The Costs and Benefits of LEED-NC in Colorado

Prepared for
Governor's Office of Energy
Management and Conservation

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October 25, 2006

Executive Summary

More and more owners and developers in Colorado are considering LEED certification for their projects. The impetus behind this is not only competition, but also the potential for added value with a more environmentally responsible and energy-efficient project. To make this commitment, owners and developers want information on whether it is cost effective to pursue LEED-NC certification and what the additional costs are.

To respond to these questions, 11 of the 20 LEED-NC certified buildings in Colorado were surveyed. We found the following concerning the costs and benefits of LEED certification in Colorado:

1. The cost premium of building a LEED-NC version 2.1 certified building compared to conventional construction ranges between 1 and 6 percent.
2. Using the modeled energy savings shows that the net present value of the predicted energy savings alone outweighs the cost premium in 7 of 9 of the projects with reported data.
3. Owner and design teams based decisions on life-cycle costs. Teams reported that life cycle cost analyses helped justify design decisions, such as more efficient mechanical systems.
4. The projects demonstrated that given a fixed budget that it is possible to achieve LEED certification through trade-offs and substitutions that give priority to achieving LEED credits.
5. The key strategies that impact the overall cost effectiveness of pursuing LEED-NC certification are forming a multidisciplinary internal team, setting a goal for LEED certification early and establishing priorities, including this goal in selection of the design team and contractor, budgeting for commissioning, basing decisions on life-cycle cost analyses, and using energy modeling to inform the design.

The table below summarizes the survey findings. The survey is somewhat limited in scope, but the sampling is significant enough to support the key conclusions. While LEED cost premiums are cited for all of the projects, projects such as CDLE and Fossil Ridge emphasized that their projects came in under the budgets originally established for these projects. The hard costs for these projects were not attributed to LEED because design decisions were driven by life-cycle cost analysis or their existing design and construction standards. However, note that the LEED premium cited for CDLE does include hard costs.

We found that soft costs alone are about 0.8% of the construction costs, or approximately $1/sf. Soft costs include fees for registering and certifying a project through the United States Green Building Council, documentation costs, commissioning costs and energy analysis costs. The soft costs vary depending on the size of the project, the experience level of the team, and the level of certification. The information on hard costs is too limited to provide budgeting guidance.

LEED Costs and Benefits for Colorado Projects

LEED Project	Certification Level / Size(sf)	Building Size (sf)	Construction Cost ($/sf)	LEED Cost Premium $/sf	Net Present Value of Energy Cost Savings $/sf	Net LEED Savings
CH2M Hill South	Certified	112,600	$156	($1.9)	$4.3	$2.4
CH2M Hill West	Certified	164,500	$156	($1.9)	$4.3	$2.4
CH2M Hill North	Certified	112,600	$156	($1.9)	$4.3	$2.4
Vehicle Storage	Certified	15,250	$129	($8.2)	$6.7	($1.5)
CDLE	Certified	40,000	$100	($3.3)	$2.3	($1.0)
Fossil Ridge HS	Silver	288,685	$122	($1.0)	$4.0	$3.0
N. Boulder Rec	Silver	62,000	$188	($8.7)	$10.4	$1.7
Pikes Peak Regional DC	Silver	111,758	$112	($0.9)	$5.1	$4.2
Tutt Science Cntr	Certified	54,123	$200	($9.2)	no data	
Snowmass Golf	Silver	10,000	$370	($20.0)	no data	
DU Law	Gold	210,000	$230	($0.7)	$3.5	$2.8

NPV calculation assumes 6% discount rate over 20 years.

Quantifying the benefits of LEED-driven design decisions proved to be much more difficult. The cost savings associated with commissioning, water reduction, waste management tipping fee reductions, downsizing systems and equipment, reduced maintenance and repair costs, and improved productivity were not available for the projects

Nevertheless, the projects gave concrete examples of the costs and benefits of various credits. All of the teams discussed the commissioning prerequisite and credit. From the survey, we found that commissioning has an average cost of $0.6/sf. The benefits of commissioning were not quantifiable from this study, although a nationwide study shows commissioning to have a payback of 5 years. Anecdotally, the Snowmass Club House stated that the commissioning process nearly paid for itself during the design development phase. Pikes Peak Regional District found that their building ran much more

efficiently than had commissioning not been conducted. CDLE and Fossil Ridge High School employ commissioning as standard practice based on their experience with improved building performance in commissioned buildings. And on the flip side, a couple of projects questioned the value of the commissioning process.

LEED Costs and Benefits

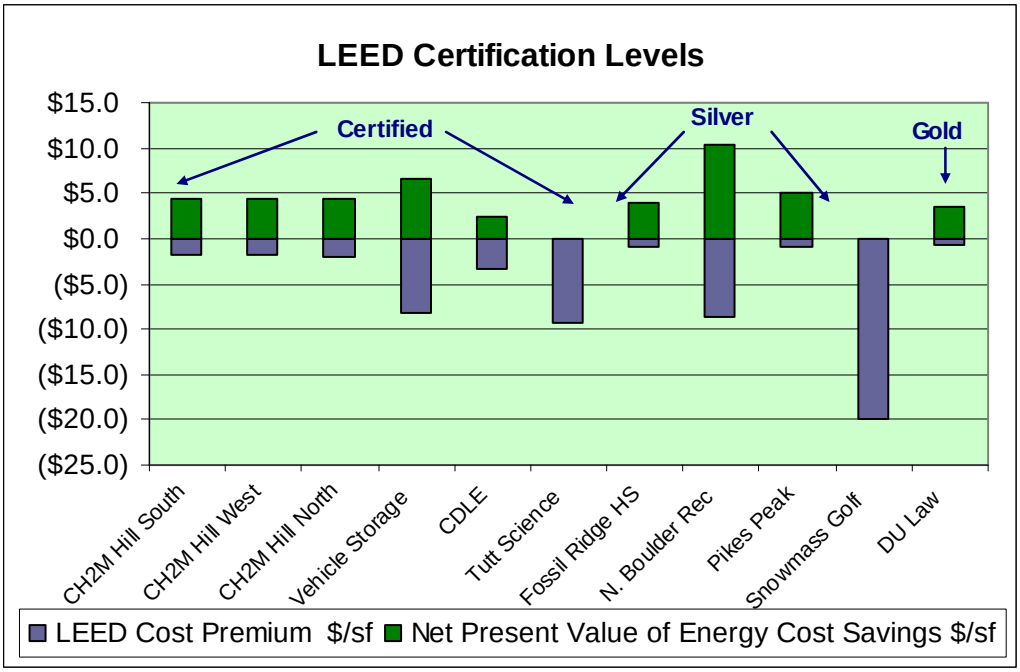
LEED Category	Cost	Benefits		
		First Cost Savings	Operating Cost Savings	Occupant
Site	Bike racks			✓
	Stormwater management	□	✓Reduce waste water fees	
	Light colored roof	□	✓Reduce cooling energy costs	
Water	Landscaping	✓Eliminate irrigation system	✓Reduce water costs	✓
	Plumbing fixtures	□	✓Reduce water costs	
Energy	Commissioning	✓Optimize systems	✓Reduce energy costs and maintenance costs	✓
	Energy efficiency	✓Downsize equipment and infrastructure	✓Reduce energy costs	✓
	Renewable energy	□	✓Reduce energy costs	□
	Measurement & Verification	□	✓Reduce energy costs	
	Green power			
Materials	Recycling	□	✓Reduce disposal fees	
	Waste management	✓Reduce tipping fees	□	
IEQ	CO_2 monitoring	□	✓Reduce energy costs if control ventilation air	✓
	Construction IAQ			✓
	Low emitting materials			✓
	System control	□	✓Reduce energy costs	✓
	Thermal comfort			✓
	Daylighting & views	□	✓Reduce energy costs if lights controlled in response to natural light levels	✓

All of the projects noted greater occupant satisfaction and the public relations value of having a LEED certified building. A few of the projects noted improvement in indoor air quality from the use of low-VOC materials. Colorado College has even incorporated the low-VOC specifications into their design guidelines. A majority of the projects also enhanced the daylight

levels and views in their facilities through the use of more glazing, high performance glazing, interior glazing, light shelves and shading.

In performing a life cycle cost analysis, the table above will assist in identifying costs and benefits of LEED credits. The table lists LEED credits that carry a cost and categorizes the potential benefits. Most of the credits will reduce operating costs and some have first cost savings. Benefits to the occupants are real, yet not easily quantified. And importantly, there are stated public relations and marketing benefits that are not included in the table.

From the cost and benefit data, we were unable to draw any general conclusions as to the costs and benefits relative to certification levels. The following chart groups the projects by certification level and there is no correlation between the costs or benefits and the certification level. Also, those projects with the lowest costs (Fossil Ridge, Pikes Peak Regional DC and DU Law) did not report hard costs. In addition, Tutt Science Center and the Snowmass Golf Clubhouse did not report their predicted energy cost savings.



Most of the project teams would and are pursuing LEED on future projects. Poudre School District will not because they cannot justify the documentation costs, although all new projects will reflect their commitment to sustainable design practices. Colorado College is certifying another project but they also find it difficult to justify the documentation costs. The

City of Fort Collins, in contrast, sees the documentation as necessary and streamlined, with the exception of that required for commissioning.

There are a number of factors and strategies to help minimize the investment in high performance and LEED-certified buildings. The United States Green Building Council has introduced an on-line certification system to streamline the certification process and reduce documentation costs. In addition, LEED-NC 2.2 includes provisions to reduce costs for commissioning and achieving energy performance points for small buildings. Projects with a commitment to LEED certification from start to finish, have the greatest success. And, as with anything, the more experience a team has with designing and building LEED-certified and / or high performance projects, the more cost effective the process will be.

We recommend that when making a decision about pursuing high performance buildings with or without LEED certification that decision-makers account for not only the hard and soft costs of the project improvements, but the hard and soft benefits as well. In most cases, the improvements in energy costs pay for themselves many times over, and enhancements in the work or learning environment provides benefits for the life of the building.

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Introduction

The impetus behind this study is to characterize LEED costs and benefits specific to LEED-certified projects in Colorado. For this study, eleven LEED-certified projects in Colorado were interviewed. The projects interviewed for this cost study are all LEED certified under LEED-NC 2.1 and include a variety of building types (Table 2). The majority of the buildings were completed by 2003. The construction costs per square foot of building conditioned area are shown and range from $100 to $370.

Table 2 Colorado LEED Certified Projects

Colorado LEED Project	Conditioned Square Footage	Certification Level	Construction Cost per Square Foot
CH2M Hill North Building	112,600	Certified	$156
CH2M Hill South Building	164,500	Certified	$156
CH2M Hill West Building	112,600	Certified	$156
City of Fort Collins Vehicle Storage Building	15,250		$128
Colorado Department of Labor and Employment Addition	40,000	Certified	$100
Fossil Ridge High School (Poudre School District)	288,685	Silver	$122
North Boulder Recreation Center	62,000	Silver	$188
Pikes Peak Regional Building Department	111,758	Silver	$112
Russel T. Tutt Science Center (Colorado College)	54,123	Certified	$200
Snowmass Golf Clubhouse (Aspen Skiing Company)	10000	Silver	$370
University of Denver Law School (includes cost of parking garage)	210,000	Gold	$230

The goal of this work is to provide design teams with insight into the costs and benefits of LEED Certification for projects in Colorado. The project teams addressed soft costs associated with LEED: design, documentation, commissioning and energy analysis; as well as hard costs, such as those for low-VOC materials and system upgrades. The benefits are more difficult to quantify. Annual energy cost savings are reported based on energy simulations. A few projects realized cost savings from commissioning up front. Other benefits were discussed, but not quantified. The teams also discussed design decisions that were or were not driven by LEED considerations.

Background

A number of comprehensive studies have been published that analyze the costs and benefits of LEED-certified projects. A report by Gregory Kats (October 2003) found the median cost premium to be less than 2% for 33 LEED-certified buildings (Table 1). He reported that buildings just meeting the certified level had little or no added cost for LEED. He also found that projects with teams with LEED experience have lower LEED cost premiums. And importantly, the cost of more sustainable materials and systems has come down as demand has increased.

Table 1 LEED Cost Premiums

LEED Rating -# of projects	Cost Premium
Certified – 8	0.6%
Silver – 16	2.11%
Gold – 6	1.82%
Platinum – 1	6.50%
Average -33	1.84%

Source: Greg Kats et al., October 2003.[1]

As for the benefits of a LEED project, owners point to the public relations value, reduced energy and water costs, and human and social benefits. A number of studies have attempted to quantify productivity gains from improvements in comfort, daylighting, and indoor air quality. With salaries and benefits accounting for 78% of business expenses (Carnegie Melon University, 1999), the greatest potential savings lie in improving productivity. A 1999 study by the Heschong Mahone Group, reported that daylighting improved test scores by 7-18% in Seattle and Denver.

[1] It's unclear from the source whether this data is a percent of project costs or construction costs.

LEED Soft Costs and Benefits

LEED Certification costs include fees for registering and certifying a project through the United States Green Building Council, documentation costs, commissioning costs and energy analysis costs. Of the prerequisites included in the LEED-NC rating system, fundamental commissioning is the only prerequisite that incurs a soft cost to all projects. As for the energy analysis, all of the projects earned at least 2 points for energy efficiency and the required energy analysis is a soft cost.

Based on the range of costs reported for this study and the uncertainty surrounding the costs, estimated soft costs are a minimum of $60,000 for projects smaller than 20,000 sf. For projects over 100,000 sf, the commissioning costs dominate the soft costs. Based on the costs reported for this study and more detailed nationwide studies, $1/sf should cover registration and certification fees, documentation, commissioning and the energy analysis.

Registration and Certification Fees

The current fees for registering and certifying a LEED-NC project are listed in Table 3. The member costs are shown because membership fees are lower than the additional costs for registering and certifying as a non-member. The LEED 2.1 projects in this study had higher registration and lower certification fees than the current USGBC fees under LEED 2.2.

Table 3 Current Registration and Certification Fees for Members

Fee	Less than 50,000 sf	50,000-500,000 sf	Over 500,000 sf
Registration	$450	$450	$450
Certification			
Design Review	$1250	$0.025/sf	$12,500
Construction Review	$500	$0.01/sf	$5,000
TOTAL	$2,200	$2,200-$17,950	$17,950

Documentation

LEED documentation costs are difficult to quantify because of indirect costs to the design team, contractor, and owner. The majority of teams reported documentation fees (Figure 1); however, the basis for these fees is inconsistent. The fee for Fossil Ridge High School is an estimate and that for the Colorado Department of Labor and Employment includes architectural, engineering and contractor fees. The costs reported for the three CH2M Hill Office Buildings are less than $3,000 per building, or $0.02/sf, while those for the Snowmass Clubhouse are $25,000, or $2.5/sf. There is no correlation on a cost per square basis.

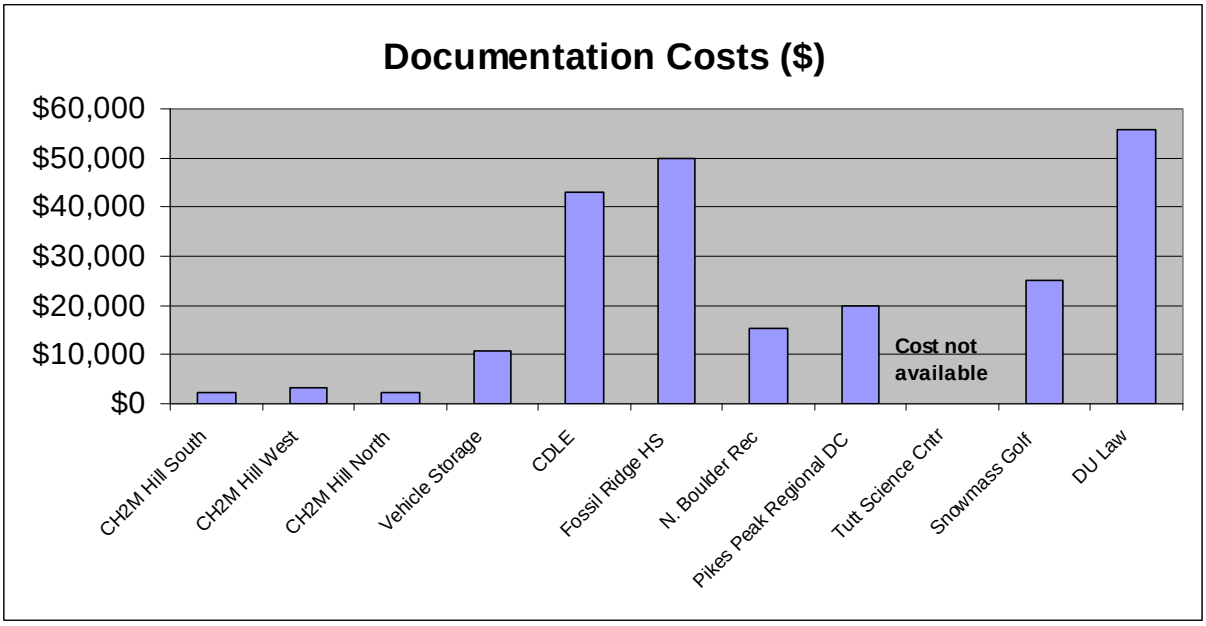

Figure 1 LEED Documentation Fees

The teams commented that the costs associated with LEED documentation are difficult to justify. Aspen Ski Company found that documentation fees on small projects can be prohibitive and is adamant about the need to rectify this. Colorado College noted that they've found that teams with more LEED experience have lower documentation costs. This is consistent with findings in other LEED studies (Kats 2003). Poudre School District (Fossil Ridge High School) estimated documentation costs at $50,000 and does not think they can justify this on future projects.

The United States Green Building Council has implemented an online application for documentation to simplify the certification process. They have also streamlined the requirements for some of the prerequisites and credits. The online system is too new to determine how it will impact documentation costs.

Commissioning

LEED requires building commissioning for all projects seeking certification. The project teams differed widely as to the value of building commissioning. Poudre School District (Fossil Ridge High School) and the Colorado Department of Labor and Employment have incorporated building commissioning into their design standards, so these owners include commissioning regardless of whether or not they are seeking LEED certification. Pikes Peak Building Department is also a strong proponent of building commissioning and states that in more complex buildings, commissioning results in lower operating costs over the long term.

On the other hand, the City of Fort Collins (Vehicle Storage Building) and Colorado College reported that the commissioning process is too documentation intensive and has questionable benefit. Colorado College already conducts detailed design reviews and performs extensive testing of building systems. Furthermore, commissioning of the Tutt Science Center failed to identify and resolve all control problems that arose.

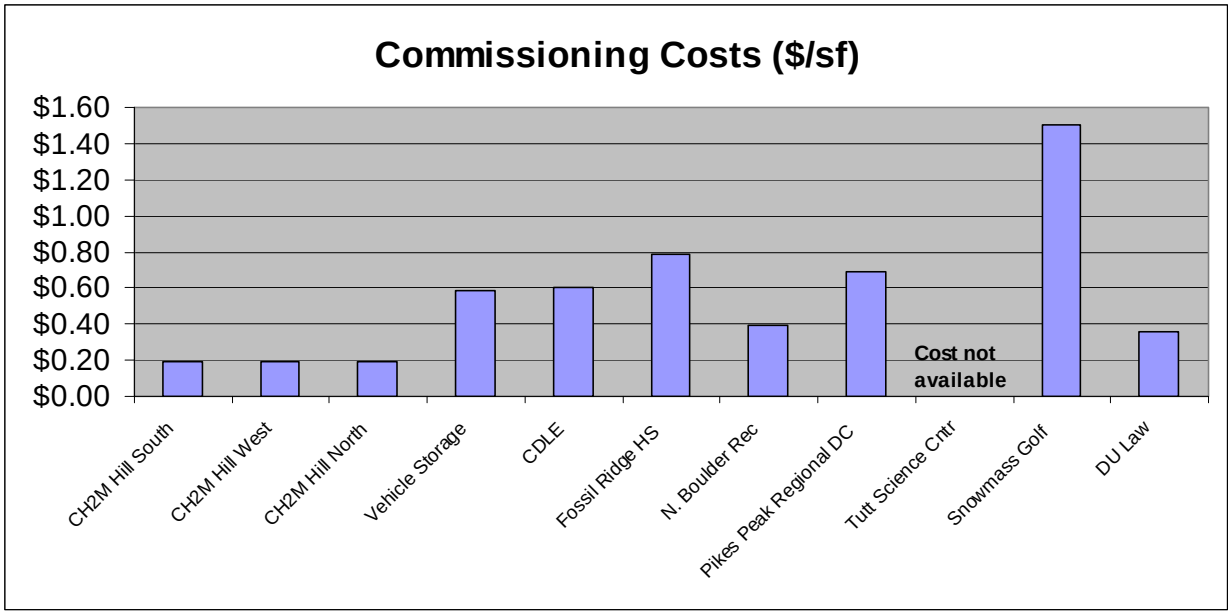

Figure 2 Building Commissioning Costs

The costs for commissioning these projects are given in Figure 2. The projects earned the point for enhanced commissioning, except for the Vehicle Storage building. The projects did not break out fundamental and enhanced commissioning costs, with the exception of North Boulder Recreation Center and Pikes Peak Building Department. Enhanced commissioning cost $7,400 on the recreation center and added 10% ($7,000) to the cost of fundamental commissioning on Pikes Peak.

Nationwide studies report commissioning costs in the $0.5/sf to $1.6/sf range with a median payback period of less than 5 years (Mills et. al. 2005). With the exception of the CH2M Hill projects, the costs for the Colorado projects are consistent with nationwide costs. The CH2M Hill buildings had fundamental and enhanced commissioning. The low costs on the CH2M Hill projects are attributed to repetitive systems in the three buildings.

The high commissioning cost at the Snowmass Clubhouse is a result of a relatively remote site and a small project. Even though the commissioning cost at Snowmass Clubhouse was $15,000, the commissioning process nearly paid for itself during design development. The commissioning agent identified a change that substantially reduced mechanical system costs without compromising the design. LEED-NC 2.2 does not require third party commissioning on projects smaller than 50,000 sf; the commissioning agent can be a qualified member of the design or construction teams. This change to the commissioning requirements is intended to help minimize the cost impact of commissioning on smaller projects.

At the Pikes Peak Building Regional Department the building systems are relatively complex. The facility manager reported that the systems ran much more efficiently in the first two years of operation than anticipated because of the commissioning process. The commissioning agent also discovered that the sequence of operation in an atrium was backwards and corrected the problem. This would have not been discovered through a typical testing and air balancing exercise.

Energy Analysis and Annual Energy Savings

Under LEED 2.1, projects must perform an hourly energy analysis to demonstrate energy cost savings relative to ASHRAE/IESNA 90.1-1999, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings (this has been updated to ASHRAE/IESNA 90.1-2004 under LEED-NC 2.2). Figure 3 presents the cost of the energy analysis as compared to the annual energy cost savings. These analysis costs are not consistent on a square footage basis; smaller projects have higher costs per square foot than larger projects. The annual energy cost savings are based on the results of the energy analysis. One year's savings are shown and these savings should be persistent over the life of the efficiency measures.

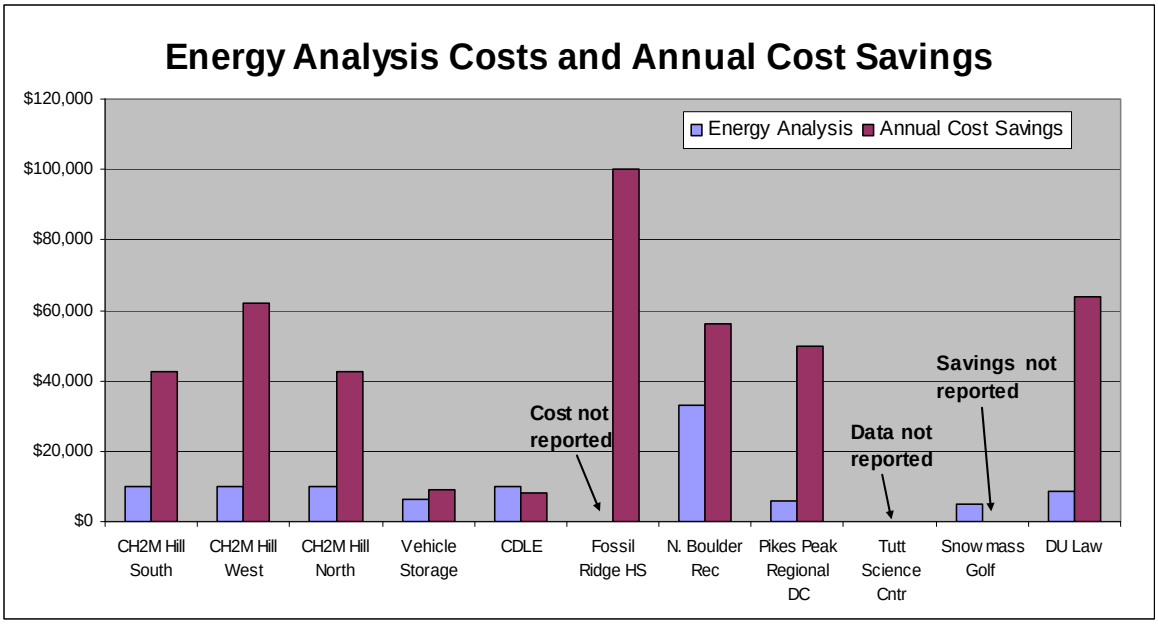

Figure 3 Energy analysis costs and annual energy cost savings.

The cost effectiveness of the energy analysis depends on whether the analysis is used to inform the design or just meet LEED reporting requirements. Aspen Skiing Company found that for small projects, the cost of the energy analysis is prohibitive although they recognize the value. LEED-NC 2.2 includes prescriptive compliance options that eliminate the requirement of hourly building simulations.

Poudre School District (Fossil Ridge High School) employs an integrated design process that includes energy and daylighting analysis; they would do this regardless of whether or not a project is pursuing LEED. The district is saving $100,000 per year in energy and water costs as compared to a Fort Collins High School they built in 1991 that is similar in size and number of students. These savings are achieved through an extensive daylighting design and controls, ice storage, and other high efficiency measures. The project earned all 10 points for 60% energy cost savings. Poudre School District also mentioned the first cost savings from downsizing mechanical equipment and transformers as a result of the more efficient envelope and lighting design and working with the building department using data from previous projects.

LEED Hard Costs and Benefits

LEED certification requires that a project incorporate environmental measures to minimize the impact on the site, water use, energy use, the atmosphere, materials and resource use, and indoor environmental quality. The certification process establishes accountability, while the strategies employed by the design and construction teams are the key to creating a more sustainable project.

The costs and benefits of these strategies are more difficult to isolate than the certification costs already presented. A few of the teams provided detailed cost data, a few of the teams stated that their projects would have incorporated the strategies and incurred the costs even had they not pursued LEED certification, and a few of the teams did not have costs broken out for these strategies. A point-by-point analysis of LEED costs by Davis Langdon (2004) is available. As for the benefits, very limited quantifiable data is available. The teams commented on operations and maintenance issues, occupant satisfaction, and public awareness.

The following sections discuss the LEED strategies by LEED category: site, water, energy and atmosphere, and indoor environmental quality. For each of the categories, a table is included that lists the credits and the percentage of Colorado LEED Certified projects that complied (Architectural Energy Corporation 2006). Those credits pursued by the highest percentage of teams are likely the most cost-effective credits in Colorado, i.e. have the highest return on investment. Keep in mind that some of the credit requirements have changed in LEED-NC 2.2, simplifying some credits and making others more difficult to achieve. For example, the local materials credits now require that materials be harvested and manufactured locally to achieve both credits, whereas in LEED-NC 2.1 the first credit only required that the materials be manufactured locally.

Site

Table 4 lists the LEED-NC 2.1 site prerequisites and credits, the percentage of projects complying with the credit and whether or not there is a cost premium associated with the credit. A number of the site credits are tied to selection of the building site and so there is no cost premium associated with complying with the credits. The heat islands credits (7.1 and 7.2) require the use of light colored surfaces. The Colorado Department of Labor and Employment reported cost premiums for substituting concrete for asphalt and for using the TPO white roof. CDLE selected the TPO roof because of its longer warranty and the cost premium cannot be identified as a LEED-related expense. The other credits, such as storm water management and

treatment, can have significant premiums; however, they also may be a requirement of the local jurisdiction and so carry no premium

Table 4 LEED-NC 2.1 Site Prerequisites and Credits

LEED Credit	Credit Name	**LEED Points Possible**	*Percent of Projects Complying with this Point*	Premium (Yes/No)
Sustainable Sites (14 Points Possible)				
Prereq 1	*Erosion & Sedimentation Control*	***Required***		No
Credit 1	Site Selection	**1**	*71%*	No
Credit 2	Urban Redevelopment	**1**	*14%*	No
Credit 3	Brownfield Redevelopment	**1**	*7%*	No
Credit 4.1	Alternative Transportation, Public Transportation Access	**1**	*71%*	No
Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rms	**1**	*93%*	Yes
Credit 4.3	Alternative Transportation, Alternative Fuel Refueling Stations	**1**	*29%*	Yes
Credit 4.4	Alternative Transportation, Parking Capacity	**1**	*43%*	No
Credit 5.1	Reduced Site Disturbance, Protect or Restore Open Space	**1**	*7%*	No
Credit 5.2	Reduced Site Disturbance, Development Footprint	**1**	*71%*	No
Credit 6.1	Stormwater Management, Rate or Quantity	**1**	*21%*	Yes
Credit 6.2	Stormwater Management, Treatment	**1**	*57%*	Yes
Credit 7.1	Landscape & Ext Design to Reduce Heat Islands, Non-Roof	**1**	*50%*	Yes
Credit 7.2	Landscape & Ext Design to Reduce Heat Islands, Roof	**1**	*43%*	Yes/No
Credit 8	Light Pollution Reduction	**1**	*50%*	Yes/No

The benefits from the site credits are significant in terms of reducing the environmental impact of development. There are potential first cost savings by minimizing parking capacity and instead relying on public transportation. While the local community is intended to benefit from new development, minimizing the influence of the development on transportation, air and light pollution, and heat islands will greatly improve its value to the community.

Water Efficiency

The importance of water conservation in Colorado has been recognized by almost all project teams. Through water efficient landscaping and low-flow fixtures, most teams have achieved two of the water credits (Table 5).

Table 5 LEED-NC 2.1 Water Efficiency Prerequisites and Credits

LEED Credit	Credit Name	**LEED Points Possible**	*Percent of Projects Complying with this Point*	Premium (Yes/No)
Water Efficiency (5 Points Possible)				
Credit 1.1	Water Efficient Landscaping, reduce by 50%	**1**	*79%*	Yes
Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	**1**	*36%*	Yes
Credit 2	Innovative Wastewater Technologies	**1**	*0%*	Yes
Credit 3.1	Water Use Reduction, 20% Reduction	**1**	*64%*	Yes
Credit 3.2	Water Use Reduction, 30% Reduction	**1**	*29%*	Yes

There is clearly a premium to reduce water use. CH2M Hill invested $24,000 for more water efficient fixtures in their three certified buildings. The Colorado Department of Labor and Employment spent $8,500 on upgrades to their water fixtures. The premium depends on the size of the building and the type of use. For example, the project cost to upgrade fixtures in a hospital would be much higher than in an office building because of the number of fixtures.

The benefits of reduced water consumption include reduced operating costs, the possibility of reduced infrastructure costs, and significant societal benefits from relieving demand on limited existing water resources.

Energy and Atmosphere

There is a cost premium associated with all of the credits in the Energy and Atmosphere category (Table 6). In addition, the commissioning prerequisite incurs a cost to all LEED projects. All of the projects earned points under Energy and Atmosphere Credit 1, Optimize Energy Performance, and had to perform an energy analysis. All of the projects also earned the enhanced commissioning credit.

Table 6 LEED-NC 2.1 Energy and Atmosphere Prerequisites and Credits

LEED Credit	Credit Name	**LEED Points Possible**	*Percent of Projects Complying with this Point*	Premium (Yes/No)
Energy & Atmosphere (17 Points Possible)				
Prereq 1	*Fundamental Building Systems Commissioning*	***Required***		Yes
Prereq 2	*Minimum Energy Performance*	***Required***		Yes/No
Prereq 3	*CFC Reduction in HVAC&R Equipment*	***Required***		No
Credit 1.1	Optimize Energy Performance, 20% New / 10% Existing	**2**	*100%*	Yes
Credit 1.2	Optimize Energy Performance, 30% New / 20% Existing	**2**	*75%*	Yes
Credit 1.3	Optimize Energy Performance, 40% New / 30% Existing	**2**	*29%*	Yes
Credit 1.4	Optimize Energy Performance, 50% New / 40% Existing	**2**	*11%*	Yes
Credit 1.5	Optimize Energy Performance, 60% New / 50% Existing	**2**	*7%*	Yes
Credit 2.1	Renewable Energy, 5%	**1**	*0%*	Yes
Credit 2.2	Renewable Energy, 10%	**1**	*0%*	Yes
Credit 2.3	Renewable Energy, 20%	**1**	*0%*	Yes
Credit 3	Additional Commissioning	**1**	*93%*	Yes
Credit 4	Ozone Depletion	**1**	*36%*	Yes/No
Credit 5	Measurement & Verification	**1**	*43%*	Yes
Credit 6	Green Power	**1**	*57%*	Yes

The energy analysis is assumed to be a soft cost, but there are hard costs associated with implementation of a more energy-efficient design. Few of the projects provided these costs. CH2M Hill spent $300,000 on evaporative condensers for the rooftop units serving the three buildings and $216,000 on indirect lighting fixtures. The three buildings each demonstrated 25% energy cost savings and earned 3 points under the energy optimization credit.

Under LEED-NC 2.1, energy savings from proper orientation could not be claimed. The Fort Collins Vehicle Storage Building re-oriented their building in response to the energy and daylighting analysis, and eliminated the need for a snow melt system. The project did not earn any LEED points for this effort; however, they reduced construction costs as a result of the design process. Under LEED-NC 2.2, ASHRAE 90.1-2004 does take into account the influence of orientation, although the energy savings from elimination of a snow melt system would not be included in the energy analysis.

No LEED-certified projects in Colorado have earned credit for renewable energy. North Boulder Recreation Center has a large solar hot water system but under LEED-NC 2.1 solar hot water systems did not qualify for points under the renewable energy credit. Under LEED-NC 2.2, solar hot water does qualify for points under this credit. In addition, the adoption of Federal tax credits and renewable energy incentives through utilities have significantly reduced the cost of renewables. It is anticipated that future LEED projects in Colorado will have renewables.

The ozone depletion credit required the elimination of the HCFC refrigerants on projects. This credit has been modified to minimize ozone depetion and global warming potential. Replacement refrigerants, such as R-410A, are more common today and the upcharge is minimal. This was not the case when Aspen Skiing Company was specifying the water-source heat pumps for the clubhouse. The cost premium to use a qualifying refrigerant was at least $50,000 on three heat pumps. The decision to upgrade the heat pumps was driven by this LEED credit; Aspen Skiing Company would not have made this change otherwise.

The CH2M Hill projects and Poudre School District earned the measurement and verification credit. Generally speaking, the cost premium for this credit is reasonable if there is a building automation system on the project. Neither project provided the actual costs associated with this credit. The Tutt Science Center has extensive instrumentation and attempted the measurement and verification credit. They did not earn the credit because the building is tied to the campus central plant and the plant is not monitored.

The green power credit (Credit EA 6) requires the owner to purchase power from a certified renewable energy source, such as wind or solar. The additional cost is $0.01/kWh to $0.02/kWh. The credit requirements have changed in LEED-NC 2.2 in terms of the purchase amount, but the associated costs are similar. The Colorado Department of Labor and Employment purchased the required 2-year amount equal to 50% of the regulated electricity use per year at a cost of $3,260. CH2M Hill spent

$15,000 on green power for the three buildings. The University of Denver Law School purchased $31,125 of green power. This cost appears to be high, although the baseline electricity use for the law school is higher than anticipated because of a 250,000 sf parking garage connected to the building.

Materials and Resources

With the exception of the Snowmass Clubhouse and the Tutt Science Center, all of the projects in this study earned the construction waste management credit and the recycled content credit (Table 7). CH2M Hill gave a cost of $17,080 for construction waste management on the three buildings. The cost reported by the Colorado Department of Labor and Employments is $1,000. The costs on the two projects are consistent at $0.04/sf. These projects all realized savings from reduced tipping fees, although they were not quantified.

Poudre School District diverted 75% of the waste sheetrock by using it as a soil amendment on site. The cost to dispose of the sheetrock is double that for recycling it on site. Poudre School District is now recycling all sheetrock on their projects.

Table 7 LEED-NC 2.1 Materials and Resources Prereq's and Credits

LEED Credit	Credit Name	**LEED Points Possible**	*Percent of Projects Complying with this Point*	Premium (Yes/No)
Materials & Resources (13 Points Possible)				
Prereq 1	*Storage & Collection of Recyclables*	***Required***		Yes
Credit 1.1	Building Reuse, Maintain 75% of Existing Shell	**1**	*7%*	Yes
Credit 1.2	Building Reuse, Maintain 100% of Shell	**1**	*0%*	Yes
Credit 1.3	Building Reuse, Maintain 100% Shell & 50% Non-Shell	**1**	*0%*	Yes
Credit 2.1	Construction Waste Management, Divert 50%	**1**	*86%*	Yes
Credit 2.2	Construction Waste Management, Divert 75%	**1**	*14%*	Yes
Credit 3.1	Resource Reuse, Specify 5%	**1**	*14%*	Yes
Credit 3.2	Resource Reuse, Specify 10%	**1**	*7%*	Yes
Credit 4.1	Recycled Content, Specify 25%	**1**	*79%*	Yes
Credit 4.2	Recycled Content, Specify 50%	**1**	*71%*	Yes
Credit 5.1	Local/Regional Materials, 20% Manufactured Locally	**1**	*100%*	No
Credit 5.2	Local/Regional Materials, of 20% Above, 50% Harvested Locally	**1**	*100%*	No
Credit 6	Rapidly Renewable Materials	**1**	*0%*	Yes
Credit 7	Certified Wood	**1**	*0%*	Yes

Boulder Community Foothills Hospital provided their spreadsheet listing material costs, recycled content and local materials. Again steel, as a high cost material on the project with a high recycled content, helped the project achieve the recycled content credit at no extra cost.

Under LEED-NC 2.1, Colorado projects all complied with the local and regional materials credits. Compliance is based on material costs. Steel structures in commercial buildings can account for the majority of the material costs and the steel is manufactured within 500 miles of the building sites. Locally harvested materials include concrete and gypsum board. These materials can be obtained at no additional charge and the Pikes Peak Regional Building Department noted lower costs for some local materials. Under LEED-NC 2.2, materials must be harvested and manufactured locally for both credits, making the credits more difficult to achieve.

Indoor Environmental Quality

There are 15 points available under the Indoor Environmental Quality category. All of the projects picked up the points for low-emitting adhesives and sealants and low-emitting carpet (Table 8). North Boulder Recreation Center and the University of Denver Law School are the only projects that did not earn the point for low-emitting paints. All of the projects except the CH2M Hill North Building complied with the pollutant source control credit. All of the projects except the CH2M Hill projects complied with ASHRAE 55 to earn the thermal comfort point.

The facility manager at Tutt Science Center has a background in indoor air quality and recognizes the importance of specifying low-VOC materials. One of the most significant changes in the college's design guidelines attributable to LEED is the inclusion of low-emitting materials. The alternative materials have not been in use long enough to assess their maintainability and durability.

It is surprising that CH2M Hill projects did not achieve the thermal comfort point given that the requirements do not go beyond typical mechanical design practice. The thermal comfort credit went through revisions during the period when these projects were being certified. Clarifications were made that allowed teams to show that no minimum humidity control was needed. Early on, it was interpreted that all projects required humidity control which can be cost prohibitive in climates where humidification is not commonly found. The current version of the comfort standard, ASHRAE 55-2004, adopted under LEED 2.2, does not require minimum humidity control.

Table 8 LEED-NC 2.1 Indoor Environmental Quality Prereq's and Credits

LEED Credit	Credit Name	**LEED Points Possible**	*Percent of Projects Complying with this Point*	Premium (Yes/No)
Indoor Environmental Quality (15 Points Possible)				
Prereq 1	*Minimum IAQ Performance*	***Required***		
Prereq 2	*Environmental Tobacco Smoke (ETS) Control*	***Required***		
Credit 1	Carbon Dioxide (CO2) Monitoring	**1**	*50%*	Yes
Credit 2	Increase Ventilation Effectiveness	**1**	*36%*	Yes
Credit 3.1	Construction IAQ Management Plan, During Construction	**1**	*71%*	Yes
Credit 3.2	Construction IAQ Management Plan, Before Occupancy	**1**	*71%*	Yes
Credit 4.1	Low-Emitting Materials, Adhesives & Sealants	**1**	*100%*	Yes/No
Credit 4.2	Low-Emitting Materials, Paints	**1**	*79%*	Yes/No
Credit 4.3	Low-Emitting Materials, Carpet	**1**	*100%*	Yes
Credit 4.4	Low-Emitting Materials, Composite Wood	**1**	*29%*	Yes
Credit 5	Indoor Chemical & Pollutant Source Control	**1**	*79%*	Yes/No
Credit 6.1	Controllability of Systems, Perimeter	**1**	*14%*	Yes
Credit 6.2	Controllability of Systems, Non-Perimeter	**1**	*0%*	Yes
Credit 7.1	Thermal Comfort, Comply with ASHRAE 55-1992	**1**	*71%*	Yes/No
Credit 7.2	Thermal Comfort, Permanent Monitoring System	**1**	*36%*	Yes
Credit 8.1	Daylight & Views, Daylight 75% of Spaces	**1**	*14%*	Yes/No
Credit 8.2	Daylight & Views, Views for 90% of Spaces	**1**	*57%*	Yes/No

The following highlights some lessons from these projects:

- ✓ The Snowmass Clubhouse is the only project that complied with the perimeter controllability of systems and the daylighting of spaces credits. With smaller projects, these credits are more easily achieved because the interior areas are a smaller fraction of the total area and there are fewer pressure balancing issues with operable windows.
- ✓ The Tutt Science Center has operable windows and controls tying the windows and VAV boxes together. They did not qualify for the controllability of systems credit.
- ✓ CH2M Hill invested $280,000 in clerestory glass and sidelights in exterior walls to improve the daylighting of interior spaces. The projects did not achieve the daylighting point.
- ✓ The Colorado Department of Labor and Employment spent $3,000 on interior glass to comply with the views credit. They were awarded the

point and would have included the glass anyway to bring natural light into the core areas.

Long-Term Performance

As part of the interview process, the teams responded to questions regarding operations and maintenance, as well as occupant satisfaction. None of the teams had problems with the operation or maintenance of a design element that was selected because of LEED. A few of the projects have annual energy cost data, although this data was not analyzed in detail to determine if the projects were realizing energy cost savings.

Pikes Peak Building Department tracked energy, water and waste water costs for 20 months. The average cost over these months was $1.12/sf/yr. The facility engineer viewed this as very efficient especially given the complexity of the building. The savings from daylighting controls have been diminished through the installation of blinds to control direct sunlight in the winter. The blinds are used year round, so the potential savings from daylighting are not being realized.

Poudre School District closely tracks energy use and reports savings of $100,000 per year ($0.35/sf) for Fossil Ridge High School over Fort Collins High School which was built 10 years earlier. The North Boulder Recreation Center compared estimated annual energy costs for 2002 with those from two of their other recreation centers. Annual energy costs are $0.59/sf to $0.79/sf lower at North Boulder Recreation Center (Southwest Energy Efficiency Project 2003).

In terms of long-term performance, occupant satisfaction is a priority, especially when considering the impact of the work environment on productivity. The projects do not have hard data from which to evaluate occupant satisfaction; however, the teams agree that there is a higher level of satisfaction with the LEED-certified buildings.

The Colorado Department of Labor and Employment has found that the addition to their existing office building has provided a number of benefits:

- ✓ Daylighting and views have improved the working conditions.
- ✓ Glass walls in the conference rooms have created a more professional atmosphere.
- ✓ Carpet tiles save money because they are easy to replace when the carpet becomes stained or damaged.

- ✓ Climate control / occupant comfort is much improved.

The owner's representative for Pikes Peak Regional Building Department noted the need to educate facility management on LEED and the sustainable features on a project. For example, there are bioswales on the site designed to have tall grasses. The areas are currently being mowed. Maintaining a LEED building requires ongoing education and buy-in from facility management.

Summary of Costs and Benefits

One of the first questions asked by an owner or developer about LEED certification relates to the cost to build a LEED-certified building. Table 9 summarizes the soft and hard costs for each project. Table 9 also includes the net present value of the annual energy cost savings using a 6% discount rate and a 20-year life cycle. The cost savings do not include savings from downsizing equipment, lower-cost material alternatives, waste management tipping fee reductions, other reduced maintenance and repair costs, or commissioning benefits.

The rows highlighted in blue identify the projects for which complete LEED cost data is missing and so the reported premiums are low. Construction costs are used to normalize the percentage cost premium because almost all of the projects supplied this data. If the percentage was presented relative to project cost, it would be lower. The two rows shaded in yellow represent projects for which the percentage cost premium is relative to project costs, not construction costs.

The results demonstrate a wide variation in LEED costs. Fossil Ridge High School has the lowest cost per square foot because Poudre School District considers the system and material upgrades to be standard practice for their schools and the school district also realizes first cost savings from downsizing equipment and on some material alternatives. The 0.8% or $1/sf for LEED soft costs at the high school (i.e. registration, certification, commissioning and energy analysis) is consistent with the findings in the LEED cost analysis by Steven Winter Associates (2004). The net present value of the energy cost savings are four times the LEED costs. And just as important, although the LEED costs are identified, the project was completed within budget.

CH2M Hill documented a $2/sf cost associated with LEED certification of their three buildings. This also includes costs for measures that did not garner

any LEED points. CH2M Hill applied the same LEED design solutions to all three buildings which resulted in lower costs for LEED. The energy cost savings are more than twice the costs, and the benefits from other LEED-related design elements are not quantified.

Table 9 Summary of LEED Costs

LEED Project	LEED Soft Costs	LEED Hard Costs	Cost Premium % of Construction	NPV of Energy Cost Savings $/sf	Notes
CH2M Hill South	$0.3	$1.6	1.2%	$4.3	
CH2M Hill West	$0.3	$1.6	1.2%	$4.3	
CH2M Hill North	$0.3	$1.6	1.2%	$4.3	
Vehicle Storage	$1.8	$6.4	6.3%	$6.7	
CDLE	$1.9	$1.3	3.3%	$2.3	Hard costs are included although most measures would have been included without LEED.
Fossil Ridge HS	$1.0	$0.0	0.8%	$4.0	Project stayed within established budget even with LEED. There are no hard costs because LEED does not change their design practices.
N. Boulder Rec	$1.2	$7.4	4.6%	$10.4	Large solar hot water system accounts for large portion of LEED costs. % Cost Premium is relative to project cost.
Pikes Peak Regional DC	$0.9	$0.0	0.8%	$5.1	Did not have LEED hard costs broken out.
Tutt Science Cntr	$5.5	$3.7	4.6%	no data	
Snowmass Golf	$4.5	$15.5	5.4%	no data	The % Cost Premium is relative to project cost.
DU Law	$0.7	$0.0	0.3%	$3.5	LEED hard costs not broken out. This only covers soft costs.

Colorado College views the cost premium of $9.2/sf at the Tutt Science Center as high. They have another project underway, the 73,000 sf Cornerstone Arts Center, that will be LEED certified. This is a more complex building than the science center with construction costs of $296/sf. Colorado College estimates LEED costs at $8.7/sf, or 2.9% of construction costs.

The LEED costs on the Snowmass Golf Clubhouse are 5.4% of construction costs and this translates to $20/sf. Auden Schendler of Aspen Ski Company has co-authored a paper and made presentations discussing these costs and the need to bring them down. He recognizes the value of an experienced design team and of incorporating LEED goals from the start of a project, but he also sees LEED certification as failing to accommodate smaller projects. LEED-NC 2.2 includes provisions to simplify commissioning and energy optimization for smaller projects to help address these issues.

The University of Colorado is certifying two current projects, the new law school building and the Atlas building. Their hard and soft costs for the two projects are about 1% of project capital costs. This includes $50,000-$60,000 on each project for LEED documentation, energy analysis and design assistance. The university has qualified staff to perform the commissioning. Estimated energy cost savings for the projects were not available.

The benefits of LEED are more difficult to quantify, especially on a short-term basis. The net present value of the predicted energy cost savings range from $2/sf to $10/sf. The net present value of the energy cost savings alone offset the LEED soft and hard costs on seven of the nine projects providing data.

The average commissioning cost is $0.6/sf, excluding the costs for the CH2M Hill projects and the Snowmass Clubhouse. Poudre School District and CDLE require commissioning on all their projects because they have found the benefits more than justify the costs. Commissioning costs were recovered almost immediately at the Snowmass Clubhouse and the Pikes Peak Regional Building DC.

A few of the projects noted improvement in indoor air quality from the use of low-VOC materials. Colorado College has even incorporated the low-VOC specifications into their design guidelines. A majority of the projects also enhanced the daylight levels and views in their facilities through the use of more glazing, high performance glazing, interior glazing, light shelves and shading.

Project Team Observations

As part of the interview process, the teams discussed their experience with the LEED certification process. All of the teams stated that the documentation requirements are too onerous. Colorado College compared the cost of documentation and other soft costs to the loss of a classroom.

A couple teams, City of Fort Collins Vehicle Storage and Colorado College Tutt Science Center, found the commissioning process to be too documentation intensive. The other teams were strong advocates of the commissioning process.

Of the eight owners that responded to the question of whether or not they will certify future projects, five answered yes, two answered no, and one answered that they will certify projects selectively.

Colorado College and Poudre School District responded no because both owners have strong commitments to life-cycle cost analysis and providing sustainable environments for their students. The schools feel the LEED process does not add enough value on top of their current practices to justify ongoing certification costs for future facilities.

Conclusions

The LEED projects in Colorado demonstrate similarities and differences in their approach to LEED certification. While it is instructive to isolate first costs associated with LEED certification, the benefits need to be considered in order to assess the value of LEED-related design solutions. Table 10 lists the projects, their costs and the energy cost savings. The cost benefits from energy efficiency alone offset the LEED cost premium in 7 of the 9 projects providing data.

Table 10 LEED Costs and Benefits for Colorado Projects

LEED Project	Certification Level / Size(sf)	Building Size (sf)	Construction Cost ($/sf)	LEED Cost Premium $/sf	Net Present Value of Energy Cost Savings $/sf	Net LEED Savings
CH2M Hill South	Certified	112,600	$156	($1.9)	$4.3	$2.4
CH2M Hill West	Certified	164,500	$156	($1.9)	$4.3	$2.4
CH2M Hill North	Certified	112,600	$156	($1.9)	$4.3	$2.4
Vehicle Storage	Certified	15,250	$129	($8.2)	$6.7	($1.5)
CDLE	Certified	40,000	$100	($3.3)	$2.3	($1.0)
Fossil Ridge HS	Silver	288,685	$122	($1.0)	$4.0	$3.0
N. Boulder Rec	Silver	62,000	$188	($8.7)	$10.4	$1.7
Pikes Peak Regional DC	Silver	111,758	$112	($0.9)	$5.1	$4.2
Tutt Science Cntr	Certified	54,123	$200	($9.2)	no data	
Snowmass Golf	Silver	10,000	$370	($20.0)	no data	
DU Law	Gold	210,000	$230	($0.7)	$3.5	$2.8

NPV calculation assumes 6% discount rate over 20 years.

Based on the discussions with the design teams and the data that was collected, we found the following:

- The average cost premium for LEED certification, soft and hard costs, is 2.5% based on cost data from all of the projects except Pikes Peak Regional DC and DU Law. The range is 1% to 6% of construction costs.
- Soft costs alone are about 0.8% of the construction costs, or approximately $1/sf. Almost all of the teams view the documentation costs as a burden, recognize the importance of accountability, and strongly recommend reducing the documentation requirements. Table 11 gives budgeting estimates for the soft costs based on the costs collected for this study and identifies the potential benefits.

- While LEED cost premiums are shown, two of the projects noted that they stayed within their originally established budget that was set before LEED certification became a priority.
- Commissioning is the other significant soft cost at an average of $0.6/sf. The majority of the teams found it to be valuable, and on one project it nearly paid for itself during design development.
- All of the teams earned at least two points for energy efficiency. The net present value of the energy savings associated with the energy efficiency measures offset the LEED soft and hard costs.
- Life-cycle cost analysis is a valuable tool in creating a high-performance building. Poudre School District, Colorado College and North Boulder Recreation Center analyze life-cycle costs and their designs tend to be the most energy efficient.
- A few of the projects noted improvement in indoor air quality from the use of low-VOC materials. Colorado College has incorporated the low-VOC specifications into their design guidelines.
- A majority of the projects also enhanced the daylight levels and views in their facilities through the use of more glazing, high performance glazing, interior glazing, light shelves and shading.
- All projects noted greater occupant satisfaction and the public relations value of having a LEED certified building.
- Most of the project teams would and are pursuing LEED on future projects. LEED-related costs are anticipated to be lower on future projects.

The most challenging aspect of this study was quantifying benefits associated with LEED-related decisions. The benefits from a more energy efficient design could be estimated from the energy analysis, but other benefits, such as:

  - Reduced air pollution
  - Reduced waste water fees
  - Reduced water consumption
  - Reduced operation and maintenance fees from commissioning
  - Reduced tipping fees
  - Reduced absenteeism from improved indoor environmental quality
  - Increased productivity from improved indoor environmental quality
  - Public relations

were not quantifiable within the scope of this study. Other national studies provide more guidance on quantifying the benefits.

Table 11 Budgeting Estimates for LEED Soft Costs

LEED Soft Cost	Budget Estimate	Benefits	Notes
Registration	$450		
Certification	$0.035/sf	Community Recognition; Marketing	See Table 3 for projects under 50,000 sf and over 500,000 sf
Commissioning	$0.6-$0.8/sf	Pays for itself within 5 years through energy savings	
Documentation	<$60,000	Accountability	Cost information for documentation did not always include involvement of design team and contractor.
Energy Analysis	$10,000	Annual energy cost savings offset initial investment (soft and hard costs)	Will depend on scope of work. Does not include time impact on design team. Recommend life-cycle cost analysis for all projects.

ACKNOWLEGEMENTS

The design teams that participated in this study were extremely helpful and provided invaluable information for owners, developers, and design teams considering LEED certification and high-performance goals for their projects. We would also like to thank the Colorado Governor's Office for Energy Management and Conservation for both their technical and financial support in conducting this survey.

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Appendices

Synopses of Interviews