# Building for Sustainability

## Introduction

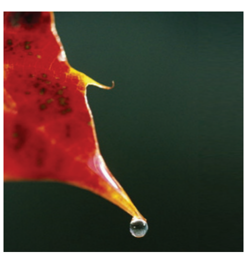
### Commitment to Sustainability

In their *Facilities Master Plan 2000*, The David and Lucile Packard Foundation includes the following design and construction goals for their facilities: (1) push the envelope of sustainability and be an example of what is reasonably possible to achieve; (2) strike a balance among sustainability and practical costs, so that others see them as replicable, not as demonstration projects; (3) use the U.S. Green Building Council's LEED™ Rating System as a guideline for addressing all aspects of sustainability and strive to achieve the maximum rating; (4) help develop the green building market through use and promotion of green building materials and practices with the ultimate goal of expanding vendor capacity

In the spring of 2001, the Foundation's design team was challenged to illustrate the potential impacts of these goals on a new 90,000 square foot office building in Los Altos, California. The results of this research effort are outlined in the Packard Foundation's *Sustainability Report and Matrix*, and in an effort to disseminate knowledge gained during this exercise, the Foundation has made the documents contained in this packet available to the public. They include general background information on the history of sustainable design, relevant resource material and specific information regarding the Foundation's Los Altos Project as summarized in the *Sustainability Matrix*.

### General Information

- Sustainability Summary - a brief overview of sustainability and its role in the history of the design and construction industry
- Reading List - a short list of publications related to sustainable design
- Organizations - an abbreviated list of organizations in the United States that focus their efforts on the environment and humankind's impact on it
- Websites - an abbreviated list of helpful websites for those interested in pursuing sustainable design issues
- California Building List - a partial list of buildings in California that employ some level of sustainable design strategies
- Sustainability Timeline - an abbreviated history of sustainability since 1960 highlighting organizations, environmental events, political events, technologies, publications and buildings that have influenced or have the potential to influence the natural and built environments



### Sustainability Report and Matrix Reference Material

- Sustainability Matrix - a summary of the *Sustainability Report*, created by the Packard Foundation's design team to help understand implications of sustainability on a building's form; short and long term costs; design and construction schedules; energy consumption, pollution generation and external costs to society

# Building for Sustainability

- Guide to Understanding the Sustainability Matrix - a brief outline of the *Sustainability Matrix* organized by categories of information in the matrix and how they were derived
- Definition of Terms for the Sustainability Matrix - a partial list of terminology used in the *Sustainability Matrix*
- Scenario Summaries - brief descriptions of the conceptual building designs of each scenario depicting various levels of sustainable design
- Building and Site Attributes Based on the LEED™ Rating System - a listing of LEED™ points achieved in each of the five LEED™ categories (Site, Water, Energy, Materials and Indoor Environmental Quality) for each of the six building scenarios
- Building Components and Energy Model Performance Criteria - a summary spreadsheet of building and site criteria used for each level of sustainability
- Net Present Value Calculations - basic information regarding formulas used in deriving the net present values indicated on the Sustainability Matrix for the three cost models (30-, 60- and 100-year)

## Contributors

### Packard Foundation Facilities Steering Committee

Ed Diener, Nancy Glaze, Don Lauro, John Pihl, Don Silva, Mark Valentine, John Walker and Marie Young

### BNIM Architects

Bob Berkebile, Shawn Gehle, Laura Lesniewski, Steve McDowell, Jason McLennan, Monica Rodriguez, Craig Scranton, Phaedra Svec and Audrey Voorhies

### Hawley Peterson Snyder Architects

Gary Crosman, Cathy Huyghe and Curtis Snyder

### Keen Engineering

Jim Burns, Tony Grice, Mark Heilman, Kevin Hydes, Blair McCarry and Jennifer Sanguinetti

### Oppenheim Lewis

Scott Lewis

### Holland Design Associates

Patricia Holland

### Peer Reviewers

William D. Browning, *Rocky Mountain Institute*; M. Adele DiMarco, *Dewees Island Real Estate, Inc.*; David Gottfried, *Gottfried Technology*; John L. Knott, Jr., *Dewees Island Real Estate, Inc.*; Vivian Loftness, FAIA, *Carnegie Mellon University*; Amory B. Lovins, *Rocky Mountain Institute*; Peter Nosler, *DPR Construction, Inc.*; Rob Pena, *Van der Ryn Architects*; Peter Rumsey, P.E., *Rumsey Engineers, Inc.*; Lynn N. Simon, AIA, *Simon & Associates*; Andrea Taber, *Van der Ryn Architects*; Ted van der Linden, *DPR Construction, Inc.*; Sim Van der Ryn, *Van der Ryn Architects*; Alex Wilson, *Building Green, Inc.*

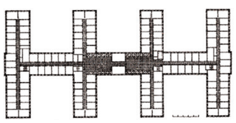
### Photo Credits

BNIM Architects - Page 3 (*middle bottom*), Page 4 (*bottom*), Page 13 (*top*); Timeline (*Pueblo, C.K. Choi, Montana State University*); Matrix (*Living Building, LEED™ Platinum, LEED™ Gold, LEED™ Certified*); Rosemary Calvert/Getty Images - Page 1 (*bottom*); Digital Images/Getty Images - Timeline (*Earth Day*); Environmental Protection Agency - Timeline (*EPA, Energy Crisis, Endangered Species Act, Three Mile Island*); Greenpeace/Sims - Timeline (*Brent Spar*); Keen Engineering - Matrix (*LEED™ Silver, Market*); Cathy Kelly (courtesy of Van der Ryn Architects) - Page 4 (*top*); Ray Massey/Getty Images - Page 2 (*top*); National Oceanic and Atmospheric Administration - Timeline (*Amoco Cadiz, Exxon Valdez (2), Oil Fires*); Pamphlet Architecture - Page 3 (*middle top*); David Patterson/Getty Images - Page 2 (*bottom*); Rocky Mountain Institute - Timeline (*Village Homes, RMI*); The David and Lucile Packard Foundation - Page 4 (*middle top*), Timeline (*Philip Merrill Environmental Center, Adam Joseph Lewis Center*); Unknown - Page 3 (*bottom*), Timeline (*PV models*); U.S. Green Building Council - Page 4 (*middle bottom*); Van der Ryn Architects - Timeline (*Bateson Building*); Joost van Santen - Timeline (*ING Bank*); Vinita Area Chamber of Commerce - Page 3 (*top*); Allen Bruce Zee - Page 1 (*top*)

# Building for Sustainability

## Sustainability Summary

Teepee design provides for natural ventilation

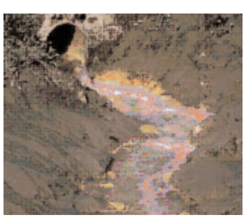


General Motors Building, Detroit, 1921, Albert Kahn Inc. Architects

When people first built structures, they designed them in a way that responded to climate, culture and place. Structures were built with local materials and relied on natural principles to provide light, heat and comfort. Structures throughout Western Civilization were built to demonstrate the cultural and political significance of a place. Because structures were intended to last for generations, they were carefully crafted to endure and remain beautiful for hundreds of years. With the Industrial Revolution came the ability for machines to mass-produce building materials with interchangeable parts more quickly and inexpensively than skilled laborers of the past. As building technology developed, people learned how to build with manufactured materials transported from greater distances to the building site. Basic design principles such as narrow building profiles and operable windows were still incorporated to provide natural ventilation and access to daylight, but it became easier to rely on mechanical building systems rather than nature to provide comfort, regardless of how hot or cold or dark it was outside.

Downtown Anchorage, Alaska

As technology continued to flourish, it became possible to build the same type of building anywhere, regardless of climate, culture and place. Building materials could be shipped from anywhere in the world. Building codes were written to require buildings to be reliant on mechanical systems to provide uniform comfort standards in any climate. Manufacturers began to warrantee only the products that were subjected to uniform temperature and humidity conditions all year round. The building industry moved away from design that was specific to place and toward uniform standards for all situations. The problem was that, in doing so, people began to exact a high price on the environment. Today, the Union of Concerned Scientists warns that "every living system on the planet is in decline and that the rate of decline is increasing." Notable problems include: global warming; ozone depletion; acid rain; soil, water and air pollution; and loss of biodiversity, soil, and ground water resources.



Soil erosion and water pollution

The building industry plays a significant role in these issues. Today, buildings in the U.S. consume 30 percent of the world's total energy and 60 percent of the world's electricity. Energy consumption by buildings results in pollution, ozone depletion and global warming, which in turn cause health problems for every living species. The natural resources used to make buildings are typically non-renewable, such as plastic or steel, or harvested more quickly than they can be replenished, as in the forestry practices of North America. Buildings also consume 5 billion gallons of potable water per day to flush toilets, which is gradually depleting our fresh water supplies. A typical North American commercial construction project generates 2.5 pounds of solid waste per square foot of floor space. During the process of construction, land and habitat are disturbed while water and topsoil are washed into storm sewers. Beginning in the 1970's, a growing number of people had realized that standard design and construction prac-

# Building for Sustainability

Farallones Institute, Occidental, California, 1975

Chesapeake Bay Foundation, Annapolis, Maryland, 2000, Smith Group

LEED™ - Leadership in Energy and Environmental Design

Sketch of The David and Lucile Packard Foundation, Los Altos, California

tices had veered too far away from earlier reliance on natural principles. The "Green Building" movement began as a reaction to oil shortages and the political and environmental events of the time. The early part of the movement, therefore, focused primarily on energy conservation. As the movement continued into the 1990's people began to focus on a wider range of issues including: livable communities; sustainable sites; water quality and conservation; materials and resource use; and indoor air quality.

Today, people refer to this movement as "sustainable design" or "green architecture." Sustainable design is an approach to design that can be incorporated into any building project regardless of type or size. It returns to the idea of designing for place, culture, and climate while embracing new and/or appropriate technologies to deliver increased comfort while reducing or eliminating negative environmental impacts. In 1993, the U.S. Green Building Council (USGBC) was created to help define and promote sustainable building practices. It created a tool called LEED™ (Leadership in Energy and Environmental Design), which recognizes buildings that incorporate sustainable design strategies. The popularity of LEED™ in the U.S. and Canada suggests a strong potential for a significant transformation of the design and construction industry.

The David and Lucile Packard Foundation has adopted LEED™ as a tool for defining and understanding sustainability for its building projects. The Foundation has already incorporated sustainable design strategies into its existing workplace and seeks to push sustainable design forward by creating a model that is replicable in the design and construction industry.

The history of sustainable design does not end here. It will continue for as long as buildings are built. The ideas shown here raise awareness of the strategies that can make sustainable design possible and feasible for any construction project. As the population of the planet grows to seven billion people, the pressure on an already strained ecosystem and social health will only increase. What must communities and buildings look like to allow for this growth? What responsible choices need to be made today to ensure economic, social and environmental prosperity for this and future generations? Imagine a future where protection of the natural environment and enhancement of the built environment are not at odds, but part of a strong alignment of common goals. This is the hope of a truly sustainable future.

# Building for Sustainability

## Reading List

### Green Design Resources

*Cold Climates*
Joseph Lstiburek, The Taunton Press 2000

*Climatic Building Design: Energy Efficient Building Principles and Practices*
Donald Watson and Kenneth Labs, McGraw Hill 1993

*Deep Design: Pathways To A Livable Future*
David Wann, Island Press 1996

*Design With Nature*
Ian L. McHarg, John Wiley & Sons 1995

*Environmental Building News Magazine*
Building Green, Inc.

*Green Development: Integrating Ecology and Real Estate*
Rocky Mountain Institute, John Wiley & Sons, Inc. 1998

*Green Development CD ROM Green Spec Environmental Building News*
Brattleboro, Vermont: EBuild Inc. 1999

*Greening the Building and the Bottom Line: Increasing Productivity Through Energy-Efficient Design*
William D. Browning and Joseph J. Romm, Rocky Mountain Institute 1994

*The HOK Guidebook To Sustainable Design*
Sandra F. Mendler and William Odell, New York City: John Wiley & Sons, Inc. 2000

*LEED Reference Guide & Technical Manual*
US Green Building Council 2000

*Mixed Climates*
Joseph Lstiburek, The Taunton Press 2000

*A Pattern Language: Towns, Buildings, Construction*
Christopher Alexander, Oxford University Press 1977

*Photovoltaics in the Built Environment*
Solar Design Associates et al, US DOE 1997

*Sun Wind & Light*
G.Z. Brown and Mark DeKay, New York City: John Wiley & Sons, Inc. 2001

*Sustainable Building Technical Manual*
Public Technology, Inc

*A Primer on Sustainable Building*
Dianna Lopez Barnett and Bill Browning, Rocky Mountain Institute 1998

*Tips For Daylighting*
Lawrence Berkeley National Laboratory

### The Environment and the State of the World

*The Sacred Balance: Rediscovering Our Place in Nature*
David Suzuki, Amherst, New York: Prometheus Books 1998

*State of the World 1999-2001*
Lester Brown, Christopher Flavin, Hilary French et al. New York: W.W. Norton World Watch Institute 2001

*Stuff: The Secret Lives of Everyday Things*
John C. Ryan and Alan Thein Durning, Northwest Environment Watch 1997

*Vital Signs*
Lester Brown et al, World Watch Institute, New York: W.W. Norton 1999

# Building for Sustainability

## Designing a New Future

*Biomimicry, Innovation Inspired by Nature*
Janine M. Benyus, New York: William Morrow and Co. 1997

*Cool Companies: How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions*
Joseph J. Romm, Washington, D.C.: Island Press 1999

*Ecological Design*
Sim Van Der Ryn and Stuart Cohen, Washington D.C: Island Press 1996

*Factor Four: Doubling Wealth, Halving Resource Use*
Ernst Von Weizsacker, Amory Lovins, and L. Hunter Lovins, London: Earthscan Publications Ltd 1997

*The Green Imperative: Natural Design for the Real World*
Victor Papanek, Thames and Hudson 1995

*Natural Capitalism: Creating the Next Industrial Revolution*
Paul Hawken, Amory Lovins, and L. Hunter Lovins, Boston: Little, Brown and Company 1999

*The Sand Dollar and the Slide Rule - Drawing Blueprints from Nature*
Delta Willis, Reading, Massachusetts: Addison-Wesley Publishing Company, Inc.1997

*Sustainable Architecture: White Papers*
Earth Pledge Foundation Series on Sustainable Development
Quebecor Printing, Inc., 2000

## Economy, Trade and the Environment

*Biopiracy: The Plunder of Nature and Knowledge*
Vandana Shiva, South End Press 1997

*The Cult of Impotence: Selling the Myth of Powerlessness in the Global Economy* (out of print)
Linda McQuaig

*Downsize This!*
Michael Moore, HarperCollins 1997

*The Ecology of Commerce: A Declaration of Sustainability*
Paul Hawken, New York: HarperCollins 1994

*Home Economics: Fourteen Essays*
Wendell Berry, North Point Press 1987

*Small is Beautiful: Economics As If People Mattered: 25 Years Later…With Commentaries*
E.F. Schumacher, Hartley & Marks 1999

# Building for Sustainability

## Organizations

| | | | |
|---|---|---|---|
| **Earth Pledge Foundation** | 149 East 38th Street<br>New York, NY 10016 | Tel:<br>Fax: | 212.573.6968<br>212.808.9051 |
| **Environmental Protection Agency** | Region 9 (for California)<br>75 Hawthorne Street<br>San Francisco, CA 94105 | Tel: | 866.372.9378 |
| **Forest Stewardship Council** | 1155 30th Street NW<br>Suite 300<br>Washington, DC 20007 | Tel:<br>Fax: | 877.372.5646<br>202.342.6589 |
| **Sierra Club** | 85 Second St., Second Floor<br>San Francisco, CA 94105-3441 | Tel: | 415.977.5500 |
| **US Green Building Council** | 1015 18th Street, NW<br>Suite 805<br>Washington, DC 20036 | Tel:<br>Fax: | 202.828.7422<br>202.828.5110 |
| **US Soil and Water Conservation Society** | 7515 North East Ankeny Road<br>Ankeny, IA 50021 | Tel:<br>Fax: | 515.289.2331<br>515.289.1227 |
| **US American Society for Testing and Materials** | 1916 Race Street<br>Philadelphia, PA 19103-1187 | Tel:<br>Fax: | 212.299.5400<br>212.977.9679 |
| **World Watch Institute** | 1776 Massachusetts Ave., N.W.<br>Washington, DC 20036-1904 | Tel: | 202.452.1999 |

# Building for Sustainability

## Websites

**www.designinsite.dk**

**Design inSite**
The purpose of Design inSite is to inspire designers to consider materials and processes that are new or unknown to them. This site has information about ceramics, composites and smart materials.

**www.ecotecture.com**

**Ecotecture**
Ecotecture is an online journal of ecological design, based in the Bay Area.

**sustainable.state.fl.us/fdi/edesign**

**eDesign Online**
This is an online journal of the Florida Design Initiative. The mission of the Florida Design Initiative is to reorient the building industry toward a new standard of practice, including the design and construction of high-performance, energy-efficient buildings.

**www.buildinggreen.com**

**Environmental Building News**
Environmental Building News is the leading newsletter on environmentally-responsible design and construction (published ten times per year). EBN contains in-depth reviews and comparisons on building materials as well as articles on energy efficiency, water conservation, indoor air quality and waste reduction.

**www.fscus.org**

**Forest Stewardship Council United States**
The Forest Stewardship Council (FSC) is an independent, non-profit, non-governmental organization. It was founded in 1993 by a diverse group of representatives from environmental and conservation groups, the timber industry, the forestry profession, indigenous peoples' organizations, community forestry groups and forest product certification organizations from 25 countries.

**www.greenmap.com**

**Green Map System**
In 91 cities across the world, a Green Map system has been produced by local communities. Using a standard set of icons these maps give an impression of the urban ecology of a city or region.

**www.greendesign.net**

**Green Design Network**
The website of the Green Design Network with "Green Clips", their news digest, as well as thorough case studies and selected papers on green design.

# Building for Sustainability

**www.usgbc.org/LEED/LEED_main.asp**

**LEED™**
The Leadership in Energy and Environmental Design (LEED™) Building Rating system is a voluntary standard for defining what constitutes a "green" building. This system was created by the US Green Building Council, a non-profit consensus organization representing the building industry. The Council promotes the understanding, development, and implementation of "green" building policies, programs, technologies, standards and design practices on a national level.

**www.o2.org**

**International Network for Sustainable Design**
This is a website of an international network of designers, with some material specifically related to architecture, including excellent interviews with green designers.

**www.oikos.com**

**Oikos**
Extensive website featuring the REDI building materials database, archives from the no longer published Energy Source Builder newsletter, and the Iris Catalog, with online ordering of many green building resources.

**www.greenbuilder.com**

**Sustainable Building Sources**
Based in Austin, Texas, this site offers a wealth of resources related to green building, including a calendar of events, listings of green building professionals and the complete Sustainable Building Sourcebook, the primary reference for the City of Austin's Green Builder Program.

**www.archleague.org/exhibitions/10shades/10shades.html**

**Ten Shades of Green**
An exhibition on architectural excellence and environmental responsibility organized by the Architectural League of New York. This web site gives ten case studies of green buildings built around the world.

**www.lib.berkeley.edu/ENVI**

**UC Berkeley Environmental Design Library - Green Design, Sustainable Architecture: Information Services**
Extensive list of green design and sustainable architecture sources from the University of California Berkeley Environmental Design Library.

**www.usgbc.org**

**United States 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.

Building for Sustainability

## California Building List

| Project | Project Type | Location | Sq. Ft. | Sustainable Strategies |
|---|---|---|---|---|
| 1074 Folsom Street | Gallery & Offices | San Francisco | - | Daylighting, photovoltaics provide more than enough energy for the entire building. |
| Bateson Building | Government Offices | Sacramento | 250,000 | Daylighting, passive solar storage, night air cooling system. |
| Cal/ EPA Headquarters Building | State Office Buildings | Sacramento | 950,000 | Daylighting, low-e exterior glass, energy-efficient lighting, future fuel cell installation, low flow toilets, zero VOC paints throughout interior, resource efficient materials throughout, vermiculture bins. LEED™ Certified (Version 1.0) |
| Camp Arroyo Environmental Technology Center | Education Facility | Livermore | 20,000 | Straw bale construction, stabilized earth, water conservation, on-site alternative wastewater treatment. |
| Capitol Area East End Project | State Office Buildings | Sacramento | - | Daylighting, improved building ventilation, recycled-content products with low to zero VOC's, water-efficient irrigation; forecast to save taxpayers $400,000 annually in energy savings. |
| DeAnza College Environmental Studies Building | Educational Facility | Cupertino | 34,200 | Recycled steel framing and masonry, east-west orientation for passive solar benefits, roof top photovoltaics, thermal mass in concrete floors, rainwater collection for irrigation, nontoxic components in flooring and paints. |
| Donald Bren School of Environmental Science & Management | Education Facility | Santa Barbara | 84,672 | Natural ventilation linked with a window interlock system for heating and daylighting controls, energy-efficient lighting, high efficiency boiler, reclaimed water in the toilets and irrigation, recycled-content materials and certified sustainable harvested wood paneling. LEED™ Platinum (Version 1.0) |
| Energy Resource Center | Education Facility | Downey | 45,000 | 80% of construction materials, interior furnishings, and displays were recycled or the products of recycled materials or manufacturing processes using renewable resources. |
| Environmental Technology Center | Education Facility | Rohnert Park | 2,200 | Energy and water-efficient landscaping, passive solar heating and cooling. |
| Farallones Integral Urban House | Teaching & Research | Berkeley | - | Organic gardens, solar dwelling, waste recycling, water conservation, renewable energy. |
| Golden Gate Park Pavilion | Public Facility | San Francisco | 2,000 | Living roof system, high efficiency hydronic radiant heating in floor, low-VOC paint, recycled and renewable materials specified, and native California landscape |

# Building for Sustainability

| Project | Project Type | Location | Sq. Ft. | Sustainable Strategies |
|---|---|---|---|---|
| Hidden Villa | Wolken Education Center | Los Altos Hills | 3,300 | Trombe wall, daylighting, solar efficient orientation, natural ventilation, photovoltaic roof directly connected to the power grid. |
| John T. Lyle Center for Regenerative Studies | Educational/ Laboratory | Pomona | - | Wind energy and photovoltaics are used; up to 20 residents live on-site; community recycles 75% of inorganic and 100% of organic material generated at the Center. |
| Lakeview Terrace Branch Library | Public Facility | Los Angeles | 10,700 | Cooling tower system to cool interior space, extended canopy for additional shading, photovoltaic cells for power regeneration. |
| Lockheed Building 157 | Commercial Offices | Sunnyvale | - | Energy savings of $500,000 annually due to improvements in lighting and daylighting. |
| Monterey Regional Waste Management District Administration Building | Public Facility | Marina | 8,050 | Expanded and remodeled using a green building approach, construction materials made from reused or recycled items were selected wherever possible, wood used is from fast growing trees rather than old growth trees. |
| Ocean Beach People's Organic Food Co-op | Public Facility | Ocean Beach | 12,900 | Photovoltaic cells to provide 50% of building's power needs, non-toxic recycled, reused, and sustainable harvested building materials, passive heating/cooling. |
| Ojai Foundation School | Education Facility | Ojai | 12,500 | Rammed earth, rainwater collection, greywater recycling, cross ventilation. |
| Real Goods Solar Living | Commercial Project | Hopland | 5,000 | Straw bale construction with passive solar heating, photovoltaic and wind electricity generation, greywater irrigation. |
| Ridgehaven | Commercial Office Building & Renovation | San Diego | 73,020 | 40 tons of construction waste was recycled, improved indoor air quality and lighting, durable environmental materials with minimal chemical emissions and recycled content. The building currently saves $70,000 in annual utility costs. |
| Romberg Tiburon Center | Office and Laboratory | San Francisco | 27,000 | Passive solar design, operable windows, non-toxic materials, operable windows. |
| The William and Flora Hewlett Foundation Headquarters Building | Office Building | Menlo Park | 48,000 | Native landscaping, 60% of site preserved for open space, stormwater control system, energy performance optimized to exceed Title 24 by a projected 35%; 69% of construction waste diverted from land fill; 64% recycled content products; 83% of all wood-based products are certified; achieved all 15 LEED™ points for indoor environmental quality, first LEED™ v2.0 Gold certification in California. |

# Building for Sustainability

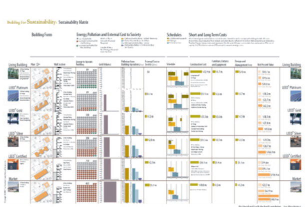
Sketch of downtown Los Altos, California

## Guide to Understanding the Sustainability Matrix

### Introduction

As an initial step in the David and Lucile Packard Foundation's Los Altos Project, a Goalsetting Charrette was held in late February 2001. The design team was charged by the Foundation's Facilities Steering Committee to develop a decision-making method or tool that would clearly explain the aesthetic, economic, schedule and environmental impacts implied by the sustainability goals for their proposed office building. In their *Facilities Master Plan 2000*, the Foundation had already decided to use the U.S. Green Building Council's LEED™ rating system as the measuring device for its sustainability goals. In collaboration with the Committee, the design team responded in the form of a report and summary matrix. The *Sustainability Report and Matrix* hold the Market building scenario and the Living Building scenario at opposite ends of a spectrum with the four LEED™ levels spread between them.

A conceptual building model for each scenario was designed and described by the team in the form of building footprints, wall sections and outline specifications. Construction costs were estimated based on these assumptions, as were impacts to research, design and construction schedules. This base information, as well as other design assumptions, is documented in the *Sustainability Report*. From the data in the *Report*, it was possible to estimate amounts of energy required to run the facility under each scenario, as well as consider how much energy could be generated on-site by the systems and technologies incorporated at each level. Based on information from Jonathon Levy's Harvard dissertation in May 1999, "Environmental Health Effects of Energy Use: A Damage Function Approach", projections were made for the external costs to society for each scenario, taking into account pollution generated by each building. This in turn implies external costs to society that are not usually "charged" to a project, such as health care and environmental cleanup. Finally, long term costs were forecast using 30-year, 60-year and 100-year cost models. These numbers were calculated as net present values and consider a range of factors such as building durability, value of money over time, equipment and/or building replacement, increasing energy costs, etc.



Sustainability Matrix

The *Sustainability Report* illustrates and outlines the base assumptions and calculations generated for each scenario and each set of data. The *Sustainability Matrix* summarizes the results of these explorations. Two versions of the cost numbers were created, each based on a 90,000 square foot office building for 300 employees with a three-level below-grade parking garage in the downtown area of Los Altos, California. For the Packard Foundation's internal use, a first set of estimated costs was documented for the actual building requirements listed above. A second set of generic cost numbers was based on this first set, but with the Market building construction costs set at $10 million and all other numbers factored proportionally, including construction costs, FF+E, and design and management fees. This second set of numbers allows outside readers to understand the cost trends more easily as well as compare with other projects of varying scale.

# Building for Sustainability

The Foundation has made these "generic" numbers available for public review. In an effort to help readers unfamiliar with the work, this "guide" is provided for each document. This is an attempt to help frame the work.

### Sustainability Report

The *Sustainability Report* documents all assumptions and calculations made for each scenario mentioned above. It is the information contained in this report that is summarized in the *Sustainability Matrix*. Key components of the *Sustainability Report* include:

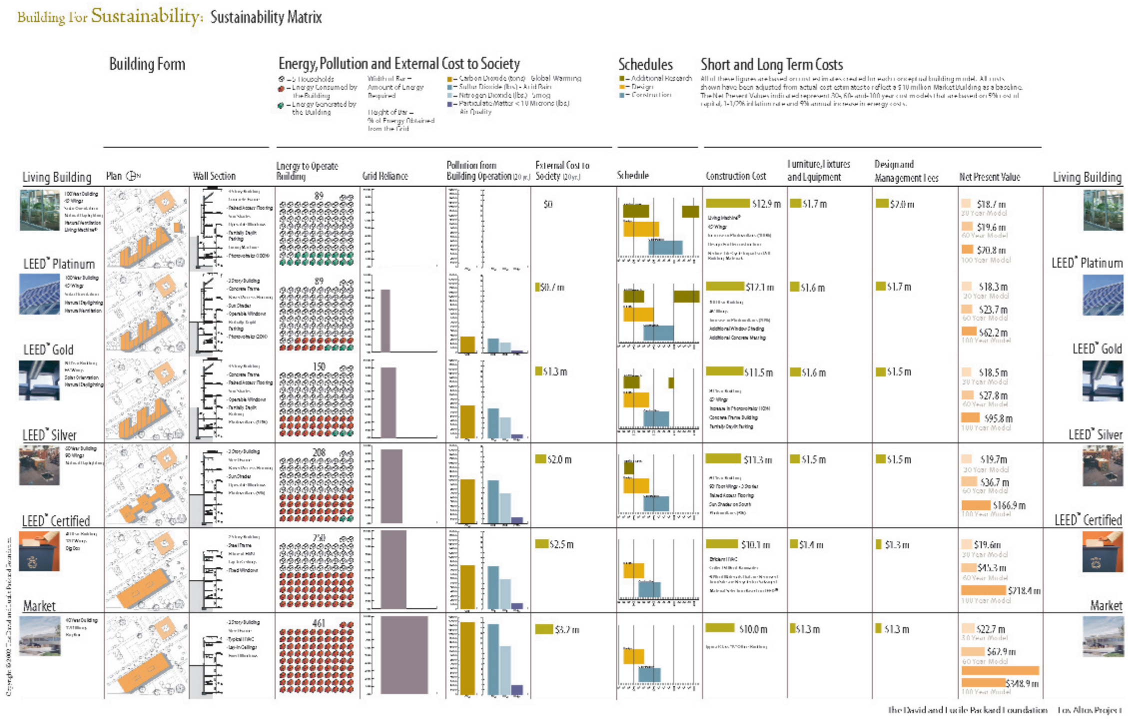
- Definition of Terms - For the purposes of this report, a consensus on terminology is provided.
- Sustainability Scenarios - A one-page summary of key data for each of the six building scenarios is provided.
- Comparison Summaries - A side-by-side analysis is provided to illustrate key assumptions made by the design team. These include side-by-side Site Plans, Cost Impacts, Schedule Impacts, Wall Sections, Building Components and Energy Model Performance Criteria, Building and Site Attributes based on LEED™ Rating System (points assigned to each level), Energy Model Backup information and External Costs to Society assumptions.
- Appendix - The appendix contains information for each level of sustainability. For each level, the following information is included: (1) Site Plan, (2) Project Narrative (a conceptual outline specification), (3) Wall Section with Description of key building components, and (4) Detail Cost Summary.
- Technology - Four technologies that may be considered for the various levels of sustainability are summarized in the final pages of the report. They include: Raised Access Flooring, Photovoltaics, Ecological Wastewater Treatment System and Fuel Cells.

### Sustainability Matrix

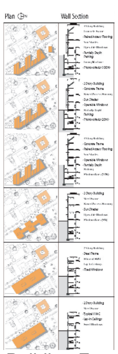
As stated earlier, the matrix format was chosen by the design team as a way to summarize and compare the information detailed in the *Sustainability Report* in as clear a format as possible. While the *Sustainability Matrix* allows a quick comparison between sustainability levels for various parameters, it also begins to reveal the interrelationship between the parameters themselves.

The Y-axis of the Matrix lists six levels of sustainability in the leftmost column: Market , LEED™ Certified, LEED™ Silver, LEED™ Gold, LEED™ Platinum and Living Building. A few characteristics of each level are listed in this leftmost column, including such things as the expected lifespan of the building, the form-generating ideas and key strategies that would most likely characterize that level, including systems such as raised access flooring or ecological wastewater treatment systems.

# Building for Sustainability




The X-axis lays out the primary criteria determined by the Committee and design team to have value in their decision-making process. These parameters can be broken out into four main categories:

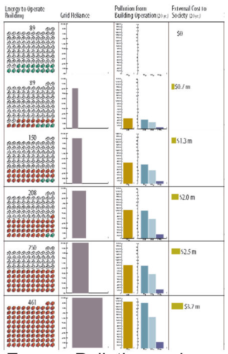

Building Form

### Building Form

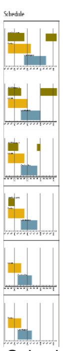
The first two columns of the *Sustainability Matrix* represent variations in building Plan and typical Wall Section as one moves from Market, represented by a "big box", to Living Building, which accounts for solar orientation and incorporates narrow building wings that accommodate natural daylight and natural ventilation for as many occupants as possible. Also listed in the Wall Section column are modifications to construction systems from one level to the next. *All plans shown in the* Sustainability Report *and* Sustainability Matrix *are oriented with North to the right.*

### Energy, Pollution and External Costs

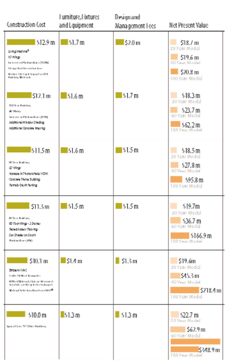
Based on the systems and building design outlined, and other basic assumptions catalogued in the *Sustainability Report*, the design team generated expected energy consumption for each level. The Energy to Operate Building quantities are illustrated using a standard unit of measure, equivalent to one typical household. Also incorporated into the graphics for the Energy column is an indication (in green) of renewable energy sources. So, by comparison, the design of the Living Building requires 89 households worth of energy to run, but the systems include generation of all of the energy by renewable sources. Grid Reliance is proportional to the



Energy, Pollution and External Costs



Schedules



Short and Long Term Costs

information in the Energy column and demonstrates the Living Building as requiring no net annual reliance on outside energy sources. The width of this bar reflects the amount of energy required for each building scenario. The height of the bar reflects the percentage of energy obtained from the grid as compared to the total amount of energy required. The Pollution column further explores the expected pollution generated by this grid reliance. Finally, a conservative estimate is made for External Costs to Society, in particular, health costs and cleanup costs associated with standard energy generation. As previously mentioned, these estimates are based primarily on Jonathan Levy's "Environmental Health Effects of Energy Use: A Damage Function Approach" (May 1999).

### Schedules

The Schedule column focuses on three major efforts: Research, Design and Construction. Variations from one scenario to the next represent two primary strategies: (1) a more sustainable design strategy involves more design team members in early meetings to ensure an integrated design approach and (2) research in the more sustainable approaches is more critical early in the process and continues after owner occupancy. It is not just limited to the "design" phases.

### Short and Long Term Costs

The next four columns contain short and long term cost information for each scenario. The first three columns in this series encompass Construction Costs, costs for Furniture, Fixtures and Equipment (FF+E) and Design and Management Fees. All of these figures are based on cost estimates created for each conceptual building model. The outline specifications for each are included in the *Sustainability Report*, along with detailed cost backup information. All costs shown in this particular report have been adjusted from actual cost estimates to reflect a $10 million Market building as the baseline. Significant components that contribute to cost increases from one level to the next are listed beneath each cost.

For all levels, three cost models were created for 30-year, 60-year and 100-year scenarios. The Net Present Values are estimates, in today's dollars, of all the expenses (annual as well as capital) associated with a building over a set period of time. Energy costs were estimated to increase 5% annually with a 5% cost of capital assumed for all models. One factor in these calculations is the expected lifespan of each building, which ranges from 40-year for Market and LEED™ Certified to 100-year for the LEED™ Platinum and Living Building levels.

*All calculations are based on information and costs available to the design team in the summer of 2002.*

It is worth repeating that the *Sustainability Matrix* does not stand alone, but is a summary of the findings described in the *Sustainability Report*, which documents the initial assumptions and calculations, and better demonstrates the process undertaken by the design team.

Building for Sustainability

## Definition of Terms

*Within the design and construction industry, many of the terms below have varying definitions, depending in part on the context in which they are used. The design team understands this and has chosen the definitions indicated in an effort to provide clarity for the Packard Foundation's* Sustainability Report and Matrix.

**Construction Costs**
The actual cost of construction of the facility, including material, labor, overhead and profit of the general contractor and their subcontractors. For the purpose of this report, costs not included in this figure include land acquisition costs, legal fees, and other related soft costs.

**Cost of Capital (interest rate, time value of money)**
The cost of capital is a factor that recognizes that interest compounds on money when it is kept. The rate is the effective interest rate that a bank or other financial institution pays annually for the privilege of keeping the funds. Also called the time value of money, this principle states that funds placed in a secure investment will increase in value in a way that depends on the elapsed time and interest rate. The cost of capital assumed in this model is 5%, which is a standard rate for a fairly conservative, stable, bond fund type of investment.

**Design and Management Fees**
Fees for professional services rendered by the architectural design team and their consultants, as well as the construction management team.

**Ecological Wastewater Treatment System**
A wastewater treatment system that relies on microorganisms and plants, in the presence of sunlight, to purify water instead of harsh chemicals and massive energy inputs.

**External Costs to Society**
This is a rough and very conservative number taken from an average of several governmental, industrial and environmental studies that quantify the cost of pollution born by the general public through a complex mixture of health-related impacts, pollution remediation impacts and losses to the economy based on resource depletion and quality of life degradation. Each scenario is analyzed to determine the amount of pollution generated and the external costs to society of the pollutants over a 20-year period. The intent of including this number is to remind ourselves that pollution imposes a real cost on our society that is not generally included in the cost of that which generates it.

**Furniture, Fixtures and Equipment (FF+E)**
This includes items purchased by the owner, typically under a separate contract from the base building construction contract.

**Inflation Rate**
The inflation rate is the change in the cost of living or price index that varies (generally increases) with time. In an economic comparison, it is important to bring all of the costs to a constant point in time so that the comparison is at a real, fixed point and is a fair comparison. In other words, the inflation rate takes into account the market pressures that make the cost of living or the cost of doing business increase, while the cost of capital takes into account the financial pressures associated with planning expenditures over a period of time. The inflation rate for a standard "basket of goods" over the past 100 years has been approximately 2%. For the analysis shown here, the rates are 1.5% for most construction-related items because these costs have traditionally inflated slower than the average. The energy costs have been inflated more quickly (5%) based on a conservative extrapolation of the latest trends in the energy market.

**LEED™**
An acronym for Leadership in Energy and Environmental Design, LEED™ is a rating system for measuring the sustainability of building projects, recently developed by the U.S. Green Building

# Building for Sustainability

Council. (Current version: 2.0, March 2000). It is also used as a design tool for designing "green buildings". For this study, a conceptual design for each of the four LEED™ ratings was based on distributing the points in each category evenly between the major categories (Site, Water, Energy, Materials, and Indoor Environmental Quality) and on awarding points beginning with the easiest to achieve and ending with the more difficult. A copy of LEED™ can be downloaded from www.usgbc.org, the website of the U. S. Green Building Council.

**Living Building**
A Living Building is defined as having zero net annual impact on the environment from an operational standpoint. While a truly sustainable building would also mitigate burdens created during construction and operation, as well as by the embodied energy in the materials, this study considers only net zero annual impact from building operation.

**Maintenance Costs**
The costs associated with keeping a building in operation including all time and materials and, for example, the cost to replace lights, fix equipment and provide general upkeep.

**Market Building**
For the purposes of this report, a Market Building is defined as a San Francisco Bay Area Class A office building. For a more detailed description, refer to the Market Scenario Summary and the Market Project Narrative provided in the *Sustainability Report*. As of March 2001, a stricter version of Title 24 (California's Energy Code) was adopted in the state of California, which is used as the baseline for the Market Building in this study.

**Net Present Value**
The value in today's dollars of all the income and expenses (annual as well as capital) associated with a building over a set period of time. The Net Present Value uses the cost of capital so that expenditures and revenues incurred at different points in time can be compared equally in today's dollars.

**Photovoltaics (PV)**
Solid-state technology, typically made from silicon and originally developed by NASA, that converts sunlight (photo-) directly into electricity (-voltaic) with no moving parts and no pollution created. The most compelling applications of PV in the building industry are those that integrate the PV cells directly into a building component, such as glazing or roofing.

**Site Plan**
The Packard Foundation property in downtown Los Altos, California is used as the basis of design for each scenario.

**Sustainable Design**
An integrated approach to the built environment that balances the social, economic and environmental aspects of our lives and enhances the well-being of our communities.

Building for Sustainability

## Scenario Summaries

### Market

OFFICE:
2 floors at 45,000 sf =
90,000 sf

GARAGE:
3 floors at 45,000 sf =
135,000 sf

BUILDING LIFE EXPECTANCY:
40 years

The Market Building is defined as a typical San Francisco Bay Area Class A office building. The building occupies most of the site with minimal traditional landscaping. All water is supplied and returned to municipal storm and sanitary systems. The construction is: steel frame; concrete floors over metal deck; precast exterior; large percentage of traditional, non-operable, exterior glazing; minimum R-values for exterior walls and roof system to meet code; flat roof; 10'-0" lay-in ceilings; gypsum board interior walls; small amounts of interior glass; and ceiling-based mechanical and electrical lighting system that meets minimum ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) and Title 24 requirements. Minimal commissioning is used. Traditional building materials are selected without knowledge of their impact on the environment or human health.

### LEED™ Certified

OFFICE:
2 floors at 45,000 sf =
90,000 sf

GARAGE:
3 floors at 45,000 sf =
135,000 sf

BUILDING LIFE EXPECTANCY:
40 years

The LEED™ Certified Building is similar to a Market Building with improved mechanical systems, envelope and more conscious use of materials. The building occupies most of the site. All water is supplied and returned to municipal storm and sanitary systems. Native, xeriscape landscaping requires little irrigation. The mechanical and electrical lighting systems improve minimum ASHRAE energy requirements by 30 percent. Ventilation effectiveness and thermal comfort are improved. Additional commissioning is used. Building materials are more likely to be salvaged, recycled content, rapidly renewable, low emitting or certified. Daylighting and views are accessible from common spaces.

### LEED™ Silver

OFFICE:
3 floors at 30,000 sf =
90,000 sf

GARAGE:
3 floors at 45,000 sf =
135,000 sf

BUILDING LIFE EXPECTANCY:
60 years

The LEED™ Silver Building is similar to a LEED™ Certified Building with improved mechanical systems, envelope and more conscious use of materials. The building footprint allows more access to exterior courtyard green space and daylight into the building. All water is supplied and returned to municipal storm and sanitary systems. Native, xeriscape landscaping requires little irrigation. The mechanical and electrical lighting systems improve minimum ASHRAE energy requirements by 40 percent. Five percent of the building's electricity is supplied by photovoltaics. Raised access flooring and some operable windows allow greater user control over thermal comfort. Additional commissioning is used. Building materials contain higher percentages of recycled content. Daylighting and outdoor views are accessible from common spaces. Horizontal exterior shading devices on the south, east, and west protect glazing from thermal heat gain.

# Building for Sustainability

## LEED™ Gold

OFFICE:
3 floors at 30,000 sf = 90,000 sf

GARAGE:
3 floors at 45,000 sf = 135,000 sf

BUILDING LIFE EXPECTANCY:
80 years

The LEED™ Gold Building is similar to a LEED™ Silver Building with improved mechanical systems, envelope and more conscious use of materials. The building orientation works better with solar orientation. Thirty percent of the building's water is supplied by rainwater and returned to municipal sanitary systems. Native, xeriscape landscaping requires little irrigation. The mechanical and electrical lighting systems improve minimum ASHRAE energy requirements by 50 percent. Ten percent of the building's electricity is supplied by photovoltaics. Partial natural ventilation is used. Raised access flooring and operable windows allow greater user control over thermal comfort. Additional commissioning is used. Building materials contain more salvaged materials. Daylighting is used for ambient general lighting. Horizontal exterior shading devices on the south, east, and west protect glazing from thermal heat gain.

## LEED™ Platinum

OFFICE:
3 floors at 30,000 sf = 90,000 sf

GARAGE:
3 floors at 45,000 sf = 135,000 sf

BUILDING LIFE EXPECTANCY:
100 years

The LEED™ Platinum Building is similar to a LEED™ Gold Building with improved mechanical systems, envelope and even more conscious use of materials. The building orientation and width are optimum for the solar orientation. Rainwater is fully utilized. Greywater is recirculated for non-potable uses within the building. Native, xeriscape landscaping requires little irrigation. The mechanical and electrical lighting systems improve minimum ASHRAE energy requirements by 60 percent. Twenty percent of the building's electricity is supplied by photovoltaics. Natural ventilation is utilized. Raised access flooring and operable windows allow greater user control over thermal comfort. Additional commissioning is used along with some monitoring. Building materials are regional. Daylighting is used for both ambient general lighting as well as in areas where critical visual tasks occur. Horizontal exterior shading devices on the south and a screen on the east and west protect glazing from thermal heat gain.

## Living Building

OFFICE:
3 floors at 30,000 sf = 90,000 sf

GARAGE:
3 floors at 45,000 sf = 135,000 sf

BUILDING LIFE EXPECTANCY:
100 years

The Living Building is similar to a LEED™ Platinum Building, but is designed to operate with zero net annual pollution created. The building materials are selected base on their life-cycle impact on social, environmental and economic systems. Rainwater is fully utilized. An ecological wastewater treatment system treats wastewater for non-potable reuse within the building (shown as separate structure on site plan). Native, xeriscape landscaping requires no irrigation. The mechanical and electrical lighting systems improve minimum ASHRAE energy requirements by 60 percent or more. Photovoltaics supply the net annual requirement of electricity for the building and will be used for on-site power generation. User control and comfort are optimized. Super commissioning and monitoring are implemented. Daylighting is optimized in all areas. Horizontal exterior shading devices on the south with vertical fins on the north, and a screen on the east and west protect glazing from thermal heat gain.

| MARKET | LEED™ CERTIFIED | LEED™ SILVER<br>All of LEED™ CERTIFIED Rating plus: | LEED™ GOLD<br>All of LEED™ SILVER Rating plus: | LEED™ PLATINUM<br>All of LEED™ GOLD Rating plus: | LIVING<br>All of LEED™ PLATINUM plus: |
|---|---|---|---|---|---|
| **SITE** | | | | | |
| Total SITE Points Possible = 14<br>Estimated LEED™ V. 2.0 Points: | 7 out of 14 | 8 out of 14 | 10 out of 14 | 13 out of 14 | 13+ out of 14 |
| Develop most of the site with building footprint and paving | Develop brownfield or non-greenfield sites | Locate near public transportation systems (buses or rail) | Reduce impervious surfaces | Manage most storm water on site | Maximize opportunities to use clean, efficient transportation |
| Develop the site without knowledge of the impacts on site resources | Reduce urban heat islands with shade or underground parking | | Manage 25% of storm water on site | Increase the zoning requirements for open space | Capture and filter the maximum possible amount of storm water on-site |
| Transfer storm water to the municipal sewer system | Minimize site disturbance and restore natural habitat | | Provide alternative fueling stations | | Eliminate or remediate any soil or water pollution |
| Consider development of greenfield or suburban sites | Minimize light pollution | | | | Protect all site resources (soil, water, habitat and bio-diversity) |
| Use conventional paving methods without knowledge of heat absorbing properties | Protect soil during construction | | | | |
| Incorporate traditional landscaping | Use native landscaping | | | | |
| | Provide bike storage and showers | | | | |
| | Increase urban density | | | | |
| **WATER** | | | | | |
| Total WATER Points Possible = 5<br>Estimated LEED™ V. 2.0 Points: | 2 out of 5 | 3 out of 5 | 4 out of 5 | 5 out of 5 | 5+ out of 5 |
| Rely on municipal water supply for landscape irrigation | Use efficient irrigation system & rainwater for 50% of irrigation needs | Use rainwater for 100% of irrigation needs | Use alternative fixtures and plumbing systems | Recirculate or treat wastewater | Maximize opportunities to use rainwater for building supply water |
| Rely on municipal water supply for building use | Use water efficient landscaping | | Use rainwater and efficient fixtures to reduce the water supplied by 30% | | Reuse all water in the building |
| Comply with minimal code requirements for fixture efficiency | Use efficient fixtures to reduce water supplied by 20% | | | | Treat all water on site |
| Convey wastewater to municipal waste water treatment plant | Convey wastewater to a municipal wastewater treatment center | | | | Filter and return clean pure water to natural aquifers |
| **ENERGY** | | | | | |
| Total ENERGY Points Possible = 17<br>Estimated LEED™ V. 2.0 Points: | 5 out of 17 | 9 out of 17 | 12 out of 17 | 15 out of 17 | 15+ out of 17 |
| Use minimal commissioning | Use additional commissioning | Reduce the energy cost budget by 40% | Reduce the energy cost budget by 50% | Reduce the energy cost budget by 60% | Use super-commissioning and continuous monitoring |
| Use minimal monitoring | Reduce the energy cost budget by 30% based on ASHRAE 90.1-1999 | Supply 5% of the building power from an on-site renewable energy source | Supply 10% of the building power from an on-site renewable energy source | Supply 20% of the building's power from an on-site renewable energy source | Supply 100% of the building's power from an on-site renewable energy source |
| Comply with minimal energy codes | Use zero CFC refrigerants | Utilize alternative air systems with greater individual control | Explore alternative air systems | | Use zero HCFC and ozone depleting refrigeration |
| Allow over-sized HVAC equipment | | Monitor lighting, HVAC, water heater and irrigation systems | | | Operate the building without creating pollution averaged annually |
| Allow building systems to function independently | | | | | Fully monitor and integrate all building systems |
| Rely on CFC & HCFC refrigerants | | | | | Right-size all building systems |
| Allow equipment efficiency to decrease over time | | | | | Reduce the energy cost budget by 60% or more |
| Rely on non-renewable power from the grid | | | | | |

# Building for Sustainability



| MARKET | LEED™ CERTIFIED | LEED™ SILVER<br>All of LEED™ CERTIFIED Rating Plus: | LEED™ GOLD<br>All of LEED™ SILVER Rating Plus: | LEED™ PLATINUM<br>All of LEED™ GOLD Rating Plus: | LIVING<br>All of LEED™ PLATINUM Plus: |
|---|---|---|---|---|---|
| **MATERIAL**<br>Total MATERIAL Points Possible = 13<br>Estimated LEED™ V. 2.0 Points: | 6 out of 13 | 7 out of 13 | 8 out of 13 | 10 out of 13 | 10+ out of 13 |
| Process workplace waste without recycling | Reduce and recycle workplace waste | Specify 20% post-consumer recycled content for 50% of the total materials used by cost | Specify salvaged material for 10% of the total materials used by cost | Specify regionally extracted raw materials for 10% of the materials regionally manufactured | Design for deconstruction |
| Specify materials based on initial cost and availability rather than on environmental impacts over their life cycle | Recycle or salvage 50% of construction waste | | | Salvage 75% of the construction waste | Reduce the life-cycle impact of building materials |
| Recycle construction waste only if it reduces initial cost | Use certified wood for 50% of the wood used | | | | Minimize transportation and energy used during construction |
| Specify wood without knowledge of the impacts on forest health | Specify 20% post-consumer recycled content for 25% of total materials used by cost | | | | Specify materials based on their social, environmental, and economic impacts over their life cycle |
| Specify materials that may require chemical maintenance | Specify regionally manufactured materials (500 miles) for 20% of the materials used by cost | | | | |
| Specify materials without knowledge of their recycled content or recyclability | Specify rapidly renewable materials for 5% of the total materials used by cost | | | | |
| Design for demolition rather than deconstruction | Specify salvaged materials for 5% of total materials used by cost | | | | |
| Use some certified wood | | | | | |
| **INDOOR ENVIRONMENTAL QUALITY**<br>Total IEQ Points Possible = 15<br>Estimated LEED™ V. 2.0 Points: | 6 out of 15 | 10 out of 15 | 12 out of 15 | 15 out of 15 | 15+ out of 15 |
| Comply with ASHRAE 62-1999 requirements for IAQ | Comply with ASHRAE 55-1992 standards for thermal comfort | Isolate printer and copy equipment | Provide partial natural ventilation | Provide a direct view to daylight for 95% of workspaces | Understand and control the sources of IAQ hazards |
| Use cleaning products without knowledge of their impact on IAQ | Comply with ASHRAE 62-1999 requirements for IAQ | Conduct a two week flush-out & filter change prior to occupancy | Utilize daylight for ambient lighting | Provide natural ventilation with sensors and controls for humidity and IAQ | Maximize use of integrated daylighting and efficient electrical lighting |
| Complete construction without monitoring IAQ | Increase effectiveness of ventilation | Provide entryway systems to reduce allergens and particulates | Install permanent temperature and humidity monitors | Monitor carbon dioxide | Specify materials that do not require chemical maintenance |
| Use materials without knowledge of their VOC emission rate | Allow zero smoking in or near the building | Isolate cleaning products | Specify additional low-emitting materials: paint | Utilize daylight for 75% of all task lighting | Maximize individual control over comfort |
| Locate copy and printing equipment in workspace | Specify low-emitting materials: adhesives, sealants, carpet, and composite wood | Provide operable windows and individual control over temperature and airflow | | | Plan landscape that does not require chemicals or polluting equipment to maintain |
| Allow smoking near the entry of buildings | Manage IAQ during construction | Separate hazardous wastewater drains | | | |
| Plan electric lighting without daylight integration | Provide a view to daylight and outdoor space for some common spaces | | | | |
| Design for zoned comfort areas rather than individual comfort control | Provide a view to daylight and outdoor space for some individual work stations | | | | |
| **MARKET – TOTAL POINTS**<br>Less than 26 out of 64 possible | **LEED™ CERTIFIED – TOTAL POINTS**<br>26 out of 64 possible | **LEED™ SILVER – TOTAL POINTS**<br>37 out of 64 | **LEED™ GOLD – TOTAL POINTS**<br>46 out of 64 | **LEED™ PLATINUM – TOTAL POINTS**<br>58 out of 64 | **LIVING BUILDING – TOTAL POINTS**<br>58+ out of 64 |

*Scores above do not account for a LEED™ accredited professional or possible innovation credits.*

# Building for Sustainability

| Design Criteria/Characteristics | | Market | LEED™ Certified | LEED™ Silver | LEED™ Gold | LEED™ Platinum | Living Building |
|---|---|---|---|---|---|---|---|
| Estimated LEED™ score | Points (V. 2.0) | Less than 26 | 26 | 37 | 47 | 58 | More than 58 |
| Site area | Total area (sf) | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 | 56,000 |
| Building form | Width (ft) | 120 | 120 | 90 | 65 | 45 | 45 |
| | Area (sf) | 90,000 | 90,000 | 90,000 | 90,000 | 90,000 | 90,000 |
| | Stories | Office: 2 floors<br>Garage: 3 levels | Office: 2 floors<br>Garage: 3 levels | Office: 3 floors<br>Garage: 3 levels | Office: 3 floors<br>Garage: 3 leve ls | Office: 3 floors<br>Garage: 3 levels | Office: 3 floors<br>Garage: 3 levels |
| | Orientation | - | - | - | Solar-based | Solar-based | Solar-based |
| Occupancy | People | 300 | 300 | 300 | 300 | 300 | 300 |
| | Percent closed office | 60% | 50% | 40% | 30% | 20% | 10% |
| Amount of glazing (percent of building skin area) | North | 60% | 50% | 40% | 40% | 40% | 40% |
| | South | 60% | 50% | 40% | 40% | 40% | 40% |
| | East | 60% | 50% | 30% | 25% | 20% | 20% |
| | West | 60% | 50% | 30% | 25% | 20% | 20% |
| Glazing characteristics (U-factor / solar heat gain coefficient / visible light transmittance) | North | .42 / .60 / .71 | .32 / .46 / .70 | .29 / .43 / .70 | .29 / .43 / .70 | .29 / .43 / .70 | .29 / .43 / .70 |
| | South | .42 / .60 / .71 | .32 / .46 / .70 | .29 / .43 / .70 | .29 / .43 / .70 | .29 / .43 / .70 | .29 / .43 / .70 |
| | East | .42 / .60 / .71 | .32 / .46 / .70 | .31 / .40 / .47 | .31 / .40 / .47 | .31 / .40 / .47 | .31 / .40 / .47 |
| | West | .42 / .60 / .71 | .32 / .46 / .70 | .31 / .40 / .47 | .31 / .40 / .47 | .31 / .40 / .47 | .31 / .40 / .47 |
| Glazing and daylight strategies | Daylight and views | Limited access to daylight and views | Daylight and views at common areas | Daylight and views at common areas | Ambient daylight for general lighting | Daylight for visual tasks | Daylight for visual tasks |
| | Insulation, operability | Double-glazed, fixed | Double-glazed, fixed | Double-glazed, operable | Double-glazed, operable | Double-glazed, operable w/ controls | Double -glazed, operable w/ controls |
| | Light shelves | No | No | No | Yes | Yes | Yes |
| Amount of shading (percent of total window area) | North | 0% | 0% | 0% | 0% | 0% | 100% |
| | South | 0% | 0% | 50% | 100% | 100% | 100% |
| | East | 0% | 0% | 0% | 50% | 100% (20% by landscaping) | 100% (20% by landscaping) |
| | West | 0% | 0% | 0% | 50% | 100% (50% by landscaping) | 100% (50% by landscaping) |
| | Exterior shade | No | No | South | South | South | South |
| | Vertical screen | No | No | No | East and west | East and west | East and west |
| | Vertical fin | No | No | No | No | No | North |
| Temperature range (degrees Fahrenheit) | Cooling/RH | 74° | 74° | 74° | 76° | 78° | 78° |
| | Heating/RH | 70° | 68° | 68° | 68° | 68° | 68° |

# Building for Sustainability

| Design Criteria/Characteristics | | Market | LEED™ Certified | LEED™ Silver | LEED™ Gold | LEED™ Platinum | Living Building |
|---|---|---|---|---|---|---|---|
| Thermal properties (overall system R -value) | Wall R-value | R-8 | R-13 | R-20 | R-25 | R-33 | R-33 |
| | Roof R-value | R-20 | R-30 | R-30 | R-33 | R-40 | R-40 |
| | Floor R-value | R-19 | R-19 | R-19 | R-23 | R-27 | R-27 |
| | Mass | No | No | No | Yes | Yes / high mass | Yes / high mass |
| Energy efficiency goal (beyond baseline – ASHRAE 90.1, 1999) | % of ASHRAE baseline | ASHRAE | 70% ASHRAE | 60% ASHRAE | 50% ASHRAE | 40% ASHRAE | < 40% ASHRAE |
| Technologi es introduced | Ecological waste - water treatment system | No | No | No | No | No | Yes |
| Renewable energy | Photovoltaic s (kW) | No | No | 30 | 60 | 80 | 200 |
| | % of net annual | 0% | 0% | 5% | 10% | 20% | 100% |
| Supply air system | | VAV | VAV | Under floor | Under floor | Under floor and natural ventilation | Under floor and natural ventilation |
| Outside air | CFM/person | 20 | 20 | 20 | 20 | 20 | 20 |
| | SF/person | 150 | 150 | 150 | 150 | 150 | 150 |
| Unit supply air | CFM/sf | 1.5 | 1.5 | 1.4 | 1.3 | .75 | .75 |
| Total air supply volume | CFM | 135,000 | 90,000 | 126,000 | 117,000 | 90,000 | 67,500 |
| Outside air | CFM – 150sf/person at 20 CFM each | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 | 12,000 |
| Design loads | Lighting (W/ft$^2$) | 1.25 | 1.2 | 1.2 | 0.8 | 0.5 | 0.5 |
| | Plugs (W/ft$^2$) | 4.0 | 2.0 | 1.5 | 0.8 | 0.5 | 0.5 |
| Electric feed size | kW | 1200 | 800 | 600 | 600 | 400 | 400 |
| Generator size | Kilowatts | 200 | 200 | 200 | 100 | 100 | 0 |
| Cooling capacity | Ft$^2$/ton | 240 | 350 | 450 | 600 | 1000 | 1000 |
| Chiller capacity | Tons | 375 | 250 | 200 | 150 | 90 | 90 |
| Heating (boiler) load | BTU/h | 950 | 850 | 950 | 950 | 875 | 875 |
| Domestic hot water load | BTU/h | 165 | 75 | Included in heating | Included in heating | Included in heatin g | Included in heating |
| Rainwater catchment tank | Gallons | 0 | 12,500 | 25,000 | 25,000 | 25,000 | 25,000 |
| Treated water storage tank | Gallons | 0 | 0 | 0 | 0 | 0 | 20,000 |
| Design fees (Design / Research / LEED™ Certification) | % of construction costs | 12% | 12% | 12% | 12% | 12% | 12% |
| | % of construction costs | - | - | 1% | 1% | 2% | 3% |
| | Estimated at $1,000 per point | - | $26,000 - 32,000 | $33,000 - 38,000 | $39,000 - 51,000 | $52,000 - 64,000 | $58,000 - 64,000 |

| Design Criteria/Characteristics | | Market | LEED™ Certified | LEED™ Silver | LEED™ Gold | LEED™ Platinum | Living Building |
|---|---|---|---|---|---|---|---|
| Materials used (percent of total material cost) | Min. 20% post-consumer recycled content materials | 0% | 25% | 50% | 50% | 50% | Reduce materi al impact based on life-cycle assessment |
| | Salvaged or reused materials | 0% | 5% | 5% | 10% | 10% | Reduce material impact based on life-cycle assessment |
| | Regionally manufactured materials | 0% | 20% | 20% | 20% | 20% | Reduce material impact based on life-cycle assessment |
| | Regionally extracted raw materials | 0% | 0% | 0% | 10% | 10% | Reduce material impact based on life-cycle assessment |
| | Low emitting materials | Carpet | Carpet, adhesives, sealants, composite wood | Carpet, adhesives, sealants, composite wood | Carpet, adhesives, paint, s ealants, composite wood | Carpet, adhesives, paint, sealants, composite wood | Understand and control sources of IAQ hazard |
| | Certified wood | 0% of wood used | 50% of wood used | 50% of wood used | 50% of wood used | 50% of wood used | Reduce material impact based on life-cycle assessment |
| | Rapidly renewable materials | 0% | 5% | 5% | 5% | 5% | Reduce material impact based on life-cycle assessment |
| Recycled construction waste | % of total waste by weight | 0% | 50% | 50% | 50% | 75% | Maximum possible |
| Plumbing | Greywater use (rainwater and building greywater) | 0% | 0% | 50% (site irrigation) | 100% (site irrigation) | 100% (building) | 100% (building) |
| | Black water use | 0% | 0% | 0% | 0% | 0% | 100% (building) |
| | Ecological wastewater treatment system | No | No | No | No | No | Yes |
| Electrical | Lighting at garage (lamps) | 175-watt metal halide | 175-watt metal halide | T-5 | T-5 | T-5 | T-5 |
| | Lighting at garage stairs (lamps) | T-8 | T-8 | T-5 | T-5 | T-5 | T-5 |
| | Interior building lighting (lamps) | T-8 | T-8 | T-5 | T-5 | T-5 | T-5 |
| Structural | Structural system | Steel | Steel | Steel | Concrete | Concrete | Concrete |
| | Floor-to-floor height | 14'-0" | 14'-0" | 13'-6" | 13'-0" | 13'-6" | 13'-6" |
| | Office ceiling height | 10'-0" | 10'-0" | Exposed | Exposed | Exposed | Exposed |
| | Height of raised access flooring | NA | NA | 16" | 16" | 16" | 16" |

Notes:
1 - These performance criteria are based on a building site located in downtown Los Altos, California with a specific owner in mind. Criteria will vary for buildings in different climates and with different owners.
2 - The Market building is designed to meet the revised version of Title 24, California's Energy Code, adopted in March 2001.

Building for Sustainability

## Net Present Value Calculations

The Net Present Value (NPV) is broken down into six areas of costs, each area having its own NPV formula.

**Capital Costs** — Initial construction costs of the building, not including design and management fees.

**Formula** Initial construction costs + (NPV of initial construction costs based on the life span of the building with 1.5% annual cost of inflation)

**Example** In the 100-year analysis, the Market building capital costs include the initial construction cost plus the building replacement cost at 40 and 80 years.

**Replacement Costs** — Replacement costs associated with maintaining the building's mechanical equipment, interior finish upgrades and exterior roof replacement.

**Formula** NPV every 20 years of (50% of initial mechanical cost + 50% of initial interior tenant finish cost + 100% of initial roof cost) with 1.5% annual cost of inflation

**Example** In the 100-year analysis, the Market building's maintenance cost includes NPV's of the formula above at 20 and 60 years. The 40- and 80-year replacement costs are included in the capital costs associated with the building replacement.

**Design Fees** — Design fees associated with initial construction and with replacement buildings.

**Formula** Initial design fees + (NPV of initial design fees based on the life span of the building with a 1.5% annual cost of inflation)

**Example** In the 100-year analysis, the Market building design fees include the initial design fees and the replacement design fees at 40 and 80 years.

**Maintenance Costs** — Maintenance costs include repair and maintenance of all building systems and are reduced or increased based on the amount of equipment required for the building.

**Formula** NPV of an industry average maintenance cost of 1.525 times 90,000 square feet with an annual increase of 1.5 % for inflation. The industry average maintenance cost is then factored based on the amount of systems in the building: Market building factor - 100% , LEED™ Certified and LEED™ Silver factor - 80%, LEED™ Gold factor - 60%, LEED™ Platinum factor - 45%, Living Building factor - 60%.

**Example** In the 100-year analysis, the LEED™ Silver building maintenance costs are the 100-year NPV of 1.525 x 90,000 x 80% with 1.5% inflation per year.

**Energy Costs** — Energy costs are the electrical costs based on energy modeling for each of the proposed levels of sustainability. The cost for energy is based on actual 2002 energy costs for Los Altos, California.

**Formula** NPV of the cost of running the building for one year with an annual increase of 5% after the first year.

**Water Costs** — The cost for providing all the water needs to the building based on occupancy, water conservation devices and cost of water in Los Altos.

**Formula** NPV of the water costs plus 1.5% inflation each year.

The total of all six categories is the total NPV of the building and the NPV value shown on matrix:

> (Capital Costs NPV + Replacement Costs NPV + Design Fees NPV + Maintenance Costs NPV + Energy Costs NPV + Water Costs NPV) for each level of sustainability for each 30-, 60- and 100-year cost model.

# Building For Sustainability: Sustainability Matrix

## Building Form

## Energy, Pollution and External Cost to Society

- = 5 Households
- = Energy Consumed by the Building
- = Energy Generated by the Building

Width of Bar = Amount of Energy Required

Height of Bar = % of Energy Obtained from the Grid

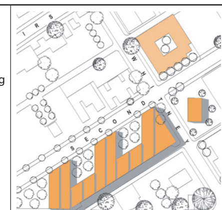
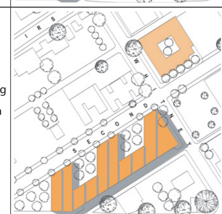
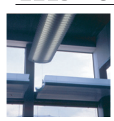
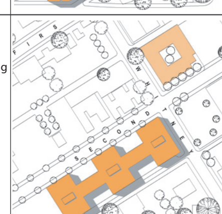
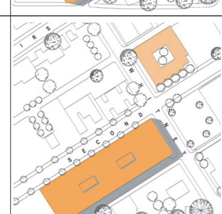
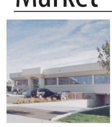
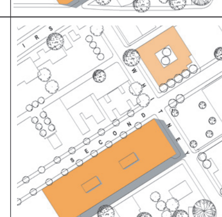
- = Carbon Dioxide (tons) - Global Warming
- = Sulfur Dioxide (lbs.) - Acid Rain
- = Nitrogen Dioxide (lbs.) - Smog
- = Particulate Matter < 10 Microns (lbs.) - Air Quality

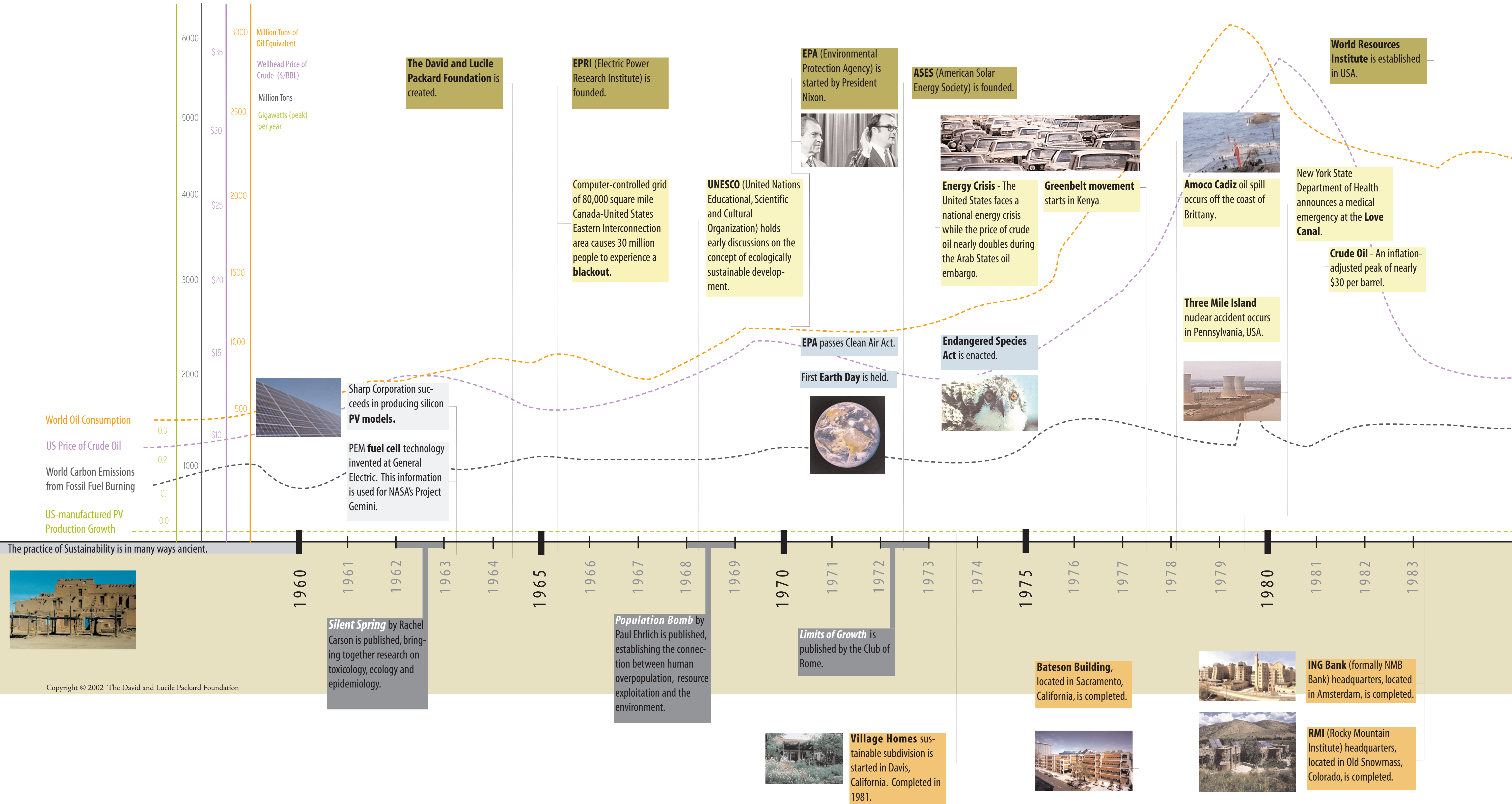
## Schedules

- = Additional Research
- = Design
- = Construction

## Short and Long Term Costs

All of these figures are based on cost estimates created for each conceptual building model. All costs shown have been adjusted from actual cost estimates to reflect a $10 million Market Building as a baseline. The Net Present Values indicated represent 30-, 60- and-100 year cost models that are based on 5% cost of capital, 1-1/2% inflation rate and 5% annual increase in energy costs.

| Building | Description | Plan | Wall Section | Energy to Operate Building | External Cost to Society (20 yr.) | Construction Cost | Furniture, Fixtures and Equipment | Design and Management Fees | Net Present Value |
|---|---|---|---|---|---|---|---|---|---|
| Living Building  | 100 Year Building<br>45' Wings<br>Solar Orientation<br>Natural Daylighting<br>Natural Ventilation<br>Living Machine® |  | · 3 Story Building<br>· Concrete Frame<br>· Raised Access Flooring<br>· Sun Shades<br>· Operable Windows<br>· Partially Daylit Parking<br>· Living Machine<br>· Photovoltaics (100%) | 89 | $0 | $12.9 m<br>Living Machine®<br>45' Wings<br>Increase in Photovoltaics (100%)<br>Design For Deconstruction<br>Reduce Life Cycle Impacts of All Building Materials | $1.7 m | $2.0 m | $18.7 m 30 Year Model<br>$19.6 m 60 Year Model<br>$20.8 m 100 Year Model |
| LEED™ Platinum  | 100 Year Building<br>45' Wings<br>Solar Orientation<br>Natural Daylighting<br>Natural Ventilation |  | · 3 Story Building<br>· Concrete Frame<br>· Raised Access Flooring<br>· Sun Shades<br>· Operable Windows<br>· Partially Daylit Parking<br>· Photovoltaics (20%) | 89 | $0.7 m | $12.1 m<br>100 Year Building<br>45' Wings<br>Increase in Photovoltaics (20%)<br>Additional Window Shading<br>Additional Concrete Massing | $1.6 m | $1.7 m | $18.3 m 30 Year Model<br>$23.7 m 60 Year Model<br>$62.2 m 100 Year Model |
| LEED™ Gold  | 80 Year Building<br>65' Wings<br>Solar Orientation<br>Natural Daylighting |  | · 3 Story Building<br>· Concrete Frame<br>· Raised Access Flooring<br>· Sun Shades<br>· Operable Windows<br>· Partially Daylit Parking<br>· Photovoltaics (10%) | 150 | $1.3 m | $11.5 m<br>80 Year Building<br>65' Wings<br>Increase in Photovoltaics (10%)<br>Concrete Frame Building<br>Partially Daylit Parking | $1.6 m | $1.5 m | $18.5 m 30 Year Model<br>$27.8 m 60 Year Model<br>$95.8 m 100 Year Model |
| LEED™ Silver  | 60 Year Building<br>90' Wings<br>Natural Daylighting |  | · 3 Story Building<br>· Steel Frame<br>· Raised Access Flooring<br>· Sun Shades<br>· Operable Windows<br>· Photovoltaics (5%) | 208 | $2.0 m | $11.3 m<br>60 Year Building<br>90' Foot Wings - 3 Stories<br>Raised Access Flooring<br>Sun Shades on South<br>Photovoltaics (5%) | $1.5 m | $1.5 m | $19.7m 30 Year Model<br>$36.7 m 60 Year Model<br>$166.9 m 100 Year Model |
| LEED™ Certified  | 40 Year Building<br>120' Wings<br>Big Box |  | · 2 Story Building<br>· Steel Frame<br>· Efficient HVAC<br>· Lay-In Ceilings<br>· Fixed Windows | 250 | $2.5 m | $10.1 m<br>Efficient HVAC<br>Collect 50% of Rainwater<br>50% of Materials that are Removed from Site are Recycled or Salvaged<br>Material Selection Based on LEED™ | $1.4 m | $1.3 m | $19.6m 30 Year Model<br>$45.3 m 60 Year Model<br>$218.4 m 100 Year Model |
| Market  | 40 Year Building<br>120' Wings<br>Big Box |  | · 2 Story Building<br>· Steel Frame<br>· Typical HVAC<br>· Lay-In Ceilings<br>· Fixed Windows | 461 | $3.2 m | $10.0 m<br>Typical Class "A" Office Building | $1.3 m | $1.3 m | $22.7 m 30 Year Model<br>$62.9 m 60 Year Model<br>$348.9 m 100 Year Model |



6000
5000
4000
3000
2000
1000
$35
$30
$25
$20
$15
$10
3000
2500
2000
1500
1000
500
Million Tons of Oil Equivalent
Wellhead Price of Crude ($/BBL)
Million Tons
Gigawatts (peak) per year
0.3
0.2
0.1
0.0
World Oil Consumption
US Price of Crude Oil
World Carbon Emissions from Fossil Fuel Burning
US-manufactured PV Production Growth
The practice of Sustainability is in many ways ancient.
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Sharp Corporation succeeds in producing silicon **PV models.**
PEM **fuel cell** technology invented at General Electric. This information is used for NASA's Project Gemini.
***Silent Spring*** by Rachel Carson is published, bringing together research on toxicology, ecology and epidemiology.
**The David and Lucile Packard Foundation** is created.
**EPRI** (Electric Power Research Institute) is founded.
Computer-controlled grid of 80,000 square mile Canada-United States Eastern Interconnection area causes 30 million people to experience a **blackout**.
***Population Bomb*** by Paul Ehrlich is published, establishing the connection between human overpopulation, resource exploitation and the environment.
**UNESCO** (United Nations Educational, Scientific and Cultural Organization) holds early discussions on the concept of ecologically sustainable development.
**EPA** (Environmental Protection Agency) is started by President Nixon.
**EPA** passes Clean Air Act.
First **Earth Day** is held.
***Limits of Growth*** is published by the Club of Rome.
**Village Homes** sustainable subdivision is started in Davis, California. Completed in 1981.
**ASES** (American Solar Energy Society) is founded.
**Energy Crisis** - The United States faces a national energy crisis while the price of crude oil nearly doubles during the Arab States oil embargo.
**Greenbelt movement** starts in Kenya.
**Endangered Species Act** is enacted.
**Bateson Building**, located in Sacramento, California, is completed.
**Amoco Cadiz** oil spill occurs off the coast of Brittany.
**Three Mile Island** nuclear accident occurs in Pennsylvania, USA.
New York State Department of Health announces a medical emergency at the **Love Canal**.
**World Resources Institute** is established in USA.
**Crude Oil** - An inflation-adjusted peak of nearly $30 per barrel.
**ING Bank** (formally NMB Bank) headquarters, located in Amsterdam, is completed.
**RMI** (Rocky Mountain Institute) headquarters, located in Old Snowmass, Colorado, is completed.

Organizations

Environmental Events

Political Events

Technology

Books

Iconic Green Buildings

**Drought in Ethiopia** causes 250,000 to 1,000,000 people to die from starvation.

**Bhopal, India** -Toxic chemical leak occurs; 10,000 dead and 300,000 injured.

**Antarctic ozone** hole discovered by British and American scientists.

***Our Common Future*** (Brundtland Report), a report of the World Commission on the Environment. The term "sustainable development" is coined.

**Chernobyl** - Accident at a nuclear station in the former Soviet Union.

**Montreal Protocol** on substances that deplete the ozone layer is adopted.

**Exxon Valdez** tanker runs aground and dumps 11 million gallons of oil into Alaska's Prince William Sound.

Hundreds of **oil fires** burn out of control in Kuwait for months following the Persian Gulf War.

***Ishmael***, a novel by Daniel Quinn.

The first **Earth Summit** is convened in Rio de Janeiro, Brazil. The agenda 21 is established to address urgent problems of environmental protection and socio-economic development.

**USGBC** (US Green Building Council) is established.

***The Ecology of Commerce: A Declaration of Sustainability*** by Paul Hawken.

**C.K. Choi Building** is completed on the campus of the University of British Columbia, Vancouver.

**World Trade Organization** is established.

**Brent Spar** located in the North Sea - Greenpeace campaign against the sinking drill platform gets international attention.

**ISO 14001** is formally adopted as an international standard for corporate environment management systems.

**The California Assembly** votes unanimously to deregulate the state's electric industry and to dismantle what is considered a government-regulated monopoly.

***Biomimicry: Innovation Inspired by Nature*** by Janine M. Benyus.

***Green Development: Integrating Ecology and Real Estate*** by Rocky Mountain Institute.

**Green Building Challenge** is founded.

**Kyoto Protocol** is signed.

**Montana State University** pilot building is designed.

***Natural Capitalism: Creating the Next Industrial Revolution*** by Paul Hawken, Amory Lovins, Hunter Lovins.

The USGBC rating system, **LEED 1.0**, certifies 12 new buildings.

**California Power Crisis** occurs, causing millions of residents in this high-tech state to face a series of stage alerts, which almost always precede rolling blackouts.

Chesapeake Bay Foundation's **Philip Merrill Environmental Center** in Annapolis, Maryland is completed.

**Adam Joseph Lewis Center for Environmental Studies** in Oberlin, Ohio is completed.

1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Where will the future take us?

Abbreviated
Sustainability Timeline
The David and Lucile Packard Foundation's
Los Altos Project