Case Study

Green City Buildings—Applying the LEED™ Rating System

prepared by

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GREEN CITY BUILDINGS: APPLYING THE LEED™ RATING SYSTEM

Prepared for
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EXECUTIVE SUMMARY

During 1999, the City of Portland, Oregon, conducted a public process to investigate options open to the City to promote the construction and operations of green buildings. This process led to development of the City's *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.

Two of the main issues raised during development and early implementation of the Initiative were what constitutes "green building" and the costs and benefits of building green. This report discusses a study conducted to provide initial answers to these questions.

S.1 STUDY OBJECTIVES AND APPROACH

S.1.1 Objectives

The study had the following primary objectives:

1. Determine how "green" three recently built City buildings are.
2. Assess how each City building **could have been built** to qualify as "green" and determine the costs and benefits that would have occurred.

Table S-1 summarizes the characteristics of the three City buildings included in our study.

S.1.2 Building Ratings

Our approach for determining the "greenness" of each building was to evaluate each one based on an appropriate green rating system. We used the rating system developed by the U.S. Green Building Council (USGBC). The Leadership in Energy and Environmental Design (LEED™) green building rating system available at the time of our study was created for rating new commercial buildings.[1] It provides the following set of categories within which specific measures or performance requirements are defined:

- Sustainable Sites

[1] We used the LEED™ commercial building rating system , Version 2, that was undergoing public review early in 2000. The final version was issued just as this study was concluded. The final version probably would not change our overall findings, but it would have allowed the redesigned buildings to qualify as "Silver-rated," rather than at the lowest certification level.

- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality

Table S-1
Study Building Characteristics

Building	Type	Number of Stories	Floor Area, sq. ft.	Year Built	Number of Occupants
1900 Building	Office	7	143,200 (office space)	1999	550
East Precinct Community Police Station	Mixed use, police station and community space	2	23,000	1997	46*
Fire Station 17	Fire station	2	4,900	1994	17**

*We were informed that 30 people work 8-hour shifts in the police station 5 days per week and 5 people work in the building the remainder of the time. On the average, this would be equivalent to 46 employees in the station for a single shift, 5 days per week.
**Based on 4 per shift, 24 hrs/day, 7 days/week.

To rate a building, it receives one or more points for meeting individual requirements specified in the rating system. The total of all points constitutes the building's rating and, based on the rating, the building can be classified into one of four certification levels (such as the Gold Level), which are defined based on a range of points (or the building can fail to meet the requirements of the minimum certification level).

S.1.3 Selecting Measures to Meet LEED™ Requirements

We assessed each building and analyzed ways in which the original design could have been changed to qualify the building under the LEED™ approach. We used two economic criteria—lowest first cost and lowest life cycle cost—to select changes to the original design. First cost was used as one criterion because of questions raised during the development of the Green Building Initiative about how much, if any, construction costs would increase for green buildings. Life cycle cost was used as the other criterion because of the importance of taking into account the future benefits that were likely to be derived from green buildings. We strove to be conservative in our analysis of the three City buildings so that benefits would not be overestimated or costs underestimated.

S.1.4 Costs and Benefits

We applied different perspectives to assess the costs and benefits of the green options considered.

- The *direct* perspective captures the direct costs and benefits that fall upon the operator/owner and building occupants.
- The *regional system* perspective accounts for impacts on regional ratepayers, which depend on marginal costs.[2]
- The *societal* perspective takes a more global view and adds externalities to the regional system costs and benefits. Unfortunately, many external impacts are not readily quantified or monetized.

There are several fundamental parameters that were needed to calculate life cycle impacts. These are listed below along with the value that we used:

- life cycle time horizon = 25 years,
- inflation rate = 2.8% (but analysis was done in real terms), and
- discount rate (used to derive present discounted value of future costs and benefits) = 5.8% nominal, 3% real.

For every option included, it was necessary to document the following:

- incremental first cost compared to the measure employed in the as-built building,
- incremental operating and maintenance costs over the life cycle of the building, and
- all other significant incremental benefits and costs including changes in occupant productivity, changes in air emissions, and changes in other environmental impacts.

S.2 Major Findings

It is important to note that our findings are based on analyses of buildings that were constructed before the LEED™ system was available. Consequently, there was no accepted way of defining green buildings or systematically selecting green options when these buildings were designed and built. As a result, these findings should be viewed as providing insights into how future City practices could lead to green buildings and what the costs and benefits will be. They should not be viewed as an assessment of past practices.

S.2.1 LEED™ Ratings

Table S-1 shows that all three buildings fell short of the 32 points required for basic LEED™ certification.[3] Generally, the LEED™ categories in which the biggest percentage gaps existed

[2] Despite a comprehensive effort to quantify marginal costs to use in our study, we were unable to obtain reliable estimates of marginal costs in any relevant category and, therefore, could calculate no differential between the direct and regional system effects. The distinction between direct impacts, however, is an important one.

[3] The requirement has been reduced to 26 points in the final Version 2 of LEED™.

between the rating and points possible were Water Efficiency, Energy and Atmosphere, and Materials and Resources.

Table S-1
LEED™ Ratings of Three City Buildings

Building	Total Points Scored As Built
1900 Building	20
East Precinct	12
Fire Station 17	17
Points Required = 32	

S.2.2 Upgrading to Meet LEED™

Although these three buildings fell short of the required point total, our analysis showed that they could have been designed to meet the requirements for a relatively small (if any) increase in first cost as shown in Table S-2.

Table S-2
Summary of Costs Required to Qualify as LEED™ Certified

Building	% Increase in First Cost	
	Lowest First Cost Approach	Lowest Life Cycle Cost Approach
1900 Building	0.3%	1%
East Precinct	1.3%	2.2%
Fire Station 17	-0.3%	0%

Figure S-1 summarizes the economic cost and benefit results for redesigning the largest of the three buildings studied to meet the LEED™ requirements. The pattern of the results was similar for the two smaller buildings, but the magnitudes were less.

For the relatively small increases in first costs, the life cycle costs to the City would have decreased for each building. Taking into account only the "hard" future costs (such as utilities, maintenance, etc.), future savings over 25 years would have more than offset the initial investment costs. Table S-3 presents the difference between the life cycle cost (first cost plus future discounted costs) for each building if it had been designed to meet LEED™ and the life cycle cost estimated for the building as built. These results were calculated over the first 25 years. The life cycle costs would have decreased primarily due to reductions in energy and potable water consumption and stormwater runoff. The use of salvaged materials in some cases also offered both first cost and life cycle cost savings opportunities.

Figure S-1
Summary of 1900 Building Costs and Benefits

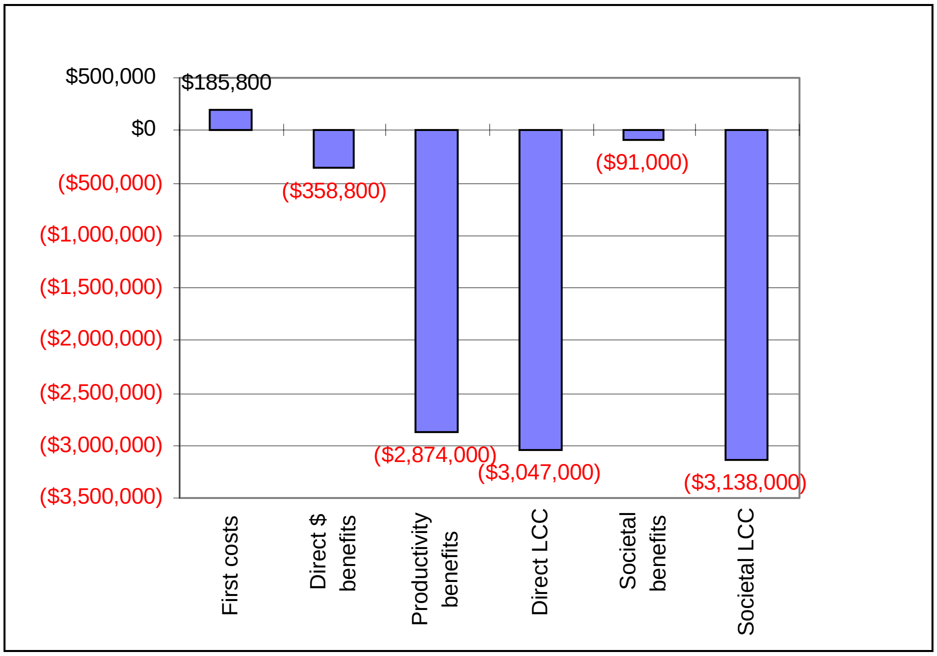

Table S-3
Change in Life Cycle Cost (Neglecting Productivity Increases), Lowest Life Cycle Cost Alternative

Building	Change in Life Cycle Cost (no productivity benefits included)
1900 Building	-$173,000
East Precinct	-$36,000
Fire Station 17	-$13,100

The biggest potential payoff for the City, however, would be probable improvements in productivity of the building occupants. These would result from better lighting, air flow, indoor air quality, etc., which would improve worker comfort and reduce complaints, absenteeism, and health problems. Table S-4 shows that, taking the productivity benefits into account, the life cycle cost savings would have been increased by a factor of about 10 to 15 (over 25 years) compared to the "hard" cost savings above. Because it was not possible to measure actual productivity changes, we based our calculations on conservative estimates from prior research. For all three buildings, the life cycle savings would have been about 15% of the original construction cost.

Table S-4
Summary of Estimated Direct Life Cycle Cost Savings Including Productivity Benefits

Building	Change in Life Cycle Cost	(Life Cycle Savings)/(Construction Cost)
1900 Building	-$3,047,000	16%
East Precinct	-$516,000	14%
Fire Station 17	-$101,900	13%

Other than options that increase productivity, the primary opportunities to reduce life cycle costs were the following:

- measures to improve energy efficiency,
- measures that reduce water consumption, and
- use of salvaged materials.

These results showed that low cost ways to improve energy efficiency should always be investigated, even for buildings that are designed to perform better than required by code. A life cycle cost analysis should be conducted to select efficiency measures that have the largest payoff.

Water consumption, both in the building and for landscaping, often can be reduced through measures that have little or no incremental costs. For example, native vegetation can eliminate the need for irrigation, thus reducing *both* first cost and future costs, as well as earning credits under LEED™.

The use of salvaged materials, another option that receives LEED™ green building credits, offers opportunities to reduce first cost and overall life cycle costs.

Our analysis also revealed that green roofs were preferred options for two of buildings from the City's life cycle cost perspective. The largest economic effect of green roofs comes from eliminating the requirement to replace conventional roof materials as often as every 12 years. Green roofs also provide life cycle benefits from reduced energy consumption and stormwater 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.

Measures that target improvements in indoor air quality, reduced use of toxic materials, and decreased negative environmental impacts also should be emphasized, even though their direct life cycle economic impacts may be difficult to quantify.

S.2.3 Application of a Green Rating System

Our results show that using a system, such as LEED™, to broaden the objectives used in the design/build process can produce significant benefits that are not likely to result from standard practices. As stressed earlier, evaluating measures based on their life cycle costs can produce significant long-term benefits for the building owner and occupants. Explicitly recognizing societal impacts can lead to decisions that also have significant payoffs beyond the building owners. In addition, an integrating framework such as LEED™ can promote the use of measures that have multiple benefits, such as green roofs.

Our case studies illustrated the necessity to develop criteria to guide the selection of measures to comply with the requirements of LEED™. The minimum first cost criterion was applied successfully to a wide range of feasible options to select those that could have been packaged together to achieve LEED™ certification at lowest first cost. The minimum life cycle cost criterion also was applied successfully, leading to a slightly different combination of measures that would minimize the life cycle cost of meeting the LEED™ requirement. In keeping with the intent of the City's Green Building Initiative and the fundamental principles underlying the concept of green buildings, we believe that using the life cycle cost criterion is the preferred approach.

S.2.4 Building Commissioning

Our approach assumed that the measures analyzed were installed and operated correctly. Based on the extensive studies that have been conducted, commissioning should be implemented to ensure the proper performance of buildings, particularly green buildings. A recent report indicates that full commissioning costs range from about 0.5% to 1.5% of total construction cost. We estimated commissioning costs based on these data and information from the City about its construction quality assurance practices. Without a rigorous analysis of each building and its systems, however, it is uncertain what the actual commissioning costs would have been, but we believe our estimates were realistic and relatively conservative.

Since no formal, systematic commissioning process has been established by the City, using an approach patterned after the commissioning process LEED™ defines could lead to a formalized and consistent approach for all new City buildings.

S.2.5 Societal and Non-quantified Impacts

Our analyses provided estimates of some of the societal benefits of designing green buildings. In particular, we estimated the economic value associated with air quality impacts from reduced electricity generation. We were unable, however, to estimate the economic value of several other benefits, including improved health of building occupants and improved fish and wildlife habitat.

Table S-5 presents the value of the life cycle cost impacts that we were able to estimate that would fall on society at large. These impacts are often referred to as externalities. Although these impacts are not extremely large compared with the cost of the buildings, they are very comparable to the direct life cycle economic benefits (excluding productivity effects) that would have accrued to the City if the buildings had been designed to meet LEED™.

Table S-5
Change in Estimated Externalities,
Lowest Direct Life Cycle Cost Alternative

Building	Change in externalities
1900 Building	-$91,000
East Precinct	-$31,000
Fire Station 17	-$1,200
Note: Direct costs on building owner/occupants are not included.	

If the societal impacts, rather than the direct impacts on the building owner/occupants, were used to select green building options, a somewhat different set of measures would have been chosen for each building. These choices would have produced larger societal and environmental benefits, and pursuing them would be consistent with the City's commitment to environmentally sound policies. The purchase of green power is one example where the benefits to society could be increased substantially, although the direct life cycle costs to the City would be higher. The recent decision by the City to purchase green power demonstrates the City's commitment to improving the environment and fulfilling its public role. By specifying purchases of green power for green buildings, the City would fulfill this commitment and receive credit under LEED™.

S.3 RECOMMENDATIONS

The major recommendations to the City from this study are the following:

1. Develop and implement a green building rating system starting with LEED™, and modify it, as needed, to take into account conditions unique to this region and environment.
2. Develop an evaluation tool to complement the rating system to assist the City and the building community in selecting among measures and documenting their probable impacts.
3. Develop tools for assessing the operating impacts of buildings and to provide guidance on decisions made during the operational life of buildings.
4. Implement the key steps remaining in the Green Building Initiative.
5. Begin including in specifications for new commercial buildings green measures based on those included in LEED™.
6. Document experiences gained from green building projects.
7. Identify differences between current City practices and the requirements of full commissioning and define consistent practices for commissioning new City buildings. Conduct research on the costs and benefits of commissioning.
8. Conduct a detailed study of potential productivity benefits from green buildings.