

To: US Green Building Council

From: Forrest Collins

Date: March 21st, 2006

Subject: LEED Energy Savings Summary for the Laramie Country Library

Project Narrative

A new state of the art, 103,000 square foot library is being constructed by Laramie County. The new facility combines an innovative architectural design with smart energy efficiency strategies. The new Laramie County Library performs 39% better than ASHRAE 90.1-1999 requirements using the ASHRAE Energy Cost Budget methodology with LEED specific amendments. This earns the project **6 LEED Points** for Energy and Atmosphere Credit 1. The following is a narrative describing the energy modeling assumptions and energy conservation measures that exceed the ASHRAE 90.1-1999 requirements.

Building Input Summary

Baseline Building Code: ASHRAE 90.1-1999 Energy Cost Budget baseline building guidelines.

Simulation Software: A combination of eQUEST (v3.54) to develop the geometry and DOE-2.2 (v44c) were used for this analysis.

Warnings and Loads Not Met: Both buildings had zero hours of loads not met. Also both buildings had the same two warnings regarding hot and chilled water primary capacity less than secondary demand. These warnings are sizing warnings and should not affect the results.

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Weather Data: The new facility will be located in Cheyenne, Wyoming. For the energy simulations, the Typical Meteorological Year (TMY2) climate data for Cheyenne, Wyoming was used. Baseline energy model characteristics were based on U.S. climatic data for Cheyenne (Table D-1 of ASHRAE 90.1-1999), and the building envelope requirements prescribed in Table B-19 of ASHRAE 90.1-1999.

Utility Data: Utility rates for the project were obtained from actual utility bills obtained from the librarians and are described in Table 1. The rates represent Xcel Energy SG rate for Wyoming, current as of 2/1/06. As seen in the table, the electricity rates include a demand component and the gas rate is flat.

Table 1: Utility Rate Information

Utility Rates for the Laramie County Library	
Utility	Cost Structure
<i>Electricity</i>	
Base Charge	~\$370/month
Consumption Charge	0.04079 (\$/kWh)
Demand Charge	12.16 (\$/kW)
<i>Gas</i>	
Flat Rate	1.33 (\$/Therm)

Operating Hours. The operating hours for the new Laramie County Library are outlined in Table 2. The schedule for the building is based on input provided by the library staff. All schedules used in the proposed and baseline buildings are identical.

Table 2: Laramie County Library Schedules

Schedule Assumptions for the Laramie County Library		
Building Occupancy Schedules	ASHRAE 90.1 – 1999 Energy Cost Budget Building	Proposed 100% Construction Documents Model
Occupancy, Lighting, and Equipment	M-Th 10am-9pm, Fri,Sa-10am-6pm, Su 1pm-5pm	M-Th 10am-9pm, Fri,Sa-10am-6pm, Su 1pm-5pm
HVAC	M-Th 8am-10pm, Fri,Sa-8am-7pm, Su 11pm-6pm	M-Th 8am-10pm, Fri,Sa-8am-7pm, Su 11pm-6pm

Geometry: The geometry and characteristics of exterior surfaces are based on the 100% Construction Documents developed by Anderson Mason Dale Designs Architects. Figure 1 is a graphical representation of the DOE-2 energy model.

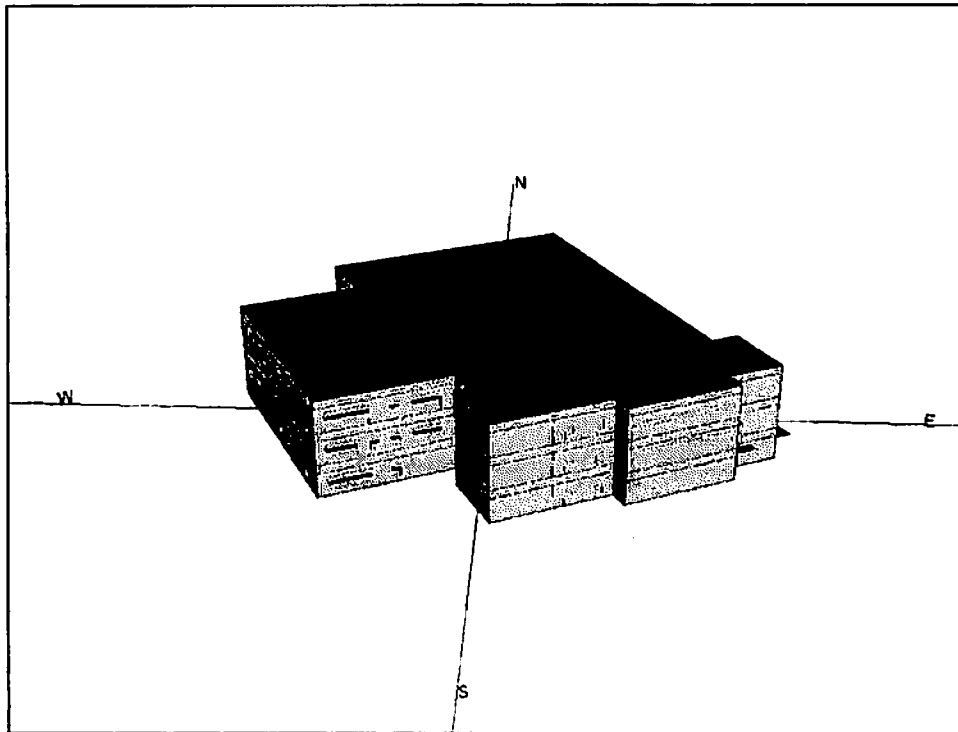


Figure 1: Graphic Representation of the DOE-2 Geometry

Building Envelope: The building envelope consists of a steel frame with R-19 batt insulation and a built-up roof assembly with five inches of polyurethane (R-25) above deck. High performance low-e glazings are used on all elevations of the building. All building envelope assemblies are in accordance with ASHRAE 90.1 Table B-19. The major envelope characteristics for the ASHRAE 90.1-1999 baseline building and the proposed building are summarized in Table 3.

Table 3: Summary of Building Envelope Characteristics

Envelope Assumptions for the Laramie County Library Base Case Buildings and the Proposed Design			
	ASHRAE 90.1-1999 ECB Baseline	Proposed 100% Construction Design Documents	Comments
Wall Insulation R-value	R-13 + R-3.8 continuous	R-19 batt insulation	Steel-frame construction
Roof Insulation R-Value	R-15 continuous	R-25 continuous	5-inches of polyurethane insulation
Floor U-Value	Not required	None	Uninsulated slab on grade construction
Glazing U-Value	0.57	0.31	
Glazing SHGC (all/north)	0.39/0.49	0.28 (vision) and 0.39 (daylight)	Proposed vision glazings based on Viricon VE-1-40 or similar. Daylight glazing is based on a Viricon VE 1-2M or similar.
Window Shading	No Shading	2.0' Overhang above some S and W windows	
Window to Wall Ratio	20-30%	25%	

Lighting Power Densities. The proposed whole building lighting power density was calculated to be 1.15 W/sf compared to the ASHRAE 90.1-1999 section 9 allowance of 1.5 W/sf for libraries, a 24% reduction. The space by space method defined in ASHRAE 90.1-1999 was used for the energy model calculations. Table 4 summarizes the space by space lighting power densities, lighting control (occupancy sensors), and equipment power densities for both the proposed and ASHRAE Budget buildings. The energy model assumed 20% reduction in LPD for offices less than 250 sf, conference rooms, bathrooms and 10% reduction in large work areas, offices, and staff areas. The LPD reductions were established per the LEED Credit Interpretation Ruling 2/4/04 and using the California Energy Commission 2005 Building Energy Efficiency Standards as a guideline for LPD reduction factors.

Table 4: Lighting Power Densities

Lighting and Equipment Assumptions for the Laramie County Library Base Case Buildings and the Proposed Design			
	ASHRAE 90.1-1999 ECB Baseline	Proposed 100% Construction Design Documents	Comments
Lighting (W/sf)			
Collection/Stacks	1.9	1.23	Per 100% CD takeoffs
Bathroom	1.0	1.14	Per 100% CD takeoffs
Office	1.5	1.16	Per 100% CD takeoffs
Multipurpose/Administration	1.5	0.91	Per 100% CD takeoffs
Reading	1.8	0.96	Per 100% CD takeoffs
Hall	0.7	0.71	Per 100% CD takeoffs
Meeting	1.6	2.25	Per 100% CD takeoffs
Computer/Classroom	1.5	0.83	Per 100% CD takeoffs
Mechanical	1.3	0.73	Per 100% CD takeoffs
Lighting Control			
Occupancy Sensors	None	Located in all offices, workrooms, conference rooms, and bathrooms	Assumed 20% reduction in LPD for offices less than 250 sf, conference rooms, bathrooms and 10% reduction in large work areas, offices, and staff areas. LPD reduction per LEED CIR 2/4/04 and using the California Energy Commission 2005 Building Energy Efficiency Standards as guideline for LPD reduction factors.
Daylight Control	None	Stepped daylight control in stack areas on first three floors	Per 100% CD takeoffs
Equipment (W/sf)			
Office/Admin EPD	1.5	1.5	
Computer/Classroom EPD	3	3	
Other EPD	0.75	0.75	

Mechanical System: The proposed building has a central heating and cooling plant composed of three 2000 MBtu gas-fired boilers (90% thermal efficiency) and a 250-ton Trane rotary vane chiller (COP = 6). The chilled water and hot water loops have variable flow controlled by variable speed drives. There are three main air handling units, each supplying 40,000 cfm of ventilation air, with a 25% minimum outdoor air fraction. Each of these three AHU's has a direct evaporative cooling section and variable flow controlled by a variable speed drive. The direct evaporative cooling is controlled to operate independently of the chilled water system (i.e. when the load is too great for the evaporative cooling alone, the evaporative cooling turns off and the

cooling coil takes over). The maximum humidity is not allowed to exceed 60%. Zone heating is provided by reheat, except some of the stack areas have radiant ceiling panels. Table 5 compares the HVAC system components for the proposed building and the ASHRAE Energy Cost Budget building.

Table 5: HVAC System Performance Characteristics

HVAC System Assumptions for the Laramie County Library Base Case Buildings and the Proposed Design			
	ASHRAE 90.1-1999 ECB Baseline	Proposed 100% Construction Design Documents	Comments
Heating			
System Type	Central Hot Water Plant	Central Hot Water Plant	
System Supply	Gas-fired boiler	Gas-fired boiler	
Boiler System	Two 3000 Mbtu boilers, with 80% thermal efficiency	Three 2000 Mbtu condensing boilers, with 90% thermal efficiency	
Zone Heating	Reheat	Reheat, some ceiling radiant panels	
HW Pump Control	Ride Pump Curve	Variable Speed Drive	
HW Reset	No Reset	Based on OA temp	ECB has no reset per exception 6.3.4.3 (b)
HW Pump Motor Efficiency	High Efficiency	High Efficiency	
Cooling			
System Type	Central Chilled Water Plant	Central Chilled Water Plant	
Chilled Water System Supply	One 250-ton water-cooled chiller, screw chiller	One 250-ton water-cooled rotary chiller	
Cooling System Efficiency	COP of 4.9	COP of 6.0	
Evaporative Cooling	n/a	Direct evaporative cooling	Direct evaporative cooling system will operate independently of chilled water system, 90% efficient
CHW Pump Control	Ride Pump Curve	Variable Speed Drive	
CHW Pump Motor Efficiency	Hi-eff	Hi-eff	
Air Handling			
System Type	VAV with hot water reheat	VAV with hot water reheat	There are three main air handling units, one for each floor.

Fan Control	Variable Speed Drive	Variable Speed Drive	Fans greater than 25hp
Fan Supply Flow	40,000 cfm	40,000 cfm	Each AHU has same flow
Fan Motor Efficiency	High Efficiency	High Efficiency	
Total Fan Static Pressure	5.5	5.5	
Static Pressure Reset	Reset to maintain one zone damper wide open	Reset to maintain one zone damper wide open	
Supply Air Temperature Reset	Based on OA temp	No reset	
Outdoor Air Minimum Flow	25%	25%	
Outdoor Air Economizing	Based on OA temp up to 75 F	Based on OA temp up to 75 F	
Domestic Hot Water			
System Type	One 100-gallon natural gas storage water heater with 80% thermal efficiency	One 100-gallon natural gas storage water heater with 80% thermal efficiency	

Energy Conservation Measures

The design team implemented several energy saving strategies to improve the energy performance of the building. The following is a summary list of all energy conservation measures which exceed the ASHRAE 90.1-1999 Energy Cost Budget baseline building and contribute to the LEED Energy and Atmosphere Credit 1 energy cost savings.

Envelope Measures

E1-Increased roof insulation. The proposed building roof assembly includes five inches of polyurethane insulation at R-5/inch. This is greater than the R-15 continuous insulation required by ASHRAE

E2-High performance glazings. The proposed building will use high performance low-e glazings throughout. The glazings exceed the minimum ASHRAE requirements for U-value and shading coefficient.

E3-Window overhangs. A two-foot overhang is included above some of the south and west facing glazings.

Lighting Power and Control Measures

L1- Reduced lighting power densities. The proposed building space LPD's are below the minimum ASHRAE requirements for lighting power densities for all spaces except the large meeting area on the first floor.

L2- Occupancy sensors. Occupancy sensors were placed in all offices, conference rooms, bathrooms, and many workspaces.

L2--Stepped Daylight Control. Photosensor stepped daylight controls were placed in the stack areas on the first, second, and third floors and control the first 3 rows of lights.

Cooling Related Measures

C1- Direct evaporative cooling. Direct evaporative cooling sections were added to the three main air handling units.

C2- Variable speed chilled water pumps. Variable frequency drives are on pumps serving the chilled water and condenser water loops

C3- Chilled water reset. The chilled water temperature is reset based on outdoor air temperature.

C4- Efficient chiller. The chiller will have a COP of 6.0 (0.58 kW/ton).

Heating Related Measures

H1- Efficient boilers. The three boilers are 90% efficient condensing boilers.

H2- Variable speed hot water pumps. Variable frequency drives are on pumps serving the hot water loop

H3- Hot water reset. The hot water temperature is reset based on outdoor air temperature

LEED Energy Calculation Methods and Results

The energy conservation measures outlined in the previous section were modeled using DOE-2.2. The LEED Calculator was then used to separate regulated and unregulated loads to determine total annual regulated load cost savings for all energy saving measures. The results show that the project will reduce annual operating costs by 39%, qualifying the project to receive 6 LEED EA Credit 1 points. Table 6 shows the LEED calculator used to calculate the energy cost savings by end use. In addition, the DOE-2.2 BEPS report for the ASHRAE Energy Cost Budget and the proposed Laramie Country Library (DEC) buildings are included in Table 7.

Table 6: LEED Calculator for Laramie Country Library

Energy Summary by End Use						
End Use	Energy Type	Proposed Building		Budget Building		Optimized Energy Performance (%)
		Energy (10 ⁶ Btu/h)	Peak (10 ⁶ Btu/h)	Energy (10 ⁶ Btu/h)	Peak (10 ⁶ Btu/h)	
REGULATED LOADS						
Lighting-Ambient	Electricity	1,270,200		2,063,500		62%
Space Heating	Natural Gas	4,084,000		5,404,600		76%
Space Cooling (Electricity)	Electricity	176,900		329,200		54%
Pumps	Electricity	78,700		379,300		21%
Fans - Ventilation	Electricity	377,300		415,100		91%
Domestic Water Heating	Natural Gas	111,400		111,400		100%
TOTAL REGULATED BUILDING CONSUMPTION		6,098,500.0		8,703,100.0		70.1%
NON-REGULATED LOADS						
Misc Equipment	Electricity	1,073,400		1,073,400		100%
Exterior Lights	Electricity	163,300		163,300		100%
TOTAL NON-REGULATED BUILDING CONSUMPTION		1,236,700.0		1,236,700.0		100%
Energy and Cost Summary by Fuel Type						
Type	DEC" Use (10 ⁶ Btu/hr)	DEC" Cost (\$)	ECB' Use (10 ⁶ Btu/hr)	ECB' Cost (\$)	DEC" / ECB' Energy % Cost %	
Electricity	1,903,100	\$ 47,187	3,187,100	\$ 79,771	60%	59%
Natural Gas	4,195,400	\$ 5,580	5,516,000	\$ 7,336	76%	76%
Total Nonrenewable	6,098,500	\$ 52,767	8,703,100	\$ 87,107	70%	61%
Renewable						
Total Including Renewable	6,098,500	\$ 52,767	8,703,100	\$ 87,107		
Percent Savings = (ECB' \$ - DEC" \$) / ECB' \$ =						39.4%

Table 7: BEPS Report for DEC and ECB Buildings

BEPS Report for ASHRAE 90.1-1999 ECB Baseline Building

REPORT- BEPS Building Energy Performance													WEATHER FILE- WY CHEYENNE		
	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEN	DOMEST HOT WTR	EXT USAGE	TOTAL		
EMI ELECTRICITY															
MBTU	2063.5	0.0	1073.4	0.0	329.2	1.4	379.3	415.1	0.0	0.0	0.0	163.3	4425.1		
FMI NATURAL-GAS															
MBTU	0.0	0.0	0.0	5404.6	0.0	0.0	0.0	0.0	0.0	0.0	111.4	0.0	5516.0		
MBTU	2063.5	0.0	1073.4	5404.6	329.2	1.4	379.3	415.1	0.0	0.0	111.4	163.3	9941.1		
TOTAL SITE ENERGY				9941.15 MBTU		97.6 KBTU/SQFT-YR GROSS-AREA				97.6 KBTU/SQFT-YR NET-AREA					
TOTAL SOURCE ENERGY				18791.46 MBTU		184.6 KBTU/SQFT-YR GROSS-AREA				184.6 KBTU/SQFT-YR NET-AREA					
PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.0															
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0															
NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.															
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BEPS Report for Proposed Building (DEC)

REPORT- BEPS Building Energy Performance													WEATHER FILE- WY CHEYENNE		
	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEN	DOMEST HOT WTR	EXT USAGE	TOTAL		
EMI ELECTRICITY															
MBTU	1270.2	0.0	1073.4	0.0	176.9	0.4	76.0	378.5	0.0	0.0	0.0	163.3	3138.7		
FMI NATURAL-GAS															
MBTU	0.0	0.0	0.0	4108.0	0.0	0.0	0.0	0.0	0.0	0.0	111.4	0.0	4219.4		
MBTU	1270.2	0.0	1073.4	4108.0	176.9	0.4	76.0	378.5	0.0	0.0	111.4	163.3	7358.1		
TOTAL SITE ENERGY				7358.08 MBTU		72.3 KBTU/SQFT-YR GROSS-AREA				72.3 KBTU/SQFT-YR NET-AREA					
TOTAL SOURCE ENERGY				13635.40 MBTU		133.9 KBTU/SQFT-YR GROSS-AREA				133.9 KBTU/SQFT-YR NET-AREA					
PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.1															
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0															
NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.															
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