The Costs and Benefits of Achieving Silver LEED For Two Seattle Municipal Buildings

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ABSTRACT

The City of Seattle's Sustainable Building Policy requires new City facilities to achieve LEED™ silver ratings. City policy makers commissioned a preliminary evaluation of the cost-effectiveness of this policy for the first two buildings completed. The resultant life cycle cost analysis quantified costs and benefits for the projected LEED credits. It considered direct benefits, such as utility cost reductions, as well as indirect benefits, such as productivity gains, from LEED-influenced actions. Key data came from design teams and city project managers, as well as relevant literature. This study found that LEED substantially influenced building designs, thereby increasing first costs slightly, but also providing significant benefits over time, mainly in reduced energy use and improved productivity. City investments in LEED certification for these two buildings proved cost-effective, although this finding depends a great deal on the future effects of commissioning, measurement and verification, and measure persistence.

Background

In 1999, the City of Seattle adopted its Sustainable Building Policy, which directed City departments that build facilities greater than 5,000 square feet to design and construct them in such a way that they achieved a Silver LEED™ rating. Seattle was the first municipality in the country to set such a goal for its own facilities. Currently, at least 16 City-owned projects, representing 2.75 million square feet of space, are participating in the LEED™ program.

The U.S. Green Building Council (USGBC) developed LEED™ (Leadership in Energy and Environmental Design) Green Building Rating System in the 1990s. According to the LEED reference guide, this system "evaluates environmental performance [of facilities] from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a 'green building'" (USGBC, 2001). Buildings can become certified at four increasingly challenging levels, based on how many credits the building earns. Silver is the third-highest level. Projects can obtain credits in six categories: (1) Sustainable Sites, (2) Water Efficiency, (3) Energy & Atmosphere, (4) Indoor Environmental Quality, (5) Materials & Resources, and (6) Innovation & Design Process.

Introduction

In late 2002, City of Seattle policy makers and the Office of Sustainability and Environment (SOSE) commissioned a preliminary evaluation of the cost-effectiveness of the Sustainable Building Policy on two buildings nearing completion in early 2003, the Seattle Justice Center and Marion Oliver McCaw Performance Hall. The resultant study had several main objectives, including (a) enumerating the costs and benefits of LEED Silver certification,

(b) calculating life cycle benefit-cost ratios for each project within data constraints, and (c) providing early feedback on the effects of the Sustainable Building Policy.

Analysis Methodology

Data Sources

Key information for the study came from numerous sources, including:

LEED reference package: general info about the intent, and potential costs and benefits of each LEED credit.

City project managers: detailed information about targeted LEED credits, actions taken to obtain them, whether actions could be considered standard practice, costs and savings associated with actions beyond baseline[1], and the decision-making process underlying LEED-related choices.

Utilities: appropriate electric, water, sewer, storm water, and natural gas billing rates, avoided cost assumptions, conservation program incentives, and baseline usage and potential savings for certain water measures.

Figure 1. Justice Center

LEED consultant: Seattle LEED Evaluation Plan (Paladino & Company, 2002) detailing techniques for estimating productivity benefits from improved indoor environmental quality for a number of city facilities. The consultant based these on estimated payroll costs and U.S. Department of Labor data for determining baseline lost productivity from thermal discomfort, illness, and respiratory distress. The effects of mitigating these problems were quantified using results from a wide-ranging review of indoor environmental research (Fisk, 2000). The LEED consultant in turn linked these quantities to the number of applicable LEED credits. Our analysis took this a step further by limiting the credited productivity increases only to those credits that resulted in actions beyond baseline. Also, because there is a great deal of uncertainty about how to apply the Fisk results to LEED situations, our analysis

[1] "Baseline" is defined as the applicable regulations or industry standard practices in the city of Seattle that would dictate what actions would be done in the absence of LEED certification.

prorated the benefits by 50% to be conservative. This also reflects the fact there can be a downside to impacts of LEED measures, e.g., daylighting can both improve comfort for some, but lead to glare complaints for others. It is important to note as well that our analysis only quantified benefits to full-time occupants of the buildings, not the public at large.

Figure 2. McCaw Hall

Mechanical design firm: detailed studies of potential energy efficiency measures at each building, based on PowerDOE hourly simulation models using the 1997 Seattle Energy Code as a baseline. We reviewed the key assumptions and results in these studies, and revised them as necessary based on our engineering judgment.

Commissioning studies: study of the quantified costs and benefits of commissioning in 20 public buildings in the Pacific Northwest (SBW Consulting, 2003).

The City stipulated the following economic assumptions: 25-year life, 2% and 6% real discount rates, and modest utility rate escalation above inflation. We assumed a general inflation rate of 2.8% based on official federal figures for 2001. From Seattle City Light and Puget Sound Energy rate schedules, we established applicable electric rates of 5.86 cents/kWh and $1.03/kW/month, and natural gas rates of $0.553/therm. Seattle Public Utilities provided an applicable average water/sewer rate of $5.45 per 1,000 gallons.

General Analysis Approach

For both projects, we used the following approach to quantify the costs and benefits resulting from LEED certification:

1. For each LEED credit or prerequisite that the project manager indicated they were likely to obtain, we obtained as much information as possible about specific actions taken to reach it, baseline activities that would have taken place in the absence of LEED certification, and the incremental costs and benefits from the action(s). Baseline activities were not included in the analysis.
2. For all quantified impacts[2], we drew extensively from the main data sources described above to estimate their initial and sustained costs and benefits. As necessary, we

[2] "Impacts" is used here as a generic term that encompasses both costs and benefits.

augmented our analysis with other sources, such as engineering judgment from results for similar projects, cost estimating guides, and information from utility conservation experts. Because both projects were still under construction at the time of the study, most of the costs and nearly all of the benefits are projections based on the best available information.

3. Individual impacts were aggregated for each of six LEED credit categories (such as "Sustainable Sites", and "Innovation and Design") and entered into a standardized economic modeling spreadsheet. The inputs to this spreadsheet were net initial costs and first-year impacts (e.g., kWh/year, CCF/year, or $/year). The spreadsheet applied the economic parameters listed above to calculate benefits in terms of net present value dollars over the study life at discount rates of 2% and 6%.
4. Net-present-value costs and benefits for the six LEED credit categories were tabulated in an analysis summary spreadsheet, which calculated overall costs and benefits at the building/city levels for each credit category, as well as overall. Dividing the net present value benefits by the corresponding costs yielded benefit-cost ratios (BCRs). We calculated BCRs for several perspectives, including to the City of Seattle overall. Total costs included the relatively nominal cost of LEED registration, certification, and application preparation.

Baseline and Long-Term Impact Assumptions

We encountered a number of critical assumptions regarding the appropriate baseline to assume, as well as the expected long-term effects of certain LEED-influenced actions. These assumptions, in most cases, significantly affected the benefit-cost ratios for the projects we analyzed. How we treated these assumptions, and the basis for doing so, are documented below.

Utility program influence. The utilities for the two projects offer substantial financial incentives for implementing efficiency measures. Since electricity-saving measures in particular make up a significant percentage of the incremental costs and benefits for both projects, understanding the role these incentives played in influencing the projects to install the measures they did was critical to properly assessing the benefit-cost ratio. We determined from city staff that pursuing utility incentives is not standard practice, so for the Justice Center, LEED certification spurred additional efficiency measures. The Seattle Center, where McCaw Hall is located, generally pursues utility incentives, but this exceeds city standard practice. So as to not penalize the Center for their aggressive conservation, we assumed the latter for the baseline.

Multiple influences on actions. The Justice Center project contained several innovative features linked to LEED certification, including a thermal buffer wall to maximize views, light shelves for daylighting, and a large central staircase to facilitate occupant circulation. Since all three of these features resulted in significant first costs, we carefully weighed the decision-making process to determine what portions, if any, of these costs should be attributed to LEED certification.

LEED learning curve. On the McCaw Hall project, construction contractors requested additional funds to comply with some LEED requirements. These contractors may have increased their funding requests significantly to account for contingencies and uncertainties in

the process, since they were unfamiliar with the LEED requirements. Thus, it is likely that on future projects, the contractors will have learned how to meet LEED requirements more efficiently. Our analysis does not adjust for this "learning curve" effect, in which higher costs for this project may result in lower costs for future projects.

Measure degradation. Past research on building system performance has shown that the savings associated with certain resource conservation measures can degrade over time without periodic maintenance and adjustment. The energy and water/sewer savings associated with LEED actions in this analysis are estimates for the first year of operation. Both the future O&M cost and the potential savings degradation are extremely difficult to quantify, but they have major impacts on the LEED benefit-cost analysis. Since O&M costs are somewhat less difficult to estimate, our analysis assumed that both buildings incurred a nominal annual O&M increase to sustain all measure savings at 100%.

Measurement & verification (M&V) and continuous commissioning. LEED guidelines provide a credit for developing a plan to verify that the predicted savings are actually being achieved once the building is operational. This M&V is a one-time event that occurs after the building is commissioned and at steady state occupancy. LEED does not, however, by itself ensure that savings are maintained, and all building systems are functioning optimally, over the life of the building. Periodically "tuning up" building systems ("continuous commissioning") requires a sustained investment of time and resources by facilities staff. Our analysis assumed that both buildings would be willing to incur a small annual expense to ensure that energy and water conservation measures are functioning properly. It is possible that they would be willing to do more, and commit to full-fledged continuous commissioning of all building systems, but this analysis does not assume so.

Findings

Study findings were based on the best available information just prior to the completion of both projects. They represent an initial attempt to analyze a complex, non-linear system, and are subject to future refinements as additional data become available.

Expected LEED Credits

Both the Justice Center and McCaw Hall projects attempted to obtain LEED Silver certification, which requires 33 to 39 points, out of 69 possible points. The projects applied for 34 and 40 credits, respectively. Table 1 below breaks down the expected points for each project by LEED credit category. The baseline column indicates the number of credits received for actions that can be considered standard practice in Seattle public buildings. These "baseline" credits dealt with siting and alternative transportation, regional materials, low-emitting materials, indoor chemical/pollution source control, and construction waste management.

Table 1. Expected LEED Credits

	McCaw Hall			Justice Center			Combined		
Credit Category	Total credits expected*	# expected credits that are baseline	Baseline as % of total	Total credits expected*	# expected credits that are baseline	Baseline as % of total	Total credits expected*	# expected credits that are baseline	Baseline as % of total
Sustainable Sites	8	5	63%	10	6	60%	18	11	61%
Water Efficiency	2	1	50%	2	1	50%	4	2	50%
Energy & Atmosphere	**6**	**0**	**0%**	**6**	**0**	**0%**	**12**	**0**	**0%**
Materials & Resources	5	4	80%	2	2	100%	7	6	86%
Indoor Environmental Quality	14	4	29%	12	7	58%	26	11	42%
Innovation & Design Process	5	1	20%	2	1	50%	7	2	29%
TOTAL	**40**	**15**	**38%**	**34**	**17**	**50%**	**74**	**32**	**43%**

* 33 credits are required for LEED Silver certification. 69 credits is the maximum possible.

The LEED rating system also has "Prerequisites," which are required actions that do not yield LEED credits, but are necessary for certification. Our analysis considers the costs and benefits associated with prerequisites, where they exceed baseline practices. Table 1 clearly indicates that these projects could have obtained a significant percentage of necessary credits (43% on average) without taking any additional action beyond standard practice, aside from completing the LEED application. The Sustainable Site and Materials & Resources categories in particular have high baseline percentages. Conversely, none of the Energy & Atmosphere credits could be considered baseline. Table 2 details the specific energy efficiency measures added to the projects because of LEED, as well as the final cost and savings estimates developed from our analysis. Some of the most significant measures concerned lighting capacity and control measures, fan-powered VAV boxes, and variable-speed pumping.

Initial Net Costs

Initial net costs were defined as the sum of all quantified incremental costs and savings that accrue because of LEED certification during the building design, construction, and start-up process. Examples include the cost of hiring a commissioning agent, or solid waste disposal savings resulting from increased construction waste recycling. The overall increase in the initial net cost of the project that can be attributed to the influence of LEED certification is $909,400 ($3.08/SF) for McCaw Hall. This represents about 0.7% of the overall project budget of $125 million. For the Justice Center, the initial net cost was $1,728,100 ($5.76/SF), which represents 1.9% of the $92 million project budget. Between the two projects, the combined initial net cost was $2,637,500, or 1.2% of the combined project budgets. Note that this percentage falls within the range established by a study of 33 LEED buildings in California (Kats 2003). Of this

Table 2. Energy Efficiency Measures

JUSTICE CENTER

ECM #	Description	Evaluated annual savings MWh	kW	kTherm	Cost $000
2	Lighting Fixtures	346	53.2	(3.5)	209
8	Fan powered VAV boxes	241	27.5	(3.9)	135
3	Lighting occupancy sensors	223	25.4	(2.2)	76
1	Efficient chiller	133	110.5	-	69
5	Variable flow - chilled water	79	9.0	-	67
6	Variable flow - htng. hot water	70	8.0	-	25
7	Delta P Valves	59	6.8	-	4
16	Daylighting controls	56	14.7	(0.6)	8
15	Timer switches	34	9.0	(0.3)	4
11	Carbon dioxide sensors	34	3.9	(1.8)	42
4	LED Exit Signs	29	3.3	(0.3)	10
12	Condensing water reset	15	12.4	-	10
17	Water loop heat pumps	9	1.1	-	62
13	Cooling tower VFD	7	5.7	-	24
10	Carbon monoxide sensors	5	1.2	-	5
9	Building envelope upgrade	-	-	-	-
18	Thermal buffer (glass wall)	-	-	-	-
19	AHU Zoning	-	-	-	-
20	Elevator use	-	-	-	-
	DOE-2 study costs	-	-	-	18
Adjusted estimates		**1,339**	**291.7**	**(12.6)**	**766**
Designer estimates		2,982	n/a	(5.7)	4,091
Adjusted/original %		45%	n/a	221%	19%

MCCAW HALL

ECM #	Description	Evaluated annual savings MWh	kW	kTherm	Cost $000
3	Demand control ventilation	219	24.9	7.0	24
5	Fan powered VAV boxes	85	22.3	0.0	14
2	Variable speed pumping	65	17.1	-	33
7	2nd balcony VAV in lobby	64	16.8	(0.3)	31
6	VAV in auditorium	34	9.1	4.3	24
A	Theater work lighting	32	11.7	(0.3)	18
8	Delta P valves	32	8.4	-	20
1	Internal operable lobby shades	24	23.7	0.1	115
B	Front of house lighting controls	22		(0.2)	33
4	VAV kitchen exhaust hood	18	2.0	1.7	12
	ECM 1-8 design costs	-	-	-	22
	DOE-2 study costs	-	-	-	18
Adjusted estimates		**594**	**136.0**	**12.1**	**365**
Designer estimates		665	n/a	13.8	323
Adjusted/original %		89%	n/a	88%	113%

combined cost, the City of Seattle paid 79% of the $2.6 million LEED cost through direct project expenses. The remaining 21% is paid for primarily through utility conservation funding.

Table 3 shows the total initial net cost broken out by the six LEED credit categories. For both projects, actions associated with Energy & Atmosphere—energy efficiency measures, commissioning, and savings verification—account for over half to nearly two-thirds of the initial net cost. Indoor Environmental Quality and Innovation & Design Process actions also account for sizeable portions. Water Efficiency and Materials & Resources actions made up a negligible share of the cost.

Sustained Net Benefits

Sustained net benefits were defined as the sum of all quantified cost reductions, ongoing expenses, or added value that persist for an extended period after construction is complete and the building is occupied. Examples include electricity savings from LEED-related energy efficiency measures, and improved indoor air quality. The analysis calculated the sustained net benefits by taking the net present value of the net savings attributed to LEED influence, accrued over a 25-year period with discount rates of 2% and 6%. Results for the more conservative 6% scenario are shown in Table 4, broken down by the six LEED credit categories, thus highlighting the categories that account for most of the benefits. This classification is somewhat rough, because some actions in one category result in benefits in other categories. An example would be the Justice Center buffer wall, where the initial net costs were placed in the Innovation &

Table 3. Initial net costs to achieve LEED

	Initial net costs			
LEED credit category	McCaw Hall	Justice Center	Combined	**Cost elements***
Sustainable Sites	$16,200	$64,100	$80,300	(M) Bike racks and charging stations. (J) Charging stations, natural gas fueling stations, Green roof, rainwater collection system.
Water Efficiency	-$5,300	$1,500	-$3,800	(M) Irrigation controls, waterless urinals.
Energy & Atmosphere	$585,500	$959,500	$1,545,000	(M, J) Commissioning, M&V plan. Energy efficiency measures (see Table 2 for detailed breakdown).
Materials & Resources	$4,000	$0	$4,000	(M) Recycled content for major items.
Indoor Environmental Quality	$177,400	$186,400	$363,800	(M) Additional diffusers, occupant controls, daylighting/views measures, building flushout, construction IAQ management. (J) Light shelf, construction IAQ activities. (CO2 sensors included in Energy & Atmos.)
Innovation & Design Process	$115,000	$500,000	$615,000	(M) Construction recycling plan, material salvage. (J) Buffer wall
LEED administration	*$16,600*	*$16,600*	*$33,200*	(M, J) LEED registration & certification fees, application preparation.
TOTAL	**$909,400**	**$1,728,100**	**$2,637,500**	
per sq. ft.	$3.14	$5.76	$4.47	

* M = Marion Oliver McCaw Performance Hall, J = Seattle Justice Center.

Table 4. Sustained Net Benefits from LEED

			LEED Credit Category						
			SS	WE	EA	MR	EQ	ID	TOTALS
			Sustainable Sites	Water Efficiency	Energy & Atmosphere	Materials & Resources	Indoor Environmental Quality	Innovation & Design Process	
Justice Center	Initial net cost	$	66,800	4,300	962,200	2,800	189,200	502,800	1,728,100
		$/SF	0.22	0.01	3.21	0.01	0.63	1.68	5.76
		% of total	4%	0%	56%	0%	11%	29%	100%
	Sustained net benefits*	$	-	300	1,023,400	-	1,533,200	-	2,556,900
		$/SF	-	0.00	3.41	-	5.11	-	8.52
		% of total	0%	0%	40%	0%	60%	0%	100%
	Benefit-cost ratio*		-	0.07	1.06	-	8.10	-	**1.48**
McCaw Hall	Initial net cost	$	18,900	(2,500)	588,200	6,800	180,200	117,800	909,400
		$/SF	0.07	(0.01)	2.03	0.02	0.62	0.41	3.14
		% of total	2%	0%	65%	1%	20%	13%	100%
	Sustained net benefits*	$	-	22,400	525,348	-	31,600	2,200	581,548
		$/SF	-	0.08	1.81	-	0.11	0.01	2.01
		% of total	0%	4%	90%	0%	5%	0%	100%
	Benefit-cost ratio*		-	--	0.89	-	0.18	0.02	**0.64**
Com-bined	Initial net cost	$	85,700	1,800	1,550,400	9,600	369,400	620,600	2,637,500
		$/SF	0.15	0.00	2.63	0.02	0.63	1.05	4.47
		% of total	3%	0%	59%	0%	14%	24%	100%
	Sustained net benefits*	$	-	22,700	1,548,748	-	1,564,800	2,200	3,138,448
		$/SF	-	0.04	2.62	-	2.65	0.00	5.32
		% of total	0%	1%	49%	0%	50%	0%	100%
	Benefit-cost ratio*		-	12.61	1.00	-	4.24	0.00	**1.19**

* Assuming 6% discount rate.

Design Process, although associated sustained net benefits accrue to IEQ.

For McCaw Hall, the sustained net benefits ranged from $581,500 to $834,700 ($1.97-2.83/SF), for the 6% and 2% discount rates, respectively. For the Justice Center, the sustained net benefits ranged from $2,556,900 to $3,708,000 ($8.52 - 12.36/SF). The two projects combined produced an aggregate benefit of $3,138,400 to $4,542,700 ($5.32 - 7.70/SF).

For McCaw Hall, actions associated with Energy & Atmosphere—energy efficiency measures, commissioning, and savings verification—account for the vast majority (90%) of the benefit. Indoor Environmental Quality (IEQ) accounts for another 6%, with Water Efficiency making up about 4%. Quantified benefits from the other three categories were negligible. For the Justice Center, virtually all of the benefits fell into two categories, IEQ (60%) and Energy & Atmosphere (40%). Aggregated, about a half of the benefits from the two projects come from Energy & Atmosphere. The remaining half comes from IEQ, in the form of increased occupant productivity. This benefit springs mainly, in nearly equal parts, from increased comfort control for individuals and a reduction in communicable respiratory diseases. IEQ category benefits at McCaw Hall were small compared to those for the Justice Center, reflecting the fact that McCaw Hall has very few full-time building occupants.

Benefit-Cost Ratios

Dividing the sustained net benefits by the initial net costs yielded the benefit-cost ratios (BCR) for the projects. A BCR greater than one indicates that a project is cost-effective over its lifetime; conversely, a ratio below one indicates that the costs ultimately outweigh the lifetime benefits. Table 4 breaks down BCRs by LEED credit category (assuming a conservative 6% discount rate). These seem to indicate that IEQ investments (combined BCR greater than four) are especially cost-effective, and that EA expenditures are marginally so (BCR of unity). Because of the uncertainties inherent in assigning cost and benefits at the credit category level, though, these results should be considered very rough indications.

Table 5 shows overall project BCRs for two perspectives. The first, most narrow perspective examines only the direct costs and benefits that accrue to the building. With this criterion, the BCR for McCaw Hall ranges from 0.79 to 1.14, depending on the discount rate assumed. Similarly, the Justice Center BCR ranges from 0.77 to 1.10. The BCR for the two projects combined is 0.78 to 1.11.

From a wider citywide perspective that combines all impacts affecting both the building and the City of Seattle, the BCRs for McCaw Hall all fall under one (0.64 to 0.92), while those for the Justice Center increase dramatically to a range of 1.48 to 2.15. The Justice Center, unlike McCaw Hall, will have a large number of full-time occupants, and thus benefits from their presumed increase in productivity stemming from IEQ improvements. Over the 25-year study life, these benefits have a net present value of $1.5-$2.3 million. Because this figure significantly influences the cost-effectiveness of LEED certifications, we performed a sensitivity analysis to determine the effect of downgrading the productivity benefits. We found that even after reducing the value of the productivity benefit by over half, the overall BCR for the Justice Center still exceeded 1.0. The combined BCR range of 1.19 to 1.72 indicates that for these buildings considered together, LEED certification has been cost-effective to the City.

Conclusions

Cost-Effectiveness of LEED Certification

Preliminary analysis of two affected buildings yielded these early conclusions about the City's Sustainable Building Policy, and in particular about the LEED Silver Rating requirement.

- For the two studied projects combined, LEED-influenced actions are cost-effective. Our analysis concluded that the City of Seattle's investment of an additional $2.64 million to obtain LEED Silver certification for the Justice Center and McCaw Hall projects is cost-effective when examined over a 25-year period. The combined long-term net benefits from LEED for both projects, from a broad citywide perspective that encompasses cost contributions from municipal utilities, are 19% to 72% higher than the costs. This large range reflects the sensitivity of the results to discount rate assumptions.
- Increased energy efficiency and occupant productivity are major quantified benefits of these two LEED projects. LEED actions in the Energy and Atmosphere credit category, which include most energy efficiency and building system performance improvements, account for a significant portion of both the costs (59% of the combined costs) and benefits (49% of the combined benefits) beyond baseline. Increased occupant productivity from improved indoor environmental quality make up most of the remainder of the quantified benefits. Because of this, LEED actions will tend to be more cost-effective at buildings with high occupancy levels.
- Applying a rigorous process for selecting LEED credits to pursue can help reduce the additional cost of obtaining LEED certification. City of Seattle projects could benefit from a standardized process early during the project design for selecting the most suitable

Table 5. Summary of Benefit Cost Ratios

	McCaw Hall	Justice Center	Combined
Incremental cost to meet Silver LEED™	$909,400	$1,728,100	$2,637,500
	$3.14/ft2	$5.76/ft2	$4.47/ft2
% of project budget	0.7%	1.9%	1.2%
Benefits (over 25 years)	$581,500 - $834,700*	$2,556,900 - $3,708,000*	$3,138,400- $4,542,700*
$/sq ft	$2.01-2.88/ft2	$8.52-12.36/ft2	$5.32-7.70/ft2
Benefit-cost ratios			
1. Primary costs & benefits to building (i)	0.79 - 1.14	0.77 - 1.10	0.78 - 1.11
2. Citywide perspective - all costs & benefits (ii)	0.64 - 0.92	1.48 - 2.15	1.19 - 1.72

*The range represents two different discount rates, 2% and 6%

(i) Primary = direct, observable financial impacts, e.g., costs of bike racks, lower electric bills.

(ii) Also includes the portion of conservation measures paid for through municipal utility incentives.

LEED credits. Another means of enhancing the credit selection process would be to

document the credit selection process and the actual costs and benefits to assess whether particular credits performed as expected, providing valuable lessons on how to obtain LEED certification most efficiently and cost-effectively in the future.

Applicability of Results Beyond Seattle

Differences between economic and regulatory situations in various parts of the country make it difficult to compare LEED projects with similar ratings (Scheuer and Keoleian, 2002). In other words, a LEED Silver building in Seattle may have a very different environmental impact than a LEED Silver building in another part of the country. The Seattle area has particularly strict codes, regulations, and policies intended to protect the environment. Examples include prohibitions on single-pass HVAC cooling, environmental tobacco smoke control requirements, and carpool preference policies. These existing requirements mean many of the LEED actions taken by the two projects studied were considered baseline. In parts of the country with less stringent requirements, these same actions on other projects would have different net costs and benefits, resulting in differing cost-effectiveness levels. The clear implication, however, is that care must be taken in applying these results to projects outside of Seattle.

Uncertainties Inherent in Analysis

Because of the study timeframe, data collection and analysis took place while both projects were under construction. As a result, some of the data necessary to accurately quantify costs and benefits were not yet fully available. In addition, the project teams had not yet prepared the necessary LEED application documentation, so much of the analysis was based upon the judgment of the City project managers and their design teams.

In addition, many of the most significant sustained net benefits from LEED actions, namely energy savings and IEQ-related productivity increases, are necessarily based on key assumptions. These assumptions fall generally into these three interrelated areas: (1) building operations, where actual conditions will undoubtedly be different that initially assumed, introducing some uncertainty into building energy use and measure savings estimates, (2) commissioning, where the actual energy-related benefits from resolving issues uncovered by commissioning during project construction and startup can vary tremendously from building to building, and (3) measurement and verification, where the benefits are wholly contingent on the nature of deficiencies found and how the buildings rectify these deficiencies. Should actual conditions be significantly different from the analysis assumptions, the associated benefits may also be very different. Since energy impacts in particular are so significant, any changes in the assumed long-term benefit stream may dramatically affect the benefit-cost ratios for these projects.

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