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CENTER FOR ADVANCED ENERGY STUDIES

Project Overview & Team

Owner: State of Idaho, Idaho State University

Location: Idaho Falls, ID

Building Type: Office and Laboratory

Size: 55,600 SF

Completion Date: August 2008

Utilities: Idaho Falls Power, Intermountain Gas Company

Architect: GSBS Architects

Mechanical Engineer: Colvin Engineering

Electrical Engineer: Spectrum Engineers

Design-Build Contractor: Big-D Construction

Region: Mountain West

ICC Zone: 5B

OVERVIEW

The Center for Advanced Energy Studies (CAES) building is operated by Idaho State University (ISU) and is located on the University Place campus in Idaho Falls. It is directly adjacent to the Idaho National Laboratory (INL) campus. The CAES organization is a public-private partnership that comprises the three Idaho public universities, Boise State University, ISU, and the University of Idaho. The building houses INL researchers and academic research faculty from all three universities. The space program includes full service research laboratories with offices meeting rooms and other support spaces. The CAES organization mission states that it “delivers innovative, cost-effective, credible energy research leading to sustainable technology-based economic development.”

In 2005, Sue Seifert, Commercial Building Energy Efficiency Specialist at the Idaho Office of Energy Resources (OER), received a grant from the US Department of Energy, to conduct a cost and benefit comparison study of designing a LEED building for a major State of Idaho project. The grant included resources to facilitate two early charrettes, an owner and user visioning charrette and a schematic design charrette that included multiple design and construction disciplines. The grant also paid for ongoing analysis of the costs and benefits associated with constructing the first LEED building commissioned for a state agency. OER contracted with Ken Baker of K Energy to help facilitate this process. According to Baker, “This project was unique because it was the first endeavor on the part of an agency or university in Idaho to design and build a LEED building.” Together, they identified the CAES building, still in the preliminary visioning stage, as the appropriate project through which to carryout this research. Why the CAES building? Baker, offered this answer,

“It is so important to have a strong leader with decision making authority who is determined to achieve the energy efficiency and LEED goals set out for this project.” He continued,

“Darrel Buffaloe, at ISU, had a strong history of demonstrated leadership for reducing energy use in existing campus facilities and we thought he was the right person to champion the first LEED building completed by the State.”

> “Setting these goals, prior to the RFP was important in order to set the expectations for the design-build team and have concrete terms of success for the project.”
>
> – Sue Seifert, Commercial Building Energy Efficiency Specialist

Photo credit: Christopher Meek & Kevin Van Den Wymelenberg

Center for Advanced Energy Studies Exterior

The initial visioning charrette included all the key stakeholders from the universities, INL, and the Division of Public Works (DPW) and was held in November 2005 prior to selecting a design team. Several key goals and process expectations emerged from that meeting and these were written into the request for proposals (RFP) for design and construction services. First, it was determined that a design-build team would be best suited to deliver the project on time and on budget. Second, the RFP stated that the building must use at least 50% less energy than the current energy code (at the time, the International Energy Conservation Code 2003, similar to ASHRAE 90.1 2001). Third, the building must achieve, at a minimum, a LEED Silver certification. “Setting these goals, prior to the RFP was important in order to set the expectations for the design-build team and have concrete terms of success for the project” said Sue Seifert.

The design-build team selected was lead by Big-D Construction, and included GSBS Architects and Colvin Engineering, all out of Salt Lake City, UT. They had experience working together and had completed several LEED buildings already. In the spring of 2006, Baker and the University of Idaho Integrated Design Lab (IDL) led a schematic design charrette that included all the key stakeholders as well as the full design team. Climate responsive design strategies were discussed and an energy programming exercise was conducted and resulted in suggested organization for space types and arrangements with consideration of internal loads, daylighting, and visual and thermal comfort criteria. One refinement to the previous goals was made, and that was to modify the energy goal from 50% below ASHRAE 90.1 2001 to 35% below ASHRAE 90.1 2004. “This was a bit of a disappointment, but was agreed to as a reasonable compromise since 90.1 2004 was more stringent than the code in place when the goal was set” said Kevin Van Den Wymelenberg, Director of the IDL.

Setting these goals resulted in a successful design-build project that earned a LEED Gold certification and was modeled to perform 38% below ASHRAE 90.1 2004. Without stating these goals explicitly in the visioning charrette it is unlikely that the building would have achieved this level of design performance.

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STRATEGIES AND FEATURES

One of the primary goals of this project was to use the integrated design process to reduce energy loads of the building. This is important to all of the following sections. For example, reducing cooling loads by using high performance glass and good shading can allow for consideration of alternative cooling system strategies. For more about load reduction through the integrated design process, visit http://designsynthesis.betterbricks.com.

Saving Tax Payer Dollars

Minimize energy use and operating expense

- Proper orientation and spatial zoning
- Architectural solar shading
- Increased insulation and high performance glazing
- Quality daylighting and integrated electric lighting controls
- Occupancy sensor lighting control
- Indirect-direct evaporative cooling (with supplemental DX)
- 88% Efficient condensing boilers serving radiant floors
- Heat recovery ventilation
- Demand control ventilation in offices
- Under floor air distribution in offices
- Occupy sensors and variable frequency drive fans on fume hoods and pumps


Photo credit: Christopher Meek & Kevin Van Den Wymelenberg

Center for Advanced Energy Studies Interior

Visual Comfort and Preference

Use daylight as the primary light source

- Two-story daylit atrium with open plan offices
- Open plan offices in the daylit zones
- Private offices organized inboard with large relights for daylight and view
- Sloped ceilings to redirect daylight and provide brighter ceiling plane
- Exterior fixed solar control on all south glazing to minimize glare and positioned as a lightshelf to redirect daylight to the interior ceiling
- Large interior lightshelf at south facing offices to minimize glare and redirect sunlight to ceiling
- 94% of all occupants have a view to exterior

Supplement daylight with quality electric lighting and controls

- High efficiency direct-indirect lighting
- Daylight sensing photo-controls and occupancy sensors

Thermal Comfort and Air Quality

Reduce loads to allow hybrid evaporative cooling system

- Proper building orientation elongated in east west axis
- High performance glazing and increased insulation
- Solar shading on all south glazing to minimize solar gain
- Demand control and energy recovery ventilation
- Return air from office space is transferred (through building pressurization) to the lab spaces in order to minimize the energy penalty for the high exhaust requirements of laboratories
- DX as final stage of cooling used only when necessary

Improved Air Quality

- Occupant control
- 30% increased ventilation over code requirements provided in specified locations
- Low and no VOC materials, systems furniture
- Isolated and ventilated chemical storage areas

ENERGY AND FINANCIAL ANALYSIS

Project Construction Budget: $15,000,000

Building Price / SF: $269

Operating Expenses: Energy – Modeled annual energy cost savings ~$59,000. As compared to baseline (ASHRAE 90.1)

Energy Analysis

Lighting			Savings
kWh	~151,000 kWh	~114,000 kWh (proposed)	24%
kBTU	~515,000 kBTU (baseline)	~390,000 kBTU (proposed)	

Space Heating			Savings
Therms	~58,000 Therms	~30,000 Therms	49%
kBTU	5,847,500 kBTU (baseline)	2,969,000 kBTU (proposed)	

Space Cooling			Savings
kWh	~127,000 kWh	~120,000 kWh	6%
kBTU	~434,000 kBTU (baseline)	~410,000 kBTU (proposed)	

Pumps			Savings
kWh	~56,000 kWh	~41,000 kWh	26%
kBTU	~191,000 kBTU (baseline)	~141,000 kBTU (proposed)	

Fans			Savings
kWh	~708,000 kWh	~315,000 kWh	56%
kBTU	~2,415,000 kBTU (baseline)	~1,076,000 kBTU (proposed)	

Miscellaneous Equipment			Savings
kWh	~695,000 kWh	~695,000 kWh	0%
kBTU	~2,376,000 kBTU (baseline)	~2,376,000 kBTU (proposed)	

Energy Use Index			Savings/yr
kBTU	211 kBTU/sf (baseline)	132 kBTU/sf (proposed)	37%
	~434,000 kBTU (baseline)	~410,000 kBTU (proposed)	

Energy Cost		Savings/yr
$179,000/yr (baseline)	$111,000/yr (proposed)	38%

Cost Analysis*

Physical Building Efficiency Measures	$125,000
Design Charrette, LEED coordination activities	$10,000
Climate, Daylight, and Wind analysis modeling	$8,800*
eQuest energy modeling	$7,000
Architectural Design Fees	$0
LEED Documentation	$40,000
LEED Registration fee	$450
LEED Certification fee	$1,250
Total Added Cost for LEED Silver	$193,100

Cost and Payback Analysis

First year avoided cost of LEED Silver	$59,000 (energy savings)
Five year avoided cost at 2007 utility rates	$294,000
Net Present Value of efficiency measures	$55,000**
ROI (Return on Investment)	30%**
Simple Payback	3.2 years**

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* These expenses are estimated costs for hours invested by the University of Idaho IDL and paid for by NEEA's BetterBricks initiative. They were not directly expensed to anyone affiliated with the CAES organization, the design-build team, or the State.

** Baker, Ken; Cost Report for LEED Certification for the Idaho Division of Public Works and the Idaho Office of Energy Resources, June 2008.

Photo credit: Christopher Meek & Kevin Van Den Wymelenberg

Center for Advanced Energy Studies Daylighting

LESSONS LEARNED

Process

- **Design-Build Project Delivery:** There were definite benefits to utilizing the design-build project delivery method, however there were also some challenges. Jim Szatkowski, the project manager for DPW, felt that a design-build project delivery method "had the highest success rate for being able to deliver what was expected regarding the high performance criteria and LEED requirements." The biggest success of using this process, Szatkowski continued, was that "the total project cost for a LEED-Gold building came in at or below what a standard, design-bid-build project without the LEED certification would have." However he also stated "gaining owner buy-in and getting them to explicitly state their expectations" required careful attention and presented challenges. Finally, many of the subcontractors on this project had not dealt with the level of complexity involved in executing a high performance laboratory facility of this nature.
- **Collaborative Integrated Design:** There are synergies between design-build and the integrated design process and integrated project delivery. Overall, the integrated design process was very successful on this project. The early visioning and schematic design charrettes were useful in setting concrete goals. Collaboration with the IDL proved useful to generate climate responsive design strategies and provide ongoing analysis of daylighting and natural ventilation strategies. The design-build team worked effectively together to further develop and successfully implement energy efficient strategies. An example is offered by Garth Shaw, Principal at GSBS Architects, "Under-floor air distribution in the office offered energy savings and improved indoor environmental quality, but this aspect of the project required team-wide collaboration. Airflow and energy modeling tools were used to improve heat distribution and airflow while contractor activities were re-sequenced to reduce contamination of the air plenum." Coordination among GSBS and Big-D resulted in decisions that ensured the project was completed on budget and on time. All of these are successful aspects of the integrated design process that was deployed. However, like with any project, there were some lessons learned as well. These will be discussed below.

> There are synergies between design-build and the integrated design process and integrated project delivery. Overall, the integrated design process was very successful on this project.

- **Daylight Harvesting:** Shaw stated, "A unique aspect of the CAES project is the introduction of daylight into research spaces. Both careful coordination and user education were required so that the design team understood how to responsibly introduce daylight, and the researchers and staff understood why it was important." GSBS Architects and the IDL worked together to conduct extensive daylight modeling with the goal of providing a high quality daylit environment that was comfortable, visually pleasing and saved energy. The toplighting solution in the atrium effectively provides ample daylight at the atrium open offices. The shading strategy, a combination of external shading devices, internal lightshelves and internal louver blinds, works to successfully mitigate glare while still providing functional daylight illumination.

  While there are several successful aspects of the daylighting design, there are also important lessons learned. The goal to daylight the laboratory spaces posed a great design challenge. Throughout the design process there were ongoing discussions about how to improve the daylighting in the laboratory spaces. Skylights were considered, but in the end it was determined to be too difficult to navigate skylights into the already complicated overhead equipment infrastructure. The laboratories have adequate ambient illumination from daylighting through tall north facing perimeter windows, and the relights at the back of the spaces provide good balance in visual brightness. However, electric lights are often required to perform specific tasks in the main working areas of the labs and a more robust task ambient solution would have afforded additional energy savings.

  There are also a couple lessons learned from the daylighting in the atrium and office spaces. While the private offices, which are pulled inboard from the windows, have significant "relight" glazed area to allow daylight penetration and view, there was discussion whether these private spaces could function without an enclosed lid and with lower sidewalls, or with fully glazed partitions, to improve the passage of daylight deeper into these spaces and airflow over them. For reasons of both privacy (fully enclosed and full height) and cost (not fully glazed), the as-built solution was determined. Also, as a cost reduction measure, the ambient lighting in the open office areas was specified with a step-switching control schematic instead of with continuous dimming ballasts. Commissioning a step-switching system so that it does not disrupt the occupants can be challenging. Typically, the dead-band and time delays need to be extended such that the daylight harvesting system does not save as much energy as dimming ballasts might. Even when properly commissioned, the light levels still change more abruptly and this is often noticed and considered unfavorable by occupants.

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Iterative Modeling

Early energy modelling was conducted during the early schematic design stages, which helped to secure many of the passive climate responsive design strategies. However, there was some miscommunication over who was responsible to continue the energy modeling during the later schematic and design development stages. It is a good idea to use energy modeling as an iterative design tool and test multiple alternatives as the design evolves. One effective way to ensure this is to include comparative energy modeling results as a required deliverable with each major design phase submittals (SD, DD, CD). Unfortunately, after the early modelling activity was complete, design decisions were not tested again through an energy model until near the end of construction documents when LEED compliance modelling was conducted. One key design element included in early energy models was a passive ventilation strategy for both night flush precooling in the summer and daytime cooling and ventilation during shoulder seasons. For various reasons, including concerns over security and dust control, this design element did not come to fruition and the incremental energy benefit was not defined to inform this decision. It is possible that the energy and indoor air quality benefits could have been made more tangible with energy and airflow modeling during late schematic and design development stages to help inform the decision making process.


Photo credit: Christopher Meek & Kevin Van Den Wymelenberg

Center for Advanced Energy Studies Daylighting

Commissioning

Garth Shaw stated that the most important lesson learned regarding the low energy design strategies employed at the CAES building was related to commissioning the laboratories; "The importance of a solid commissioning process involving qualified individuals cannot be overstated in laboratories. The commissioning process should go beyond typical core and shell, HVAC and electrical components and include laboratory exhaust and other process type systems." Laboratories are energy intensive areas by nature and tend to have sophisticated control schemas to ensure optimum performance for research, environmental health and safety, and overall system efficiency. Commissioning these systems in their entirety will produce benefits immediately in terms of both energy use and system performance.

Operation, Measurement and Verification

Any organization that is serious about energy use will track annual building performance at some level. While energy models are useful for comparing design alternatives, they should not be expected to predict actual consumption for a host of reasons. First of all, models are based upon 'typical' annual weather data and actual energy use results from real weather conditions. Assumptions about occupancy and system definition and control in the model as compared to reality also contribute to differences. The energy modeling community is taking this seriously and working to reduce these differences. Nonetheless some type of comparison is essential. Comparing actual consumption to modeled consumption should be only one method of measuring performance. Other data sources such as the Energy Information Agency's Commercial Building Energy Consumption Survey (CBECS) and year over year comparison of the same facility should also be considered. The following table illustrates this type of well rounded analysis.

Energy Use Index Comparisons

CBECS 2003 climate specific average laboratory	255 kBTU/SF*YR
Architecture 2030 50% reduction goal	130 kBTU/SF*YR
CAES proposed design energy model	132 kBTU/SF*YR
2009 Actual CAES Consumption	188 kBTU/SF*YR
2010 Actual CAES Consumption	164 kBTU/SF*YR

Monthly Demand

Electricity Demand (kW)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Demand_Electricity_2009	0	0	123	132	145	107	90	128	104	106	113	83
Demand_Electricity_2010	100	105	106	127	102	108	109	131	116	138	119	135

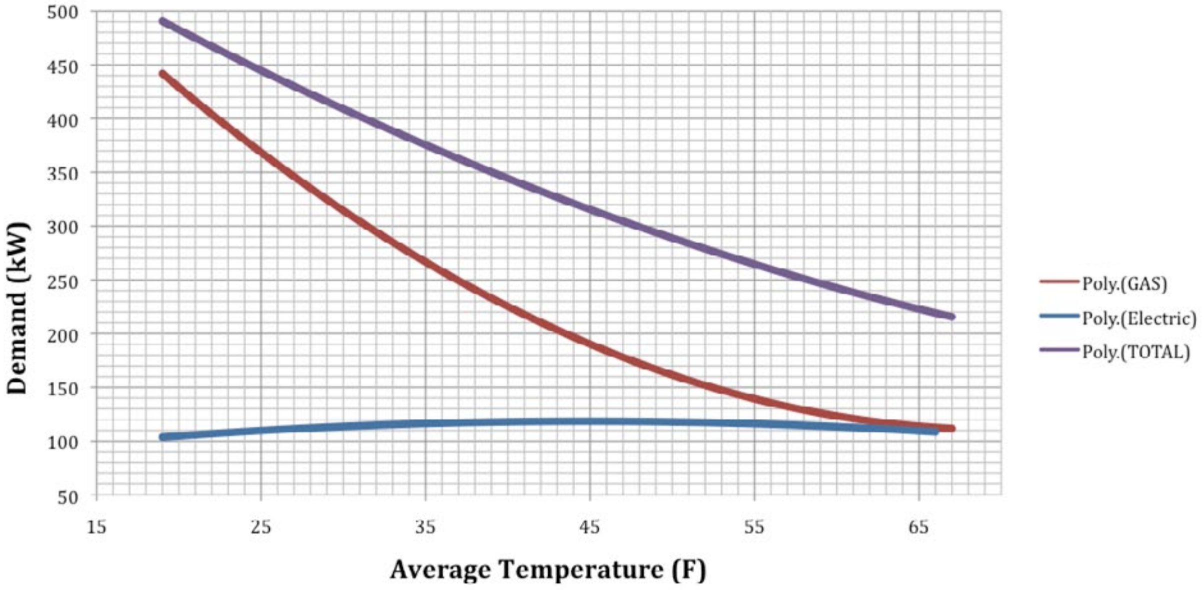
Gas Demand (kW)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Demand_Gas_2009	437	561	301	315	215	163	110	97	107	175	227	363
Demand_Gas_2010	445	339	327	240	174	133	120	103	119	105	170	0

Demand Total (kW)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Demand_Total_2009	437	561	423	447	359	270	201	225	212	281	341	446
Demand_Total_2010	545	443	434	366	276	241	229	233	235	242	289	135

Annual Actual Consumption by Fuel Split

	Electric Consumption			Gas Consumption			Total EUI
Year	kWh	kBTU	kBTU/SF*YR	kWh	kBTU	kBTU/SF*YR	kBTU/SF*YR
2009	830,400	2,834,986	51	2,224,954	7,595,993	137	188
2010	1,019,600	3,480,914	63	1,650,967	5,636,402	101	164

CAES Energy Signature



Even with robust commissioning employed, while a building transitions into full occupancy it is critical to measure performance and engage in ongoing commissioning activities. This is especially true with laboratory facilities, as there tends to be a more involved move-in process as lab equipment is purchased and updated as research programs evolve. There are operational aspects of laboratories that can have a tremendous impact on energy consumption. For example, routinely closing fume hood sashes when not in use can result in the difference between a typical fume hood using the equivalent energy of 1-2 homes on an annual basis to it using 4-5 homes worth of energy annually. Furthermore, decisions about appropriate ventilation rates in laboratories are not only important during design stages but also throughout the life of the building.

The CAES is committed to routine energy benchmarking of its facility. The 2010 Actual Consumption is 36% below CBECS 2003 Regional Average and marked a 13% improvement over the previous year. This is evidence of the CAES commitment to improve performance by improving operations. The CAES leadership recognizes that there is more that can be done. In fact, the CAES plans to use its facility as a living laboratory for improved energy performance for years to come. They are considering ideas for efficiency improvements related to even more aggressive fume hood exhaust strategies and wind speed and occupancy driven laboratory ventilation rates. They are also exploring distributed wireless mesh metering projects to better understand, energy flows on both the building system side and the lab equipment side, as well as occupant comfort and environmental quality factors throughout their facility.

CONTACTS AND RESOURCES

NEEA's BetterBricks Initiative:
www.betterbricks.com

Big-D Corporation
www.big-d.com
801.415.6000

GSBS Architects:
www.gsbsarchitects.com
801.521.8600

Integrated Design Lab, Boise:
www.idlboise.com
208.429.0220

Idaho Falls Power:
www.ifpower.com
208.612.8526

Intermountain Gas Company:
www.intgas.com
208.542.6600

About NEEA's BetterBricks Initiative

BetterBricks is the commercial building initiative of the Northwest Energy Efficiency Alliance (NEEA), which is supported by Northwest electric utilities. Through BetterBricks, NEEA advances ideas to accelerate energy savings in new and existing commercial buildings. BetterBricks education & training, online resources and recognition of industry leaders guide and inspire building professionals to embrace best practices, improve energy performance and achieve their sustainability goals. Visit www.BetterBricks.com to connect to these powerful energy ideas and more.