



CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

The Value of Sustainability

By

Rachel Castillo & Ngai Chi Chung

**CIFE Working Paper #091
SEPTEMBER 2004**

STANFORD UNIVERSITY

COPYRIGHT © 2004 BY
Center for Integrated Facility Engineering

If you would like to contact the authors, please write to:

*c/o CIFE, Civil and Environmental Engineering Dept.,
Stanford University
Terman Engineering Center
Mail Code: 4020
Stanford, CA 94305-4020*

I) Abstract

The goal of our research project is to investigate what drives decision makers to choose sustainable measures for AEC projects. Our research object is three-fold: To understand the process and perception of sustainability in the AEC industry, to investigate the true economic cost and benefits of sustainability, and to assess the decision basis of sustainability: idealism or economics? Our research method includes a survey distributed to industry professionals to analyze their perception of sustainability, and three case studies on existing successful sustainable projects. Both the results of the survey and the case studies indicated that sustainable projects are driven primarily by idealism and not economic profit. However, based on the slight but existing economic benefits, as well as the equity and environmental benefits of sustainability, future owners may want to look into sustainability for more than just idealism.

II) Introduction

Sustainability can be defined as the “ability of developers, users, communities and societies to continue current practices, given predicted rates of demographic change, economic and social resources, objectives of developers, the community and society, carrying capacities of ecosystems” (Fischer, Kunz, Levitt, 2003) These environmentally-friendly designs have been emerging as a very important determinant of the value of a building due to its future impact on society and environment. Sustainable design and construction practices not only decrease negative impacts on the environment, they also provide economic benefits, productivity benefits, and enhance public relations. Sustainability improves the economic bottom line by reducing operating costs and optimizing life-cycle economic performance. Further economic benefits include increasing building valuation and improved risk management. Productivity benefits include improved occupant performance, reduced absenteeism and turnover rate, and increased productivity and sales. Public relations enhancements include decreased vacancy, improved retention, and marketing advantage established by the official LEED standard recognized throughout the industry (Gottfried, 2003).

However, there is a lack of data, especially in the private sector, on why some projects employ sustainable design measures and others do not. Our research goal is to find out how a sustainable project goes from the initiative, to proposal, then to construction phase in the practical AEC industry. We investigated the people and the process behind a successful green project. Our methods were to construct a survey of project developers and do detailed case studies.

III) Definitions

A) LEED and Sustainability

Leadership in Energy & Environmental Design (LEED)'s standard, established by the U.S. Green Building Council, defines "green building" by establishing a common standard of measurement. By providing design guidelines and a third-party certification tool, the LEED standard requires a company to earn points by using designs that improve occupant well-being, environmental performances and economic returns of buildings using established and innovating practices, standards, and technologies (USGBC, 2003A). LEED Certification allows projects to gain a four-tiered rating system: Platinum (52-69 points), Gold (39-51 points), Silver (33-38 points), and Certified (26-32 points). For a building to be LEED-certified, the developers must meet the appropriate sustainability requirements, complete information forms, and pay a fee (USGBC, 2003B). For the purposes of this paper, "sustainable" and "green" will be used interchangeably.

B) Triple Bottom Line Framework

Developed by SustainAbility, Inc., the Triple "E" Bottom line Framework is very useful in explaining the many benefits of sustainable building. The Triple Bottom Line (TBL) consists of Economic, Environmental, and Equity. The framework outlines a look at sustainability not just on the additional environmental value, but also on the economic and social (equity) value the buildings add – and destroy (Figure 1). At its narrowest, the term 'triple bottom line' is used as a framework for measuring and reporting building performance against economic, social and environmental parameters. At its broadest, the term is used to capture the whole set of values, issues and processes that companies must address in order to minimize any harm resulting from their activities and to create economic, social and environmental value (SustainAbility, 2004).

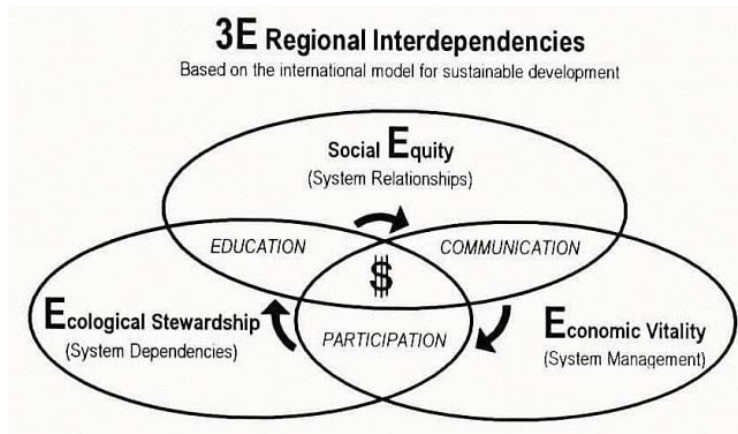


Figure 1: The Triple Bottom Line. Equity, Economics, and Ecology all impact the success of a sustainable building. Source: SustainAbility, 2004

IV) Background Research

A) UC Berkeley IEQ Survey

The Occupant Indoor Environmental Quality (IEQ) Survey is conducted by the Center for the Built Environment of University of California at Berkeley. This research developed and implemented a web-based survey instrument that quantifies how a building is performing from the perspective of its occupants. The Survey provides a cost-effective method of rating building performance for a range of environmental criteria. The primary conclusion of the research suggests that improved indoor environments could produce annual productivity gains of as much as \$168 billion in the U.S. (Center for the Built Environment, 2003).

B) Kats' Study

The Report “Costs and Financial Benefits of Green Buildings: *A Report to California's Sustainable Building Task Force*” by Greg Kats, the Chair of the Energy and Atmosphere Technical Advisory Group for LEED, suggests that sustainable building is a cost-effective investment (Kats, 2003). This study is currently known as the most definitive cost-benefit analysis of green buildings ever conducted, and its findings should encourage communities across the country to “build green.” The conclusions of the study indicate that the total financial benefits are over ten times higher than the average initial investment required to design and construct a green building. As shown in Figure 2 below, a large proportion of the benefit of sustainability is attributed to increased productivity and health of the occupants, concurring with the findings of the IEQ Survey.

Category	20-year NPV
Energy Value	\$5.79
Emissions Value	\$1.18
Water Value	\$0.51
Waste Value (construction only) - 1 year	\$0.03
Commissioning O&M Value	\$8.47
Productivity and Health Value (Certified and Silver)	\$36.89
Productivity and Health Value (Gold and Platinum)	\$55.33
Less Green Cost Premium	(\$4.00)
Total 20-year NPV (Certified and Silver)	\$48.87
Total 20-year NPV (Gold and Platinum)	\$67.31

Figure 2: The Financial Benefits of Green Buildings – Summary of Findings of Kats Study (psf). The greatest savings are due to Productivity and Health Value, an area difficult to measure and predict. Source: “The Costs and Financial Benefits of Green Buildings” by Greg Kats

C) “Building Momentum” Report

The Report “Building Momentum: National Trends and Prospects for High-Performance Green Buildings” based on the Green Building Roundtable identifies the current trends, barriers, and recommendations for sustainability methods in modern buildings (Green Building Roundtable, 2002). It suggests that sustainability is exhibiting enormous growth in popularity in the AEC industry as there are now 600 private and

public buildings, comprising 86 million square feet, that have registered for LEED certification. From May 2002 to February 2003, USGBC membership has jumped from 1500 to 2600 companies and organizations. The federal government remains major leader of green building, with the private sector beginning to join.

However, one of the barriers for sustainability includes the increase of initial costs from an average of 2 to 7 percent, and only some projects can recoup its overall net costs in a short period of time. In addition, decision-makers rarely use life cycle cost analysis to account for those reduced operating expenses and increased productivity and well being stemming from sustainability. This first-cost bias accompanied by the lack of research in the field of the cost benefit of green buildings comprises an unconvincing business case for high-performance green buildings.

The report, prepared for the U.S. Senate Committee on Environment and Public Works, recommends that sustainability can be increased through Federal Agency Projects requiring LEED certification, economic incentives, and further research and data collection.

D) “Business Case for Green Design”

An article in the November 2002 issue of *Building Operation Management* entitled “Business Case for Green Design” outlines the importance of communicating with senior executives in financial terms. In the past, when planning and constructing a building, cutting down up-front construction costs was all that mattered. However, the article describes how green buildings require a different kind of budget approach: one that takes into account life-cycle costs. The life cycle cost of a building includes continuous maintenance, energy, and repair costs. The savings in this cost window are extremely high, considering that less than 10 percent of the total life cycle cost of a building lies in construction. 60 to 85 percent lies in the ongoing expenses. However, it has been widely hypothesized that the major benefit of sustainable design stems from worker productivity. The article states that “if a sustainable design can help improve worker health, productivity or retention, the payoff is far greater than any reduction in building life cycle costs” (Morton, 2002).

E) Miscellaneous Information

Other reports such as “White Paper on Sustainability” sponsored by the U.S. General Services Administration made similar suggestions as the “Building Momentum” report on the benefits and popularity trends of green buildings (U.S. General Services Administration, 2002). The emergence and profitability of green building consultancies such as Kema Green (www.kemagreen.com) and the Capital E Group (www.cap-e.com) indicate the existing market of sustainability.

V) Objectives

The objectives of this VPUE-sponsored research project are two-fold:

- 1) Investigate how industry professionals perceive sustainability and how they propose/push sustainability through approvals and fundings to the final construction reality.
- 2) Identify the professional's perception of the benefits of sustainability and how much they value these benefits on their projects.

The consistent goal of our research is to gauge the perception of the decision makers of the industry. It is proven in studies that sustainability methods and other objectives improve the value of a building (Gottfried, 2004). However, if the industry decision makers are uninformed, these beneficial methods may not come true in real life AEC projects. This research aimed to find out if there exists significant discrepancy between the true value of green buildings and the perceptions of industry professionals.

We gathered data through an online automated survey (*see sections VI and VII*), and analyzed it for its significance and meaning. The results are saved on an online database for future addition of information, as well as ongoing research and benchmarking of building valuations.

In addition, three case studies were conducted on three different AEC projects that involved a number of sustainability measures: Jasper Ridge Sun Field Station, Montage Laguna Beach Hotel, and the California Academy of Sciences in Golden Gate Park (in construction). Interviews with key decision makers of the projects were performed, and economic and engineering data was obtained from the projects. By finding life cycle cost and benefits of sustainability, we are able to present an even more convincing case for sustainability, in an economic sense and beyond.

VI) Research Method

In mid-June 2004, we gave a survey to the attendees of Stanford University's Center for Integrated Facility Engineering's Summer Conference. In attendance were project managers, owners, engineers, and others in the AEC industry. The purpose of this survey was to identify the main objectives in an AEC project and their importance relative to one another. The first half of the survey asked general questions which pertained to any projects, while the second half applied only to sustainable projects. The questions regarding sustainable projects were to give insight to why companies decide to build green. However, after distributing the surveys, initial feedback led to its immediate revision. Some questions and concepts were clarified, and although it remained very similar to the first survey, it was re-distributed. This survey consisted of 43 questions, all questions multiple choice except those that required a dollar amount.

Once the conference ended, the results were analyzed in relation to the research. A newer, shorter, and more focused survey was then created. This survey intended to unearth whether it is common business practice to analyze the life-cycle savings of green buildings before construction, as well as why companies decide to build green. The

participants were asked to report information regarding any project they closely worked with that was at least proposed as a sustainable project. It was distributed through the Stanford University’s Center for Integrated Facility Engineering’s mailing list which is delivered to researchers, professors, AEC firms, and owners. This final survey consisted of 17 questions, 8 being multiple-choice or yes/no and 9 open-ended. See Appendix A for a complete list of questions and question type.

The hypothesis for all versions of the survey remained constant: because economic profit is the main objective of AEC projects, the initial costs of sustainable projects cause them to be built for idealism.

VII) Survey Results

The final and most useful draft of the survey had 25 responses. Clearly, this is not enough to make general conclusions about the business of sustainability, but the results do give some insight into the industry. Figure 3 shows that the majority of participants (70 percent) reported implementing sustainability because of environmental benefits. In Figure 4, we see that 75 percent of those who did not employ sustainable methods cited economic costs as their reason. In this particular survey, 33 percent of the participants said that the sustainable project was presented to decision makers in the form of economics. This number, while lower than the 58 percent whose projects were presented from an environmentally friendly standpoint, still indicates that some companies may choose sustainability for economic reasons (Figure 5). However, when asked to provide projected economic benefits of sustainability, most of the participants could not produce an exact quantity. Of those that did give a quantity, these numbers only took into account energy savings. Only 11 percent of the participants stated economic value as the most important reason for obtaining LEED certification of sustainability for the project.

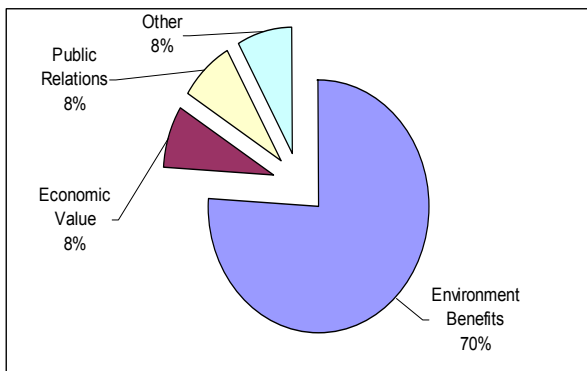


Figure 3: Most Important Reason Behind Sustainability. The dominating reason for building green in the AEC industry is environmental benefits.

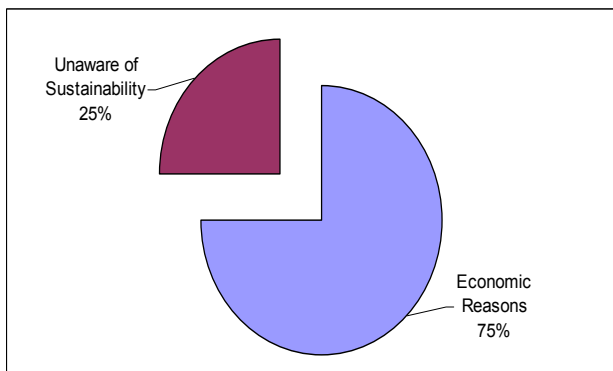


Figure 4: Reasons for NOT Implementing Sustainability. The initial investment in sustainability keeps companies from building green.

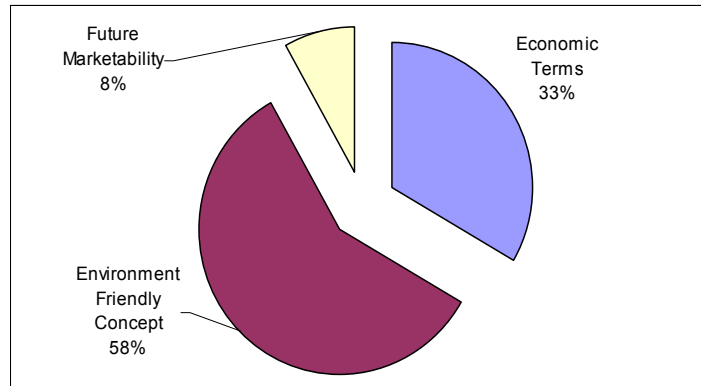


Figure 5: How was Sustainability presented to decision-makers? The AEC industry continues to look at sustainability as solely an environmental investment.

VIII) Case Study at Stanford’s Jasper Ridge

A) Introduction:

The Leslie Shao-ming Sun Field Station at Jasper Ridge Biological Preserve serves as a research and educational building for those working or visiting the preserve. As the educational base of the 1,189 acre area, the station houses several lab areas, offices, and classrooms. After its construction in 2002, the building quickly became Stanford University’s premier green building. Since then, the station has received the first San Mateo County Green Building Award, was a finalist in Stanford University Center for Integrated Facility Engineering’s Exceptional Building Competition in June 2004, and has influenced the preparation and planning of other green buildings (CIFE, 2004).

B) Final cost of building

Due to careful planning, the final cost of the Sun Field Station was 3.29 million dollars. Uncharacteristically, this number is on par with other, non-sustainable university buildings. It cost only \$249 per square foot, including the retail price of the donated photovoltaic panels. Extra costs incurred due to the sustainability of the building are as follows:

Other	\$2,948,667
Thermal windows	\$27,160
Photovoltaic panels	\$155,490
Solar Heating Panels	\$132,861
Rainwater Cistern	Do not know
Newsprint Insulation	\$25,822
Total	\$3,290,000

Reduced first- costs due to sustainability are as follows:

Recycled Furniture	-\$492,900	vs. New Furniture
Used redwood siding	-\$93,500	vs. New Redwood
Landscape/irrigation	-\$49,500	vs. Normal Landscaping
Lack of Air Conditioning	Do not know	

Source: Personal email from Philippe Cohen, 2004 C.

C) Why did they go Green?

In the case of the Sun Field Station, it was not the architects or engineers who decided on a green design, it was the owner. The Administrative Director of the preserve, Dr. Philippe Cohen, wanted an environmentally friendly site. To achieve this, Stanford University had to approve of the sustainable design. According to Dr. Cohen, he worked diligently to cut the cost of the project into a reasonable range. When first conceived, a sustainable building on the Jasper Ridge Preserve was estimated to cost over 5 million dollars. However, Dr. Cohen soon realized that the budget was made with certain assumptions that did not hold true in sustainable buildings, such as the presence of an air conditioning system. During a meeting with other planners, Dr. Cohen cut the budget down by over 1.5 million dollars. Stanford University was interested in keeping capital costs down. Neither Dr. Cohen nor Stanford University looked into the future and took into account life-cycle savings. The project was ultimately approved due to the reduced capital costs and the idealistic desire to have an environmentally friendly building (Cohen, 2004A).

D) Sustainability Measures (Cohen, 2004B)

1) Windows

The building's many southern-facing thermal windows are double paned, with a thin layer of film in between. This film creates two air pockets of insulation instead of one while allowing more light to enter the building than tinted windows. These windows reduce the amount of energy needed to warm the building, as well as prevent heat from entering the building during the warm months. These windows along with clear, non-thermal north-facing windows are generously installed on that side of the building, and along with skylights, provide enough natural light to eliminate the need for artificial light. Most rooms and offices have operable windows, allowing natural ventilation and cooling from the outdoors.

2) Photovoltaic Panels

These panels supply over 78% of the energy required by the Sun Field Station. In addition to their role as a free energy source, they shade the south side of the

building. Their position prevents the sun from directly shining into the windows which reduces the heat inside, as seen in Figure 6.



Figure 6: The photovoltaic panels not only generate solar heat, but also provide shading for the north side of the building during the summer months, reducing the internal temperature of the building.

Source: Jasper Ridge “Leslie Shao-min Sun Field Station”, 2004

3) Redwood recycling

The redwood siding of the building was gathered from local houses and buildings that were torn down, reusing it instead of putting it in a landfill. The used wood was less expensive than new redwood, and is also more durable due to the weather wear it had previously been through. The maintenance cost for used wood is also less than new redwood. Figure 7 shows the extensive use of used redwood on the building.



Figure 7: Stanford saved money using used redwood for the siding as opposed to new redwood.

Source: Jasper Ridge “Leslie Shao-min Sun Field Station”, 2004

4) Restroom Facilities

Both the men and women’s restrooms use less water than traditional restrooms. The men’s restrooms contain waterless urinals which prevents using 45,000 gallons of water a year. The women’s restrooms have double-flush toilets, which offer the option of using less water when flushing.

5) Recycled cabinets

The cabinets installed throughout the building were bought from a biotech lab that no longer used them. The station was able to purchase them for much lower than their retail value.

6) *Rain Cistern*

The station houses a 25,000 gallon cistern to collect rainwater. It uses this water for exterior landscaping and watering the dirt road surrounding the preserve for dust control purposes.

7) *Fly Ash Concrete*

Instead of traditional concrete, the station is comprised of fly ash concrete, which is made from the ashes of coal burning. The concrete costs the same as the traditional formula and is structurally the same. Figure 8 gives an illustration of the concrete and other sustainable features used in the Jasper Ridge building.

8) *Walls*

There are no load bearing walls in the station. This allows for easy and quick alterations to the building.

9) *Heating*

The station has solar hot water panels provide the majority of heating during the cooler months. Also, the south-facing insulated windows reduce the amount of heat let inside during the summer, while the north-facing windows allow the winter sun to naturally heat the building. The roof insulation was placed on the exterior of the building, which reduces thermal leakage.

10) *Newspint Insulation*

Old newspaper insulates the walls in the station. This not only helps the environment, but is more fire proof than traditional insulation.

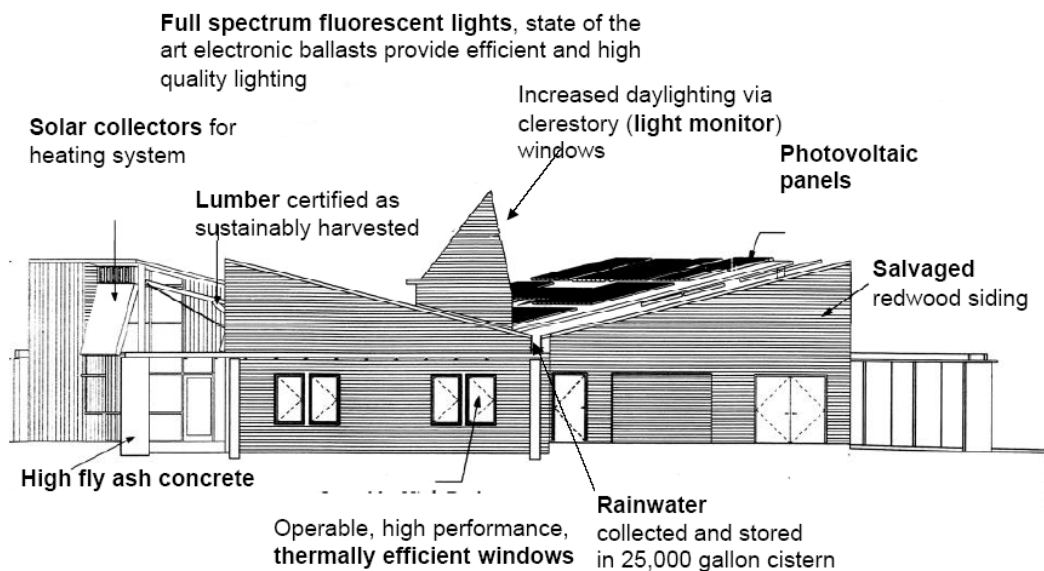


Figure 8 shows many of the sustainable features employed by Jasper Ridge. Almost all of these features either cost less initially or provide life cycle savings for the building.

Source: Jasper Ridge “Leslie Shao-min Sun Field Station”, 2004

E) Life Cycle Savings

Due to all of its energy-saving devices and photovoltaic panels, the Sun Field Station purchases very little power from its supplier, Pacific Gas & Electric. The photovoltaic panels supplied an average of 78% of the power used by the station since it began operation (Jasper Ridge Biological Preserve). From July 2003 to June 2004, Stanford University spent a total of \$928 on energy at the station (Gould, 2004). Compare this number to Vaden, a medical facility on campus with comparable usage, on which Stanford spent \$80,330 for electricity (Mann, 2004B). The university spent \$0.07 per square foot on the Sun Field Station versus the \$2.68 per square foot it spent on Vaden. This means on a building of the same size, Stanford would have spent \$34,580 more on energy in one year than it did at the Sun Field Station. Due to the cistern, the site saves \$146.25 a year on water. The waterless urinals provide a savings of \$81.25 (Cohen, 2004B).

Maintenance costs at Jasper Ridge's Sun Field Station were higher than those of Vaden. Between July 2003 and July 2004, Stanford University spent \$27,000 on maintenance on the Sun Field Station and \$38,000 at Vaden, yielding a difference of \$11,000 (Mann, 2004A).

Jasper Ridge		Vaden	
<u>Cost</u>	<u>PSF</u>	<u>Cost</u>	<u>PSF</u>
Energy: (per sq ft per yr)	\$0.06	Energy: (per sq ft per yr)	\$2.68
Maintenance:	\$2.04	Maintenance:	\$1.27
Taxes:	same	Taxes:	same
Rent:	same	Rent:	same
Productivity:	\$300	Productivity:	\$300
Net:	\$297.90	Net:	\$296.05
		Difference	\$1.85

(Selkowitz, 2004)

These numbers don't include productivity and health, the category in which most experts theorize that sustainable buildings have their greatest cost payback.

IX) California Academy of Sciences (Li, 2004)

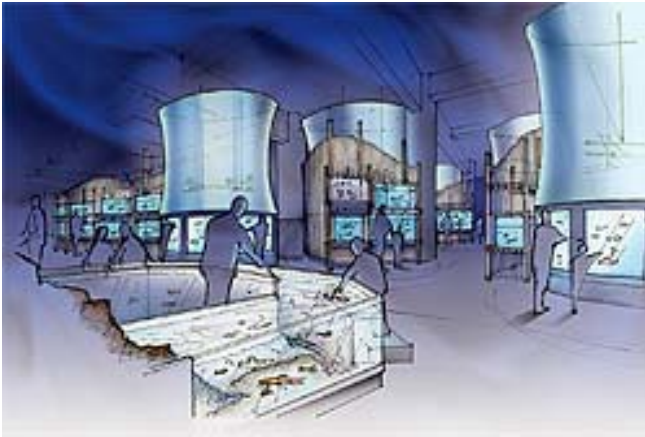


Fig. 9 – Sketch of the interior of the California Academy of Sciences. The high profile project will employ sustainable designs, some of which generate no economic profit or initial savings.

The project owner is the foundation of California Academy of Sciences. The owner's main objective in this project is to create an educational facility that is very high-profile. Therefore, the world-renowned architect Renzo Piano from Italy was employed to be the chief design architect of this project. The owner also pushed for LEED certification, mainly for public relations and image purposes. A cost analysis of the exact economic benefits of sustainability measures was never performed. It is almost impossible to do so because the project is designed in the first place with sustainability measures in mind, therefore, there is no baseline data of a non-sustainable project to compare it with.

One of the most prominent sustainable features includes the grass covered roof and the photovoltaic panels on the roof. The grass covered roof conserves energy by providing insulation for the building, thus yielding economic profits. It also earns 1 LEED point of being a Heat Island. The photovoltaic panels generate profit. However, other sustainable measures of the project may not yield significant economic savings. For example, forest-certified lumber was used to earn 1 LEED point. However, the forest-certified wood provided no significant economic or energy profit; it only yields a LEED point leading to marketing/public relations benefits.

X) Montage Laguna Beach Hotel Case Study (Claypool, 2004)

A) Introduction

The Montage Laguna Hotel is located on the coast of the beautiful Laguna Beach in Southern California. It has been in use for about a year, and generates the most revenue per hotel room in the United States.

The hotel property is divided into three parts: Residential, Park, and Hotel. The residential area consists of seven luxury condominiums and seven luxury estates yet to be built. The park stretches from the north to the south end of the property and is open to the public. The hotel consists of the guestrooms, a swimming pool, and restaurant.

B) Sustainability Measures

1) Recycled Water

The hotel utilizes recycled water from South Coast plant to water most of the landscape, except for the front of condominiums units because of safety reasons of accidental ingestion by infants or children. Claypool projects that the hotel uses 770 gallons of recycled water per day on average. He estimates that recycled water costs 30% less than potable water, and it is also invaluable in terms of environmental benefits.



Fig. 10 – Purple-colored sprinkler head, indicating recycled water. This prevents guests and workers from mistaking it for potable water.

Recycled water sprinklers and pipes are all colored purple to prevent confusion and to avoid potential consumption accidents. The extensive system of recycled water used for irrigation is built primarily because of the City Council/Government ordinance. The Laguna Beach City Council has strict guidelines concerning new hotel developments. However, Claypool and the hotel ownership are very proud of the cost savings and environmental benefits of the recycled water.



Fig. 11 – Plaque displayed publicly in the Hotel Park certifying Montage’s support of water conservation through using recycled water for irrigation, enhancing its marketability.

The plaque shown in Figure 11 is displayed in a very prominent location in the hotel park area, which shows that the use of recycled water not only improves the hotel economically, but also enhances its marketability. The Montage Laguna Hotel caters to high class hotel users, thus the image, quality and consistency of service are very important. A public display of the support of conservation undoubtedly adds to the hotel’s already refined customer image.

2) Web-based Chilled Water System Monitor

The hotel uses a web-based system to monitor the chilled water system of the building. The chilled water system utilizes a closed loop of water, in which any build-up inside would result in severely decreased efficiency and eventually a less-than-expected life expectancy. The web-based monitor keeps track of the Total Dissolved Content (TDC) and other ionic content of the chilled water. The system has only operated for one year, with an estimated energy saving of 15%.

However, since most ordinary chilled water systems in hotels are not equipped with this device, they often require expensive maintenance and repair costs during the system’s lifetime. Ordinary systems produce unstable service, have a shorter than expected lifetime, and often require extensive system repairs when failures occur. On the other hand, with the technologically-advanced monitor, the chilled water system at Montage is expected to last as long as or longer than its expected lifetime and has provided consistently high-quality service. The system is in place under Claypool’s push for the philosophy of investing in technology and investing in maintenance. He disagrees with the philosophy of delaying maintenance. He believes that cost cutting on maintenance and technology now will only result in catastrophic losses, such as the complete replacement of the extensive chilled water system.

3) Wastewater Redirection



Fig. 12 – The Montage Laguna Hotel is situated next to the ocean. The hotel’s close proximity to the water causes the environment to be a top priority for those planning and visiting the site.

Although Montage Laguna Beach is next to the ocean, the hotel does not pollute the environment by dumping its wastewater into the ocean. 10% of its total capacity of storm water direction is redirected back to sanitation. Under most normal circumstances, 10% of its total storm capacity is more than enough to direct all of its landscape irrigation water and light rainwater into sanitation. This system is in place because of government ordinance, but it also helps the hotel economically by reducing the cost of supplying some of the sewage water to almost none.

4) Astronomical Clock-Dependent Light Settings



Fig. 13 – The restaurant “Studio” utilizes astronomical clock-sensitive light settings to conserve energy and maintain a consistent lighting environment.

Astronomical clock-dependent light adjustments are implemented in the gourmet hotel restaurant “Studio”. Seeing that sunrise and sunset occur at different times of the day every day, the computer controlled system adjusts the interior lighting according to the astronomical clock. There are three main modes of lighting schemes: Day, Twilight, and Night Dining. Weather conditions may vary depending on the day, but experience shows that it does not alter the appropriate light scheme much. The restaurant employees can manually override the computer settings if the weather is very extreme. This system is in place not only to conserve energy, but also to produce a consistently good dining atmosphere for the guests. Claypool believes only consistently good service will keep

customers coming back for more. This is ultimately an economic benefit as Montage has a loyal consumer base.



Fig. 14 – Getty Museum’s Computer-controlled Skylight is similar to those in the Montage Laguna Beach Hotel. They are installed in various galleries that change their angles to let a different amount of light in as the outside conditions vary, saving money and increasing the amount of natural sunlight in the room.

The idea is very similar to the computer-controlled skylights in the Getty Museum. They both provide economic benefits *and* quality improvement. The Getty Museum skylights are installed in various galleries that change their angles to let a different amount of light in as the outside condition varies. This system not only saves money on energy, it also lets the viewers see the art under natural sunlight, the way art was meant to be seen. This benefit is invaluable.

5) Web-based System Monitoring Technology

Since the owner and the operator of the Montage Hotel are from the same company that Claypool represents, it is possible for Montage to push the construction design company to employ all the best technology rather than the cheapest technology that can do the job for a short period of time. The technology emphasis is put in place because the operators of the hotel know what they would like, and as the owner of the hotel, they can make it happen. Claypool believes that good maintenance can save cost in the long run.

Claypool aims to, with the Montage Hotel, let computer software do as much operating and monitoring as possible. This philosophy can reduce the human factor in maintenance, thus reducing employee costs and human errors. This web-based monitoring system can ensure a consistent quality of maintenance and service. The employees who control this advanced maintenance system are highly trained and are all established in Claypool’s effective and responsible work culture.

A software program with a very intuitive user interface controls all of the hotel’s utilities. The computers throughout the hotel are all connected through a central hotel server, so settings of the hotel systems can be changed from multiple locations in the hotel. Their own hotel server eliminates the possibility of Internet server failures. Since the system

can be securely accessed on the web, employee can make changes instantly on the system from their own homes. When certain utilities, chemical content, anything that seems out of the ordinary, the software programs are set to give off an alarm in the form of emails, text messages, and phone calls to hotel maintenance employees to notify them of the problem. The hotel employees would then attend to these problems. Claypool believes that it is more efficient when human personnel only fixes problems when there are problems, and leave the mundane system monitoring to the computer.

We have tried repeatedly to contact hotel personnel to obtain projected and actual economic savings of the sustainable measures. No quantitative data has been received as of the time of this report.

XI) Analysis

According to the numbers from Scott Gould, the Leslie Sun Field Station saved nearly \$35,000 on energy alone this past year, as well as over \$200 on water as compared to a building of the same usage but lacking sustainable measures (2004). Based on these numbers, the building has a projected savings of over \$1.4 million over the next 40 years. Due to precise planning, the Sun Field Station's budget matched that of other similar-use buildings and had no additional capital costs. Therefore, all the savings from sustainability can theoretically be considered net profit.

Along with the measurable savings from energy, water, and waste as mentioned earlier, the single largest benefit of a sustainable building comes from increased worker productivity [Kats, 2003]. With money savings at every corner, building green makes business sense, independent of its environmental impact. The capital costs of the buildings should not prevent owners looking to make a profit. Also, along with others, the AEC industry is finding they are able to cut down the extra costs associated with green buildings. The construction of sustainable buildings with budgets equal to that of their traditional counterparts has been growing according to *Building Operating Management* (2002). Large money savings inherently lie in sustainability.

XII) Conclusions

Although this money savings can be approached as a vital aspect of sustainability, it seems that companies and organizations have largely ignored this benefit in their executive decision making. Neither the Sun Field Station nor Montage Laguna Beach Hotel had predicted life-cycle savings during the planning stages, and still lacked them at the time of this research. Written information on green buildings focuses largely on environmental benefits. Articles, public focus, and industry attention a sustainable project receives all result from its novel environmental saving ideas. Recently, more studies on the savings of sustainable design have come about, but the driving reasons behind building green remain environmental. Companies who build green continue to do so mainly for idealistic reasons, and not for profitable ones.

XIII) Recommendations

Triple Bottom Line: Economic, Ecology, and Equity (SustainAbility, 2004)

For sustainability to branch beyond its environmentalist clientele base, it must clearly show the owners and decision makers that it can improve the project in the aspects of economics, ecology, and equity.

Firstly, sustainability needs to be recognized not only as environmentally friendly, but also as a worthy investment. For the most part, the AEC industry does not market sustainable design as a profit boosting enterprise. However, marketing in this way may be what it takes to provide sustainable methods a mainstream market. The user of a sustainable facility will likely experience a rise in worker productivity and an overall well-functioning building. Architects and engineers should lower the initial cost of building green through careful planning which will increase business. Life-cycle cost analysis coupled with lowered capital costs of proposed sustainable designs and the profit involved will likely win over owners and investors who would otherwise give the new method no attention at all.

Secondly, considering ecology, it is undeniable that sustainable buildings vastly improve the environmental impact as compared to their traditional counterparts. Not only are the energy and water usages drastically reduced, but the waste from these buildings decreases significantly as well. During construction, most of these buildings help to reduce waste from other buildings by using recycled material. In green buildings, the negative environmental effects that inevitably result from a building are as minimal as today's technology can allow.

Thirdly, equity must be taken into consideration by decision makers. Sustainable buildings provide all the same functions and comforts of a traditional building. In fact, due to the improved air quality, many theorize that the comforts of a sustainable building to be higher, but this claim has not been proved with any statistical data as of yet. Because worker productivity cannot easily be measured, sustainable designs do not yield a high enough predictable profit to use economics as a sole reason for construction. However, the amount that they do save should not be ignored when making business decisions. Also, as experience in green building grows, the incremental capital costs are decreasing to the point where the budget and quality of a sustainable project matches that of a traditional building. This economic benefit coupled with the enormous environmental improvement should be the driving force behind building green. The exclusively idealistic approach many are taking today shuts out potential owners. Green buildings have constantly decreasing additional costs associated with their construction, no decrease in performance, and large environmental benefits. It is only fair that owners should look towards green building because it offers similar costs and benefits as a traditional building, but will improve our environment, productivity, and future.

XIV) The Future

As we continue our undergraduate education at Stanford University, we plan to investigate sustainable building options by researching more cost-effective building systems (first cost + life cycle). Since we have learned a great deal about sustainable design this summer, we plan on taking that knowledge with us into future research and classroom projects. We encourage the Civil and Environmental Engineering Department at Stanford to emphasize, educate, and promote the benefits of green building. As for the AEC industry, we recommend they look beyond the idealism and into the economics of sustainability in order to enhance their quality, equity, and image.

Appendix A
Survey Questions

Question	Answer
1) Have you worked with an AEC project that proposed using sustainable methods?	Yes/No
2) Did the project ultimately use sustainable methods?	Yes/No
3) If your project used sustainable methods, what were the most important reasons for sustainability?	Multiple Choice
4) If Other, please specify	Opened Ended
5) If your project did not use sustainable methods, what were the most important reasons for NOT using sustainability?	Multiple Choice
6) If Other, please specify	Opened Ended
7) How was sustainability proposed to the Owner/Financial Officers/Other Decision Makers?	Multiple Choice
8) What was the projected economic impact (including additional design/construction costs and future life-cycle savings per year) of sustainable methods at the time of project proposal?	Opened Ended
9) If sustainable measures were used in the project, what is the actual measured economic impact of these sustainable measures?	Opened Ended
10) If the project has a LEED certification, what are the most important reasons behind obtaining certification?	Multiple Choice
11) If Other, please specify	Opened Ended
12) If the project does NOT have a LEED certification, what are the most important reasons for not certifying it?	Multiple Choice
13) If Other, please specify	Opened Ended
14) Do you plan to change the way you present sustainability methods in the future? In what ways?	Opened Ended
15) Your position on the project	Multiple Choice
16) If Other, please specify	Opened Ended
17) What is the main function of the building?	Opened Ended

Bibliography

- Center for the Built Environment. "Occupant Indoor Environmental Quality (IEQ) Survey." November, 2003.
- CIFE, Stanford University. "First Annual CIFE-CDI Award for Achieving Exceptional Building Project Value." Accessed June, 2004. <http://www.stanford.edu/group/CIFE/sp04/ExecProgram/index.htm>.
- Claypool, Bill A. Personal Interview. 11 July 2004.
- Cohen, Philippe. Personal Interview. 6 July 2004A.
- Cohen, Philippe. Personal Interview. 15 July 2004B.
- Cohen, Philippe. Email to Rachel Castillo and Ngai Chi Chung. 6 July 2004C.
- Fischer, Martin, Kunz, John, and Levitt, Raymond. "Management and Leadership Education for Civil Engineers: Teaching Virtual Design and Construction for Sustainability." 2003. Accessed July 2004. <http://www.stanford.edu/class/cee320/CEE320A/Sustainability.pdf>.
- Gottfried, David. Personal Interview. May, 2004.
- Gottfried, David. "The Dollars & Sense of Green Building." Stanford University. 9 October 2003.
- Ghould, Scott. *Re: Request for energy costs for Leslie Sun Field Station*. Email to Rachel Castillo. 3 August 2004.
- Green Building Roundtable. "Building Momentum: National Trends and Prospects for High-Performance Green Buildings." April, 2002.
- Jasper Ridge Biological Preserve, Stanford University. "Leslie Shao-ming Sun Field Station Energy Monitoring Kiosk." Accessed July, 2004. http://jrsolar.stanford.edu/kiosk/slow_kiosk.html.
- Jasper Ridge, Stanford University. "Leslie Shao-ming Sun Field Station." Accessed August, 2004. <http://cife/sp04/EB/Sun.pdf>.
- Kats, Greg. "The Costs and Financial Benefits of Green Building: *A Report to California's Sustainable Building Task Force*." October, 2003.
- Li, Wendy. Personal Interview. 2 August 2004.

- Mann, Chuck. *Re: Request for energy costs for Leslie Sun Field Station*. Email to Rachel Castillo. 3 August 2004.
- Mann, Chuck. *Re: Request for energy costs for Leslie Sun Field Station*. Email to Rachel Castillo. 29 July 2004.
- Morton, Steve. "Business Case for Green Design." *Building Operating Management*. Nov. 2002. Accessed July, 2004. <http://www.facilitiesnet.com/BOM/Nov02/Nov02environment.shtml>.
- Selkowitz, Steven. Email to John Kunz. April, 2004.
- SustainAbility. "The Triple Bottom Line." Accessed August, 2004. <http://www.sustainability.com/philosophy/triple-bottom/tbl-intro.asp>.
- U.S. General Services Administration. "White Paper on Sustainability: Building Design & Construction." November, 2002.
- USGBC (U.S. Green Building Council). "An Introduction to the US Green Building Council and The LEED Green Building Rating System." 18 March 2003A.
- USGBC (U.S. Green Building Council). "LEED Green Building Rating System (LEED-NC v2.1)." 14 March 2003B.