California SUSTAINABLE DESIGN Training 2001

HDR

California Sustainable Design Training Table of Contents

California SUSTAINABLE DESIGN Training 2001

Section 1: Introduction to Sustainable Design

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Introduction to Sustainable Design

Defining Sustainable Design

One of the most widely used definitions of ***sustainable development*** is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This definition could apply to meeting any human need, such as for clothing, shelter, and food. This definition, however, is very broad based. A more concise definition of sustainability in a design context, from Governor Gray Davis' Executive Order on sustainable design, is:

"…to site, design, deconstruct, construct, renovate, operate, and maintain state buildings that are models of energy, water, and materials efficiency; while providing healthy, productive and comfortable indoor environments and long-term benefits…"

Key Attributes of Sustainable Design
A state plan for integrating sustainable design, called "A Blueprint for State Facilities", notes key attributes of sustainable design as:

Siting considerations that
- evaluate proximity to public transportation and affordable housing;
- promote economic renewal;
- and analyze building design and placement options to optimize resource efficiency;

Energy, water, and materials efficiency;
Improved indoor environmental quality and comfort; and;
The use of environmentally preferable products and processes, such as
- waste diversion techniques
- recycled-content materials

Characteristics of Sustainable Design
Embracing sustainable design enhances building design. Characteristics include:
- High performance
- Good quality
- Durability
- Added value
- Acceptable cost based on life cycle assessment
- Pleasing aestheticsReduced operating costsReduced environmental impacts

Impacts of Buildings

Buildings have an enormous impact on the environment, including resource consumption, the production of pollutants, and numerous impacts to habitats and species.

Energy Consumption and Air Emissions
Worldwide, daily energy consumption requires 10,000 days to replenish depleted fossil fuels. Worldwide energy consumption will grow by 59 percent over the next 20 years, according to an annual forecast released by the U.S. Department of Energy. Carbon dioxide emissions linked to global climate change are expected to nearly double by the year 2020.

Unfortunately, even though renewable energy use is expected to increase by 53 percent between 1999 and 2020, its current nine percent share of total energy consumption is projected to drop to eight percent by 2020.

In the U.S., buildings consume 30% of energy and
60% of the electricity produced, much of which is produced from combusting fossil

fuels. Serious problems associated with non-renewable electricity production include:

- 35% of all CO_2 emissions
- 75% SO_2 emissions
- 30% of NOx emissions

These emissions contribute to global warming, lead to the formation of smog, and negatively impact air quality.

Energy consumption also costs building owners significant amounts over the life of the building. The Energy Information Administration notes that commercial building owners pay approximately $15,300 per building for electricity, natural gas, fuel oil, and district heat.

Resource Consumption

According to the Worldwatch Institute Paper "A Building Revolution: How Ecology and Health Concerns are Transforming Construction", in the U.S., construction annually consumes

- 40% raw stone, gravel & sand
- 25% virgin wood. Since 1950, a fifth of the world's forest cover has been removed3 billion tons of raw materialsUp to 40% of landfill content
- Up to 15% of materials used in construction may be wasted
- Waste creates long-term hazards to human health and ecosystem

Water Use and Quality

In the U.S., 340 billion gallons of fresh water are withdrawn daily. In office buildings, occupants use an average of 20 gallons per day. However, water efficient strategies employed in buildings can reduce usage by 30%, significantly reducing water use.

Notes:

Water use also has to be treated at wastewater treatment plants and stormwater runoff from fertilized turf and impervious paved surfaces can pollute streams and rivers. Freshwater supply constraints also mean that building related water consumption competes with water needs in the ecosystem and in agriculture.

The U.S. Census Bureau notes that in 1995, California accounted for almost 11% of all freshwater used in the U.S.

Site Development

According to the U.S. Bureau of Census Data on Urbanized Areas, 95% of the total sprawl in California from 1970-1990 was related to population growth. Furthermore, despite accepting the densest living conditions in the country, LA sprawled 394 square miles from 1980-1990 and added 3.1 million residents.

California's population is projected to rise from its current 35 million residents to just under 50 million in 2025. This would make California as densely populated as China is now.

Sprawl contributes to environmental problems such as:

- Disruption of habitat corridors
- Soil erosion
- Increased stormwater runoff
- Destruction of ecosystems
- Loss of agricultural land
- Air pollution related to transportation

Indoor Environmental Quality

According to the EPA:

- Indoor air is often more polluted than outdoor air, sometimes as much as 100x more polluted. This is a huge concern given the fact that Americans spend approximately 90% of their time indoors.
- Indoor air pollution is one of the top five environmental risks to public health. According to the Worldwatch Institute, in fact, Sick Building Syndrome affects 30% of new & renovated buildings. It is estimated that this translates to lost productivity totaling billions annually.

IEQ impacts occupant productivity, performance, health, and satisfaction.

Sustainable Design Principles

It is easier to grasp all of the aspects of building design, construction, and operation that might impact the natural environment or building occupants by addressing five key principles of sustainable design: ***Sustainable Sites, Safeguarding Water, Energy and Atmosphere, Indoor Environmental Quality, and Materials and Resources***. Following is an overview of these principles as well as a few examples of opportunities to integrate related sustainable solutions. More detailed information on all of these principles will be presented during the training.

Sustainable Sites

Overall goal: Minimize the negative impact of site selection and site design.
For example:

- Select building sites with access to public transportation
- Reuse a building instead of building new
- Minimize building footprint
- Encourage urban development
- Plant drought-resistant vegetation

Notes:

Safeguarding Water
Overall goal: conserve water and protect water quality.
For example:
- Use low-flow fixtures
- Integrate vegetated filter strips and grass swales
- Collect and use rainwater
- Plant indigenous vegetation
- Use pervious surfaces
- Use of reclaimed or recycled water for irrigation

Energy & Atmosphere
Overall goal: Design for energy efficiency and consider renewable sources.
For example:
- Generate electricity on-site (fuel cells; photovoltaics, for example)
- Eliminate CFCs and HCFCs
- Utilize occupancy sensors
- Consider alternative power contracts
- Recover waste heat

Materials & Resources
Overall goal: Minimize the life-cycle impact of materials.
For example:
- Practice Construction Waste Management
- Specify:
  - Rapidly renewable materials
  - Certified wood
  - Recycled content
  - Low emitting materials
  - Durable materials

Indoor Environmental Quality
Overall goal: Enhance the health and comfort of building occupants.
For example:
- Include a construction Indoor Air Quality plan

- Provide for occupant control of lighting, air flow, or operable windows
- Provide access to daylight and the outdoors
- Use materials with low emissions
- Design for good acoustics

Benefits of Sustainable Design

There are many benefits associated with integrating sustainable design concepts.

Increased Community Perception. Environmental awareness continues to increase. Building owners who utilize sustainable design approaches send a "good neighbor" message to the community.

Reduced Operating Costs. One of the primary goals of sustainable design is to reduce operating costs. For the most part, this is due to reduced energy consumption.

Reduced Liability. A building's healthy indoor environment can offset the trend towards increased insurance claims related to indoor air quality problems.

Increased Market Demand/Building Value. Buildings designed using sustainable design principles are leasing faster. Since sustainable buildings are often less expensive to operate, some building owners are willing to pay more for them.

Increased Productivity. Many studies show that sustainably designed buildings will increase occupant productivity. Rocky Mountain Institute's publication, Greening the Building and the Bottom Line documents eight case studies that show that productivity gains from green design can be as high as 16 percent.

Efficient Operations & Maintenance. Longer lasting products, less cleaning with toxic substances, increased use of control systems for water delivery and energy use can lower O&M costs. This is one of the primary goals of sustainable design.

Regional Economic Development. Sustainable design encourages the use of regionally or locally produced materials to minimize the energy and air emissions impacts related to transporting materials.

Increased Employee/Occupant Satisfaction. Studies indicate that building occupants are healthier and more satisfied in sustainably designed buildings.

Environmental benefits include the Conservation of Natural Resources and Reduced Waste.

National Sustainable Design Trends

California is not unique in embracing sustainable design. There are several national trends that are resulting in the increased acceptance of sustainable design principles. These include the development of Federal and State initiatives, sustainable building incentives, and the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System.

Federal Government Requirements

The Federal Government has been an early leader in integrating sustainable design into projects. This was partially due to Federal Executive Orders (E.O.s) that were issued beginning in the late 1990s. The first E.O.s addressed waste reduction and energy efficiency. Later E.O.s, however,

required that Federal Agencies address sustainable design comprehensively, including energy efficiency, efficient use of water, waste reduction, sustainable site planning, and indoor environmental quality. Executive Order 13123, Greening the Government through Efficient Energy Management, issued in June of 1999, went so far as to require the Department of Defense, General Services and Administration and the Department of Energy to provide sustainable design training to their staff.
These are just a few of the Federal Agencies requiring sustainable design:

General Services Administration (GSA).
The GSA requires the use of the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System for all new buildings funded in 2001 or later (more information on LEED™ is presented later in this chapter). All agencies (such as the Environmental Protection Agency and the Department of the Interiors) that lease space from the GSA are required to meet the GSA's Green Lease Acquisition requirements.

National Parks Service (NPS). The NPS developed the "Guiding Principles of Sustainable Design". These guidelines address incorporating sustainable design into Parks' projects.

U.S. Postal Service (USPS). The USPS built the first "Green Post Office" in Fort Worth, Texas and is currently integrating lessons learned into other facilities.

State Requirements
Many states are now following the lead of the Federal government, and making sustainable practices/design a policy or

Notes:

legislative requirement for their own facilities. Some of these state requirements are:

Indiana, Executive Order, 1999. The goal of this order is to improve the environmental performance of all state operations.

North Carolina, Executive Order, 1999. This Executive Order addresses environmental sustainability, reduction of solid waste, and procurement of environmentally preferable products in state government.

Oregon, Executive Order, 2000. Requires that all state agencies integrate sustainable design into all state projects.

California, Executive Order 16, August 2000. Requires that an interagency task force be established to determine how sustainable design could be integrated into all state projects.

Maryland, Executive Order, 2001. This Executive Order requires energy efficient and environmentally responsible facilities; sets goals for purchasing green energy; outlines energy conservation strategies.

Incentives
There are many existing incentives for sustainable design. For example,

Arlington County provides a density incentive for developers who use the LEED™ Rating System.

New York City offers green building tax credits for sustainable design. Other cities are looking at the New York City model as the basis for developing similar legislation.

Effective October 8, 2001, businesses in Oregon can get a tax credit for buildings that achieve a Silver Rating or higher under the US Green Building Council's LEED™ Rating System (more information on LEED follows).

Grants
There are both local, and in some cases, federal rebates for integrating sustainable technologies, devices, and/or systems. Most of these deal with energy efficiency. The California Consumer Energy Center has a database of state grants, rebates, and incentives.

Incentive Programs
Savings by Design is a program to encourage high-performance nonresidential building design and construction. Sponsored by four of California's largest utilities under the auspices of the Public Utilities Commission, Savings By Design offers building owners and their design teams a wide range of services, including design assistance, design team incentives, and building owner incentives. This program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company and the Southern California Gas Company.

California Energy Commission
Programs include peak load reduction energy efficiency financing and renewable energy and distributed generation incentives. These programs lower first costs or financing costs.

California Requirements

Notes:

Executive Order D-16-00

On August 2, 2000, Governor Gray Davis signed Executive Order D-16-00, which established the state's sustainable building goal. The Secretary of State and Consumer Services Agency (SCSA), Aileen Adams, was called to consult with "appropriate private sector individuals and public officials" including:

- Director of the Department of Finance
- Secretary of Business, Transportation, and Housing
- Secretary for Education
- Secretary for Environmental Protection
- Secretary of Health and Human Services
- Secretary for Resources

One outcome was the official recognition of an interagency sustainable design Task Force, formed to prepare policy recommendations and report annual progress in meeting the goals of the Executive Order.

Sustainable Design and LEED™

The U.S. Green Building Council (USGBC) is a non-profit organization with 800+ members nationwide. Its membership includes representation from all aspects of the building industry including: product manufacturers, environmental groups, building owners, building and design professionals, utilities, city governments, the federal government, research institutions, professional societies, and universities.

Membership is voluntary and diverse, and operates on consensus principles. The purpose of the U.S. Green Building Council

is to make sustainable design become mainstream practice.

In the mid-1990s, the USGBC responded to inquiries from its membership regarding how to define green buildings or sustainable design. The membership, after researching existing systems that rated the environmental performance of buildings, concluded that none of the existing systems fit what was needed in the U.S.

The membership developed the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System. The USGBC maintains administrative authority of LEED™.

Overview of LEED™

LEED™ is based on accepted energy and environmental principles and strikes a balance between known effective practices and emerging concepts. The first version of LEED™ was released in January of 2000. Approximately 40 buildings, called Pilot Projects, volunteered to test the system. 13 of those completed all documentation necessary to receive certification under the system. Comments from the Pilot Projects and industry professionals were used to enhance LEED™. The new version, 2.0, was released in March 2000.

The existing system is intended to be used to rate commercial and high-rise residential buildings, including new construction, major renovation, and built projects. The system is self-assessing.

LEED™ Format

The rating system is point based. Each credit describes a performance-based goal. For each credit, there are a certain number of points available. For example, there is one credit called “Optimizing Energy Efficiency”. Depending on how efficient the building is expected to operate (shown using energy modeling), up to 10 points may be earned.

Credits are categorized into each of the five principle areas of sustainable design.

Sustainable Sites (8 credits/14 points)

Water Efficiency (3 credits/5 points)

Energy and Atmosphere (6 credits/17 points)

Materials and Resources (7 credits/13 points)

Indoor Environmental Quality (8 credits/15 points)

LEED™ Certification Levels

There are 69 possible points in the system. Different levels of achievement can be reached depending on the total number of points obtained.

LEED™ Certified:		26-32 points
LEED™ Silver:	33-38	
LEED™ Gold:	39-51	
LEED™ Platinum:	52+	
Total possible points:	69	

LEED™ Example, Energy Credit 1
Reduce design energy cost compared to the energy cost budget for regulated energy components described in the requirements of ASHRAE Standard 90.1-1999, as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11.

New Bldgs.	Existing Bldgs.
20%: 2 points	10%: 2 points
30%: 4 points	20%: 4 points
40%: 6 points	30%: 6 points
50%: 8 points	40%: 8 points
60%: 10 points	50%: 10 points

Other LEED™ Systems
Since LEED™ is targeted for new commercial construction, a number of other LEED™ systems are currently under development, with a target release date of 2005.

LEED™ for Existing Buildings: Primarily for major renovations or existing buildings.

LEED™ Residential. For residential buildings.

LEED™ Commercial Interiors. For interior renovation projects.

The anticipated release date for these new systems is 2005.

A ***California LEED™ supplement***, which is tailored to state requirements and goals, has also been developed. It is not an adopted standard, but may be at some time in the future.

LEED™ can be used on any project at any time to set sustainable design goals and integrate sustainable design. Projects may also be certified through the U.S. Green

Notes:

Building Council by gathering required documentation to prove that sustainable criteria have been integrated into the project.

Introductory Resources

Well-known resources for sustainable design include:

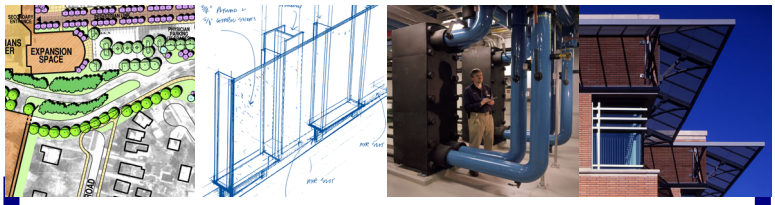
1. Environmental Building News (EBN) is a monthly publication with articles, reviews, and news stories on energy-efficient, resource-efficient, and healthy building practices.
2. Environmental Design and Construction is a free publication dedicated to the sustainable design and construction industry.California Integrated Waste Management Board Green Design and Construction web site.
4. OIKOS is a web site devoted to serving professionals whose work promotes sustainable design and construction.

Resource	Description	Website
A Building Revolution: How Ecology and Health Concerns Are Transforming Construction;	A publication by the Worldwatch Institute: Worldwatch Paper 124, March 1995; addressing impacts of buildings.	http://www.worldwatch.org
California Executive Order D-16-00	The Executive Order further directs Secretary Adams to submit a report to the Governor recommending strategies to incorporate sustainable building practices into the development of State facilities, including leased property.	http://www.ciwmb.ca.gov/GreenBuilding/TaskForce/
California Integrated Waste Management Board (CIWMB) Green Design and Construction Web Site	The six-member Integrated Waste Management Board is responsible for protecting the public's health and safety and the environment through management of the estimated 60 million tons of solid waste generated in California.	http://www.ciwmb.ca.gov/GreenBuilding/
Consumer Energy Center	A California source for consumer info on energy efficiency, energy rebates, transportation & renewable energy.	http://www.consumerenergycenter.org
Environmental Building News (EBN)	EBN is a monthly publication with articles, reviews, and news stories on energy-efficient, resource-efficient, and healthy building practices.	http://www.buildinggreen.com
Environmental Design and Construction	A free publication dedicated to the sustainable design and construction industry.	http://www.edc.com
Federal Executive Order 13123, Greening the Government through Efficient Energy Management	E.O. requiring comprehensive sustainable design, June 1999	http://www.wbdg.org/federalMandates.asp

Resource	*Description*	*Website*
Greening the Building and the Bottom Line.	Publication of the Rocky Mountain Institute; eight documented case studies show that productivity gains from green design can be as high as 16 percent.	http://www.rmi.org/images/other/GDS-GBBL.pdf
Leadership in Energy and Environmental Design (LEED™)	LEED is a green building rating system developed by the U.S. Green Building Council (USGBC). The intent was to develop a rating system that provided a framework for measuring "how green a building is".	http://www.leedbuilding.com
Oikos	A web site devoted to serving professionals whose work promotes sustainable design and construction.	http://www.oikos.com
SavingsByDesign	A rebate program providing financial incentives to the owner, the design team or both depending upon the design approach used and the energy performance goals.	http://www.savingsbydesign.com
U.S. Bureau of Census Data on Urbanized Areas, Sprawl City		http://www.sprawlcity.org/studyCA/index.html
U.S. Census Bureau California Quick Facts		http://quickfacts.census.gov/qfd/states/06000.html
U.S. Environmental Protection Agency, Indoor Air Quality Program. Targeting Indoor Air Pollution, EPA's Approach and Progress, March 1993	US EPA report on IAQ.	http://www.epa.gov/iaq/pubs/targetng.html
U.S. Geologic Service		http://ga.water.usgs.gov/edu/qausage.html#HDR2

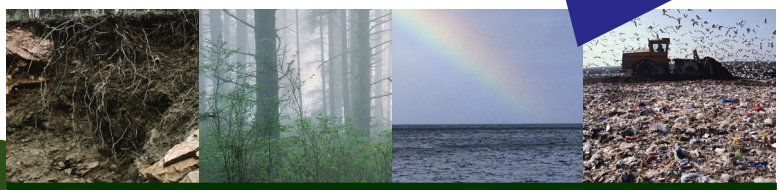
Resource	*Description*	*Website*
U.S. Green Building Council	The U.S. Green Building Council is the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable, and healthy places to live and work.	http://www.usgbc.org

Introduction to Sustainable Design



Decisions Made Regarding

- Site Selection
- Site Design
- Building Design
- Material Selection
- Construction Practices
- Building Operation



Impact

- Waste Production
- Natural Resource Consumption
- Air, Water, Soil Contamination

Resulting In

Long Term Impacts to:

- Ecosystems
- Health
- Economic Outcomes

California SUSTAINABLE DESIGN Training 2001

Section 2: The Sustainable Design Process

HDR

The Sustainable Design Process

This section of the training addresses how to integrate sustainable design into the existing DGS design and construction process.

Application of Sustainable Design

Sustainable design can be beneficial to all project types, including:

- Repairs & Alterations
- New Construction
- Historic Renovations
- Leases

Integrated Approach

An integrated approach is required for successful sustainable design, but the overall process can vary depending on the building owner, project schedule, and when sustainable design is introduced into a project. (Ideally, sustainable design is considered and integrated into the design process as early as possible.) This section focuses on integrating sustainable design into the Capital Outlay Process.

The key to sustainable design is to maintain communication between all project team members, including the Department of Finance, the customer, project managers, design team, and building operators.

Why Should DGS Integrate Sustainable Design?

Building California's Sustainable Future: A Blueprint for State Facilities includes the following recommendations:

Recommendation 1:

Modify the State's capital outlay policies and processes to incorporate the Governor's sustainable building goals.

- Formally establish the Sustainable Building Task Force
- Identify specific modifications to existing capital outlay policies
- Incorporate sustainable building practices into all significant projects
- Require technical review of certain leadership projects by the Task Force

Recommendation 2:

Incorporate life cycle costing, integrated design, commissioning, and post-occupancy evaluation into the State's Capital Outlay Program.

- Incorporate the use of an integrated design approach in the project development process;
- Develop an applicable life cycle costing method to analyze the full range of quantitative and qualitative sustainable building benefits;
- Establish commissioning and post occupancy evaluation programs to ensure that building performance is

periodically monitored and systems operate as designed.

Notes:

Integration into Capital Outlay Process
At each step in the Capital Outlay Process, there are opportunities to address some aspect of sustainable design. The phases of the Capital Outlay Process include:

- Concept Phase
- Budget Package Phase
- Site Acquisition
- California Environmental Quality Act Compliance
- A/E Selection
- Preliminary Plans
- Working Drawing Phase
- Construction Documents
- Bidding Phase
- Construction Phase

The following suggestions are provided to encourage opportunities for sustainable design at each step of the Capital Outlay Process:

Concept Phase or Capital Outlay Budget Change Proposal

Include possible sustainable vision or goals desired.

Examples:
Goal: "This project shall set, as a priority, the integration of renewable energy. Specifically, it is desired to generate at least 5% of the building load from a renewable source".

Goal: "This project shall use rainwater or reclaimed water for all irrigation needs".

The Sustainable Design Process

Budget Package Phase
Include sustainable solutions to the extent possible.

Example: If it has been suggested that photovoltaics be utilized on this project, include appropriate numbers in the preliminary budget. Remember that the Department of Finance has agreed to add up to an additional 3% to the A/Es design fees, to be evaluated on a project-by-project basis. These funds can be available if a sustainable design solution is shown to be a beneficial long-term solution.

A/E Selection - Notification Advertisement
Include intent to provide sustainable requirements.

An example of the Caltrans District 7 Headquarters Evaluators Handbook is included at the back of this section.

RFQ
Include criteria-specific sustainable design requirements (Tier List requirements at a minimum).

Examples:

"At a minimum the project shall obtain LEED™ Certified status."

"The project shall meet requirements for an Energy Star Building Label."

A/E Evaluation
Include sustainable design in the evaluation requirements.

Example: Caltrans District 7 Headquarters
Evaluators Handbook

"Team shall be evaluated in experience, including energy efficiency and sustainable building design."

"Energy efficiency and Sustainable Design Measures will be evaluated on overall performance of the systems in energy efficiency, sustainable measures including recycling and resource conservation, indoor air quality, alternative energy technologies, and other factors deemed relative."

Standard DGS A/E Agreement
Incorporate sustainable design definitions:

Energy efficiency - design that minimizes energy consumption, integrates passive and active design elements, while meeting the operational needs of the facility.

Sustainable building measures - design that results in minimizing pollution, resource waste and environmental impacts associated with facility construction operation, and if applicable, demolition.

Applicable Laws and Regulations
California Energy Code – Current Edition
Government Code Section 15814.30-31

Lists of possible energy efficiency and sustainable building measures:

Energy Efficiency Measures – Tier 1 List
Energy Efficiency Measures – Tier 2 List

Sustainable Building Measures – Tier 1 List
Sustainable Building Measures – Tier 2 List

Tier List forms must be submitted, at Schematic Design Phase and 50% & 100% Working Drawing Phase.

Tier 1 List Requirements
All Tier 1 List items are expected to be included in project within established:
- Scope
- Construction budget
- Project schedule

Project shall be designed and constructed within the project construction budget to exceed Title 24 Energy, 2001 Edition by as much as is cost effective.

Tier 2 List Requirements
Items in the Tier 2 list should be considered for inclusion by the Consultant. If the Consultant concludes that some of the items are feasible, the State should be notified of any additional cost and benefits. This information should be provided to the Project Manager, who in turn will discuss it with the Department of Finance. The customer should also be made aware of such discussions.

Preliminary Plans
Schematics
Design Development
1. Identify life-cycle solutions
2. Review plans and specifications for sustainable solutions, which include, but are not limited to: sustainable material selection; energy efficiency; construction waste management; indoor environmental quality solutions; water efficiency.

Notes:

3. If commissioning is a project requirement, consideration should be given to start the commissioning process in the design phase.

   Examples. Expect:
   - Development of a preliminary construction waste management plan
   - Identification of energy saving devices and systems
   - List of reclaimed materials that could possibly be used
   - List of other sustainable materials
   - Development of an initial indoor environmental quality plan

Working Drawing Phase/Construction Documents

Review plans and specifications for: sustainable material selection; energy efficiency; construction waste management; indoor environmental quality solutions; water efficiency.

Bidding Phase

Respond to questions regarding sustainable design and provide contractor with information such as sustainable goals and Construction Waste Management Resources.

Construction Phase

Confirm that sustainable design solutions are being included, such as:

- Continue with commissioning requirements, if applicable
- Follow-up on construction waste management reporting
- Verify that materials selected are installed
- Verify that the Indoor Environment Protection Specification construction practices are being adhered to.

Other Sustainable Design Strategies

Taking suitable steps during the standard DGS design and construction process may result in the integration of sustainable design solutions. However, the identification and employment of further sustainable design solutions will more likely happen if other methods are used.

Some of these methods are demonstrated by a project scheduled for completion in 2002 at the Pentagon in Arlington, Virginia. The Washington D.C. area light rail system, the Metro, currently makes a stop at the Pentagon. Due to security concerns, the Metro Entrance Facility (MEF) was re-designed to bring Metro and bus traffic further away from the Pentagon.

Metro Entrance Facility Project Team
Contractor-led Design Build
Client: Pentagon Renovation Office
Contractor: Hensel Phelps Construction Co.
Architect: HDR Architecture, Inc.
Landscape: Lee & Liu Associates
Mechanical: Southland Industries
Electrical: M.C. Dean
Commissioning: Sebesta Blomberg

This project was a fast-track Contractor-led Design-Build project with a large number of team members. Over the last few years, the Pentagon Renovation Office has been raising expectations for sustainable design on renovation projects.

Project Requirements
The initial MEF sustainable design requirements were as follows:
Standard Federal Requirements:

- E.O. 13123, Greening the Government Through Efficient Energy Management
- 10CFR435, Energy Conservation Voluntary Performance Standards for New Buildings
- EPA 's Comprehensive Procurement Guidelines

Additional MEF Requirements.
Not permitted:

- Ozone-depleting compounds, including CFCs and HCFCs
- Polyvinyl Chloride (PVC) or other chlorine-based compounds
- Volatile Organic Compounds (VOCs)
- If no-VOC is unavailable, low VOC considered with prior approval

Material Selection Requirements

- All dimensional wood and wood products to be wood certified by the Forestry Stewardship Council
- Construction waste management, 50% diversion minimum, including metals, wood, asphalt, concrete, land clearing debris, beverage containers, and all other material for which there is a market demand

Sustainable Design Process

Sustainable Design Kick-Off Meeting
"Problem Seeking"

Notes:

The Sustainable Design Process

To better understand complex design problems like the MEF, an initial Sustainable Design Kick-off Meeting is often held with the following goals:

- Ensure that the entire project team understands the project-specific sustainable design requirements
- Establish initial sustainable design project goals
- Clarify Team Commitment and End Expectations
- Describe End Documentation
- Develop a sustainable design vision statement

Attendees

Attendees at a DGS Kick-Off Meeting could include:

- DGS staff: Finance, Project Directors, Design Staff
- Building Operator
- A/E
- Building Tenant/Building Owner
- Consultants

Sustainable Vision Statement

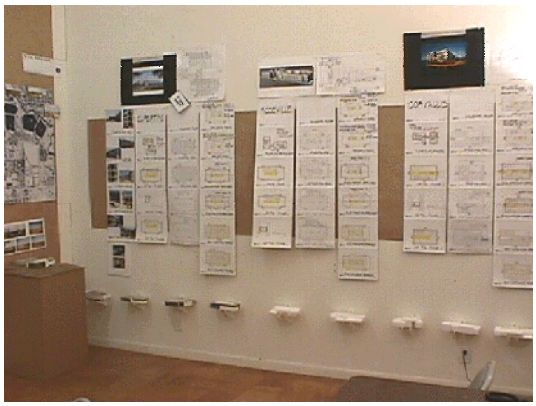
The vision statement should be a broad-based description of what the sustainable vision is for a particular project.

For the MEF, it is:
"The design and construction of the Pentagon MEF will use an integrated, life-cycle approach to create a facility with a 50 year life span that:

- *optimizes operations and maintenance*
- *reduces long-term cost*
- *minimizes long-term environmental impact*

In addition, the project should:

- *integrate with the natural environment*
- *be user-friendly with a sense of place that encourages the use of mass transit. "*



Sustainable Design Kick-Off Notes

Another example of a vision statement is from the remodel of the Department of Transportation in Washington, DC:

> *"…design construction and on-going operation of the project must minimize the impact on the environment and the utilization of energy and other scarce non-renewable resources"*

Initial Sustainable Goals

Initial sustainable design goals should define generally what sustainable achievements are expected. Some of these expectations may be set by the building owner. The project team may set others. Based on their expertise, the team can set initial targets for sustainable design performance.

For example, on the MEF, there was an overall effort to achieve, at a minimum, a LEED™ Certified Rating.
MEF project-specific goals included:

- Recycle at least 50% of all construction waste (set by the Pentagon Renovation office)

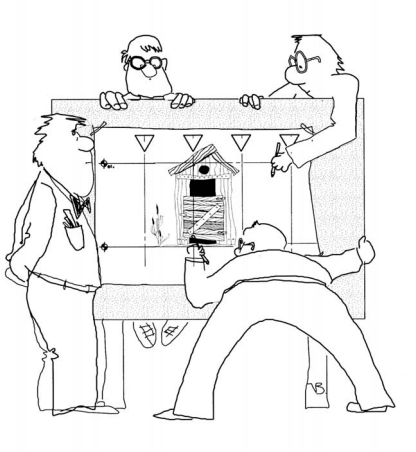
- 50% of all materials should have some recycled content (set by the Pentagon Renovation office)
- Exceed ASHRAE 90.1 energy efficiency requirements by 20% (set by the project team)
- Utilize native, low-maintenance vegetation (set by the project team)

Notes:

Green Design Charrette

"Problem Solving"

After the preliminary investigations from the Kick-Off Meeting are concluded, the Design Team is ready to begin with the problem-solving stage. Often this is begun with a *charrette* – a group design/brainstorm session of limited time. Solutions are energetically conceived and presented. The lessons learned are documented with a future plan of action.



Sample Green Design Charrette Agenda

- Confirm goals are criteria-specific
- Brainstorm; consider multiple options
- Evaluate cost, feasibility
- Refine solutions; narrow options
- Document materials and systems
- Record findings with specific recommendations

- Describe further research to be done
- Commit to a strategic plan of action

Ideas for specific sustainable goal-setting

1. The CA LEED™ Supplement and Tier Lists.
2. It is also recommended that goals be set in each sustainable design category:
   - Site Planning
   - Energy Efficiency
   - Materials & Resources
   - Safeguarding Water
   - Indoor Environmental Quality
3. Utilize tools such as the Green Building Advisor.
4. The team should remember that in addition to setting goals for environmental performance, the overall goal is to design quality spaces that also meet the project scope.

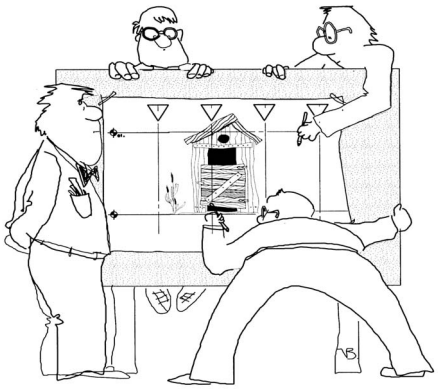
Sustainable Design Solutions

Sustainable design solutions are strategies or methods for achieving the sustainable design goals. For example the **MEF** was expected to exceed ASHRAE 90.1 energy efficiency requirements by 20%. T o achieve this the following *solutions* were suggested:

- Install an Energy Star Roof
- Employ a Commissioning Process
- Use Photovoltaics to generate electricity.

To meet the goal that 50% of all materials should have some recycled content, the following *materials* were recommended:

- Concrete with high-content fly ash
- Recycled content ceiling tiles and floor tiles
- Recycled-content carpet backing
- Reprocessed paint
- Cellulose insulation



Considering Sustainable Solutions

After initial sustainable solutions are identified, they should be considered just as any other potential design solution. They should be evaluated, as such, for cost, feasibility, ease of installation, etc.

Document materials and systems

The possibility of successfully integrating sustainable design on any project can be increased by making sustainable design a regular part of project meetings and by developing some method of tracking progress. An example of the **tracking form** used on the Pentagon Metro Entrance Facility is included in this section.

Resources

Resources such as the Environmental Building News web site or tools such as

the Green Building Advisor™ may be useful to develop initial project goals and solutions.

Notes:

The Green Building Advisor™

The Green Building Advisor is an interactive software that can be used to identify potential strategies for green building design. Over seven hundred solutions can be reviewed. Information about a particular project can be input in order for the program to process solutions that might be most appropriate to the characteristics of a particular renovation or new construction. In this case, the software sorts the solutions according to those that are:

- Strongly Recommended
- Moderately Recommended
- Not Recommended

The solutions are organized by those categories of sustainable design that have already been presented in this training, including:

- Site & Ecosystems
- Energy Use
- Water Use
- Resources & Materials
- Indoor Environment

The software also contains numerous case studies, sustainable product listings,

technical articles, and links to Internet resources.

Barriers to Sustainable Design

There are a number of barriers to sustainable design. They include:

1. ***Incomplete integration***
   a. Each project phase is typically isolated.
   b. Feedback and reporting mechanisms are lacking.

   Recommendation: Encourage communication throughout the design regarding process and solutions. Share lessons learned.
2. ***Focus on first costs***

   Recommendation: Identify as early as possible those solutions that may have a positive impact on long-term cost. Provide information to Finance regarding these solutions and specific calculations showing estimates of long-term economic benefits.
3. ***Lack of an accepted life cycle costing methodology***
   a. Lack of agreed-to variables to utilize in life-cycle models.
   b. Frequently additional up-front costs are recoverable.

   Recommendation: Encourage the Department of Finance to participate in project discussions on life-cycle decisions.
4. ***Insufficient building performance and operating standards***
   a. No uniform building performance and/or operating standards for state buildings.

   Recommendation: Consider existing standards such as Title 24 as a minimum and strive to exceed where possible.
5. ***Lack of incentives***
   a. Builders and designers do not profit directly from a building's operational cost savings, environmental performance or worker productivity.

   Recommendation: State may develop incentives that not only promote sustainable building but also reward its application.
6. ***Failure to comply with state laws***
   a. Recycled-content product procurement statutes, for example.

   Recommendation: Recognize that fines can be imposed for non-compliance. Also become familiar with resources to assist in meeting such requirements as most of them are reasonable and will not take an extraordinary amount of time.
7. ***Concerns about specific technologies***
   a. Unfamiliarity with products, technologies, and systems.

   Recommendation: Do not try to implement a huge quantity of sustainable solutions initially. Instead, select a smaller number of new technologies or products most likely to have the biggest long term impact for evaluation. Then be sure to record any research or conclusions drawn for use on future projects.

Other DGS Initiatives

DGS sustainable design requirements are not intended to take priority over any other DGS initiatives. In fact, sustainable design should compliment other programs such as the DGS Excellence in Public Buildings Initiative and the Golden Seal Program.

Resource	*Description*	*Website*
Green Building Advisor	Green Building Advisor (GBA) is an interactive software program that helps you design new buildings and retrofit existing buildings to be environmentally friendly.	Order at: http://www.buildinggreen.org
Executive Order 13123, Greening the Government Through Efficient Energy Management	This page on the Whole Building Design Guide web site provides links to Executive Orders related to sustainable design.	http://www.wbdg.org/federalMandates.asp
10CFR435, Energy Conservation Voluntary Performance Standards for New Buildings		http://www.eren.doe.gov/buildings/codes_standards/stkgen.htm

II. STEP 1 – REQUEST FOR QUALIFICATIONS

REQUEST FOR QUALIFICATION

Step 1 of the evaluation process is based on the qualifications of the Design-Builder. The three (3) parts of this step are: Part A–Mandatory Requirements, Part B–Subjective Criteria, and Part C–Interview.

- **Part A Mandatory Requirements Evaluation.** The Mandatory Requirements will be evaluated by the RFQ Evaluation Team and reviewed for completeness and conformance to project requirements. Each Design-Builder must meet or exceed the requirements and provide written answers to all questions in Part A–Mandatory Requirements in order to be evaluated on the criteria set forth in Part B–Subjective Criteria. No points are scored in this part; a submittal either qualifies or not.

- **Part B Subjective Criteria Evaluation.** The Subjective Criteria will be evaluated by the RFQ Evaluation Team and assigned quality points for relative merit of written data and answers based on the criteria listed below. Representatives of the California Energy Commission (CEC), California Integrated Waste Management Board (CIWMB), The Air Resources Board, (ARB), and the Department of Health Services (DHS) will evaluate the criteria pertaining to energy efficiency and sustainable building measures. The Rating System discussed earlier will be the basis for scoring quality points. Points assigned indicate the relative importance of each category.

1. **Relevant Experience of the Design-Build Team**

   Each of the participants listed below will be required to designate three (3) relevant design-build projects having been fully constructed and clearly identifying relevance of each. Specific project related experience, design-build experience, energy efficiency and sustainable building design experience, and historical client information and satisfaction shall be considered.

a.	Relevant Experience of the General Contracting Firm based on size, scope, complexity, energy efficiency and sustainable building design experience, and other factors.	500 Points
b.	Relevant Experience of the Architectural Firm based on size, scope, complexity, energy efficiency and sustainable building design experience, and other factors.	250 Points
c.	Relevant Experience of the Structural Engineering Firm based on size, scope, complexity and other factors.	125 Points
d.	Relevant Experience of the Mechanical Engineering Firm based on size, scope, complexity, energy efficiency and sustainable building design experience, and other factors.	125 Points
e.	Relevant Experience of the Electrical Engineering Firm based on size, scope, complexity, energy efficiency and sustainable building design experience, and other factors.	125 Points

f. Relevant Experience of Other Firms based on size, scope, complexity, energy efficiency and sustainable building design experience, and other factors. — 125 Points

2. **Relevant Experience/Training of Key Personnel**

List of proposed key personnel and references for the Design-Builder's team who would be assigned to or is responsible for work on this project. An organization chart indicating lines of responsibility and authority levels for each position is also required.

a. Relevant Experience of General Contractor's Personnel based on size, scope, complexity, energy efficiency and sustainable building design experience, education, training, and other factors. — 200 Points

b. Relevant Experience of Architect's Personnel based on size, scope, complexity, energy efficiency and sustainable building design experience, education, training, and other factors. — 100 Points

c. Relevant Experience of Engineers and Other Team's Personnel based on size, scope, complexity sustainable building design experience, education, training, and other factors. — 100 Points

Recommendation

Based on the scoring of the Subjective Criteria, the RFQ Evaluation Team will identify up to the five (5) most qualified Design-Builders to be interviewed by the Selection Committee. The points received in Part B–Subjective Criteria will not carry over into Part C–Interview. However, the ranking of the teams will be made available to the Selection Committee for verification. This list of five (5) most qualified Design-Builders, along with their submitted qualifications, will be provided to the Selection Committee in preparation for the interview process.

☐ Part C Interview — 500 Points

The Selection Committee will conduct interviews with each of the five (5) Design-Builders. The interview process will be used to narrow the list of potential proposers from five (5) to no more than three (3) Design-Builders. The interview will provide the Design-Builder the opportunity to elaborate on the written material previously submitted in their Qualifications Package and to give the Selection Committee the opportunity to meet their key personnel.

The Design-Build teams will be evaluated on the relative experience of the individual firms and their key personnel. These are the same criteria that formed the basis for Part B– Subjective Criteria of the Request for Qualifications. A simplified score sheet will be provided to the Selection Committee for their ranking of the Design-Builders.

The Design-Builders should be prepared to describe the roles and responsibilities of their proposed team members and their experience in the design and construction of relevant design-build projects, including experience in energy efficiency and sustainable building design measures. The Design-Build teams should have those individuals responsible for the management of the design and construction disciplines describe their personal and firm experience. They should emphasize their experience as it relates to the understanding of the proposed design-build process and their approach to insuring conformance to the Criteria Documents. Attention should be given to demonstrating the relative experience of the team utilizing energy efficiency and sustainable building design measures. Each Design-Builder should be prepared to respond to specific questions about their qualifications.

Prior to the pre-qualification interviews the client contact provided for the relevant projects may be contacted to obtain additional information. Each reference will be asked the same information based on pre-prepared questions

No more than the three (3) top ranked Design-Builders will be invited by the Selection Committee to participate in the Request for Proposal phase.

Comparative Scoring Method

Each criterion is assigned a total point value. The evaluator will assess each response in comparison to the other two and determine its relative level in comparison to that proposed by the other two Design/Build teams. The evaluator will distribute the points among the three proposals relative to its comparative merits such that the total point value for the category is not exceeded.

Example:

A criterion is assigned a point value of 10. In comparison the responses are judged equal to each other. The evaluator should award the same number of points to each response making sure that the aggregate total for the criterion does not exceed the point value, in this case 10 points (e.g., 3-3-3 or 2-2-2, etc.). The total of points may be less than the point value.

Should one or two of the responses be evaluated as being superior to the other(s) the scoring should reflect this (e.g., 5-3-2 or 4-4-2 or 3-2-2, etc.). In each case the aggregate score can be less but never more than the point value assigned.

Designated Subcontractors **Comparative Scoring 17% of total score**

Each Design/Builder will be required to list the specific subcontractors, by license classification, as designated by the State in the RFP. The Design/Builder may, at its option, designate up to two (2) additional subcontractors.

Similar to the qualification evaluation, designated subcontractors shall be evaluated as to their experience and expertise on relevant projects. These criteria include experience in design/build delivery; projects of similar size, scope, and complexity; their work history with the Design/Builder; experience in proposed role; experience with public work; and other factors deemed relevant and applicable.

Each designated subcontractor will be evaluated by the comparative method described above.

Building Systems Description **Comparative Scoring 23% of total score**

Scoring will be by the comparative method described above.

a. Exterior Closure/Wall System will be evaluated on design, function, aesthetics, level of quality, and other relevant factors.

b. HVAC System evaluation criteria include functional design, life cycle costs including maintenance and replacement costs, energy management controls system, distribution and zoning, and other relevant factors.

c. Structural Framing/Foundation System will be comparatively evaluated on the relative design qualities and characteristics of the, foundation systems, lateral and vertical load resisting systems, functional flexibility, and other factors deemed relevant.

d. Electrical System evaluation criteria functional life cycle costs including maintenance and replacement costs, energy management controls system, distribution and zoning, operational flexibility, and other relevant factors.

e. Interior Office Design will be evaluated on function and flexibility, aesthetics, level of quality, and other relevant factors.

f. Energy Efficiency and Sustainable Design Measures will be evaluated on overall performance of the systems in energy efficiency, sustainable measures including recycling and resource conservation, indoor air quality, alternative energy technologies, and other factors deemed relevant.

Design and Construction Management Plan **Comparative Scoring 29% of total score**

This evaluation considers the quality and effectiveness of the Design and Construction Management Plan. Requirements include addressing, at a minimum, the following: 1) waste management plan, 2) construction traffic plan, 3) tree management plan, 4) QA/QC plan, 5) safety plan, 6) close-out and commissioning plan, 7) scheduling plan, 8) management organization and lines of communication and authority, 9) coordination of project team, 10) community outreach, and other factors deemed relevant. Scoring will be by the comparative method described above.

Quality Enhancements/Extras **Modified Comparative Scoring 22 % of total score**

Because the content and number of enhancements proposed will vary, a modified comparative scoring will be used. Each enhancement will be individually evaluated using the worksheets provided. Upon completion of this initial evaluation the enhancements will be considered in its totality for each proposal and comparatively scored in comparison to the totality of each of the other two proposals.

Proposed Quality Enhancements or Extras consist of specific elements wherein the Design/Builder believes that its proposal will deliver a level of quality in excess of the minimum requirements as set forth in the criteria documents. In this Part, Design/Builders are ranked on the basis of value added to the project, design and construction innovation, and responsiveness to quality of systems and materials. Examples of enhancements or extras that could be considered are described in the Proposal Form.

Small Business/DVBE Utilization Plan **Comparative Scoring 4% of total score**

The evaluation also considers the Design/Builder's response to the requirements for a Small Business/Disabled Veterans Business Enterprise Utilization Plan Scoring will be by the comparative method described above.

Cost Proposal with Detail Breakdown **Comparative Scoring 5% of total score**

The Proposal shall include a cost proposal identifying all costs with supporting detail indicating that the Design/Builder's Proposal is within the Stipulated Sum. The cost estimate template provided will be used to review the Proposers' proposals. The evaluation should consider completeness and reasonableness of Proposers unit costs and quantities and identify potential cost issues for negotiation, if necessary.

Evaluation Report

After completion of the scoring evaluations by each group of the Technical Evaluation Committee, the TEC will meet as a whole and arrive at a consensus scoring and evaluation report. These will be transmitted to the Selection Committee prior to the final interviews.

The elements of the final report in outline form are attached to the forms section of this handbook.

	Building Energy Consumption	Building IAQ	Building IEQ	Site / Building Water Usage	Other Environmental Impacts	Operations
Site Design						
Building Orientation	x	x	x		x	x
Material Selection				x	x	x
Landscape Design					x	x
Building Design						
Envelope Design	x	x	x		x	x
System Selection			x		x	x
Lighting	x		x		x	x
HVAC	x	x	x	x	x	x
Electrical Distribution	x				x	x
Plumbing				x	x	x
Material Selection		x			x	x
Construction Practices		x			x	
Operations	x	x		x	x	x

Roles During Integrated Sustainable Design

	Customer	Facility Manager	Real Estate	DGS Project Manager	Finance	Architect	Mechanical Engineer	Electrical Engineer	Lighting Designer	Civil Engineer	Interior Designer
Sustainable Goal Setting	x	x	x	x	x	x	x	x	x	x	x
Site Selection	x		x		x						
Site Design											
Building Orientation	x			x		x	x	x		x	
Material Selection	x	x		x		x				x	
Landscape Design	x			x						x	
Building Design											
Envelope Design	x			x		x	x		x		
System Selection				x							
Lighting	x	x		x		x	x	x	x		
HVAC	x	x		x		x	x				
Electrical Distribution	x	x		x		x		x			
Plumbing	x	x		x		x	x				
Material Selection	x	x		x		x					x
Construction Practices				x		x					

LEED V 2.0 EVALUATION
Project:

Most Recent Comments Recorded on:

LEED PREREQUISITES/ CREDITS	REQUIREMENT	POINTS AVAIL.	YES	PROBABLE	MAYBE	NO	COMMENTS FROM DESIGNERS	SUSTAINABLE REVIEW COMMENTS/ ACTION ITEMS	ESTIMATED ADDITIONAL COST
LEED CERTIFIED: 26-32 Points; Silver: 33-38 Points; Gold: 39-51 Points; Platinum: 52+ Points									
MATERIALS and RESOURCES									
Materials Prerequisite: Storage & Collection of Recyclables	Provide an easily accessible area that serves the entire building that is dedicated to the separation, collection and storage of materials for recycling including (at a minimum) paper, glass, plastics, and metals.	REQ'D.							
Materials Credit 1: Building Reuse	Reuse large portions of existing structures during renovation or redevelopment projects.								
	Maintain at least 75% of existing building shell (exterior skin and framing excluding window assemblies).	1							
	Maintain an additional 25% (100% total) of existing building shell (exterior skin and framing excluding window assemblies).	1							
	Maintain 100% of existing building shell AND 50% non-shell (walls, floor coverings, and ceiling systems).	1							
Materials Credit 2: Construction Waste Management	Develop and implement a waste management plan, quantifying material diversion by weight.	N/A							
	Recycle and/or salvage at least 50% (by weight) of construction, demolition, and land clearing waste.	1							
	Recycle and/or salvage an additional 25% (75% total by weight) of the construction, demolition, and land clearing debris.	1							
Materials Credit 3: Resource Reuse	Specify salvaged or refurbished materials for 5% of building materials.	1							
	Specify salvaged or refurbished materials for 10% of building materials.	1							
Materials Credit 4: Recycled Content	Specify a minimum of 25% of building materials that contain in aggregate a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material.	1							
CREDIT TOTALS									

California SUSTAINABLE DESIGN Training 2001

Section 3: Sustainable Sites

HDR

Sustainable Site Design/ Water Efficiency

Sustainable Site Issues

The impact of site selection and design is no less important than the sustainable design of a building itself. The three issues that should be considered regarding sustainable sites are:

- Sustainable Site Selection
- Sustainable Site Design
- Water Efficiency and Water Quality

There are many sustainable design solutions for any project. The designer should, in order to integrate the best sustainable solutions, ask at every phase during the design process “will this design decision reduce long-term negative impacts on the natural environment or building occupants while meeting all other project requirements?”

Sustainable Site Selection

Selecting a site can have long-term impacts on the environment. Consider, for example:

- What are the potential environmental impacts related to the site location?

For example, do not build near wetlands; avoid land close to the flood plain

- How far will building occupants have to travel to get to the site?

Consider distance from site to public transportation

- Are there options for building occupants to take non-polluting forms of transportation to the site?

Select sites with existing infrastructure

- Has the site been developed before, or will construction damage previously undisturbed land?

Consider building on brownfields

- Is the site home to endangered habitat or vegetation?

Avoid endangered species habitats

- Are there local air quality problems that might impact building occupants?

Select a site that avoids nearby sources of potential air quality problems

As with all good design practices, there are some common sustainable selection and design practices and requirements that may be considered good sustainable site design.

Good Site Selection Practices

DGS Directive on Location of State Offices

This memo, in response to Executive Order D-46-01, directs DGS staff as well as client agencies to consider factors, including sustainable building programs, when establishing the location of state offices. The policy “should reduce to the extent feasible traffic congestion and air

pollution, and it should support sound growth patterns in California's population centers". Specifically, the following smart growth factors should include:

- Locating in a central city…in order to strengthen California's population centers;
- Locating in proximity to public transit corridors;
- Locating in proximity to available and affordable housing;
- Demonstrating sensitivity to building design, scale, and environmental concerns;
- Exploiting objectively viable opportunities for mixed use.

Notes:

Sacramento Municipal Utilities District (SMUD)

One good example of sustainable site selection is the location of the SMUD Customer Service Center is Sacramento. Primary factors for selecting the current site included:

- The proximity of the site to the existing administrative building to minimize employee travel time and effort. The proximity of the site to the RT Light Rail and bus station to encourage more use of mass transit. The orientation of the site on an east-west axis. This provides an optimal north-south exposure for daylighting and minimizes exposure to east and west sunlight. The proximity of the mature redwood groves that can provide natural cooling and shading to the building.

Sustainable Site Design

The following recommendations will help reduce impacts of site design.

- Use urban-derived (i.e. organic materials diverted from disposal) compost & mulch to build healthy soils
- Minimize impact to the site during construction
- Reduce quantity of stormwater runoff and improve quality of runoff
- Specify resource-efficient landscape design and installation
- Consider building water reuse or capture of rainwater
- Specify recycled-content products for use in landscape areas

Site Design Recommendations

1. Use urban-derived (i.e. organic materials diverted from disposal) compost & mulch to build healthy soils.

Organic materials comprise over 40 percent of the disposed waste stream. Diversion of these materials is crucial for conserving landfill capacity, and for reducing the generation of green house gasses (carbon dioxide and methane) from municipal solid waste landfills.

In addition, the urban derived compost and mulch products (i.e. compost and mulch product made from organic materials diverted from disposal) provide a value-added organic product for use in landscape areas.

Use of these urban derived compost and mulch products can reduce the need for chemical fertilizers, herbicides and pesticides.

Typically, when new development takes place, existing vegetation and native soil are removed. After construction, a thin layer of topsoil is spread on very compacted subsoil. The new landscape acts much like an impervious surface. Rainwater, unable to infiltrate into the soil, quickly runs off into streams carrying sediments, pesticides, fertilizers, and other chemicals. Soil amended with compost and other organic amendments can transform poor soils into a fertile growth medium that supports healthy plant growth while reducing water, fertilizer, and pesticide requirements. The soil can also act as a biofilter, capturing and holding potential pollutants in place so soil microbes can decompose them. The end

result is fewer chemicals, less irrigation, fewer stream problems, cleaner water, thriving landscapes, and lower maintenance costs.

The California Integrated Waste Management Board maintains an Index to Compost and Mulch Source List. Information includes a list of counties that have businesses that market organic materials products. Information includes primary distribution points for compost and mulch, feedstock used, annual production, and products available.

2. Minimize impact to the site during construction

- Use a site sedimentation and erosion control plan
- Limit access of heavy equipment
- Consider relocating disturbed vegetation
- Minimize disturbance to existing vegetation

3. Reduce quantity of stormwater runoff and improve quality of runoff

Problems associated with stormwater runoff include the quantity of runoff and the quality of stormwater runoff. The management of stormwater runoff requires supporting infrastructure and associated maintenance. Stormwater is also polluted from contaminants and sediment collected from pavement and non-pervious surfaces.

First reduce stormwater volumes. For example:

- Reduce impervious surfaces
- Design a smaller building footprint

Notes:

- Use roof gardens or green roofs
- Capture stormwater for reuse (such as for fire sprinklers or sewage conveyance)

Next, filter stormwater. For example:

- Design detention ponds
- Design natural features to filter runoff, such as constructed wetlands, vegetated filter strips, or bioswales
- Use other technologies or systems to filter runoff, such as oil and grit separators

Chicago City Hall Roof Garden

The picture is of the Chicago City hall green roof. The roof was installed for the Chicago City Hall Urban Heat Island Initiative project. This is a sophisticated design that includes a range of roof landscape environments, ranging from a 3.5-inch deep 'extensive' system to 24-inch deep 'intensive' landscape islands. Approximately 14,000 cf of polystyrene was used to create the illusion of a rolling terrain. The project included a drip irrigation system fed partially by water collected from the adjacent penthouse roof. Construction at one of the city's busiest intersections also added to the challenges associated with this project. The project was intended to demonstrate the benefit of green roofs in moderating summer temperatures within ultra-urban environments. The roof is monitored to demonstrate these benefits.

The Austin, Texas Greenbuilder Program publishes the Sustainable Building Sourcebook. The content regarding pervious paving includes specifications, implementation issues, guidelines, and resources.

4. Design and Install Landscape for Resource-Efficiency

- Design and plant for proper plant spacing (avoid overplanting which results in excess pruning, possible plant removal, and generation of green waste)
- Limit turf areas (avoid narrow strips, severe slopes, etc.) These turf areas are hard to maintain, encourage water/chemical runoff, and can cause hardscape damage. Turf areas should be functional and designed for easy maintenance.
- Consider other ground covers, native grasses and wildflowers instead of turf.
- Aim for diversity. Monocultures are prone to disease and insect infestation.
- Group plants that have similar watering needs to prevent over-watering and excessive plant growth.
- Select appropriate plants for local microclimates.
- Plant water-efficient species (including native species if appropriate). This type of plant material requires less water, fertilizers, pesticides, and pruning; generates less green waste, & supports wildlife.
- Select plants that will not grow too large for their space or over walkways, driveways, etc., as they will require

constant pruning & generate excessive green waste.
- Avoid using invasive plant species.
- Use water efficient irrigation systems and energy efficient lighting in landscape areas.
- Provide for the onsite composting and/or chipping and grinding of landscape trimmings, prunings and grass clippings for reuse onsite; or ensure that these materials are diverted to a local compost facility.
- If a cafeteria is included in the building, incorporate a food scrap collection program as part of the organic materials composting program. The resulting compost product should be reused in landscape areas.

The State of California Department of Water Resources provides a number of related resources including an Efficient Landscape Ordinance, and a publication titled Irrigation Water Needs of Landscape Plants in California

5. Consider building water reuse or capture of rainwater

Rainwater Catchment at a Ft. Worth, TX Post Office

The rainwater collection storage tanks at the Ft. Worth Post Office was installed to provide drinking water, but was first used as irrigation while the water quality was tested. As a semi-private federal agency,

Notes:

the Postal Service was not under the jurisdiction of local building and health codes, which have made this installation more difficult.
It is estimated that the combination of water conservation strategies and water collection in this facility will save over one million gallons per year, resulting in cost savings to the USPS of about $2,800.

The State of California Department of Water Resources offers a a Graywater Standard and a Graywater Guide.
The Department of Health Services also has numerous resources on recycling water.

6. Specify recycled-content products for use in landscape areas:

- Outdoor furniture, such as benches, tables, and chairs, etc., should be purchased from suppliers making recycled content productc
- Bender board - purchase a plastic lumber product for use in planter bed areas.
- Tree stakes and ties - Use recovered lumber, or other recycled content product, for tree stakes and ties made from waste tires.
- Irrigation equipment - specify the use of recycled content plastic pipes, joints, and fittings.

Recycled Content Park Bench

The California Integrated Waste Management Board's Recycled-Content Product Database includes site products.

Other Site Issues

- Properly site building to take advantage of microclimate (Refer to Energy section of the training manual)
- Use vegetation to provide shade
- Design site lighting that minimizes light pollution in the night sky
- Create positive connections between the new/renovated facility and it's community.
- Encourage development of urban infill sites or rehabilitation of an existing building.

Benefits of Sustainable Site Design

- Reduce water usage on site
- Associated labor and resource cost
- Reduce long-term energy consumption
- Reduce operating cost
- Reduce negative impacts of energy production
- Reduce chemical usage on site
- Environmental benefits
- Improve local water quality
- Reduce disturbance to habitat and ecosystems
- Reduce emissions

Sample Projects in California

Solar Living Center, Hopland
Sustainable site features

- On-site water sources
- Agricultural well
- Storm-water runoff
- Gray water
- Potable water
- Water flow controlled by a solar-powered pump
- Constructed wetlands and ponds

Project benefits:

- Reduces irrigation needs
- Reduces energy use
- Restores water resources
- Connects visitors with landscape and seasonal cycles
- Provides associated cost savings

The final project cost was $1.86 million, including all site and building development costs. Annual savings related to water efficiency and reuse measures is approximately $7,800 annually.

GAP Headquarters, San Bruno

Sustainable site features:

- Roof covered with a mixture of native grasses and wildflowers (solution is low-maintenance, provides thermal and acoustic insulation, and contributes to increased energy savings; roof also absorbs rain, slowing run-off to local storm drains)
- A grove of mature oaks existing on the site was preserved.
- Natural ventilation
- Form of building is designed to integrate into surrounding terrain

Notes:

Resource	Description/ Notes	Website
American Rainwater Catchment Systems Association	ARCSA was formed in Austin, Texas in 1994 to promote rainwater catchment systems in the United States. The association has prepared a publication for guidance in developing and building rainwater catchment systems.	http://www.nku.edu/~biosci/arcsa/arcsa.html
CA Air Resources Board "Asbestos in Rocks and Soils" Guidance	(CA LEED Supplement Reference)	www.arb.ca.gov/toxics/asbestos.htm
CA Air Resources Board of Toxic Hot Spots	The purpose of these guidelines is to provide procedures for use in preparing health risk assessments required under the Air Toxics "Hot Spots" Act.	http://www.arb.ca.gov/ab2588/riskassess.htm
California Department of Health Services Guidelines for Recycled Water	Standards for the use of treated and reclaimed wastewater.	http://www.dhs.ca.gov/ps/ddwem/publications/waterrecycling/index.htm
DGS Policy on Location of State Facilities		http://www.osp.dgs.ca.gov/Publications/sam/mmemos/mm01_18.pdf
Index to Compost and Mulch Source List	List on the California Integrated Waste Management Board web site of counties that have businesses that market organic materials products. Information includes primary distribution points for compost and mulch, feedstock used, annual production, and products available.	http://www.ciwmb.ca.gov/Organics/SupplierList/
Irrigation Association	The Irrigation Association has a certification program for irrigation specialists.	http://www.irrigation.org

Resource	*Description/ Notes*	*Website*
Pervious Paving Materials Resources	The Austin, Texas Greenbuilder Program publishes the Sustainable Building Sourcebook. The content regarding pervious paving includes specifications, implementation issues, guidelines, and resources.	http://www.greenbuilder.com/sourcebook/PerviousMaterials.html
Recycled-Content Product Database	The California Integrated Waste Management Board's Recycled-Content Product Database includes site products.	http://www.ciwmb.ca.gov/RCP/
Regional County Sanitation District Recycling Water for Irrigation	Information on water recycling for irrigation in Sacramento and surrounding areas.	www.srcsd.com/recyclwat.html
State of California Department of Water Resources	Resources include: Water Efficient Landscape Ordinance; Revised Graywater Standard; Graywater Guides; Irrigation Water Needs of Landscape Plants in California	http://wwwdpla.water.ca.gov/urban/land/
State Water Resources Control Board, Construction Storm Water Program	Construction activity resulting in a land disturbance of five acres or more, or less than five acres but part of a larger common plan of development or sale must obtain described permits.	http://www.swrcb.ca.gov/stormwtr/constfaq.html
Wateruse Association of California	The WateReuse Association (WateReuse) is a national organization dedicated to increasing the beneficial use of recycled water.	http://www.webcom.com/h2o/
WaterWiser	This site contains information on water efficiency and conservation. Site services include an interactive conference, reference searching, a service company directory, and links to related sites.	http://www.waterwiser.org/

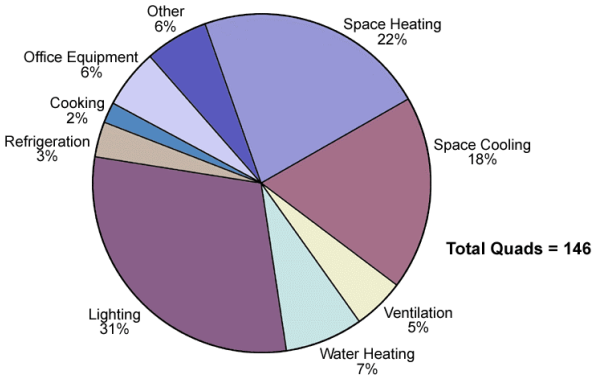
California SUSTAINABLE DESIGN Training 2001

Section 4: Energy

HDR

Energy

U.S. Energy Consumption



According to the Energy Information Administration, approximately 45% of the energy consumed in a commercial building is used to artificially heat and cool a space. Approximately 31% is used for artificial lighting.

California Codes and Guidelines

TITLE 24, Part 6 Energy Efficiency Standards Title 24 was established in 1978 by the California Energy Commission to reduce energy demand. Title 24 includes **prescriptive and performance approaches** to meeting code i.e.;

- Maximum energy use for standard office building: 17 KwH/ft^2-yr
- Maximum Office lighting 1.2 watts/ft^2

Mandatory measures include the building envelope, the mechanical system, ducts, and lighting.

Performance standards vary according to building type. There are thirteen non-residential building types identified.

The latest revisions, AB 970, effective June 2001, were written in response to the energy crisis. They included significant revisions to glazing and lighting.

Government Code Sections 15814.30 – 15814.35 states that "State Buildings shall be models of energy efficiency…."

Sustainable Design Task Force Energy Tier Lists

DGS Tier list requirements are as follows:

- All Tier One measures are required to be implemented on all projects unless not applicable or inappropriate
- Tier Two measures should be considered and recommended as appropriate on a project-by-project basis

California Leadership in Energy and Environmental Design Standard (LEED™) Supplement

A California-specific LEED supplement is currently under development. The supplement references local and regional standards in addition to the national standards referenced in LEED.

Energy Design Goals

The long-term energy consumption of a building has the most significant environmental impact, and from an operational cost standpoint, the most economic impact, than any other building characteristic.

Two of the most critical steps toward the design and construction of a sustainable building are:

- **Setting energy design goals** at the beginning of a project, and
- **Evaluating all opportunities for an energy efficient design**

Notes:

Setting Energy Goals

An integrated approach should be used to determine goals early in the design. This can include:

- Collaboration and prioritization setting
  - Input from all design and engineering professionals, project managers, tenant/owners, facility mangers
  - Establish performance goal in relation to Title 24
  - Use life cycle economic analysis and financial incentive programs to lower first costs and costs of ownership
- Initial team meetings to learn team member styles, priorities and approaches
- Use of common software to facilitate plan and document sharing
- Utilize energy modeling software to simulate energy use based on various system configurations and building orientation

Priorities in Setting Energy Goals

1. ***Consider Building Orientation***
   - Site building to take advantage of natural light and decrease heat gain
2. ***Design Building Envelope, considering:***
   - Exterior materials
   - Insulation
   - Daylighting, including: window selection, use of building design elements such as clerestories, lightshelves
3. ***Select appropriate building systems***
   - Design for HVAC (premium) efficiency

- Use advanced building controls and commissioning

4. ***Consider distributed generation technology sources***

Increased energy efficiency reduces:
- energy demand
- need for new power plants
- green house gas emissions;
- and saves money.

Example: SMUD Customer Service Center

SACRAMENTO MUNICIPAL UTILITY DISTRICT
CUSTOMER SERVICE CENTER BUILDING

Architect: Williams and Paddon – Architects and Planners
Size: Two to Four Story, 190,000 s.f.
Completion: November, 1995
Awards: 1993 American Institute Of Architects Design Award
Project Features Sacramento Metropolitan Utilities District (SMUD), a customer-owned utility, presented the following challenge:
- to create a new 190,000 s.f. Customer Service Center
- be cost effective on a lifecycle basis
- and most importantly, become an effective ambassador for energy efficient design in their service area.

The building is focused on Customer Service, supported by an employee Fitness Center, a public Cafe, and an Energy Education Center that supports the Utility's growing attention to demand side energy management.

SMUD Design Process
The design process included
- Detailed masterplanning
- Design charrettes with all disciplines
- Target efficiencies established early
- Detailed systems energy modeling to meet targets

SMUD Energy Design Goals
The design goals for this building as they relate to the energy systems are summarized as follows:The primary design goal is to provide a working environment that emphasizes the health, comfort, safety and productivity of the occupant,Maximize occupant control of their work environment for comfort and productivity,Surpass the California energy code (Title 24) for commercial buildings by at least 25%,Use efficient, commercially available, proven technology for energy systems and equipment,Evaluate design alternatives on a life-cycle cost basis, and; Provide flexibility in construction to permit easy retrofit of new technologies and demonstration systems.

In addition to designing a building that used at least 25% less energy **than a comparable office building, the design team looked for design solutions that used natural ventilation, natural daylighting and solar energy in a cost-effective manner.**

Why Exceeding Title 24 Most well designed buildings today are considerably better than the energy code minimum.

Good architects and engineers recognize that the greatest value to the owner usually means going beyond the minimum.

A California Energy Commission study found that, for office buildings throughout the State, efficiencies of 20% better than T-24 are possible with simple payback periods of less than 5 years.

Notes:

Climate Zone	Payback Period (yrs)	% Better than 24
Small Office		
12 (Sacramento)	0.9	21%
10 (Riverside)	1.3	22%
3 (Oakland)	1.8	19%
Large Office		
12 (Sacramento)	2.4	21%
10 (Riverside)	1.1	23%
3 (Oakland)	1.2	21%

Exceeding Title 24 can be accomplished by:

- Provide interdisciplinary whole building approach
- Site building to take advantage of natural light and decrease heat gain
- Design envelope with material thermal resistance, proper insulation, efficient glazing
- Use daylighting features for natural light to offset artificial lighting demand
- Design for HVAC (premium) efficiency (detail a few items)
- Use advanced building controls and commissioning

Energy

Public Buildings Exceeding Title 24
There are a number of examples of buildings in California that exceed Title 24 and show significant energy savings. They include:

Capitol Area East End Complex
This building, currently under construction is expected to perform at least **30% below Title 24**, with an associated **savings: $400,000 annual** energy savings predicted.

City of San Diego Ridgehaven Building
Operating at 61% below Title 24.

City of Santa Monica Public Safety Facility
Operating at least 40% below Title 24.

Building Orientation

Building orientation can have long-term implications on the energy consumption of a building. Buildings should be sited to take advantage of solar orientation, wind patterns, and vegetation that might contribute to shading.

SMUD Building Siting
Before work started on the building design, the spatial relationships of the project were studied. From an energy perspective, the best site would allow the building to align with the natural path of the sun which directly affects energy for cooling and daylighting. The energy required for the day-to-day activities of customers, visitors and employees was also considered.
Siting resulted in:

- Long axis in East/West direction
- Allows elimination of west windows
- Reduces air-conditioning load

SMUD East-West Axis Building Orientation

Building Envelope Design
The building envelope design will have significant impact on the long-term cost of operating a building. Materials should be carefully selected to properly insulate the building, allowing appropriate amounts of daylighting into the facility, while reducing unnecessary solar gain.

The U.S. DOE Energy Efficiency and Renewable Energy Network has extensive amounts of information on building envelope design including:
Technologies:

- Windows
- Insulation
- Walls
- Alternative Building Materials
- Roofing

Issues

- Moisture and Leakage Control
- Thermal Bridges
- Indoor Air Quality and Air Exchange
- Whole Building Design

Other resources include:

The Building Technology Center at Oak Ridge National Laboratory Building Thermal Envelope Systems and Materials program.

[Rocky Mountain Institute Weatherization, Insulation and Windows]

Notes:

SMUD Envelope Design

- R values greater than the current Title-24 standards
- Shading of all glass areas from direct sunlight
- Optimized placement of glass: no west-facing windows, south glass completely shaded, north glass is maximized to provide optimum daylighting
- Visual access to natural lighting provided to all employee workspaces
- Operable windows allow employees to choose natural or mechanical ventilation.
- Exterior and interior light shelves: used to project daylight further into the interior, shade the windows and interior spaces from direct sunlight
- Extensive use of daylighting through exterior fenestration and skylights on the top floors: photocells turn off lights when a specific level of daylight is reached.
- Skylights triple glazed with white prismatic lenses: diffuses and captures more daylight for the interior, photocells control operable louvers

which open or close to maintain proper light levels.

SMUD Atrium, Showing Protected Redwood Grove Photographs: Williams and Paddon –Architects and Planners © 99

Daylighting Strategies

Benefits of optimizing the use of natural light include:

- occupant comfort
- ascetically pleasing;
- lowers electric lighting load
- reduces building's interior heat load

Considerations and variables include:

- building orientation, footprint, surrounding structures and site shading
- window placement, glazing, facades, skylights, light shelves
- layout of workspaces

Not only is daylighting important to reduce unnecessary energy consumption, according to the article "Do Green Buildings Enhance the Well Being of Workers? Yes" (Environmental Design and Construction, July/August 2000), contact with nature and sunlight has been found to **enhance emotional functioning**, resulting in positive emotions which are in turn, **associated with creativity and cognitive "flow"**. (Refer to the Indoor Environmental Quality section for more information on the benefits of daylighting).

Energy Efficient Lighting

Optimizing the use of natural light reduces the amount of artificial light needed in a building, which in turn reduces cooling loads related to heat given off by lighting fixtures.

Other efficient lighting strategies include:

- Reduced overhead lighting
- Use of task lighting
- Reflective ceiling
- Energy efficient lighting fixtures

Lighting controls

- Photo sensors with continuous dimming ballasts
- Occupancy sensors
- Programmable Energy Management Control Systems; voltage reduction and programmable scheduling

The Whole Building Design Guide has numerous resources and strategies for energy efficient lighting.
The Illuminating Engineering Society is the prime authority on lighting design. It sets standards for illumination, energy efficiency, and promotes lighting as a design element

SMUD Lighting Strategies

Considerations/Variables

- building orientation, footprint, surrounding structures and site shading
- window placement, glazing, facades, skylights, light shelves
- layout of workspaces

Solutions

- Indirect/direct system: provides ultimate in visual comfort and no glare VDT environment, low to medium ambient supplemented with task lighting, maximum control with adjustable articulating fixtures
- Programmable energy management control system with sweeps and phone accessed zone control
- Full time dimmable photosensor controlled daylighting system

Notes:

4th floor, night

Energy Management Systems

Energy management control systems are hardwired programmable logic control system that allow control of energy consuming systems in buildings and allows for real time monitoring of electrical load.

- Allows execution of sequences resulting in energy savings. For example, can turn off lights and control zone temperature settings, peak load shaving, site-wide hot and cold water reset
- Allows execution of sequences positively impacting indoor air quality

Energy

When to use

- Consider in all multi-zone buildings
- In retrofits, at a minimum, add to main air handling equipment; evaluate additional equipment based on cost/potential savings

Suggested Resources:

Building Controls

National Institute of Standards and Technologies Mechanical Systems and Controls Group

HVAC

The Pacific Energy Center offers a number of resources, classes, and services. This includes HVAC systems optimization studies.

American Society of Heating, Refrigerating, and Air Conditioning Engineers, ASHRAE

Commissioning

Commissioning is a systematic process of ensuring that building systems perform interactively according to the design intent and the owner's operational needs.

Portland Energy Conservation, Inc. Model Commissioning and Guide Plan Specifications

Commissioning for Better Buildings in Oregon, Commissioning Resources

Distributed Generation Technologies

Distributed Generation is the use of small-scale power generation technologies located close to the load being served. Examples include

- Microturbines
- Fuel Cells
- Photovoltaics
- Wind

In addition to the brief descriptions of the technologies that follow, refer to the summaries at the end of this section for more information.

Microturbines

- Similar to a small jet aircraft engine but typically has a compressor, turbine, and generator integrally combined in a single shaft
- Size range: 28 to 60 kW
- High potential for heat recovery (cogeneration)
- Heat Rate at full capacity 15,000-17,000 Btu/kWh
- Installed costs range $1,300 - $1,800/kW
- NO_x emissions .50-.70 lb/MWh

Fuel Cells

- Operating principle is conversion of chemical energy to electrical energy
- Energy conversion using fuel such as hydrogen and natural gas without combustion
- Low environmental impact
- Size range: 10 to 200 kW typical, but may be stacked to configure any desired size
- Heat Rate at full capacity 8,000-9,000 Btu/kWh
- Combustion generators produce electricity at an efficiency of 33-35%.
- Fuel cells are 40-50% efficient, up to 85% efficient if heat is reclaimed in the cell's heat exchanger
- Installed costs range $3,000 - $4,000/kW

Photovoltaics

- Operating principle is conversion of sunlight directly to electricity

- Simple off-grid systems include PV modules, batteries, mounting structure, and associated wiring
- Environmentally benign
- Size Range: 10 to 200 kW typical, but may be linked to configure any desired size
- Installed Costs (without subsidies) range $7,000 to $10,000/kW
- Designing as an oversized system provides income potential via net metering in California

Wind Turbines

- Operating principle is conversion of the wind's energy to electricity.
- Fastest growing segment of renewable energy
- Environmentally benign
- Typically these consist of generators with rotating blades on towers installed in areas with high, steady winds
- Size Range: 10 to 750 kW (individual turbines may be connected to produce a wind farm to yield a much larger capacity)
- Installed Costs range $850-$3500/kW

Distributed generation **economic factors** include:

- Desired payback period and rate of return
- Fuel
- Maintenance
- If heat is recovered, how the heat is used
- Operating Hours
- Emissions (for fuel cells, microturbines potential for regulatory compliance costs)
- Displaced power value vs. average cost of electricity
- Application of demand charges if unit(s) fail(s)

Notes:

Measures of Economic Performance

In order to determine the economic feasibility of these, or any other technology, it is necessary to address life-cycle. Important terms in life-cycle analysis include:

Simple Payback: the time in years to recoup an initial investment.
Life-Cycle Cost: costs over life of equipment
Net present value (PV): future dollars discounted to today's value

Simple Payback

Simple payback can be calculated by dividing the initial investment by the annual energy cost savings.

Advantages
- Minimum data needs
- Widely used
- Easy to understand

Disadvantages
- Ignores costs and savings that occur after payback is reached
- Does not include time value of money
- Ignores operation and maintenance costs other than energy

Life-Cycle Cost

Life-cycle cost addresses finding the alternative with the lowest life-cycle cost

Advantages
- Considers all costs and benefits throughout the study period
- Accounts for the time value of money
- Considers the residual value of the investment at the end of the study period
- Other measures of economic performance such as savings-to-investment ratio, internal rate of return and discounted payback are based on life-cycle cost analysis

Disadvantages
- Requires that the analyst collect data on replacement costs, operation and maintenance costs, and residual value
- More difficult for some people to understand

Life Cycle Cost =
Initial Investment
+ PV(Replacement Costs)
- PV(Residual Value)
+ PV(O&M Costs)
+ PV-(Energy Costs)

Life Cycle Cost Comparison Example: FDA at Irvine, CA

The following information includes highlights of a life-cycle cost comparison of mechanical equipment performed for a new laboratory designed by HDR Architecture for the Food and Drug Administration in Irvine, CA. The life-cycle cost evaluated central plant changes. The Air Handling Units for laboratory space and offices stayed constant. The labs utilized three constant volume terminal reheat units and the office utilized three variable air volume systems.

Mechanical Equipment Configurations

The following four configurations were modeled:

BASE
- 1 1500 KW electric chiller
- 1 1000 KW electric chiller with heat recovery for CVTRH coils

- 2 1000 KW gas boilers

OPTION 1

- 2 1500 KW electric chillers
- 2 1000 KW gas boilers

OPTION 2

- 1 1500 KW electric chiller
- 1 1500 KW gas absorption chiller
- 1 1000 KW gas boiler

OPTION 3

- 1 1500 KW electric chiller with heat recovery for CVTRH coils
- 1 1500 KW gas absorption chiller
- 1 1000 KW gas boiler

The graph on the following page, titled ***Annual Energy Use, Central Plant Options*** shows the annual energy usage for the four options. The blue bars (on the left of each pair of bars) indicate energy use in KWh for the base case and three options. The purple bars (on the right in each pair of bars) indicate gas consumption. The base model would consume more electricity than the other options, but less gas.

The table following the graph indicates the associated annual energy costs. This table shows the large cost associated with electricity use. Although gas represents 1/2 to 2/3 of the total KWh used, the associated cost of the gas is low. Electric demand charges are the largest factor for all options. The plot titled ***Monthly Energy Costs, Base Case***, illustrates these charges on a monthly basis for the proposed, base case design.

Finally, the chart titled ***Life-Cycle Comparisons***
Compares the following for each option:

- Initial Cost (PV)
- Annual Maintenance Cost
- Life Cycle Cost (PV

Notes:

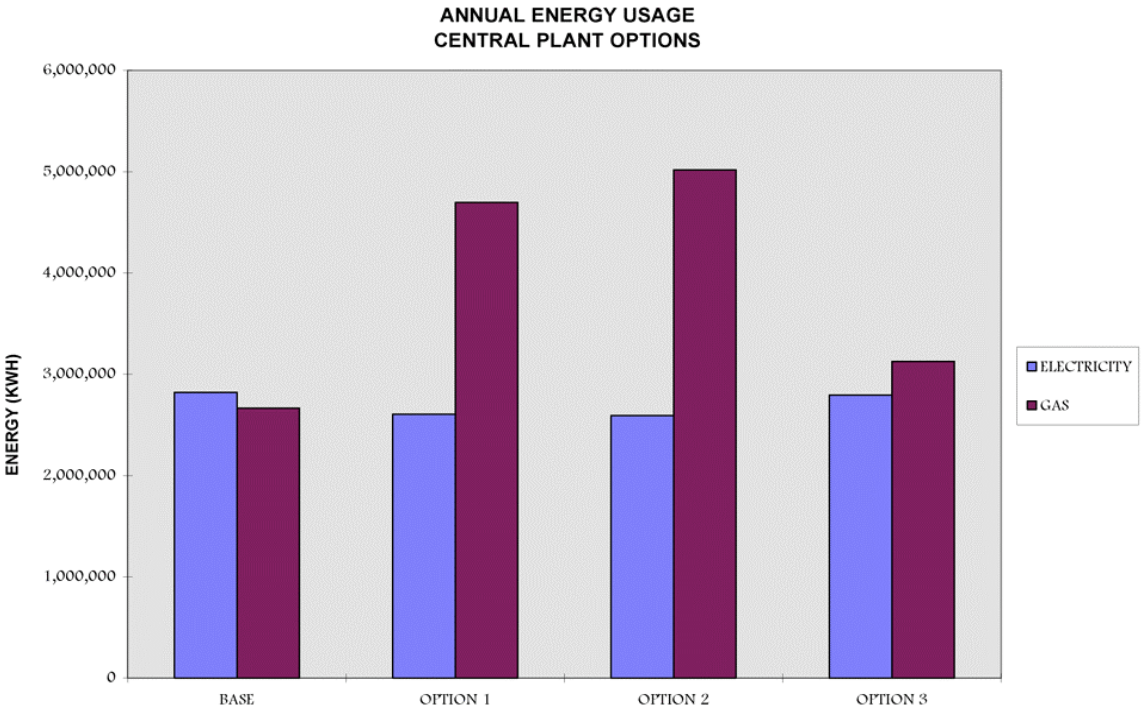
Energy

- Average Annual Energy Usage (Mbtu. Equiv.)

Summary of Results

Simulation of the four alternatives provided interesting results in terms of energy use and their associated cost. The proposed design showed a slightly higher life cycle cost when compared to Option 3. However, Option 3 is the most expensive and costly of the options. With such close life-cycle costs, special attention should be paid to other factors pertaining to the appropriateness of each system.

Option 3 has a slightly better Life Cycle Cost than the proposed design due to the reduction in demand charges by over $20,000 per year. The two options are very close. In fact, the difference in life cycle cost is less than 1%. There is, however, significantly less initial cost and maintenance associated with the proposed design, which should be considered. The proposed design does consume less energy.



ANNUAL ENERGY COSTS ($)
FDA LABORATORY AT IRVINE

	BASE	OPTION 1	OPTION 2	OPTION 3
DEMAND	225,714	224,118	207,719	204,309
ENERGY	176,943	163,641	162,503	175,302
GAS	46,311	81,241	90,106	52,083
TOTAL	448,968	469,000	460,327	431,694

Life-Cycle Comparisons

Project Alternative	Initial Cost (PV)	Annual Maintenance Cost	Life Cycle Cost (PV)	Avg. Annual Energy Usage (Mbtu. Equiv.)
Base Case (Proposed)	$262,000	$4,250	$7,203,490	18,728
Option 1	$250,000	$4,000	$7,506,828	24,926
Option 2	$425,000	$5,500	$7,527,863	25,978
Option 3	$437,000	$5,750	$7,171,653	20,199

Technology: Ground Source Heat Pumps (GSHP)

Features: The general concept of ground source heat pumps is simple: rather than generate heat why not transfer it from another source? The typical GSHP system, or *GeoExchange* – a popular industry term, is a long continuous loop of special plastic tubing buried well below the frost line. An antifreeze solution is pumped continuously through the tubing transferring warmth (heat energy) from the ground. This heat energy is collected in a heat exchanger unit within the building's HVAC system and used to pre-heat air in the cycle. This pre-heated air requires less energy to be warmed to thermally comfortable levels. By consuming less energy and decreasing wear on the heating system, consistent savings are realized.

In summer the same looped cycle continues but the heat exchange happens in reverse; heat from the building is deposited into the heat exchanger through the HVAC system. The antifreeze solution absorbs the heat and distributes it into the ground in a continuous cycle. Again, this process reduces energy loads on cooling systems, and helps moderate thermal fluctuations throughout summer days.

While the concept for ground source heat pumps is over a century old, the technology continues to become more refined in terms of reliability, standardization, and efficiency. Because sub-ground temperatures fluctuate very moderately on an annual scale, GSHP systems can be predictably engineered to very precise levels of operational efficiency.

Ground source heat pumps can be small in scale (single pumps for typical residential applications), or quite large (multiple and/or staged pumps for commercial use). The only requirement is to have access to enough ground (or water) mass to cause sufficient heat gradient exchange in the cycling process to be productive. The most cost-effective systems are installed during initial site construction, where access to ground mass is not hindered by building structure.

Economics: The typical residential ground source heat pump system costs between $2500 per ton of heating/cooling capacity. Most homes require between 2.5-4.5 tons of capacity, depending on size and location of home. The payback period depends on unit size, the amount of operation, and the local price for energy. It is common to payback the added cost of a ground source heat pump system within a few years, and the total cost between 10-14 years.

Case Studies: *Feather River College* in Quincy, California recently installed a GSHP system with a $518,000 price tag. Their annual energy savings is over $50,000. In five years the additional cost over a conventional system will be fully paid back in savings. In ten years, the system should be fully paid off, saving the community college as much as $190,000 per year in 1999 dollars. The *Esperanza del Sol (Hope of the Sun)* affordable housing development in east Dallas, Texas is the first housing project in the United States to meet the standards of the Energy Efficiency Institute E Seal certified utility

program. In conjunction with other renewable energy strategies ground source heat pump technology supplements hot water and air conditioning for six family houses. The total cost to power the houses is approximately $300 per year.

Resources: Sources dealing with ground source heat pumps are plentiful and often linked to other alternative energy saving strategies:

Web Sites:

Federal Energy Management Program	http://www.eren.doe.gov/femp/prodtech/pumps_federal_facilities.html
Description of Ground Source Types For Heat Pumps	http://www.geothermie.de/oberflaechennahe/description_of_ground_source_typ.htm
Department of Energy – Office of Building Technology, State and Community Programs – Choosing A Heat Pump (including ground source)	http://www.eren.doe.gov/buildings/heatcool_choosepump.html
International Energy Association Heat Pump Centre – Heat Sources	http://www.heatpumpcentre.org/tutorial/heat_src.htm
U.S. Environmental Protection Agency – "Geothermal Heat Pumps"	http://www.groundloop.com/
OIKOS – Green Building News Archives	http://www.oikos.com/news/index.html

Environmental Building News
122 Birge Street Suite 30
Brattleboro, VT 05301

Organizations:
International Ground Source Heat Pump Association
490 Cordell South
Stillwater, OK 74078-8018

Geothermal Heat Pump Consortium, Inc.
701 Pennsylvania Avenue N.W.
Third Floor
Washington, DC 20004-2696

Geothermal Energy Association (GEA)
209 Pennsylvania Avenue SE
Washington, DC 20003

Geothermal Resources Council (GRC)
P.O. Box 1350 - 2001 Second Street., Suite 5
Davis, CA 95617-1350

Technology: Fuel Cells

Features: Recent advances in fuel cell technology offer great promise toward achieving sustainable energy production. While the fuel cell was invented over 160 years ago, today's versions are radically changing the automotive transportation, and how industrial power is produced. A fuel cell works like a battery, except that rather than storing electricity, a fuel cell creates electricity directly (without combustion) as long as it receives fuel. Because no heat energy is lost in an intermediate internal combustion step, most fuel cells are approximately 50% more efficient, and have little emissions. They also create little heat, and are noiseless.

Fuel cells are used in various applications where power is needed. In order to create sources sufficient to drive machinery, fuel cells are clustered in stacks that provide standard units of power. In the case of automobiles, this electrical power must be converted into motive power via a drive train. This system component is currently a large part of the research and development in fuel cell technology.

There are many variations of fuel cells in development today. Most of these differ in types of fuel or in the nature of the catalytic membrane used. Those that use fuels such as methanol or even gasoline require an extractor to remove hydrogen – the "fuel" used to create electricity. The most promising are those that use pure hydrogen as a fuel source, as they have no emissions except water, and require no extraction processor.

Economics: While fuel cells have been used in space program applications for decades, commercial applications in the automotive industry are not expected until 2005. There are, however, several recent examples of fuel cell use in commercial building. Forward-thinking municipalities are investigating the impacts of new types of fuel delivery and mass transit applications of this new technology. To bridge the gap between concept and economic reality, the size of fuel cell stacks and drive trains need to be decreased, manufacturing costs must come down, and widespread infrastructure must be ensured to support viability.

Because there are few commercial applications to date to study on the viability of fuel cell technology, realized implications are still unknown. It is obvious that the potential for energy savings is great. Decreased reliance on fossil fuel extraction and the reduction of emissions should significantly save money by cost-avoidance of related detrimental environmental and health risk liabilities.

Case Studies: California's *Zero Emission Vehicle Act* (which mandates 10% of all new vehicles sold in the state by 2003 be completely emission-free), has provided the needed incentive to dissolve the business-as-usual mentality in American automotive manufacturing. California's *Fuel Cell Partnership* has brought together automobile manufacturers and multi-level government agencies, along with various energy and environmental groups to foster a fast-paced collaboration with targeted goals. Already

there are several fuel cell-powered buses running in California in pilot programs, and many automobile manufacturers are competitively touting their fuel cell prototypes.

The largest commercial application to date of grid-connected fuel cells was recently installed in the U.S. Postal Service Mail Processing Center in Anchorage, Alaska. This system produces 1 megawatt of power and is independent of the utility grid supply.
Resources: Fuel cell resources are somewhat sparse in printed form, but are frequently sited in journals and related trade or consumer-interest organizations:

Web Sites:

California Fuel Cell Partnership	http://www.fuelcellpartnership.org/
Fuel Cell World	http://fuelcellworld.org/fuelcellorg/framesets/frame_index.htm
Fuel Cell Online	http://www.fuelcellonline.com/
Fuel Cells 2000	http://www.fuelcells.org/
The California Hydrogen Business Council	http://www.ch2bc.org/bulletin/bulletin20010708.htm
EPRI – Office of Advanced Automotive Technologies	http://www.cartech.doe.gov/research/fuelcells/index.html

Literature:
Fuel Cell Handbook by A.J Appleby and F.R. Foulkes, Van Norstand Reinhold, New York, NY 1989.

Powering the Future: The Ballard Fuel Cell and the Race to Change the World by T. Koppel, John Wiley & Sons, New York, NY 1999.

Organizations:

U. S. Fuel Cell Council
1625 K Street NW, Suite 725
Washington, DC 20006

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

United States Department of Energy
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA
15236-0940

Environmental and Energy Study Institute
122 C Street NW
Washington, DC 20001

Alternative Fuel Vehicle Group
215 Park Avenue South, Suite 1301
New York, NY 10003

Technology: Building Integrated Photovoltaics (BIPV)

Features: Building integrated photovoltaic panel systems deliver renewable energy to the consumer with great advantage: PV panels produce no emissions, are fueled at no cost by the sun, have no moving parts, and are made primarily from silicon, a common substance. A typical systems produces12 volt direct current (DC) electricity, which is inverted into 120 volt alternate current (AC) power. Most systems include a battery system to store this power during non-solar hours. Many states, including California, allow systems to be connected to the utility grid to sell excess electricity to the utility, a process known as "net metering".

Unlike conventional standalone photovoltaic arrays, BIPV's are either attached to a building as banks of panel arrays (normally mounted to a roof top) or incorporated into a building as architectural elements such as awnings, roof shingles, panels, etc,. While the latter application is usually more expensive than mounted arrays, their dual use can help offset total building costs, provide needed shade, and consolidate land use.

Because BIPV's produce power at the source of consumption - each house or building is its' own power plant - dependence on utility grid distribution is decreased. This network of micro power producers moderate demand for grid-source power, especially during peaks hours, thereby reducing brownouts. As little as 200 square feet of PV panels will supply the 800-2000 kilowatt hours per month used by the average household.

California is well suited for photovoltaic energy, with an Average Annual Solar Radiation Index of 2.6-3.0 megawatt hours/sq. meter. Domestic production of photovoltaic technology has increased annually for the past five years by an average of 22%, much of it in California. Diverse events such as the widespread brownouts in the spring of 2001 and the State's Public Interest Energy Research (PIER) program have created a heightened awareness of the need for a multiplicity of energy sources, preferably renewable. BIPVs will continue to play an increasing role towards achieving this goal.

Economics: Current PV technology approaches 2-2.5 times the generation cost of most utility grid suppliers. However, this cost ratio continues to decrease as newer panel technology becomes more efficient, and as increased manufacturing volume reduces consumer capital investment. Most current photovoltaic customers realize a full payback within 8-12 years. Most PV systems are warranted to last 20 years. Because of this,

BIPV technology is most appropriate for residential and commercial consumers who are comfortable with long term returns on their investment. Nominal maintenance and monitoring is required to operate a typical small scale PV system.

Case Studies: Several examples are found throughout California where BIPV technology is used successfully. *The Solar Living Center* in Hopland, California is a retail store that sells environmentally-based goods and serves as an educational facility for sustainably-built environments. Photovoltaics are just one of several renewable energies employed to operate their facility. An innovative partnering application has been realized by the *Sacramento Municipal Utility District's PV Pioneer* program, where residential customers are able to purchase reduced-cost roof top BIPV systems from SMUD. In exchange, the home owners agree to have their system hooked up to the SMUD utility grid and to sell back excess electricity.

Resources: The following resources are helpful in understanding current application of Building Integrated Photovoltaics:

Web Sites:

The Solar Living Center	http://www.solarliving.org/overview.cfm
SMUD PV Pioneer Program	http://www.smud.org/pv/pv_pioneer1.html
California Energy Commission Consumer Energy Center	http://www.consumerenergycenter.org/buydown/index.html
United States Department of Energy Office of Energy Efficiency and Renewable Energy:	http://www.eren.doe.gov/
Inside BIPV	http://www.pvpower.com/bipv.html
Center for Renewable and Sustainable Technology (CREST)	http://www.crest.org/

Literature:
NREL, *Photovoltaics in the Built Environment: A design guide for architects and engineers*, DOE/GO-10097-436. NREL, Golden, Colorado, 1997.

SOLAR TODAY
301 Oxford Valley Road, Suite 1301
Yardley, PA 19067
Phone: 215-321-9662 x25
Fax: 215-321-9636

Organizations:

American Solar Energy Society
2400 Central Avenue, Ste. G-1
Boulder, CO 80301

Center for Renewable Energy and Sustainable Technology (CREST)
1612 K Street, NW
Suite 202
Washington, DC 20006

University of California Energy Institute
2539 Channing Way
Berkeley, CA 94720-5180
Solar Electric Power Association
1800 M Street, N.W., Suite 300
Washington, DC 20036-5802

Technology: Micro turbines

Features: A technology that has been used world wide for centuries, wind-powered turbines ("windmills") are finding renewed use throughout the United States. Of particular interest to many consumers are *micro turbines* – small, inexpensive windmills most often installed in residential applications. Recent advances in materials and design have led to systems that maximize efficiency and durability while decreasing both noise and cost. Annual sales of micro turbines are growing at an approximate rate of 60% in the United States.

Like photovoltaic systems, micro turbines generate electricity only during times of "fueling" – in this case, when there is a sustained wind. Unlike their bigger counterparts, micro turbines work best in wind velocities found closer to the ground, about 8 miles per hour. Micro turbines require mounting on a tower between 20-30 feet in height, and are most effective when used with a battery system to store energy for use during periods of low wind exposure.

Micro turbines are small-scale renewable energy suppliers, and as such are usually not intended to be sole power providers to a home or business. Like many other renewable energy generators they are a significant means to offsetting complete reliance on large-scale utility grid power. Their use often complements other renewable energy strategies very well, especially photovoltaic panels. Combining PV panels with micro turbines greatly insures reliable energy as wind exposure is greatest during seasonal periods of overcast weather, when photovoltaic cells are less efficient.

Economics: Micro turbines must be used with discretion, as some sites simply don't have enough wind exposure to be economically feasible. It is usually advisable to perform a one-year wind survey on a site before making the decision whether to install a micro

turbine. Most manufacturers sell or rent anemometers to document annual wind exposure. This cost can often be subtracted from the purchase of a system. Municipal ordinances concerning noise and height restrictions for on-site structures should also be investigated.

Wind power is the lowest cost source of renewable energy. While turbine systems big enough to power the average home can be expensive – often $30,000 or more – they can take as little as 8 years to pay back. However, prior to installing a micro turbine, the local utility charge for kilowatt hours must be compared to the realistic generation of kilowatt hours by the system. The size (and therefore cost) of the system must fit the consumers goals for decreasing reliance on utility source power and cost savings.

Since micro turbines have moving parts, they should be inspected on a regular basis. Most systems are warranted to last five years before required maintenance.

Case Studies: Pennsylvania has recently mandated that public utilities improve their power buy-back (net metering) standards. While over a dozen small wind turbines provide 100 kilowatts of power, the state government is fostering potential power generation by the placement of smaller micro turbines throughout the state.

On a larger scale over 4900 wind turbines at the Kern Wind Energy Association in Tehachapi, California generate as much energy as the rest of the United States – combined.

Resources: Wind energy use is very documented and resources are abundant.

Web Sites:

National Wind Technology Center	http://www.nrel.gov/wind/smalltur.html
Wind Energy Resource Atlas of the United States	http://rredc.nrel.gov/wind/pubs/atlas/atlas_index.html
Federal Energy Management Agency "Wind Turbines"	http://www.energy.wsu.edu/cfdocs/tg/38.htm
American Wind Energy Association "Small Wind Systems"	http://www.awea.org/smallwind.html
U.S. Department of Energy "Wind Energy for Homeowners"	http://www.eren.doe.gov/wind/homeowner.html
Illustrated History of Wind Power Development	http://telosnet.com/wind/index.html

Literature:

Wind Energy Basics by Paul Gipe. Chelsea Green Publishing Co. White Plain Junction, VT. 1999.

Reaping the Wind by Peter Asmus. Island Press. Washington DC, 2000

Energy

Home Power Magazine
PO Box 520
Ashland, OR 97520
800-707-6585

Wind Power Monthly
PMB #217, P.O Box 496007
Redding, CA 96049-6007

Organizations:
American Wind Energy Association
122 C Street, NW, Suite 380
Washington, DC 20001

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393

National Wind Coordinating Committee
1255 23rd Street NW, Suite 275
Washington, DC 20037

California Energy Commission
1516 Ninth Street, MS-29
Sacramento, CA 95814-551

Resource	Description	Website
"Daylighting in Schools" PG&E, Heschong Mahone Group	Proof that daylighting improves human performance (in this case, student test scores) over the typical artificially illuminated environment.	http://www.h-m-g.com/Daylighting/schoolc.pdf
"Designing with Daylight" Architectural Record, November 2000	This article serves as a primer for design professionals aiming to improve their use of daylight as a design tool. Basic core concepts are well illustrated, and several case studies are presented.	http://www.archrecord.com/conteduc/articles/11_00_2.asp
"Photovoltaic Technology Comes of Age" Architectural Record, January 2001	The use of building integrated photovoltaic panels is celebrated with successful projects noted. Technical information is provided along with testimony about BIPV's as a cladding material.	http://www.archrecord.com/conteduc/articles/01_01_1.asp
"Skylighting and Retail Sales" PG&E, Heschong Mahone Group	This study reveals the positive effects that daylighting has on retail sales. Specific variables such as window types and consumer behavior are well documented.	http://www.h-m-g.com/Daylighting/retailc.pdf
"The Return of Natural Ventilation" Architectural Record, July 2001	The new appreciation for natural ventilation in various building types is explored through international case studies.	http://www.archrecord.com/conteduc/articles/07_01_2.asp
"Using multiple glass skins to clad buildings" Architectural Record, July 2000	The use of twin-faced glazing as an exterior building skin is discussed with attention to components, spacing, and the lessons learned thus far.	http://www.archrecord.com/conteduc/articles/7_00_2.asp
"What? No Air Conditioning in this Building?" Architectural Record, May 2000	The use of natural ventilation as a viable means of cooling and ventilating are described in this article. Operable windows and building orientation is discussed by several architects.	http://www.archrecord.com/conteduc/articles/5_00_1.asp

Energy

Resource	Description	Website
AIA Committee on the Environment (COTE)	COTE promotes environmental leadership among architects and seeks to make environmental considerations and sustainable design integral to the practice of architecture.	http://www.aia.org/pia/cote/topten/Default.asp
ASHRAE Guideline "The HVAC Commissioning Process"	ASHRAE's Guideline 1-1996 details the process for insuring that HVAC performance properly coincides with design intent.	www.ashrae.org
Building Energy Software Tools	Described on this DOE Energy Efficiency and Renewable Energy web site are 151 energy-related software tools for buildings, with an emphasis on using renewable energy and achieving energy efficiency and sustainability in buildings.	www.eren.doe.gov/buildings/tools_directory/
Building for Environmental and Economic Sustainability (BEES)	BEES is a tool that helps in the identifying of building materials that will reduce energy use, improve air quality and other conditions that could improve the environmental performance of buildings. The National Institute of Standards and Technology (NIST) developed the software program under a federal interagency agreement with funding from the EPA.	http://epic.er.doe.gov/epic/
CEC Cool Roof Program:	The California Energy Commission Cool Roof program promotes roofing systems with high albedo to minimize solar heat gains.	http://www.consumerenergycenter.org/coolroof
CEC: California Consumer Energy Center	The California Consumer Energy Center has a database of state grants, rebates, and incentives.	http://www.consumerenergycenter.org/
CEC-Bright Schools Program	This California Energy Commission program promotes daylighting in schools.	http://www.energy.ca.gov/efficiency/brightschools/index.php

Resource	Description	Website
Charles Eley Assoc., reference specifications	This San Fransisco architecture firm is developing a source for green building specifications at this site.	www.eley.com; www.eley.com/specs/
PECI Commissioning References	Several guidelines for building commissioning along with operations & maintenance are listed at this site	http://www.peci.org/cx/index.html or http://www.energy.state.or.us/bus/comm/bldgcx.html
Database of State Incentives for Renewable Energy	The U.S. DOE initiated the National Database of State Incentives for Renewable Energy (DSIRE) through the Interstate Renewable Energy Council. Each of the 50 states was surveyed for available information on financial and regulatory incentives that are designed to promote the application of renewable energy technologies.	www.dcs.ncsu.edu/solar/dsire/dsire.cfm
EPA Energy Star	ENERGY STAR offers a suite of programs designed to assist those who wish to pursue energy-efficient upgrades. These programs include: Energy Star Buildings and Green Lights Partnership; Energy Star Products; Energy Star Building Allies & Energy Star Purchasing.	www.energystar.gov
FEMP Procurement Guide	The Federal Energy Management Program lists multiple product efficiency recommendations at this web site.	http://www.eren.doe.gov/femp/procurement/begin.html

Energy

Resource	Description	Website
Green Energy Financing	This site is sponsored by the U.S. DOE and the U.S. EPA, and was developed for the Center of Renewable Energy and Sustainable Technology. This database is a one-stop shop of energy efficiency financing resources for the homeowner, building manager, architect, lending institution, or other user interested in clean energy financing.	www.energyfinance.org
Guide to Energy Efficient Equipment	The American Council for an Energy-Efficient Economy touts the benefits of responsible energy use in several ways.	http://www.aceee.org/
Illuminating Engineering Society (IES) Handbook, 9th Edition	The IESNA is the prime authority on lighting design. It sets standards for illumination, energy efficiency, and promotes lighting as a design element.	http://www.iesna.org/
PG&E Cool Tools	Pacific Gas & Electric's promotional program for efficient water chiller plants is introduced at this site.	http://www.pge.com/003_save_energy/003c_edu_train/pec/toolbox/hvac/003c1b4_HVAC_resource.shtml
PG&E Daylighting study	This lists PG&E's documented case studies on the positive effects of daylighting.	http://www.pge.com/003 save energy/003c edu train/pec/daylight/daylight.shtm
PG&E Rebate Programs	Several rebate programs from PG&E are listed to promote energy efficiency.	http://www.pge.com/003_save_energy/003b_bus/
PG&E Savings By Design	PG&E offers design assistance and financial incentives to advocate energy efficiency.	http://www.pge.com/003 save energy/003b bus/003b1c1 program info.html
SMUD Rebate Programs	SMUD offers several rebates for Sacramento residents that choose energy efficient appliances and materials.	http://www.smud.org/rebatespromos.html
So Cal Edison	Southern California Edison offers this energy use web site for building design professionals.	http://www.energydesignresources.com/

Resource	Description	Website
Southern Cal. Edison Energy Conservation	This utility web site highlights technical advances in energy efficiency, describes rebate programs, and lists home energy efficiency tips.	http://www.sce.com/002_save_energy/index.shtml
Energy Information Administration	This site illustrates the percentages of different energy sources used for common commercial and residential tasks.	http://www.atl-inc.com/commercial
CA DGS Energy Management Division	The Energy Management Division provides comprehensive administrative services to all aspects of energy use in California.	http://www.emd.dgs.ca.gov/
TITLE 24, Part 6 Energy Efficiency Standards	This is the official web source for California Energy Commission's Title 24, Part 6 Energy Code.	http://www.energy.ca.gov/title24/standards/index.html
California Sustainable Design Task Force	The SDTF encourages sustainable buildings that promote occupant well being and protect the environment.	http://www.ciwmb.ca.gov/GreenBuilding/TaskForce/
Capitol Area East End Complex	This added capitol complex will demonstrate the many benefits of sustainable design and construction to CA citizens.	http://www.resd.dgs.ca.gov/projects/eastend/default.asp?mp=GreenPage/main.asp
City of San Diego RidgeHaven Building	This municipal building is highlighted on the US Green Building Council web site for its high-energy efficiency.	http://www.usgbc.org/resource/ridge.htm
City of Santa Monica Public Safety Facility	This web cam page shows the new facility in construction. It is expected to be completed in 2003, and will feature several green building solutions.	http://santamonicapd.org/PSFWebCam/PSFWebCamCurrent.htm
Building Thermal Envelope Systems & Materials Program	This group promotes the use of thermal mass and appropriate enclosure materials for optimum energy efficiency.	http://www.ornl.gov/roofs+walls/

Energy

Resource	Description	Website
Rocky Mountain Institute Weatherization, Insulation, and Windows	The RMI has long advocated energy reduction as the first measure towards sustainable living. Here actual energy and dollar savings are charted in typical energy use examples.	http://www.rmi.org/sitepages/pid347.php
NIST Mechanical Systems and Controls Group	This NIST group promotes the use of "intelligent, integrated, and optimized building mechanical systems and controls."	http://www.bfrl.nist.gov/863/bc.html

CALIFORNIA PUBLIC UTILITIES COMMISSION

Distributed Generation Policies and Programs

Distributed Generation (DG) is the installation of small electric generating facilities at or near the end-user's location. DG currently supplies on-site power to hospitals, universities, commercial, industrial, agricultural and government sites. Distributed generation is one option California is using to help increase supply, delivery, and reliability of electricity in the state.

The CPUC's policy is to facilitate deployment of distributed generation in California by assuring that developers and customers can readily interconnect to the utilities' system and removing unreasonable barriers to project development. The CPUC adopted new utility rules effective January 1, 2001 which simplify and standardize utility interconnection protocols.

In its current DG proceeding, Rulemaking 99-10-025, the CPUC will issue a policy decision on pricing principles for standby charges and other rate design issues. The CPUC is implementing recent legislation, Senate Bill X1 28, which exempts some DG facilities which begin operation within the next two years from paying standby charges for up to 10 years. The exceptions are diesel-fired generators and facilities over five megawatts in size.

The CPUC will also issue a policy decision resolving the remaining jurisdictional, environmental and associated market issues regarding DG.

CPUC Self Generation Incentive Program

Assembly Bill 970 directed the Commission to develop an incentive program to encourage customers of investor-owned utilities to purchase and install distributed generation to help lower demand for electricity during peak periods. This program provides incentives for customers of investor-owned utilities to purchase and install microturbines, small gas turbines, wind turbines, photovoltaics, fuel cells and internal

combustion engines to provide some or all of their electricity for onsite use. Greater incentives are provided for generation using renewable fuel. No incentives are provided for diesel-powered or back-up generation. The CPUC approved program funding of $125 million annually through 2004.

The following table describes the incentive payments and maximum incentive and system size limits.

Incentive category	Incentive offered	Maximum percentage of project cost	Minimum system size	Maximum system size	Eligible Technologies
Level 1	$4.50/W	50%	30 kW	1 MW	▪ Photovoltaics ▪ Fuel cells operating on renewable fuel ▪ Wind turbines
Level 2	$2.50/W	40%	None	1 MW	▪ Fuel cells operating on non-renewable fuel and utilizing sufficient waste heat recovery
Level 3	$1.00/W	30%	None	1 MW	▪ Microturbines utilizing sufficient waste heat recovery and meeting reliability criteria ▪ Internal combustion engines and small gas turbines, both utilizing sufficient waste heat recovery and meeting reliability criteria

A copy of the CPUC's decision adopting the Self Generation Incentive Program may be accessed at:

http://www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/6083.htm

Customers with DG units under 30 kW in size which do not qualify for the CPUC Self Generation Incentive Program may be eligible to participate in the California Energy Commission (CEC) Emerging Renewables Buydown Program. The CEC program provides incentives for small photovoltaics, small wind turbines and fuel cells. Customers may contact the CEC at 1-800-555-7794, or access the website at

http://www.energy.ca.gov/greengrid

The program is administered by the utilities in the service territories of PG&E, SCE, and Southern California Gas. In SDG&E's service territory, the program is administered by the San Diego Regional Energy Office. Questions about these programs should be directed to these entities. Applications for the program are expected to be available by July 1, 2001.

Pacific Gas & Electric (PG&E)

Web Site:	www.pge.com
Email Address:	selfgen@pge.com
Telephone:	(415) 973-2362
Fax:	(415) 973-2510
Mailing Address:	Self-Generation Incentive Program Attn: Dean Heatherington P.O. Box 770000 Mail Code B29R San Francisco, CA 94177-001

San Diego Regional Energy Office (SDREO)

Website:	www.sdenergy.org
Contact Person:	Mike Magee, Program Manager
Telephone:	619-595-5634
Email:	mma@sdenergy.org
Mailing Address:	401 B. Street - Suite 700 San Diego, CA 92101

Southern California Gas Company (SoCalGas)

Web Site Address:	http://www.socalgas.com/candi/cash_for_you/selfgen.html
Telephone:	1-800-GAS-2000
Fax:	1-213-244-8384
Mailing Address:	Self Generation Incentive Program Administrator Mail Location GT15F4 Southern California Gas Company 555 West Fifth Street Los Angeles, CA 90013-1011

California SUSTAINABLE DESIGN Training 2001

Section 5: Indoor Environmental Quality

HDR

Indoor Environmental Quality

Indoor Environmental Quality (IEQ) is *any* factor of the built environment that impacts the health and/or comfort of building occupants.

For example:
- Glare on computers
- Acoustics
- Air quality
- Access to natural light

The Importance of IEQ

According to the Environmental Protection Agency's Indoor Air Quality Program:
- Indoor air is often more polluted than outdoor air, sometimes as much as 25% more polluted, and occasionally more than 100 times as much.
- Americans spend approximately 90% of their time indoors.
- Sick Building Syndrome - 30% of new & renovated buildings.
- Lost productivity costs billions of dollars annually.
- Indoor air pollution is one of the top five public health risks.

Potential Benefits of IEQ

The quality of the indoor environment can significantly impact building occupants. Quality indoor environments can result in:
- Increased occupant satisfaction
- Enhanced performance/productivity
- Reduced absenteeism
- Marketing advantage
- Reduced liability
- Lower operations and maintenance costs

Significant studies and reports addressing the benefits of good indoor environmental quality include:

A study titled "Greening the Building and the Bottom Line" completed by the Rocky Mountain Institute showed:
- Productivity increases up to 15%.
- Decreased absenteeism up to 25%.
- Increased sales in the daylit portion of WalMart's "Eco-Mart" in Lawrence, KS

This report is included at the back of this section.

An article titled, "Do Green Buildings Enhance the Well Being of Workers? Yes" that appeared in the July/August 2000 issue of EBN Magazine, addressed the impact of the built environment on physical, psychological, social, and neurological-cognitive well-being of building occupants.

Pacific Gas & Electric has a Daylighting Initiative that has produced several significant studies regarding the impacts of natural light on building occupants. The studies include:
- Daylighting in Schools
- Daylighting and Retail Sales

Buildings that provide access to natural light facilitate increased retail sales and, in the case of schools, improved student test scores!

IEQ Factors

The factors that define indoor environmental quality should be considered integrated components; the qualities of one factor significantly affect those of another. For example, the decision to place a window can affect each of the following factors, with results that may not coincide with design intent. The caveat is that every IEQ decision should be regarded as having potential positive or negative consequences in each of the following:

- Access to natural light
- Artificial lighting
- Connection to the outdoors
- Acoustics
- Thermal comfort
- Occupant control
- Air quality

Notes:

Access to natural light / Connection to the outdoors.

Exposure to natural light is very important to human health. Daylighting throughout the year helps building occupants maintain bio-rhythms that mesh with diurnal and seasonal changes, resulting in greater well-being.

Areas with natural light tend to be gathering places. Both indoor and outdoor relaxation areas with vegetation and views are likely to enhance social interactions and sense of belonging.

According to the a White Paper written by Andersen Window's Advanced Design Research Group, group behavior studies repeatedly show that given a choice of occupancy, **75% of people prefer to work in areas illuminated by natural light**.

Daylighting Resources include:
The Daylighting Section of the Whole Building Design Guide.

Environmental Design & Construction, 2 part series on Daylighting:

1. September 1999: Energy and Productivity Benefits
2. October 1999: Bringing Daylight Deeper Into Buildings

Lawrence Berkeley Labs daylighing guide: Tips for Daylighting with Windows

Artificial Lighting

With regard to the indoor environment, artificial lighting should:

- Minimize glare on computer terminals
- Render appropriate color
- Provide adequate occupant control

It is also noteworthy that:

- Proper lighting increases productivity
- Highly controllable IEQ element
- Artificial lighting uses up to 50% of all building energy

Artificial Lighting Resources include:
The Lighting Research Center, part of Rensselaer Polyttchnic Institute's School of Architecture.

The National Lighting Product Information Program (NLPIP) is a non-profit, independent effort to provide manufacturer-specific performance data on efficient lighting products.

Acoustics

Few factors play as profound an effect on environmental quality as sound characteristics.
Poor acoustical qualities in a work or school environment results in increased stress and fatigue and also hinders verbal communication. Background noise levels should be carefully monitored and regulated with sound-dampening mechanisms where necessary. Sound absorption materials and acoustic barriers should be used to provide privacy where needed. Design consideration should be used to place point sources of sound (such as HVAC compressors or fans) away from areas where low acoustic levels are critical.

Thermal Comfort

Thermal comfort factors include:

- Humidity
- Temperature
- Air Flow

There are many important reasons to provide an environment that has stable thermal comfort. Careful control of temperature and humidity not only makes occupants more comfortable, but also achieves significant operating and maintenance savings over the life of a building. Furthermore, thermally comfortable buildings are more likely to retain employees and occupants, raising property values and income.

To help achieve this goal, several published thermal comfort standards are used:

ASHRAE 55-1992: Thermal Environmental Conditions for Human Occupancy, sets an 80% satisfaction quota as a target for human comfort

Cal/OSHA Minimum Ventilation Standard, Title 8, Sec. 5142

Title 24 Indoor Air Quality Standards

Resources on Thermal Comfort include:
Innova AirTech Instruments, Introduction to Thermal Comfort..

Occupant Control

Giving occupants control over some aspect of the indoor environment has shown:

- Increased occupant satisfaction
- Positive impact on occupant health
- Increased productivity

Examples of components that may be controlled by occupants include:

- Operable windows
- Thermostat controls
- Air flow
- Lighting

Resources on Occupant Control include: Environmental Satisfaction, Personal Control and the Positive Correlation to Increased Productivity, a white paper written by Johnson Controls.

Center for the Built Environment studies:

- Operable Windows and Thermal Comfort.
- Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building

Herman Miller SQA Case Study

The Herman Miller SQA (Simple, Quick, Affordable) Building in Zeeland, MI, is a fine example of the potential benefits of a facility designed with good indoor environmental quality in mind.

Project Facts

- 290,000 square feet
- McDonough & Partners designers
- Manufacturing plant and office/ showroom
- 700 employees: 600 in the manufacturing plant; 100 in offices
- Occupied in 1996
- 18 Month start-to-completion
- $49.00 per square foot

Notes:

Indoor Environmental Quality

Project Goals

- Occupant health, comfort, and communication
- Integration of exterior landscape
- Maximum use of daylighting

Sustainable Solutions

- Daylit interior "street"
- Daylighting, including:
  - Roof monitors
  - Skylights
  - Sloped glazing
  - Photo sensors

Outcomes/Benefits

- **Annual energy savings estimated at: $35,000**
- On a square foot basis, as compared to previous facility
  - Natural gas costs decreased by 7%
  - Electrical costs decreased by 18%
  - Water and sewer costs decreased by 65%
- Overall increases in productivity of 0.22% in the 9 month period following the move
- On-time delivery increase from 98.54% to 99.53%
- Product quality increased from 98.97% to 99.23%
- Due to productivity increases, **the building essentially paid for itself in less than 2 years!**

Additional project information, including photographs, can be obtained from:

U.S. Green Building Council Herman Miller SQA Case Study

Cornell University Herman Miller SQA Headquarters Case Study

Resource	Description	Website
U.S. Environmental Protection Agency, Indoor Air Quality Program. Targeting Indoor Air Pollution, EPA's Approach and Progress, March 1993.	At this site the EPA critically examines the current and projected status of indoor air quality in the US. Contaminant sources are revealed with immediate and long-term effects comprehensively discussed.	http://www.epa.gov/iaq/pubs/targetng.html
Article, "Do Green Buildings Enhance the Well Being of Workers? Yes."	July/August 2000 issue of EBN Magazine. The author, Judith Heerwagen, is an Environmental Psychologist whose research and writing have focused on workplace ecology.	www.edcmag.com/archives/7-00-1.htm
Greening the Building and the Bottom Line, Increasing Productivity Through Energy-Efficient Design	Eight documented case studies show that productivity gains from green design can be as high as 16 percent.	http://www.rmi.org/images/other/GDS-GBBL.pdf
ASHRAE 55-1992	Thermal Environmental Conditions for Human Occupancy; sets an 80% satisfaction quota as a target for human comfort .	www.ashrae.org
Title 24 Indoor Air Quality Standards	The California Energy Commission describes the causes of poor indoor air quality and how they can be alleviated.	www.energy.ca.gov/title24/nonresidential_manual/APPENDIX_D.PDF
Cal/OSHA Minimum Ventilation Standard, Title 8, Sec. 5142	California's EPA/Air Resources Board symposium reviews air quality regulations and how their implementation can improve IEQ.	http://www.arb.ca.gov/research/indoor/proceedings.PDF See also: http://www.dir.ca.gov/title8/5142.html
Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building	Paper by Fred S. Bauman, P.E.; Center for the Built Environment; University of California, Berkeley, CA 94720-1839; Presented at World Workplace 99, October 3-5, 1999, Los Angeles, CA	www.fmlink.com.au/images.au/Papers/bauman.htm

Indoor Environmental Quality

Resource	*Description*	*Website*
Pacific Gas & Electric Daylighting Initiative	Pacific Gas & Electric Daylighting Initiative Reports offer case studies that quantify the benefits of daylighting in schools, several retail buildings, and in governmental buildings.	http://www.pge.com/003_save_energy/003c_edu_train/pec/daylight/daylight.shtml
Environmental Design & Construction, Two Part Series on Daylighting	September 1999: Energy and Productivity Benefits October 1999: Bringing Daylight Deeper Into Buildings	www.edcmag.com
Innova AirTech Instruments, Introduction to Thermal Comfort	This manufacturer of IEQ monitoring equipment offers this thorough introduction to thermal comfort and how it is achieved.	http://www.innova.dk/books/thermal/thermal.htm
The Whole Building Design Guide - Daylighting	This portion of the WBDG outlines the qualities of daylighting and shows how it is strategically implemented into building design.	http://www.wbdg.org/DesignResource.asp?Resource=11&Introduction=7&Principles=5
Environmental Building News	Daylighting and its effects on energy use are discussed with an emphasis on construction issues.	http://www.buildinggreen.com/
The Lighting Research Center	As part of Rensselaer Polytechnic Institute's School of Architecture, the LRC is the world's largest university-based center for lighting education and research.	http://www.lrc.rpi.edu/
National Lighting Product Information Program	This resource provides unbiased data on lighting products, with technical specifications, reports, and a comprehensive glossary.	http://lrc102.lightingresearch.org/nlpip/
Environmental Satisfaction, Personal Control and the Positive Correlation to Increased Productivity	In this site numerous case studies are cited that confirm employee performance increases with environmental comfort.	http://www.johnsoncontrols.com/cg/PersEnv/pe_whitepaper.htm
Center For the Built Environment	UC Berkeley provides building performance data through this private/public collaboration.	http://www.cbe.berkeley.edu/

Resource	*Description*	*Website*
U.S. Green Building Council Herman Miller SQA Case Study	The USGBC demonstrates how this innovative design solution integrates an industrial facility with the environment.	http://www.usgbc.org/resource/miller.htm
Cornell University Herman Miller SQA Headquarters Case Study	Cornell University's Dept. of Design and Environmental Analysis examines the Herman Miller SQA Headquarters with an index of Design Considerations.	http://dea.human.cornell.edu/ecotecture/Case%20Studies/Miller/Miller_home.htm

DAYLIGHTING *initiative*

Design tools and information from PG&E

Phillip Burton Federal Building

Pacific Gas and Electric Company

WE DELIVER ENERGY.™

PG&E'S DAYLIGHTING INITIATIVE

PG&E's Daylighting Initiative has two goals: to raise awareness of good daylighting practice within the design community and to improve the practice of daylighting design. This case study is one of a dozen case studies undertaken within the initiative. Together, they document a wide range of successful technical solutions demonstrated across a number of different commercial applications.

The Daylighting Initiative includes projects that will make better design tools available to the daylighting design community. The Desktop Radiance project, a collaborative effort of Lawrence Berkeley National Laboratory and PG&E, is bringing the powerful Radiance lighting simulation capabilities into the practical world of architectural CAD software. The Daylighting Initiative also includes a series of workshops and seminars at the Pacific Energy Center in San Francisco. For more information, visit the project's web site at www.pge.com/pec/daylight.

Lighting The Way

Daylighting controls gained large er

Built in 1962, the 20-story, 1.45 million sq.ft. Phillip Burton Federal Building is the second largest building in San Francisco. It is located at 450 Golden Gate Avenue and houses Federal Courts, the FBI, GSA, and other public agencies. A partnership among the General Service Administration (GSA), Pacific Gas & Electric, and the Department of Energy created an unprecedented 180,000 sq.ft. advanced lighting controls test bed at the building.

Current lighting controls have the potential to reduce lighting energy use by up to 35% in existing multistory office buildings compared to conventional lighting systems without controls.

Strategies for lighting control include:

- Daylighting (automatically dimming the lights in response to available daylight).
- Scheduling (dimming or switching fixtures on and off according to occupancy).
- Lumen maintenance (automatic light compensation for long-term lumen losses).

DAYLIGHTING FEATURES PHILLIP BURTON FEDERAL BUILDING 450 GOLDEN GATE PROJECT

1 VERTICAL GLAZING

The conventional building envelope has single-glazed windows running from 3 feet above the floor up to the dropped ceiling. Each window is fitted with miniblinds that are operated by occupants to block direct sunlight and glare. All but the north-facing windows had been retrofitted some time ago with solar film to reduce the visible transmittance to about 40%.

2 LIGHTING CONTROLS

Lighting controls from eight different manufacturers were installed on floors 3 and 5. Several different control system configurations were tested.

In single- and multiple-person offices, occupancy sensors plus daylight and occupancy sensors with manual dimming were installed. In the open-planned areas, daylight dimming and wide area occupancy sensors were incorporated. In the 2,900 sq.ft. open-planned office spaces on the north and south sides of the 3rd floor, dimming 3-lamp electronic ballasts were installed.

Each light zone is controlled by a single photosensor and controller. Adjustment of the system is set at the controller after installing the lighting controls.

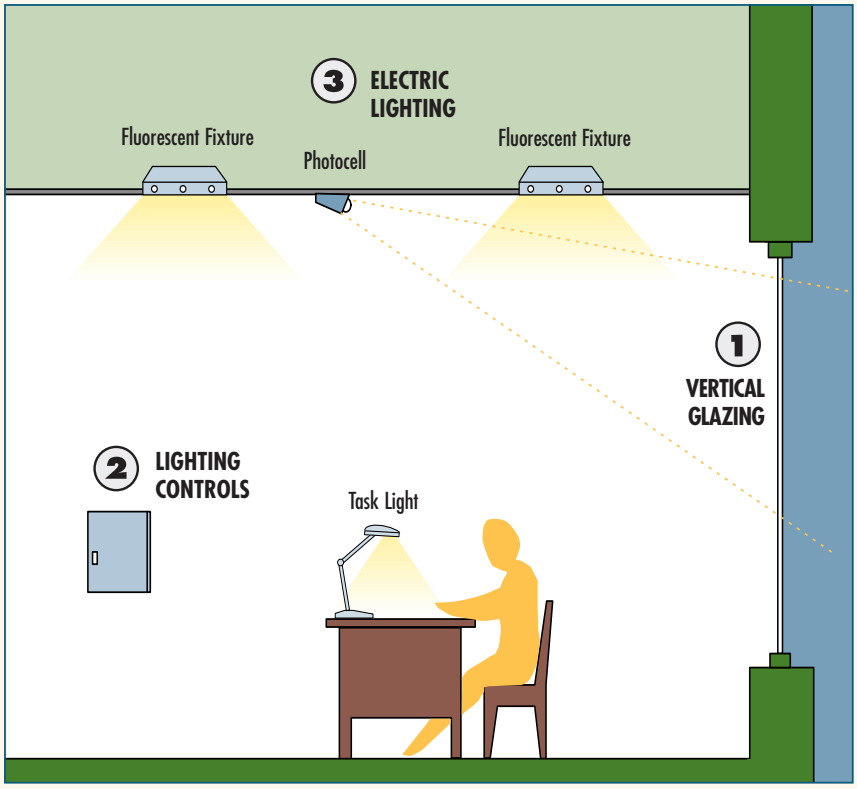
3 ELECTRIC LIGHTING

Electric lighting for the test bed consists primarily of 3-lamp direct parabolic-type luminaires, T-8 fluorescent lamps, and electronic ballasts that have become a building standard since 1993. In the perimeter areas, dimmable ballasts were specified.

T-8 fluorescent lamps are installed throughout the test site.

To Energy Savings

nergy savings for this test site retrofit.



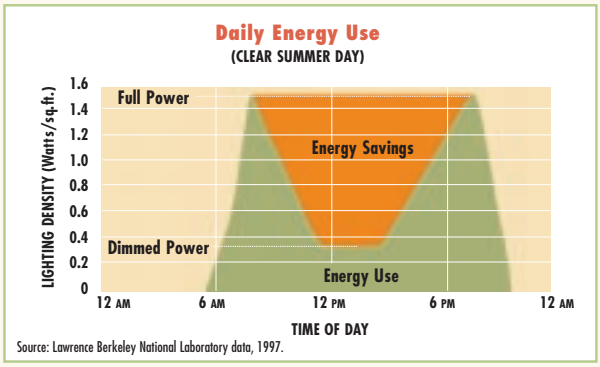
These lamps were seasoned on-site by operating continuously for 100 hours at full intensity immediately after re-lamping. Based on a survey conducted at night, the interior illuminance in open-planned spaces without partitions was measured at 80–90 foot-candles. In the partitioned spaces and in the individual offices with ceiling-high partitions, the measured illuminance at the work plane was 50–70 fc.

"We're very excited about the Phillip Burton Federal Building. It is an outstanding demonstration of the very latest in lighting controls… [and is] a great model for other industries to follow."

Christine A. Ervin
Former Asst. Secretary
Energy Efficiency and Renewable Energy
Department of Energy

LIGHTING 450 Golden Gate Project

Following the National Energy Policy Act of 1992, President Clinton issued Executive Order 12902 directing federal facilities to reduce energy consumption by 30% by the year 2005, based on 1985 levels. The 450 Golden Gate Project aims to provide valuable information that can be transferred throughout the industry, as well as the federal government. In addition to testing a variety of daylighting controls for perimeter lighting, the advanced lighting control test bed evaluated various applications of occupancy, manual dimming, and scheduling control strategies. Additional evaluation of lighting energy monitoring and real time price scheduling strategies continues. For additional information on Executive Order 12902 and the Federal Energy Management Program, refer to web site: www.eren.doe.gov/femp. Additional technical papers on the 450 Golden Gate Project test bed can be found at http://eetd.lbl.gov/btp/pub/LGpub.html.



This chart illustrates how the electric lights, in the first row on the building's south side, respond to available daylight on a clear summer day. Annual energy savings reached a high of 2.0 kWh/sq.ft.-yr., or 41% in some of the daylight-linked control areas.

RESULTS

This office building represents a type that is prevalent in today's building stock. A building such as this, with significantly occupied areas exposed to the perimeter skin and adequate windows, can be retrofitted with daylight sensors. Doing so will have a large impact on our national energy use. In this building, the results are impressive. After analyzing a half year's data in the daylight-linked control areas of the test site, the annual energy savings was 41% and 30% for the outer rows of lights on the south and north sides of the building, respectively. The annual energy savings dropped to 22% and 16% for the second row of lights for the south and north, respectively. Combined, these two areas represent 30% of the office floor space.

These results help the GSA improve the operation of its lighting systems and move toward the goal of 30% energy savings. The results also provide the lighting community with invaluable information for taking advantage of control technologies that improve user comfort and reduce energy costs.

RESOURCES

PG&E does not endorse particular products or services from any specific manufacturer or service provider. High efficiency products and services similar to those used in this project are available from multiple suppliers. For informational purposes, PG&E notes that the following companies provided equipment or services to the project:

Dimmable Ballasts/Lighting Control/Photosensors:
Lutron Electronics Co, Coopersburg, Pennsylvania
www.lutron.com — 1-800-523-9466

ADDITIONAL CONTACT INFORMATION

Pacific Energy Center, San Francisco, California
www.pge.com/pec/daylight — 415-973-7206

Building Technologies Program
Lawrence Berkeley National Laboratory, Berkeley, California
Contact: Francis Rubinstein
FMRubinstein@lbl.gov — 510-486-4096
For technical papers:
http://eetd.lbl.gov/btp/pub/LGpub.html

Federal Energy Management Program (FEMP)
www.eren.doe.gov/femp — 1-800-363-3732

This program is funded by California utility customers and administered by Pacific Gas and Electric Company, under the auspices of the California Public Utilities Commission.

DAYLIGHTING *initiative*

Design tools and information from The Pacific Gas and Electric Company

Skylighting and Retail Sales

An Investigation into the Relationship Between Daylighting and Human Performance

Condensed Report

August 20, 1999

Submitted to:

George Loisos
Pacific Gas and Electric Company
on behalf of the
California Board for Energy Efficiency Third Party Program

Submitted by:

HESCHONG MAHONE GROUP
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Lisa Heschong, Partner in the Heschong Mahone Group, Fair Oaks, CA, directed the study. She has been assisted at the Heschong Mahone Group by Douglas Mahone, Kalpana Kuttaiah, Nehemiah Stone, Cathy Chappell, Jon McHugh, and Jackie Burton.

Stacia Okura of RLW Analytics, Sonoma, CA, conducted the statistical analysis under the direction of Dr. Roger Wright, Principal, RLW Analytics.

Barbara Erwine of Cascadia Consulting, Seattle, WA, and Michael Holtz of Architectural Energy Corporation, Boulder, CO, participated in initial study design and analysis methodology.

We are deeply indebted to the personnel at the participating company who made this study possible, by providing data and allowing us access to facilities. Many other companies were involved in the initial phases of this study, as we sought to identify the best possible participants. We greatly appreciate the time and effort that they put into helping us identify sources.

We are very thankful to the many other people who also made this study possible, through their interest in the significance of this work and willingness to provide helpful information and support. We would especially like to thank those who took the time to review and comment on the draft reports: Gregg Ander, Dr. Ed Arens, Dr. Gale Berger, Dr. Robert Clear, Dr. Rick Diamond, Dr. Margaret Morris, and Dr. David Wyon; and Steven Selkowitz who organized the review.

EXECUTIVE SUMMARY

This study looks at the effect of daylighting on human performance. It specifically focuses on skylighting as a way to isolate daylight as an illumination source, and avoid all of the other qualities associated with daylighting from windows. In this project, we established a statistically compelling connection between skylighting and retail sales, and between daylighting and student performance. This report focuses on the retail analysis.

We analyzed data on the sales performance of a chain retailer that operates a set of nearly identical stores. The analysis included 108 stores, where two thirds of the stores have skylighting and one third do not. The design and operation of all the store sites is remarkably uniform, with the exception of the presence of skylights in some. The electric lighting was primarily fluorescent. Daylight from the skylights often provided more than two-to-three times the target illumination levels. Photo-sensor controls turned off some of the fluorescent lights when daylight levels exceeded target illumination.

The monthly gross sales per store were averaged over an 18-month period that went from February 1 of one year to August 31 of the following year. This average sales figure was transformed into a “sales index” that we could manipulate statistically, but that did not reveal actual dollar performance. Stores in the sample were located within a limited geographic region and had similar climatic conditions. The buildings in the study fell within constrained ranges of size and age. The geographic region has a relatively sunny climate. All of the stores in the data set are one story.

The multivariate regression analysis allowed us to control for the influence of other variables, which might influence sales. Other variables considered included the size and age of the store, hours of operation, and economic characteristics associated with the zip code location.

Skylights were found to be positively and significantly correlated to higher sales. All other things being equal, an average non-skylit store in the chain would likely have 40% higher sales with the addition of skylights, with a probable range between 31% and 49%. This was found with 99% statistical certainty. After the number of hours open per week, the presence of skylights was the best predictor of the sales per store of all the variables that we considered. Thus, if a typical non-skylit store were averaging sales of $2/sf, then its sales might be expected to increase to between $2.61 and $2.98 with the addition of a skylighting system.

The skylights are seen to have a major impact on the overall operation of the chain. Were the chain to add the skylighting system to the remaining 33% of its stores, yearly gross sales are predicted to increase by 11%. The difference between having none of their stores skylit and all their stores skylit is an increase of up to 40% in gross sales for the retail chain.

1. INTRODUCTION

The purpose of this study was to see if we could demonstrate a clear relationship between the presence of daylight and human performance in buildings. We postulated that by focusing on buildings with skylights rather than daylighting from windows, we could isolate the effect of daylight.

In this study, we used a statistical technique called multivariate regression analysis which analyses the importance and impact of many variables simultaneously. The performance data used were gathered from four organizations: one retailer and three school districts. This analysis allowed us to estimate the effect of each of the known variables and to determine which variables have no significant effect. Using this method, we established a statistically compelling connection between skylighting and retail sales, and between daylighting and student performance. This report focuses on the retail analysis.

This Condensed Report is intended for the non-specialist reader. It is a summary of a more extensive report that details the study methodology and statistical analysis. If you have questions about the study that are not answered here, we recommend the Detailed Report.

1.1 Background

Skylights provide a simple illumination function, whereas windows may have a far more complex effect on people. Windows typically offer a view, which may provide relaxation, inspiration or distraction. They are often operable, which may add ventilation, air quality, and thermal comfort issues. Daylight illumination levels from windows are highly variable within a space, and may include components of unacceptable contrast and glare. User control of blinds or curtains also adds another variable that may be hard to account for. Windows are also connected with personal status, and may have psychological implications beyond their mere physical attributes. Skylights would not seem to be as imbued with cultural meaning and don't tend to have as much variability in their function.

Skylighting was a widely used method of providing light to industrial and warehouse buildings before the widespread use of fluorescent lighting. Most single-story industrial buildings built before the 1950's had rows of north-facing roof monitors which allowed ample light into the interior of these large buildings. With the advent of inexpensive fluorescent lighting and air conditioning, daylighting techniques were abandoned in favor of electric lighting.

Recent analysis has shown that skylighting has enormous potential to provide energy savings in single-story commercial buildings. Turning off electric lights when sufficient daylight is available can save a significant amount of lighting energy costs. Because daylight introduces less heat into a building than the equivalent amount of electric light, cooling costs can also be reduced. Analysis

has shown that an appropriately sized skylighting system, combined with photosensor controls to turn off unneeded electric lights, will produce net whole building energy savings in almost all parts of the country[1]. Recognizing this, some utilities provided incentive programs to encourage their customers to consider adding skylighting systems to their buildings. Nationally, 40% of all commercial buildings are single-story, and 60% of commercial square footage is directly under a roof[2]. In California, those numbers are even higher, where it is estimated that 90 percent of new construction is single-story[3]. Thus, increased use of skylighting systems could potentially save a considerable amount of energy nationally.

Retail buildings tend to be a fairly straightforward application for skylighting. The trend is towards large, single-story retail centers, with open expanses of shelving; a building type that is well adapted to a skylighting approach. Skylighting in these buildings can save significant amounts of money. For example, a skylighting system in a typical grocery store in Los Angeles has been observed to save about $10,000 per year[4]. A number of national retailers have adopted skylighting as a standard design feature of their stores in order to take advantage of these savings.

With the advent of more skylit stores, anecdotal stories began to surface that stores with skylighting had higher sales. One retailer reported that clothing returns decreased dramatically after installing skylights. In December of 1994 an article appeared on the front page of the Wall Street Journal describing Wal-Mart's experience with adding skylights to their experimental "Eco-Mart" in Lawrence, Kansas[5]. Although no numbers were offered, this article considerably raised the interest level in skylighting for retail applications. It reported that, as a last minute cost saving measure, Wal-Mart had installed skylights in only half of store.

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[1] Analysis with *SkyCalc*, a simulation program, available by downloading from www.energydesignresources.com

[2] Derived from the US Energy Information Agency publication, *Commercial Building Energy Consumption* (CBECs) 1995

[3] Personal communications from PG&E and SDG&E staff.

[4] Per monitoring by PG&E for daylighting case study series, which showed savings of 2kWh/yr per sf for a 50,000sf store paying $0.10/kWh.

[5] "Letting the Sun Shine is Good for Business," John Pierson, *The Wall Street Journal*, November 20, 1995, page B1.

> *Wal-Mart claims energy savings from drawing natural light through the skylights. But 'something else has gotten the corporation's attention,' says the [Rocky Mountain] Institute. In every Wal-Mart store, each cash register is connected in real time back to headquarters in Bentonville, Ark. According to Tom Scay, who was then the company's vice president for real estate, sales were 'significantly higher' in those departments in the daylit half of the store, and they were also higher there than in the same departments at other stores. Employees in the half without daylighting continue to try to have their departments move to the daylit side."*

Such anecdotal studies have been intriguing, but have not offered a measure of how large such a positive effect might be. It has been clear for awhile that the value of such productivity impacts are potentially much greater than energy savings, not only for retailers, but for any business. A building that promises 1% higher productivity is likely to be far more interesting to an owner than a building that is guaranteed to use 10% less energy. Thus, we set out to see if a daylighting effect on performance could be demonstrated and quantified using rigorous statistical techniques.

The implications of the results of this study extend beyond the retail sector. By considering these retail findings with those from the companion study showing improved student performance in daylit classrooms, we can make a case that the beneficial effects of daylight are not likely to be confined to just schools or retail establishments, but rather that human activity in general is likely to benefit from exposure to daylighting.

2. METHODOLOGY

Our interest was to study the potential effect of daylighting on the performance of people in similar buildings with and without skylights. To do this, we sought organizations with pre-existing productivity measurements that could be compared between buildings with and without skylights (or daylight). We began by casting a wide net looking for the ideal organizations that could provide us with data sets amenable to our analysis.

We were looking for organizations that operated at many nearly identical sites, where about half the sites contained skylights and the other half did not. It was important that, other than variations in daylighting, the sites be as identical as possible. They should follow similar operations, and be in similar climates. It was also necessary that there be an on-going measure of performance for each site. We conducted a nationwide search looking for organizations that met these criteria.

The Retailer

We were lucky to find a retailer who met all of these conditions, and was willing to participate in the study. This retailer provided us with basic descriptive information about its stores and a "sales index" for each location. The sales index became the measure of productivity. The retailer, which wishes to remain anonymous, operates a set of nearly identical chain stores that sell a variety of consumer merchandise.

This retailer has had a policy of building their new stores with skylights for a number of years. However, they also have a considerable number of stores built during the same period that do not have skylights. About 2/3 of the stores in the data set have skylights and 1/3 do not. Most of these non-skylit stores were acquired during mergers with other chains. The merged sites were then remodeled to match the design image and layout of the primary chain; however, skylights were not added. About ¼ of the non-skylit stores were originally built that way by the retailer itself. Apparently some new managers acquired during the merger did not agree with the skylighting policy, and so the new store sites where they had the greatest influence were built without skylights. Thus, there was not a systematic decision made about which sites should have skylights.

The retailer believes that they are seeing significant operational savings by turning off the electric lights under the skylights. However, we did not attempt to confirm these claims in any way. Our interest was in the impacts on sales.

The design and operation of all the stores in the chain is remarkably uniform. Other than the presence of skylights, the skylit stores have two other features that differentiate them from the non-skylit stores: higher ceilings and photosensor control of the lights under the skylights. No other systematic difference between skylit and non-skylit stores was observed.

The store design of the retailer in this study would best be described as an exemplary skylighting application. The skylights diffuse any sunlight so that there is even illumination below. The design provides high illumination levels during peak daylighting conditions, often two-to-three times the electric lighting levels. The electric lighting design throughout the stores is also carefully thought out in relation to the skylighting and is consistently applied. Most of the electric lighting is fluorescent, with strategic display lighting and highlighting used in both the skylit and non-skylit stores. Quality lighting design is very clearly considered part of the merchandising strategy for the chain.

A sampling of stores, both with and without skylights, found seemingly equal attention to other design elements such as building façade, signage presence on the street, and parking lot size and accessibility. All of the stores were laid out in nearly identical fashion, so that similar items were located in similar places. Stores of the same vintage had similar signage and decoration within the stores. The individual stores are managed at the corporate level, so management and advertising is extremely similar between sites.

Data from the Retailer

The retailer provided us with sales performance data for over 100 stores that included 2/3 with skylights and 1/3 without skylights. The monthly gross sales per store were averaged over an 18-month period running from February 1 of one year to August 31 of the next. Before it was given to us, this average was mathematically transformed into a “sales index” that was appropriate for statistical analysis, but that did not reveal actual dollar performance.

Stores in the sample were selected to operate within a limited geographic region that had similar climatic conditions, and to have constrained ranges of size and age. The geographic region has a relatively sunny climate. All of the stores in the data set are one story.

The retailer was also able to provide us with additional data about each store, which included:

- Square footage of store
- Hours of operation
- Location (zip code)
- Date of original construction
- Date of most recent major renovation
- Historical “type” of store, which influenced basic construction materials and architectural design.

Additional Data

In addition, we wanted to control for potential demographic effects of each store location. The retailer did not provide us with demographic information about the store locations, so we used census data tied to the zip code location of each store. To do this, we added two fields of data derived from the U.S. 1990 Census: population and average household income per zip code.

This demographic information is only a proxy for the influence of store location. We would have preferred a population density measure instead of raw population per zip code, but that information was not easily available. We do not know how representative the zip code location is of the population actually served by the store. The store could be located on the edge of a zip code boundary and more predominately serve other neighboring zip codes. We don't know how large each store's territory is. In some cases sales may be reduced by other members of the chain that are close by, reducing the effective population served by each store. We also don't know how many competing companies are within the territories for each store. Presumably some locations have more competition than others do.

A more sophisticated analysis would have also included a measure of the number of competitors within a given range, more information about the demographic characteristics of the population served by the store, and perhaps also information about a store's relation to various traffic corridors. Internal analysis might also have included information about the experience of individual store managers, or other measures of how well the sales staff might be expected to perform. However, this information was not available to us, and therefore we cannot account for the influence of these variables.

On-site Observations

We visited one dozen of the stores to confirm the information in the data set, and perform some on-site observations. On-site observations involved walking around the public areas of the store, observing and interviewing customers and staff. The focus of these site visits was to see if there was any other obvious influence on sales that we should explore further, or if there was any obvious correlation between skylighting and some other aspect of store configuration or operation that we should try to account for. We also used the site visits as an opportunity to probe how the skylights might potentially have an effect on sales.

Interviews

Informal interviews with shoppers repeatedly confirmed that the vast majority of shoppers were not aware of the skylights. The questioner, looking just like any other shopper, would approach a shopper and ask: "May I ask you a question?" The response was universally affirmative. We then asked, "What do you think of the skylights in this store?" The typical response was to look up, look puzzled, and then say, "That's funny. I never noticed them before." Out of 42 interviews in 10 skylit stores, only three shoppers could be found who were already aware of

the skylights. Two of those volunteered that they had only noticed the skylights because their small child had pointed them out on an earlier trip, while looking up at a balloon or other bright object.

The questioner then asked: "Does this store feel any different to you than other stores like this?" By far the most common response (80%) was, "This store feels cleaner." The second most common response (65%) was, "It feels more spacious, more open." About one third of the respondents also mentioned that it was brighter. Three middle-aged respondents volunteered that they specifically came to this store instead of another closer to their home because they liked how it felt—cleaner, more open. Three elderly respondents commented on how important the brightness and the light quality were for them (although none had been aware of the skylights). Two middle-aged respondents talked about how important "natural" light was. Two older men commented that the energy savings must be considerable. Not one respondent objected to the skylights or had any negative comments about them.

Five store managers were interviewed about the skylights. All were positive about them, and reported they thought their customers liked them. Two mentioned the importance of energy savings. One commented on the "inviting feeling" the skylights created. Five store clerks were also interviewed: three were generally indifferent to the skylights; two were very positive, one saying, "I love them!"

3. FINDINGS

Using statistical analysis, it was determined that there were five main variables that had a significant effect on the gross sales per store. These variables are: the presence of skylighting, the number of hours the store is open per week, the population and income of the store's zip code, and the number of years since the store has last been remodeled. Next, the magnitude of the effect of these variables was determined.

The results of these statistical tests are graphed in Figure 3 below. This graph clearly shows the magnitude of the skylighting impact compared to the other significant variables. We discuss each variable in turn.

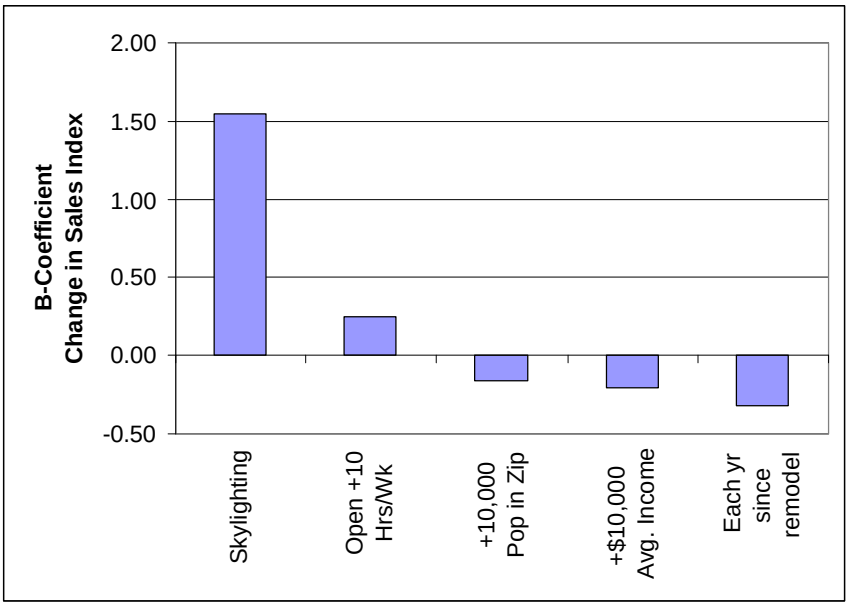

Figure 1: Change in Sales Index per Variable

Skylighting: A store with skylights is observed to have a sales index higher than an equivalent store without skylights. This is clearly the largest effect of any of the variables considered, (at B=+1.55). It is possible that there may be other reasons that the skylit stores are performing so well as a group. In our site visits, we made every effort to try to identify other characteristics of the skylit stores that might contribute to higher sales, but we did not find any obvious candidates. However, that possibility should always be kept in mind when examining these results.

Hours per Week: Opening more hours per week is seen to have a weak positive effect on store sales. Ten additional hours of operation per week shows a sales index increase of 0.2. The small effect here may be a function of the compressed range of hours possible for the stores in this chain, or the likely possibility that the

optimum hours of operation for each store location has already been determined and implemented.

Population and Income: The negative effects shown here might seem to be counter intuitive. One might expect that having more people in the zip code where the store is located, and especially having a higher average income, would instead produce a positive effect on sales. However, the negative effect may occur since more densely populated and higher income areas may attract more competition, both from within the chain and from outside competitors. Indeed, on our site visits we noted that the stores in the chain did seem to be more closely spaced together in higher income areas. This was not confirmed in any formal fashion.

Years Since Remodel: The number of years since the last full remodel of the store is a highly significant variable. Each year since the last remodel shows a negative effect. A store, which was last remodeled five years ago, has lost about as many sale index points as a skylit store gains. Thus, according to this equation, if the chain remodeled all of its stores at least every five years, the effect would be of the same magnitude as adding skylights to all of the stores.

Figure 2 below presents the results of the regression equation in tabular form.

SIGNIFICANT VARIABLES:	B	Std. Error	t	Sig.	**Order of Entry**	**Change in R^2**
(Model Constant)	2.47	1.52	1.63	0.106		
Skylights	**1.55**	**0.36**	**4.35**	**0.000**	**5**	**0.04**
Hours open per week	0.02	0.01	2.65	0.009	1	0.16
Population (per 10,000)	-0.16	0.08	-1.99	0.049	9	0.02
Average income ($10,000s)	-0.20	0.10	-2.03	0.045	8	0.01
Years since last retrofit	-0.32	0.06	-5.12	0.000	3	0.09
Outlier 97	6.91	1.41	4.90	0.000	2	0.12
Outlier 57	4.98	1.44	3.47	0.001	7	0.05
Outlier 94	4.23	1.43	2.97	0.004	4	0.05
Outlier 15	5.82	1.57	3.70	0.000	6	0.04
					Model R^2	**0.58**
NON SIGNIFICANT VARIABLES:		Store types				
		Gross square feet				
		Years since original opening				

Figure 2: Retailer Regression Findings

The table shows that the skylighting variable has the strongest positive effect on sales of all variables considered. In addition, there is a 99.9% certainty that this is a true effect associated with skylighting.

4. DISCUSSION AND CONCLUSION

It is useful to try to translate the results of the model into terms that can be applied to other situations. In this analysis, we were not able to describe the absolute dollar value of the skylighting variable, therefore we will try to describe the relative effect of the presence of skylighting on sales in other ways.

Interpreting the Retailer Results

These results show that adding skylighting to the average non-skylit store within the chain would be likely to improve its performance by 40%, with a probable range somewhere between 31% and 49%. Thus, if this non-skylit store were averaging sales of $2/SF, then its sales might be expected to increase to between $2.61 and $2.98 with the addition of a skylighting system.

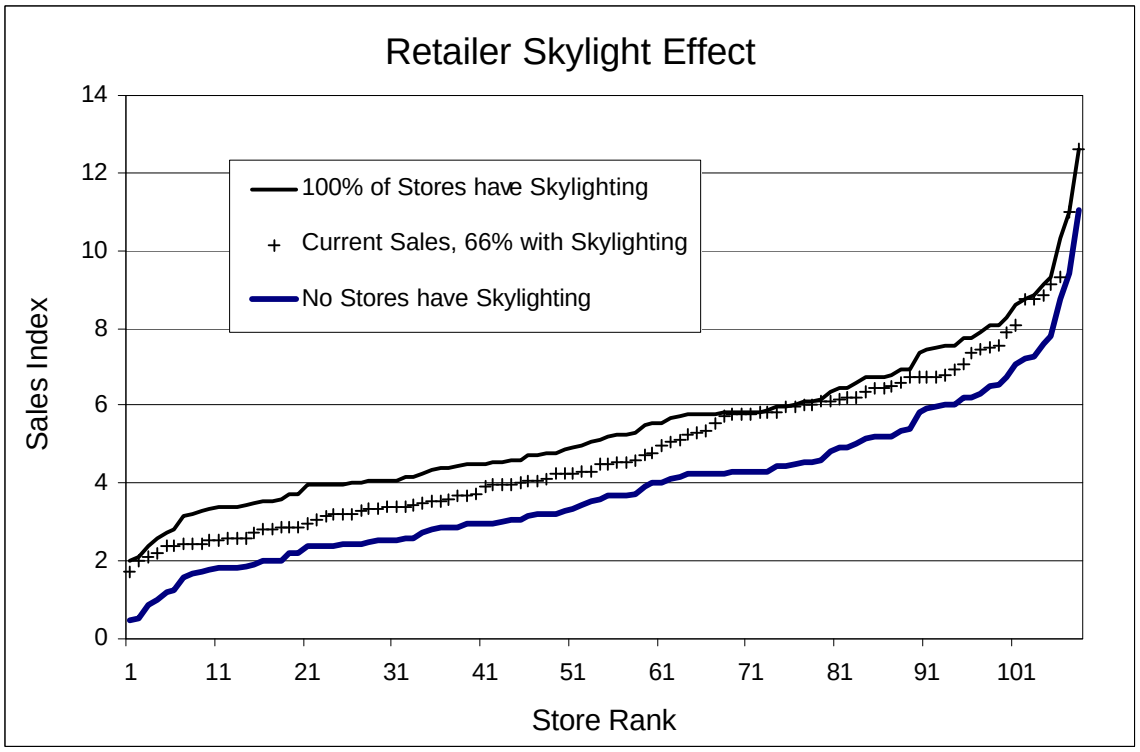

Figure 9: Chain-wide Sales Index with and without Skylighting

An alternative way to think about the impact of the skylighting is to ask how skylighting affects the overall gross sales for the chain as a whole. Currently 66% of the chain's stores have skylighting. If the chain added skylights to the rest of its locations, what effect would that have on gross sales? Figure 9 shows both the effect of adding skylighting to all stores in the chain, and the effect of removing the skylighting from all stores. The difference is dramatic. If this particular chain were to add skylighting to the remaining 34% of its stores, chain-wide sales could increase by up to11%. The difference between no skylighting in

any of the stores, and skylighting in all of the stores, is a likely 40% increase in chain-wide gross sales.

It should be remembered that there were many other variables not considered in our analysis, such as the number of competitors within a store's territory. Also, in spite of the apparent uniformity of the stores, there may be operational differences between skylit and non-skylit stores that were not visible to the observer. For example, the air temperatures might be slightly different, or they may tend to use different music play lists that somehow affect sales. If such additional variables could be properly identified and found significant in the analysis, then magnitude of the skylighting effect would probably be reduced somewhat.

There is also no way to know how these results would translate to another retail chain. A different chain would have a different distribution of sales per store, which would change the percentage effect. It is, of course, also unknown how skylighting of a different design would affect a store with different operations. The results of the regression equation are specific only for this data set. However, while magnitudes may vary in other analyses, we can say that in this case there clearly seems to be a strong positive effect to skylighting, and it is quite significant.

Mechanisms

With this analysis, we have shown a clear relationship between skylighting and increased sales, and quantified the effect for this particular chain. The next question that arises is why does this happen? What is causing the increased sales?

Unfortunately, this kind of analysis cannot prove that skylighting causes increased sales. It can only demonstrate that there is a strong correlation between the presence of skylighting and increased sales. The reason for the effect is left to hypothesis at this point. Below we discuss a number of possible mechanisms for such an effect.

Customer Loyalty: In our interviews, it was clear that customers were not consciously aware of the skylights. But a number of them did express loyalty to a skylit store, because it seemed cleaner, or had better lighting. A few mentioned that they did routinely travel a little farther to shop at a skylit store over another option closer to their home. This informal survey suggests that there may a customer loyalty effect to skylights. This would translate into a competitive advantage in attracting and keeping more customers.

More Relaxed Customers: It may be that once a customer is in the store the skylights somehow relax them, in a manner similar to piped-in music, which has been found so effective at relaxing customers and encouraging them to spend more time in a store shopping. We do know from interviews that customers seem to have positive feelings about the skylit stores and identify those stores with an airy, clean feeling.

Better Visibility: The high illumination levels along with improved lighting quality from the daylight may make it easier or more comfortable for customers to select products. Especially for elderly customers with declining eyesight, labels are likely to be more legible during the peak daylight hours. It may be easier to find products and/or discriminate between alternatives with daylight illumination.

More Attractive Products: The skylights may make products seem more attractive, inducing customers to buy more expensive products, or simply more products, than they otherwise would. It is possible that the visual quality provided by daylighting, with high color rendition and three-dimensional modeling, may make products look more appealing.

Employee Morale: It could be that employees have higher morale, and as a result provide better service. We did not have any way to measure employee productivity. Ultimately, in a retail environment, employee productivity would be measured by sales per employee hour. Logically, if there are higher sales per store, and no increase in the staffing level, there will also be higher sales per employee hour.

Any one of these mechanisms, or all of them, may be responsible for the increased sales. In order to apply these findings to other retailers, and other organizations, it would be useful to understand which qualities of skylighting are the most influential. However, understanding the actual mechanisms may ultimately not be as important as determining the design characteristics of a high performing skylighting system. At this point in time, that information may best be obtained from a knowledgeable designer with substantial daylighting experience, rather than from a scientific study.

Applying the Results outside of Retail

Another important question to consider is whether these results translate outside of the retail sector. If skylighting is associated with higher sales, does that mean it might increase productivity in a manufacturing building, or improve morale in an office building, or reduce absenteeism at a postal facility? If so, by how much? The answer is, of course, that we don't know.

However, in a companion study, we have shown that daylighting is associated with higher test scores in elementary school students. Considered as a whole, the two studies suggest that there is a general principle at work whereby daylight affects human beings in a positive way. Furthermore, these studies indicate that when this effect can be quantified, the impact can be quite significant.

California SUSTAINABLE DESIGN Training 2001

Section 6: Indoor Air Quality

HDR

Indoor Air Quality

Indoor Air Quality (IAQ) Facts

In "An Introduction to Indoor Air Quality", on EPA's Indoor Air Quality Program web site:

- Indoor air is often more polluted than outdoor, sometimes as much as 25% more polluted, and occasionally more than 100 times higher.
- Americans spend approximately 90% of their time indoors.
- Sick Building Syndrome occurs in approximately 30% of buildings, including both new and renovated buildings. Sick Building Syndrome, as defined by the EPA, is a term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building.
- Lost productivity costs billions of dollars annually.
- Indoor air pollution is one of the top five environmental risks to public health

Types of Indoor Air Contaminants

The following definitions are from the EPA's IAQ Program Glossary:

Biological Contaminants

Excessive concentrations of bacteria, viruses, fungi (including molds), dust mite allergen, animal dander, and pollen may result from inadequate maintenance and housekeeping, water spills, inadequate humidity control, condensation, or may be brought into the building by occupants, infiltration, or ventilation air. Allergic responses to indoor biological pollutant exposures cause symptoms in allergic individuals and also play a key role in triggering asthma episodes for an estimated 15 million Americans. ***Molds*** are a category of fungi with an estimated 20,000 species worldwide. Fungi survive by digesting plant and animal-based material specifically the starches and sugars stored in wood or paper. Mold spores are found almost everywhere and given the right surface, temperature and moisture can germinate and establish colonies very quickly. Molds can make people very sick, degrade building materials, and can cause structural damage to buildings**.**

Chemical Pollutants

Sources of chemical pollutants include tobacco smoke, emissions from products used in the building (e.g. office equipment; furniture, wall and floor coverings; and cleaning and consumer products) accidental spill of chemicals, and gases such as carbon monoxide and nitrogen dioxide, which are products of combustion. Noteworthy are ***Volatile Organic Compounds*** **(VOCs).** VOCs are compounds that vaporize (become a gas) at room temperature. Common sources which may emit VOCs into indoor air include housekeeping and maintenance products, and building and furnishing materials. In sufficient quantities, VOCs can cause eye, nose, and throat irritations, headaches, dizziness, visual disorders, memory impairment; some are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans. At present, not much is known about what health effects occur at the levels of VOCs typically found in public and commercial buildings. ***Heavy Metals;***

Airborne Lead and Mercury Vapor. Lead toxicity can cause acute illness and cognitive and developmental deficits in children. Latex paints that contain phenyl mercuric acetate (a preservative that prolongs shelf life) can expose persons to mercury. Note: since the mid 1990's PMA has been prohibited in newly manufactured paints.

Notes:

Particles

Particles are solid or liquid substances which are light enough to be suspended in the air, the largest of which may be visible in sunbeams streaming into a room. However, smaller particles that you cannot see are likely to be more harmful to health. Particles of dust, dirt, or other substances may be drawn into the building from outside and can also be produced by activities that occur in buildings, like sanding wood or drywall, printing, copying, operating equipment, and smoking.

Sources of IAQ Problems

Potential sources of indoor air quality problems ***inside the building*** include:

- HVAC system related problems such as improper air balance, dysfunctional supply and exhaust systems, malfunctioning controls, dirty cooling coils.

Dust Accumulated Inside a Mechanical Duct

- Human activities such as personal activities; housekeeping activities; and maintenance activities
- Building furnishings including the collection of dust or fibers; or the release of chemicals
- Unsanitary conditions or water damage
- Other sources include accidental events
- Inadequate ventilation of special use areas such as smoking lounges or food preparation areas, or copy machines
- Dust and particles from renovation projects

Sources outside building include:

- Pollen, dust, sprayed pesticides, smoke or industrial pollutants
- Emissions from nearby sources, such as loading docks or vehicle exhaust
- Soil gasses such as radon or pesticides
- Moisture or standing water

Symptoms of IAQ Problems

There are many symptoms of indoor air quality problems. Immediate effects include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Symptoms of some diseases may also show up, such as asthma. Long-term effects include respiratory diseases, heart disease, and cancer.

Designing for Good IAQ

There are many strategies that can be used to reduce the chances of indoor air quality problems.

Source Control refers to reducing potential sources of IAQ problems. Potential problems can be avoided via strategies that cover areas including selection of materials, design of the envelope, design, sizing and placement of the Heating Ventilation and Air Conditioning (HVAC) equipment and ductwork, appropriate construction practices and maintenance and repair schedules in building operations. It is difficult, if not impossible, to eliminate all sources of IAQ problems. Therefore, it is important to ***reduce potential IAQ problems*** through proper ventilation and regular maintenance practices.

Designing for good IAQ includes:

1. Material Selection

Many building materials contain volatile organic components and other components that are, or may be, hazardous to human health. Selecting low-emitting materials and furniture reduces the amount of toxins being brought into the building. Other ideas include:

- Consider non-paper faced gypsum board
- Use entrance mats to remove pollutants before an occupant enters a building
- Specify low-emitting materials
- Avoid vinyl wall covering on exterior walls

Sustainable Material Resources

The State of California has published several documents, including Environmental Specifications for Office Furniture Systems and Reducing Occupant Exposure to Volatile Organic Compounds from Office Building Construction Materials: Non-Binding Guidelines.

Other sources of low-emission standards are:

1. California's Indoor Air Quality Specifications as listed in Section

1350 of the Specifications for the Capitol Area East End project.
2. Adhesives: South Coast Air Quality Management District Rule #1168
3. Paints and Coatings: Green Seal Requirements
4. Carpet: Carpet and Rug Institute Green Label Indoor Air Quality Test Program

Notes:

2. Envelope Design Ideas

- Provide drainage tile at foundation footings with a minimum slope of ½" per 10 ft.
- Provide polyethylene vapor retarder under floor slabs
- Locate ducts within the conditioned envelope to reduce the likelihood of moisture condensating on cold surfaces.
- To the extent possible, use exterior wrap for duct insulation

3. System Design

Some of the key ventilation issues that influence indoor air quality include:

- Ventilation effectiveness. Ventilation effectiveness refers to how well air changes occur throughout a building.
- Air changes. The number of air changes required in various building and room types is typically dictated by code.
- Location of air intakes. The location of air intakes can impact indoor air quality. The CA LEED Supplement suggests locating a building's outdoor air intakes at least 25 feet from potential and existing sources of contamination.
- Duct insulation. To the extent possible, use exterior wrap for duct insulation, taking into consideration

sound attenuation requirements. Avoid oversizing the AC equipment as that will reduce dehumidification performance of the system.

4. Construction Practice Ideas

The air quality of a renovated or new building may be compromised by poor construction practices. One of the most widely recognized standards for good indoor air quality is the Sheet Metals and Air Conditioning Contractors Association's (SMACNA) Guidelines for Occupied Buildings Under Construction, 1995. SMACNA addresses:

HVAC Protection. HVAC equipment should be protected from dust and odors. Protection of the return side, supply side, and central filtration should be addressed.
Source Control. This includes addressing pollution that can be controlled at the source, such as product substitutions, use of construction equipment, demolition practices, exhausting work areas, and air cleaning.
Housekeeping. Surfaces should be kept clean and dry. Non-toxic cleaning products should also be used where possible.
Pathway Interruption. In occupied spaces, construction practices should include preventing air movement from the work area to occupied areas.
Scheduling. Especially in renovation projects, scheduling of work and occupant movement is critical.

Specific construction practices that help prevent degradation of IAQ include:

- HVAC Protection. Seal exhaust fan penetrations and ducts to keep dust and moist air from leaking into a wall or ceiling cavities.
- Occupant Protection. If building is partially occupied prevent air from the working areas from moving into the occupied areas. Using the air distribution system, flush out work area spaces prior to occupancy
- Sequencing of Installation. If products such as carpet and ceiling tiles are installed before wet products such as paint, the carpet and tiles may absorb paint emissions. These emissions may then be released into the indoor environment over long periods of time.
- Protection of materials. Keep building materials off the ground and under cover

5. Operational Practice Ideas

- Regularly clean and replace air filters
- Establish a vacuuming schedule for installed carpets based upon traffic rate
- Use cleaning agents on the basis of non-toxicity
- Clean exposed surfaces and furniture regularly
- Develop a comprehensive program of integrated pest management, minimizing or eliminating the use of chemical pesticides
- Locate equipment with exhausts away from areas where they will compromise ventilation of buildings.

Investigating IAQ

Methods used in an IAQ investigation may include

- Identification of pollutant sources
- Evaluation of HVAC system
- Observation of work practices
- Measurement of contamination levels and employee exposure
- Medical testing or physical examinations
- Employee interviews

- Review of records of medical tests, job histories and injuries and illnesses

One good resource is the EPA's Building Air Quality: A Guide for Building Owners and Facility Managers (December 1991). Because many indoor air quality problems are best resolved by responsible government agencies at the State and local level, EPA has developed both a live instructional course on indoor air quality issues, entitled Orientation to Indoor Air Quality, and a self-paced learning module entitled Introduction to Indoor Air Quality (April 1991) for these audiences.

Benefits of Eliminating IAQ Problems

Potential benefits of taking steps to avoid any indoor air quality problems include:

- Reduced liability risk
- Reduced insurance premiums
- Improved occupant health
- Increased productivity/reduced absenteeism

The Scoping Study on the Costs of Indoor Air Quality Illnesses: An Insurance Loss Reduction Perspective, written by Allan Chen and Edward L. Vine of Ernest Orlando Lawrence Berkeley National Laboratory, notes that "the incidence of commercial buildings with poor indoor air quality (IAQ), and the frequency of litigation over the effects of poor IAQ is increasing. If so, these increases have ramifications for insurance carriers, which pay for many of the costs of health care and general commercial liability"…."The literature search and discussions with insurance and risk management professionals reported in this paper turned up little specific information about the costs of IAQ-related problems to insurance

Notes:

companies. However, those discussions and certain articles in the insurance industry press indicate that there is a strong awareness and growing concern over the “silent crisis” of IAQ and its potential to cause large industry losses, and that a few companies are taking steps to address this issue”.
In the Report to Congress on Indoor Air Quality, 1989, it was noted that “It is generally agreed that poor indoor air can adversely affect employee health and productivity. These costs to industry have been estimated to be in the "tens of billions of dollars per year".

Examples of IAQ Liability
The ***EPA Headquarters*** located in the Waterside Mall in Washington, DC was renovated in 1987-1988. Five employees sued the Waterside Mall operator for alleged exposure to organics from new carpet that was installed during the renovation. The employees cited symptoms including cough, scratchy throat, sinus infections, fatigue and dizziness. The jury awarded nearly $1 million to the defendents.

Law enforcement and judicial staff occupied the new ***DuPage County Courthouse*** in DuPage, IL in 1991. Over 400 occupants soon began to suffer headaches, nausea, dizziness, and respiratory irritation. In March of 1992, several employees were removed by ambulance and the building was evacuated. A number of lawsuits followed. First, occupants filed a suit against DuPage County asking for closure of the building. The building did close in September of 1992 so that the ventilation system could be rebuilt. A second lawsuit was filed by the occupants against the architects, general contractors and HVAC contractors, suggesting that their illnesses were due to the design and the presence of VOCs. Yet another lawsuit was filed by the county against the architects and contractors. This suit asked for $3 million for fixing the ventilation system and another $1 million for reimbursement of worker’s claims.

The final verdict was that the County’s operation of the ventilation system was the problem. The County received no money for damages. The individual suits were settled out of court. Millions of additional dollars were spent on investigations, legal fees, renovation, and occupant compensation.

Resource	Description	Website
A Scoping Study on the Costs of Indoor Air Quality Illnesses: An Insurance Loss Reduction Perspective	A publication of the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory;	http://eande.lbl.gov/CBS/insurance/LBNL-41919.html
ASHRAE 62-1999	Ventilation for Acceptable Indoor Air Quality and approved Addenda.	www.ashrae.org
Building Air Quality: A Guide for Building Owners and Facility Managers	A 1991 publication by the EPA. ***Section 2, Factors Affecting Indoor Air Quality is included in this section of the manual.***	http://www.epa.gov/iaq/largebldgs/baqtoc.html
Carpet: Carpet and Rug Institute Green Label Indoor Air Quality Test Program		www.carpet-rug.com
Environmental Specifications for Office Furniture Systems	Information on low-emitting furniture and materials is available from the California Department of Health Services Indoor Air Quality Program.	http://www.cal-iaq.org/VOC/workstation.pdf
EPA Indoor Air Quality Web Site		http://www.epa.gov/iaq
Green Seal Requirements	Suggestions for emission limits for paints and coatings.	www.greenseal.org
OSHA Indoor Air Quality Web Site		http://www.osha-slc.gov/SLTC/indoorairquality/index.html
Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials: Non-Binding Guidelines	A 1996 publication from the California Department of Health Services Indoor Air Quality Program	http://www.cal-iaq.org/VOC/VOC.html

Indoor Air Quality

Resource	Description	Website
South Coast Air Quality Management District Rule #1168.	Suggestions for emission limits for adhesives and sealants.	www.aqmd.gov
Targeting Indoor Air Pollution, EPA's Approach and Progress, March 1993.	A 1993 U.S. Environmental Protection Agency Indoor Air Quality Program publication.	http://www.epa.gov/iaq/pubs/targetng.html
The Sheet Metal and Air Conditioning Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings Under Construction, 1995	Recommendations for good IAQ construction practices.	http://www.smacna.org

Factors Affecting Indoor Air Quality

2

The indoor environment in any building is a result of the interaction between the site, climate, building system (original design and later modifications in the structure and mechanical systems), construction techniques, contaminant sources (building materials and furnishings, moisture, processes and activities within the building, and outdoor sources), and building occupants.

The following four elements are involved in the development of indoor air quality problems:

Source: there is a source of contamination or discomfort indoors, outdoors, or within the mechanical systems of the building.

HVAC: the HVAC system is not able to control existing air contaminants and ensure thermal comfort (temperature and humidity conditions that are comfortable for most occupants).

Pathways: one or more pollutant pathways connect the pollutant source to the occupants and a driving force exists to move pollutants along the pathway(s).

Occupants: building occupants are present.

It is important to understand the role that each of these factors may play in order to prevent, investigate, and resolve indoor air quality problems.

Four elementsÑ sources, the HVAC system, pollutant pathways, and occupantsÑare involved in the development of IAQ problems.

SOURCES OF INDOOR AIR CONTAMINANTS

Indoor air contaminants can originate within the building or be drawn in from outdoors. If contaminant sources are not controlled, IAQ problems can arise, even if the HVAC system is properly designed and well-maintained. It may be helpful to think of air pollutant sources as fitting into one of the categories that follow. The examples given for each category are not intended to be a complete list.

Sources Outside Building

Contaminated outdoor air

- pollen, dust, fungal spores
- industrial pollutants
- general vehicle exhaust

Emissions from nearby sources

- exhaust from vehicles on nearby roads or in parking lots, or garages
- loading docks
- odors from dumpsters
- re-entrained (drawn back into the building) exhaust from the building itself or from neighboring buildings
- unsanitary debris near the outdoor air intake

Soil gas

- radon
- leakage from underground fuel tanks
- contaminants from previous uses of the site (e.g., landfills)
- pesticides

Moisture or standing water promoting excess microbial growth

- rooftops after rainfall
- crawlspace

Equipment

HVAC system

- dust or dirt in ductwork or other components
- microbiological growth in drip pans, humidifiers, ductwork, coils
- improper use of biocides, sealants, and/or cleaning compounds
- improper venting of combustion products
- refrigerant leakage

Given our present knowledge, it is difficult to relate complaints of specific health effects to exposures to specific pollutant concentrations, especially since the significant exposures may be to low levels of pollutant mixtures.

Non-HVAC equipment

- emissions from office equipment (volatile organic compounds, ozone)
- supplies (solvents, toners, ammonia)
- emissions from shops, labs, cleaning processes
- elevator motors and other mechanical systems

Human Activities

Personal activities

- smoking
- cooking
- body odor
- cosmetic odors

Housekeeping activities

- cleaning materials and procedures
- emissions from stored supplies or trash
- use of deodorizers and fragrances
- airborne dust or dirt (e.g., circulated by sweeping and vacuuming)

Maintenance activities

- microorganisms in mist from improperly maintained cooling towers
- airborne dust or dirt
- volatile organic compounds from use of paint, caulk, adhesives, and other products
- pesticides from pest control activities
- emissions from stored supplies

Building Components and Furnishings

Locations that produce or collect dust or fibers

- textured surfaces such as carpeting, curtains, and other textiles
- open shelving
- old or deteriorated furnishings
- materials containing damaged asbestos

Unsanitary conditions and water damage

- microbiological growth on or in soiled or water-damaged furnishings
- microbiological growth in areas of surface condensation
- standing water from clogged or poorly designed drains
- dry traps that allow the passage of sewer gas

Chemicals released from building components or furnishings

- volatile organic compounds or
- inorganic compounds

Other Sources

Accidental events

- spills of water or other liquids
- microbiological growth due to flooding or to leaks from roofs, piping
- fire damage (soot, PCBs from electrical equipment, odors)

Special use areas and mixed use buildings

- smoking lounges
- laboratories
- print shops, art rooms
- exercise rooms
- beauty salons
- food preparation areas

Redecorating/remodeling/repair activities

- emissions from new furnishings
- dust and fibers from demolition
- odors and volatile organic and inorganic compounds from paint, caulk, adhesives
- microbiologicals released from demolition or remodeling activities

Indoor air often contains a variety of contaminants at concentrations that are far below any standards or guidelines for occupational exposure. Given our present knowledge, it is difficult to relate complaints of specific health effects to exposures to specific pollutant concentrations, especially since the significant exposures may be to low levels of pollutant mixtures.

HVAC SYSTEM DESIGN AND OPERATION

The HVAC system includes all heating, cooling, and ventilation equipment serving a building: furnaces or boilers, chillers, cooling towers, air handling units, exhaust fans, ductwork, filters, steam (or heating water) piping. Most of the HVAC discussion in this document applies both to central HVAC systems and to individual components used as stand-alone units.

A properly designed and functioning HVAC system:

- provides thermal comfort
- distributes adequate amounts of outdoor air to meet ventilation needs of all building occupants
- isolates and removes odors and contaminants through pressure control, filtration, and exhaust fans

Thermal Comfort

A number of variables interact to determine whether people are comfortable with the temperature of the indoor air. The activity level, age, and physiology of each person affect the thermal comfort requirements of that individual. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 55-1981 describes the temperature and humidity ranges that are comfortable for most people engaged in largely sedentary activities. That information is summarized on page 57. The ASHRAE standard assumes "normal" indoor clothing. Added layers of clothing reduce the rate of heat loss.

Uniformity of temperature is important to comfort. When the heating and cooling needs of rooms within a single zone change at different rates, rooms that are served by a single thermostat may be at different temperatures. Temperature stratification is a common problem caused by convection, the tendency of light, warm air to rise and heavier, cooler air to sink. If air is not properly mixed by the ventilation system, the temperature near the ceiling can be several degrees warmer than at floor level. Even if air is properly mixed, uninsulated floors over unheated spaces can create discomfort in some climate zones. Large fluctuations of indoor temperature can also occur when controls have a wide "dead band" (a temperature range within which neither heating nor cooling takes place).

Radiant heat transfer may cause people located near very hot or very cold surfaces to be uncomfortable even though the thermostat setting and the measured air temperature are within the comfort range. Buildings with large window areas sometimes have acute problems of discomfort due to radiant heat gains and losses, with the locations of complaints shifting during the day as the sun angle changes. Large vertical surfaces can also produce a significant flow of naturally-convecting air, producing complaints of draftiness. Adding insulation to walls helps to moderate the temperature of interior wall surfaces. Closing curtains reduces heating from direct sunlight and isolates building occupants from exposure to window surfaces (which, lacking insulation, are likely to be much hotter or colder than the walls).

Humidity is a factor in thermal comfort. Raising relative humidity reduces the ability to lose heat through perspiration and evaporation, so that the effect is similar to raising the temperature. Humidity extremes can also create other IAQ problems. Excessively high or low relative humidities can produce discomfort, while high relative humidities can promote the growth of mold and mildew (see *Appendix C*).

A number of variables, including personal activity levels, uniformity of temperature, radiant heat gain or loss, and humidity, interact to determine whether people are comfortable with the temperature of the indoor air.

Ventilation to Meet Occupant Needs

Most air handling units distribute a blend of outdoor air and recirculated indoor air. HVAC designs may also include units that introduce 100% outdoor air or that simply transfer air within the building. Uncontrolled quantities of outdoor air enter buildings by infiltration through windows, doors, and gaps in the exterior construction. Thermal comfort and ventilation needs are met by supplying "conditioned" air (a blend of outdoor and recirculated air that has been filtered, heated or cooled, and sometimes humidified or dehumidified).

The amount of outdoor air considered adequate for proper ventilation has varied substantially over time. The current guideline issued by ASHRAE is Standard 62-1989.

Large buildings often have interior ("core") spaces in which constant cooling is required to compensate for heat generated by occupants, equipment, and lighting, while perimeter rooms may require heating or cooling depending on outdoor conditions.

Two of the most common HVAC designs used in modern public and commercial buildings are **constant volume** and **variable air volume** systems. Constant volume systems are designed to provide a constant airflow and to vary the air temperature to meet heating and cooling needs. The percentage of outdoor air may be held constant, but is often controlled either manually or automatically to vary with outdoor temperature and humidity. Controls may include a minimum setting that should allow the system to meet ventilation guidelines for outdoor air quantities under design conditions.

Variable air volume (VAV) systems condition supply air to a constant temperature and ensure thermal comfort by varying the airflow to occupied spaces. Most early VAV systems did not allow control of the outdoor air quantity, so that a decreasing amount of outdoor air was provided as the flow of supply air was reduced. Some more recent designs ensure a minimum supply of outdoor air with static pressure devices in the outdoor air stream. Additional energy-conserving features such as economizer control or heat recovery are also found in some buildings.

Good quality design, installation, and testing and balancing are critically important to the proper operation of all types of HVAC systems, especially VAV systems, as are regular inspections and maintenance. (See *Appendix B* for further discussion of HVAC system types.)

The amount of outdoor air considered adequate for proper ventilation has varied substantially over time. The current guideline issued by ASHRAE is ASHRAE Standard 62-1989. The building code that was in force when your building HVAC system was designed may well have established a lower amount of ventilation (in cubic feet of outdoor air per minute per person) than is currently recommended. (A table of outdoor air quantities recommended by ASHRAE is reproduced on page 136 in *Appendix B.* Note that other important aspects of the standard are not included in this table.)

Control of Odors and Contaminants

One technique for controlling odors and contaminants is to dilute them with outdoor air. Dilution can work only if there is a consistent and appropriate flow of supply air that mixes effectively with room air. The term "ventilation efficiency" is used to describe the ability of the ventilation system to distribute supply air and remove internally generated pollutants. Researchers are currently studying ways to measure ventilation efficiency and interpret the results of those measurements.

Another technique for isolating odors and contaminants is to design and operate the HVAC system so that pressure relationships between rooms are controlled. This control is accomplished by adjusting the air quantities that are supplied to and removed from each room. If more air is supplied to a room than is exhausted, the excess air leaks out of the space and the room is said to be under **positive pressure**. If less air is supplied than is exhausted, air is pulled into the space and the room is said to be under **negative pressure**.

Control of pressure relationships is critically important in mixed use buildings or buildings with special use areas. Lobbies and buildings in general are often designed to operate under positive pressure to prevent or minimize the infiltration of unconditioned air, with its potential to cause drafts and introduce dust, dirt, and thermal discomfort. Without proper operation and maintenance, these pressure

differences are not likely to remain as originally designed.

A third technique is to use local exhaust systems (sometimes known as dedicated exhaust ventilation systems) to isolate and remove contaminants by maintaining negative pressure in the area around the contaminant source. Local exhaust can be linked to the operation of a particular piece of equipment (such as a kitchen range) or used to treat an entire room (such as a smoking lounge or custodial closet). Air should be exhausted to the outdoors, **not** recirculated, from locations which produce significant odors and high concentrations of contaminants (such as copy rooms, bathrooms, kitchens, and beauty salons).

Spaces where local exhaust is used must be provided with make-up air and the local exhaust must function in coordination with the rest of the ventilation system. Under some circumstances, it may be acceptable to transfer conditioned air from relatively clean parts of a building to comparatively dirty areas and use it as make-up air for a local exhaust system. Such a transfer can achieve significant energy savings.

Air cleaning and filtration devices designed to control contaminants are found as components of HVAC systems (for example, filter boxes in ductwork) and can also be installed as independent units. The effectiveness of air cleaning depends upon proper equipment selection, installation, operation, and maintenance. Caution should be used in evaluating the many new technological developments in the field of air cleaning and filtration.

POLLUTANT PATHWAYS AND DRIVING FORCES

Airflow patterns in buildings result from the combined action of mechanical ventilation systems, human activity, and natural forces. Pressure differentials created by these forces move airborne contaminants from areas of relatively higher pressure to areas of relatively lower pressure through any available openings.

The HVAC system is generally the predominant pathway and driving force for air movement in buildings. However, all of a building's components (walls, ceilings, floors, penetrations, HVAC equipment, and occupants) interact to affect the distribution of contaminants.

Chases, crawlspaces, and other hidden spaces can be both sources and pathways for pollutants.

For example, as air moves from supply registers or diffusers to return air grilles, it is diverted or obstructed by partitions, walls, and furnishings, and redirected by openings that provide pathways for air movement. On a localized basis, the movement of people has a major impact on the movement of pollutants. Some of the pathways change as doors and windows open and close. It is useful to think of the entire building — the rooms and the connections (e.g., chases, corridors, stairways, elevator shafts) between them — as part of the air distribution system.

Natural forces exert an important influence on air movement between zones and between the building's interior and exterior. Both the **stack effect** and **wind** can overpower a building's mechanical system and disrupt air circulation and ventilation, especially if the building envelope is leaky.

Stack effect is the pressure driven flow produced by convection (the tendency of

The basic principle of air movement from areas of relatively higher pressure to areas of relatively lower pressure can produce many patterns of contaminant distribution.

warm air to rise). The stack effect exists whenever there is an indoor-outdoor temperature difference and becomes stronger as the temperature difference increases. As heated air escapes from upper levels of the building, indoor air moves from lower to upper floors, and replacement outdoor air is drawn into openings at the lower levels of buildings. Stack effect airflow can transport contaminants between floors by way of stairwells, elevator shafts, utility chases, or other openings.

Wind effects are transient, creating local areas of high pressure (on the windward side) and low pressure (on the leeward side) of buildings. Depending on the leakage openings in the building exterior, wind can affect the pressure relationships within and between rooms.

The basic principle of air movement from areas of relatively higher pressure to areas of relatively lower pressure can produce many patterns of contaminant distribution, including:

- local circulation in the room containing the pollutant source
- air movement into adjacent spaces that are under lower pressure (*Note*: Even if two rooms are both under positive pressure compared to the outdoors, one room is usually at a lower pressure than the other.)
- recirculation of air within the zone containing the pollutant source or in adjacent zones where return systems overlap
- movement from lower to upper levels of the building
- air movement into the building through either infiltration of outdoor air or reentry of exhaust air

Air moves from areas of higher pressure to areas of lower pressure through any available openings. A small crack or hole can admit significant amounts of air if the pressure differentials are high enough (which may be very difficult to assess.)

Even when the building as a whole is maintained under positive pressure, there is always some location (for example, the outdoor air intake) that is under negative pressure relative to the outdoors. Entry of contaminants may be intermittent, occurring only when the wind blows from the direction of the pollutant source. The interaction between pollutant pathways and intermittent or variable driving forces can lead to a single source causing IAQ complaints in areas of the building that are distant from each other and from the source.

BUILDING OCCUPANTS

The term "building occupants" is generally used in this document to describe people who spend extended time periods (e.g., a full workday) in the building. Clients and visitors are also occupants; they may have different tolerances and expectations from those who spend their entire workdays in the building, and are likely to be more sensitive to odors.

Groups that may be particularly susceptible to effects of indoor air contaminants include, but are not limited to:

- allergic or asthmatic individuals
- people with respiratory disease
- people whose immune systems are suppressed due to chemotherapy, radiation therapy, disease, or other causes
- contact lens wearers

Some other groups are particularly vulnerable to exposures of certain pollutants or pollutant mixtures. For example, people with heart disease may be more affected by exposure at lower levels of carbon monoxide than healthy individuals. Children exposed to environmental tobacco smoke have been shown to be at higher risk of respiratory illnesses and those exposed to nitrogen dioxide have been shown to be at higher risk from respiratory infections.

Because of varying sensitivity among people, one individual may react to a particular IAQ problem while surrounding occupants have no ill effects. (Symptoms that are limited to a single person can also occur when only one work station receives the bulk of the pollutant dose.) In other cases, complaints may be widespread.

A single indoor air pollutant or problem can trigger different reactions in different people. Some may not be affected at all. Information about the types of symptoms can sometimes lead directly to solutions. However, symptom information is more likely to be useful for identifying the timing and conditions under which problems occur.

Types of Symptoms and Complaints

The effects of IAQ problems are often non-specific symptoms rather than clearly defined illnesses. Symptoms commonly attributed to IAQ problems include:

- headache
- fatigue
- shortness of breath
- sinus congestion
- cough
- sneezing
- eye, nose, and throat irritation
- skin irritation
- dizziness
- nausea

All of these symptoms, however, may also be caused by other factors, and are not necessarily due to air quality deficiencies.

"Health" and "comfort" are used to describe a spectrum of physical sensations. For example, when the air in a room is slightly too warm for a person's activity level, that person may experience mild discomfort. If the temperature continues to rise, discomfort increases and symptoms such as fatigue, stuffiness, and headaches can appear.

Some complaints by building occupants are clearly related to the discomfort end of the spectrum. One of the most common IAQ complaints is that "there's a funny smell in here." Odors are often associated with a perception of poor air quality, whether or not they cause symptoms. Environmental stressors such as improper lighting, noise, vibration, overcrowding, ergonomic stressors, and job-related psychosocial problems (such as job stress) can produce symptoms that are similar to those associated with poor air quality.

Environmental stressors such as improper lighting, noise, vibration, overcrowding, ergonomic stressors, and job-related psychosocial problems (such as job stress) can produce symptoms that are similar to those associated with poor air quality.

The term **sick building syndrome (SBS)** is sometimes used to describe cases in which building occupants experience acute health and comfort effects that are apparently linked to the time they spend in the building, but in which no specific illness or cause can be identified. The complaints may be localized in a particular room or zone or may be widespread throughout the building. Many different symptoms have been associated with SBS, including respiratory complaints, irritation, and fatigue. Analysis of air samples often fails to detect high concentrations of specific contaminants. The problem may be caused by any or all of the following:

- the combined effects of multiple pollutants at low concentrations
- other environmental stressors (e.g., overheating, poor lighting, noise)
- ergonomic stressors
- job-related psychosocial stressors (e.g., overcrowding, labor-management problems)
- unknown factors

Building-related illness (BRI) is a term referring to illness brought on by exposure to the building air, where symptoms of diagnosable illness are identified (e.g., certain allergies or infections) and can be directly attributed to environmental agents in the air. Legionnaire's disease and hypersensitivity pneumonitis are examples of BRI that can have serious, even life-threatening consequences.

A small percentage of the population may be sensitive to a number of chemicals in indoor air, each of which may occur at very low concentrations. The existence of this condition, which is known as **multiple chemical sensitivity (MCS)**, is a matter of considerable controversy. MCS is not currently recognized by the major medical organizations, but medical opinion is divided, and further research is needed. The applicability of access for the disabled and worker's compensation regulations to people who believe they are chemically sensitive may become concerns for facility managers.

Sometimes several building occupants experience rare or serious health problems (e.g., cancer, miscarriages, Lou Gehrig's disease) over a relatively short time period. These **clusters** of health problems are occasionally blamed on indoor air quality, and can produce tremendous anxiety among building occupants. State or local Health Departments can provide advice and assistance if clusters are suspected. They may be able to help answer key questions such as whether the apparent cluster is actually unusual and whether the underlying cause could be related to IAQ.

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Section 7: Construction Waste Management

HDR

Construction Waste Management

National / California Statistics

Waste

- On new commercial projects, the waste to square foot ratio may be as high as one ton for each 100 square foot of building floor space.
- Buildings and infrastructure generate about 30% of the state's solid waste materials according to the California Integrated Waste Management Board.

Recycling

According to the California Integrated Waste Management Board, in 2000 approximately 28 million tons of waste was recycled in California. Tipping fees have reached as high as $85.00 a ton in some regions of the state.

CA Regulations

Assembly Bill AB 939, California Integrated Waste Management Act of 1989, requires local jurisdictions to reduce the amount of waste they are sending to landfills by 50% in the year 2000. Local jurisdictions who fail to comply can be fined up to $10,000 /day for non-compliance.

Assembly Bill 75 requires state agencies to reduce the amount of material they are sending to the landfill by 25% in 2002 and 50% in 2004. Again, it is anticipated that non-compliance could have negative budgetary impact on a state agency.

CA/DGS Construction Waste Management (CWM) Requirements

The current DGS A/E Agreement includes requirements for construction waste management based on the Tier Lists.

Tier 1 List. Projects are required to incorporate these solutions. For construction waste this requires the development of a recycling plan/program that diverts 50% or better of demolition and construction materials from landfills.

Tier 2 List. If economically feasible, project teams are encouraged to divert 75% or better.

Benefits of Construction Waste Management

- Increases longevity of existing landfills
- Prevents costly process of siting new landfills
- Prevents emissions of air/water pollutants
- Conserves energy
- Preserves resources
- Creates jobs
- Decreases green house emissions

- Stimulates development of greener technologies
- Cost savings from lower disposal fees, avoided labor and implementation expenses.

A study called the Environmental and Economic Benefits of Increased Recycling was sponsored by U.S. EPA and developed by the Tellus Institute.
The Tellus Institute performed an analysis of the economic and environmental benefits if the State of Iowa increased its recycling rate to 50% in 2000 relative to 25% in 1990. Four categories of benefits were examined:

Energy. The energy benefit is the energy saved by manufacturing a product from recycled materials as opposed to virgin materials.

Greenhouse gas (GHG) emissions. The GHG emission benefits are the net emissions per ton due to the recycling of a given material minus the net emissions from storing it in a landfill.

Value of materials recovered. The materials benefit is the value of the additional material recycled. It is based primarily on the price of recycled feedstock purchased by end users and mills.

Amount of landfill space saved. The landfill benefit is the landfill space saved by recycling. A per-ton multiplier was developed for each of the four categories. These multipliers were applied to each ton of waste recovered to determine the benefit of recycling that material.

Environmental benefits noted in the study.

- 1,307,220 tons diverted from landfill

Notes:

- 96,981,741 cubic feet of landfill space avoided
- 210,997 acres of forests not harvested
- 11,094,003 lbs of carbon monoxide eliminated
- 2,763 lbs of lead burden to environment eliminated
- 5,261,384 lbs of nitrogen oxide eliminated
- 455,190 MTCE greenhouse gasses eliminated

Economic benefits noted in the study.

- 650 jobs created processing recyclables
- 1,290 additional "piggybacked" jobs
- $100.3 million in industrial sales statewide
- State revenue: $2,400,000
- Local government revenue: $3,900,000
- End use value of recycling to 50% rate: $359,000,000
- End use jobs created/enhanced; 8,800

Who is Responsible for CWM?

DGS Staff, the Architect, and the Contractor all have a role to play in developing a plan for Construction Waste Management. As noted in the RFP and the DGS Standard A/E agreement, it is a requirement that CWM be included in every DGS project.

Typically, the Architect is responsible for developing the CWM Plan. If the Contractor has experience in writing and/or implementing a CWM plan, the Contractor may assist in developing the plan.

Refer to page 7.8-7.10 for ***a flowchart that outlines the steps to develop a successful construction waste management plan***.

Additional information that will be helpful in developing the plan is included below:

Identifying Materials for CWM Plan

Consider the following materials for ***reuse or salvage***

- Doors/windows
- Fixtures
- Appliances
- Wood/lumber
- Brick
- Soil
- Plants
- Cabinets/Millwork
- Architectural finishes
- HVAC equipment

Consider the following materials for ***recycling in a new construction project***

- Brick
- Metal
- Cardboard
- Drywall
- Asphalt Pavement
- Concrete
- Paint
- Insulation
- Wood
- Glass
- Tile and masonry
- Gypsum
- Beverage containers

The following may be ***recycled in renovation projects***

- Ceiling tile

- Carpet and pad
- Plumbing fixtures
- Electronic fixtures and wire

On-site / vs. Off-site Separation

One of the key steps in developing the CWM Plan is determining if construction waste will be sorted on-site or off-site. Some of the key issues and considerations of each option are listed below.

Site Separation
On-site separation refers to the sorting of construction waste on-site for delivery to a recycler. On-site separation spreads the cost and benefits of collection, and provides a clean waste stream. This concept of was first formalized by the document WasteSpec which was generated by the Triangle J Council of Governments in North Carolina.

WasteSpec requires that separate material bins be located at the site for recyclables. The general contractor is responsible for verifying that all subcontractors are sorting construction waste from their own activities. It is the general contractor's responsibility to provide bins or containers and maintain them as part of daily cleaning.

Implementing and enforcing a plan involves careful planning as well as continuing education of all trades in weekly meetings and "tool box" talks.

Remote Separation
In this scenario, an independent recycler owns a materials recovery facility (MRF). Typically, an independent recycler

Notes:

underbids a garbage hauler. The independent recycler takes containers of construction waste from the site to recycler's own plant where separation takes place.

Many independent recyclers use sophisticated equipment and have access to large sites for the storage of materials until the markets for various materials are more lucrative. Waste haulers may also offer a recycling service. However, the owner and architect must be satisfied that such a firm has a proven track record of recycling in this manner and has the resources required to satisfy the contract requirements. This is a serious issue that often justifies an audit. All participants should be aware of the increased possibility of contamination.

CWM Reporting

A CWM specification should identify CWM expectations, set diversion goals, and define how CWM will be audited. This is the only means by which the owner can be satisfied that construction and demolition waste is being properly recycled.

Site Separation
For site-separation projects, the contractor would be required to generate a form with weight tickets, signatures and other forms of validation that reflect the kind and amounts of materials that have been recycled.

Remote Separation
For remote-separation projects, the recycler should be able to define general percentages of materials as well as their weight. To better facilitate future programs, it is important to quantify and qualify recycling efforts, thereby reinforcing successes and defining failures.

A sample weigh ticket is included on page 7.11.

City Ordinances
Several municipalities have established ordinances to control construction and demolition waste. Some of these cities tie the ordinances to general permits. The City of Dublin requires that each project over $100,000.00 submit a waste management plan detailing how that project will divert 50% of it's materials from the landfill. Applicants for building or demolition permits involving any Covered Project shall complete and submit a Waste Management Plan ("WMP"), on a WMP form approved by the City for this purpose as part of the application packet for the building or demolition permit. The completed WMP shall indicate all of the following:
(1) the estimated volume or weight of project C&D debris, by materials type, to be generated;
(2) the maximum volume or weight of such materials that can feasibly be diverted via reuse or recycling;
(3) the vendor or facility that the Applicant proposes to use to collect or receive that material; and
(4) the estimated volume or weight of C&D materials that will be landfilled.
http://www.stopwaste.org/pr-dublin.html

The California Integrated Waste Management Board (CIWMB) web site posts links to local government programs, ordinances, contract language, and permit conditions.

There is a ***sample ordinance from the City of Oakland*** located at the back of this section.

Notes:

Project Team Coordination
The single most effective way to ensure success with a construction and/or demolition waste management program is through *communication*. Experience shows the most effective Project Team coordination includes the following communication components:

On-Site CWM Manager - An on-site CWM operations manager should be appointed. Their responsibility should include verifying conformance with the CWM plan, coordinating proper emptying of containers, and resolving any related issues.

Plan Distribution – Since the CWM plan may effect any department during its' implementation, the CWM plan should be distributed to all levels of management. People who are informed about a policy early in its deployment are far more likely to become invested in its successful outcome.

Education – Because different groups of people will be working at the site throughout the project duration, it is important that a formal educational presentation of the CWM program be given to all contractors – including subs - prior to their admittance to the job site. The On-Site CWM Manager should review the container locations and relevant sorting procedures with all workers.

Signage – Signage throughout the job site will help increase recovery rates of waste materials. Signs can be used to direct

worker's attention to the appropriate C & D policies, the location and use of the collection receptacles, and the recovery progress to date.

Monitoring – The On-Site CWM Operations manager should verify that all team members are sorting their recyclables properly. The success of any recycling program depends on *usable* recovered materials.

Overcoming Obstacles

The Owner and the Architect or Engineer must take a proactive approach to ensuring success of CWM for the following reasons:

- Monetary savings.
- The construction team will be more likely to fully comply if they witness sponsorship of the CWM plan from management.
- One CWM plan successfully implemented encourages further successful CMW plans.
- It is State law
- It's good public relations for all involved.

Obstacles will vary depending on the strategies employed during each project:

Logistics – Great effort is often required to determine exactly what should or can be recycled for a project in any given geographical area. Before a CWM plan can be formed, some initial investigation will need to be done for each project.

Infrastructure Constraints - Several issues may hinder a CMW plan. Can the materials be stored on-site until collection? Is there a market for the recylables nearby? One option to overcome these is to have an *on-site public sale* of the materials.
Another option is *vertical integration* of materials, whereby the building or demolition company operates a construction company or salvage yard to handle material themselves. Ideally, the material is reclaimed on-site and prepared for re-use in another local building project.

Tracking - It is more difficult to track the quantities of specific recyclables that have not been site- sorted. Since sorting at the time of deposit requires little additional time, it is the most cost-effective way to sort construction waste. Salvage companies pay more for carefully sorted materials, and can more easily provide documentation of what, and how much, is being collected.

Community Benefits

While the benefit to recycling is primarily environmental, it is vital to understand that recycling efforts also reflect commitment to the *total economic well-being of a community*. Financial returns from recycling continue to increase as supporting industry infrastructures grow. Increased recycling volumes make the process more cost-effective for both supplier and receiver. By providing full, sustained support to recycling enterprises, communities throughout California are realizing enhanced economic returns.

There are also subtle economic returns from recycling. Avoided are the costs of collecting and burying "trash". The burden of future environmental cleanup and associated public health liabilities is

reduced. Recycling also provide new jobs and affiliated industries. Furthermore, communities that are viewed as being environmentally responsible are more likely to attract progressive industries and the workforce to run them.

It is important to look at the whole chain of economic benefits from Construction Waste Management. What may appear to be a break-even venture, in fact has more return for a community than is initially apparent.

Notes:

Resources

California Integrated Waste Management Board CalMAX: California Materials Exchange - Free Classified Ads to help businesses find markets for materials traditionally discarded. http://www.ciwmb.ca.gov/CalMAX

King County, WA Solid Waste Division
King County, Washington's Department of Natural Resources' Solid Waste Division web site has extensive information on sustainable design and construction waste management. http://dnr.metrokc.gov/swd/bizprog/sus_build/how_others.htm

Used Building Materials Association
The Used Building Materials Association is a non-profit organization which helps companies gather and redistribute building materials. http://www.ubma.org

California Division of General Services – Energy Management
WasteSpec a publication with the specification language required to insure

Construction Waste Management

CWM compliance, is available from David Weightman, DGS Energy Management Division.
David.Weightman@dgs.ca.gov

Design Phase

Identify Recyclable Building Components

CIWMB Recycled-Content Product Database

http://www.ciwmb.ca.gov/RCP/default.asp?FLAG=5

Consider Availability of Salvaged Material

Minimize Use of Materials

Checklist for Environmentally Responsible Design and Construction

http://www.buildinggreen.com/ebn/checklist.html

http://www.ciwmb.ca.gov/ConDemo/SampleDocs/PaloAlto

Identify Local Ordinances / Regulations

City of Palo Alto: General Permit Conditions For C&D
City of Sacramento: C&D Ordinance

http://www.ciwmb.ca.gov/ConDemo/SampleDocs/

Evaluate Local Resources

California Construction & Demolition Recyclers Database

http://www.ciwmb.ca.gov/ConDemo/Recyclers/

Craft Construction / Demolition Waste Specification That Will Work

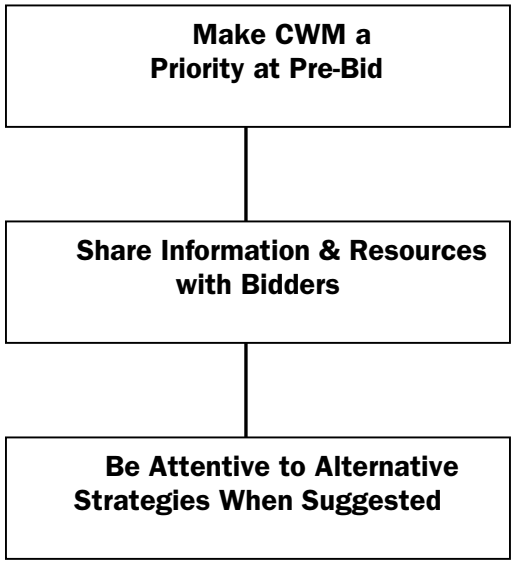
WasteSpec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling

http://www.tjcog.dst.nc.us/cdwaste.htm

Tie Performance Into Payment

Construction Waste Management

Bidding Phase



Construction Phase

Submit CWM Plan

Set up a Waste Management Plan for your Job-site

http://dnr.metrokc.gov/swd/bizprog/sus_build/a_pla

Include as Agenda Item at Project Meetings

Provide Training for All Trades

Training

http://www.thoreau.org/Design/recycling.html

Enforce Audits

Enforce Audit

http://www.ciwmb.ca.gov/ConDemo/SampleDocs/Oakland

Publish Final Report

City Of Oakland

Recycling and Waste Reduction Practices for City Construction and Demolition Projects

Background

The City of Oakland is required by the California Integrated Waste Management Act of 1989, Assembly Bill 939 (AB 939), to reduce 50% materials landfilled by the year 2000. Additionally, the Alameda County Waste Reduction and Recycling Act of 1990 (Measure D) requires a reduction of more than 50% of materials landfilled.

Construction and demolition waste constitutes approximately 14% of Oakland' s existing waste stream going into landfills. This includes 7.33% inert material such as concrete and asphalt and 6.42% unpainted wood. These materials have a significant potential for recycling and waste reduction. The City is targeting these materials for recycling to reduce the disposal of construction and demolition waste generated from the City' s projects.

Purpose

In order to comply with AB 939 and Measure D requirements, the City is requiring its construction and demolition contractors to minimize materials being landfilled by developing and implementing a Job Site Recycling and Waste Reduction Plan (JSR & WRP). Contractor shall prepare and implement a JSR & WRP for any City construction and demolition project where cost exceeds $150,000. The submitted Plan JSR & WRP shall be reviewed by the Public Works Agency, Environmental Services Division.

Definitions

Recycling/Recyclables are defined as non-hazardous residential, commercial, or industrial material(s) or by-products which are set aside, handled, packaged, or offered for collection in a manner different than Solid Waste for the purpose of being reused or processed and then returned to the economic main stream in the form of commodities.

Reuse shall mean reusing materials on the job site.

Salvage shall mean salvaging materials for resale or storage for reuse on future projects.

Solid Waste (garbage for landfill disposal) shall mean all putrescible and non putrescible solid, semisolid, and liquid wastes, including garbage, trash refuse, paper rubbish ashes, industrial wastes, non-recyclable demolition and construction wastes, discarded home and industrial appliances, treated or chemically fixed sewage sludge which is not hazardous waste.

Information required in the Job Site Recycling and Waste Reduction Plan

Contractor shall include the following information:

1. Name of project manager and emergency telephone numbers.
2. Amount of waste expected to be generated.
3. Identification of types and estimates of quantities of material to be recycled, reused or salvaged.
4. On-site material sorting and separation procedures.
5. Name of proposed sub-contractors for recycling service, if applicable.

6. A brief statement on how the contractor plans to inform sub-contractors and workers on the project of recycling and waste reduction activities proposed in the JSR & WRP

7. Estimates of quantities of materials that are not recyclable, reusable or salvageable and will be disposed as solid waste (garbage for landfill disposal).

Submittal of JSR & WRP
The contractor shall submit the **Job Site Recycling and Waste Reduction Plan** form with the required bid submittal packet. The City will provide the successful bidder with technical assistance to recycle, reuse or salvage materials. The City encourages innovative approaches to recycling, reuse or salvage.

Review and Evaluation of the JRS & WRP
Environmental Services Division staff will review and evaluate the JSR & WRP based on the following criteria:

- Reasonableness of materials targeted for recycling, reuse or salvage based on the project and local markets for materials.

- Constraints of the job site.

Project Completion-Reporting Requirements
The contractor shall submit the attached Summary Report (SR) Format conclusion of the project. The report shall list:

1. Type of material recycled, reused or salvaged

2. Actual tonnage, volume or quantity of materials recycled, reused or salvaged

3. Handling procedure of the materials:
   * A brief description of how the recyclable materials were separated from other wastes and the destination of materials recycled.
   * A brief description of materials separated on-site for reuse or salvage.

4. Actual tonnage or volume of solid waste disposed in a landfill from the job site

The Summary Report Form must be completed at the conclusion of the project and submitted to the City Resident Engineer before final payment.

CITY OF OAKLAND

Project No.

___ Approved

___ Waived

___ Not Approved

Staff Initials _____

Job Site Recycling and
Waste Reduction Plan Form (JSR & WRP)
Submit with Bid

1. Please answer the following questions:

Construction Waste Management

Project Address _____
Name of Project Manager _____
Phone Number _____
Cellular Phone No. _____
Fax Number _____

1. Estimate the amount of waste this project will generate on the waste assessment table on the back of this page.

2. Estimate the types of materials to be recycled, reused and salvaged on the work assemmsent table on the bace

3. Briefly state how materials will be sorted for recycling, reuse or salvage on the job site.

4. Will this project require the use of sub-contractors. ❑ Yes ❑ No

   If yes, briefly state how you plan to inform and ensure participation by the sub-contractors of your **Job Site Recycling and Waste Reduction Plan**.

Waste Assessment
Identify the materials and quantities that you estimate can be recycled, reused or salvaged. Specify any additional materials that can be recycled, reused or salvaged. Estimate the amount of solid waste generated and disposed in landfill.

Material Type	**Est. Amount** (tons/yards)	**Proposed Processing Methods** (check all that is applicable)			
		Recyclable	Reuseable	Salvageable	Landfill
Asphalt & Concrete					
Brick, Tile					
Building Materials					

(Doors, windows, fixtures, etc…)					
Corrugated Cardboard					
Dirt/Clean Fill					
Drywall					
Padding-Carpet/Foam					
Plate Glass/Non-Container					
Scrap Metals					
Unpainted Wood & Pallets					
Yard Trimmings, Brush, Trees, Stumps, etc.					
Others					
Garbage-soild waste trash, rubbish, discarded food					
Total					

If no materials are targeted for recycling, reuse or salvage, please state why.

_____ _____

Contractor's Signature **Date**

City of Oakland

Summary Report Form (SR)

Project No. _____

Project Address _____

_____

Construction Waste Management

Submit at project completion

1. Please indicate the material type recycled, reused or salvaged and the actual quantities processed from this project. State if the material was recycled, reused or salvaged. Describe the handling procedure or destination of each material. Indicate the actual amount of solid waste produced and disposed in landfill.

Material Type	**Est. Amount** (tons/yards)	**Actual Quantities**				**Handling Procedures/ Destination**
		Recyclable	Reuseable	Salvageable	Landfill	
Asphalt & Concrete						
Brick/Tile						
Building Materials Doors, windows, fixtures, etc.						
Corrugated Cardboard						
Dirt/Clean Fill						
Drywall						
Padding-Carpet/ Foam						
Plate Glass/Non-Container						
Scrap Metals						
Unpainted Wood & Pallets						
Yard Trimmings Brush, trees, stumps, etc.						
Others						

Garbage Solid Waste Trash, rubbish, discarded food, etc.						
Total						

If no recycling took place, please explain why.

_____ _____

Contractor's Signature **Date**

Resource	*Description*	*Website*
California Integrated Waste Management Board	The California Integrated Waste Management Board site Demolition Debris Recycling Program.	www.ciwmb.ca.gov/ConDemo/
King County, Washington	Extensive information on sustainable design and construction waste.	http://dnr.metrokc.gov/swd/bizprog/sus_build/how_others.htm
Waste Specifications	Model specifications for construction waste reduction, reuse, and recycling developed by the Triangle J Council of Governments.	www.tjcog.dst.nc.us/cdwaste.htm
Alameda County Waste Management Authority	Local governments such as Alameda County, can often provide excellent information on local infrastructure for recycling C & D Materials. Alameda maintains a database of businesses that accept C & D materials.	http://recycle.stopwaste.org/group.asp?groupcode=CD
Used Building Materials Association	A non-profit, membership based organization that represents companies and organizations involved in the acquisition and/or redistribution of used building materials.	http://www.ubma.org

California SUSTAINABLE DESIGN Training 2001

Section 8: Materials

HDR

Case Studies

Refer to the end of this section of the manual for case studies on the Monterey Regional Waste Management District Office Building and the EPA's Regional Headquarters in Philadelphia.

Misperceptions

There are a few key misperceptions that may hinder the use of sustainable products. These include:

1. The perception that sustainable products are lesser in quality than standard products. Sustainable products should be required to meet the same performance requirements as any other product. It is true that some products may have had problems associated with them, such as difficulty with installation, or durability, but this rarely is due to the sustainable characteristics of a product.
2. The perception that sustainable products "look different" than standard materials. Certainly some products may look like they are environmentally friendly (such as some agricultural products, for example). However, many sustainable products would not be noticeable to a building owner or building occupant. These include such products as refurbished furniture partitions, low VOC paints, or recycled content ceiling tiles.
3. The perception that sustainable products always cost more. Some sustainable products do cost more than 'typical' products. However, this additional first cost is often offset by increased durability of product, reduced maintenance costs, or other benefits to building occupants such as enhanced indoor air quality.There are a large number of sustainable products available that do not cost any more than the standard product.
4. The perception that sustainable products are not readily available. Some sustainable products are not available in all locations. A good example is products made from industrial waste or certified wood. However, it is rare that there would be a delay on the delivery of a sustainable product due to delays in the manufacturing process.
5. The perception that a number of sustainable products are proprietary or do not have competitive manufacturers. There are some products that are proprietary, but this is the exception rather than the rule.

Evaluating Materials

Product Life-cycle

Evaluating a material, or comparing two materials to determine if the product(s) is a sound environmental product depends on the evaluation of a material's life cycle, often called the cradle-to-cradle analysis of a material.

This process typically addresses the environmental impacts of:

Resource acquisition. This includes addressing the environmental impacts of extracting the resources necessary to manufacture the product.

Manufacturing. This includes evaluating the environmental impacts of the manufacturing process.

Transporting. This includes considering the impacts of transporting the material to the manufacturing or assembly location, as well as transporting the material to the site.

Installation. This includes considering the impact the installation of the product will have on the installer as well as any building occupants.

Impact to Building Occupants. This includes evaluating what impact the product will have on occupants during its use.

Performance. This includes considering how durable the product is, as well as what kind of maintenance requirements the product has.

End of use options. This includes considering if the product can be disassembled, recycled, or reused.

Methods of Product Evaluation
There is not one 'standard' for evaluating the sustainable characteristics of all building materials. There are some tools that can be used, however, when selecting materials, at least in part, due to their sustainable characteristics. They include:

- National Institute of Standards and Technology Building for Economic and Environmental Sustainability (BEES). BEES measures the environmental performance of building products by using the environmental life-cycle assessment approach specified in ISO 14000 standards
- AIA's Environmental Resource Guide. This guide presents detailed life-cycle

Notes:

information about a number of building products.
- LEED Material Credits. The material credit requirements in the LEED Green Building Rating System address some of the key criteria for product selection.
- Environmental Building News simplified criteria, outlined in the article, Building Materials: What Makes a Product Green?

Environmental Building News Criteria
The criteria highlighted in the Environmental Building News called Building Materials: What Makes a Product Green? Represent a simplified methodology that can be utilized by anyone attempting to consider the sustainable qualities of building products. This article is reproduced at the end of this section. Note that **information on materials presented in the training** is also included at the end of this section.

The general idea presented in the article is that certain key product criteria can be evaluated to determine how sustainable a product might, or might not, be.

The criteria are as follows:
Products made from Environmentally-Attractive Materials
Specifically:
- Products that reduce material use
- Salvaged products
- Products with post-consumer recycled content
- Products with post-industrial recycled content
- Certified wood products
- Products made from agricultural waste material
- Natural or minimally processed products

California, in fact, has a State Agency Buy Recycled Campaign, requiring that state agencies purchase products that contain recycled materials whenever the following are comparable
- Price
- Quality
- Availability

State agencies must spend a specified minimum on products that have recycled content. The required minimum procurement goal is 50 percent of all the funds the agencies spends in 11 product categories. Construction products include glass products, paint, tire derived products, steel products

Products that are Green Because of What Isn't There
Specifically:
- Alternatives to ozone-depleting substances
- Alternatives to products made from PVC and polycarbonate
- Alternatives to conventional preservative-treated wood that contains toxins
- Alternatives to other components considered hazardous

Products that Reduce Environmental Impacts during Construction, Renovation, or Demolition
Specifically:
- Products that reduce the impacts of new construction
- Tackable carpet
- Products that reduce the impacts of renovation
- Raised flooring
- Products that reduce the impacts of demolition
- Low mercury fluorescent lamps

Products that Reduce Environmental Impacts of Building Operation

Specifically:

- Building components that reduce heating and cooling loads
- Equipment that conserves energy
- Renewable energy and fuel cell equipment
- Fixtures and equipment that conserve water
- Products with exceptional durability or low maintenance requirements
- Products that prevent pollution or reduce waste
- Products that reduce or eliminate pesticide treatments

For example, consider the following comparison of the use of a 27 watt compact fluorescent vs. a 100 watt incandescent lamp.

	Fluorescent	**Incandescent**
Cost of Lamps	$14.00	$0.50
Lamp Life	4.5 years	0.5 years
Annual Energy $	$5.91	$21.90
# Lamps Replaced in 4.5 years	0	10
Total Cost	$40.60	$103.55
Savings Over Lamp Life	$62.95	0

Products that Contribute to a Safe, Healthy Indoor Environment

Specifically:

- Products that don't release significant pollutants into the building
- Products that block development and spread of indoor contaminants
- Products that remove indoor pollutants
- Products that warn occupants of health hazards in the building
- Products that improve light quality

Other Methods of Evaluation

There are also some resources for evaluating specific products. They include:

Notes:

Carpet. The Carpet and Rug Institute's Green Label Indoor Air Quality Test Program indicates that a carpet manufacturer is committed to developing ways to minimize any adverse effects on indoor air quality. A representative sample of the product type is tested by an independent laboratory and meets the established requirements for each program.

Certified Wood. There are certification programs for wood products that come from well-managed forests. They include: SmartWood and the Forest Stewardship Council.

Green Seal. Green Seal is the independent, nonprofit organization dedicated to protecting the environment by promoting the manufacture and sale of environmentally responsible consumer products. It sets environmental standards and awards a "Green Seal of Approval" to products that cause less harm to the environment than other similar products.

Benefits of Green Materials

There are many benefits to selecting sustainable products, such as

1. Reduced maintenance costs; for example
   - By specifying easy-to-maintain materials
   - By leasing equipment or materials

2. Reduced operational costs; for example
   - By selecting products that result in energy savings

3. Reduced replacement of materials
   - By selecting durable materials

4. Reduced environmental impact; for example
   - By reducing unnecessary resource extraction
   - By minimizing waste generation

5. Reduced impacts to air quality; for example
   - By selecting low-emitting materials
   - By using indoor air quality monitors

No Cost Material Solutions

There are many products that may be considered sustainable that would not add anything to a project's cost. They include, for example

- Low VOC sealants, adhesives and paints
- Recycled content ceiling tiles
- Recycled content ceramic tile – Ecocycle by Crossville Ceramics
- Reclaimed nylon in carpet
- Reprocessed or consolidated latex paint

Cost Competitive Sustainable Materials

There are a number of products that are cost competitive with standard products.

Agriboard in lieu of particleboard

Agriboard is a term used for agricultural based products such as wheatboard or strawboard. These products do not contain formaldehyde like most particleboard does, and they are as durable.

Recycled content rubber flooring in lieu of vinyl composition tile

Using recycled content rubber flooring assists in closing the recycling loop as

opposed to using a product with little or no recycled content.

Linoleum in lieu of sheet vinyl flooring.
Linoleum is made primarily from renewable resources, such as linseed oil, pine resins, jute, cork, and wood wastes. Specifying linoleum also eliminates specifying a product that uses chlorine in the manufacturing process.

Polyolefin wall coverings in lieu of vinyl wall coverings
Polyolefin wall covering, in contrast with vinyl wall covering, allows the wall to "breath"; it does not require the use of chlorine in the manufacturing process; and it may be recycled.

TPO Energy Star roofing in lieu of EPDM
Energy Star roofs have high reflectances and can assist in reducing a building's operating costs by reflecting heat.

"ChipSeal" treatment for improving solar reflectance asphalt paving
Chip seals are applied in a three-part process. The asphalt emulsion binder is first sprayed onto the pavement. This is followed immediately by an application of rock chips. Finally, the rocks are pressed into the asphalt binder using a heavy roller.

Comparing Materials

Following are two examples of how two products might be compared for both environmental and economic criteria.

Polyisocyanurate roofing insulation as alternate to extruded polystyrene insulation.

Pros:

Notes:

Sustainable Materials

- No ODS used as blowing agent.
- Reclaimed resins per CPG.
- Available in boardstock, tapered and nailbase.
- Meets UL, FM, ICBO criteria for roofing applications.

Cons:

- Proprietary
- Cannot be used in vertical waterproofing applications.
- Cannot be used in building interiors because of toxicity when burning.

Cost is same as other polyisocyanurates and, depending on market, less than extruded polystryrenes.

Comparing Materials

The following article, which includes a table created by Joe Hittinger, is Reprinted with Permission by Interiors & Sources magazine. It is taken from "***The Green Exchange***", which was created as a forum for sustainable design, a place where readers can come to ask questions, find the latest technologies and trends, research current industry standards and product information." The information presented is regarding a study done for materials for an office complex.

The client, a single occupancy tenant in a newly constructed building, is occupying 250,000 square feet. When finishes were chosen the design team proposed using linoleum sheet flooring in lieu of vinyl composition tile in support areas such as copy/print rooms, pantries and file rooms. These support areas comprise approximately 12,000 square feet of the space. The team felt that the linoleum fared better than VCT in environmental impacts and possibly in performance. Although the client expressed concern for the environment, the client also wanted to understand the increased cost, what would be gained for this increased cost, and if there would be the possibility of recouping any of that expense. The analysis on the facing page was prepared.

From this information, it was determined that payback for the increased first cost of linoleum would come after the second year, with additional savings for every year thereafter.

The conclusions drawn by the owner allowed us not only to use linoleum in support areas, but in an additional 6,000 square feet of space as well. The client was thrilled to do something to help the environment and the building occupants, as well as aiding its bottom line.

The following table summarizes the results of the study:

Comparison of VCT and Linoleum

CHARACTERISTIC	VCT	LINOLEUM SHEET
Composition	Binders, fillers, pigments (some pigments contain heavy metals). Vinyl content is 30% maximum.	Linseed oil, cork, wood flour, pine rosins on jute backing, man-made, environmentally friendly pigments.
Impact resistance (Static Load Limit)	75 p.s.i.	150 p.s.i.—450 p.s.i.
Disposal	Non-biodegradable	Biodegradable
Antistatic Properties	Not antistatic	Inherently antistatic (not static dissipative). Repels dust and dirt.
Hygienic Properties	No antimicrobial properties	Inherently antimicrobial. Inhibits the growth of many microorganisms.
VOC Emissions	VOCs come from maintenance procedures.	No harmful agents.
Availability	Produced in U.S. Stocked in U.S.	Produced in Europe. Shipped and stocked in U.S. (Lower energy requirements in manufacturing offset shipping energy.)
Stain Resistance	Good	Excellent
Chemical Resistance		
High pH solutions	Excellent	Good
Solvents	Good	Excellent
Acids	Good	Good
Warranty	5 years	5 years
Maintenance	Traditional waxing with periodic stripping and resealing.	Wet method or dry method (preferred)

Initial Cost (Installed)	$1.50 (aver.)/sf	$3.50 (aver.)/sf
Maintenance Cost (per year)	$1.45/sf	$.50/sf
Costs:		
Year 1	$2.95	$4.00
Year 2	$4.40	$4.50
Year 3	$5.95	$5.00
Year 4	$7.45	$5.50
Year 5	$8.90	$6.00

Case Study

Project Name:	Monterey Regional Waste Management District Administration Building
Location:	Marina, CA
New Project or Renovation:	Renovation
Project Size:	8,050 sq. ft.
Cost/ft2:	$1,436,000 $178/sq.ft.
Completion Date:	March of 1994
Owner:	Monterey Regional Waste Management District
Architect:	Paul Davis Partnership

Overview

In an effort to "close the recycling loop," the administration building and scalehouse were expanded and remodeled in 1994 using a green building approach. Construction materials made from reused or recycled items were selected wherever possible. In addition to recycled content products, items made from renewable resources were selected.

The project included a new boardroom, an expanded second story, two new truck scales, a separate scalehouse, a new septic system, roadways, paving, landscaping and other site improvements, equipment, and furniture.

Project Goals

Showcase of high quality, affordable, recycled-content and/or environmentally friendly building materials.

Key Elements

Energy Efficient System

- Building powered solely through the electricity generated by the Landfill Gas Project.

Resource Efficient Materials

- The linoleum flooring is made from linseed oil, pine resins, jute, and cork rather than petroleum products.
- The decorative and structural beams, instead of being made from old growth trees, are made from small, fast growing trees that were "reassembled" into straight, strong, and defect-free parallel beams.
- The oriented strand board (OSB) replacing plywood, for exterior sheathing applications, is made from fast growing trees instead of old growth trees.
- The two types of insulation used in the walls and ceiling contain recycled material. The fiberglass insulation is made from 30% recycled bottle glass, and the cellulose insulation is made from 100% recycled newspapers.
- The wall paneling in the boardroom and upstairs conference room is made from 100% recycled newspaper. More than 600 lbs. of newsprint were used to make the 960 sq. ft. of paneling. Homasote Paneling,
- The floor tiles in the entryway are made from recycled automobile windshields. The manufacturer combines old windshields from trucks, cars, and airplanes, as well as glass scrap from new windshields and grinds it into a fine powder. This powder is the major component of the tile–each one contains more than 70% recycled windshield glass. Manufacturer: Terra Green Ceramics
- The carpeting throughout the building is made from recycled plastic soda bottles. More than 21,200 2-liter soda bottles were used to make the 590 square yards of carpeting. Manufacturer: Image Industries, Inc.
- The restroom partitions are made from 35% recycled plastic.
- The wheel stops in the parking lot are made from 70% recycled plastic.

Benchmarking

N/A

Outcomes

Sustainable materials were integrated at no additional cost.

Lessons Learned

No matter whether a goal for recycled content materials is developed for a project, it is important to pick materials carefully. Tile was specified in the lobby for a high profile recycled content material, however, when it gets wet it is very slick. Additionally, there were two colors of recycled content carpet incorporated into the public building and the lighter colored carpet has shown spots more than the darker colored carpet.

Case Study

Contact Information
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Email: hfeldman@mrwmd.org

Web Address
http://www.ciwmb.ca.gov/GreenBuilding/CaseStudies/Public/Monterey.htm

Case Study

Project Name:	EPA Regional Headquarters
Location:	Philadelphia, PA
New Project or Renovation:	Renovation
Project Size:	305,750 sq. ft.
Cost/ft2:	
Completion Date:	Summer 1998
Owner:	General Services Administration

Overview
In 1992, The EPA, Region VII began looking for 300,000 square feet of new space. The space was to be leased not owned. The EPA wanted to do what they could to support the environmental efforts the EPA was known for. The design solution of the space needed to support a multi-tenant office building in which they would be rental tenants.

Project Goals
Incorporate every sustainable, green building principle within their financial and practical restraints

Approach
The EPA, GSA, building owners, managers and general contractor worked as a team communicating, developing, and incorporating green design ideas.

Key Elements
Recycling

- -Construction waste management plan reduced landfill waste.
- -Recycling approximately 11,000 fluorescent lamps diverted harmful mercury from the landfill.

Materials Reuse

- Reuse of 260 interior office doors diverted seven tons of material form the landfill, resulting in a savings of $60,000.

- Reuse of acoustical tile and steel ceiling structure diverted 42.5 tons of material from the landfill, resulting in a savings of $320,000.
- Partial reuse of existing HVAC systems reduced cost.
- Reuse of 3,000 lighting fixtures avoided 45 tons of material disposal and saved $420,000
-
- Reuse of bathroom tiles, fixtures, and stalls reduced cost.
- Use or recycled content steel studs in place of wood reduced resource use.

Energy Efficiency
- Electronic ballasts, energy efficient lighting, and motion detectors conserves energy.
- Energy management control system to monitor comfort levels for occupant comfort.
- Energy efficient appliances and low-flow bathroom fixture saves resources.

Air Quality Management
- Emissions' limits on volatile organic compounds (VOCs) from building materials and furniture minimized impact to indoor environment
- Elimination of paint emissions and used wood products containing no formaldehyde reduced potential IEQ problems.
- Productivity gains estimated at $780,.000 annually were expected thanks to a healthier indoor environment.

Transportation
- Secure, interior bicycle parking and showers on site encourage alternative transportation.
- Building is located above one of the main regional rail and subway stations. 95% of employees are estimated to be using public transportation.

Outcomes

The EPA negotiated a reduction in lease costs due to the energy saving devices incorporated into the project. The project was completed 25% below budget with a cost savings of approximately $500,000.

Web Address

http://www.libertynet.org/macredo/grlsintr.htm

Sustainable Material Examples

Following is a list of materials shown as examples during the training. The CIWMB nor DGS do not promote the manufacturers or products listed. They are included for informational purposes only.

Product/ Manuf.	*Product Type*	*Characteristics*	*Website*
Bamboard; CWI Products	Bamboo Flooring	Rapidly renewable material	http://www.bamboardusa.com/
Primeboard	Bio-based utility board	Formaldehyde-free biobased particleboard substitute. Rapidly renewable material	http://www.primeboard.com/
Cacoon; Louisiana Pacific	Building Insulation	70 to 90 percent recycled newsprint cellulose insulation (CPG item).	http://www.greenstone.com/
Envirelon; Talisman Mills:	Carpet	100 percent recycled PET carpet	http://buildingforhealth.com/carpet.html#anchor3225042
Carpet Tile, Interface	Carpet Tile	100 percent post industrial fiber and backing	http://www.interfaceinc.com/us/
Mortar Net; Mortar Net	Cavity wall mortar barrier	100 percent recycled polyester (50 percent post consumer)	http://www.mortarnet.com
Astro ClimaPlus; USG	Ceiling Tile	85 percent recycled content mineral fiber ceiling tile.	http://www.usg.com/Product_Index/1_3_0_astro_features.asp
Eurostone; Chicago Metallic	Ceiling Tile	Zero Flame Spread, Zero Smoke developed, no man made mineral fibers or organic binders that support growth of bacteria.	http://www.chicago-metallic.com/cmc1-4-5.htm
Terra Classic; Terra Green, Inc.	Ceramic Tile	55 percent recycled glass from airplane windshields	http://www.terragreenceramics.com/index.html

Product/ Manuf.	Product Type	Characteristics	Website
EcoCycle; Permagrain	Ceramic Tile	Manufactured from post-industrial tile scrap	http://www.permagrain.com/as.htm
Cork Tile; Expano Cork Company	Cork floor tile	Rapidly renewable material	http://www.expanko.com/
Fiberglass Insulation; Guardian	Fiberglass Insulation	Minimum 20 to 25 percent recovered content (CPG product)	http://www.guardianfiberglass.com/
Fiberock, USG	High impact resistant gypsum wallboard	Typical product composition is 60 percent gypsum, 20 percent recycled paper products, 10 percent perlite and 5 percent copolymers and silica.	http://www.usg.com/product_index/_product_index.asp?vProdCat=1&vFamily=1&vGreenLink=1
Top Lab Plus; Trespa	Laboratory casework	Contains 70 percent wood fibers and 30 percent organic binding agent.	http://www.trespanorthamerica.com/
Deliplan Royal; DLW	Linoleum	Rapidly renewable material	
LumberLast; Temple-Inland	Lumber	Recycled HDPE	
Medite; Sierra Pine	Medium Density Overlay Board	Formaldehyde free SCS Certified	http://www.sierrapine.com/
Classica; MDC Wallcoverings	Polyolefin Wallcovering	No PVC, heavy metals or phthalates. Can be recycled.	http://www.mdcwallcoverings.com/

Sustainable Material Examples

Product/ Manuf.	*Product Type*	*Characteristics*	*Website*
GreenGuard Protection Board; Pactiv.	Protection Board	One of two extruded insulations that are manufactured without the use of ozone-depleting substances. (No boardstock insulation is manufactured without ODS – only protection board.)	http://www.pactivbuildingproducts.com/
Atlas ACFoam; Atlas Roofing Product	Roofing Insulation	Polyisocyanurate foam manufactured without CFCs or HCFCs (ozone depleting substances)	http://www.atlasroofing.com/insulation/acultra.html
Syndecrete	Solid Surface Material	Manufactured from cement containing flyash, recycled materials such as metal shavings, plastic regrinds and recycled glass. Syndecrete incorporates a minimum of 30 percent recycled or recovered materials from both post-consumer and post-industrial sources.	http://www.syndesisinc.com/
Rubberific Mulch; Green Edge Enterprises	Synthetic mulch	Synthetic Mulch from crumb rubber	
EcoNights; Dodge-Regupol	Tile or sheet flooring	Manufactured from EPDM and SBS rubber.	http://www.regupol.com/
Comtec Industries	Toilet Partitions	Recycled HDPE toilet partitions.	http://www.comtecindustries.com/
Sure-Weld; Carlisle	TPO roofing membrane	Energy Star listed. Non-halogenated. Recyclable.	http://www.carlisle-syntec.com/main_index.cfm?act=5.8
Vision; Moment: Cellulose/Polyester	Wall Covering	Type II wall covering. PVC, heavy metal and VOC free	

Product/ Manuf.	*Product Type*	*Characteristics*	*Website*
Timeless Series 3; Permagrain Products	Wood flooring from FSC certified forest	Certified lumber	http://www.permagrain.com/

Green Material Resources

Resource	*Description*	*Website*
Building for Environmental and Economic Sustainability (BEES)	BEES is a tool that helps in the identifying of building materials that will reduce energy use, improve air quality and other conditions that could improve the environmental performance of buildings. The National Institute of Standards and Technology (NIST) developed the software program under a federal interagency agreement with funding from EPA.	The BEES program runs on a Windows-based system. Currently available free on disk from the Pollution Prevention Information Clearinghouse at (202) 260-1023. Their website is http://epic.er.doe.gov/epic/.
Comprehensive Procurement Guidelines	A key component of the government's "buy-recycled" program. Federal requirements are explained. Product and manufacturers information are included.	www.epa.gov/cpg
Environmental Building News	Web links to many product reviews /product information from EBN publication.	www.buildinggreen.com
Environmentally Preferable Purchasing	EPP is a federal-wide program that encourages and assists executive agencies in the purchasing of environmentally preferable products and services.	www.epa.gov/opptintr/epp/
Green Building Materials: A Guide to Product Selection and Specification	A book by Ross Spiegel and Dru Meadows. Published by John Wiley and Sons.	Available for purchase in www.amazon.com.
GreenSpec	The GreenSpec Binder provides up-to-date information on more than 1,200 green building products as selected by the editors of EBN. Available in hard copy or an on-line version.	www.greenspec.com.

Resource	*Description*	*Website*
National Parks Services Sustainable Design & Construction Database	This database has approximately 1,300 product listings from over 550 manufacturers, listings of over 7,000 recyclers of construction debris nationwide, and expanded listings of books, periodicals, organizations, and on-line resources of sustainable information. Last updated in 1996, it is still a useful tool. (Note: to use, you must download. This is a large file.)	www.nps.gov/dsc/dsgncnstr/susdb/
Resources for Environmental Design Index (REDI)	REDI is an on-line database of green building products featuring more than 1,800 companies. Also available at this web site is a Product Gallery, with highlights of new products that save energy, natural resources and personal health.	http://www.oikos.com/
Whole Building Design Guide	Internet resource initially developed by the Navy.	www.wbdg.org

Designing With Vision…

A Technical Manual for Material Choices in Sustainable Construction

Revised July 2000

California Environmental Protection Agency
Integrated Waste Management Board

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United States
Environmental Protection
Agency

Solid Waste
and Emergency Response
(5306W)

EPA530-F-00-009
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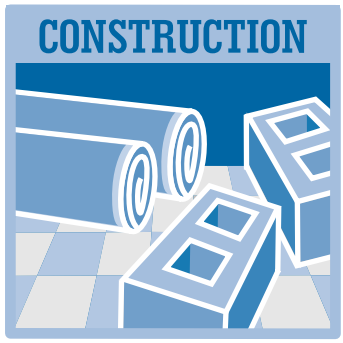
www.epa.gov/cpg

EPA

ECO PURCHASING

2000 Buy-Recycled Series
Construction Products



Construction project managers are learning what the U.S. Army and U.S. Navy already know—recycled construction products are cost-effective, reliable, easy to obtain, and environmentally friendly. Whether you're erecting a new building or constructing a new highway, high-quality recycled-content products can help you get your project off to a great start!

To make it easier to buy recycled, the U.S. Environmental Protection Agency (EPA) updates the Comprehensive Procurement Guidelines (CPG) every 2 years. Through the CPG, EPA designates items that must contain recycled materials when purchased by federal, state, and local agencies, or by government contractors, using appropriated federal funds. Among these items, EPA has designated several construction products, ranging from carpet made from soda bottles to insulation made from yesterday's newspaper. EPA's research shows that the items designated in the CPG are of high quality, widely available, and cost-competitive with virgin products. EPA also issues nonregulatory companion guidance—the Recovered Materials Advisory Notice (RMAN)—that recommends levels of recycled content for those items.

From small jobs to major projects, inside or out, recycled-content construction materials are the way to go. So, whether you're laying the foundation of a building, installing carpet, or constructing and painting walls, choose recycled-content products to make each job a success while doing your part to help conserve natural resources!

EcoPurchasing means considering attributes such as

❖

recycled content
toxicity
reusability
durability
repairability

❖

before you buy a product.

Printed on paper that contains at least 30 percent postconsumer fiber.

What Is The CPG?

The CPG requires federal agencies to buy items made from recovered materials.

Recycling is more than just dropping off your cans, bottles, and newspapers at the curb or at a local collection facility. Diverting recyclables from the waste stream is only the first of three steps in the recycling process. The second step occurs when companies use these recyclables to manufacture new products. The third step comes when you purchase products made from recovered materials. That's how we close the loop.

To support markets for the materials collected in recycling programs and to help these programs expand, the Resource Conservation and Recovery Act requires agencies to buy recycled-content products designated by EPA. In addition, President Clinton signed Executive Order 13101 in September 1998, which called for an increase in the federal government's use of recycled-content and other environmentally preferable products.

Issued in May 1995, the first CPG designated 19 new products and incorporated five previously designated items (including insulation and cement and concrete containing coal fly ash) in seven product categories. Procuring agencies are required to purchase these items with recycled content. The first CPG update (CPG II) was published in November 1997, and designated an additional 12 items, including shower and restroom dividers/partitions and reprocessed and consolidated latex paint. A second CPG update (CPG III) was published in January 2000 and designated an additional 18 items, including carpet cushion, flowable fill, and railroad grade crossing surfaces.

Procuring agencies include all federal agencies, and any state or local government agency or government contractor that uses appropriated federal funds to purchase the designated items. If your agency spends more than $10,000 per year on a product designated in the CPG, you are required to purchase it with the highest recycled-content level practicable. The CPG also applies to lease contracts covering designated items.

Once designated, an agency has 1 year to develop an affirmative procurement program (or revise an existing one) for a designated item it purchases. By May 1, 1996, agencies were required to develop affirmative procurement programs to incorporate buy-recycled requirements for construction board, thermal insulation, floor tiles, and carpet. By November 13, 1998, agencies were required to revise their affirmative procurement programs to add shower and restroom dividers/partitions and reprocessed and consolidated latex paint. Agencies also must revise their affirmative procurement programs to add the items designated under CPG III by January 19, 2001. This effort might involve reviewing specifications for those products and eliminating provisions that pose barriers to procuring them with recycled content (such as aesthetic requirements unrelated to product performance).

The CPG acknowledges, however, that specific circumstances might arise that preclude the purchase of products made with recovered materials. Your agency may purchase designated items that do not contain recovered materials if it determines that: 1) the price of a given designated item made with recovered materials is unreasonably high, 2) there is inadequate competition (not enough sources of supply), 3) unusual and unreasonable delays would result from obtaining the item, or 4) the recycled-content item does not meet the agency's reasonable performance specifications.

Key Terms

Before purchasing construction products containing recovered materials, you might need to review certain key terms:

- **Coal fly ash:** Coal fly ash is a byproduct of coal burning at electric utility plants. It is called "fly" ash because it is transported from the combustion chamber by exhaust gases.
- **Flowable fill:** Flowable fill is a wet, flowable slurry made up of coal fly ash, water, a coarse aggregate (such as foundry sand), and a portland cement that is used as an economical fill or backfill material. It can take the place of concrete, compacted soils, or sand commonly used to fill around pipes or void areas.
- **Foundry sand:** Foundry sand is clean, high-quality silica sand or lake sand from both ferrous and nonferrous metal castings.
- **Ground granulated blast furnace (GGBF) slag:** Blast furnace slag is a byproduct of iron blast furnaces. The slag is ground into granules finer than portland cement and can be used as an ingredient in concrete.
- **Rock wool:** This composition of fibers manufactured from slag or natural rock is used in building insulation.
- **Structural fiberboard:** This is a panel made from wood, cane, or paper fibers matted together and used for sheathing, structural, and insulating purposes.
- **Laminated paperboard:** These boards are made from one or more plies of kraft paper bonded together and are used for decorative, structural, or insulating purpose.
- **Reprocessed paint:** This is postconsumer latex paint that has been sorted by a variety of characteristics that are dictated by the recycler. In general, the paint is sorted by type (i.e., interior versus exterior), by light and dark colors, and by finish (i.e., high-gloss versus flat). The reprocessor adds raw materials to meet the performance and color requirements expected or required by the end user.
- **Consolidated paint:** This product consists of postconsumer latex paint with similar characteristics (such as type, color family, and finish) that is consolidated at the point of collection. The postconsumer paints are blended together and repackaged, usually with few or no new ingredients added to improve the performance of the resulting paint.

How Do I Purchase Recycled-Content Construction Products?

EPA issues guidance in RMANs, which are designed to make it as easy as possible to buy the designated items. The RMANs recommend recycled-content levels to look for when purchasing construction products, as shown in the chart on page 6. Following the RMANs' recommended levels will help ensure your affirmative procurement program and standards meet the buy-recycled requirements.

Rather than specifying just one level of recycled content, the RMANs recommend ranges that reflect actual market conditions. The recommendations are based on market research identifying recycled-content products that are commercially available, competitively priced, and that meet buyers' quality standards.

Refer to EPA's availability list entitled "Construction Products Containing Recovered Materials" for sources of the designated construction items. See the last section of this fact sheet for this and other helpful resources.

CASE STUDY: King County, Washington, Hits a Home Run with Recycled Paint

In the spring of 1997, King County, Washington, hit a home run by using 100 percent reprocessed latex paint in the administrative offices of the Kingdome, home of the Seattle Mariners. Averaging $7.50 per gallon, the reprocessed paint was not only less expensive than its virgin counterpart, but it covered just as well, according to stadium administration.

In addition, the King County Solid Waste Division continues to test new reprocessed latex paints for use at county parks and municipal buildings. In the past few years, the county has used between 100 and 150 gallons of reprocessed latex paint, primarily in remodeling efforts in the county. The county also works to ensure recovery of all unused paint through a well-established household hazardous waste collection program and industrial materials exchange, diverting usable paints and paint products to citizens, schools, and businesses that can reuse the materials. For more information, contact Karen Hamilton of King County at 253 296-4317.

CASE STUDY: Fly Ash Takes Wing at ACE

The engineers at the Army Corps of Engineers (ACE) are no strangers to mixing cement and concrete using recovered materials. Their contracts have specified the use of coal fly ash in concrete for more than 20 years and, more recently, have required the use of GGBF slag in concrete mixes for buildings and roads. While pleased with the overall performance of both recovered materials, the engineers say they particularly like the improved workability that coal fly ash provides over concrete mixed with portland cement. For more information, contact Greg Hughes of ACE at 202 761-4140.

CASE STUDY: U.S. Georgia Department of Transportation Eases the Flow

In 1996, the Georgia Department of Transportation (GDOT) developed contract specifications for the use of flowable fill as an alternative to compacted soil in construction and maintenance projects. Flowable fill replaced soil in applications such as beddings, encasements and closures for tanks and pipes, and general backfill for trenches and abutments. The GDOT mixture combines portland cement, fly ash, fine aggregate, air entraining, and water, according to engineer approval, to create a self-leveling product. Flowable fill "...is as good as compacted soil and it's quicker and easier to use," explained GDOT's Mike Cown. For more information on GDOT's specifications or its use of flowable fill, contact Mike Cown at 404 363-7513.

CASE STUDY: U.S. General Services Administration—Practicing What it Preaches

As the major supplier of reprocessed paint to government agencies, the U.S. General Services Administration's (GSA's) Paint and Chemical Commodity Center takes its environmental commitment seriously. In 1996, the agency painted its regional administrator's office in Seattle, Washington, with the recovered paint it sells. The recovered paint provided excellent coverage and durability. The agency built on the success of this project by painting a number of other GSA offices and facilities with recovered content latex paint in 1997. For more information, contact Janice Douglas of GSA at 206 931-7081.

CASE STUDY: High Cliff State Park, Wisconsin—Maintenance Free and Recycled, Too!

High Cliff State Park in Menasha, Wisconsin, has used recovered-content plastic dividers in all its restroom facilities for 4 years. Although the initial cost of the dividers was higher than those used in the past, the park saved money in reduced maintenance and repair costs. Park officials are extremely pleased with the quality and performance of the product, having experienced no rusting, corrosion, repainting, or graffiti problems since installing the new dividers. For more information, contact Fran Dietzan of the Wisconsin Department of Natural Resources at 920 989-1404.

How Do I Purchase Recycled-Content Construction Products? (Continued)

EPA's Recommended Content Levels for Construction Products

Product	Material	Percentage of Postconsumer Materials	Percentage of Total Recovered Materials
Structural Fiberboard	Recovered Materials	-	80–100
Laminated Paperboard	Postconsumer Paper	100	100
Rock Wool Insulation	Slag	-	75
Fiberglass Insulation	Glass Cullet	-	20–25
Cellulose Insulation (loose-fill and spray-on)	Postconsumer Paper	75	75
Perlite Composite Board Insulation	Postconsumer Paper	23	23
Plastic Rigid Foam, Polyisocyanurate/ Polyurethane: Rigid Foam Insulation	Recovered Material	-	9
Foam-in-Place Insulation	Recovered Material	-	5
Glass Fiber Reinforced Insulation	Recovered Material	-	6
Phenolic Rigid Foam Insulation	Recovered Material	-	5
Floor Tiles (heavy duty/commercial use)	Rubber Plastic	90–100 -	- 90–100
Patio Blocks	Rubber or Rubber Blends Plastic or Plastic Blends	90–100 -	- 90–100
Polyester Carpet Fiber Face	Polyethylene terephthalate (PET) Resin	25–100	25–100
Latex Paint: —Consolidated[1] —Reprocessed[2] –White, Off-White, Pastel Colors –Grey, Brown, Earthtones, and Other Dark Colors	 Recovered Material Recovered Material Recovered Material	 100 20 50–99	 100 20 50–99
Shower and Restroom Dividers/Partitions:	Plastic Steel[4]	20–100 16 67	20–100 25–30 100
Carpet Cushion: —Bonded Polyurethane —Jute —Synthetic Fibers —Rubber	 Old Carpet Cushion Burlap Carpet Fabrication Scrap Tire Rubber	 15–50 40 - 60–90	 15–50 40 100 60–90
Railroad Grade Crossing Surfaces —Concrete —Rubber[3] —Steel[4]	 Coal Fly Ash Tire Rubber Steel	 - - 16 67	 15–20 85–95 25–30 100

[1] Consolidated latex paint used for covering graffiti, where color and consistency of performance are not primary concerns.

[2] Reprocessed latex paint used for interior and exterior architectural applications such as wallboard, ceilings, and trim; gutterboards; and concrete, stucco, masonry, wood, and metal surfaces.

[3] The recommended recovered materials content for rubber railroad grade crossing surfaces are based on the weight of the raw materials, exclusive of any additives such as binders or additives.

[4] The recommended recovered materials content levels for steel in this table reflect the fact that the designated items can be made from steel manufactured from either a Basic Oxygen Furnace (BOF) or an Electric Arc Furnace (EAF). Steel from the BOF process contains 25-30% total recovered materials, of which 16% is postconsumer steel. Steel from the EAF process contains a total of 100% recovered steel, of which 67% is postconsumer.

Specifications for Cement, Concrete, Flowable Fill, and Rubber Railroad Grade Crossing Surfaces Containing Recovered Materials

Cement Specifications	Concrete Specifications	Flowable Fill	Rubber Railroad Grade Crossing Surfaces
ASTM[1] C 595, "Standard Specification for Blended Hydraulic Cements."	ASTM C 618, "Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete."	ASTM D 4832-95el, "Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.	ASTM D 2000-96, "Rubber Products in Automotive Applications."
ASTM C 150, "Standard Specification for Portland Cement."	ASTM C 311, "Standard Methods of Sampling and Testing Fly Ash and Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete."	ASTM D 5239-92, "Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization."	ASTM D 2240-97, "Rubber Property—Durometer Hardness."
AASHTO M 240, "Blended Hydraulic Cements."	ASTM C 989, "Ground Granulated Blast-Furnace Slag for Use in Concrete Mortars."	ASTM D 5971-96, "Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material."	ASTM D 412-97, "Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension."
	AASHTO[2] M 302, "Ground Granulated Blast Furnace Slag for Use in Concrete and Mortars."	ASTM D 6103-07, "Standard Test Method for Flow Consistency of Controlled Low Strength Material."	ASTM D 297-93, "Rubber Products—Chemical Analysis."
	American Concrete Institute Standard Practice ACI 226.R1, "Ground Granulated Blast-Furnace Slag as a Cementitious Constituent in Concrete."	ASTM D 6023-96, "Standard Test Method for Unit Weight, Yield, Cement Content and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM)."	ASTM E 303-93, "Measuring Surface Frictional Properties Using the British Pendulum Tester."
		ASTM D 5971-96, "Standard Practice for Sampling Freshly Mixed Controlled Low Strength Material."	ASTM D 1171-94, "Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)."
		ASTM D 6024-96, "Standard Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application."	ASTM D 573-88, "Deterioration in an Air Oven."
			ASTM D 395-89, "Rubber Property—Compression Set."
			ASTM D 257-93, "DC Resistance or Conductance of Insulating Materials."
			ASTM D 2137-94, "Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics."

[1] ASTM = American Society for Testing and Materials.
[2] AASHTO = The American Association of State Highway and Transportation Officials.

How Can I Get More Information?

Information Available From EPA

This fact sheet and the following publications on buying recycled-content products are available or can be accessed in electronic format on the Internet at <www.epa.gov/cpg>. Use Internet e-mail to order paper copies of documents. Include the requestor's name and mailing address on all orders. Address e-mail to: rcra-docket@epa.gov.

Paper copies also may be ordered by calling the RCRA Hotline. Callers within the Washington Metropolitan Area must dial 703 412-9810 or TDD 703 412-3323 (hearing impaired). Long-distance callers may call 800 424-9346 or TDD 800 553-7672. The RCRA Hotline operates weekdays, from 9 a.m. to 6 p.m., e.s.t.

- ***Federal Register (FR)*** notices promulgating CPG I (60 FR 21370/EPA530-Z-95-006) and RMAN I (60 FR 21386/EPA530-Z-95-007), May 1, 1995. FR notices promulgating CPG II (62 FR 60961/EPA530-Z-97-009) and RMAN II (62 FR 60975/EPA530-Z-97-010), November 13, 1997. FR notices promulgating CPG III (65 FR 3070) and RMAN III (65 FR 3082), January 19, 2000.
- ***EPA Expands Comprehensive Procurement Guideline (CPG)*** (EPA530-F-00-017). This fact sheet provides general information about the CPG and the development of affirmative procurement programs.
- ***Environmental Fact Sheet—EPA Guideline for Purchasing Cement and Concrete Containing Fly Ash*** (EPA530-SW-91-086). This 2-page fact sheet provides general information about concrete mixed with coal fly ash.
- ***Construction Products Containing Recovered Materials*** (EPA530-B-99-017). This list identifies sources of construction products containing recovered materials.
- ***A Study of State and Local Government Procurement Practices that Consider Environmental Performance of Goods and Services*** (EPA742-R-96-007). This report provides important program elements and case studies of state and county agencies purchasing environmentally preferable products and services. For a copy of the report or more information on EPA's Environmentally Preferable Purchasing (EPP) program, contact the Pollution Prevention Information Clearinghouse at 401 M Street, SW. (7409), Washington, DC 20460. Phone: 202 260-1023. Fax: 202 260-4659. Visit the EPP Web site at <www.epa.gov/oppt/epp>.

Other Sources of Information

- **The American Association of State Highway and Transportation Officials (AASHTO)**. AASHTO publishes concrete and cement-mixing specifications, which are listed in this fact sheet and in RMAN I. Contact: AASHTO, 444 North Capitol Street, NW., Suite 249, Washington, DC 20001. Phone: 202 624-5800. Fax: 202 624-5806. The Publications Sales Office's mailing address is P.O. Box 96716, Washington, DC 20090-6716. Phone: 888 227-4860. Fax: 800 525-5562. Web site: www.aashto.org
- **American Concrete Institute (ACI)**. ACI publishes a standard for concrete containing GGBF slag and offers several relevant publications. Contact: ACI, P.O. Box 9094, Farmington Hills, MI 48333. Phone: 248 848-3700. Web site: www.aci-int.org
- **American Society for Testing and Materials (ASTM)**. ASTM publishes standards for mixing cement and concrete. Contact: ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Phone: 610 832-9585. Fax: 610 832-9555. Web site: www.astm.org
- **Buy Recycled Business Alliance**. The Alliance includes over 3,200 companies and organizations committed to increasing their use of recycled-content products and materials in their day-to-day operations. The Alliance offers educational materials, a quarterly newsletter, and product-specific guides. Publications include fact sheets on insulation and coal fly ash, and *Building for Tomorrow: Buy Recycled Guidebook for the Commercial Construction Industry*. Public purchasing entities can join free of charge. For more information, contact Kevin Barry, National Recycling Coalition, 1727 King Street, Suite 105, Alexandria, VA 22314-2720. Phone: 703 683-9025, Ext. 210. Fax: 703 683-9026. Web site: www.nrc-recycle.org/brba/index.htm E-mail: brbainfo@nrc-recycle.org

- ***Directory of Recycled-Content Building and Construction Products***. This regional directory includes 500 construction and building products manufactured partially or totally from recycled materials. Contact: Clean Washington Center, First Interstate Center, 999 Third Avenue, Suite 1060, Seattle, WA 98104. Phone: 206 464-7040. Fax: 206 464-6902. Web site: www.cwc.org
- ***Environmental Building News***. This monthly newsletter on environmentally responsible design and construction includes articles on new products and materials, technologies, and construction methods. Contact: 122 Birge Street, Suite 30, Brattleboro, VT 05301. Phone: 802 257-7300. Fax: 802 257-7304. Web site: www.ebuild.com
- ***Environmental Resource Guide***. Published by the American Institute of Architects (AIA), this 1,100-page guide presents comprehensive lifecycle information on building materials and applications, including products and recyclability. Contact AIA at 1735 New York Avenue, NW., Washington, DC 20006-5292. Phone: 800 225-5945. Price: $221 ($198.90 for members). Web site: www.aiaonline.com
- **Federal Highway Administration (FHWA).** With assistance from the American Coal Ash Association, Inc., FHWA published Fly Ash Facts for Highway Engineers (FHWA-SA-94-081), August 1995. It also maintains a database of state specifications for using coal fly ash and GGBF slag. Contact: Gary Crawford, Federal Highway Administration, 400 Seventh Street, SW., Washington, DC 20590. Phone: 202 366-1286. Web site: www.fhwa.dot.gov
- **U.S. General Services Administration (GSA)**. GSA publishes various supply catalogs, guides, and schedules for recycled-content products available through the Federal Supply Service. Copies of Carpet, Carpet Tiles, and Carpet Cushion, Multiple Award Schedule FSS72-I-A are also available. Contact GSA, Centralized Mailing List Service (7CAFL), 4900 Hemphill Street, P.O. Box 6477, Fort Worth, TX 76115-9939. Phone: 817 334-5215. Fax: 817 334-5561. GSA also offers recycled content paint through requisition and processing. For more information on how to purchase this product, contact the GSA Paint and Chemical Commodity Center at 800 241-7246. You can also access GSA Advantage!, GSA's Internet-based online ordering system, to order any GSA product at <www.fss.gsa.gov/cgi-bin/advwel>.
- ***Greening the Government: A Guide to Implementing Executive Order 12873*.** This guide provides detailed information on establishing and implementing federal affirmative procurement plans. Updated in the summer of 1997, it is available from the Office of the Federal Environmental Executive, Ariel Rios Building, Mail Code 1600S, 1200 Pennsylvania Avenue, NW., Washington, DC 20460. Phone: 202 564-1297. Fax: 202 564-1393. Web site: www.ofee.gov
  You can also download an electronic version on the Internet at <www.ofee.gov/html/guide/html>.
- ***Guide to Recycled Products: Building and Construction***. This guide is published by Metro, a regional government agency serving the Portland, Oregon, area, but may be useful for procurement officials in other areas of the country. It is designed to help locate hundreds of recycled-content building products. Contact: Metro, 600 NE. Grand Avenue, Portland, OR 97232. Phone: 503 234-3000. Fax: 503 797-1851. Web site: www.metro-region.org
- ***A Guide to Resource Efficient Building Elements***. In addition to tips on efficient design and job-site recycling, this guide lists several manufacturers that make products using recovered materials. Contact: Center for Resourceful Building Technology, P.O. Box 100, Missoula, MT 59806. Phone: 406 549-7678. Fax: 406 549-4100.
- ***The Harris Directory of Recycling and Pollution Preventing Materials for Home, Office, and Garden.*** This computer database for MacIntosh and Windows lists construction products made with recovered materials. Users can search for topics using either a key word search or by consulting an accompanying 24-page handbook. Contact B.J. Harris, P.O. Box 2024, Candler, NC 28715. Phone: 888 844-0337. Web site: www.harrisdirectory.com
- ***National Institute of Governmental Purchasing (NIGP).*** NIGP maintains a library of product specifications and sample bid documents for both virgin- and recycled-content products, including concrete. It also offers procurement training workshops for members. For more information, contact Fuad Abu-Taleb, 151 Spring Street, Suite 300, Herndon, VA 20170. Phone: 703 736-8900, Ext. 241. Fax: 703 736-9644.

How Can I Get More Information? (Continued)

- ***Official Recycled Products Guide.*** This directory lists more than 5,000 manufacturers and distributors of recycled-content products. Contact: Recycling Data Management Corporation, P.O. Box 577, Ogdensburg, NY 13669. Phone: 800 267-0707. Fax: 315 471-3258.
- ***Recycled Plastic Products Source Book.*** This booklet lists more than 1,300 plastic products from approximately 300 manufacturers. For more information, call the American Plastics Council (APC), 1801 K Street, NW., Suite 701-L, Washington, DC 20006. Phone: 202 974-5400. Fax: 202 296-7119. Web site: www.plasticsresource.com
- ***Resource Guide to Recycled Construction Products***. This recycled construction products list is available from the Los Angeles Integrated Solid Waste Management Office, 433 South Spring Street, Suite 500, Los Angeles, CA 90013. Phone: 213 847-1444.
- **U.S. Army Corps of Engineers (USACE)**. USACE has specifications for cement containing coal fly ash. Contact Greg Hughes, USACE, 20 Massachusetts Avenue, NW., Washington, DC 20314. Phone: 202 761-4140. Fax: 202 761-4139. Web site: www.usace.army.mil

Internet Sites

Government Sites

- **The Comprehensive Procurement Guidelines:** <www.epa.gov/cpg>. This site describes EPA's effort to facilitate the procurement of products containing recovered materials, including information on CPG, RMANs, and the Buy-Recycled Series.
- **Environmentally Preferable Purchasing (EPP):** <www.epa.gov/oppt/epp>. EPA's Environmentally Preferable Purchasing program encourages and assists federal agencies to purchase environmentally preferable products and services. The site explains EPA's proposed guiding principles for including environmental performance in purchasing decision-making and posts case studies of successful pilot projects in both the public and private sectors.
- **Federal Trade Commission:** <www.ftc.gov/bcp/grnrule/guides980427.htm>. The Federal Trade Commission issued Guides for the Use of Environmental Marketing Claims in May 1998.
- **Jobs Through Recycling:** <www.epa.gov/jtr>. EPA's Jobs Through Recycling program stimulates economic growth and recycling market development by assisting businesses and supporting a network of state and regional recycling contacts. This Web site provides information on financing and technical assistance for recycling businesses as well as other market development tools.
- **King County Recycled Product Procurement Program:** <www.metrokc.gov/oppis/recyclea.html>. This site describes the tools and techniques developed by King County, Washington, agencies for purchasing recycled products.
- **Municipal Solid Waste:** <www.epa.gov/msw>. This site includes information on recycling, source reduction, and reuse. Contains state municipal solid waste data and the latest facts and figures on waste generation and disposal.
- **WasteWise: <**www.epa.gov/wastewise>. WasteWise is a free, voluntary EPA program through which organizations eliminate costly municipal solid waste, benefitting their bottom line and the environment. The program provides hands-on assistance to members to help them purchase or manufacture recycled-content products, prevent waste, and recycle solid waste materials.

Product Information

- **Recycling Data Network Information Services:** <www.epa.gov/cpg/links.htm>. This commercial Web site provides access, on a subscription basis, to a recycled-content products database of over 4,500 listings in 700 product classifications. It also provides a reference library and a newsletter. Managed by the publisher of the Official Recycled Products Guide, the product database is considered to be the largest of its kind.
- **Environmental Building News:** <www.ebuild.com/>. This site is the online version of *Environmental Building News*, the leading periodical on environmentally sustainable design and construction. It contains articles, reviews, and news stories on energy-efficient, resource-efficient, and healthy building practices.
- **Oikos Green Building Source: <**oikos.com>. This site contains a catalog of books, videos, and software for sustainable construction; a searchable database of companies that feature products with environmental attributes; and links to other green building sites.

- **The Fedmarket Procurement Assistance Jumpstation: <**www.www.fedmarket.com/sales_resources/bids/federal.html>. This site contains links to many sites containing procurement information.
- **Sustainable Building Sources:** <www.greenbuilder.com/general/buildingsources.html>. This site contains green building news articles, conference announcements, links to other green building sites, and the *Sustainable Building Sourcebook*.

In addition, contact your state solid waste management agency for information about local and regional businesses that produce or distribute recycled-content products.

United States
Environmental Protection Agency
(5306W)
Ariel Rios Building
1200 Pennsylvania Avenue, NW.
Washington, DC 20460

Official Business
Penalty for Private Use
$300

California SUSTAINABLE DESIGN Training 2001

Section 9: Specifications

HDR

Sustainable Specifications

There are three key recommendations to including sustainable design information into project specifications.

1. Front end specifications
2. "Unique" sustainable product specifications
3. Sustainable criteria **Division 1 Specifications**

Division 1 specifications define how the Contractor is to administer the work. Specifications that can be added to emphasize sustainable design include***Indoor Environment Protection***. This specification should address construction practices and design requirements with the purpose of minimizing indoor air quality problems that might otherwise negatively impact workers and building occupants.

Environment Protection. The intent of this specification is to minimize environmental pollution and damage as the result of construction operations. For example, soy diesel as an additive to construction equipment fuel could be addressed in this section.

Construction Waste Management. This section identifies materials to be recycled or salvaged during construction and sets the overall diversion goal for the project, Based on the Tier 1 list, the minimum standard for state projects is 50% diversion of Construction and Demolition materials.

Sustainable Design Plan. This section can include a summary of sustainable design requirements found in each specification section. It could also include specific environmental project goals.**Unique product specifications**

Sustainable information should be integrated into the standard CSI Format.

PART 1 - GENERAL. There are two crucial paragraphs in Part 1 to convey necessary information on sustainable products. Every building product that has been specified with sustainable attributes is identified in the SUBMITTALS paragraph. The SUBMITTALS paragraph requires that sustainable information found in Part 2 of the specifications is recorded. Likewise, the paragraph "QUALITY ASSURANCE" identifies those properties that make products both sustainable and compliant with accepted performance standards.

PART 2 - PRODUCTS. In the "PRODUCTS" paragraphs of the specification, performance criteria are established and acceptable manufacturers are identified. This is where the specific information that must be submitted is located. It is the intent, where two products are equal in terms of performance characteristics, to only include that product that has better environmental features. Likewise, some products are simply not specified where the Owner and the A/E have previously identified them as not appropriate for the project.

PART 3 - EXECUTION. Typically PART 3 criteria, where not established by recognized standards, are addressed in INDOOR ENVIRONMENT PROTECTION, ENVIRONMENT PROTECTION and CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS documents.

Sample product specifications for Building Insulation and Carpentry are included at the end of this section. Highlights from those specifications are as follows.

Sample Format: Carpentry
Part 1, General
1.1 Quality Assurance. If wood from certified forests is preferred, add the following:
Certification of wood from sustainable forests:
Forest Stewardship Council
SmartWood

1.2 Definitions
Sustainable Forest Certification: A voluntary third party certification in conformance with Scientific Certification System (SCS) that timber harvested meets forest management and ecological standards.

1.3 Submittals
Certification by Forestry Stewardship Council that lumber furnished is from certified sustainable forest.

Part 2 Products
2.1 Materials – Rough Carpentry
Wood product from sustainable forest:
Base: Columbia Forest Products

2.1 F
FSC Certified Fire Resistant Particleboard:
1. Minimum ¾ IN thick.
2. Flame Spread: 25.
3. Density 45 PCF minimum.
4. Willamette Industries; Duraflake FR

Notes:

Sample Format: Building Insulation
Part 1, General
1.2 Submittals
Certification of a minimum of 20% recovered material content in fiberglass insulation.
Certification of a minimum of 9% recovered material content in rigid plastic foams.

Certification of a minimum of 75% recovered material content in cellulose insulation.

Part 2, Products
Cellulose insulation – manufactured from 75-80% recovered material, most of which is post-consumer.

Sustainable Criteria

In addition to sustainable products, there are sustainable criteria, or characteristics, of products that can be included in specifications. These characteristics may be "transparent" to the Contractor and occupant, but will still reduce negative environmental and/or health benefits of a particular product.

Examples of sustainable criteria that might be added to standard product specifications include: Emission limits

- Recycled content
- Regional materials
- Certified wood

Example:
Low-Emitting Joint Sealants
Silicone Sealants shall have **0 g/L VOC** in compliance with South Coast Air Quality Management District regulations.
Polyurethane sealants shall have **no more than 250 g/L VOC** in compliance with South Coast Air Quality Management District regulations.
Interior sealants **shall not contain** mercury, butyl rubber, neoprene, SBR (styrene butadiene rubber), nitrile, aromatic solvents (organic solvent with a benzene ring in its molecular structure), fibrous talc or asbestos, formaldehyde, halogenated solvents, lead, cadmium, hexavalent chromium, or their components.

Compressible foam joint fillers: Polyester polyurethane foam impregnated with neoprene rubber or acrylic ester styrene copolymer, **manufactured without CFC blowing agents.**

Example:
Recycled Content: Carpet

- Minimum 30 percent total recovered nylon fiber material.
- Minimum 15 percent post-consumer and total recovered material for polyurethane backing.
- Minimum 40 percent post-consumer and total recovered material for jute backing.
- Minimum 60 percent post-consumer and total recovered material for rubber backing.
- 100 percent total recovered material for PET.
- Secondary Backing: 100% recycled post-consumer and total recovered material.

Recommendations

- Meet minimum state requirements for recycled content and material emissions
- Meet minimum requirements of State Agency Buy Recycled Campaign
- At a minimum, include recommended Division 01 specifications
- Do not try to "green" all specifications the first time. Instead, select materials used in the largest quantity to make the biggest impact.

Specifications

Heading

Resource	*Description*	*Website*
CIWMB Green Project Specifications		www.ciwmb.ca.gov/greenbuilding/specs
EPA Research Triangle Park Specifications	Environmental specifications for the new EPA Laboratory in Research Triangle Park	http://www.epa.gov/rtp/new-bldg/environmental/specs.htm
Reference Specifications for Energy and Resource Efficiency Public Interest Energy Research (PIER)	Specifications for energy efficiency by the California Energy Commission.	www.eley.com/specs/index.htm
WasteSpec	Model specifications for construction waste, reduction and reuse	www.tjcog.dst.nc.us/cdwaste.htm

SECTION 07210
BUILDING INSULATION

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Insulation reference standards:
   1. UL requirements.
   2. ASTM-C518.
   3. ASTM-C739.
   4. ASTM-E84.
   5. ASTM-E90.
   6. ASTM-E119.
   7. ASTM-E970.

B. Insulation value exterior walls: R-19.

C. All adhesives shall comply with South Coast Air Quality Management District VOC regulations.

1.2 SUBMITTALS

A. Project information:
   1. Manufacturer of listed products.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable manufacturers:
   1. Rigid extruded polystyrene board insulation:
      a. Base:
         1) Dow Chemical.
      b. Optional:
         1) Tenneco Building Products.
         2) UC Industries.
   2. Rigid expanded polystyrene insulation:
      a. Base:
         1) AFM Corporation.
   3. Blanket or batt insulation:
      a. Base:
         1) Owens-Corning Fiberglas.
      b. Optional:
         1) Thermafiber.
         2) Schuller International.
   4. Formaldehyde free fiberglass batt insulation
      a. Base:
         1.) Johns Manville.
      b. Optional
         1.) Owens Corning.
   5. Cellulose Insulation:
      a. Base:
         1) Greenstone.
      b. Optional:

1) **Celbar.**.

6. Rigid fiber insulation:
   a. Base:
      1) Owens-Corning Fiberglas.
   b. Optional:
      1) Thermafiber.
      2) Schuller International.
7. Spandrel insulation:
   a. Base:
      1) Thermafiber.
   b. Optional:
      1) Owens-Corning.
8. Vapor retarder:
   a. Base:
      1) Fortifiber.
   b. Optional:
      1) Alumiseal.
9. Vapor retarder tape:
   a. Base:
      1) Avery Dennison Specialty Tape.
10. Granular insulation:
    a. Base:
       1) Grace (WR) Masonry Products.
    b. Optional:
       1) Other Vermiculite Association Companies.
11. Stud strips:
    a. Base:
       1) Grace (WR) Masonry Products.
12. Adhesives:
    a. Base:
       1) Sonneborn Building Products.
    b. Optional:
       1) GEMCO.
13. Other materials:
    a. Base:
       1) As indicated.
14. Other manufacturers desiring approval, comply with Document 00440.

B. Insulation, rigid board:
   1. Foamed, extruded polystyrene.
   2. Compressive strength: Minimum 25 PSI.
   3. Water vapor permanence for 1 IN product: 1.00 perm, maximum.
   4. Water absorption: Maximum 0.15 percent.
   5. Thermal resistance: R-value of 5.0 per inch at 75 degF mean temperature.
   6. Integral high density skin.
   7. Styrofoam, Amofoam, or Foamular.
   8. Minimum thickness: 2 IN.

C. Adhesives for adhering polystyrene insulation:
   1. Contech PL200 Construction Adhesive, or GEMCO Tuff-Bond No.9.
   2. Comply with SCAQMD VOC Regulations.

D. Insulation, blanket or batt:
   1. Inorganic fibers and resinous binders formed into flexible blankets or semi-rigid sheets.
   2. Thermal resistance: R-value of 3.7 per inch at 75 degF mean temperature.
   3. Unfaced.
   4. ASTM-E84 flame spread: Not greater than 25.

5. Minimum thickness: 3 IN.
6. **Minimum 25 percent total recovered material content per EPA/CPG guidelines.**
7. ***Formaldehyde-free fiberglass batt****:*
   a. Kraft faced, 31/2 IN, R-13.

E. Insulation, spandrel:
1. Mineral wool fibers and resinous binders formed into batts with aluminum foil scrim/vapor retarder.
2. Nominal 4 PCF.
3. Nominal 4 IN.
4. Flame spread not to exceed 20 when tested in accord with ASTM-E84.
5. Smoke developed not to exceed 20 when tested in accord with ASTM-E84.
6. FSP Curtainwall insulation, Thermafiber.
7. **Minimum 25 percent total recovered material content per EPA/CPG guidelines.**

F. Insulation, cellulose:
1. **Minimum 80 percent recycled wood-based cellulosic fibers.**
2. **Flame spread: Less than 25 when tested in accord with ASTM-E84.**
3. **Density: Not less than 1.6 LB/CF in accord with ASTM-C739.**
4. **Thermal Resistance: R value of 4.5 per IN when tested in accord with ASTM-C739.**
5. **Thickness as indicated.**
6. **Minimum 75 percent total recovered material content per EPA/CPG guidelines.**
7. **Greenstone.**

G. Vapor retarder:
1. Two directional, reinforced, foil faced vapor retarder or foil/mylar.
2. Permeance: Not exceeding 0.02 perm.
3. ASTM-E84 flame spread: 25 maximum.
4. Rolls: 50 IN wide.
5. Base: Sisalkraft Pyro-Kure 615.
6. Optional: Alumiseal Zero Perm.

H. Vapor retarder tape:
1. Heavy duty 3 IN wide laminate consisting of 0.00035 IN aluminum foil, glass fiber reinforced two directional patterned Kraft paper or aluminum/mylar.
2. UL listed class A.
3. Base: FasTape 0820 FR-FSK, or FasTape 0821FR-FSK-30.
4. Optional: Zero Perm Pressure Sensitive Tape.
5. If vapor retarder tape fails to adhere to surface, spray on Norton; Spray Trim Adhesive, No.82130-1 or a similar product by 3M to augment adhesion of tape.

I. Stud strips:
1. "U" shape metal furring channels.
2. 1-5/8 IN wide with 5/8 IN serrated edges.
3. Roll formed from 25 GA galvanized steel.
4. Furring channels used in Grace Products Div., W R Grace &, Zonolite Thermo-Stud system.
5. TGIF system by Dow using SM/TG board.
6. Insulation thickness: Minimum 2 IN.

J. Insulation, granular: Water resistant vermiculite.

PART 3 - EXECUTION

3.1

A. Not Included

SECTION 06000
CARPENTRY

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Lumber grading rules and species:
   1. US Department of Commerce, PS-20-70.
   2. Western Wood Products Association (WWPA).
   3. Southern Forest Products Association (SFPA).

B. Plywood grading rules and recommendations:
   1. For softwood plywood: US Department of Commerce PS-1-83.
   2. For hardwood plywood: US Department of Commerce PS-51-71.
   3. American Plywood Association (APA).

C. Factory marking:
   1. Identify type, grade, moisture content, inspection service, producing mill, and other qualities.
   2. Marking may be omitted if certificate of inspection is provided for each shipment.
      a. Mark each piece of fire retardant treated material.

D. Standards for fire hazard classification for fire retardant treated material: Underwriters' Laboratories, (UL) and American Wood Preservers Institute (AWPI).
   1. Test method: ASTM-E84.

E. Preservative and pressure treatment standards: American Wood Preservers Association (AWPA).
   1. Provide continuous monitoring of production and kiln temperatures by third party inspection agency to assure that production methods are same as those used on elevated temperature strength test specimens. Indicate compliance in factory marking.

F. Workmanship finish carpentry: Architectural Woodwork Institute (AWI) Premium Grade Standards.

G. Certified Wood:
   1. Forest Stewardship Council.
   2. Smartwood.

1.2 DEFINITIONS

A. Exposed surfaces: Surfaces visible when doors and drawers are closed:
   1. Door and drawer fronts, and their edges.
   2. Inside of doors.
   3. Exposed ends.
   4. Countertop and backsplash and exposed edges.
   5. Face frame (if used).
   6. Interior of open cabinets.
   7. Toe strip not covered by separate base.
   8. Wall mounted adjustable shelves.
   9. Bottom of wall case over 1220 mm 4 FT above floor.
   10. Top of cases less than 1830 mm 6 FT above floor.

B. Concealed surfaces:
   1. Surfaces not visible after installation, and:
   2. Web frames.

3. Dust panels.

C. Semi-exposed surfaces: Other surfaces not exposed or concealed.

D. Sustainable Forest Certification: A voluntary third party certification in compliance with Scientific Certification System (SCS), that timber harvested meets forest management and ecological standards.

1.3 SUBMITTALS

A. Project information:
1. Certification of preservative or fire retardant treated material.
2. Fasteners approved for use of preservative or fire retardant treated material.

B. Certification:
1. Certification by Forestry Stewardship Council that lumber finished is from Certified Sustainable Forest.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Store in dry, weather tight, ventilated spaces.

B. Do not bring items into building until receiving spaces have humidity controlled to between 25% and 65%

C. Stack to provide air circulation.

D. Store and protect materials in areas where moisture content can be maintained.

E. Time delivery and installation to avoid delaying progress of other work.

F. Handle treated material and repair damage in accordance with AWPA-M-4.

1.5 JOB CONDITIONS

A. Drawings indicate type, arrangement, and location of items of finish carpentry and millwork.

B. If variations from arrangement or profile indicated are required, notify Architect.

C. Make such variations at no added expense to Owner.

D. Contractor is responsible for fitting to recesses, including trim pieces, fillers and closures.

PART 2 - PRODUCTS

2.1 MATERIALS - ROUGH CARPENTRY

A. Acceptable manufacturers:
1. Fire retardant treated lumber:
a. Base:
1) Hoover Treated Wood Products.
b. Optional:
1) Hickson.
2) Chemical Specialties.
2. Fire retardant/preservative treated lumber:
a. Base:
1) Hoover Treated Wood Products.
3. Certified Wood:
a. Base:
1) Columbia Forest Products.
b. Optional:
2) Willamette Industries.

4. ACQ Preservative Treated Lumber:
   a. Base:
      1) Chemical Specialties.

B. Lumber for framing, blocking, nailers, furring, cant strips, grounds, and similar members:
   1. Comply with dry size requirements of PS-20, Douglas fir WWPA No.3, or SFPA No.2.
   2. Thoroughly seasoned, well fabricated materials of longest practical lengths and sizes.
   3. Free of non-correctable warp.
   4. Discard material which would impair quality of work.

C. Plywood:
   1. PS1, exterior type, A-C Grade.
   2. Provide MDO-EXT-APA Plywood, as indicated.

D. Preservative treated material:
   1. Provide preservative treated materials for material used outside building, in roof, parapets and below grade..
      a. Preserve; Chemical Specialties, Inc
   2. Treated lumber standard: AWPA C-2.
   3. Treated plywood standard: AWPA C-9.
   4. Preservative treatment standard: AWPA ACQ-94.
   5. Kiln dry to 15 percent moisture content.
   6. Where possible, precut material before treatment.
   7. The use of arsenic is prohibited.
   8. Provide fire retardant treated materials for material used within exterior walls of building, including parapets, within metal roofing systems, and within interior walls of wet areas.
      a. Type: Hoover, Exterior Fire-X Blue.

E. Fire retardant treated material, interior areas.
   1. Provide fire retardant treated material inside building:
      a. Type: Hoover, Pyro-Guard.
   2. Treated lumber standard: AWPA C-20.
      a. Kiln dry to 19 percent moisture content.
   3. Treated plywood standard: AWPA C-27.
      a. Kiln dry to 15 percent moisture content.
   4. Maximum flame spread rating: 25, ASTM-E84.
   5. Use treatment which will not bleed through or adversely affect bond of applied finish.
   6. Provide UL label or certificate for each piece of fire retardant treated material.

F. FSC Certified Fire Resistant Particleboard:
   1. Minimum ¾ IN thick.
   2. Flame Spread: 25.
   3. Density 45 PCF minimum.
   4. **Willamette Industries; Duraflake FR**

G. Anchorage and fastening materials: Proper type, size, material and finish for application.

PART 3 - EXECUTION

3.1 NOT INCLUDED

SECTION 02848- PARKING BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Work included: Furnish and install all recycled composite parking bumpers (wheel stops) and speed bumps.

B. Related work:

1. Special environmental requirements are specified in Section 01350.

C. Related documents.

D. Definitions.

1.2 SUBMITTALS

A. Submittals procedures: Refer to Section 01350.

B. Special environmental requirements: Submit the following in accordance with the requirements of Section 01350:

1. Resource Efficient Product Data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental Issues Certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (Specifications, submittals, and/or test data) in terms of recycled content and recyclability.

C. Product data: Submit manufacturer's published descriptive literature and complete specifications for products specified herein.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Packaging and shipping: Refer to Section 01350 for use of recycled or recyclable packing materials.

B. Acceptance at site.

1.4 WARRANTY

A. Manufacturer's warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURED PRODUCTS

A. Parking bumpers: "Power-Stop", by Collins & Aikman (510-536-2600 or 800-444-0254), or approved equal meeting the following requirements:

1. Material: 100% recycled composite parking stops manufactured from fibrous reinforcement and a blend of vinyl, nylon fibers, post consumer plastics, and post industrial plastics. Wheel stops shall contain 30-35% post consumer recycled content, 65-70% post industrial recycled content, and shall contain no wood products. In addition, parking bumpers shall be 100% recyclable.
2. Physical Properties:
   a. Density (ASTM D79): 60 lbs/cf.
   b. Leaching (EPA 1311): Pass.

c. Water Absorption (ASTM D1027): 0.2%
d. Nail Pull-Out (ASTM 1761): 170 lbs.
e. Compressive Stress (ASTM D198): 3104 psi.
f. Modulus of Rupture (ASTM D198): 2307 psi.
g. Modulus of Elasticity (ASTM D198): 120731.

3. Size: 5-3/4" x 3-1/2" x length indicated.
4. Provision for Installation: Pre-drill parking stops for two 5/8" diameter rebar anchors.

B. Speed bumps: 96-100% post-consumer recycled plastic with countersunk holes for bolts. Provide lag bolts and required hardware. Exposed surfaces shall be dense and smooth, free of pits, honeycombs or other defects.

C. Installation adhesives: As recommended by parking stop and speed bump manufacturer for surface to which installed. Adhesives must comply with the requirements of Section 01350 if used in an indoor environment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of conditions.

3.2 PREPARATION

A. Substrate preparation.

3.3 INSTALLATION

A. General:
1. Low-VOC emission type, heavy duty adhesives as recommended by the manufacturer (for indoor application) or expansion-type steel bolts set in holes drilled into concrete paving.

3.4 CLEANING AND PROTECTION

A. Construction cleaning

B. Protection of work: Protect completed or in-place wheel stops and speed bumps from damage due to subsequent construction or finishing activities.

C. Damaged or defective work.

END OF SECTION

NOTES

SECTION 02848 - PARKING BUMPERS NOTES

JUSTIFICATION

Use of recycled product reduces impact on landfill and lessens depletion of natural resources.

EXAMPLE PRODUCTS/MANUFACTURERS

"Power-Stop", by Collins & Aikman (510-536-2600 or 800-444-0254), http://www.ciwmb.ca.gov/BuyRecycled/StateAgency

NOTES

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Section 10: Operations and Maintenance

HDR

Operations & Maintenance

Golden Seal Program

In August 2000 DGS RESD Building and Property Management (BPM) established the Golden Seal Program. The Golden Seal Program is a comprehensive environmentally acceptable operations and maintenance program based upon a thorough review of our cleaning chemical procurement process for custodial/maintenance products statewide.

This research activity allowed the DGS RESD BPM to better evaluate the overall impacts to worker health and environmental issues associated with chemical cleaning products statewide.

The Golden Seal Program has three main elements:

- Promote And Incorporate Purchase Of Environmentally Friendly "Green" Building Products.
- Enhance Employee Awareness To Reduce, Reuse, And Recycle.
- Convert Existing Buildings Into Sustainable Buildings.

Sustainability in BPM

- Prevent harm to the natural environment and human health, and
- Benefit the community and local economy for current and future generations.
- Sustainability = 3 Rs: Reduce, Reuse, Recycle.

BPM Environmental Safety Health And Operations Program (Eshop)

Bpm's eshop is designed to: Provide Industrial Hygiene services, that incorporate a comprehensive, environmentally sensitive purchasing, operations and maintenance program within the DGS RESD BPM that involves all areas of BPM operations such as cleaning, groundskeeping, HVAC, trades and engineering for consistency with applicable laws, regulations, and tenant requirements.

ESHOP IH Assessment: Environmentally Preferable Cleaning Products

- Inventory all existing chemical products.
- Review quantity and purpose of use.
- Review active ingredients.
- Assess history of injuries to BPM Workers.
- Select test products, train BPM staff in use, monitor effectiveness, and obtain BPM staff and tenant feedback.

Examples of Environmentally Unsafe/Harmful Product Ingredients

- Benzyl Alcohol: Carcinogenic
- Diethanolamine: Carcinogenic
- Methyl Chloroform: Kidney/heart damage
- Methyl Ethyl Ketone: Damage to liver, reproduction
- Naphthalene: Carcinogenic
- Nitrilotriacetic Acid: Carcinogenic
- Tricholoroethylene: Liver, carcinogenic

DGS RESD BPM Common Cleaning Products

All Purpose Cleaner

- Glass and Window Cleaner
- Bathroom Cleaner/Deodorizer
- Liquid Hand Soap
- Lime and Scale Remover
- Carpet Shampoo (rotary brush)
- Furniture Polish
- Chrome and Brass Polish/Cleaner
- Graffiti Remover
- Floor Finish Disinfectant
- Floor Stripper
- Wood Floor Wax/Cleaner
- Solvent Spotter/Gum Remover

Testing BPM's Golden Seal Program for EPP

Notes:

Initially, BPM staff tested four specific products as EPP items: Handsoap, General Purpose Cleaner, Glass Cleaner, Restroom Tile Cleaner.

BPM janitorial crews tested these environmental cleaning products in a variety of State Office Buildings.

Implementation of Janitorial Testing for Golden Seal / EPP

Testing of new products was implemented at the beginning portion of regular janitorial meetings.

Janitor supervisors received training on EPP purchasing and advised on cleaning effectiveness of products. Dwell time was the main concern, yet buy-in was successful.

Products were used as a comparison to existing products.

RESULTS of BPM Testing for New Cleaning Products

Environmental Preferable Product (EPP)
Manufacturers: Naturally Yours (NY), Clean Environment (CE), ZEP

Handsoap	1	NY, CE, ZEP
General Purpose Cleaner	2	NY, CE, ZEP
Glass Cleaner	3	NY, CE, ZEP
Restroom Tile Cleaner	2	NY, CE, ZEP

Scale:
Excellent (1) Good (2) , OK (3) , Fair (4) , Poor (5)

Examples of additional BPM's EPP Cleaning Products

Old Products	New Products
AJAX	CSP
Bleach	SK32
Forward	Neutral Quat
Steamette	Potpourri

Newer ingredients are safer for use, produce better indoor air quality and are lower impact on the waste stream.

Lessons Learned

1. Education of janitorial staff through training is essential to promote conversion from older products to EPP.
2. Dwell time of EPP merchandise requires longer action time for results.
3. MSDS training needed.

Golden Seal EPP List

Naturally Yours
http://www.naturallyyoursstore.com

All Purpose Cleaner; Product Number :NY2
Clepaner Degreaser: NY3
Basin, Tub and Tile Cleaner: NY4
Glass and Window Cleaner: NY6
Clinging Toilet Bowl Cleaner: NY7

GOLDEN SEAL EPP LIST

Rochester-Midland
www.rochestermidland.com

Enviro-Care All Purpose Cleaner
Enviro-Care Neutral Disinfectant
Enviro-Care Washroom and Fixture Cleaner

The Clean Environment
www.greencities.net

All Purpose Cleaner Product Number	: N-1
Basin, Tub and Tile Cleaner	: N-7
Clinging Toilet Bowl Cleaner	: N-8
Furniture Polish and Protector	: N-11
Glass and Hard Surface Cleaner	: N-13
Heavy Duty Degreaser/Cleaner	: N-14
Cycle-Graffiti Remover	: C-54

Benefits of Environmental Preferred Products

- Saves money
- Consume less energy
- Lowers annual utility bills
- Reduces air pollution
- Provide same or better performance
- Better IAQ for tenants
- Save taxpayer dollars through lower energy bills
- Reduced air pollution levels
- Same or better quality
- Name-brand products
- Publicly demonstrate commitment to environment and citizens

Savings Opportunities Through EPP Purchasing

- State and Local Govt spend $12 billion on energy bills
- Individual potential for 30-50% energy savings
- Potential for annual 4.1 MMTC reduction
- Potential for annual $107.2 million in energy savings

Barriers to EPP Purchasing

1. What is environmental preferable purchasing?
2. Where can I find information about EPP products and energy efficiency?

3. Will this limit competition?
4. How will I know which product will save the most amount of money over time?
5. Is EPP of equal quality to what I'm buying now?

Notes:

Overcoming Barriers and Answering Questions

ENERGY STAR® Purchasing Tool Kit

One-stop shopping guide to answer these questions and more
Includes:

- savings calculator to demonstrate benefits
- purchasing guidelines
- product listings to show widely-available, name-brand products

Savings Calculator

- Compares energy-efficient vs. conventional equipment
- Demonstrates benefits of reduced energy and maintenance costs
- User inputs for accurate results

Products Availability

Office Equipment

- computers/monitors
- printers, fax machines
- copiers, scanners
- multifunction devices

Exit Signs

Residential Heating and Cooling Equipment

- furnaces, boilers, heat pumps

Residential Light Fixtures

Transformers

Residential Appliances

- refrigerators
- dishwashers
- clothes washers
- room air conditioners

TVs, VCRs, and TV/VCRs

Roof Products

Insulation

Windows

Energy Efficiency Product Availability

Recommendation levels from FEMP
(Federal Energy Management Program)

Non-residential Lighting Products

- Ballasts
- Fluorescent Tube Lamps

Non-residential Heating and Cooling Equipment

Residential Appliances

Commercial Ice Cube Machines

Electric Motors

Steps to Successful EPP Implementation

6. Review DGS purchasing policies at www.dgs.ca.gov
7. Identify product categories where savings opportunities exist
8. Use Savings Calculation Tool to determine savings opportunities
9. Check web site at www.energystar.gov for product listings
10. Call 1-888-STAR-YES
11. Coordinate with appropriate offices within your agency
12. Encourage energy-efficient purchasing and identified EPP products

Department of General Services
Real Estate Services Division
Building and Property Management Branch
Contact: Vincent Paul, Environmental Safety Manager
1304 O Street, Suite 300
Sacramento, CA 95814
(916) 323-0749
Vincent.Paul@dgs.ca.gov
October 13, 2001

I. Summary of EPP Activities

In August, 2000, the Department of General Services (DGS) Real Estate Services Division (RESD) Building and Property Management Branch (BPM) established a comprehensive environmentally acceptable operations and maintenance program based upon a thorough review of our cleaning chemical procurement process for custodial/maintenance products. This activity allows the DGS BPM to better evaluate the overall worker health and environmental impacts associated with cleaning products and their use in DGS BPM buildings statewide.

The following is a list of product categories the DGS BPM requires for custodial purposes. Each product submitted must be identified with one of these categories.

All Purpose Cleaner Glass and Window Cleaner
Bathroom Cleaner Deodorizer
Liquid Hand Soap Lime and Scale Remover
Degreaser/Cleaner Carpet Shampoo (rotary brush)
Furniture Polish Chrome Polish/Cleaner
Graffiti Remover Brass Polish/Cleaner
Floor Finish Disinfectant
Floor Stripper Enzymatic Cleaner/Degreaser
Wood Floor Wax/Cleaner
Solvent Spotter/Gum Remover

THE DGS RESD BPM EPP consists of the following:

- Testing of selected “green” products, review market research, and examine success/failure rates of chosen products on select trial bases.
- Define and establish a list of environmentally sensitive products and equipment (denoted as "Golden Seal" products).
- Review and recommend procedures for implementing a solid waste recovery plan in compliance with Assembly Bill (AB) 75.
- Coordinate with Procurement and other branches to implement required legal and contractual changes to procurement and contracting methods.
- Implement a comprehensive, environmentally sensitive purchasing, operations and maintenance program within the Building and Property Management branch of the Real Estate Services Division of DGS.
- Identify methods to educate and train BPM staff in the program goals and objectives.

- Coordinate mission objectives with other RESD branches and existing charter teams with overlapping areas of concern (i.e. Cleaning Charter, RESD Sustainable Buildings Charter, Education/Vocational Training Charter).
- Incorporate written product procurement standards emphasizing the use of environmentally friendly cleaning in consultation with cleaning charter team consultant hired by BPM. Preparation and/or Revision will be done with RESD, OLS, Procurement assistance.
- Present required information to Labor Relations and Personnel concerning standards affecting BPM janitorial staff. Move forward on Charter areas where possible.
- Develop pilot program for expanding the goals to include other BPM products and supplies such as HVAC chemicals, pest applications, grounds keeping, etc..

Resource	*Description*	*Website*
Naturally Yours	All Purpose Cleaner Product Number: NY2 Cleaner Degreaser Product Number: NY3 Basin, Tub and Tile Cleaner Product Number: NY4 Glass and Window Cleaner Product Number: NY6 Clinging Toilet Bowl Cleaner Product Number: NY7	http://www.naturallyyoursstore.com
Rochester-Midland	Enviro-Care All Purpose Cleaner Enviro-Care Neutral Disinfectant Enviro-Care Washroom and Fixture Cleaner	www.rochestermidland.com
The Clean Environment	All Purpose Cleaner Product Number: N-1 Basin, Tub and Tile Cleaner Product Number: N-7 Clinging Toilet Bowl Cleaner Product Number: N-8 Furniture Polisher and Protector Product Number: N-11 Glass and Hard Surface Cleaner Product Number: N-13 Heavy Duty Degreaser/Cleaner Product Number: N-14 Cycle-Graffiti Remover Product Number: C-54	www.greencities.net

California SUSTAINABLE DESIGN Training 2001

Appendix: Glossary

HDR

Glossary

Alternative generation – Electrical power generation by wind, solar, geothermal, wave power, biomass or biomass byproducts.

Ambient lighting – Lighting in an area from any source that produces general illumination, as opposed to task lighting. Sustainable Building Technical Manual.

ASHRAE – American Society of Heating, Refrigerating and Air conditioning Engineers, Inc.

Biogas - Term used for the gas produced by the breakdown of organic matter in the absence of oxygen that can be used as a fuel. Soton.ac.uk/~engenvir/glossary

Biomass – Biomass is plant material such as trees, grasses, and crops. These materials are renewable and can be produced sustainably, providing a continuous feedstock source for fuel generation. Fuel sources can then be used to generate electricity or provide heating and transportation. USGBC, LEED™ Reference Guide 2.0.

Blackwater – Waste water from toilets and kitchen sinks that contains organic materials. USGBC, LEED™ Reference Guide 2.0.

Brownfield - Abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination. US EPA

Building footprint – The building footprint is the area on a project site that is used by the building structure and is equal to the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint. USGBC, LEED™ Reference Guide 2.0.

Certified wood – Those products made with wood from certified forests, forests that sustainably manage production while respecting the integrity and health of a particular forest ecosystem.

CFC - CFCs are chemicals manufactured from hydrocarbons, such as methane, chlorine, fluorine, or bromine. Used in refrigerants and solvents, they can destroy the ozone in the upper atmosphere when released. The EPA has banned their use by 1997. AIA Denver Committee on the Environment.

Cogeneration – The joint production and use of electricity and heat. Typically, electricity is the primary output of such large facilities as power plants. As a byproduct, heat can be used in food processing, district heating, or oil recovery. In contrast, industrial or small systems (e.g., laundromats, health clubs, and car washes) may be designed primarily to heat water while the generation of electricity is secondary. A Primer on Sustainable Building, Rocky Mountain Institute.

Commissioning – The start-up phase of a new or remodeled building. This phase includes testing and fine-tuning of the HVAC and other systems to assure proper functioning and adherence to design criteria. Commissioning also includes preparation of the system manuals and instruction of the building maintenance personnel. Sustainable Building Technical Manual.

Notes:

Construction and Demolition Waste - Waste building materials, dredging materials, tree stumps, and rubble resulting from construction, remodeling, repair, and demolition of homes, commercial buildings and other structures and pavements. May contain lead, asbestos, or other hazardous substances. US EPA

Daylighting – The controlled admission of natural light into a space through glazing with the intent of reducing or eliminating electric lighting. By utilizing solar light, daylighting creates a stimulating and productive environment for building occupants.

Energy management control system - A control system capable of monitoring environmental and system loads and adjusting HVAC operations accordingly in order to conserve energy while maintaining comfort. US EPA.

Energy Star Program - ENERGY STAR was introduced by the US Environmental Protection Agency in 1992 as a voluntary labeling program designed to identify and promote energy-efficient products, in order to reduce carbon dioxide emissions. EPA partnered with the US Department of Energy in 1996 to promote the ENERGY STAR label, with each agency taking responsibility for particular product categories. ENERGY STAR has expanded to cover new homes, most of the buildings sector, residential heating and cooling equipment, major appliances, office equipment, lighting, consumer electronics, and more. US EPA

Glossary

Erosion – A combination of processes in which the materials of the earth's surface are loosened, dissolved, or worn away, and transported from one place to another by natural agents. USGBC, LEED™ Reference Guide 2.0.

Fly ash – The fine ash waste collected from the flue gases of coal combustion, smelting, or waste incineration. Sustainable Building Technical Manual.

Geothermal - Geothermal Energy can be understood as the energy stored as heat within the earth. When the earth was formed 5 billion years ago from a cloud of hot gas, it was very hot indeed. Ever since then the earth has been cooling down, losing its heat to the cold reaches of space. However a lot of this heat still remains and can be used as a source of energy for the ever increasing demands of civilization. Soton.ac.uk/~engenvir/glossary.

Gray water – Wastewater from lavatories, shower, bathtubs, washing machines, and sinks that are not used for disposal of hazardous or toxic ingredients or wastes from food preparation. USGBS, LEED™ Reference Guide 2.0.

Greenfield – A Greenfield is defined as undeveloped land or land that has not been impacted by human activity. USGBC, LEED™ Reference Guide 2.0.

Halon - Bromine-containing compounds with long atmospheric lifetimes whose breakdown in the stratosphere causes depletion of ozone. Halons are used in firefighting. US EPA

HCFC - Hydrochlorofluorocarbons or hydrogenated chlorofluorocarbons. Because they are less destructive to ozone, they are a substitute for CFCs, although less efficient as refrigerants and sometimes quite toxic. AIA Denver Committee on the Environment.

Hydro(electric) – Electricity that is produced when falling water turns generators. It is a renewable energy source derived from gravity and rain. Very small generation facilities, producing up to 50 kilowatts, are called micro-hydro. A Primer on Sustainable Building, Rocky Mountain Institute.

Indigenous vegetation – Native vegetation, a plant whose presence and survival in a specific region is not due to human intervention. Certain experts argue that plants imported to a region by prehistoric peoples should be considered native. The term for plants that are imported and adapt to survive without human cultivation is naturalized. Sustainable Building Technical Manual.

Indoor air quality(IAQ) – According to the U.S. Environmental Protection Agency and National Institute of Occupational Safety and Health, the definition of good indoor air quality includes (1) introduction and distribution of adequate ventilation air; (2) control of airborne contaminants; and (3) maintenance of acceptable temperature and relative humidity. According to ASHRAE Standard 62-1999, indoor air quality is defined as "Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority(80 percent or more) of the people

exposed do not express dissatisfaction." Sustainable Building Technical Manual.

Integrated design – A holistic process that considers the many disparate parts of a building project, and examines the interaction between design, construction, and operations, to optimize the energy and environmental performance of the project. The strength of this process is that all relevant issues are considered simultaneously in order to "solve for pattern" or solve many problems with one solution. The goal of integrated design is developments that have the potential to heal damaged environments and become net producers of energy, healthy food, clean water and air, and healthy human and biological communities. A Primer on Sustainable Building, Rocky Mountain Institute.

Life Cycle Assessment – An informed decision making process that can be applied to building components, design strategies, and other measures associated with building alternatives. The LCA process is beneficial because it considers initial capial costs in addition to ownership and maintenance costs over a specified lifetime. USGBC, LEED™ Reference Guide 2.0.

Life cycle cost benefit analysis - The total cost of a product or material including the initial cost and the long term maintenance costs. This approach can often be used to justify more expensive and energy efficient systems which save money over the life of the product.

Light shelf – A horizontal device positioned (usually above eye level) to reflect daylight onto the ceiling and to shield direct

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sunlight from the area immediately adjacent to the window. The light shelf may project into the room, beyond the exterior wall plane, or both. The upper surface of the shelf may be specular or nonspecular but should be highly reflective (that is, have 80 percent or greater reflectance). Sustainable Building Technical Manual.

Model - A way to represent a system for the purposes of reproducing, simplifying, analyzing, or understanding it. RreDC.com

Microclimate - Localized climate conditions within an urban area or neighborhood. 2. The climate around a tree or shrub or a stand of trees. US EPA

MRF - A recycling facility that sorts and processes collected mixed recyclables into individual streams for market. Also known as an intermediate processing center (IPC). GRN.com

Oriented strand board (OSB) – A manufactured wood sheet product made from large flakes of wood pressed together with glue, usually a dry phenolic type. OSB is used for structural sheathing and subfloors. Sustainable Building Technical Manual.

Ozone - A molecule that occurs naturally in the Earth's atmosphere, in both the upper atmosphere, the stratosphere, and the lower atmosphere, the troposphere. It is important to life on Earth primarily because it absorbs biologically harmful ultraviolet radiation, preventing it from reaching the Earth. See Ozone Depletion. AIA Denver Committee on the Environment.

Passive solar and/or thermal design - Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun. Passive systems are simple, have few moving parts, and require minimal maintenance and require no mechanical systems. Greenbuilder.com

Photovoltaics – Photovoltaics or PV are composite materials that convert sunlight directly into electrical power. USGBC, LEED™ Reference Guide 2.0.

Post consumer recycled content – A reclaimed waste product that has already served a purpose to a consumer, such as used newspaper, and has been diverted or separated from waste management systems for recycling. Sustainable Building Technical Manual.

Post industrial recycled content – The percentage of waste material by weight available from industrial use incorporated into a building material. USGBC, LEED™ Reference Guide 2.0.

Potable water – Water suitable for drinking and that is supplied from wells or municipal water systems. USGBC, LEED™ Reference Guide 2.0.

Radon - An odorless gas that passes from some soil types into buildings and may cause cancer. AIA Denver Committee on the Environment.

Recycle – The process by which materials that would otherwise become solid waste are collected, separated or processed and returned to the economic mainstream to be reused in the form of raw materials or finished goods. GRN.com

Recycled material – Material that would otherwise be destined for disposal but is diverted or separated from the waste stream, reintroduced as material feed-stock, and processed into marketed end-products. Sustainable Building Technical Manual.

Relative humidity – The ratio of partial density of water vapor in the air to the saturation density of water vapor at the same temperature. USGBC, LEED™ Reference Guide 2.0.

Renewable – A renewable product can be grown or naturally replenished or cleansed at a rate that exceeds human depletion of the resource. Sustainable Building Technical Manual.

Renewable energy – Active, passive, and photovoltaic strategies integrated into building design. Sustainable Building Technical Manual.

Residual or salvage value – The market value of an item to be salvaged or reused.

Reuse – A strategy to return a material to active use in the same or a related capacity. USGBC, LEED™ Reference Guide 2.0.

R value – A unit of thermal resistance used for comparing insulating values of different materials; the higher the R-value, the greater its insulating properties. A

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Glossary

Primer on Sustainable Building, Rocky Mountain Institute.

Salvaged - The utilization of waste materials. US EPA

Sick building syndrome – According to the EPA and NIOSH, Sick Building Syndrome is defined as, "Situations in which building occupants experience acute health and/or comfort effects that appear to be linked to time spent in a particular building, but where no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be spread throughout the building." Occupants experience relief of symptoms shortly after leaving the building. Sustainable Building Technical Manual.

Sustainable – The condition of being able to meet the needs of present generations without compromising those needs for future generations. Achieving a balance among extraction and renewal and environmental inputs and outputs, as to cause no overall net environmental burden or deficit. To be truly sustainable, a human community must not decrease biodiversity, must not consume resources faster than they are renewed, must recycle and reuse virtually all materials, and must rely primarily on resources of its own region. Sustainable Building Technical Manual.

Task ambient conditioning (TAC) A combination of task and ambient lighting designed so that the level of ambient light is less than and complementary to the task lighting. Kansas City, MO Power & Light

Task lighting – Providing lighting in the immediate area where tasks are performed, i.e., at desks, counter tops, etc.; as opposed to ambient or general lighting.

Thermal comfort – A condition of mind experienced by building occupants expressing satisfaction with the thermal environment. USGBC, LEED™ Reference Guide 2.0.

Tipping fee – Fees charged by the landfill for dumping large volumes of disposable waste. The fee is usually quoted for one ton of waste. USGBC, LEED™ Reference Guide 2.0.

Variable air volume (VAV) – A method of modulating the amount of heating or cooling effect that is delivered to a building by the HVAC system. The flow of air is modulated rather than the temperature. VAV systems typically consist of VAV boxes that throttle supply airflow to individual zones, some mechanism to control supply fan flow to match box demand, and the interconnecting ductwork and components. Sustainable Building Technical Manual.

Volatile Organic Compounds, VOC's – Chemical compounds based on carbon and hydrogen structures that are vaporized at room temperatures. VOC's are one type of indoor air contaminant. Although thousands have been identified in indoor air, only a few are well understood and regulated. Sustainable Building Technical Manual.

Waste diversion techniques – The recycling and reuse of materials or components instead of depositing in

landfill; i.e., diversion from the conventional waste stream.

Wetlands – In storm water management, a shallow, vegetated, ponded area that serves to improve water quality and provide wildlife habitat. Sustainable Building Technical Manual.

White Noise – Sound that has constant energy per frequency. Sustainable Building Technical Manual.

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