SOUTHWEST ENERGY EFFICIENCY PROJECT
LEED CASE STUDY: LARAMIE COUNTY LIBRARY, CHEYENNE, WY

October 3, 2008

SUMMARY

There is growing interest nationwide by educators, school districts, and parents and students to promote green schools that provide a superior learning environment, while reducing operating costs and minimizing environmental impacts of schools. This case study describes the features, performance and cost effectiveness of the new Laramie County Library ('the Library'), located in Cheyenne, WY. The Library was designed and built to achieve a minimum of LEED-Silver Certification under the U.S. Green Building Council's LEED for New Construction program, and is the first public building in Wyoming to achieve LEED certification. The Library was designed and built using resource conservation practices, such as minimizing construction waste and recycling materials. It was designed to achieve nearly a 40% reduction in energy costs compared to a typical library built to current energy code requirements. It replaces the former Laramie County Library, built in 1969, which was too small to house the Library's growing collections.

The Library was funded by a voter-approved tax passed in November, 2003 in Laramie County, which increased sales tax by 1 cent to raise $26.9 million for library facilities. The Laramie County Library Foundation donated $1.7 million in funds for additional enhancements and amenities throughout the building. The Wyoming Business Council, State Energy Program, provided funding for energy modeling, commissioning and LEED Certification of the library. The Library has received notable recognition, including a "Library of the Year" award, and LEED-Gold Certification by the USGBC.

This case study describes the process used to design and build the Library, with emphasis on energy efficiency measures that were implemented. The case study includes analysis of the modeled versus observed energy performance of the Library during its initial six months of operation, estimates of the expected energy savings, avoided emissions and net economic benefits of the efficiency measures designed for use at the library, and findings and recommendations for the use of the LEED rating system in future new or renovated public facilities in Wyoming.

This case study was prepared by the Southwest Energy Efficiency Project, under contract to the Wyoming Business Council, State Energy Program. The case study was prepared in consultation with the project's Commissioning agent and personnel at the Laramie County Library. For more information, or to provide comments on this case study, contact SWEEP:

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INTRODUCTION

There is growing interest in applying green building techniques to library facilities throughout the U.S. and around the world. In the U.S., there are more than 40 LEED Certified Libraries, and approximately 200 additional libraries that are pursuing LEED Certification.[1] Libraries view green building as a way to advance their mission to improve human knowledge, educate citizens about societal issues, and empower individuals to make a difference through their own actions, and collectively as a community (Tseng 2007). Libraries are increasingly interested in educating the public about multiple aspects of sustainability, particularly in the areas of resource and energy consumption. The Laramie County Library system is no exception. In an age of electronic media, libraries are also undergoing transformation on multiple levels, by investing heavily in technology and multimedia, demonstrating state-of-the-art technology, and demonstrating their investment in the future of the community. Green building and sustainable design support all of these objectives, and provide a public demonstration of libraries commitment to their community and a more sustainable future. In an era of increasingly tight budgets, green building can also help libraries manage costs, by reducing energy and other operating costs, increasing patronage, and improving employee morale and productivity.

Entrance, Laramie County Library. Photo: SWEEP

"As the first publicly funded LEED certified project in Wyoming, the Gold LEED rated Laramie County Library is truly groundbreaking in many ways. With assistance from a grant to fund LEED certification from the Wyoming Business Council, the new library will serve as a model for others interested in LEED construction. Thanks to the support of the citizens of Laramie County, the library is a focal point – it serves as a community center, educational facility, gathering place and destination that strengthens the fabric of our community. It brings new opportunities for interaction, learning and expression of ideas, and now it serves as an example of sustainable design and operation. We are proud to receive a Gold LEED rating and value the contribution the LEED certification process had in our selection as the *Library Journal*/Gale *Library of the Year for 2008.*"
- **Lucie Osborn**, County Librarian

Features of the new library include:

- My Library Place, a spectacular interactive literacy center for children
- Five new meeting rooms for the community, each with extensive audio-visual services, and eight study rooms

[1] USGBC, LEED Projects Directory. Accessed June 27, 2008. http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx

- A 50-station computer center and training classroom (plus 23 more stations just for kids and teens)
- The Capital Room, a quiet reading area that serves as the living room for the community
- Expanded collections of books, audio books, movies, music, and more
- The Loft, an area made just for teens (with input from the award-winning Youth Advisory Board)
- Self- check stations, with anticipated usage of 90% by library patrons

Photo: AndersonMasonDale, Architects

The Laramie County Library is located in Cheyenne, WY. Construction of the library was completed in August 2007. The new Library replaces the original Laramie County Library, built in 1969. The total construction cost was $16.7 million for the 103,593 square foot facility ($161 per square foot). An additional $500,000 was included in the construction cost to upgrade the energy efficiency of the HVAC system. The additional cost for LEED certification and commissioning of the building was approximately $234,000, equivalent to 1.4% of total construction costs, or $2.27 per square foot. The Wyoming Business Council, State Energy Program, paid for the additional costs of LEED Certification of the Library via Petroleum Violation Escrow funds.

SWEEP has prepared this case study and analysis of the energy savings and performance of the Library for the Wyoming Business Council, State Energy Program. The case study includes recommendations regarding green building programs for use in the construction of future libraries and other public facilities in Wyoming. An additional case study is also available for Greybull Elementary School, which is the first LEED-Certified Elementary School in Wyoming.

ABOUT LEED FOR NEW CONSTRUCTION (LEED-NC)

The LEED® Green Building Rating System™ is the national benchmark for the design, construction, and operations of high-performance green buildings. LEED for New Construction is the recognized benchmark for green buildings.

Benefits of building a LEED-Certified Library include:

- A healthy, productive environment for library patrons and staff
- Improved patronage rates and staff productivity
- Financial savings to the library, the library system and taxpayers
- Hands-on learning opportunities
- Environmentally friendly design, construction and operating practices

For more information, visit the US Green Building Council Website, at: www.usgbc.org

LARAMIE COUNTY LIBRARY: LEED PROJECT FACTS

Description: This project consists of a 3-story library facility completed in August 2006 on an in-fill site in Downtown Cheyenne, WY. The facility also serves as a gathering place for the community, with meeting and study space, reading rooms, a café, and computer lab for instructional purposes. The structure is steel on drilled caissons with masonry and stone veneer, zinc panels, curtain wall and an EPDM roof. The project has obtained LEED Gold Certification, with a total of 40 credit points. Energy and resource efficiency improvements include the use of high efficiency HVAC equipment, daylighting with adjustable interior lighting controls, recycled content materials, low-water use fixtures, landfill waste diversion and indoor air quality requirements.

Location: 2200 Pioneer Ave, Cheyenne, WY

Library Information
Lucie P. Osborn, County Librarian
Laramie County Library System
Phone 307-773-7220
Web site: www.lclsonline.org

LEED Certification level: LEED-Gold

Date of Completion: August 2007 (opened 9/8/07)

Facility size and features:

- 103,593 sq. ft., including public reading rooms, special collections, computer lab with 50 PCs, café, children's play area, staff offices and work space, and shipping and receiving facilities.

Circulation and occupancy:

- 75 full-time staff, average monthly circulation (print and audio visual material) of 84,895.

Construction cost data

- Construction: $16.7 million ($161 per square foot).
- Contract terms: Cost of the Work plus a fee with a Guaranteed Maximum Price
- LEED Certification cost: $234,000 (1.4% of total construction costs)

Energy efficiency features

- High efficiency HVAC, including direct evaporative cooling and 90% efficient boilers
- Daylighting with adjustable interior controls
- Increased insulation levels and energy efficient windows

Energy design goals

- Reduce annual energy demand by 26%, and
- Achieve annual energy use (site energy) target of 72.3 kBTU/ft^2
- Lower annual energy costs by $39,000 (39% savings)

Design and Construction Teams

Architect:
Anderson Mason Dale and Tobin & Associates

Construction Contractor: FCI Constructors, Inc.

Energy Modeling: Architectural Energy Corporation

Commissioning Agent: Architectural Energy Corporation

Laramie County Library, Information Desk
Photo: SWEEP

LARAMIE COUNTY LIBRARY: THE LEED CERTIFICATION PROCESS

The Laramie County Library was registered and certified under LEED for New Construction (LEED-NC), Version 2.1.[2] The LEED-NC, Version 2.1 certification requirements include the following:

1. Sustainable Sites (16 possible points)
   Ensure buildings are sited and use construction practices that minimize environmental impacts and promote alternative transportation, such as bicycling and public transit.

2. Water Efficiency (7 possible points)
   Conserve water resources through interior and exterior water efficiency measures.

3. Energy & Atmosphere (17 possible points)
   Reduce energy demand and greenhouse gas emissions through a combination of energy efficiency measures, refrigerant management, and renewable energy (generated onsite or purchased as green power). The Energy and Atmosphere category includes the following 3 prerequisites:

   a) Fundamental Commissioning of the Building Energy Systems
   b) Minimum energy performance (14% improvement for new buildings; 7% for existing buildings renovations)
   c) Fundamental refrigerant management

4. Materials & Resources (13 possible points)
   Designed to minimize waste generation and conserve resources through reuse of buildings and materials, diverting construction waste from landfills, incorporating recycled content products, and sourcing materials regionally or from sustainable sources. Prerequisites include providing space for storage and collection of recyclables.

5. Indoor Environmental Quality (20 possible points)
   This category establishes minimum indoor air quality (IAQ) performance criteria to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

6. Innovation & Design Process (6 possible points)
   This category provides design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED for Schools Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED for Schools Green Building Rating System.

The USGBC assigns LEED certification levels based on the total point score of the building. The LEED for New Construction certification scale is as follows:

- 26 - 32 Certified
- 33 - 38 Silver
- 39 - 51 Gold
- 52 - 69 Platinum

The LEED points by category for the Laramie County Library are shown in Table 1. The project received a total score of 40, making it eligible for LEED Gold Certification.[3]

[2] LEED-NC Version 2.2 has replaced Version 2.1. As of January 1, 2006, all new LEED for New Construction projects must register under Version 2.2, found at: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220.

[3] The Library received notification in June 2008 from the USGBC that it will be certified as LEED-Gold.

Table 1. Summary of LEED Points by Category for Laramie County Library

LEED Category	Prerequisites	Category Points at Laramie Library / Notes
Sustainable Sites (14 possible)	• Erosion and Sedimentation Control	7 points
Water Efficiency (5 possible)		3 points, including water efficient landscaping, and 30% water use reduction
Energy & Atmosphere (17 possible)	• Fundamental Commissioning • Minimum Energy Performance • Fundamental Refrigerant Management	8 points, including 6 points in credit 1 (minimum of 37.5% energy savings)
Materials & Resources (13 possible)	• Storage & Collection of Recyclables	7 points, including 50% salvage or recycle of construction waste, specify up to 15% recycled content materials, 20% of materials manufactured locally, and minimum of 50% harvested locally, certified wood
Indoor Environmental Quality (15 possible)	• Minimum IAQ performance • Environmental Tobacco Smoke (ETS) Control	10 points, including construction IAQ management plan, low-emitting materials and adhesives, thermal comfort monitoring systems, and daylight and views (90% of space)
Innovation & Design Process (5 possible)		5 points, including educational outreach, process water treatment, and LEED AP included on project.
Total Score, Laramie County Library		40 points (LEED Gold)

LEED DESIGN FEATURES OF THE LARAMIE COUNTY LIBRARY

The Laramie Library installed several measures to reduce the environmental impacts of the library during site selection, construction, and in the operations of the building. Notable features are summarized below.

Site selection

- The building is oriented to maximize solar gain in the winter, with shading devices to minimize solar gain during the summer.[4] Light louvers, lighting controls, and motion sensors are used throughout the building.
- The library is located on an underutilized infill site located in downtown Cheyenne. There used to be two abandoned homes and a parking lot on the site.
- The site incorporates stormwater management measures to reduce runoff, such as pond catchments for parking lots

Water efficiency

- Drought tolerant plants are used for landscaping, along with natural pest controls and fertilizers that help conserve water. Exterior water use is controlled via a soil moisture monitoring system.
- Waterless urinals and/or low-flow toilets and fixtures are used in the restrooms

Materials and resources

- The building is constructed with concrete derived from fly-ash
- Interiors use sustainable materials, including bamboo floors, rubber, and recycled materials in floor tiles

Indoor air quality

- Use of low-VOC paints and materials
- Flooring materials without formaldehyde

ENERGY EFFICIENCY MEASURES INSTALLED AT LARAMIE LIBRARY

The primary energy efficiency design practices, equipment and control systems are summarized below. They include improvements to the building envelope, a more efficient HVAC system, and improved lighting efficiency and controls. For a detailed description of energy efficiency strategies used at the Library, see Appendix B.

BUILDING ENVELOPE

The following energy efficiency improvements were implemented to improve the efficiency of the building envelope:

[4] The Cheyenne city street grid in which the library is located was originally platted at an angle of 26.4 degrees from true north to optimize solar gain during the wintertime.

- Increased wall and roof insulation levels compared to ASHRAE 90.1 minimum requirements (R-25 versus R-15 in roof, R-19 versus R-13+R3.8 in walls)

- High performance window glazing is used that exceed the minimum ASHRAE requirements for U-value and shading coefficient (U-value of 0.31 versus 0.57, SHGC reduced from 0.39/0.49 to 0.28 (vision) and 0.39 (daylight)

- Selected south and west-facing glazings are shaded by two-foot overhangs

HEATING AND COOLING SYSTEMS

- High efficiency boilers (three 2,000 MBTU condensing boilers, with 90% thermal efficiency)

- Direct evaporative cooling system, 90% efficiency. The direct evaporative cooling system is designed to operate separately from the chilled water system, up to a maximum humidity level of 60%.

- Variable speed hot water and chilled water pumps. Variable frequency drives are on pumps serving the hot and chilled water and condenser water loops.

- Hot and chilled water reset. The hot and chilled water temperature is designed to be reset based on the outdoor air temperature.

- Efficient chiller, with a COP of 6.0 (0.58 kW per ton of cooling)

LIGHTING

- Reduced lighting power densities. The proposed lighting power densities are 10% - 20% below the ASHRAE minimum requirements (e.g., an average of 1.15 Watts per square foot versus the ASHRAE 90.1-1999 allowance of 1.5 Watts per square foot for libraries).[5]

- Occupancy sensors are used in all offices, conference rooms, bathrooms and in portions of workspaces.

- Stepped daylight control. Photosensors with stepped daylight controls (to adjust lighting level based on amount of daylight) were placed in the stack areas on the first, second, and third floors and control the first 3 rows of lights.

[5] The reductions in lighting power density were established in accordance with LEED Credit guidelines, and the California Energy Commission's 2005 Building Energy Efficiency Standards.

THE COMMISSIONING PROCESS

The Commissioning process involves inspection, analysis and evaluation of a completed building by a third-party , known as a Commissioning Agent, to ensure that all components and systems are designed, installed, and tested to perform according to the design intent and the building owner's operational needs. The commissioning process is not an energy audit, but rather a review of the building to determine if all components and systems are working as intended. Commissioning is a requirement for LEED for Schools Certification. The commissioning agent was Architectural Energy Corporation, based in Boulder, Colorado.

The Commissioning process ensures that a new building performs to an optimal level, and improves the likelihood that the building will maintain an optimal level of performance. The scope of the commissioning process includes:

- A design review of calculations, specifications, and drawings by the project engineer to ensure they match the designer's and owner's intentions.
- Inspection of the mechanical systems during construction of the building.
- Conducting rigorous performance testing of HVAC systems and controls
- Preparing a report with recommendations for correcting any deficiencies in the building envelope, controls or mechanical systems.
- Training the building facility managers and occupants on how to properly operate and maintain the building.

The scope of commissioning activities at Laramie County Library included the following major tasks:

- Provide commissioning specifications, which were incorporated into the general requirements, mechanical and electrical systems sections.
- Development of a commissioning plan.
- Review of mechanical submittals.
- Review of control submittals, including a thorough review of the proposed control sequence.
- Perform periodical construction phase job walks and provide construction observations.
- Preparation of prefunctional checklists for the new mechanical equipment, including the ground source heating and cooling water systems, air-handling units, heat recovery units, heat pumps, duct furnaces, a gas unit heater, and exhaust fans.
- Witnessing selected startup activities for major mechanical equipment.
- Preparation and implementation of functional test procedures to verify the proper control and operation of the mechanical systems.
- Preparation of a list of deficiencies discovered during the functional test procedures.
- Assist in preparation of systems training for school district personnel.
- Preparation of a final commissioning report.
- Review of the Operation & Maintenance (O&M) Manual.
- Preparation of a Systems Manual.
- Perform end-of-warranty walk through the building.

The commissioning process identified several issues with the design, installation and operation of the building mechanical systems. The Commissioning agent evaluates the system design, conducts testing, and makes recommendations to improve the overall efficiency of the building system. The most significant issues identified in the Commissioning process are summarized below.

- Evaporative Cooling System. The direct evaporative cooling system was initially inoperable. The system is shutting off when humidity levels rise, but the system has not been programmed to turn the evaporative coolers back on until the next day. This means the chillers must run longer than if the system were programmed to allow the evaporative cooling units to resume operation. The system has been reprogrammed, but further testing is needed to verify the evaporative cooling and chiller systems are now functioning properly.

- Demand Ventilation Control. According to the Commissioning Agent, the local building code official is not allowing the use of demand controlled ventilation. The library was designed to allow the flow of ventilation air to be reduced below the minimum required by code as long as the measured CO_2 levels do not exceed a nominal set-point. This strategy is well known and proven by ASHRAE (Standard 62.1) for reducing energy use in a building. The control system, however, has not been programmed to adjust ventilation levels based on occupancy. The local code official is also restricting the use of demand ventilation control in the building. This issue has not been resolved.

- Fan Controls. The fan controls are programmed to maintain constant minimum air flow, rather than increasing or decreasing based on occupancy level in the building (i.e., a classroom that is unoccupied would have lower airflow than an occupied classroom). This issue has not been resolved.

- Unoccupied Cycle (night setback). Night Setback" was not programmed at the zone level as had been called for in the specifications. At night when the Air Handling Units are off, the zone thermostats should control to a lower set-point than they do when the Air Handling Units are on during the day. This is a fundamental energy-saving control strategy, but had not been implemented. It also can cause the system to call for simultaneous heating and cooling. For example, heat that is generated at night by the boiler system must then be removed by the cooling system in the morning, since heat builds up in the ductwork (because the ventilation fans are turned off). The system has been reprogrammed to enable night setback of the ventilation system.

- Chilled Water and Supply Air Temperature Reset. The controls for resetting the chilled water and supply air temperatures were not properly installed and programmed. This issue was identified during the commissioning process and is in the process of being resolved.

- Sequencing Boiler Systems for Optimum Energy Performance. The boilers were programmed to turn on individually, rather than in sequence (they run more efficiently when all three are operating at low speed). The boilers have been reprogrammed per the recommendation from the Commissioning Agent.

Some of the issues have been subsequently resolved, while others have not. More detail is available in the final Commissioning report, Appendix C.

ANALYSIS OF ENERGY PERFORMANCE AT THE LARAMIE COUNTY LIBRARY

This section compares the observed energy performance at the Library in comparison to the design intent performance levels, and other recently completed high performance library facilities. The total building energy consumption was modeled to be 939,512 kBtu/yr, compared to 1,667,942 kBtu/yr for the baseline building, for an annual energy savings of approximately 30%, and energy cost savings of $39,000. Table 2 summarizes the expected energy consumption by end use for the proposed building (that was actually built) versus the budget building. The LEED Energy Savings Summary report, found in Appendix C, provides additional information on the assumptions used for both the proposed building and the budget building.

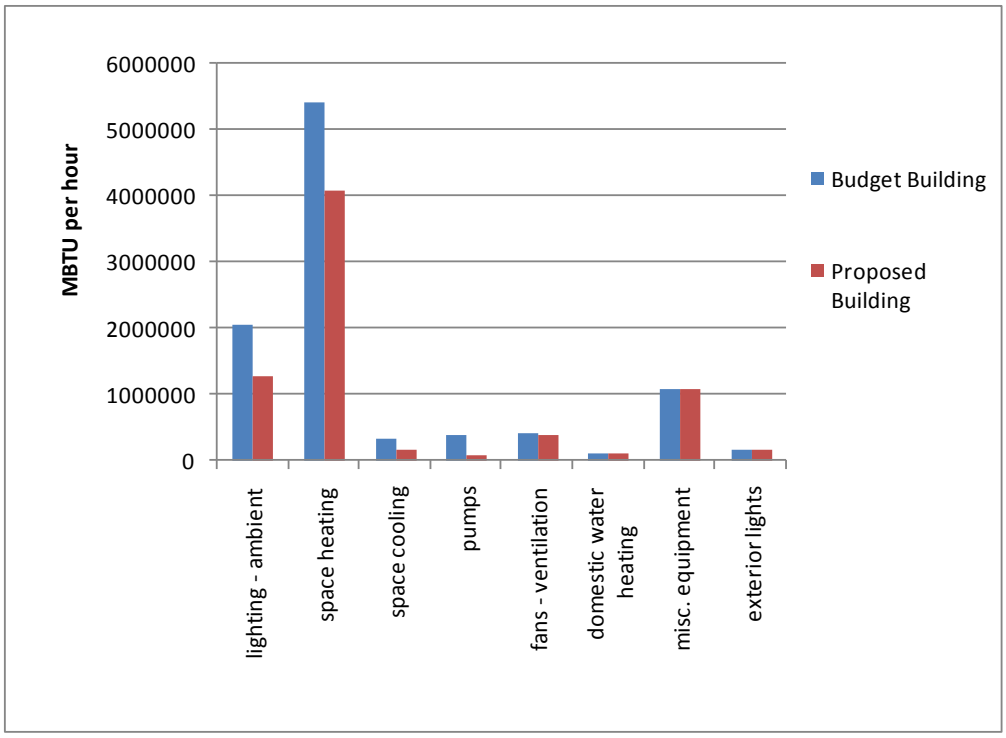
Table 2. Building Energy Performance for the Reference and Proposed Building
(all values in total site energy MBTU, electricity and natural gas)

	Lights	Misc Equip	Space Heating	Space Cooling	Heat Reject	Pumps & Aux	Vent Fans	Domestic Hot Water	Exterior Usage	Total
Reference Building	2063.5	1073.4	5404.6	329.2	1.4	379.3	415.1	111.4	163.3	9941.1
Proposed Building	1270.2	1073.4	4108.0	176.9	0.4	76.0	378.5	111.4	163.3	7358.1
% decrease	38%	0%	24%	46%	71%	80%	9%	0%	0%	26%

Source: Architectural Energy Corporation, LEED Energy Savings Summary for the Laramie County Library, Table 7.

The distribution of energy consumption by end use is shown in Figure 1. Primary heating is responsible for approximately one-half (56%) of total building energy consumption. The next largest categories are lighting (17%) and miscellaneous equipment (15%). Note that there is no reduction in miscellaneous equipment loads between the budget building and proposed building.

Figure 1. Energy Summary by End Use: Budget Building and Proposed Building, Laramie County Library



Source: energy modeling analysis, Architectural Energy Corporation

The electricity, natural gas and total energy consumption for the first eight months of operation at Laramie County Library (July 2007 – February 2008) is summarized in Table 3. Total electricity consumption averaged just over 100,000 kWh per month. Peak electricity use occurred in September 2007, when demand reached 141,600 kWh. Natural gas consumption averaged 304 dekatherms per month. Natural gas use peaked in December 2008 at 508 dekatherms. The average monthly electric usage was approximately 40% higher than the expected usage for the proposed building, and the average monthly natural gas usage was 14% below the amount estimated by the energy model for the proposed building. Total combined energy use for the initial eight months of building operations was only 9% higher than the proposed building (668 MBTU observed versus an average of 613 MBTUs for the proposed building). We do not have a full year of observed energy use for the building, so this estimate is only approximate and may change depending on the amount of energy consumed during the summer 2008 cooling season.

Table 3. Observed energy consumption, electricity and natural gas: July 2007 – February 2008

Month	**Electricity (kBTU)**	**Natural Gas (kBTU)**	**Total KBTU**
July, 2007	309,822	181,480	491,302
August, 2007	473,605	168,000	641,605
September, 2007	483,159	162,000	645,159
October, 2007	423,106	219,000	642,106
November, 2007	363,052	247,000	610,052
December, 2007	287,985	590,000	877,985
January, 2008	286,620	479,000	765,620
February, 2008	287,985	388,000	675,985
Average kBTU, per month	364,416	304,310	668,727

Although the observed energy demand tracks closely to the proposed building, the actual energy costs to the Library are dramatically higher. Table 4 summarizes the actual building energy costs compared to the estimated costs of the proposed building. The average monthly bill was $11,345, peaking at $13,332 in September 2007. The average monthly cost for the proposed building was estimated to be approximately $4,400, and only $7,258 for the budget building. Approximately sixty percent of the electricity costs were attributable to a combination of the system capacity charge and the monthly demand charge ($11.91 per kW), with the remainder of electric energy costs being direct energy charges ($0.027/kWh), service and facility charges, and franchise fee. Natural gas usage is charged on actual metered use (in Dekatherms), with a commodity charge and gas cost adjustment ($3.34 per Dekatherm).

Table 4. Energy costs: observed versus proposed and budget building

	Observed – Actual Building	**Proposed Building (energy model)**	**Budget Building (energy model)**
Monthly average energy cost	$11,345	$4,397	$7,258
Total cost (8 months)	$90,760	$35,000	$58,000
Annual cost	$136,140*	$52,767	$87,107

*Annual cost estimate is based on initial eight months of observed bills.

COMPARISON OF THE LARAMIE COUNTY LIBRARY TO OTHER LEED-CERTIFIED LIBRARIES

SWEEP collected data on the energy efficiency of other LEED Certified libraries across the nation to evaluate the expected and observed energy performance of the Library to others. The benchmark used for comparing energy performance is site energy use intensity, express in thousand BTUs per square foot of occupied space (kBTU/ft2), including electricity and natural gas (all units are converted to kBTUs). Table 5 shows the national average site EUI for libraries, the site EUI for the Laramie County Library (as modeled and observed) and observed energy use for other libraries across the U.S. The data shows that the energy consumption for the Laramie County Library is well below the national average (71 kBTU/ft^2 versus a national average of 104 for libraries, equivalent to about 30% better than the average library). This value is still higher than other LEED-certified libraries though, which have achieved less than 50 kBTU/ft^2 performance levels.

Advanced building design initiatives, such as Architecture 2030, have set aggressive goals for improving energy performance in commercial buildings. The initial Architecture 2030 goal for library buildings is a 50% reduction in building energy use, equivalent to 33 kBTU /ft^2 per year.[6] Although this goal may seem very aggressive, there are many examples of buildings that have achieved energy performance levels in this range. It may not be feasible for the Laramie County Library to achieve such a score, but it should strive to continuously make operational improvements that will achieve additional savings, in the range of 15% to 25% above current energy consumption levels. This would result in an annual energy consumption level in the range of 53 to 60 kBTU /ft^2 per year.

[6] For more information, see the Architecture 2030 website, at: www.architecture2030.org.

Table 5. Energy Performance of LEED-Certified Libraries

Library	Location	Rating (LEED or other)	Site Energy Use Intensity (kBTU / ft2)
CBECS Average - Library Facilities	National Average	n/a	104
Laramie County Library - Reference Building	Laramie, WY	n/a	97
Laramie County Library - Design Goal		LEED-Silver	72.3
Laramie County Library - Observed		LEED-Silver	71
Bozeman Public Library	Bozeman, MT	LEED Silver	n/a
Cesar Chavez Library	Phoenix, AZ		43.6
Fayetteville Library	Fayetteville, AR	LEED Silver	87.7
Hillsdale Library	Portland, OR	LEED Gold	49
Minneapolis Public Library	Minneapolis, MN		n/a
Utah Valley State College Library	Orem, UT	UT High Performance Building Program	60% more efficient than code
Architecture 2030 Goal (2010)	Nationwide		33

The energy performance of the Library could be improved through additional enhancements to the HVAC system controls, as well as other operational changes such as managing plug loads (see findings and recommendations for more information). The building will likely improve as the building controls and operations are 'fine-tuned', since many of the recommendations from the Commissioning Report are still being implemented.

FINDINGS AND RECOMMENDATIONS: LARAMIE COUNTY LIBRARY

The new Laramie County Library provides a high quality community library facility, using design practices, materials, and systems that were designed to minimize environmental impacts and energy demand. The Library is clearly a valued community asset in many ways. Library patronage and circulation rates have increased dramatically, and the facility facilitates additional uses such as meetings, separate spaces for teens and children, and for training and educational classes in the computer lab. The Library is much larger than the old facility, allowing additional holdings from the Library's collection to be displayed, and spaces dedicated to specialized activities such as reading rooms, children's area, special collections, and study and computer resources. The staff workspaces have also been improved, and automated systems added for processing book returns and sorting materials. Anecdotal information has shown increased employee satisfaction with improved working conditions, and a few managers have chosen to stay longer than expected.

While many of the design choices, features and operating procedures have increased energy efficiency, unfortunately there are many aspects of the building's mechanical systems used for heating and cooling that have yet to reach their optimum performance level. This has impacted the overall energy usage in the building, and resulted in higher than expected energy costs. Our main findings regarding the performance of the mechanical systems are as follows:

1. The building is not utilizing demand ventilation control (DVC) as called for in the engineering design and in the Commissioning report. This is a fundamental aspect of the ventilation control strategy, and energy costs for the library are substantially higher because DVC has not been properly implemented.

2. The direct evaporative cooling system is not programmed properly. The current programming sequence shuts the system off for the entire day if the chiller turns on, rather than resuming operation once the humidity levels drop back to an acceptable level (less than 60% relative humidity). It appears that the evaporative cooling system is being shut-off prematurely because the relative humidity sensors are located near the sump for the evaporative cooling unit (which would cause the sensor to detect higher relative humidity levels than actual conditions).

3. Simultaneous heating and cooling. Multiple aspects of the HVAC controls programming and operating sequences are resulting in the building calling for heating and cooling to take place simultaneously in the building. The Commissioning study identifies each of the causes and recommends specific steps to that will correct this problem.

Each of the issues identified could be resolved through further diagnostic testing and 'tuning' of the building systems, combined with a comprehensive measurement and verification process to identify specific aspects of the building operations that are contributing to high energy use. The cost of implementing these corrective actions would be paid back through reduced energy bills.

LEED Certification facilitated the use of an integrated design process involving the architect, general contractor, energy modeling consultant, and the project's Commissioning Agent. The energy modeling work was very extensive, and resulted in the use of design practices, equipment and components with much higher efficiency levels, such as low-E windows and high efficiency boilers. A detailed Commissioning Plan and Design Intent Summary were developed, with the intent of ensuring the design intent and owner's expectation were met during construction and after the building was occupied. The Design Intent Summary document was developed jointly by

the building owner and the design team, which helped achieve benchmarks for the performance objectives of the equipment undergoing commissioning.

The final results of the Commissioning report suggest that most of the design objectives were met, but not all, despite a very robust specification for the Commissioning process. A few members of the project team, particularly the controls subcontractor, did not appear to have adequate experience with the design and installation of advanced mechanical systems and their controls. Several of the key recommendations for improving the energy and operational performance of the mechanical systems that were provided by the Commissioning Agent to the mechanical systems contractor (on the 'Issues Log') were not implemented. In the case of Demand Ventilation Control, this was because the local building code official specifically restricted its use, citing that it did not comply with the commercial building code. In other cases, the controls contractor did not implement the Commissioning Agents recommendations, either because of a lack of technical expertise or unwillingness to deviate from standard practices. This has resulted in ongoing performance issues, such as simultaneous heating and cooling of the building.

The feedback provided by the Commissioning Agent to SWEEP reinforces the importance of ensuring that all members of the project team, including subcontractors, are fully committed to achieving the project goals articulated in the Design Intent Summary and Commissioning Plan, and have the proper technical background, knowledge and expertise to implement advanced building systems.

RECOMMENDATIONS FOR THE LARAMIE COUNTY LIBRARY

SWEEP makes the following recommendations for the Laramie County Library:

- The building owner and general contractor should meet with the Commissioning Agent to review the final issues log and Commissioning report, and develop an action plan for resolving the remaining issues with the design and operation of the mechanical systems and controls.

- Continue to conduct measurement and verification of the building systems and controls for another year (August 2008 to August 2009). There were significant changes made or yet to be made to the building system during its first year of operation. These changes need to be monitored to determine their effectiveness, and whether further adjustments are needed. Observed energy consumption should be tracked monthly using an online energy tracking tool, such as the ENERGY STAR Portfolio Manager, to evaluate progress and determine if further adjustments to the building systems are needed. [7]

- Request approval from the local building code official to allow the use of Demand Ventilation Control at the Library. Having M&V in place for another year may help facilitate this approval, by providing documented information on observed CO_2 levels within the building.

- Develop and implement strategies for managing plug loads within the building, including computers and PC workstations, photocopiers and other electronic devices. This is an area that is often overlooked as a source of potential energy savings. Potential strategies for reducing plug loads include:

    - Installing 'green strips' that automatically shutoff peripherals when a primary device is powered down (e.g., a PC with a monitor, printer and other equipment). These power strips cost about $25 each, and can save up to $45 annually.

[7] Portfolio Manager is available free at www.energystar.gov.

- Enabling power management software on PCs, computer monitors, copiers, fax machines, and other electronic devices.
- Implement a daily 'power down' policy where staff computer equipment is shutoff (at the power strip) at the end of the business day and on weekends. ENERGY STAR provides free power management software for PCs; copiers and facsimile machines have built-in power management capabilities.
- The library could also incorporate the plug load reduction measures as part of its educational materials. For example, signs could be posted next to catalog search stations and other PCs indicating the PC is 'asleep' to save energy, and a 'Did you know fact showing how much energy and money is saved each year by enabling the standby mode.

FINDINGS AND RECOMMENDATIONS FOR FUTURE LEED-CERTIFIED PROJECTS IN WYOMING

The Laramie County Library was designed and constructed to reduce environmental impacts, and many of these choices are clearly evident to the visitor. They include the choice of an infill site within an existing neighborhood, waste reduction and recycling during construction, and reuse of materials, and providing preferred parking for carpools. Many of these actions may not have been implemented without the LEED Certification requirement.

The additional cost for LEED Certification ($234,000), including energy modeling and commissioning work, represent a small fraction (1.4%) of the $16.4 million construction budget for the building. This additional cost will be paid back through energy savings alone (assuming the building controls issues are resolved) in less than 7 years. The LEED costs will be paid back in many other ways too, besides energy savings. The mechanical systems require less maintenance, and should last longer than standard equipment. Usage of the library facility has increased dramatically, with higher circulation rates and additional programs being offered. The Library staff members are more productive and employee retention rates could be higher as well. The Cheyenne community also received a building designed for multiple purposes housed under one roof, potentially eliminating the need to construct separate facilities for youth programs, training classes, and community meetings.

The costs of building and certifying new public facilities under the LEED rating system will progressively decrease as the design approaches, construction specifications and operating procedures become standardized, and opportunities for further cost savings are incorporated into building design practices. For example, a building designed with a highly efficient envelope allows the engineering team to downsize the mechanical systems, reducing both their initial cost and operating cost.

SWEEP recommends that future public facilities in Wyoming consider pursuing certification under the LEED rating system, or equivalent rating guidelines. The projects should be required to meet minimum criteria for energy savings (we recommend achieving at least a 30% reduction in energy use over ASHRAE Standard 90.1, 2004), along with a requirement for post-occupancy commissioning and monitoring and verification for at least 1 year to ensure that systems are functioning properly.

In order to ensure that projects receive sufficient funding to effectively implement LEED, the building owner should consider allocating a minimum percentage of the project budget to LEED certification and commissioning costs (e.g., up to 2 percent of the project cost). A portion of this funding (.5%) could be used to fund critical post-

occupancy commissioning and monitoring and verification work, or paid as a bonus incentive to the project team (e.g., architect, energy modeling consultant, general contractor, commissioning agent) if the building meets a predetermined energy performance level for regulated loads (e.g., heating and cooling, domestic hot water, and interior lighting). The incentive mechanism could be structured so that it is on top of a fixed fee contract, to provide a financial incentive for contractors to ensure the building is designed, constructed and operated to perform well. The incentive mechanism could be removed once project teams have gained sufficient experience with LEED-Certified projects, or by incorporating specific operating energy performance criteria in the terms of the contract.

Information Resources

ARTICLES:

Library of the Year 2008: Laramie County Library System, Wyoming: The Impact Library.
http://www.libraryjournal.com/article/CA6566453.html
Energy design incorporated in Wyoming public buildings
http://www.wyomingbusiness.org/pdf/energy/Vol_14_No_2.pdf

PROJECT CONTACTS

Function	Name/Address	Contact Info
Owner	Laramie County Library System 2800 Central Avenue Cheyenne, Wyoming 82001-2799	Lucie Osborne Tel: 307-635-1032 x122 Fax: 307-634-2082 Mobile: 307-286-2913 losborn@lclsonline.org
Owner's Representative	Moreng Construction Consulting 8421 North County Road 15 Fort Collins, CO 80524	Jon C. Moreng Tel: 970-224-3056 Mobile: 970-217-7498 morengjon@aol.com
Architect	AndersonMasonDale 1615 17th Street Denver, CO 80202	John Everin Tel: 303-294-9448 Fax: 303-294-0762 jeverin@amdarchitects.com
Construction Administrator	Tobin & Associates 209 East 20th Street Cheyenne, Wyoming 82003	Nate Mulliken Tel: 307-632-3144 Fax: 307-632-6645 Mobile: 307-21-6854 nate@tobin-assoc.com
Mechanical Engineer	Cator, Ruma & Associates 1550 Dover Street, Suite 2 Lakewood, CO 80215	Dave Yeingst Tel: 303-232-6200 Fax: 303-233-3701 dyeingst@catorruma.com
Electrical Engineer	Cator, Ruma & Associates 1550 Dover Street, Suite 2 Lakewood, CO 80215	Jerry O'Brien Tel: 303-232-6200 Fax: 303-233-3701 jobrien@catorruma.com
General Contractor	FCI Constructors Inc. 4001 N. Valley Drive Longmont, CO 80504	Becket Hinson Tel: 970-535-4725 Fax: 970-535-4867 bhinson@fciol.com
Mechanical Contractor	Mechanical Systems, Inc. 1313 W. Lincolnway Cheyenne, Wyoming 82001	Matt Thomas Tel: 307-634-7419 Fax: mthomas@msiwyo.com
Electrical Contractor	Weifield Group Contracting 5835 West 6th Avenue, Unit 4A Lakewood, CO 80214	Tel: 303-428-2011 Fax: 303-202-0466
Controls Contractor		
Test and Balance Contractor	Lawrence Finn & Associates 372 E. 16th Street Greeley, CO 80631	Tel: 970-353-8210 Fax: 970-353-1828
Commissioning Agent	Architectural Energy Corporation Suite 201 2540 Frontier Avenue Boulder, CO 80301	Dan Bertini Tel: 303-444-4149 Fax: 303-444-4304 Mobile: 720-841-3294 dbertini@archenergy.com

Wyoming Business Council, State Energy Program

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INFORMATION RESOURCES ABOUT LEED FOR NEW CONSTRUCTION

WEBSITES

US Green Building Council
www.usgbc.org

Green Libraries Directory
www.greenlibraries.org

Toolkit for Planning and Building Public Libraries: Energy Efficiency
http://library.utah.gov/librarian_resources/toolkit/energy.htm

ENERGY STAR (includes benchmarking tools and energy management guidelines for public facilities, including libraries)
www.energystar.gov

REPORTS

Brown, B. 2003. The new green standard: With the LEED rating system in place it is easier to make sure your new library saves money as it treads lightly on natural resources [Electronic Version]. Library Journal, 128(20), 61-4.

Kats, G. 2003. The Costs and Financial Benefits of Green Buildings. Prepared for the Massachusetts Technology Collaborative. http://www.cap-e.com/ewebeditpro/items/O59F3481.pdf

Morris, P. and Matthiessen, L. 2004. Costing Green: A Comprehensive Cost Database and Budgeting Methodology, July 2004. Davis Langdon. http://www.usgbc.org/Docs/Resources/Cost_of_Green_Full.pdf

Morris, P. 2007. What Does Green Really Cost? Davis Langdon.
http://www.davislangdon.com/USA/Research/ResearchFinder/What-Does-Green-Really-Cost/

New Buildings Institute. 2008. Energy Performance of LEED for New Construction. Prepared by: Cathy Turner, Senior Analyst Mark Frankel, Technical Director, for the U.S. Green Building Council.
https://www.usgbc.org/ShowFile.aspx?DocumentID=3930

Tseng, S.H. (2007) An eco-building, a healthy life, and good service: A new Century in public library architecture [Electronic version]. *Public Libraries 46*(4), 50-5.