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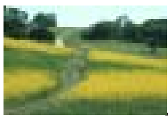
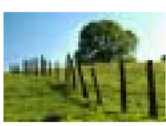
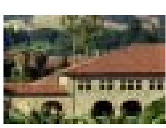




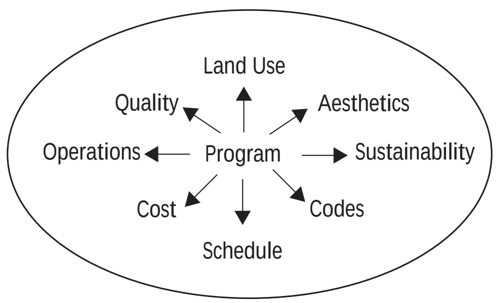


EXECUTIVE SUMMARY

Stanford University has a long history of good land use planning and resource conservation. Nevertheless, as members of the local and regional community, we face environmental and political concerns such as water limitations, conflicts over land use, rising energy costs, and ongoing operations and maintenance costs as we endeavor to provide healthy buildings for our students, faculty, staff, and visitors. In addition, we recognize the building industry has a tremendous impact on the natural environment on a national and global scale, including deforestation and global climate change due to fossil fuel use.

The Environmental Stewardship Committee[1] was formed in the spring of 2001 and set itself the task of developing a set of Stanford-specific sustainable building guidelines and integrating them into the facilities planning, design, and operations processes.
The Guidelines for Sustainable Buildings (The Guideline) demonstrates Stanford University's commitment to plan and develop high-value, quality, long-term, cost effective facilities and landscapes that enhance the academic mission of the University, embrace our partnership with our community, and reinforce our stewardship of Stanford lands.

The Guideline is intended to serve as both a communication and working tool that aids in planning, design, and construction of new buildings and renovations with an appropriate level of attention to economic, ecological, and social concerns. It complements Capital Planning & Management's **Project Delivery Process (PDP) Manual** and provides guidance to Project Managers, Architects, and other members of the new construction or major renovation Project Team. At Stanford, sustainability is to be considered at the same level as traditional competing priorities such as cost, quality, and schedule. Competing priorities must be equally considered and in balance to support the program within the building, as suggested by the illustration below:



Section I of **The Guideline** provides an overview and introduction. It explains how the word "sustainability" is used in the context of this document and why it is important at Stanford University. Section II, Process Phases, describes the process for implementing sustainable principles in a building project, with a discussion of sustainability issues for each phase of design and construction. The Technical Guidelines for sustainability are contained in Section III. They provide technical information in the form of goals and strategies to which Stanford University's consultants should refer during the design process. The Technical Guidelines are organized by the several areas in which sustainability features can be integrated into the design of any building type: site design and planning, energy use, water management, materials/resources/waste, and indoor environmental quality. Section IV contains a discussion of Funding, Decision Tools, and Metrics that support and document a sustainable building process. **The Guideline** concludes with an Appendix which contains a Technical Resource Library with a list of resources for further information about sustainable building design and construction.

[1] Chaired by the Vice-Provost of Land & Buildings with membership encompassing students, faculty, and staff from Facilities Operations, Capital Planning & Management, Environmental Health & Safety, and the University Architect/Planning Office.

WHAT MAKES A BUILDING "SUSTAINABLE"

"In our every deliberation, we must consider the impact of our decisions on the next seven generations."
Great Law of the Iroquois Confederacy

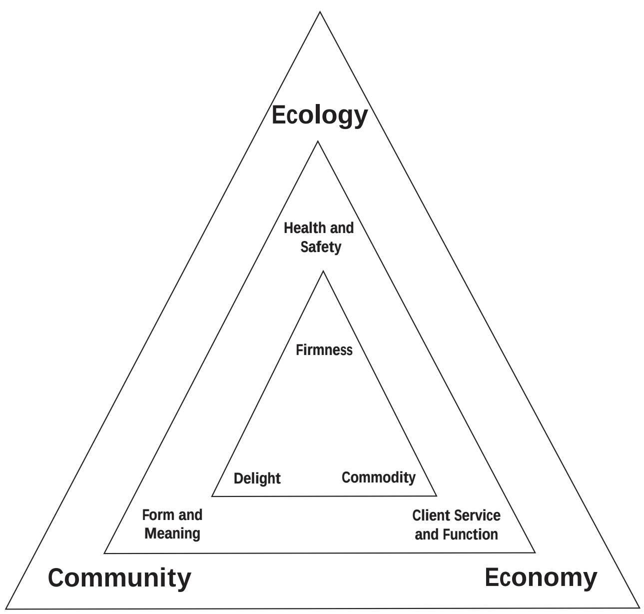
"Development is sustainable when it meets the needs of the present without compromising the ability of future generations to meet theirs."
United Nations World Commission on Environment and Development, 1987

"Sustainable communities evolve incrementally over time, preserving the best elements of the past while planning for the future."
National Council of Architectural Registration Board, 2001

BACKGROUND

The term "sustainability" has existed in planning parlance for many years, with its definition evolving over time. It is a positive sign that the term is being discussed, debated, and most importantly, used to make decisions about such diverse issues as jobs, housing, transportation, open space, resource conservation, air/water quality, and building design. The definition of the word "sustainability" must incorporate a balanced concern for the future preservation of three interdependent areas: community, economy, and ecology.

It is within this context of increasing concern for sustainability that Stanford University has developed these guidelines for its future facility projects, both new and renewal. A sustainable building may be termed "green," "high performance," or "energy- and resource-efficient." At Stanford University, "sustainable buildings" refer to buildings that use energy, water, and other natural resources efficiently and provide safe and productive indoor environment. Achieving these goals requires an integrated development process.



The diagram above illustrates the linkage between sustainability concerns and classic architectural design principles.

WHY SUSTAINABILITY IS IMPORTANT

ENVIRONMENTAL CONCERNS

The impact of a building spans a wide range of sustainability concerns that range from local to well beyond our region's borders. Locally, we face environmental and political concerns such as water use and quality, land use, energy use, and ongoing operations and maintenance costs. On a national and global scale, the building industry has a tremendous impact on the environment of which we are a part, ranging from alteration of community character to resource depletion to global warming. The entire range of impacts should be taken into consideration when designing and constructing buildings to help ensure that they have minimal environmental impact while still fulfilling their programmatic directives.

We have identified five sustainability categories for evaluating the impacts of a building project: 1) site design and planning, 2) energy use, 3) water management, 4) materials, resources, and waste, and 5) indoor environmental quality.

Site Design and Planning

Building projects affect the environment and transform the land in both obvious and subtle ways. Traditionally, the project site has been defined in terms of metes and bounds, setbacks and height limits, points of entry and egress, fire lanes and utility connections, etc. While these definitions are useful and necessary, sustainability requires a broader set of issues to be included that incorporate community health and welfare, economy in terms of resource utilization during and after development, and environmental impacts with regard to local and regional microclimates and biodiversity. Sustainable site planning identifies ecological, infrastructural, and cultural characteristics of the site to assist designers in their efforts to integrate the building and the site. The intent is to encourage optimum use of natural/existing features in architectural and site design of campus buildings, such that building energy use is diminished and the environment is enhanced.

Energy Use

A building project utilizes energy both during construction and ongoing operation and maintenance. The Worldwatch Institute (1995) has estimated that approximately forty percent of the world's energy demand is due to the development and operation of built structures. This energy use has serious impacts on the environment; buildings account for about one-third of the emissions of heat-trapping carbon dioxide from fossil fuel burning and two-fifths of acid rain-causing sulfur dioxide and nitrogen oxides. Buildings also contribute to other side effects of energy use, including oil spills and river damming. Therefore, it has become increasingly important to focus on the energy use of buildings. For example, community health may be served best by using sunlight and natural ventilation for both ambient lighting and suitable temperature modulation. By making its buildings more energy efficient, Stanford can reduce its energy consumption and cost and the pollution associated with the burning of fossil fuels.

Water Management

Sustainable design dictates that water and its relationship to building design, development and operation be managed carefully. The community requires adequate potable water in the times of drought, and planning should provide for protection from storm waters and floods. At the same time, the biodiversity of each region is dependent on water for maintaining appropriate habitat conditions. The principles of sustainable building seek to increase the value we derive from our water resources by designing and operating our structures more efficiently. Stanford is currently approaching its limit for water use under its General Use Permit; and as further growth of the campus is planned, the need for water conservation becomes even more apparent.

WHY SUSTAINABILITY IS IMPORTANT *(Continued)*

Materials, Resources, and Waste

The building industry consumes three billion tons of raw materials annually -- forty percent of the total material flow in the global economy (Roodman and Lenssen, 1995). Construction materials are "reorganized matter," and this reorganization process creates significant environmental and social impacts. A life-cycle assessment (LCA) of materials is a tool that allows design and planning experts to measure and minimize the impact on both communities and the environment. From a sustainability perspective, the best building materials are those that are long-lived, least disruptive to harvest, ship, and install, and are also easiest and safest to maintain and reuse.

Waste is generated throughout the life of a building and transported to landfills during building demolition, renovation, and construction. According to the U. S. Environmental Protection Agency, construction and demolition waste represents a quarter to a third of all waste landfilled in the United States. Stanford already diverts fifty percent of its waste from landfills, but sustainable design at all stages of building development, including plans to recycle or reuse construction and demolition waste, can help to further alleviate the pressure on our landfills and natural resources.

Indoor Environmental Quality

Research has shown that buildings with daylight, fresh air, and occupant control are consistently rated as more comfortable and contribute to occupants' performance and productivity. Evidence suggests that daylighting can enhance the rate of learning for elementary students and leads to sharply higher test scores (Hawken, et al. 1999). These benefits of a good indoor environmental quality may likely also extend to the performance and productivity of Stanford's students, faculty, and staff.

IMPLEMENTING SUSTAINABILITY AT STANFORD

Implementing sustainable building practices is an ongoing process. Key elements of implementation will include appointment of a Sustainability Coordinator, supplementing the project architect selection process, and project team education.

Sustainability Coordinator

Each Capital Planning and Management building Project Manager will work with a Sustainability Coordinator who will act as facilitator and teacher. This person will be a Capital Planning and Management staff member who may at times solicit the assistance of qualified consultants or other Stanford personnel, as needed. The Sustainability Coordinator's responsibility is to support the Project Team in their efforts to follow **The Guideline.** It will be the responsibility of the Project Manager to ensure informed decision making. It is expected that the Sustainability Coordinator will take an active role on the Project Team, particularly those led by Project Managers who are using **The Guideline** for the first time. The Sustainability Coordinator will act as an educator, rather than an "inspector," so that the Project Team develops the knowledge and commitment to achieve the best balance for the project. It is expected that the role of the Sustainability Coordinator will become consultative over time as training, education, reviews, and project experience lead to a cultural shift toward complete and routine incorporation of sustainable design and construction practices.

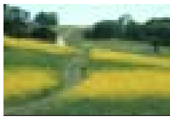
Project Architect Selection

The University Architect's Office will include sustainable building design qualifications as one of the criteria for selecting the design architect for each project. Requests for Qualifications/Proposals for design architects will include experience/qualification in the area of sustainable building design and these qualifications will be considered during the selection process. Requests for Proposals given to potential design architects will include **The Guideline** as an attachment.

Project Team Education

The entire Project Team will review the principles of sustainable building design in general and will reference **The Guideline** throughout the project. This education is most important during the initial project phases. All members of the Project Team will receive a printed copy of **The Guideline** which includes a reference to the web site (http://cpm.stanford.edu) where **The Guideline** will be regularly updated and revised to reflect new technologies and learning. During the course of the project delivery process, a work session on the topic of sustainability shall be conducted at the request of the Project Manager. The Project Team should attend this work session and focus on educating attendees as to the current sustainable opportunities and next steps in the process.

II. PROCESS PHASES



THE PROJECT DELIVERY PROCESS AT STANFORD

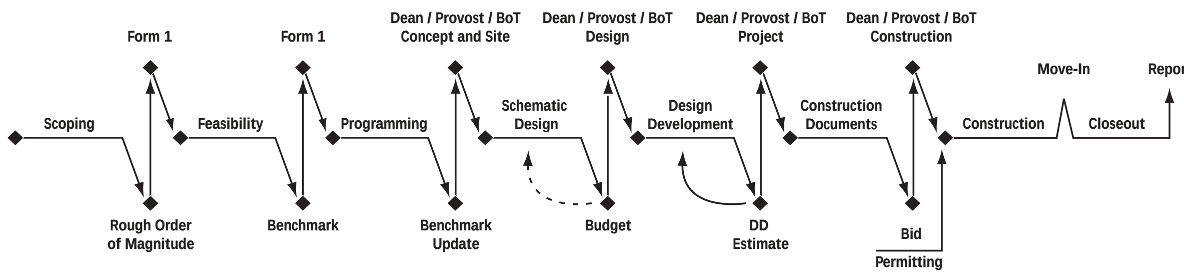
Each of the nine Process Phases (Scoping, Feasibility, Programming, Schematic Design, Design Development, Construction Documents, Permitting, Construction, and Closeout) are presented in the **PDP Manual, Volume I.** This section of **The Guideline** discusses specific process activities as they pertain to sustainability. **The Guideline** and the **PDP Manual** are designed to be used in conjunction with each other.

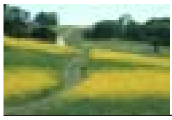
The greatest achievements in sustainability occur when the building and how it functions is considered in the design. Decisions made in one area may affect the performance in another. Therefore, **The Guideline** and the **PDP Manual** outline an integrated or "whole-building" design approach. The process steps are identified to set performance goals and to ensure that decisions are made in a collaborative and informed manner. The maximum benefits to the programmatic mission can be achieved when sustainability is considered in the early phases of the project delivery process.

Each process phase requires specific tasks to be performed and deliverables to be produced prior to obtaining the necessary approvals to move forward. Recommended sustainability tasks appear in the **PDP Manual, Volume II** checklists for each project delivery phase, which are available online at http://cpm.Stanford.edu. A graphic representation of the process phases and the necessary approvals, referred to as the "Heartbeat," is shown below.

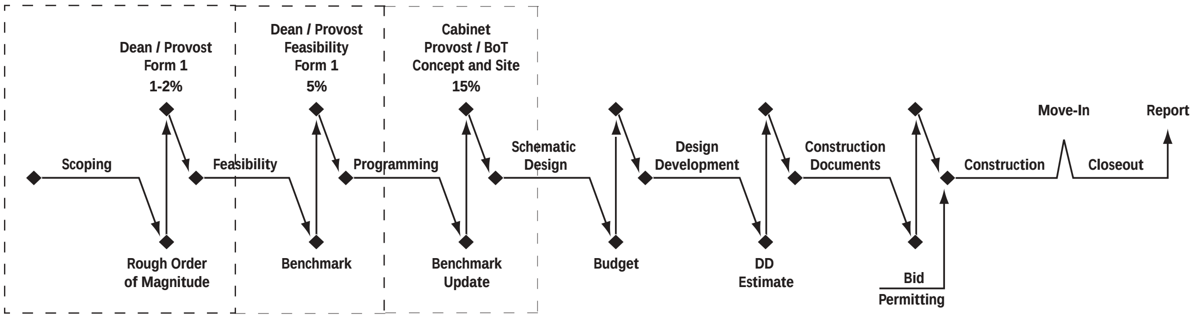
HEARTBEAT

New Construction





SCOPING, FEASIBILITY, AND PROGRAMMING PHASES



SCOPING

Sustainability Goal

The goal of project Scoping is to translate academic or departmental initiatives into potential facility needs to determine if a capital construction project is necessary. Sustainable features should be introduced to the Project Team (the User Group, the Technical Group, and the Consultant Group) at an early stage so they can be considered with other information for the **Project Planning Guide** as it is being developed.

For an explanation of the Project Scoping process, reference the **PDP Manual, Volume 1**, p. 11. For an explanation of the Project Team, reference the **PDP Manual, Volume 1**, p. 7.

FEASIBILITY

Sustainability Goal

The goal in the Feasibility phase is for the Project Team to develop the options outlined in the **Project Planning Guide** and understand any costs or savings that may be incurred in order to create a more sustainable building. Sustainability factors may include additional design costs and potential impacts to the construction cost.

For an explanation of the Feasibility process, reference the **PDP Manual, Volume 1**, p. 12.

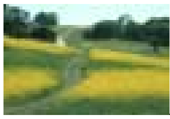
PROGRAMMING

Sustainability Goal

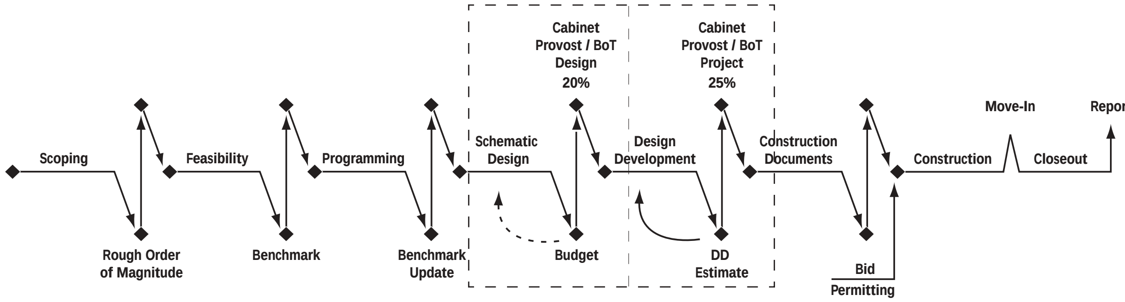
During the Programming phase, the option approved by the Dean and Provost should be further developed to include sustainability issues as they pertain to user needs and design parameters. As the Project Team develops the Programming Report, a summary schedule, and a preliminary budget, the Project Manager should arrange a Sustainability Work Session to review **The Guideline** and the underlying principles of sustainability as they relate to building design, construction, and operation.

The Project Team should also consider sustainability as it relates to the siting, orientation, and specific design guidelines for a proposed facility and discuss strategies that yield efficiencies in building space and function. This Sustainability Work Session should be facilitated by a University staff member or consultant who can identify the benefits of sustainable building design for the building user/occupants. The benefits and potential cost savings or increases in cost should be understood when including sustainable elements.

For an explanation of the Programming process, reference the **PDP Manual, Volume 1**, p. 13.



SCHEMATIC DESIGN AND DESIGN DEVELOPMENT



SCHEMATIC DESIGN

Sustainability Goal

Schematic Design (SD) is a critical phase where the general scope, initial design, scale, and relationships among the components of the project are determined. At the beginning of the Schematic Design phase, program priorities and associated assumptions should be reevaluated to determine if spaces and functions can be shared or co-located with the sustainability goal of reducing the volume of the building, increasing space efficiency, using fewer raw materials, and optimizing energy and water use.

The largest energy impacts of the project should be identified, prioritized, and discussed at design meetings. As discussed in Section IV of this document, energy modeling, using software tools such as DOE-2, eQUEST, or ENERGY-10, should be used to evaluate energy-efficient design alternatives and refine the project's sustainability goal for energy usage.

For an explanation of the Schematic Design process, reference the **PDP Manual, Volume 1**.

DESIGN DEVELOPMENT

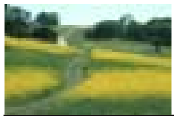
Sustainability Goal

During the Design Development (DD) phase, the approved schematic design begins to include a level of detail necessary to work out a clear, coordinated description of all aspects of the project. Because the Design Development phase is one of the last opportunities for the User Group to become involved in the design, it is crucial that sustainability principles be fully discussed and implications be understood and integrated as appropriate.

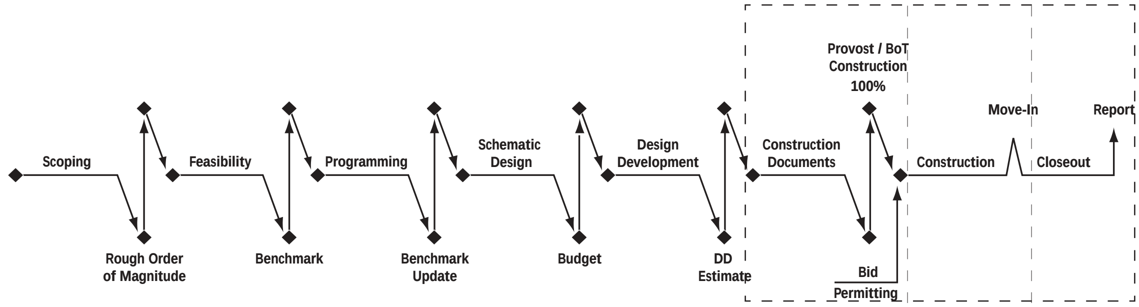
Design and construction costs associated with the sustainability elements of the project should be clarified. Sustainable component cost metrics (capital and life-cycle) should be developed and cost and/or savings decisions evaluated against performance and life-cycle cost considerations. Section IV of this document can be used as a tool to perform the life-cycle cost analyses and ensure informed decisions.

The Project Team should ensure that the project schedule allows adequate time for implementing the activities that may lead to a more sustainable project such as commissioning, construction, demolition waste diversion, and training.

Reference Section IV of **The Guideline**. For an explanation of the Design Development process, reference **PDP Manual, Volume 1**, p. 15.



CONSTRUCTION DOCUMENTS, CONSTRUCTION AND CLOSEOUT



CONSTRUCTION DOCUMENTS

Sustainability Goal

During the Construction Document (CD) phase, a comprehensive, fully coordinated set of construction documents and specifications are issued by the Contractor to obtain the necessary permits and construct the project. A review of sustainability elements should be included in the 50% CD Technical Group review. This review should specifically address materials selection.

For an explanation of the Construction Document process, reference the **PDP Manual, Volume 1,** p. 16 and **The Guideline**, Section III, p. 21.

CONSTRUCTION

Sustainability Goal

The objective of the Construction phase is to safely build the project as represented in the contract documents within the parameters approved by the Board of Trustees. A representative from the general contractor, each subcontractor, and a Sustainability Coordinator should attend the pre-construction meeting. The sustainability goals and design features of the project should be discussed at this meeting. Contractor ideas and opinions should be encouraged during these discussions to allow for innovations and efficiencies during construction.

For an explanation of the Construction process, reference the **PDP Manual, Volume 1**, p. 18-19.

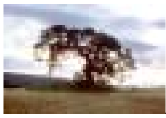
CLOSEOUT

Sustainability Goal

Closeout facilitates the occupancy and turnover of the finished and fully commissioned project to the User Group and maintenance department. It is important for building occupants and maintenance personnel to understand how their facility is designed to function, particularly as it relates to specific user behavior, in order for it to operate as efficiently as possible. A training program should be developed to educate the Zone Manager and Building Manager about the sustainable features of the building and how the building is supposed to operate, including any user-influenced control strategies.

Closeout also provides an opportunity for the Project Team to discuss how the process of implementing **The Guideline** could be improved. Performing post-occupancy evaluations will be important for determining the effectiveness of the design and product selections.

III. TECHNICAL GUIDELINES



TECHNICAL GUIDELINES

These guidelines draw heavily from the *University of Minnesota Sustainable Design Guide,* the *City of New York High Performance Building Guidelines,* and the *LEED™ Green Building Guidelines and Rating System*.

The Technical Guidelines are organized into five different categories:

- Site Design and Planning
- Energy Use
- Water Management
- Materials, Resources, and Waste
- Indoor Environmental Quality

In view of the environmental concerns associated with buildings, sustainable design embodies certain goals within each sustainability category. The discussion of each sustainability category begins with a set of goals, followed by a list of suggested strategies to be used in achieving those goals. The sustainability strategies included here are not comprehensive; the Technical Guidelines are intended to provide ideas and not exclude any from consideration. The Project Team is encouraged to develop additional strategies.

The second section of the Technical Guidelines outlines the seven building use types found on the Stanford campus:

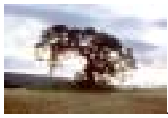
- Residential
- Offices and Classrooms
- Libraries
- Wet Labs
- Dry Labs
- Computer Facilities
- Athletic Facilities

Each building use type section begins with a description of the building type, followed by sustainability issues and opportunities particular to the type.

“Whole Building” Design Approach

Following a category-based presentation of technical strategies potentially applicable to all building types, **whole-systems design** is crucial for sustainability. The sustainability categories and strategies are interdependent; none stand in isolation. Decisions made in one area may affect the performance in another. A single design improvement might simultaneously improve several building systems' performance; for example, careful decisions on building shape and window placement that take into account both prevailing wind and sun angles may not only enhance a building's thermal performance but can also result in improved daylighting. On the other hand, considering one building system alone without regard to others may result in poorer performance in the other systems; for example, improving indoor environmental quality by increasing outside ventilation may compromise the energy performance of the building. Any conflicts among categories should be resolved by using an integrated design approach; and careful decisions should be made to select those designs that can trigger multiple savings or other benefits. It is essential that all members of the Project Team work together and consider all sustainability categories in order to be aware of the influence of their decisions on the overall sustainability performance of the building in each category.

In addition, not all strategies suggested here are relevant for every project and certainly not all strategies will be implemented in every project. Considerations and decisions will have to be balanced by the Project Team and strategies worked out that make sense for each project.



SITE DESIGN AND PLANNING

GOALS:

- Promote sensitive infill development that relates well to both natural systems and existing infrastructure.
- Maintain and enhance the biodiversity of natural systems and/or the existing character of the site.
- Respond to Stanford's microclimates and natural site conditions.
- Reduce energy use for transportation and site related activities.
- Contribute to the cohesiveness and intelligibility of the existing campus.

STRATEGIES:

Guide Development to Environmentally Appropriate Infill Areas

As much as possible, select a site that:

- Meets the conditions of the approved General Use Permit for Stanford University (2000 GUP).
- Is characterized as previously developed land.
- Utilizes a floor-area ratio that is at minimum in the range of 0.25 - 0.35 (or equivalent).
- Avoids habitat for any sensitive species and species on the Federal or State threatened or endangered list (e.g., California tiger salamander, red-legged frog, and steelhead trout) or is a wildlife or riparian corridor.
- Avoids the loss of mature oaks and other trees.

Maintain and Enhance the Biodiversity and Ecology of the Site

Integrate the building with the site in a manner that minimizes the impact on natural resources, while maximizing human comfort and social connections. The development footprint should enhance the existing biodiversity and ecology of the site by strengthening the existing natural site patterns and making connections to the surrounding site context. Consider and apply the appropriate strategies below:

- Minimize the impacts of the development process to reduce alteration and ecological disturbance.
- For greenfield sites, the ratio of disturbed to undisturbed land during construction should not exceed that of the main campus.
- Design the site to reconnect fragmented landscapes and establish contiguous networks with other natural systems both within the site and adjacent systems beyond its boundaries.
- Avoid major alterations to sensitive topography, vegetation, and wildlife habitat.
- Minimize the area of the site dedicated to the building, parking, and access roads and attempt to increase the floor-area ratio beyond the campus average.
- Site the building to create traffic patterns that promote non-motorized access.
- Maintain setbacks that effectively utilize the site while respecting surrounding environmental conditions.

Optimize Building Placement and Configuration for Energy Performance

Place, orient, and configure the building on the site to minimize energy use by means of daylighting, solar heating, natural ventilation, and shading from vegetation or other buildings.

Use Microclimate and Environmentally Responsive Site Design Strategies

Design the site and building to respond to microclimate and environmental conditions. Consider and apply the appropriate strategies below:

- Locate trees and shrubs to support passive heating and to complement cooling in outdoor spaces and buildings and to create seasonally appropriate heatsinks and natural ventilation corridors.
- Locate site features (plazas, patios, etc.) to take advantage of seasonal sun angles, solar access, and solar orientation.
- Locate site elements to maximize heating and cooling benefits, to ensure proper drainage, and to make pedestrian/vehicular movements safe and coherent.
- Design the overall site to reduce "heat island" effects. Exploit shading opportunities, and explore the possible use of high-albedo materials. Consider pervious surfaces for parking, walkways, plazas, etc. Use permeable paving for roads with infrequent use (e.g., fire roads).
- Design site lighting to eliminate light trespass from the building and site and to minimize impact on nocturnal environments

Use Native or Drought-Tolerant Trees, Shrubs, Plants, and Grasses

Use vegetation on the site that conserves water, reduces pesticide use, maintains a Stanford "sense of place," reduces plant mortality, and lowers operational maintenance.

ENERGY USE

GOALS:

- Reduce total building energy consumption and peak electrical demand.
- Reduce air pollution, contributions to global warming, and ozone depletion caused by energy production.
- Slow depletion of fossil fuel reserves.
- Achieve energy cost and related savings due to upgrades to infrastructure.

STRATEGIES:

Reduce Loads

Optimize Building Envelope Thermal Performance

Design building envelope to optimize thermal performance. Consider and apply the appropriate strategies below:

- Size openings, select glazing, and utilize shading devices (interior or exterior) to optimize daylighting and glare control while minimizing unwanted heat loss and heat gain.
- Optimize insulation to reduce heating and cooling energy consumption by heat losses and gains through the building envelope.
- Moderate interior temperature extremes by using thermal mass where appropriate.
- Ensure the integrity of the building envelope to provide thermal comfort and prevent condensation. Use best air/vapor barrier practices and avoid thermal bridging.
- Reference the Facilities Design Guidelines, Section 01900 (www-facilities.stanford.edu/fdcs/).

Provide Daylighting Integrated with Electric Lighting Controls

Ensure that daylighting is designed in coordination with the electric lighting system to reduce energy consumption while maintaining desired lighting characteristics. Consider and apply the appropriate strategies below:

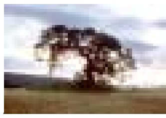
- Shape the architectural plan and section and use appropriate strategies to maximize the amount of useful, controlled daylight that penetrates into occupied spaces (e.g., roof monitors, clerestory windows, atriums and courtyards).
- Use shading devices such as overhangs on south elevations, vertical fins on east and west elevations, and/or vegetation to let in natural light but reduce glare and overheating.
- Use light shelves combined with higher, more reflective ceilings to bring natural light deeper into perimeter spaces and control glare and excessive contrast.
- Select clear films or spectrally-selective low-e glazing to increase daylighting while minimizing heat gain.
- Use photocell-dimming sensors that adjust electric lighting in response to available daylight.
- Reference the Facilities Design Guidelines, Section 16500 (www-facilities.stanford.edu/fdcs/).

Design Efficient Systems

Provide Efficient Electric Lighting Systems and Controls

Design the electric lighting systems and components to minimize electric lighting energy use while still meeting project requirements and high visual quality. Consider and apply the appropriate strategies below:

- Use high efficiency lamps and luminaires with electronic ballasts.
- Use controls to reduce energy use (e.g., dimmers, occupancy sensors, photocells, and time clocks).
- Use low levels of ambient light with task lighting where appropriate. Direct/indirect lighting fixtures illuminate ceilings and walls, producing low-level ambient light that minimizes glare in computer rooms.
- Reference Facilities Design Guidelines, Section 16500 (www-facilities.stanford.edu/fdcs/) and the Outdoor Lighting Plan (Stanford University Architect/Planning Office).



Maximize Mechanical System Performance

Design the building heating, ventilating, and air conditioning (HVAC) system to minimize energy use while maintaining standards for indoor air quality and occupant comfort. Consider and apply the appropriate strategies below:

- When possible, minimize or eliminate air conditioning.
- Use central campus steam and chilled water system when building in the core campus.
- Group similar building functions into the same HVAC control zone so those areas can be scheduled separately (e.g. separate around-the-clock areas from classrooms and offices).
- Apply direct/indirect evaporative cooling and/or pre-cooling for conditioned spaces.
- When not using central steam or chilled water, design boilers and chillers using high efficiency equipment, use multiple modular boilers to allow more efficient part-load operation, high efficiency condensing boilers, or gas heater/chillers.
- Modulate outside air according to occupancy, activities, and operations. Use occupancy sensors and variable air volume distribution systems to minimize unnecessary heating or cooling.
- Use heat recovery systems to reduce heating energy use.
- Use zero CFC-based refrigerants in HVAC and refrigeration equipment. Phase out CFC-based refrigerants for renovation projects.
- Reference Facilities Design Guidelines, Sections 15800 and 15900 (www-facilities.stanford.edu/fdcs/).

Use Efficient Equipment and Appliances

Design and/or select any building equipment and appliances to optimize energy efficiency. Consider and apply the appropriate strategies below:

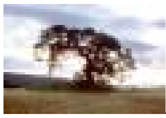
- Use equipment with premium efficiency motors and variable speed drives.
- Select new equipment (including transformers) and appliances that meet EPA ENERGY STAR® criteria.
- Use efficient equipment to heat and supply service water to the building. When feasible, consider use of tankless water heaters.
- Reference the Facilities Design Guidelines, Sections 01650 and 15800 (www-facilities.stanford.edu/fdcs/).

Use Energy Sources with Low Environmental Impact

Use Renewable or Other Alternative Energy Sources

Consider the use of alternative energy sources and supply systems to reduce the building's total energy load and minimize environmental impacts of burning fossil fuels such as air pollution and global warming. These systems can be either building-integrated or directly connected.

- For buildings and activities not served by Cardinal Cogen, evaluate possibilities for the use of renewable energy (such as photovoltaic panels, solar water heaters, and wind turbines).
- Evaluate possibilities for other alternative energy supply systems (such as fuel cells).
- In the future, if Stanford has the option of selecting its power provider, a provider with a higher percentage of renewable energy in its generation mix should be considered.



WATER MANAGEMENT

GOALS:

- Preserve site watersheds and groundwater aquifers.
- Conserve and reuse stormwater.
- Maintain appropriate level of water quality on the site and in the building(s).
- Reduce potable water consumption.
- Reduce off-site treatment of wastewater.

STRATEGIES:

Manage Site Water

Stormwater

Implement an effective stormwater management plan that meets the requirements of the Stanford stormwater program and the local jurisdiction. Consider and apply the appropriate strategies below:

- Select a site and develop design strategies that will require minimum alterations and ecological impacts to the watershed.
- Use biologically based stormwater management features such as swales, sediment control ponds, pools, wetlands along drainage courses, and infiltration basins to retain and treat stormwater on site and/or in adjacent areas.
- Retain and/or maximize pervious and vegetated areas of the site.
- Minimize hardscapes and use permeable paving and surface materials to maximize site water absorption.
- Design pavements to reduce stormwater velocity and to facilitate water infiltration into the soil.
- Capture rainwater from impervious areas of the building for groundwater recharge or reuse.

Erosion Control

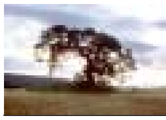
Consider and apply the appropriate strategies below:

- Prevent soil erosion before, during, and after construction by controlling stormwater runoff and wind erosion. Consider silt fencing, sediment traps, construction phasing, stabilization of slopes, and maintaining and enhancing vegetation and groundcover.
- Protect hillsides using adequate erosion control measures such as hydro seeding, erosion control blankets, and/or sedimentation ponds to collect runoff.

Irrigation and Specialty-Use Water

Minimize the need for irrigation. Consider and apply the appropriate strategies below:

- Select drought tolerant plant species.
- Use efficient irrigation systems that utilize technologies such as drip irrigation, moisture sensors, and weather data-based controllers.
- Match system to water use.
- Use correct nozzles on irrigation heads.
- Use recirculating water in fountains, water displays, and for process cooling.
- Use lake water (in place of potable water) irrigation systems.
- Incorporate gray water systems (see Gray Water Systems following).



Use or Establish Infrastructure for Future Use of Gray Water Systems

Gray water systems are used to reduce the use of potable water on the site and/or within the building. Currently, gray water use is allowed in California only in single-family dwellings for "subsurface" irrigation. Use rainwater and/or consider establishing gray water infrastructure (for future use if regulatory constraints are lifted) for non-potable water uses such as irrigation, toilets, vehicle washing, sewage transport, HVAC/process makeup water, etc. Technologies could include constructed wetlands, basins, and ponds, cisterns, a mechanical recirculating sand filter; and gray water reclamation and plumbing systems.

Use Biological Waste Treatment Systems

A biological waste treatment system is used to reduce the volume of blackwater entering the municipal system. Alternatives include peat moss drain fields, constructed wetlands, aerobic treatment systems, solar aquatic waste systems (or living machines), composting or ecologically-based toilets, etc.

Reduce Building Water Consumption

Design strategies and systems to reduce building water use to exceed the requirements of the *Energy Policy Act (EPACT) of 1992*. Consider and apply the appropriate strategies below:

- Use infrared faucet sensors and delayed action shut-off or automatic mechanical shut-off valves.
- Use low flow toilets, preferably dual-flush toilets, that have been tested and rated to function reliably. EPACT requirement: 1.6 gallons (6 liters) per flush (GPF).
- Use waterless urinals or 0.5 gallons per flush urinals. EPACT requirement: 1.0 GPF.
- Use lavatory faucets with flow restrictors for a maximum rate of 0.5 gallons per minute (GPM), or use metering faucets at 0.25 gallons per cycle. EPACT requirement: 2.5 GPM.
- Use low-flow kitchen faucets. EPACT requirement: 2.5 GPM.
- Use low-flow showerheads. EPACT requirement: 2.5 GPM.
- Use domestic dishwashers that use 10 gallons per cycle or less. Use commercial dishwashers that use 120 gallons per hour (conveyor type) or one gallon or less per rack (door type).
- Use clothes washers that meet EPA ENERGY STAR® requirements or consider ozone laundry systems for facilities handling large quantities of textiles.

MATERIALS, RESOURCES, AND WASTE

GOALS:

- Reduce consumption and depletion of material resources, especially nonrenewable resources.
- Minimize the life-cycle impact of materials on the environment.
- Enhance indoor environmental quality.
- Minimize waste generated from construction, renovation, and demolition of buildings.
- Minimize waste generated during building occupancy.
- Encourage better management of waste.

STRATEGIES:

Raw Material Extraction

Use Materials with Low Life-Cycle Cost[1]

When available, use a life-cycle methodology (such as *ATHENA™* or *BEES* assessment tools and other resources found in the Appendix) to evaluate materials, focusing on those used in large quantities or with significant negative environmental impact (e.g., steel). Choose those materials with the lowest environmental impact when possible.

Production

In order to conserve embodied energy of materials and reduce the consumption of natural resources, consider and use as much as is appropriate of the following:

- Salvaged materials
- Remanufactured materials, such as engineered wood products[2]
- Recycled-content (post-consumer and/or pre-consumer) products and materials
- Materials with post-consumer recycled content are preferred to those with pre-consumer content
- Reusable, recyclable, and biodegradable materials
- Materials from renewable sources[3] (e.g., wheat, cotton, cork, bamboo, etc.)
- Wood certified by the Forest Stewardship Council

Distribution

Use Locally Manufactured Materials

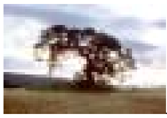
Attempt whenever possible to obtain materials and products from local resources and manufacturers (within Northern California), thereby minimizing energy use and pollution associated with transporting materials from great distances.[4]

[1] "Life-cycle cost" means the amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of the product.

[2] Engineered wood products are manufactured from sawdust and chips, traditional waste products from lumber and plywood manufacturing processes. The main drawback is the use of formaldehyde-based glues, though a few engineered wood products that don't use formaldehyde glues are available.

[3] Renewable resources are those materials that substantially replenish themselves faster than traditional extraction demand.

[4] A tradeoff exists between the resource-conservation benefits of using these products versus the extra energy input to transport these products from distant sources.



Use

Use Durable Materials

Use products or materials (including masonry, steel, glass, and some timber products such as beams, columns, floorboards, etc.) that are durable (with a life cycle of at least 50 years), weather well, and last more than one building lifetime (i.e., through a remodel or reuse in other buildings).

Conserving Resources

Design for Less Material Use

- Reuse existing buildings.
- Employ design strategies to use fewer materials, including reducing the size of the building and spaces; eliminating unnecessary architectural and finish materials; using modular and standard dimensioning; and using strategies that decrease waste during construction.

Design Building for Adaptability

Incorporate interior or exterior design options into the project to facilitate building adaptability. Consider and apply the appropriate strategies below:

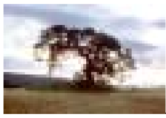
- Consider site planning and building configuration to accommodate future additions and alterations.
- Plan for maximum standardization or repetition of building elements and details to increase the ease of adapting the structure for future alterations or upgrades.
- Design cladding to accommodate future alterations and upgrades such as shading devices, more efficient glazing, and lighting controls.
- Design cladding systems that are fixed by snap release connectors, friction, or other joints that do not require sealants. Use joints and connections that facilitate adaptability, including bolts, screws, and clips.
- Consider spatial configurations, floor deck, structure, mechanical and ceiling options to facilitate adaptability.
- Use a sandwich space between the ceiling to floor level for structure, sprinklers, supply and return ductwork, lighting fixtures, and ceiling system (allowing the space to be more easily altered).
- Use raised floor systems for power and telecommunications wiring to accommodate reconfiguration of spaces and information technology support.
- Use modular space planning, partitions, and furnishings.

Design Building for Disassembly

Incorporate interior or exterior design options into the project to facilitate building disassembly. Consider and apply the appropriate strategies below:

- Use structural systems, cladding systems, and non-load bearing wall systems that facilitate disassembly.
- Use structure/shell systems that maintain integrity when demounted or disassembled (e. g., steel, glass, or concrete and panel claddings).
- Use materials, systems, and components that can be recycled or reused.
- Use materials, systems, and components that can be assembled or fastened in a manner that facilitates reassembly into new construction or remodeling.
- Use snap release connectors, friction, or other joints which do not require sealants. Use joints and connections that facilitate disassembly, including bolts, screws, and clips.
- Use homogeneous materials rather than composite materials (such as reinforced plastics and carpets fibers and backing), as they are generally easier to separate and recycle.[1]

[1] An exception is the use of engineered wood products, which are composites and are environmentally preferable to using virgin lumber.



INDOOR ENVIRONMENTAL QUALITY

GOALS:

- Provide and maintain acceptable indoor air quality, which 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% or more) of the people do not express dissatisfaction."* (ASHRAE 62-1999).
- Monitor and avoid indoor air quality problems during renovation, demolition, and construction activities.
- Provide occupants with operational control of lighting and HVAC systems whenever possible.
- Produce environments that enhance human comfort, well-being, performance, and productivity by reducing sick time.

STRATEGIES:

Indoor Air Quality

Provide a Clean and Healthy Environment

- Comply with Cal/OSHA regulations that pertain to the design, operation, inspection and maintenance of ventilation systems: 8CCR5142 *Mechanically Driven Health, Ventilation and Air Conditioning* (HVAC) *Systems to Provide Minimum Building Ventilation.*

Control Moisture to Prevent Microbial Contamination

- Where moisture precautions are needed, materials should be specified to discourage microbial growth.
- Address moisture control on the site, within the building envelope and inside the building.

Provide Ample Ventilation for Pollutant Control and Thermal Comfort

Attempt to adhere with the latest consensus standards that pertain to ventilation and thermal comfort by using strategies to provide appropriate ventilation and thermal comfort:

- Recommend adhering with the latest consensus standards that pertain to ventilation and thermal comfort:
  ASHRAE Standard 62-1999, Ventilation for Acceptable Indoor Air Quality
  ANSI/AHIA Z9.5-1992, American National Standard for Laboratory Ventilation
  ASHRAE Standard 55-1992, Thermal Environmental Conditions for Human Occupancy
- Comply with Stanford University's Laboratory Design Guide, which addresses ventilation considerations in laboratories: (http://www-facilities.stanford.edu/fdcs/).

Use Low VOC[1]-emitting Materials

Use low or no VOC-emitting materials (including paints, coatings, adhesives, carpet, ceiling tiles, and furniture systems) to help ensure good indoor air quality.

- Comply with Facilities Design and Construction Standards, Section 01310, Part 1.03 and 1.05 (http://www-facilities.stanford.edu/fdcs/), which focuses on the selection and management of new construction materials and renovation activities in order to minimize indoor air quality issues.
- The section instructs contractors to:
  - Ensure that all construction materials, interior finishes and major furnishings installed at Stanford comply with most recent industry standards or regulatory agency Volatile Organic Compound (VOC) emission standards, including specific requirements for carpet systems and paint products.
  - Follow material conditioning procedures.
  - Follow project sequencing procedures (e.g., allow wet products to dry before installing porous products).
  - Reduce dust emissions in occupied buildings through the use of wet methods, etc.

[1] *Pollutants including Volatile Organic Compounds (VOCs), e.g. formaldehyde, are found in many building materials and assembled products.*

- Submit Material Safety Data Sheets (MSDS) for EH&S review and approval prior to construction for projects that require:
  (a) the large scale use of potentially toxic or odor producing products (e.g., roofing material, paint, epoxy), or
  (b) projects conducted in close proximity to sensitive areas.

Human Factors

Provide Appropriate Thermal Conditions
Address environmental and seasonal considerations for dry bulb temperature and radiant temperature profile, relative humidity, and occupants' activities and modes of dress.

Provide Effective Lighting
Illuminance Levels: Use design strategies and features to ensure that the illuminance Levels and Luminance Ratios are appropriate for the users, activities and tasks.
Color Temperature: Use design strategies and features to ensure that color temperature, color rendering, and modeling of light are appropriate for the users, activities and tasks.
Glare: Use design strategies and features (e.g., selection of lighting fixtures, installations, and controls) to avoid glare in ways that support the program, user purposes, and preferences.

Provide Appropriate Building Acoustical and Vibration Conditions
Vibrations: Use design features and strategies to control sources of externally and internally induced vibrations from wind loads, passing traffic, interior foot traffic, building HVAC systems, and interior machinery.
Noise Control: Use design features and strategies to control sources of noise from mechanical and electrical equipment and from sources exterior to the building. Select wall assemblies with appropriate Sound Transmission Class (STC) ratings based on the conditions of the site, building program and activities. Noise elimination, control, or isolation from equipment should be addressed through acoustic zoning, equipment selection, construction, and appropriately designed ducts, piping, and electrical systems.
Soundscapes: Use design features and strategies to create appropriate sound reverberation levels, background sound levels, sound rendition, and speech interference levels.

Provide Views, Viewspace, and Connection to Natural Environment
Exterior and Interior Views: Use design strategies to provide windows, skylights, and/or clerestories for outside view access from all work areas or regularly occupied spaces or to provide contact with patterns and textures of the natural world through interior recreations (e.g., atria, plazas, gardens, courtyards, plantings, and similarly restorative interior design treatments).
Viewspaces: Use design features and strategies to create connected interior and exterior viewspaces which provide the proper combinations of spaciousness, privacy, personal security, visual relief, and visual access to routes and settings within and to the outside of the building.

BUILDING USE TYPES

Although the Technical Guidelines should be considered in the design of all buildings, not all strategies apply to all buildings. Depending on what a building is used for, different constraints exist and some categories of sustainability can be more easily applied to some building types than others. Stanford buildings can generally be divided into seven types: Residential, Offices and Classrooms, Libraries, Wet Labs, Dry Labs, Computer Facilities, and Athletic Facilities. It is important to note, however, that many buildings have mixed uses. For example, the Terman Engineering building houses offices, classrooms, and labs.

Residential Use Buildings

Residential buildings are occupied by students, faculty, postdocs, and staff and are in use 24 hours a day. Residences include undergraduate dorm complexes with a central dining hall (e.g., Wilbur), smaller undergraduate houses, each with their own kitchen (e.g., Row Houses), graduate student apartments with kitchens (e.g., Rains), family apartments (e.g., Escondido Village), and single-family houses. Residences typically have a relatively low electric load density, although electric plug load is growing rapidly as students bring more computer equipment and appliances.

Given that much of Stanford's planned construction is housing for undergraduate and graduate students, there are great opportunities for sustainability in this use type. In general, residences are not air-conditioned and heating is provided by central steam or natural gas. Water usage is one of the largest concerns, though greater sustainability should be a goal in all categories.

Offices and Classrooms

Offices and classrooms are typically scheduled for the normal workday; they are mostly used between 8 a.m. and 5 p.m. on weekdays. These buildings include faculty, graduate student, departmental, and administrative offices, as well as classrooms and auditoriums used for teaching purposes. Out of all the building types on the Stanford campus, offices and classrooms have the greatest seasonality in use; although still used in the summers, their use decreases significantly. They use return air systems and have noncritical cooling and heating loads. They also have normal user electric loads and minimal domestic water use. Buildings with retail space (e.g., Tresidder and the Bookstore) are also grouped into this building type since they follow similar use patterns and requirements.

Many of the offices and classrooms on campus are located in the Main Quad, where the thick sandstone walls aid the thermal performance of the buildings. These older buildings also have historical preservation issues to take into account. Since they are used less in the summer, they may not need as much cooling during these lower-use times.

Libraries

This use type includes both libraries (such as Green Library) and museums (such as the Cantor Center for the Arts). Like offices and classrooms, their use is scheduled and a return air system is used. They generally have low use per square foot for chilled water, steam, and electricity, except when strict temperature and humidity control is specified.

Libraries and museums are subject to specific temperature and moisture controls in order to protect against drastic temperature fluctuations and provide the appropriate conditions to preserve books and art. However, their typical large mass can help with their thermal performance and should be taken into account in design.

Wet Labs

Wet labs are science and engineering labs such as those found in Mudd Chemistry, Gilbert Biological Sciences, or the Allen Center for Integrated Systems (CIS). They have a high density of fume hoods and dense user electric loads and they require large amounts of chilled water and steam. The experiments that take place in these labs often use hazardous, toxic chemicals and other materials. Thus, air is allowed to travel only once through the building to protect the researchers and ensure the health of the building's occupants; the system is characterized as "once-through." Wet labs, especially those with intense washing and sterilization of lab glassware, can have high water consumption as well. Wet labs cannot typically be scheduled and must run around the clock.

Wet labs are by necessity extremely energy- and resource- intensive, which presents a particular sustainability challenge. Once-through cooling with high levels of air changes does not lend itself well to alternative ventilation options. Both the water and the air in the building cannot be reused once they have become contaminated. There are also several heath and safety issues associated with loss of power or supply air.

Dry Labs

Dry labs also are science and engineering labs. They have dense user electric loads and may also have some fume hoods. These buildings may use mixed once-through cooling and return air. The primary difference between wet and dry labs, however, is their steam requirements: large internal loads may reduce steam loads and dry labs typically require large amounts of chilled water. On the other hand, dry labs do not have much domestic water use. Examples of dry labs include the David Packard Electrical Engineering and Durand buildings.

Some or at least parts of these dry lab buildings should be able to be scheduled so that the areas of the building that need to be operated 24 hours a day, seven days a week are separated from the daytime use sections. Health and safety issues may be associated with loss of power and/or supply air.

Computer Facilities

Computer facilities are characterized by high internal loads; high electricity use is required to run the computers and cooling is required to offset the heat load generated by the equipment. Thus, they have large chilled water loads and have reduced steam requirements. A return air system is used. Computer facilities have minimal water consumption. Many of these buildings, such as Sweet Hall, house the network servers for the campus, and thus are required to run continuously.

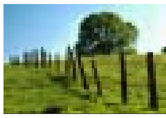
Similar to libraries and museums, computer facilities need temperature control against wide temperature swings to protect the equipment. However, the expectations of the degree of cooling required may at times exceed the actual need, and it may be possible to use economizers to take advantage of cool outside air at night to help cool the building.

Athletic Facilities

Athletic facilities on campus encompass a wide range of facilities, from the football stadium, to the Avery Aquatic Center, to gyms, to the fields for soccer, field hockey, etc. Most are not continually in use throughout the day. They are, however, used year-round: for the varsity teams and other students and members of the community during the school year and for sports camps in the summers. In general, these buildings have high domestic water and heating needs, such as the pools and those buildings with shower facilities.

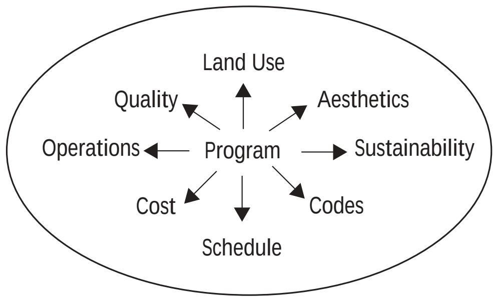
The maintenance of many of these facilities extends beyond the building itself and site needs are often increased. Site irrigation (e.g., watering the athletic fields) and nighttime lighting needs may be greater than other parts of campus. User education may be an important part of sustainability (e.g., covering the pools at night to prevent heat and water loss).

IV. Funding, Decision Tools, and Metrics



FUNDING, DECISION TOOLS, AND METRICS

The Funding, Decision Tools, and Metrics section provides tools and examples for how to make educated decisions about trade-offs among conflicting priorities. At Stanford, sustainability is to be considered at the same level as traditional competing priorities such as cost, quality, and schedule. It does not control any other priorities, and often, sustainability benefits the others. For example, daylighting may contribute to building aesthetics and reduce operations cost. The competing priorities must be equally considered and in balance to support the program within the building, as suggested by the illustration below:

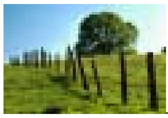


Each of the priorities in the circle should be carefully considered during each process phase.

“GREEN” FUNDING

For sustainable building features that have significant environmental or social benefits but have no clear economic benefit, the project should investigate alternative funding sources. Other benefits, such as public relations and educational value, may also be considered.

A dedicated “green” funding source at Stanford has not yet been identified, but possible sources include gifts, revenue bonds, and tuition. The University is considering establishing a “Green Fund” for the explicit purpose of funding certain sustainable building features when cost considerations otherwise make it prohibitive or difficult to justify.



FUNDING, DECISION TOOLS, AND METRICS *(Continued)*

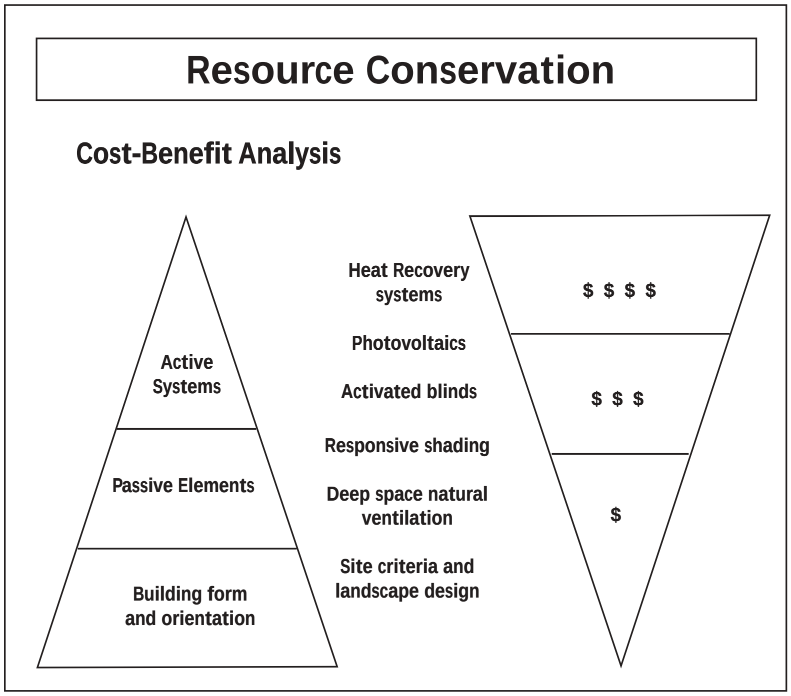
DECISION TOOLS

Tools for Decision Making include economic, social, and environmental decision tools and software-based design tools. When considering the benefits and costs associated with a particular course of action, it is common to focus only on those which are easily quantified and monetized. However, the principles of sustainability require that the full range of costs and benefits be taken into consideration to avoid limiting the choices in the future. The table below provides examples of economic, environmental/ecological, and social/community benefits, both direct and indirect, that might follow from typical building design choices.

Benefit	Examples
Economy	Reduced operating energy expenditures Reduced operations and maintenance costs Improvements in employee performance/productivity Reduced first cost (e.g., optimized wood framing)
Environmental/Ecology	Pollution prevention Preservation of forests Less resource usage Reduced waste in landfill Reduced greenhouse gas emissions
Social/Community	Aesthetics Development of environmentally preferable product markets Behavior modification (cultural change) "Good neighbor" Institutional leadership

Cost-Benefit Analysis

A cost-benefit analysis attempts to articulate and weigh all of the costs associated with a particular action against all of the benefits that will accrue from that action. If the benefits are greater than the costs, then the correct decision is in favor of the action.



Source: Foster and Partners
Redrawn by: University Architect/Planning Office, Stanford University

The diagram above illustrates the importance of incorporating sustainability in the basic design elements, such as building form and orientation. It shows that incorporating sustainable design features early in the design process requires less incremental capital outlay while still yielding a significant environmental benefit.

During the project delivery process, the Project Team should identify sustainable features as low-cost, no-cost, or cost-saving alternatives. Often there is no clear-cut choice for a selection of sustainable features in a building project. Cost-Benefit Analyses are tools that facilitate informed decision-making.

Economic Analysis Decision Tools

Although Stanford University does not have a formal standard for performing economic or financial analyses, there are effective tools to assist in making informed decisions. **Life-Cycle Cost (LCC) Analysis** can be applied to all kinds of investment decisions about equipment, materials, and products. The LCC Analysis sums, for each investment alternative, the costs of acquisition, maintenance, repair, replacement, energy and any other monetary costs that are affected by the investment decision. The time-value of money must be taken into account for all amounts, and the amounts must be considered over the relevant period. All amounts are usually measured in present value. The preferred investment should have the lowest life-cycle cost but not necessarily the lowest first cost. Two methods to perform LCC Analysis are described on the following page:

FUNDING, DECISION TOOLS, AND METRICS *(Continued)*

Internal Rate of Return (IRR) Method

The internal rate of return method solves for the interest rate for which dollar savings are just equal to dollar costs over the relevant period. This interest rate is the rate of return on the investment. It is compared to the investor's minimum acceptable rate of return to determine if the investment is desirable.

Discounted Payback Method

This method measures the elapsed time between the point of an initial investment and the point at which accumulated savings, net of other accumulated costs, are sufficient to offset the initial investment, taking into account the cost of capital. It is used to indicate the amount of time at which the investment breaks even. The discounted payback method is not always the best tool for performing financial analysis. It should be considered a rough guide, or supplementary measure to the other financial analysis tools. It is important to point out that a discount rate should be used to account for the time-value of money rather than simply using X-year costs and benefits.

There are several important considerations to keep in mind when using the financial analysis tools:

- New Stanford buildings are depreciated over 30 years, while renovations are depreciated over 20 years (straight-line depreciation).
- Future costs must be discounted to present value to account for the time-value of money.
- It is important to establish common assumptions and parameters and document their sources. These assumptions include:
    - Utility rates
    - Change-out/replacement periods
    - Discount/inflation rate
    - Expected loads
    - Expected building "life"
    - Maintenance labor rates
    - Identity of final decision maker once analysis is performed

Social and Environmental Analysis Decision Tools

Social and environmental benefits often do not have direct economic benefits and are thus difficult to quantify in dollar terms. Environmental life-cycle assessment software tools and databases can aid with product and material selection decisions. Some examples of these tools are *Building for Environmental Economic Sustainability (BEES)* software and the *ATHENA™ Life-cycle Inventory Product* Databases. These tools can be supplemented with *The Environmental Resource Guide*, *GreenSpec Product Directory* and other resources in the Appendix.

Decision matrices can also be useful in helping to prioritize environmental and social goals and to choose among different options. One way to construct a decision matrix is by taking the following steps:

- Define options (e.g., Site A versus Site B).
- Determine criteria (e.g., distance from stream; area previously disturbed).
- Rank or weight criteria[1] (optional).
- Give each option a relative score for each criteria.
- Multiply score for each option by criteria weighting (optional).
- Sum scores for each option and compare.

[1] For guidance on ranking environmental criteria, see "Establishing Priorities with Green Building" (full reference in the Appendix)

Design Tools

Energy modeling, using software tools such as *DOE-2, eQUEST*, or *ENERGY-10*, is used to simulate the proposed design's response to climate and season. Designers can preview and improve the performance of interdependent features such as orientation, alternative building shell design, and various mechanical systems. Energy modeling quickly evaluates cost-effective design options for the building envelope or mechanical systems by simulating the various alternatives in combination. This process takes guesswork out of sustainable building design and specification and enables an accurate cost-benefit forecasting.

METRICS: PROJECT SUSTAINABILITY PERFORMANCE

Successful implementation of **The Guideline** depends on a number of factors. The establishment and use of performance benchmarks and metrics are two of these important factors. Informed decisions and incremental improvements based on data is essential to gauge the progress being made. During the first year of implementation, a database will be created to measure performance in existing buildings. For example, an indicator of energy use is the annual Btu consumption per square foot; an indicator of water management is the number of gallons of water used per occupant; and an indicator of waste reduction is the percent of materials (by weight) that are reused, recycled, or otherwise diverted from landfill.

Metrics are used to answer the questions, "How are we doing?" and "Are we moving in the right direction?" The University is committed to developing two tools for establishing sustainability metrics. The first tool is the Performance Indicator Database. The Database will be populated with data from Stanford's existing building stock to provide "low," "median," and "high" performance benchmarks for each building use type. This database will be accessible to Project Team members and Stanford staff as an aid in project-specific sustainability goal-setting. It will be updated annually by the Utilities Division and Capital Planning & Management to reflect the contributions of new projects and major renovations.

The second tool is the Project Sustainability Performance Chart. The Chart is intended to visually summarize the Performance Indicators and provide a mechanism for establishing sustainability goals and outcomes for each project. As indicated in the **PDP Manual, Volume II,** the Project Team will establish their building's performance goals and refine them as more details become available. When a project is completed, the performance metrics will be verified and added to the benchmarking database. These charts will thereby serve as tools for implementing sustainability, documenting sustainable features, and (over time) serve as a way to assess progress toward improving the sustainability of Stanford's building stock.

ACKNOWLEDGEMENTS

The Environmental Stewardship Committee consists of:

Chair: Robert C. Reidy, Vice Provost, Land and Buildings
Craig Barney, Environmental Programs Manager, Environmental Health and Safety
Joshua Bushinsky, Earth Systems, Undergraduate Student
Audrey Chang, School of Engineering, Graduate Student
Chris Christofferson, Associate Vice Provost, Facilities Operations
Philippe S. Cohen, Administrative Director, Jasper Ridge Biological Preserve
Lawrence Gibbs, Associate Vice Provost, Environmental Health and Safety
Ted Giesing, Project Engineer, Capital Planning and Management
Scott Gould, Energy Engineer, Facilities Operations
Susan Kulakowski, Campus Energy Manager, Facilities Operations
David J. Neuman, University Architect and Associate Vice Provost, Planning
Boyd Paulson, Professor of Engineering, Construction Engineering and Management, Department of Civil and Environmental Engineering
Ruth Todd, Associate University Architect
Langston Trigg, Associate Vice Provost, Land and Buildings

The Guideline is compiled from and modeled after many existing resources, including the *City of New York High Performance Building Guidelines* and The Project Delivery Process at Stanford. Many concepts of **The Guideline** were presented to the Committee on Land and Buildings of the Stanford University Board of Trustees.

The Guideline is a result of hard work and the advice of each of the Environmental Stewardship Committee members. The lead authors and compilers were Audrey Chang, Ted Giesing, and Susan Kulakowski. Additional contributors include Therese Brekke, Megan Davis, Laura Goldstein, Nash Hurley, David Neuman, Robert Reidy, Kerry Shanahan, and Langston Trigg. Graphic art was provided by Kathy Mize. The illustrations on pages 2 and 30 were developed by David J. Neuman; the illustrations on pages 8-11 were developed by Bob Reidy. The photograph on the front cover was taken by Andy Butcher, Facilities Operations, Grounds Department. The inside front and back cover and the small photographs of the foothills were taken by the Stanford University News Service.

Section III, Technical Guidelines, draws heavily from the *University of Minnesota Sustainable Design Guide,* the City of New York *High Performance Building Guidelines,* and the *LEED™ Green Building Guidelines and Rating System.*

In Section IV, Funding, Decision Tools, and Metrics, the discussion of financial tools is from "Economic Methods," R. Ruegg, National Institute of Standards and Technology, from *CRC Handbook of Energy Efficiency,* Kreith & West, (eds), 1997.

APPENDIX

This section contains resources for further information about sustainable buildings that will be valuable in implementing the strategies in **The Guideline.** This list will continue to be updated and is available at the CP&M web site (http://cpm.stanford.edu). The symbol ❖ indicates the references that are available in the Sustainability Resource Library, which is located on the Stanford Campus at 655 Serra Street, 2nd Floor, Conference Room C.

Technical Resource Library

GENERAL

Architectural Record – Green Architect.
http://www.archrecord.com/GREEN/GREEN.ASP

Ecologic Architecture, R. Crowther. ❖

Environment: Resources, Pollution and Society, W. Murdoch. ❖

Energy, Environment and Building, P. Steadman. ❖

Environmental Stewardship and the Green Campus – The Special Role of Facilities Management, Walter Simpson. State University of New York at Buffalo Green Office, 2001.
http://wings.buffalo.edu/ubgreen

Gentle Architecture, M. Wells. ❖

Green Architect: A Guide to Sustainable Design, M. Crosbie. ❖

The HOK Guidebook to Sustainable Design, S. Mendler and W. Odell.

Living in the Environment: Concepts, Problems, and Alternatives, T. Miller. ❖

Natural Capitalism, P. Hawken, A. Lovins and L. Lovins. ❖

Northern California Resource Directory, Sustainable Design, Building + Development.
http://www.greendesign.net/resdir/nocal/index.htm

Sustainable Design/Green Architecture Information Sources, University of California at Berkeley.
http://www.lib.berkeley.edu/ENVI/GreenAll.html

Sustainable Communities, S. Van der Ryn and R. Calthorn. ❖

Sustainable America: A New Consensus, The President's Council of Sustainable Development. ❖

SITE DESIGN AND PLANNING

Ecological Design and Planning, G. Thompson and F. Steiner, John Wiley & Sons, 1997.

Sustainable Development Plan, October 5, 2000. University of Oregon, 1999-2000 Development, Policy, Implementation and Transportation Subcommittee, University Planning Office.

Toward Sustainable Communities: Resources for Citizens and their Governments, M. Roseland, New Society Publishers, 1998.

ENERGY USE

California Energy Commission.
http://www.energy.ca.gov/index.html

Daylighting for Sustainable Design, M. Guzokski, McGraw-Hill Publications, 2000.

Energy Efficiency and Renewable Energy (EREN) - Solar Energy Topics.
http://www.eren.doe.gov/RE/solar.html

Energy Use, American Solar Energy Society (ASES).
http://www.ases.org/index.html

Passive Solar Commercial and Institutional Buildings: A Sourcebook of Examples and Design Insights, International Energy Agency; principal editor, S. R. Hastings. Chichester, New York: J. Wiley, c1994.

Passive Solar Design Strategies: Guidelines for Home Building, San Francisco, California, Passive Solar Industries Council, National Renewable Energy Laboratory, Charles Eley Associates: 1990 to 1998.

The Passive Solar House, James Kachadorian. White River Junction, Vt.: Chelsea Green Pub. Co., c1997.

Photovoltaics and Architecture, edited by Randall Thomas. London; New York: Spon Press, 2001.

Photovoltaics in Buildings: A Design Handbook for Architects and Engineers, principal editors, Friedrich Sick and Thomas Erge. London: James & James, Science Publishers Ltd., c1996.

Photovoltaics in the Built Environment: A Design Guide for Architects and Engineers. Washington, D.C.: U.S. Dept. of Energy, 1997.

Practical Photovoltaics: Electricity from Solar Cells, Richard J. Komp; introduction by John Perlin. 3rd ed. Ann Arbor, Mich.: Aatec Publications, 1995.

Residential Manual for Compliance with the 1998 Energy Efficiency Standards (for low-rise residential buildings), Sacramento, Calif.: California Energy Commission, 1999.

WATER MANAGEMENT

Builder's Greywater Guide: Installation of Greywater Systems in New Construction and Remodeling, A. Ludwig, Oasis Design, 1997.

MATERIALS, RESOURCES, AND WASTE

Architectural Resource Guide, David Kibbey.

Bay Area Green Pages: The Local Handbook for Planet Maintenance, Green Media Group. 1st ed. Berkeley, CA: Green Media Group, 1990.

Building materials for the Environmentally Hypersensitive. Rev. ed. Ottawa: Canadian Mortgage and Housing Corporation, c1997.

California Materials Exchange – a free service designed to help businesses find markets for materials they may have traditionally discarded.
http://www.ciwmb.ca.gov/calmax/

Certified Forest Products Council.
http://www.certifiedwood.org/

Construction Site Recycling & Reuse Guide, A Directory of Construction & Demolition Material Recycling Locations in San Mateo Area. ❖
http://recycleworks.org/cgi-bin/bin/user/guide.pl?id_guide=4

EcoDesign Building Products.
http://www.ecodesign.bc.ca/products.htm

Forest World – This includes links to sustainable forest marketplace and woods of the world database.
http://www.forestworld.com/

Green Building Materials Resource Guide, Alameda Country Waste Management Authority.
http://www.stopwaste.org/Resource_Guide.pdf

GreenSpec: The Environmental Building News Product Directory
Sortable by products, manufacturers, CSI category.
http://www.greenspec.com/

Matrix of recycled content levels and product availability.
http://www.ciwmb.ca.gov/GreenBuilding/Materials/Matrix.htm

Recycled Content Products Database.
http://www.ciwmb.ca.gov/rcp/
Searchable by CSI.

Recycled content products manufacturers database - Updated annually.
http://www.ciwmb.ca.gov/ConDemo/Products/default.asp

The Sourcebook for Sustainable Design: A Guide to Environmentally Responsible Building Materials and Processes, Andrew St. John, editor. Boston, MA: Architects for Social Responsibility, c1992.

Woods of the World. WOW.Version 2.5 Burlington, VT: Tree Talk, Inc., c1994-1997 - Database for woodworkers, wood researchers, and wood users. It includes detailed information on wood species and products.

INDOOR ENVIRONMENTAL QUALITY

EPA Indoor Air Quality (IAQ).
http://www.greendesign.net/gbrc/index.html

Eco-Interiors: A Guide to Environmentally Conscious Interior Design, Grazyna Pilatowicz. New York: John Wiley & Sons, 1995.

The Healthy School Handbook: Conquering the Sick Building Syndrome and other Environmental Hazards in and around your School, N. Miller, National Education Association, 1995.

Indoor Air Quality and HVAC Systems, D. Bearg, Lewis Publishers, 1993.

Natural Ventilation in Buildings: A Design Handbook, F. Allard, James & James, Science Publishers Ltd., 1998.

Sun, Wind, and Light: Architectural Design Strategies, G. Brown and M. DeKay, John Wiley & Sons, 2000.

SPECIFICATIONS

Alameda County, Resourceful Purchasing Manual.
http://www.stopwaste.org/fsfreeindex.html

Architectural Record —Green Product Guide.
http://www.archrecord.com/GREEN/GREEN.ASP

Environmentally Responsive Specifying, It's Not Easy Building Green Workshop, Henry Berg. PG&E Center, San Francisco, May 3, 2000.

Environmental Assessment and Specification of Green Building Materials, The Construction Specifier, Lynn M. Froeschle, October 1999, p. 53.

Green Building Advisor – software application containing environmental strategies, case studies, references and green product information. Order through Building Green, Inc. (800) 861-0954. ❖

Green Building Materials: A Guide to Product Selection and Specification, Ross Spiegel and Dru Meadows. John Wiley & Sons, Inc., New York, 1999.

Green Building Resource Guide, John Hermannson.
www.greenguide.com

GreenSpec: The Environmental Building News Product Directory
Sortable by products, manufacturers, CSI category. ❖
http://www.greenspec.com/

GreenSpec binder: EBN product directory with manufacturer's literature. Brattleboro, VT: Ebuild, Inc. c1999. ❖

Material ConneXionSM - Specifications and manufacturers for innovative materials and processes.
http://www.materialconnexion.com/PA1.asp

Oikos Green Product Gallery - a product index searchable by category and name.
http://oikos.com/products/

Resourceful Specifications.
http://www.stopwaste.org

Wastespec.
http://www.tjcog.dst.nc.us/cdwaste.htm#wastespec

GREEN GUIDELINES

Blueprint for a Green Campus - An Environmental Action Plan for the University of Colorado at Boulder. ❖

CSU Architectural and Engineering Guidelines, California State University Chancellor's Office.
http://www.calstate.edu/CPDC/AE/Standards/Energy.pdf

Green Building Design & Construction Guidelines, City of Santa Monica, April 1999. ❖

Guidelines for Creating High Performance Green Buildings, Commonwealth of Pennsylvania.
http://www.gggc.state.pa.us/publictn/gbguides.html

High Performance Building Guidelines , New York, April 1999. ❖

Minnesota Sustainable Design Guide ,1999-2001. ❖
http://www.sustainabledesignguide.umn.edu/

North Carolina Triangle Council of Governments, High Performance Building Guidelines, Version 2.0, September 2001.
http://www.tjcog.dst.nc.us/hpgtrpf.htm

Think Green, A UB Guide To Campus Ecology, State University of New York at Buffalo, 1999.
http://wings.buffalo.edu/ubgreen

University of Oregon, Sustainable Development Guidelines, October 2000, effective February 2001.
http://www.uoregon.edu/~uplan/SDPFull.pdf

University of Minnesota, Oakland Sustainable Design Guide. ❖
http://www.buildingresearch.umn.edu/develop/oakland/

EDUCATION

Educating Architects for a Sustainable Environment (EASE). This site features more than 140 recommendations, 50 implementation strategies, and 5 model curricula for sustainably oriented approaches to architectural education.
http://www.bsu.edu/cap/ease/

"Environmental Building News," The Leading Newsletter on Environmentally Responsible Design & Construction. ❖
http://www.buildinggreen.com/menus/ebn.html ❖

The Wallace Stegner Environmental Center is located in the northwest corner of the 5th floor of San Francisco's Main Library. The Center is dedicated to chronicling environmental history as well as providing access to the most current information and materials on environmental issues. Phone: 415-557-4595.

RATING SYSTEMS

Building Research Establishment Environmental Assessment Method (BREEAM) - BREEAM is a widely used international method of assessing building quality and performance in terms of energy efficiency, environmental impact, health and operation and management.
http://www.breeamcanada.ca/

U. S. Green Building Council's Leadership in Energy and Environmental Design (LEED) - The LEED Green Building Rating System is a voluntary, consensus-based, market-driven building rating system based on existing proven technology. It evaluates environmental performance from a "whole building" perspective over a building's life cycle. ❖
http://www.usgbc.org/programs/index.htm

DECISION MAKING TOOLS

ATHENA™ Model - "Cradle to grave" environmental life-cycle assessment of building products.
http://www.athenasmi.ca/ath_model/model_main.htm

BEES (Building for Environmental and Economic Sustainability) - Software for environmental life-cycle assessment of building products.
http://www.bfrl.nist.gov/oae/software/bees.html

"Establishing Priorities with Green Buildings," from *Environmental Building News.*
http://ww.buildinggreen.com/features/4-5/priorities.html

International Performance Measurement & Verification Protocol - Concepts and Options for Determining Energy and Water Savings, Volume 1, January 2001.
www.ipmvp.org

Life-Cycle Costing Manual for the Federal Energy Management Program, US Department of Commerce, Sieglinde K. Fuller and Stephen R. Petersen. Technology Administration, National Institute of Standards and Technology, 1995.