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

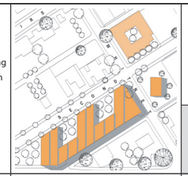
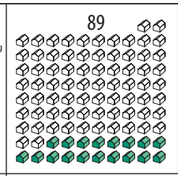
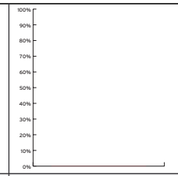
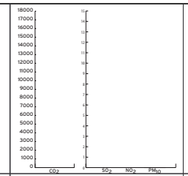
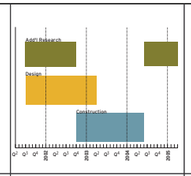
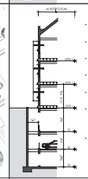
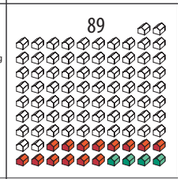
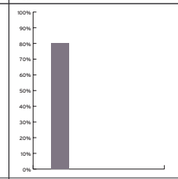
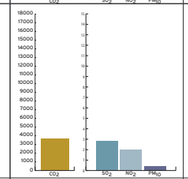
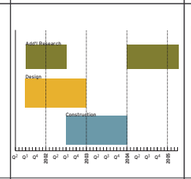
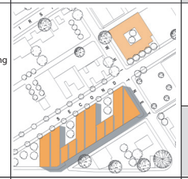
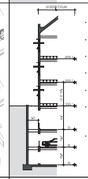
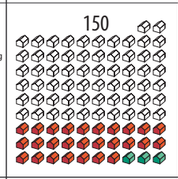
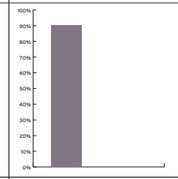
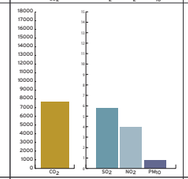
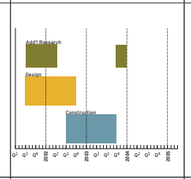
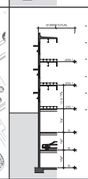
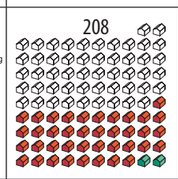
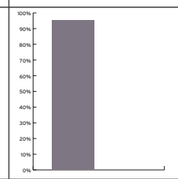
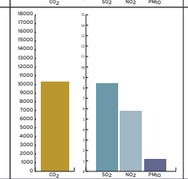
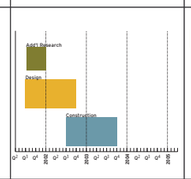
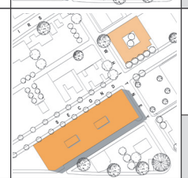
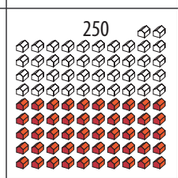
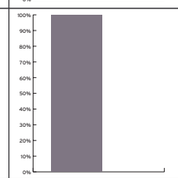
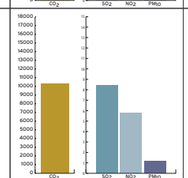
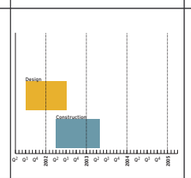
= Carbon Dioxide (tons) - Global Warming
= Sulfur Dioxide (lbs.) - Acid Rain
= Nitrogen Dioxide (lbs.) - Smog
= Particulate Matter < 10 Microns (lbs.) - Air Quality

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.

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

Building for Sustainability

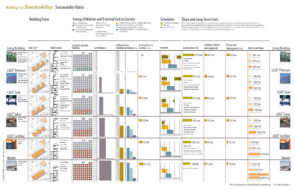
Sketch of downtown Los Altos, California

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 Systems and Fuel Cells.

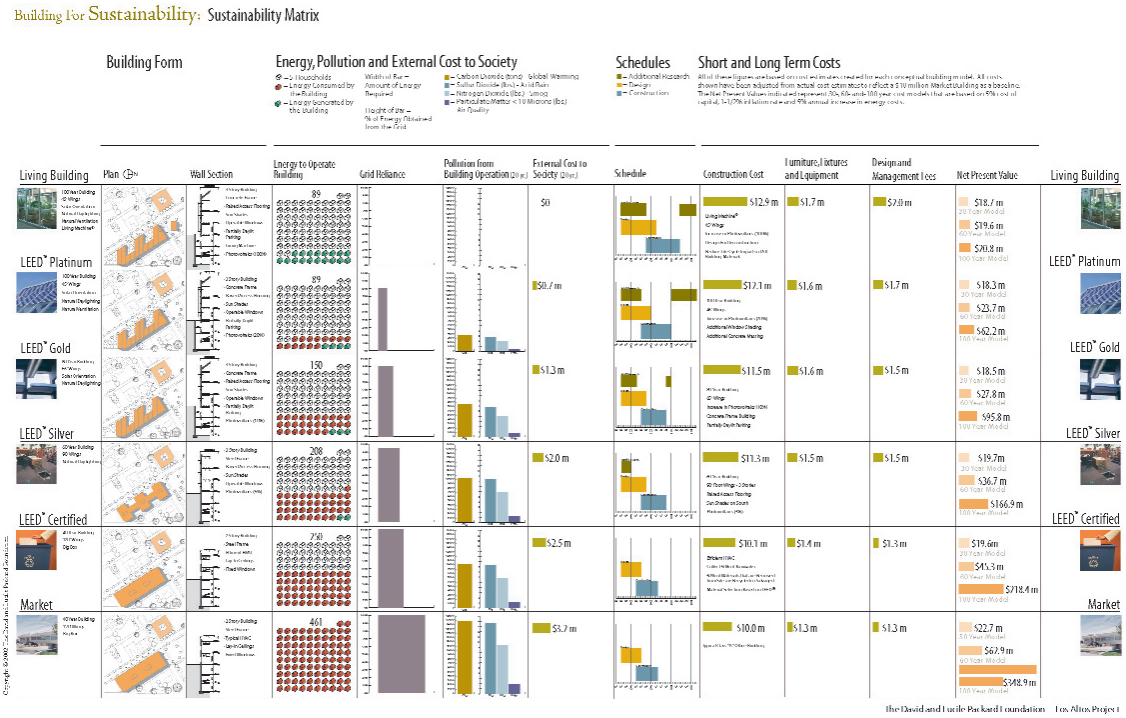
Sustainability Matrix

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.

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 for Sustainability



Building Form

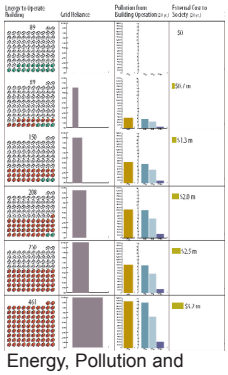
Building Form

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.*

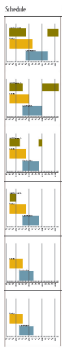
Energy, Pollution and External Costs

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 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

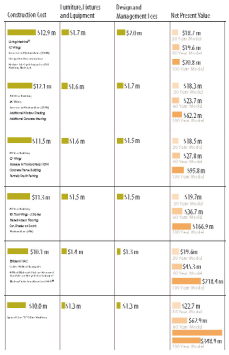
Building for Sustainability



Energy, Pollution and External Costs



Schedules



Short and Long Term Costs

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.

Photo Credits

BNIM Architects - Matrix (*Living Building, LEED™ Platinum, LEED™ Gold, LEED™ Certified*), Page 1 (*top*); Keen Engineering - Matrix (*LEED™ Silver, Market*)