Portland's Green Building Initiative and An Application of the LEED™ Rating System

Rob Bennett, Portland Energy Office
Allen Lee, XENERGY, Inc.
Geof Syphers, XENERGY, Inc.
Alan Scott, SERA

ABSTRACT

In 1999, the City of Portland, Oregon, initiated a Green Building Initiative to overcome barriers to green buildings and to promote their construction. A study was conducted in support of the Initiative to assess what constituted green buildings and what their costs and impacts would be. Based on the retrospective analysis of three recently built City buildings, this paper presents the results of applying the LEED™ green building rating system, the criteria used to select green building options, and the first costs, life cycle costs, and societal costs associated with greening these buildings.

Introduction

Since initial efforts by local governments such as those in Austin, Texas, and Boulder, Colorado, the number of local and national organizations developing green building programs has increased rapidly. Cities such as Seattle, Los Angeles, Santa Monica, and Denver and organizations such as the U.S. Green Building Council have promoted green building programs actively. At the local level, such programs are often part of comprehensive policies and programs to promote sustainability.

During 1999, the City of Portland, Oregon conducted a public process to investigate options to promote the construction and operations of green buildings. This effort was spearheaded by the Sustainable Portland Commission (SPC), a public body appointed to advise the City Council on issues related to sustainability. The Portland Energy Office provided technical and staff support to the SPC. Portland has been a leader in efforts to balance community development, growth management, and environmental stewardship. Faced with projections of significant growth, City planners initiated steps to improve the quality and performance of buildings while reducing stress on the environment.

The innovative building and site design techniques that can realize these goals—typically referred to as "green building"—are gaining currency worldwide. Lack of information, regulatory disincentives, and financial barriers, however, have hindered the implementation of green building practices. To help alleviate these barriers, the City developed the *Green Building Initiative*, which has two overarching principles: 1) expand market demand by educating building industry professionals and the public about the benefits of green building; and 2) make green building practices easier to implement by developing technical services and resources for building industry professionals. Key steps in the Initiative include establishing policies and procedures to facilitate building green, developing green building criteria and a rating system, implementing incentives to encourage green building practices, and providing education and training to City personnel and the private sector.

Two of the main issues raised during development and early implementation of the Initiative were how to define "green" and the costs and benefits of building green. This paper summarizes a study (XENERGY 2000) conducted to help define what would qualify as a green building and provide initial estimates of the costs associated with building green.

Approach

The City decided to analyze three existing, relatively new City buildings to help answer these questions. The analysis was conducted retrospectively by identifying how the three buildings *could have been built* to qualify as green and the associated costs and resulting impacts. The study was not intended to examine how the buildings could have been modified after they were constructed.

The LEED Methodology

Several methods have been developed and proposed for assessing green buildings (Andereck and Schoen 1999). The Leadership in Energy and Environmental Design (LEED™) method, issued by the Green Building Council in 1998, is probably the most widely applied system in the U.S. The original LEED™ system has been used to evaluate over 50 buildings (Paladino 1999). Version 2 was issued for comment in January 2000, modified, and adopted in May.

LEED™, V. 2, provides a checklist of site and building measures for commercial buildings that can be used to rate their "greenness." LEED™ reference materials provide guidance in the selection of measures. LEED™ organizes measures into these five categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality.

A sixth category (Innovation and Accredited Professional) is available to score bonus points. The system assigns points to individual measures and a specific point total is required for certification. The method provides several levels of green certification and certification can be achieved in any number of ways as long as the required point is obtained.

Although recent studies have addressed the costs and benefits of LEED™ certification (for example, Paladino 1999), the system itself does not quantify the costs and benefits of meeting the requirements in alternative ways.

Study Approach

As part of the Initiative, in December 1999, the City issued an RFP and the team of XENERGY and SERA Architects was selected to conduct a study of three existing City buildings. The study had two purposes—1) unofficially rate the "greenness" of the buildings using LEED™, Ballot Version 2[1]) determine what measures *could have been used* in the buildings initially to qualify them under LEED™ and determine the costs and benefits of the selected measures. As this study was being completed, the final LEED™ Version 2 was issued. It does not differ substantially from the version used in our study; however, it requires fewer points for LEED™-certification than the version we used.

The overall study methodology is shown in Figure 1. The study started with a kickoff meeting involving the City staff responsible for each building. The meeting introduced the City personnel to the analysis method, data needs, and products. Data were then collected on the building and site characteristics, and green option costs and benefits. The rating of each building was conducted based on the features incorporated in the building and the site.

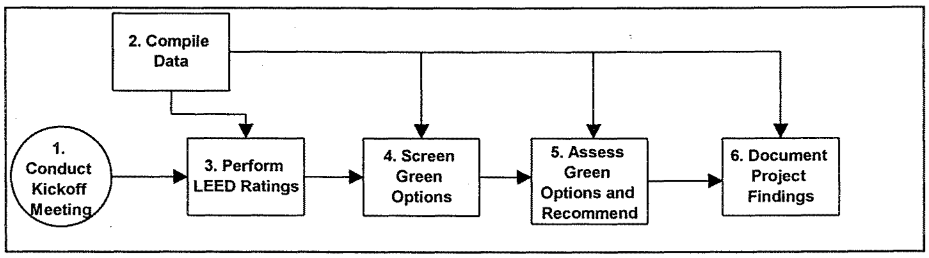

Figure 1. Overall Study Approach

Potential green options that could have been included in the building were then identified and screened based on initial determinations of their first and life cycle costs. Those options that survived the initial screening were then analyzed in more detail. Finally, specific measures were selected that could have been used to LEED™ certify each building.

It is important to stress that the range of options included was limited by the fact that this exercise was conducted after the building siting, design, and construction decisions had been made. We limited the options considered to those that could have been made as marginal changes to the building as built. It is very likely that more cost-effective options could have been identified if a green building perspective and integrated approach had been applied at the beginning of the design process. For this reason and the fact that we attempted to not understate costs or overstate benefits, our results should be viewed as conservative.

Building Rating Process

To apply the LEED™ method to each building, we needed detailed information on the building. The City project managers and their subcontractors provided construction drawings, code compliance documents, and other types of building and site information. We also conducted a walkthrough of each building, noting the design, construction, and materials details. Table 1 provides basic descriptive information for each of the buildings.

Generally, the information required for a LEED™ rating is fairly straightforward and readily available. Some information, however, is not universally available. In trying to rate these buildings, we encountered limitations in obtaining data for one or more buildings on the amounts of construction and demolition materials recycled, the cost of specific materials, and

[1] Note that we did not attempt to produce an *official* LEED™ rating of the buildings. However, our team members were familiar with LEED™, and one had attended formal training.

sources of materials. Where data were unavailable, we made reasonable assumptions based on our experience and discussions with the project manager.

Table 1. Building Descriptions

Building	Type	Floor area	Year built
1900 Building	Seven-story office building	143,200 sq. ft.	1999
Fire Station 17	Two-2-story fire station	4,900 sq. ft.	1994
East Precinct	Two-story, multi-use police station	23,000 sq. ft.	1997

As noted earlier, we took a conservative approach in trying to develop a rating for each building. Where judgment was required or information was unavailable, we made assumptions that were designed to give the building the most defensible rating possible.

Greening Analysis

Once the basic rating of each building was completed, the next step was analyzing ways that the building *could have been constructed* to qualify as LEED™ certified. To conduct this analysis, however, we had to develop criteria and a process for selecting among possible green options, and we needed to analyze the impacts of the measures selected.

Selection criteria. Viewing buildings in terms of their "greenness" is considerably more complicated than analyzing them in terms of one criterion, such as energy efficiency, alone. Because the green perspective encompasses a wide range of impacts, numerous criteria are available to consider for selecting among green measures. Energy impacts, CO_2 emissions, water runoff, health effects, solid waste generation, air emissions, and their associated first cost and life cycle costs and benefits are all likely considerations.

In theory, measures could be selected by optimizing one or more of these potential costs or benefits. A number of generic tools and methodologies have been developed for analyzing multiple attributes and using weighting techniques to select the optimum combination of measures that satisfy multiattribute criteria (see for example, Norris and Marshall 1995). In recent years, tools have been developed that apply such a comprehensive framework and data to the selection of building materials based on sustainability criteria (see for example, Lippiatt 1998). Because such a comprehensive analysis was beyond the scope of this study, however, we decided to focus our analysis by assessing different measures based on specific criteria that were consistent with the study scope and objectives.

We chose two alternative selection criteria. Because this research was motivated, in part, by concerns about the first costs of green buildings, we used *lowest first cost* as one criterion. Because the Green Building Initiative was predicated on the understanding that most green building benefits would accrue over the life of the building, we chose *lowest life cycle cost* as the second criterion for selecting an optimum mix of measures to meet LEED™.

Scope of costs and benefits. One critical issue in any cost-benefit analysis is who should be included when assessing costs and benefits. Prest and Turvey (1974, p.76) note the importance of "the wide class of costs and benefits which accrue to bodies other than the one sponsoring a project, and the equally wide issue of how far the sponsoring body should take them into account" in cost-benefit analysis.

The principle underlying green buildings is based on an inherently broad and long-term perspective of costs and benefits. In addition, city and other government buildings serve the public interest and they should, therefore, be evaluated from a broadly public and long-term perspective. Consequently, we sought an approach that considered impacts as broadly as possible within the study constraints.

In this study, we adopted a framework similar to that often used in cost-benefit studies of utility energy-efficiency programs to identify the actors included in the cost-benefit analyses. The utility program approach traditionally considers several cost-benefit tests including, among others, the participant, nonparticipant, and societal tests. Our selected cost-benefit categories were similar, as shown in Table 2. The table presents examples of each cost and benefit type. Note that all costs and benefits are determined on an incremental basis relative to the building as built.

Table 2. Categories of Costs and Benefits Included in Analysis

	Direct	Regional System	Societal
Definition	Monetary costs/benefits incurred directly by building owner/operator or occupants: based on average costs	Monetary costs/ benefits incurred by the regional system: based on marginal costs	Regional system costs/ benefits plus monetary and non-monetary externalities
Examples	• First cost of green measures • Maintenance costs of measures • Electric utility bills	• System marginal costs of electricity • System marginal costs of water treatment	• First costs of green measures • Monetized CO_2 impacts

By presenting these three cost-benefit perspectives, our framework is relatively comprehensive. The *direct* perspective is most relevant to the building operator/owner because it captures the costs and benefits that fall upon the operator/owner and building occupants. We limit this category to those impacts that can be readily monetized. The *regional system* perspective accounts for the fact that increased utility services impact the system as a whole and impacts on all ratepayers depend on marginal costs, while the direct rate impacts on the building occupant usually are based on system average costs. Consequently, this the regional system perspective assesses system costs and savings in terms of marginal costs. The *societal* perspective takes a more global view and adds externalities to the regional system costs and benefits. This final perspective is very important given that the environmental impacts of green buildings affect a population larger and more expansive than the building's owner/operator and occupants and populace living in the metropolitan area. Because some impacts are not readily monetized, the analysis also includes non-monetary impacts (e.g., tons of pollutants). Other impacts are not even quantifiable (such as wildlife habitat effects), given current knowledge and information, yet they are important; in these cases the impacts are described, even though they're not presented numerically.

In virtually all cost-benefit studies, practical limits make it necessary to restrict the breadth of costs and benefits included. In this study we relied on the study scope and objectives to help eliminate secondary and tertiary costs and benefits that were likely to be small, of only indirect importance, or difficult to quantify.

Cost-benefit analysis and selection of green options. Once we had identified a set of options to consider further, the selection process was relatively direct. In the case where we selected options based on lowest first cost, we simply listed the options in the order from lowest to highest first cost per LEED™ credit. We then selected the measures in order until the green options included led to a building that met the LEED™ requirement. In the lowest life cycle cost case, we followed the same approach, but ordered the measures in terms of their effect on life cycle cost.[2] In both cases, measures were selected based on direct costs and benefits only, but we estimated and documented the regional system and societal impacts. In both cases, those measures that were prerequisites in LEED™ were included also.

Findings and Results

This section presents our findings from the ratings of the three City buildings and our results from the analysis of options needed to certify the buildings under the LEED™ system.

Building Ratings

Table 3 summarizes our ratings by the total number of points each building received in the LEED™ categories.[3]

Table 3. Building Point Ratings As-Built

Building	Options Category						
	Sustain-able Sites	Water Efficiency	Energy & Atmo-sphere	Materials & Re-sources	Indoor Envir. Quality	Innova-tion & Accredi-ted Pro-fessional	Total Points
1900 Building	7	1	2	3	7	0	20
Fire Station 17	6	0	2	2	7	0	17
East Precinct	7	0	0	2	3	0	12
Note: A minimum of 32 points was required for basic LEED™ certification in the version we applied. The requirement was reduced to 26 in the final adopted version.							

[2] Incremental life cycle costs included the change in first cost plus the present discounted value (PDV) of changes in future costs. Future costs included energy, potable water, stormwater services, workers' wages, and maintenance. We used a real discount rate of 3% (5.8% nominal) to calculate PDVs and a 25-year time horizon.

[3] Note that LEED™ also allows credits for innovation and involvement of a LEED™ professional, but these are for bonus credits and are not part of the core requirements.

All buildings fell considerably short of the 32 points required for basic certification.[4] The 1900 Building received the highest rating of the three buildings, scoring at least one point in each category. The 1900 Building incorporated an innovative raised floor system that provided energy efficiency and indoor air quality benefits. All buildings scored relatively well in the Sustainable Sites category. All scored poorly in the Water Efficiency category. The energy efficiency of two buildings was 20% better than the minimum requirement and earned 2 points.

Green Option Results

To illustrate the results of our analysis, the building and site options selected to upgrade the 1900 Building to qualify as LEED™ certified are summarized below for two categories.

Water Efficiency Measures

Lowest first cost options	Lowest life cycle cost options
Water-efficient landscaping—plant native vegetation and eliminate irrigation	Water-efficient landscaping—plant native vegetation and eliminate irrigation
Water use reduction—install high-efficiency plumbing components	Water use reduction—install high-efficiency plumbing components

Energy and Atmosphere Measures

Lowest first cost options	Lowest life cycle cost options
Best practice commissioning and measurement and verification	Best practice commissioning and measurement and verification
Optimize energy performance—30% improvement over ASHRAE 90.1-1999 Standard	Optimize energy performance—40% improvement over ASHRAE 90.1-1999 Standard
Green power—purchase 30% green power	

In the case of Water Efficiency measures, the options selected were identical under both the lowest first and lowest life cycle cost cases. The first measure was to plant native vegetation that would permit elimination of the irrigation system. This option would reduce the use of potable water for irrigation and provide environmental benefits associated with native plantings.

In the case of Energy and Atmosphere measures, we included the LEED™ option of best practice commissioning. Fundamental commissioning is a prerequisite for a rating, so this measure would have to be implemented in all cases. We elected to include best practice commissioning for all three buildings because the literature has demonstrated the benefits of full commissioning. Since the estimated energy and water savings assumed that all installed measures worked properly, we felt that it was essential to include full commissioning in the analysis to ensure proper system performance. Consequently, we included the costs of full commissioning and used the estimated energy and water savings to calculate the benefits of

[4] The final Version 2 of LEED™ established a point total of 26 for basic certification.

each measure. The only benefits that we attributed to commissioning were increases in worker productivity, as discussed later.

We conducted similar analyses for the other two buildings. The impacts of the selected options were then tabulated. The results are summarized in Table 4 for each building and for both the lowest first cost and lowest life cycle cost cases. The results are discussed after the table.

Table 4. Summary of Costs and Benefits by Building and Selection Criterion

Cost/ Benefit Category	1900 Building Measure Selection Criterion		Fire Station 17 Measure Selection Criterion		East Precinct Measure Selection Criterion	
	Lowest first cost	Lowest LCC	Lowest first cost	Lowest LCC	Lowest first cost	Lowest LCC
Direct first costs	$66,300	$185,800	-$2,580	-$277	$58,700	$98,800
Direct and regional system LCC	-$2,890,000	-$3,047,000	-$101,200	-$101,850	-$1,886,000	-$1,915,000
Societal LCC	-$3,010,000	-$3,138,000	-$102,300	-$103,000	-$1,911,000	-$1,944,000

Regional system costs. Note that we estimated the direct and regional system life cycle cost effects to be the same in this analysis. This was because 1) we were unable to obtain long-term projections for marginal costs to be used to estimate regional system cost impacts and 2) the short-term marginal cost forecasts that were available indicated that marginal costs were not higher than average costs. This was the case for potable water, energy, and water treatment costs. However, we believe that over the long run, marginal costs will be larger than average costs and the regional system impacts will, in fact, be larger than the rate impacts on the building occupants. Because of the importance of considering marginal cost impacts, we identify them in the table even though we were unable to provide reliable estimates, and we believe that they should be analyzed in future studies of green buildings.

Incremental first cost effects. The first cost impacts were significantly more favorable using the lowest first cost criterion than when applying the lowest life cycle cost criterion. For the 1900 Building the first costs were estimated to increase by about $66,000 if the least cost options had been selected to achieve LEED™ certification, or only about one-third the first cost increase under the lowest life cycle cost scenario. For the East Precinct, the increase was about half what it would have been if the lowest life cycle cost approach had been selected. The results for Fire Station 17 were revealing because we found options that would have decreased the first cost in both cases. This resulted from proposing the use of salvaged materials and eliminating the need for an irrigation system. The change in first cost ranged from a *decrease of 0.3% to an increase of 2.2% in construction costs.*

Direct/regional system life cycle cost effects. In all three cases, *implementation of the green options that we recommended would have reduced life cycle costs.* The amount ranged from about $100,000 to over $3M over a 25-year analysis period.

The majority of the life cycle cost reductions was attributable to estimated productivity improvements. This finding is consistent with the limited research available and conventional wisdom about the benefits of greening buildings. Although the actual effect on productivity that would be achieved is debatable, we used conservative estimates. Studies that have documented productivity effects have produced estimates from a few percent to 20% or more (see, for example, Romm and Browning 1998). We assumed increases between 1% and 2% and attributed them to thorough commissioning of the building's systems and modifications that would improve indoor air quality and comfort.

Our results showed that, *even without including any productivity benefits, however, life cycle costs would have decreased, primarily due to reductions in energy and potable water consumption and stormwater runoff.* The use of salvaged materials also offered both first cost and life cycle cost savings opportunities. Without including productivity benefits, estimated savings ranged from about $13,000 to over $160,000 over a 25-year period.

Societal and unquantified impacts. The only societal impacts that we included explicitly were the estimated value of reduced air pollution. Using recent estimates of monetary benefits of these externalities, *the incremental societal life cycle savings of just these impacts ranged from $1,200 to $173,000.* Across the three buildings, the CO_2 reductions totaled about 370 tons per year, which would be equivalent to removing about 85 cars from the streets. Although these amounts are not very large, the aggregate effects across all new City buildings could be significant.

We were unable to quantify many other impacts. The most notable ones we did not quantify included benefits to fish and wildlife habitat, worker health, aesthetics, and forests.

Conclusions and Recommendations

Major Conclusions

LEED™ rating system. Green building rating systems and evaluation tools are relatively new. LEED™ is the most recognized and applied system in the U.S. We found that Version 2 appears to comprehensively cover the likely impacts that should be accounted for in a green building assessment. The options included within the five main categories also appeared to be appropriate and fairly complete, given current technologies and the state-of-the art.

The LEED™ rating system, however, needs to be supplemented in two ways: *LEED™ provides little guidance for the design professional who wants to meet the certification requirements based on specific objectives and the principles underlying the system are not explicitly presented.* The rating system simply assigns points to specific building or site characteristics, without providing insights into costs or other impacts.[5] It also fails to provide a clear conceptual foundation that relates it to broader sustainability issues and overall goals.

Overall, we believe that LEED™ can be a useful tool for promoting a systems perspective in building design and construction. Because it covers a diverse range of options

[5] At the time of this study the LEED Reference Guide for Version 2 was unavailable; it is our understanding that the guide will provide some information to assist in the selection of various options, so our comments should be treated as preliminary and based only on the information we had available.

and impact categories, it is an effective means, if applied early on, for encouraging building professionals to think beyond their usual disciplines and issues. To meet the certification requirements all aspects of a building and site have to be taken into account and all professionals involved must examine what tradeoffs can be made and what their impacts will be. For this reason alone, we believe that this method can be a useful tool to encourage efforts to improve the environmental impacts of buildings.

Ratings of current buildings. Using the LEED™ method, we found that the buildings we studied, which were all constructed within the past five years in the Portland area, fell considerably short of meeting the LEED certification level.[6] This is despite stringent local energy codes and a regional commitment to solid environmental and planning policies and practices. This finding points out that a green building is far more than a building that emphasizes just energy efficiency or any other single attribute. To qualify under the LEED™ system a building (and site characteristics) must perform well in many areas requiring that the design and construction process be approached very systemically.

Despite the gap between the rating of these buildings as-built and the LEED™ certification level, we found that several reasonable options could have been implemented to reach the basic certification level.

Upgrades to qualify as green buildings. The key to selecting options for greening buildings is to determine what criteria will guide the selection. Our approach was to apply two criteria. One was least first cost, which is the criterion that probably will be considered to be most important by typical building designers and owners. Unfortunately, emphasizing this criterion is counter to green building concepts because these concepts inherently require a broader view of the costs and benefits of buildings; at the least, costs and benefits should be considered from a life cycle perspective.

Consequently, lowest life cycle costs were the second criterion we used to select green building options. Our analysis used the owner/occupant life cycle cost perspective to minimize life cycle costs.

For each building, we found options that would meet the green building certification requirement based on minimum first cost and minimum life cycle cost. As noted earlier, we limited the options that we considered to exclude those would have required major design changes, and consequently, the results are unlikely to be the optimum that could have been achieved if the analysis had been conducted during site selection and planning. In general, the best approach appeared to be to consider measures that

- improve energy efficiency,
- reduce water consumption and runoff, and
- take advantage of salvaged or recycled materials.

Our analysis also showed that green roofs on Portland City buildings may be a desirable option from the life cycle cost perspective. The largest economic benefit of green roofs comes from reducing the frequency of replacing conventional roof materials. Green roofs also provide life cycle benefits from reduced energy consumption and stormwater

[6] As noted earlier, the final Version 2 LEED™ would make it easier for these buildings to obtain a basic certification.

runoff, and provide difficult to quantify, but important, aesthetic and heat island benefits. In general, it would appear to be worthwhile to evaluate a green roof option on a case-by-case basis.

Other measures should be considered on a regular basis because of their other benefits. In particular, those measures that target improvements in indoor air quality, reduced use of toxic materials, and decreased negative environmental impacts should be emphasized, even though their direct life cycle economic impacts may be difficult to quantify.

Costs and benefits of building green. Table 5 shows that, based on our analyses, all three of these buildings could have been built to meet LEED™ for a small or no increase in first cost. The green investments would have yielded life cycle cost savings to the City ranging from 13% to 43% of construction costs. As noted earlier, the air emission externalities that we were able to quantify would have produced societal benefits valued at $1,200 to $173,000. The majority of the life cycle savings we estimated were due to potential increases in worker productivity, but even if no productivity enhancements occurred the City would have experienced direct economic benefits over a 25-year period in each case.

Table 5. Costs and Benefits of Building Green Based on Lowest Life Cycle Costs

Building	% Change in First Cost	(Change in Direct Life Cycle Costs) (Construction Cost)	Change in Quantified Externalities
1900 Building	+1%	-16%	-$173,000
Fire Station 17	0%	-13%	-$1,200
East Precinct	+2.2%	-43%	-$36,000

Recommendations to the City

Based on our study, we recommended the following to the City:

- *Portland should develop a green commercial building rating system based on LEED™.* Other rating systems should be investigated to identify features that should be incorporated. Local conditions and the environment should be taken into account. The system should be designed to reflect basic guiding principles such as those offered by The Natural Step (see www.naturalstep.org). The City also should develop tools that incorporate evaluation criteria, including first and life cycle costs, to supplement the green rating system.
- *The City should develop required policies, information, and technical assistance and incentives to promote green buildings.* Demonstration projects with new buildings should be conducted to get "hands-on" green building experience. Information should be provided to assist agencies and the building community implement green building practices. Barriers to green building should be removed and incentives should be provided selectively to encourage green building practices.

- *Portland should take immediate steps to implement green building practices.* The information from this study should help select near-term actions that can be taken to accelerate the adoption of green building practices.

Acknowledgments

The authors would like to thank the Northwest Energy Efficiency Alliance and the Portland Energy Office for providing the funding to conduct the research upon which this paper is based.

References

Andereck, Kelly Jon and Richard Schoen. 1999. "A Comparison of Performance Rating Systems and Tools." In *Proceedings of Mainstreaming Green: National AIA Conference.* October 14-17, 1999, Chattanooga, Tenn.: American Institute of Architects.

Paladino, Thomas. 1999. "Cost Benefit analysis of a LEED™ Model Building." In *Proceedings of Mainstreaming Green: National AIA Conference.* October 14-17, 1999, Chattanooga, Tenn.: American Institute of Architects.

Norris, Gregory and Harold Marshall. 1995. *Multiattribute Decision Analysis Method for Evaluating Buildings and Building Systems.* NISTIR 5663. Gaithersburg, Maryland: National Institute of Standards and Technology.

Lippiatt, Barbara. 1998. *BEES 1.0: Building for Environmental and Economic Sustainability Technical Manual and User Guide.* NISTIR 6144. Gaithersburg, Maryland: National Institute of Standards and Technology.

Prest, A. and R. Turvey. 1974. "The Main Questions." In *Cost-Benefit Analysis.* Great Britain. Penguin Books.

Romm, Joseph and William Browning. 1998. Greening the Building and the Bottom Line. Rocky Mountain Institute, Snowmass, Colorado.

XENERGY, Inc. 2000. Applying the LEED™ Green Building Rating System to City Buildings. Prepared for City of Portland, Portland, Oregon.