (Carrier)	Weathermaker	92	All models beginning with 58MXA
Carrier Corporation (Carrier)	Condensing Furnace	90	All models beginning with 58MSA
Carrier Corporation (Carrier)	Condensing Furnace	91	All models beginning with 58MCA
Consolidated Industries	True Blue 90	90	All models beginning with USA, DSA or DCA
DMO Industries	Ultramax	90.7-92.7	All models beginning with HDF
Dornback Furnace Division	HEO Series, Oil Fired	95	All models beginning with HEO
Dornback Furnace Division	SHEO Series, Oil Fired	95	All models beginning with SHEO
Ducane Company	Fits All 95	94-95	All models beginning with CMPA
Ducane Company	Classic 94	93-94	All models beginning with FPAA
EVCON		92-94	All models beginning with DGU or DGD
Fraser-Johnston		92-94	All models beginning with P*HD, P*LU or P*ND
Goodman Manufacturing	92 % Condensing	92	All models beginning with GMPN
Goodman Manufacturing	92 % Sealed Combustion	92	All models beginning with GSU
Heat Controller (Comfort-Aire) (Century)	Conquest 90	94	FLUA45-E3
Heat Controller (Comfort-Aire) (Century)	Conquest 90	93.3	GLUA60-E3
Heat Controller (Comfort-Aire) (Century)	Conquest 90	92.8	GLUA75-E3
Heat Controller (Comfort-Aire) (Century)	Conquest 90	92.8	GLUA75-E4
Heat Controller (Comfort-Aire) (Century)	Conquest 90	93.5	GLUA90-E5
Heat Controller (Comfort-Aire) (Century)	Conquest 90	92	GLUA105-E5
Heat Controller (Comfort-Aire) (Century)	Conquest 90	94.2	FLUA120-E5
Heat Controller (Comfort-Aire) (Century)	Conquest 90	92.7	ELDH45-E3
Inter-City Products (Airquest)	DV 90	90	All models beginning with NUG9
Inter-City Products (Airquest)	DC 90	90.1-92	All models beginning with NTGM, NDGM, NCGM
Inter-City Products (Arcoaire)	(None)	90	All models beginning with GUM
Inter-City Products (Arcoaire)	Enviroplus 90	90.1-92	All models beginning with GUK, GDK, GCK
Inter-City Products (Comfortmaker)	(None)	90	All models beginning with GUM
Inter-City Products	Enviroplus 90	90.1-92	All models beginning with GUK, GDK, GCK

(Comfortmaker)			
Inter-City Products (Heil)	DV 90	90	All models beginning with NUG9
Inter-City Products (Heil)	DC 90	90.1-92	All models beginning with NUGM, NDGM, NCGM
Inter-City Products (Tempstar)	DV 90	90	All models beginning with NUG9
Inter-City Products (Tempstar)	DC 90	90.1-92	All models beginning with NUGM, NDGM, NCGM
Lennox Industries	Elite 90 Gas Furnace	90.9-92.4	All models beginning with G26 or GHR26
Lennox Industries	Complete Heat	90	All models beginning with AM30/HM30
Lennox Industries	Dimension Gas Furnace	93.0-94.2	All models beginning with G32
Lennox Industries	Pulse 21 Gas Furnace	93.2-96.2	All models beginning with G21 or GSR21
Lennox Industries	Pulse 21V Gas Furnace	93.4-94.5	All models beginning with G21V or GSR21V
Luxaire		92-94	All models beginning with P*HD, P*LU or P*ND
Nordyne Incorporated (Intertherm)	G5RC	90	All models beginning with G5RC
Nordyne Incorporated (Intertherm)	G6RC	90	All models beginning with G6RC
Nordyne Incorporated (Intertherm)	G2RS	93-94	All models beginning with G2RS
Nordyne Incorporated (Intertherm)	G6RL	90	All models beginning with G6RL
Nordyne Incorporated (Miller)	G5RC	90	All models beginning with G5RC
Nordyne Incorporated (Miller)	G6RC	90	All models beginning with G6RC
Nordyne Incorporated (Miller)	G2RS	93-94	All models beginning with G2RS
Oneida Royal	Royal Air 90 U Series	90	90U050D30AZC, 90U050D36AZC, 90U075D30AZC, 90U075D42AZC, 90U100D42AZC, 90U125D60AZC
Payne	Condensing Furnaces	90-92	PG9M
Rheem Manufacturing	Classic 90 Plus	92-94	All models beginning with RGTA, RGRA
Rheem Manufacturing	90 Plus	93-94	All models beginning with RGRJ, RGTJ
Rheem-Ruud (WeatherKing)	Select 90 Plus	92-94	All models beginning with WGTA, WGRA
Rheem-Ruud (WeatherKing)	Select 90 Plus	93-94	All models beginning with WGRJ, WGTJ
Ruud Air Conditioning Division	Achiever 90 Plus	92-94	All models beginning with UGTA, UGRA
Rudd Air Conditioning Division	90 Plus	93-94	All models beginning with UGRJ, UGTJ
Thermal Zone	90% Multi Position Furnace	90	All models beginning GU***M

Thermal Zone	90% Downflow Furnace	90	All models beginning with GD***M
Thermal Zone	93% Upflow Furnace	93	All models beginning with GU***N
ThermoPride	CCA	90-96	All models beginning with CCA
ThermoPride	CHB	93-95	All models beginning with CHB
ThermoPride	CCB	92-95	All models beginning with CCB
The Trane Company	XE 90	90-92.8	All models beginning with TUC
The Trane Company	XE 90	90-92.8	All models beginning with TDC
The Trane Company	XE 90	90-92.8	All models beginning with TUX
The Trane Company	XE 90	90-92.8	All models beginning with TDX
The Trane Company	XV 90	90-92.8	All models beginning with TUY
The Trane Company	XV 90	90-92.8	All models beginning with TDY
Thermo Products Incorporated (Thermo Pride)	CHA	92-93	All models beginning with CHA
Thermo Products Incorporated (Thermo Pride)	CHA/CCA	90-96	All models beginning with GLC
York International Corporation	Diamond 90 Series	92-94	All models beginning with P*UR
York International Corporation	Stellar PLUS Series	92-94	All models beginning with P*CD, P*HD

Note: Air-Ease is a Johnson line by Armstrong Air Conditioning
Note: York International produces Evcon, Luxaire, and Fraser-Johnston products
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