

Costing Green: A Comprehensive Cost Database and Budgeting Methodology

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DAVIS LANGDON

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Introduction

The first question often asked about sustainable design is: what does 'green' cost, typically meaning does it cost more? This raises the question: more than what? More than comparable buildings, more than the available funds, or more than the building would have cost without the sustainable design features? The answers to these questions have been thus far elusive, because of the lack of hard data.

This paper uses extensive data on building costs to compare the cost of green buildings with buildings housing comparable programs, which do not have sustainable goals. The foundations are also laid to analyze incremental costs over starting budgets, and to compare the costs for different specific measures and technologies. Additionally, we present a budgeting methodology that provides guidelines for developing appropriate budgets to meet the building program goals, including sustainability goals.

This report looks only at construction costs. It is true that the costs and benefits of sustainable design can and should be analyzed holistically, including operations and maintenance implications, user productivity and health, design and documentation fees, among other financial measurements. However, it is our experience that it is the construction cost implications that drive decisions about sustainable design. By assisting teams to understand the actual construction costs on real projects of achieving green, and by providing a methodology that will allow teams to manage construction costs, we hope to enable teams to get past the question of whether to green, and go straight to working on how.

From this analysis we conclude that many projects achieve sustainable design within their initial budget, or with very small supplemental funding. This suggests that owners are finding ways to incorporate project goals and values, regardless of budget, by making choices.

However, there is no one-size-fits-all answer. Each building project is unique and should be considered as such when addressing the cost and feasibility of LEED. Benchmarking with other comparable projects can be valuable and informative, but not predictive. Any assessment of the cost of sustainable design for a particular building must be made with reference to that building, its specific circumstances and goals.

Basis of Analysis

A Measure of Sustainability

The United States Green Building Council (USGBC)'s Leadership in Energy and Environmental Design (LEED[®]) rating system is useful for gauging level of sustainability, or 'greenness' in a building. Thus, in order to answer the question of the cost of sustainable design, we can look to the costs involved in meeting each level of LEED certification when compared to non-LEED buildings.

The USGBC developed the LEED rating system, "a voluntary, consensus-based national standard for developing high-performance, sustainable building¹" as a measure to assess the sustainability of buildings in the United States. Using a point system, project teams identify sustainable design measures that can be incorporated into the project, and self-evaluate their success in doing so. If the building meets certain qualifications, it is recognized, with certification levels of Certified, Silver, Gold, or Platinum. The highest levels of certification (Gold and Platinum) are intended to require significant effort and ingenuity on the part of the project owners and designers, challenging them to push the boundaries and create highly efficient, sustainable buildings to serve as examples, and push market transformation.

LEED provides a means to actually measure sustainability using accepted standards and methodologies, and often using cost and quantities as determinants. It therefore lends itself to statistical analysis. Also, LEED has effectively become the accepted standard for measuring green design in the United States; most project teams have the basic knowledge allowing them understand the implications of the analysis undertaken here.

Gathering the Information: The Davis Langdon Knowledgebase

As a cost consulting company, Davis Langdon analyzes the detailed costs for hundreds of projects each year. Each of these projects contains important information that can be used to compare buildings and help determine costs for future buildings. Corporate experience over the past thirty years includes estimating work for thousands of projects, on every continent (including Antarctica)

One of the main focuses of Davis Langdon's research department has been to establish an internal knowledge database to serve as a clearinghouse of cost information for all projects estimated within the Davis Langdon offices. At the time of this report, the database contains information from nearly 600 distinct projects in 19 different states, encompassing a wide variety of building types, locations, sizes, and programs. As information from new projects is added to the database, the number of building programs and locations represented will continue to increase.

This database provides an opportunity to evaluate a large number of projects across a range of project types. We track the construction costs and design parameters of all of our projects. This includes quantitative measures of the buildings, as well as specific sustainability measures and LEED points targeted, or achieved, by the building. We also track detailed cost and program data and design narratives.

The most common program types for projects in the knowledgebase are (in no particular order):

- Universities and Colleges (academic buildings)
- Classrooms (higher education and K-12)
- Laboratories (academic and commercial)
- Offices
- Hospitals
- Libraries
- Multilevel Parking Structures (underground and above ground)

¹ LEED http://www.usgbc.org/leed/leed_main.asp

- Theaters
- Gymnasiums, Multipurpose rooms, and Auditoriums
- Sports Facilities
- Museums and Art Galleries
- Animal Care Facilities (such as shelters and vivariums)

In addition to these, the knowledgebase contains cost data for courthouses, visitor and community centers, police and fire stations, emergency operation centers, hotels, convention centers, retail stores, restaurants, apartments and student housing, and many other program types.

While the database was built to store information about each project such as estimate phase and date, inclusions and exclusions, and construction conditions, the main focus of the knowledgebase centers on the collection of component cost information for the projects. This data allows us to run comparison reports for total costs as well as individual component costs, across program type, building size, or project location.

Customized search functionality built into the database provides the ability to specify selection criteria, such as program type or location. Once criteria are specified and the search is run, a list of projects is displayed, which can then be sorted, selected or discarded as needed. Once selected, the data is then extracted into a side-by-side comparison within a worksheet, listing control quantities and component costs, and displayed as total numbers and as cost per square foot. If desired, design development or cost contingencies stored with project information can be applied to all costs as they are extracted. Once the data is extracted, further statistical or graphical analysis can easily be performed.

In addition to cost data, the knowledgebase also stores point-by-point information about LEED for applicable projects. For each point that is sought the database stores credit identity, cost for the point (where applicable), level of point achievement, and any notes that may be necessary to provide explanation for the point attempted or achieved. This information is stored to allow quick calculations of total points per project, as well as to provide statistical analysis on which points projects are or are not seeking.

Feasibility and Cost

Point by Point Analysis

The LEED rating system comprises 7 prerequisites and 69 elective points, grouped into 6 categories. Of these, some will result in no additional cost to a project, while others may result in an identifiable cost. When considering LEED for a building project, it is crucial first to determine which points are achievable by the project. From there, an understanding of the potential costs of each achievable point can be developed.

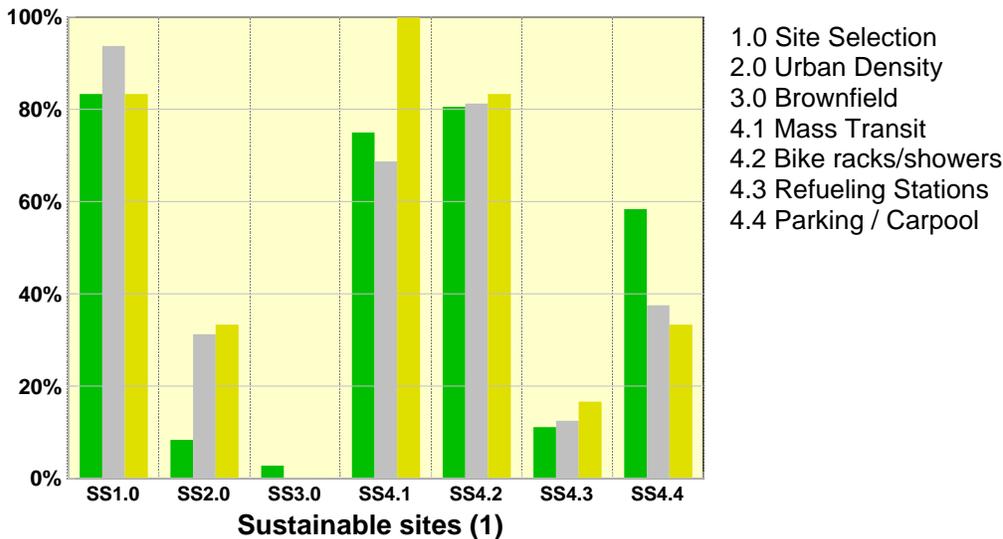
The following section discusses feasibility of each LEED point, based on the points either earned or being attempted by the projects studied for this report.

The graphs shown in each category discussion show the percent of projects that have indicated that they expect to qualify for those points. For the purposes of this paper we determined that a point would be counted if it was specifically included in the design and budget for the project; where a point appears to be wishful only, it has been excluded. Additionally, feasibility is divided by LEED category. The green bars indicate those projects aiming for Certified; the silver bar is for Silver ratings, and the Gold bar encompasses both Gold and Platinum projects.

Following each graph is a discussion of the more salient implications. Further study of the links between cost and feasibility is underway and will be made available at a later date.

Point percentages were calculated based on LEED checklists obtained from 61 LEED-seeking projects selected from our knowledgebase.

Sustainable Sites



It is our experience that building project sites are rarely selected for their LEED-related impact. The first four points have to do with site selection, urban density, brownfield reclamation, and proximity to mass transit; the ability of a project to get any of these points is usually unconnected to whether or not the project has a LEED goal.

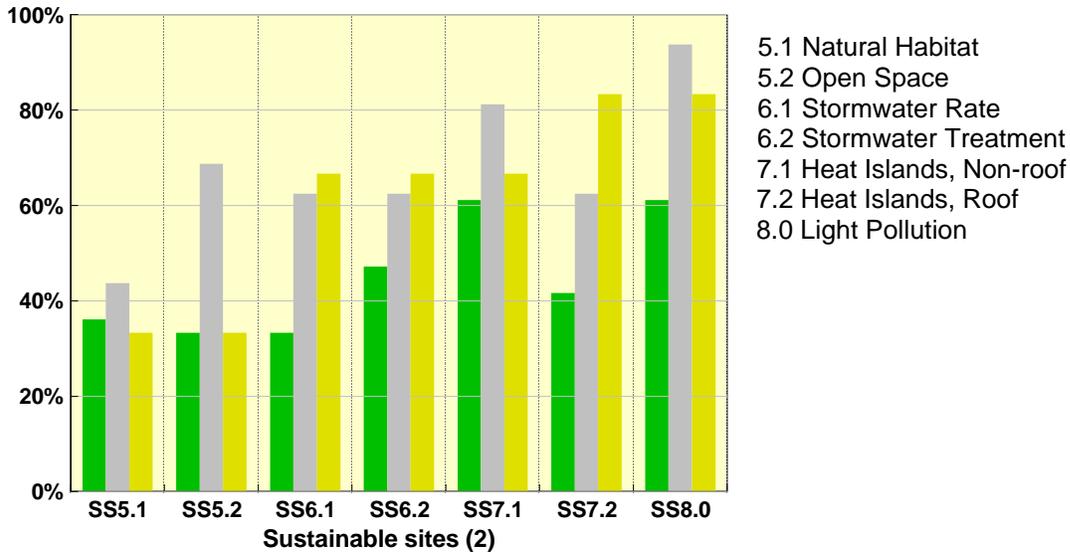
One of the more prescriptive LEED points, Site Credit 4.2 requires the provision of bike racks and showers. This is a relatively inexpensive point with low design impact; most projects target this point from the start.

Site Credit 4.3 similarly has relatively low cost and design impacts; electric refueling stations can be added almost any time during design and construction. However, electric cars are not the future trend once expected, and there are no other market-ready options available. While this

point can be awarded if an owner provided a fleet of alternatively fueled vehicles, our database contains only a handful that have taken this route.

Most projects that achieved Site Credit 4.4 did so by making minimal design changes – adding striping and signage for car and vanpool parking. Few projects actually reduced total parking in order to achieve this point. This is therefore a low cost and design impact point.

Like all the Prerequisites, Erosion and Sedimentation Control, is not shown on the chart. In terms of cost, the standards and technologies are standard to most projects, or easily achieved at minimal added cost.



Unlike site selection, site design is often modified to meet LEED criteria. In general, most Certified projects achieve 5 or 6 of the total 14 available site points, with the higher LEED levels achieving 9 or more.

Credit Site 5.1 requires either the minimization of site construction – usually achieved only where there is minimal construction cost implication, i.e. where substantial excavation is not required, or by restoring half of the non-building area to natural habitat. Projects in our study achieved this point typically by replacing a portion of plant materials with native species. Credit 5.2 is also typically achieved at minimal cost or not achieved at all; we have not seen projects actually reduce their development footprint by any appreciable amount. Rather, projects have realized that open space is indeed available and have obtained commitment from the owner.

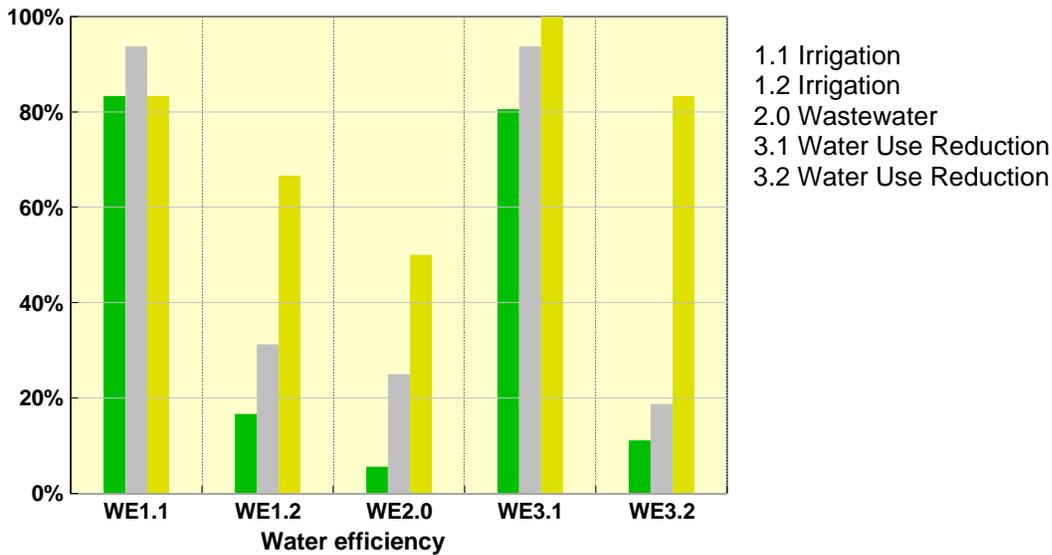
Methods used to slow stormwater flow, and to treat stormwater, are linked to LEED Site Credits 6.1 and 6.2. Site size plays a significant role in whether or not the stormwater-related points result in additional cost. Swales tend to have a minimal cost impact, retention or detention ponds are more expensive, and installation of stormwater collection tanks can be very costly. Projects on large sites tend to install swales or ponds, while buildings on limited sites, usually urban, use collection tanks and filters to meet this point. In general, projects used the less costly approaches, or did not attempt the rate and quantity point, choosing to target treatment only using filters. Several Silver and Gold projects used the more costly underground tank approach to the first point; these projects also capitalized on opportunity for synergies between this point and other irrigation and water use reduction points.

Most LEED projects target the first heat island effect point, SS 7.1. This is most often achieved by changing the color of concrete paving and adding shade elements for relatively low cost, with design standards being the only impediment.

Specification of high-emissivity roofing for the second point can be costly. However, design impacts are minimal and the change relatively easy to make if undertaken early enough. We have seen few projects attempt this point via a green roof. This may have a little to do with cost, but probably has more to do with perceived structural and maintenance issues, more substantial aesthetic impact, and added design effort.

Most projects attempt Light Pollution Credit, SS C8.0. However, many will not achieve it. Clients and code officials often perceive this point to be at odds with security requirements. In addition, project teams may be dissuaded because the standards cited are not always well understood and the required documentation time consuming. Hard costs are reasonable, typically having to do with the placement of more light standards.

Water Efficiency



Irrigation point WE 1.1 is typically easily achieved by designing high efficiency irrigation, at minimal cost, although this can be difficult to achieve if the landscaping includes turf grass. (The use of turf grass can also preclude attainment of Site Credit 5.2; it is often impossible to filter phosphorous used in fertilizing lawns to the standard required for the point.)

While the first irrigation point is high on the list of points to attempt, the second is less popular. This is often because the decision to install no permanent irrigation requires stronger commitment than many project owners feel. Most projects that achieved this point by using reclaimed water did so using water supplied to the site by the local water district. Costs were therefore low. Where reclaimed water was available, project teams often elected to bring the water into the building for use at sewage conveyance, thus achieving several more points.

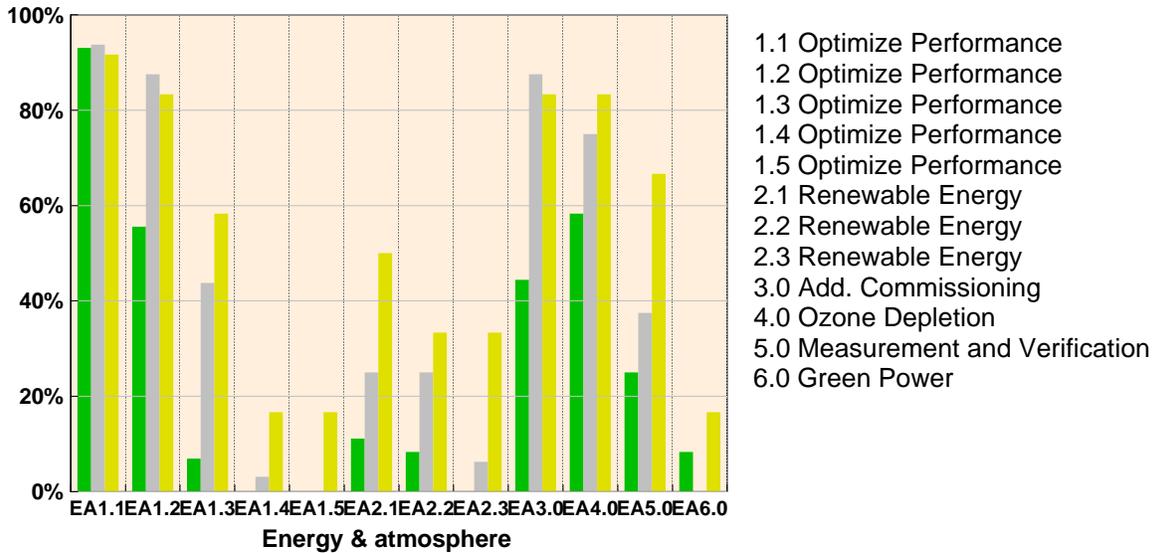
The preponderance of projects that achieved Water Credit 2.0, the wastewater point, did so by installing waterless urinals and low-flow toilets. While there is usually no cost impact to the use of the urinals, there may be difficulty in implementation. This is still unfamiliar technology in many areas, and resistance from operators and code officials can be a stumbling block to achieving this point. Feasibility is therefore often a larger concern than cost.

The installation of low flow fixtures and other standard water saving devices such as faucet aerators or sensor flow controls in public bathrooms facilitates achievement of the water use reduction point WE 3.1. The second point is often more difficult to achieve and is usually only attempted by those projects reaching for a higher level of LEED certification. This point is often achieved in conjunction with Credit 2.0 by the use of waterless urinals.

In general, Certified and Silver projects tended to achieve the first irrigation and water use reduction points, using standard technologies at no additional cost. Gold and Platinum projects tended to achieve all 5 water points, typically at reasonable added cost, but with significant

commitment. Further analysis will look at the synergies between these and other systems and site points.

Energy and Atmosphere



In many cases, projects can earn the first two to three energy use reduction points with relatively little changes to the existing design approach. local code requirements often establish minimum levels of efficiency which allow a project to qualify for some of these LEED points very little additional effort and cost. However, as the graph shows above, as energy use reduction requirements rise, the difficulty in reaching those levels also rises, and the last few energy use points are usually only attempted by projects hoping to qualify for the higher levels of LEED. These points require a high level of integrated design and/or innovative technology. Costs range widely; some projects added significant costs and others actually save money. In every case, an integrated design process and early commitment to sustainable design enable high achievement.

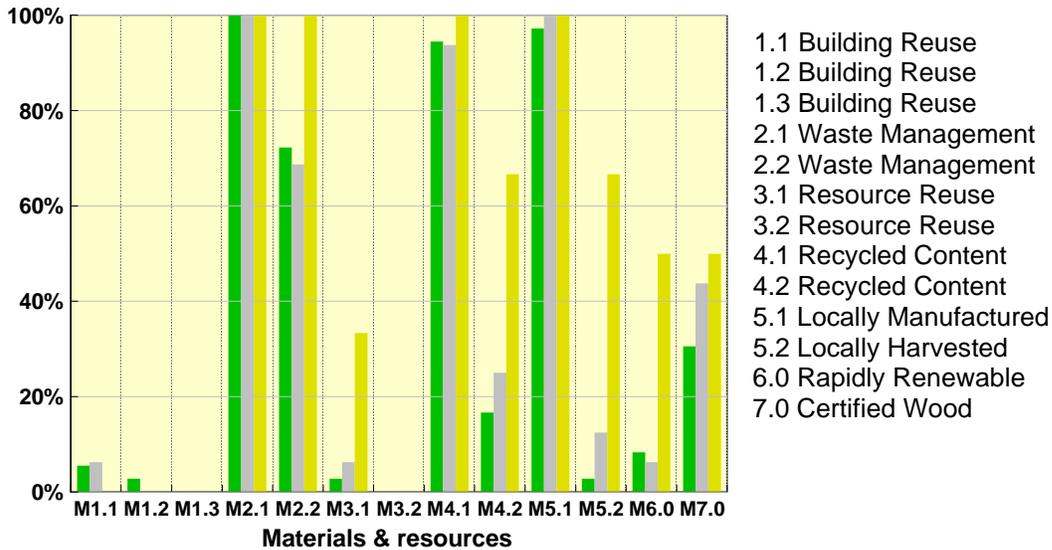
On-site generation of renewable energy – almost always photovoltaics – has a substantial construction cost impact. However, installation of these systems usually provides a long term cost savings. Additionally, incorporating renewable energy into design will earn the project at least one additional energy use reduction point. Many projects offset costs through available incentives, integration of photovoltaics into architectural features, and overall reduction of energy use requirements.

The additional commissioning point represents a reasonable added cost as compared to the substantial costs that come with attaining the commissioning prerequisite. Point feasibility is more often predicated on design team intent than on cost; this is one of the few LEED points that literally requires early commitment.

Many projects attempt to qualify for the additional measurement and verification point. However, this point requires a higher level of monitoring than provided by most Building Control Management Systems, and so will result in substantial added costs. Projects attempting this point typically have fairly complex systems, and users/operators that are likely to actively use the resulting data. In our study, this point was targeted by laboratories and larger buildings on campuses with a strong facilities department. Many of these projects use the DDC for user education as part of an innovation point.

The acquisition of offsite-generated renewable energy is typically considered an operations rather than first cost, and is usually reasonable.

Materials and Resources



Certified and Silver projects tend to achieve 4 of the 13 points in this category, while Gold and Platinum achieve 8 or more.

Few projects incorporate the Building Reuse points. It can be difficult for remodeling projects to achieve other points, especially site and energy use reduction, without a significant increase in cost. We find, therefore, that few remodel projects seek to pursue LEED certification. These points in themselves do not necessarily add cost to a project; it is the impact of the cost of achieving the other necessary points that tends to make these points uncommon.

Construction waste management is achieved at some level on almost every project. Costs vary greatly depending on project location and availability of established construction waste recycling programs. While urban projects are typically able to achieve these points for minimal cost impact, rural projects may see cost greater impacts. Additionally, waste management is greatly dependant on how familiar or comfortable the general contractor is with such practices. Cost impact is therefore extremely dependent on contractor commitment. Thus, in order to understand the potential cost impact of achieving these points, we must not only be familiar with the programs available within the area, but also with the ability and willingness of the contractors to comply.

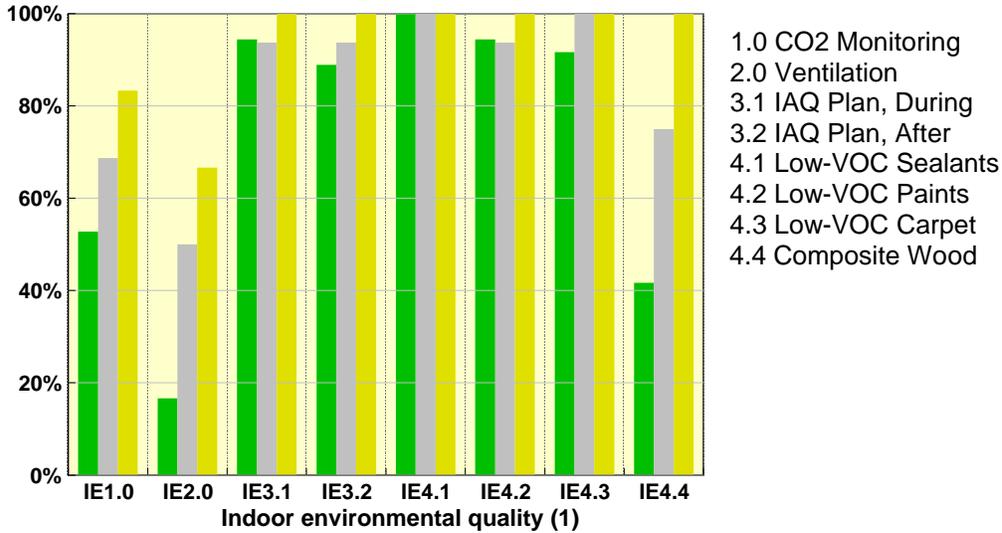
The use of recycled content is usually not difficult for most projects, at minimal or no added cost. Steel framed buildings usually qualify for at least one point for recycled content with no additional cost impact. The balance of materials required can be made up in standard materials.

Use of locally harvested and/or produced materials is usually neither difficult nor costly for most projects to achieve. By comparing the point expectations of our study projects with the actual achievements of the current USGBC certified projects, we find that more projects actually earn these points than are anticipated in our study. This is because the difficulty of these points lies more with the documentation than with the actual specification; once the contractor develops a documentation procedure, meeting the points becomes relatively straightforward. As with recycled content, these points are typically earned using standard materials.

Most projects are unable to meet both the rapidly renewable materials and reused materials points. While many applicable materials tend to be high-end finishes and therefore costly, projects tend to lost these points more because it is quite difficult to achieve the required percentage of building materials, than because of cost.

Certified wood is usually more expensive than non-certified wood, and prices tend to fluctuate. Knowledge of sources and prices is needed to establish actual cost impact on any individual project.

Indoor Environmental Quality



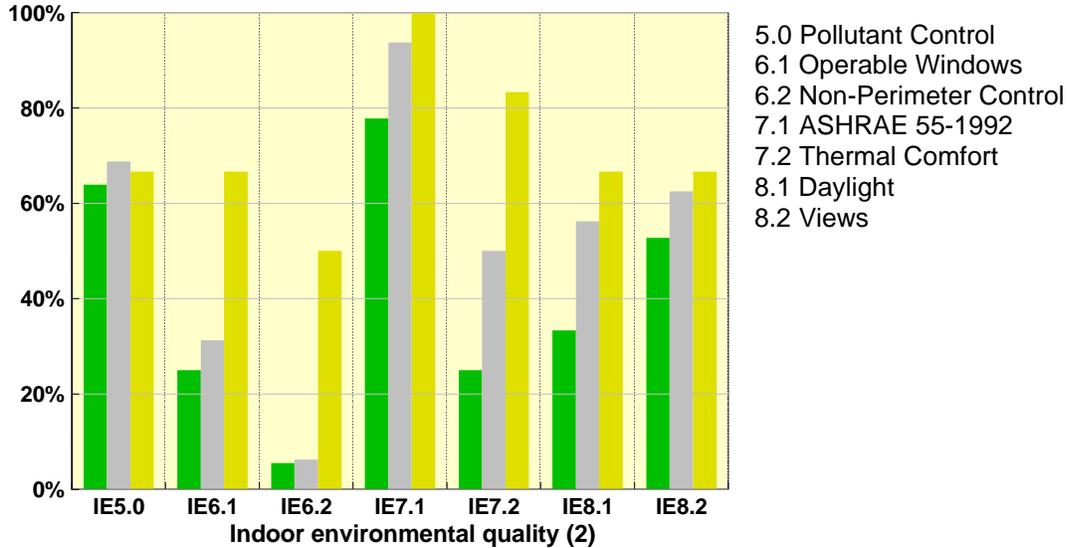
Of all the categories, the points in the Indoor Environmental Quality category tend to be the most often sought. This is likely because so many of these points are already incorporated into normal designs, due to building codes and availability of materials.

Establishing an air quality plan during the construction process is high on the list of points projects attempt to achieve, but fail to qualify for. This is because this point requires significant coordination and management on the part of the contractor and all members of the construction crew, as well as a strong commitment by all members of the construction crew to abide by the rules. In order to qualify for these points, construction must be carefully planned and sequenced, and crew members must be carefully trained and monitored to ensure that all criteria are met. The direct cost of this point is relatively low, but the impact on the contractor’s bid can be very significant if the contractor views this as onerous and undesirable.

The feasibility of the second air quality point depends a great deal on the climate. In hot, dry areas such as most of California a two week flush-out with outdoor air is quite feasible as long as it is planned into the construction schedule. In areas where there is high humidity, however, this point is simply not feasible, since a two week flush-out with outdoor air in wetter climates is more likely to expose the interior of the building to mold and other problems.

Neither of the indoor air quality points needs to have a cost impact on a project if the project owners and construction team are committed. However, not all crews are willing or able to maintain the level of management needed to ensure the performance necessary to meet these points successfully. These points may seem easy to achieve, but often turn out far more complicated, and thus less feasible, than anticipated.

The materials points in this category are usually fairly easy to achieve. In many cases, local or regional ordinances may already require that projects meet those standards. For example, in California, buildings are required to meet standards which allow projects built under those rules to qualify for most – if not all – of the materials points without any impact to cost or design. Where local or regional regulations do not already establish the use of low emitting materials, making use of these should have only minimal – if any – impact on cost, as these are usually widely available.



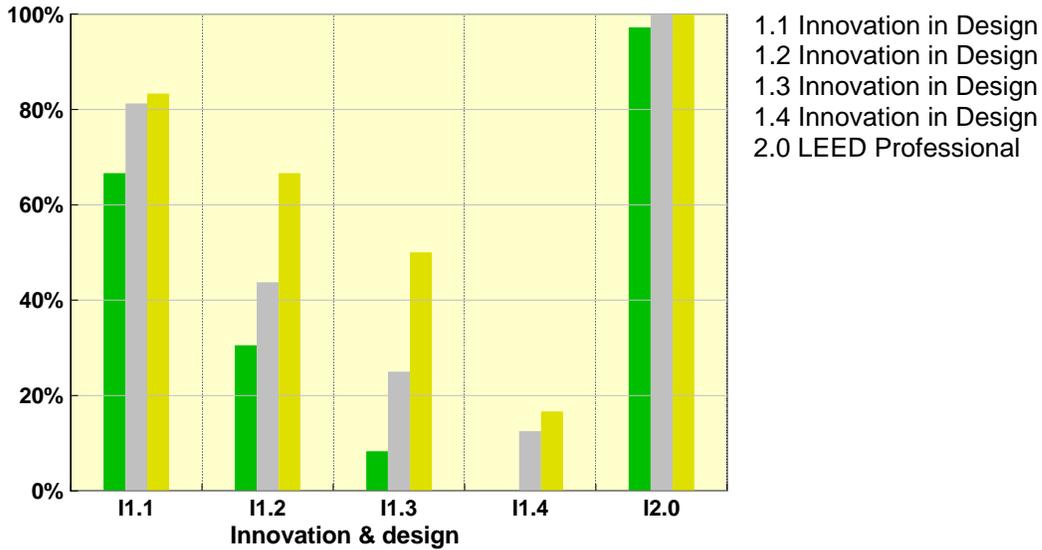
The pollutant control requirement can usually be met with little added cost, although the requirements do add some exhaust ductwork and drainage.

Operable windows have a fairly low direct cost premium over fixed windows, but often have a significant added cost when combined with a traditional air conditioning system. Owners often require control interlocks between the air conditioning and the windows to ensure that the air conditioning is not running while the window is open. This can add controls, zones and ductwork, leading to a premium cost much greater than the cost of the windows. Operable windows may also simply be impractical or undesirable; laboratories and healthcare facilities can not have operable windows, owners may have a concern for the security of occupants or contents, or the climate may simply not lend itself to operable windows for much of the year.

Non-perimeter control can be much more difficult to achieve, since it requires control by individual occupants. Few buildings have systems geared to individual control, and adding such systems can significantly increase the number of controls and zones. Raised floor systems are the most common and economical way of achieving this point.

Many projects attempt to qualify for the last two points in this category – daylighting and views. However, these points are calculated based on mass and depth of the building and light actually entering the interior spaces, making these points are more difficult to achieve than most people realize. We expect that this will improve as design standards change over time and the benefits of daylighting and views become more desired. Because these two points have to do with mass and depth there is no feasible way to assign a single line-item cost to either.

Innovation and Design



The Innovation and Design category is a catch-all section, designed to allow projects to earn points for items that may not fall into any other designated point. Innovation points can be achieved by either:

- Going over and above the required level of a specific point, such as establishing higher reductions in estimated energy or water use than specified by those points.
- Incorporating something not already addressed into the design. In the past this has included things such as providing educational signage in the building which points out the sustainable features, or making use of other innovative technologies, such as straw bale or rammed earth construction, fuel cells, and so on.

Most projects achieve at least one innovation point. By and large, projects are doing so at minimal added cost by simply capitalizing on measures already included in the project design, or by pursuing one of several previously defined, low-cost innovation points. The former might include exemplary performance in water use reduction or construction waste management – both essentially already paid for in the base points. The latter might include green housekeeping or educational signage, both reasonable cost adds.

The expected rates shown above are low compared to actual rates of Certified projects: many of the projects in this study may find themselves achieving points not currently targeted.

Virtually all projects are achieving the point for including a LEED Accredited Professional, at no added construction cost.

As time goes on and the sustainable techniques listed in the LEED points become more mainstream we expect that concepts that were once considered innovative will eventually be incorporated into standard design.

Factors That Influence Feasibility and Cost

As already touched on briefly in the overview of the LEED points, there are a number of factors which can greatly influence the cost of green (or the ability to achieve certain points). These include:

- Demographic Location
- Bidding climate and culture
- Local and regional design standards, including codes and initiatives

- Intent and values of the project
- Climate
- Timing of implementation
- Size of building
- Point synergies

Demographic Location

The location of the project can have a significant impact on the cost and feasibility of certain of the LEED points. To demonstrate the implications of simply siting a building in a rural versus an urban setting, we took a newly built library which achieved a LEED Silver rating. It was built in the middle of a large city – an urban setting. To examine the effects of site selection on cost and feasibility we ‘moved’ it to a rural setting and looked to see what might have had to change.

	rural	urban
Site Selection		✓
Urban Redevelopment		✓
Alternative Transportation , Public Transportation Access		✓
Reduced Site Disturbance , Protect or Restore Open Space	✓	
Reduced Site Disturbance , Development Footprint	✓	
Stormwater Management , Rate and Quantity	✓	\$\$\$
Stormwater Management , Treatment	✓	\$\$\$
Water Efficient Landscaping , Reduce by 50%	✓	
Water Efficient Landscaping , No Potable Use or No Irrigation		✓
Construction Waste Management , Divert 50%		✓
Construction Waste Management , Divert 75%		✓
	5	6 to 8

This chart lists the LEED points which would be most impacted by the type of site selected for the building. As we can see, the urban redevelopment and alternative transportation points would only be available in the urban setting. However, the rural setting would allow the project to earn a few of the other Site Selection points which the urban setting could not. These included the points which involve open space and protection of natural habitat. The rural site would be more likely to include larger areas of green space around the building. This would improve the ability of the project to earn the stormwater management points, since the larger areas provide an easier and less expensive alternative to capturing and treating stormwater. While in the urban site there was cost associated with stormwater management, due to the lack of space and thus the need to install detention tanks, a larger, rural setting provides space for low-cost retention ponds, as well as more landscaping to both filter and slow the rate of the stormwater runoff.

The ability of the project to earn the construction waste management points is also clearly impacted by the selection of the urban versus the rural setting. In urban environments there is more likely to be well-established construction waste recycling or reclamation programs. Additionally, contractors are more likely to be familiar with these practices.

Bidding Climate

Perhaps the most significant single factor in the cost of sustainable design is the bidding climate, or the response of bidders to the green requirements in the contract. There are some measurable direct costs to be borne by the contractor. These include the cost of documentation of the material credits, the application of the construction indoor air quality credits, and some of the schedule impacts of post construction building flush-out. These, however, are relatively low costs.

A far greater impact comes where the contractor perceives the sustainable requirements as onerous or risky. Below are clauses from two actual construction contracts:

The Contractor shall:

- “ensure that the Project achieves LEED”
- “deliver a finished Work Product that assists the Owner in achieving a LEED green building rating of Certified”

The first of these clauses transfers the liability for achieving LEED certification to the contractor. The second engages the contractor in the process, seeking cooperation rather than obligation. Clearly the contractor, when faced with the former, will include a greater risk contingency into their bid, if they are willing to bid at all. In order to manage the impact of sustainable design on bid response it is necessary to write reasonable specifications and contracts, and to engage the contractor in a collaborative process, possibly even including training and bonuses for compliance, rather than transferring risks and applying penalties for failure.

In many areas where bidders are unfamiliar with building sustainable projects, they are likely to be more wary. This has two effects: firstly bidders are inclined to add contingencies or risk premiums to cover the perceived risk; secondly, the bid pool diminishes, leading to poorer competition and higher bid prices. As bidding communities become more familiar with sustainable buildings, the risk premiums decrease, and the competition increases, reducing or eliminating the green premium.

The cost impact of bid climate is more pronounced when bidders have plenty of alternative work. When work is scarce, bidders are more willing to discount the risk in order to remain in business. For this reason it is essential to understand the bid community and the work availability.

California currently has one of the highest levels of LEED-seeking buildings in the country. Thus, it makes sense that more contractors in California are familiar with sustainable design, and thus more contractors are willing to bid on green projects. However, the recent high levels of construction growth has created an atmosphere where bids may still be higher than expected, because there is so much other work available for the contractor that they may be less willing to bid (or else they will bid high) on projects they consider ‘difficult’. This might translate into higher bids on LEED Gold and Platinum projects.

As opposed to California, many other parts of the country have experienced a slower recovery from the economic downturn of the past few years. The New York and New Jersey region, for example has had less growth, and in fact contractors are struggling to return to work. Contractors are thus more willing to take on sustainable design projects, even if they might be considered more ‘difficult’ than non-green projects.

As we can see, there needs to be an understanding of the balance between the construction market in the area and whether or not the local environment supports, and is familiar with, sustainable building. Attempting to build green in an area where sustainable design is not a familiar concept, and where contractors are unwilling to bid, can significantly impact the cost of the project.

Intents / Values

Another one of the key factors in determining the feasibility of incorporating sustainable design into a building is the established intent and values of the building owner and project team. The best and most economical sustainable designs are ones in which the features are incorporated at an early stage into the project, and where the features are integrated, effectively supporting each other. If the owner has no expressed desire to incorporate elements of sustainable design, it becomes more difficult to incorporate the necessary modifications into the design.

This underscores the importance of understanding the actual intents and desires of the owner and the design team. If they are not actually serious, or are unwilling to invest the time and cooperation that may be needed, it will be much more difficult to reach the desired LEED level. This is also likely to impact cost to build.

Climate

The climate where the building is to be constructed can play a key role in whether or not the project can actually achieve certain LEED points. It can also impact the cost to achieve particular LEED ratings.

To study how the climate can impact cost and feasibility, we took the design for the Bren School (a laboratory building which achieved LEED 1.0 Platinum) on the University of California, Santa Barbara campus, and placed it into five hypothetical settings, each with its own, unique climate issues. The design, as it was built in Santa Barbara, was costed for each climate to determine the impact of each. For the purpose of this study, we chose to minimize the variables by keeping the base building design constant, as opposed to optimizing the design for the different climates.

	Platinum*	Gold*	Silver*
UCSB	7.8 %	2.7 %	1.0 %
San Francisco	7.8 %	2.7 %	1.0 %
Merced	10.3 %	5.3 %	3.7 %
Denver	7.6 %	2.8 %	1.2 %
Boston	8.8 %	4.2 %	2.6 %
Houston	9.1 %	6.3 %	1.7 %

Costs are shown as a percentage of starting budget, and indicate additional cost necessary to reach each specified level of LEED.

The climates selected were the following:

- Mild Coastal – Santa Barbara and San Francisco
- California Central Valley – Merced
- Gulf Coast – Houston
- Northeast Coast – Boston
- Rocky Mountains - Denver

It will be noted that not only are the premiums different by location, but also, there is quite a wide variation in the steps between levels. For example, Silver in Houston has a lower premium than Merced, but Gold has a higher premium. Some of the variations in premium relate to specific issues arising from the method of calculation. Since the LEED point is based on cost of energy saved, the relative cost of heating and cooling energy in each market can have an impact on the effectiveness of energy economy measures.

This analysis underscores the need to understand the climate and the energy costs where the building will be located. Yearly temperature fluctuations and levels of humidity can play a significant role in determining cost for mechanical systems, as well as whether or not the project may be able to use passive heating or cooling instead of relying on a mechanical system.

Feasibility and Cost - Conclusion

As we can see, there are a number of factors which can have a significant impact on both the ability to achieve specific LEED points, and on the cost to build a sustainable building. When considering cost and feasibility for pursuing LEED certification for any building, it is extremely important that you:

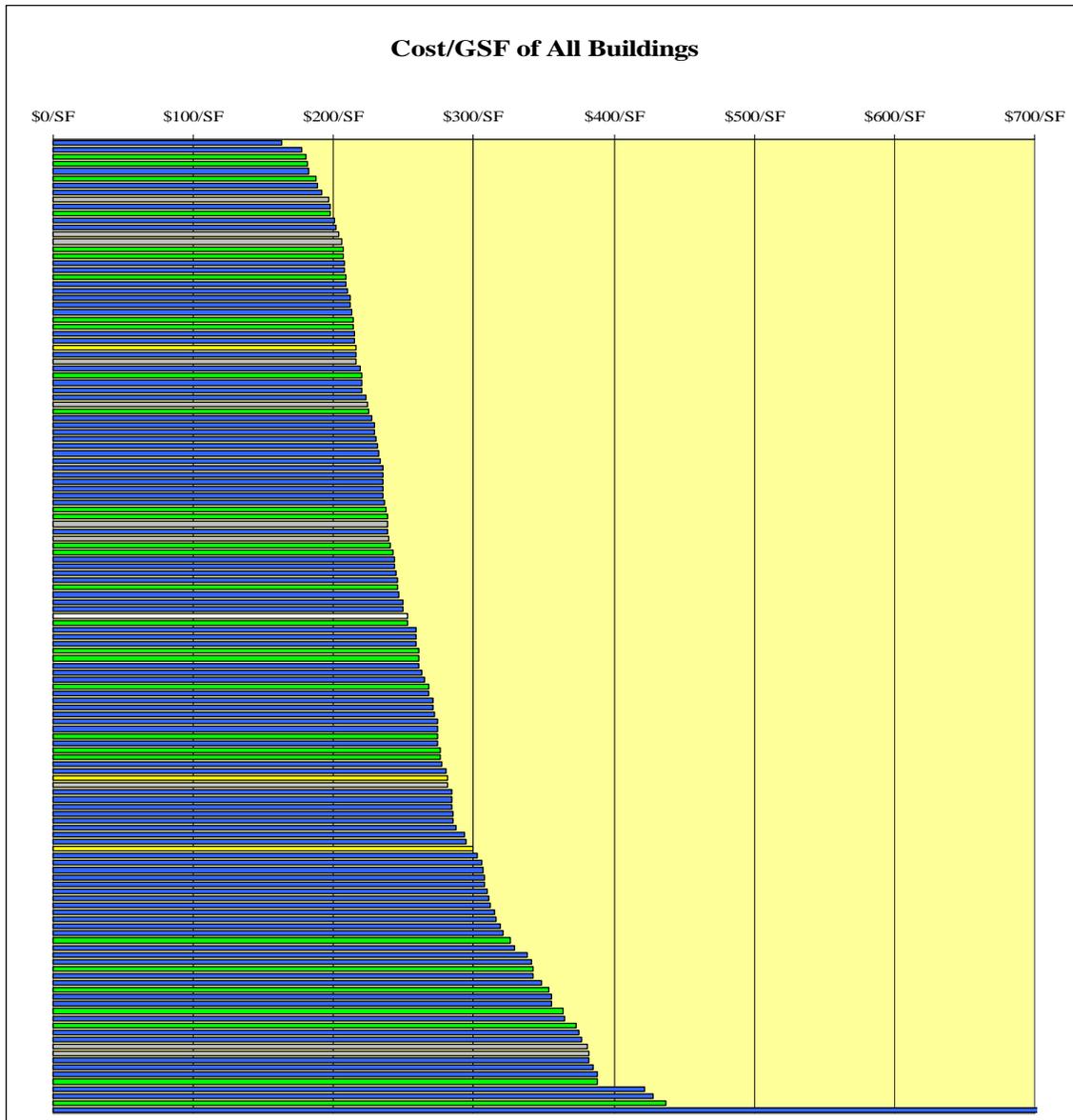
- Understand the feasibility of each point for your project
- Understand the factors affecting cost and feasibility

Having a comprehensive understand of these factors allows an owner to more accurately determine potential costs, and to make better choices as to which LEED points a particular building should pursue.

Analyzing the Data – Cost Analysis of Similar Buildings

In this study, our goal was to compare construction costs of buildings where LEED certification was a primary goal to similar buildings where LEED was not considered during design. We selected projects from our extensive database of cost information which were designed with a goal of meeting some level of the USGBC's LEED certification. 61 buildings were selected which met this criteria. Of these, the most common three program types were libraries, laboratories, and academic classroom buildings – these categories made up 45 of the buildings studied.

We compared the green projects in the three largest categories to buildings with similar program types. 138 buildings were studied – 93 non-LEED and 45 LEED-seeking. All costs were normalized for time and location in order to ensure consistency for the comparisons. It is important to note that the only distinction between the buildings was the intent to incorporate sustainable design in order to achieve LEED rating. The non-LEED buildings all would have earned some LEED points by virtue of their basic design, but sustainability had not been the intent. We will look at the differences between LEED-seeking and non-LEED a little later.



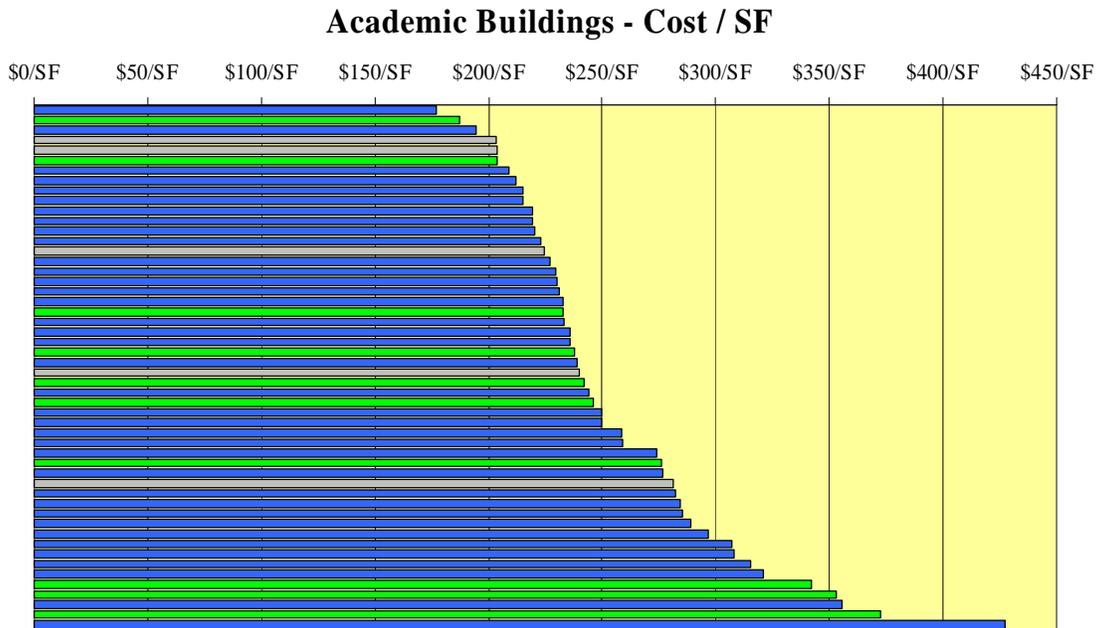
The graph above compares the cost per square foot for all buildings in our study, from lowest to highest. Blue lines show non-LEED buildings, green lines indicate buildings attempting LEED Certified, silver lines indicate those seeking LEED Silver, and gold lines indicate those buildings seeking to achieve either LEED Gold or Platinum.

In a comparison between all projects – LEED-seeking versus non-LEED, something interesting came to light: the cost per square foot for the LEED-seeking buildings was scattered throughout the range of costs for all buildings studied, with no apparent pattern to the distribution. This was tested statistically using the t-test method of analyzing sample variations. This test indicated that there was no statistically significant difference between the LEED population and the non-LEED population. In other words, any variations in the samples, or the sample averages, were within the range to be expected from any random sample of the whole population. It is important to note, however, that the standard deviation in dollars per square foot cost for each category (LEED-seeking and non-LEED) was quite high, since there is such a wide variation in building costs.

Academic Buildings

After comparing all 138 projects, we next compared buildings by category. First we looked at academic classroom buildings, located on college and university campuses. A total of 52 buildings were studied – 15 LEED-seeking and 37 non-LEED.

As we can see from the graph below, there was no indication that the LEED-seeking projects tended to be any more expensive than the non-LEED. The difference between average cost per square foot was, again, statistically insignificant for academic classroom buildings.

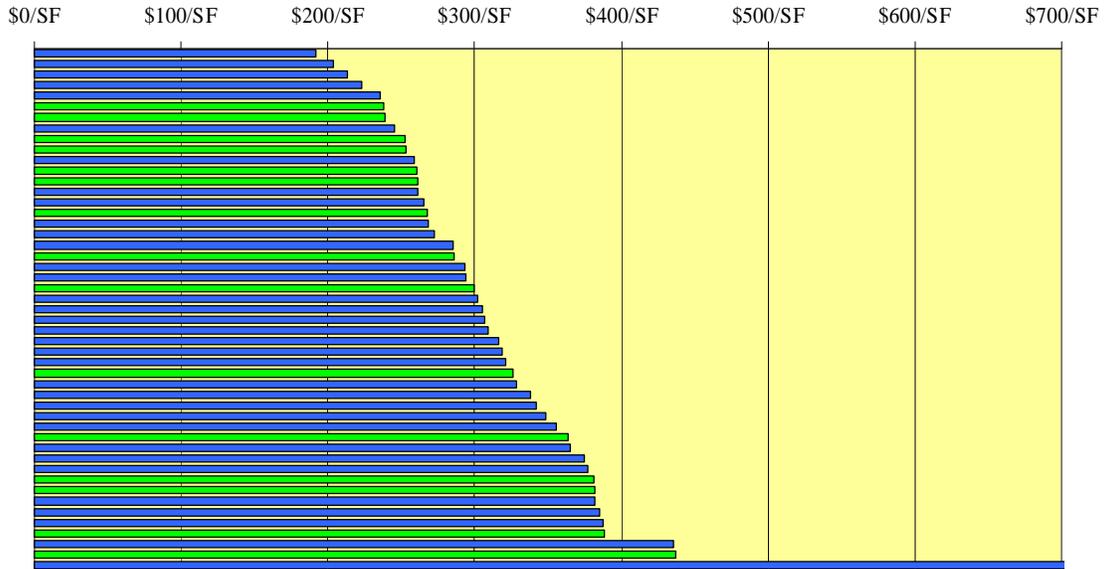


In the sampling of academic classroom buildings which were LEED-seeking, the only LEED levels attempted were Certified and Silver (Certified are shown as green bars in the graph above, while Silver projects are shown as silver bars). When the Silver projects were averaged and that average compared to the average cost per square foot for non-LEED buildings, there was still no significant difference noted.

Laboratory Buildings

The next category examined was laboratory buildings. 15 LEED-seeking laboratories were compared to 34 non-LEED laboratory buildings.

Laboratories - Cost / SF



Again, no significant statistical difference was noted between the average costs per square foot for LEED-seeking versus non-LEED laboratories. However, we did see a fairly large standard deviation in price between the labs. This was not unexpected, since construction costs for laboratory buildings often varies widely depending on the type of laboratory being built. For example, materials and forensics laboratories tend to be more expensive, while teaching and environmental studies laboratories tend to be less expensive overall.

To try to eliminate the effect of this wide variation in costs due to laboratory type, we took a closer look at only the wet labs, excluding teaching and materials labs to remove the higher and lower end costs from the analysis. For this, only 22 total buildings were studied – 7 LEED-seeking and 15 non-LEED.

Wet Laboratories - Cost / SF

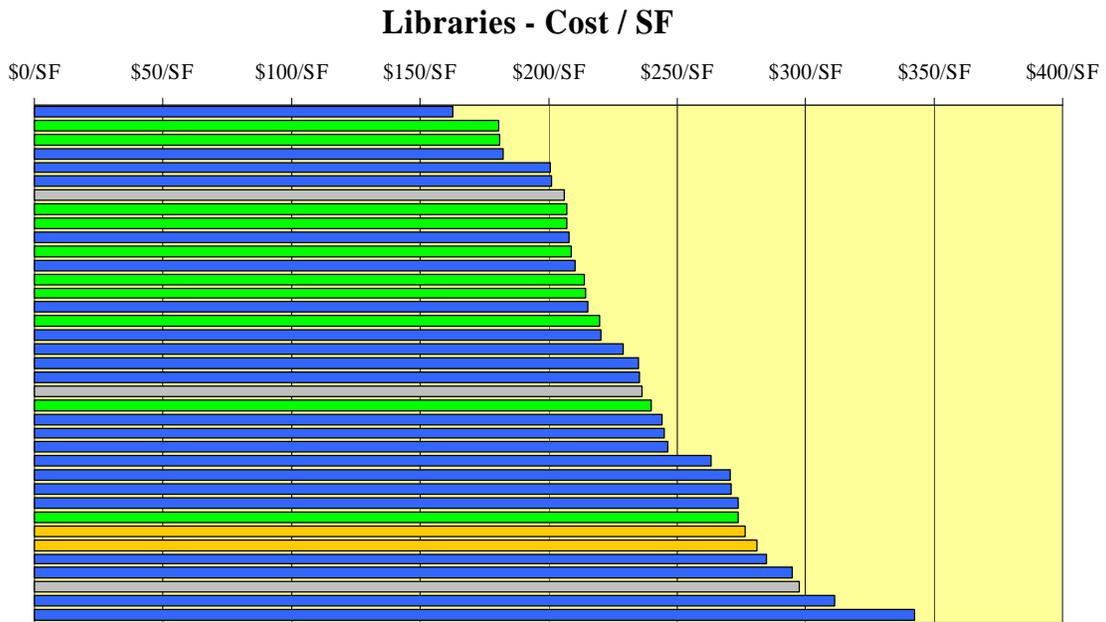


In this graph, LEED levels are denoted by the different colors. Green bars indicate Certified buildings, silver bars indicate Silver buildings, and the gold bar indicates a laboratory which was attempting LEED Gold rating. Interestingly, while we drastically reduced the standard deviation between lowest and highest cost for the buildings studied, we still saw no significant statistical differences between average costs per square foot for the LEED-seeking versus the non-LEED buildings.

Library Buildings

Finally, we compared 15 LEED-seeking libraries to 22 non-LEED libraries.

Bar color denotes LEED level attempted – gold for LEED Gold, Silver for LEED silver, and green for LEED Certified.

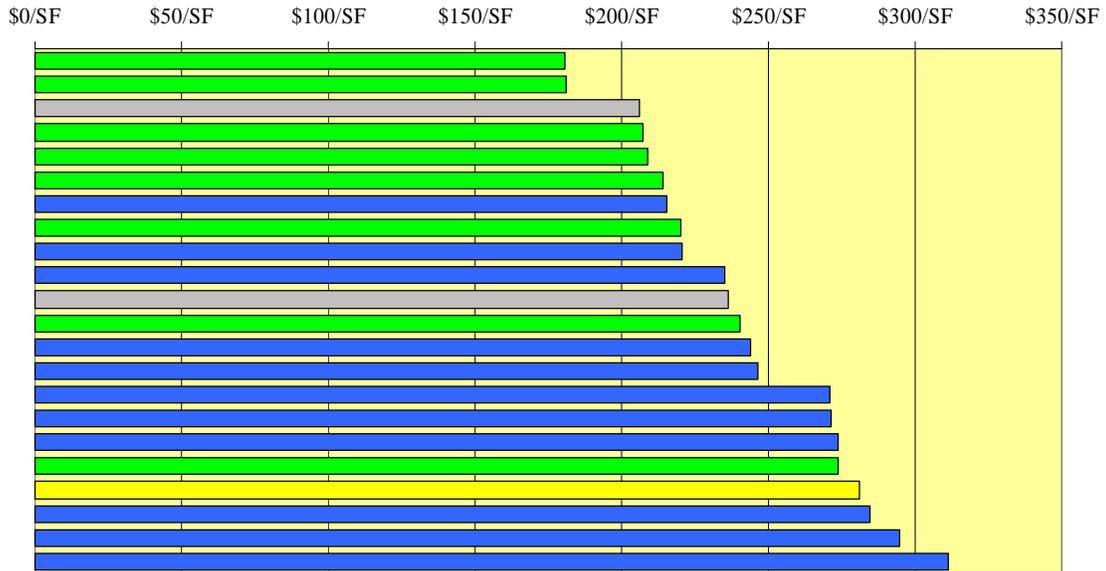


It is interesting to note that the majority of the LEED-seeking libraries tend to fall into the lower half of the range for cost per square foot. However, this does not automatically suggest that green libraries are, overall, less expensive than non-LEED libraries to build. A majority of those libraries were all built by the same owner, who has mandated LEED for all libraries, regardless of the assigned budget. This comparison does suggest, however, that green libraries are certainly affordable and achievable.

Due to the fact that so many of the LEED-seeking libraries come from one owner and constituted tighter construction budgets, the average cost per square foot for green was slightly lower than the average cost per square foot for non-LEED libraries. This difference, however, was again not statistically significant, nor, if it had been significantly different, could we have surmised that this was a true result which could be applied to any LEED-seeking libraries across the board.

As with laboratories, there does tend to be a wide variation in construction costs per square foot overall for libraries, based on the type of library constructed (academic, main community library, or city or community branch library). To narrow the analysis by library type, we excluded all but branch libraries from the comparison – looking only at those libraries that were less than 40,000 total square feet. This reduced the numbers to 11 LEED-seeking and 11 non-LEED library buildings.

Branch Libraries - Cost / SF



Bar color denotes LEED level attempted – gold for LEED Gold, Silver for LEED silver, and green for LEED Certified.

When we narrowed in on these types of buildings, we finally see a statistically significant difference in cost per square foot between LEED-seeking and non-LEED libraries. The difference noted suggested that the LEED-seeking libraries were cheaper to build than the non-LEED! However, again, we point to the fact that a majority of those green libraries in the analysis were from a single owner with a set commitment to achieve LEED, and with tight controls over budget and costs to suggest that this statistically significant difference in cost is likely skewed by this fact.

LEED-Seeking versus Non-LEED

Throughout these comparisons we have referred to the two groups as LEED-seeking and non-LEED. However, it is important to keep in mind that the difference between these groups is simply that the LEED-seeking buildings were designed with LEED certification in mind, while this was not one of the goals for the non-LEED buildings. Non-LEED buildings qualified for at least some LEED points by virtue of their design, location, and other factors.

To compare LEED-seeking to non-LEED buildings, ten non-LEED buildings were selected at random from the 93 examined for this study. A LEED checklist was created for each of these ten buildings to determine the number and type of points each project would receive with their current design.

This analysis concluded that these non-LEED projects achieved between 15 and 25 points with their established designs, and in fact one project was estimated to qualify for 29 points – enough to earn a rating of LEED Certified if the building owners had so desired.

Closer examination of the non-LEED and LEED buildings suggests that for any building, there are usually about 12 points that can be earned without any changes to design, due simply to the building’s location, program, or requirements of the owner or local codes. Up to 18 additional points are then available for a minimum of effort, and little or no additional cost required.

Cost Analysis of Similar Buildings – Conclusion

We can draw four key conclusions from our analysis of construction costs for LEED-seeking versus non-LEED seeking projects:

- There is a very large variation in costs of buildings, even within the same building program category.
- Cost differences between buildings are due primarily to program type.
- There are low cost and high cost green buildings
- There are low cost and high cost non-green buildings.

There is such a wide variation in cost per square foot between buildings on a regular basis, even without taking sustainable design into account, that this certainly contributed to the lack of statistically significant differences between the LEED-seeking and non-LEED buildings. Additionally, comparisons of this type can not be considered reliably meaningful because budgets can never be compiled based on an average. Any number of factors can distort the results obtained, as we saw with the comparison of library buildings, such that the same comparisons done with a completely different sampling of buildings might yield completely different and conflicting results. While we saw no significant differences in cost per square foot in the sampling of buildings studied, this could easily not be the case for any other data configuration. Averages will always be highly dependent on the data pool being sampled.

What does this mean in regard to the cost of green? The conclusion is that comparing the average cost per square foot for one set of buildings to another does not provide any meaningful data for any individual project to assess what – if any – cost impact there might be for incorporating LEED and sustainable design. The normal variations between buildings are sufficiently large that analysis of averages is not helpful. Remember – buildings can never be budgeted on averages.

Analyzing the Data – Initial Budget

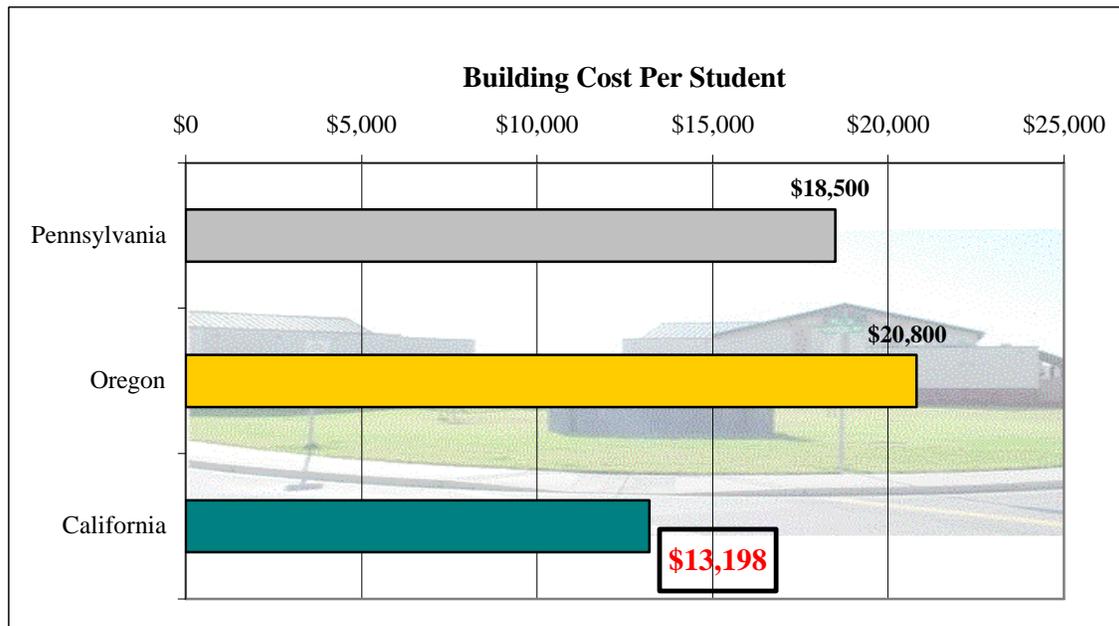
One of the most common methods used to establish the cost of green has been to compare the final construction costs for the project to the established budget. In other words, was the budget increased to accommodate the sustainable elements, or were those elements incorporated into the project within the original available funds. Within the 61 LEED seeking buildings we studied, we found that over half the projects had original budgets that were set without regard to sustainable design, and yet received no supplemental funds to support sustainable goals. Of those that did receive additional funding, the supplement was usually provided only for specific enhancements or requirements, such as photovoltaic systems, and the range of monies supplemented, for those few that required it, was typically in the range of 0 – 3% of initial budget.

The projects that were the most successful in remaining within their original budgets were those which had clear goals established from the start, and which integrated the sustainable elements into the project at an early stage. Projects that viewed the elements as added scope, tended to experience the greater budget difficulties.

It is important to be circumspect when using initial budget performance as a benchmark, however, as the budget performance alone may not present the full picture. The following graph compares the building cost per student for schools built in Pennsylvania, Oregon, and California:

- The Pennsylvania elementary school obtained a LEED Silver certification for a premium of 2%².
- In Oregon, a middle school was built that obtained a rating of LEED Gold for no additional premium³.

Taken without additional information, one might surmise that LEED certification could be obtained for around 2% over starting budget.



However, this conclusion would be misleading. As can be seen from the chart, the cost per student allocated to each newly constructed school varies widely between the states. The Silver-

² “Clearview Elementary School – Highlighting high performance”,

<http://www.nrel.gov/docs/fy02osti/32680.pdf>

³ “Case Study – The Dalles Middle School”, <http://www.energy.state.or.us/school/thedalles.pdf>

rated elementary school was built at a cost of \$18,500 per student. The Gold-rated middle school in Oregon was built at a cost of \$20,800 per student. Compare this to the average amount spent per student in California, which is just over \$13,000⁴. Clearly we can see that starting budget must play a role in determining final LEED premium for these projects.

As we can see from this example, simply comparing a project's cost to its budget does not give an accurate picture of the true cost of green.

Initial Budget Cost Analysis - Conclusion

As the various methods of analysis showed, there is no 'one size fits all' answer to the question of the cost of green. A majority of the buildings we studied were able to achieve their goals for LEED certification without any additional funding. Others required additional funding, but only for specific sustainable features, such as the installation of a photovoltaic system. Additionally, our analysis suggested that the cost per square foot for buildings seeking LEED certification falls into the existing range of costs for buildings of similar program type.

From this analysis we can conclude that many projects can achieve sustainable design within their initial budget, or with very small supplemental funding. This suggests that owners are finding ways to incorporate the elements important to the goals and values of the project, regardless of budget, by making choices and value decisions.

⁴ "Fact Book 2003: Handbook of Education Inform", <http://www.cde.ca.gov/resrc/factbook/factbook03.pdf>

Budgeting Methodology for Green

When establishing a design and a budget for a LEED building, the key point to remember is that sustainability is a program issue, rather than an added requirement. Our analysis indicates that it is necessary to understand the project goals, the approach to achieving the goals, and the factors at play in for the project. Simply choosing to add a premium to a budget for a non-green building will not give any meaningful reflection of the cost for that building to meet its green goals. The first question in budgeting should not be “How much more will it cost?”, but “How will we do this?”

This must be done as early as possible in the project and it must be considered at every step of design and construction. This is done by:

- Establishing team goals, expectations & expertise
- Including specific goals in the Program
- Aligning budget with program
- Staying on track through design and construction

Perhaps the most important thing to remember is that sustainability is **not** a below-the-line item.

Establish Team Goals, Expectations and Expertise

When considering sustainability, it is important to understand your team. As we discussed previously, the feasibility and potential cost impact of a number of LEED points can be significantly increased or decreased by whether or not the members of the design and construction teams are familiar with sustainable practices, and willing to commit to following established protocols and procedures.

It is also important to ensure that the team includes the expertise that will be necessary to allow the sustainable elements to be incorporated smoothly. And finally, you must align the goals and values of the project such that all members of the team accept and understand them.

Include Specific Goals

A LEED checklist should be prepared at the start of the project and at every program stage. This will enable the project team to clearly understand their current ability to meet the project's established goals and values. Additionally, the team should specify specific design measures to be employed in meeting the goals, and these should be routinely monitored to ensure complete compliance.

It may seem to be impractical to develop a sustainable design strategy during the program stage of design, when so little of the building is defined. It is our experience, however, that many of the features can be identified, visualized and incorporated into the cost model if sufficient attention is paid to them.

In the design, include contingency points, recognizing that some of the points may be unsuccessful. It is essential to plan for at least three or four points more than the minimum required for a given level. We have found that where projects need “just one more point”, those last points tend to be difficult and very expensive.

It is also important to be specific in point selection. There will always be points which are uncertain, which should properly be counted as points in the ‘maybe’ column on the checklist. The ‘maybe’ column should not, however, be used as a substitute for thinking through the feasibility of a point; ‘maybe’ is not the same as indecision.

Align Budget with Program

It is essential to align the budget with the program during the programming phase of the project. If there are insufficient funds to fulfill all of the program goals, either the goals must be reduced, or the budget increased. Too often projects move forward with a mismatch, either because the

project team is unaware of the mismatch, or more often, due to wishful thinking that something will turn up to resolve the problem.

In order to align the budget with the program, a cost model should be developed, which allocates the available funds to the program elements. It is quite possible to develop a thorough cost model from program information, even when design information is limited. The program will dictate the majority of the cost elements, both in quantity and quality, and from that it is possible to build a cost model. The cost model will both reflect the program – highlighting areas of shortfall – and provide planning guidance for the design team by distributing the budget across the disciplines.

The cost model also provides a communication tool for the project team, allowing clear understanding of any budget limitations. These must be addressed by adjusting scope, design or funds. Proceeding with inadequate funding will lead to more drastic scope reductions at later stages in the design process, and greater conflict between competing interests in the program. It is in these cases that sustainable elements are most vulnerable to elimination as unaffordable expenses.

In order to align your budget with your program you must:

- Understand your starting budget.
- Generate a cost model for the project to understand where costs lie.
- Allocate funds.
- Address limitations in the budget at the Program stage.

It is the choices made during design which will ultimately determine whether a building can be sustainable, not the budget set.

Stay On Track

Once you have a clear understanding of the goals and values for the project, as well as the budget available, it is important to stay on track throughout the entire process. The steps for staying on track include:

- *Documentation:* Begin any necessary documentation as early as possible, and maintain it as you go.
- *Update / Monitor Checklist:* Update and monitor the LEED checklist so you have a clear picture of how the sustainable goals are being met, and whether the LEED goal is succeeding.
- *Energy / Cost Models:* Use energy and cost models as design tools. Energy models are useful during all design phases to establish the design criteria necessary to meet selected LEED points. Cost models will allow you to track cost impacts from any necessary changes to design or procedure as the project progresses. Energy and cost models can be combined to make a very effective decision making tool, preferably early in design.

Budgeting Methodology – Conclusion

The only effective way to budget for sustainable features within buildings is to identify the goals, and build an appropriate cost model for them. If they are seen as upgrades or additions, the cost of the elements will also be seen as an addition. It is possible to establish goals and budgets from the very beginning of the project. Other methods are ineffective and unnecessary.