nbi new buildings institute

BETTERBRICKS
Powerful Energy Ideas. Delivered by NEEA.

Case Study

Deep Energy Savings in Existing Buildings

Overview

Site Details

- Owner: Northern Plains Resource Council
- Location: Billings, MT
- Building Type: Office
- Project Description: Major Renovation
- Size SF: 8,500
- Stories: 1
- Project Completion: 2006
- Year Built: 1940

Recognitions

- LEED-NC Platinum
- 2007 Energy Star Award
- AIA Top 10 Green Awards 2008

HOME ON THE RANGE

Northern Plains Resource Council (NPRC) organizes Montana citizens to protect the region's water quality, family farms and ranches, and unique quality of life. It is a member of the Western Organization of Resource Councils (WORC), a regional network of seven grassroots community organizations. In 2003, Northern Plains and WORC decided to create a permanent home by purchasing and renovating an existing building - a vacant concrete block building constructed in 1940 as a grocery store. Working with High Plains Architects and Hardy Construction Company, they managed to transform an uninsulated, largely windowless building — widely considered one of the most blighted properties in Billings, Montana — into a demonstration of "green" building strategies and technologies. *Northern Plains Resource Council website.*

The U.S. Green Building Council (USGBC) prepared a case study on the Home on the Range Project in 2008, including data on energy performance for one year. This Project Profile builds on that information and provides updated owner feedback and energy use data.

Home on the Range (HOTR) demonstrates a very successful renovation in terms of actual energy use compared with older buildings. The actual energy use of the building is currently 46 kBtu/sf/yr, 51% better than the average U.S. office building.

Motivations

Project goal: The goal was to express the organizations' commitment to energy conservation and community values. The Home on the Range energy strategy is to minimize demand, incorporate as much energy efficiency as possible and maximize the use of renewable energy sources. Teresa Erickson, staff director

The Home on the Range energy strategy is to minimize demand, incorporate as much energy efficiency as possible and maximize the use of renewable energy sources.

at the Northern Plains Resource Council, felt it was important that the nonprofit become a model for green building for both the City of Billings and the State of Montana, with the ability to influence other buildings and owners. The building achieved LEED-NC Platinum and received the EPA Energy Star Award in 2007.

Rationale and economic criteria: According to owner representative Teresa Erickson, the building needed to align with "[their] values of promoting clean and renewable energy and fighting dirty energy. We don't want to pay any higher utility bills than we have to." NPRC consistently looked at costs and eliminated anything that was not functional, but eventually incorporated most energy efficiency measures considered into the project. Daylighting and radiant floors were the highest priority measures.

Barriers and resolutions to energy efficiency measures: Northern Plains Resource Council did extensive research into energy efficiency. Its employees knew what they wanted for their building, but were often questioned regarding their approach by the design professionals. NPRC was challenged to get the architect, engineers and contractors on board and transform them into "believers" in a low-energy building (NPRC succeeded). In addition, the project was built during a construction boom when prices were high, posing an additional challenge. This factored into their decision to install a permeable parking lot made from recycled, pulverized glass in response to a tripling in the cost of asphalt.

Technologies and Design Strategies

HVAC: The building has a high-efficiency boiler; a radiant-floor hydronic system, which uses less energy than an air-based system; and a direct evaporative cooling system, which is more efficient than refrigeration air conditioning in Billings' climate zone. Fans use variable frequency drives. Monitoring CO^2 levels allows Northern Plains to minimize the percentage of outside air exchanged in the building while meeting American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards for commercial buildings.

Envelope: Energy demand was minimized with a building shell insulated to a higher degree than required by code. Because the wall insulation is on the exterior of the concrete block walls, the building benefits from considerable thermal mass. The renovation included low-E windows. Exterior walls and roofs were painted a light color, and the south windows incorporate the use of exterior louvers, awnings and trellises to reduce solar heat gain.

Lighting: T8 fixtures are used throughout the building. NPRC had looked at T5 and dimming ballasts but ultimately chose T8 since the lumens per watt were comparable. Daylight sensors turn off or dim fixtures when sufficient ambient light exists. According to Erickson, the general area lighting served by the T8 system is dimmed to the lowest reasonable level, with only task lighting

"We have been continually fine-tuning the building controls to maintain a healthy, comfortable work space and at the same time prevent the wasting of energy."

in work areas for the majority of the year. Only during the winter months is natural light insufficient for general illumination. Erickson also noted the ideal would be sufficient penetration of daylight to work surfaces to eliminate the need for task lighting, but the task lighting does allow staff to exercise their personal preferences.

Daylighting: The building was designed in an open floor plan to allow daylighting to penetrate the space. Openings in the existing building (which was virtually windowless) were strategically located around the perimeter and on the roof (skylights) to deliver the right amount of daylight where needed. Perimeter windows have light shelves that evenly distribute daylight deeper into the building by reflecting it to the ceiling plane. The building is almost entirely day-lit. NEEA/BetterBricks provided a daylighting analysis and lighting technical assistance through the Daylighting Lab in Seattle.

Controls: Lighting controls consist of on/off photoelectric daylight sensors and occupancy sensors. The occupants routinely override the lighting controls in favor of flexibility, but as daylighting is the primary source of light, lights are off most of the time. HVAC controls incorporated into the project are thermostats with night set-back and occupancy-based CO^2 demand control ventilation (DCV). DCV allows for ventilation to be based on actual occupancy rather than assuming full occupancy, thereby reducing energy for conditioning and moving the air. According to Technology Coordinator Tim Ennis: "We have been continually fine-tuning the building controls to maintain a healthy, comfortable work space and at the same time prevent the wasting of energy."

Commissioning: One of the major lessons learned was the value of commissioning. Initially the owners did not want to pay the upfront cost, but the contractor was committed to the project and gave them a reduction in cost. The commissioning agent identified problems with the installation of the radiant-floor hydronic system and worked closely with the controls contractor to fine-tune the control system and allow for easier identification of issues by the building operator. Through the commissioning process, Home on the Range realized substantial savings in both maintenance and energy costs.

Renewables: The building has a 9.9 kW photovoltaic (PV) system and a solar water heater on the roof. The PV system has produced an average of 34% of the electricity and 15% of total energy over the 2006-2010 period, and the system includes net metering, which facilitates the sell-back of excess electricity produced in the summer. Purchased energy is offset with green tags for wind power supplied through a Green-e renewable energy contract. The efficiency aspects of the building – particularly evaporative cooling and daylight sensors to reduce electric lighting – lead to a peak electricity need on hot days lower than the PV generation. As a result, the Home on the Range building actually contributed electricity to the grid during hot, brownout-prone summer spells.

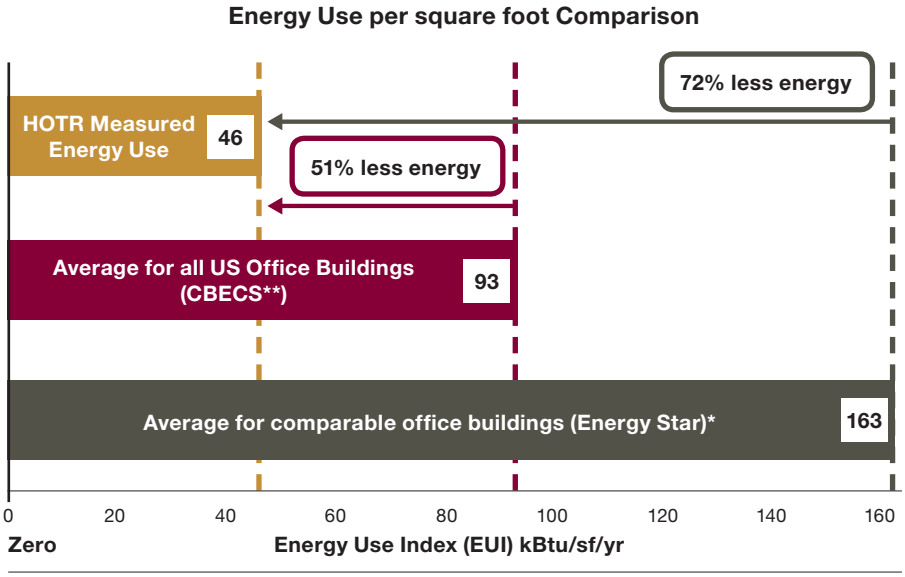
Efficiency Measures

- High-efficiency boiler
- Radiant-floor hydronic system
- Variable frequency drives
- Demand Control Ventilation (CO^2 sensors)
- Increased insulation
- Low-e glazing
- Commissioning
- T8 fixtures with dimmable ballasts and daylighting controls
- Light shelves
- Occupancy sensors
- HVAC controls
- Photovoltaics

Site: The City of Billings granted the project a variance to allow for a permeable parking lot. Instead of asphalt, the parking lot is made of recycled, pulverized glass which is aesthetically pleasing, functions well and makes use of material that would otherwise go to waste. The glass parking lot has two other environmental benefits: its reflectivity mitigates the urban heat island effect and allows the wattage of parking-area lighting to be reduced.

Monitoring systems: While it does not sub-meter the building, Northern Plains does track utility bills on a monthly basis. By fine-tuning controls, it has achieved an estimated five percent additional savings over the last five years. The building is typically occupied by 25 people working a standard 40-hour office work week. NPRC also averages 20 visitors per week (approximately two hours per visitor).

Energy Performance



* Comparable office average energy use from the Energy Star Portfolio Manager program based on like type, size, occupancy, hours, and climate - determined from statistical analysis of the CBECS dataset
**Average energy use for all U.S. Office buildings through the Commercial Building Energy Consumption Survey (CBECS)

Home on the Range has tracked its electric and gas bills since occupancy in mid-2006. This data showed the energy use of the building in 2010 of 46 kBtu/sf/yr (EUI[1]) and an average energy use since occupancy of just 44 kBtu/sf/yr - approximately half that of the average for offices in the U.S.[2] A more specific comparison can be made through the Energy Star Portfolio Manager program, which determines the energy use of a building of like

Energy Performance

% Better than Baseline	51%
Baseline	**Average for U.S. Offices***
Measured Energy Use (KBtu/SF/yr)	46
Energy Star Score	99

** CBECS – U.S. DOE Energy Information Agency's Commercial Building Energy Use Index 2003*

1 An Energy Use Intensity (EUI) is the total energy (gas and electric) used expressed in thousands (k) of British thermal units (Btu) divided by the square feet (sf) of the space – resulting in a commonly-used metric of energy use in kBtu/sf/yr.
2 CBECS – The Energy Information Agency's Commercial Buildings Energy Consumption Survey 2003.

type, size, hours of use and climate. In this example the Energy Star program calculated that comparable buildings would use more energy than the average for U.S. office buildings (probably driven primarily by the cold Montana climate). The HOTR Building, however, uses less energy than either reference point, and 72% less energy than the Energy Star estimate. The HOTR Building earns an ENERGY STAR score of 99 (out of 100), putting it in the top 1% of office buildings in the U.S. The actual whole-building energy use is also 12% below the LEED energy modeling analysis done for the renovation, which estimated 53 kBtu/sf/yr. The measured energy data also verified an approximate five percent drop from its 2008 use, indicative of continued improvement. At HOTR, photovoltaics produce close to 35% of total electricity and roughly 12% of total energy.

The HOTR Building is an impressive example of investing in design and systems during a remodel that optimize energy efficiency and that truly yield measurable results in terms of savings.

Financial

Total project cost: $1,435,243, $169/sf (after incentives)

Funding and Incentives: Member donations provided the bulk of initial funding, which was later supplemented by private foundation grants, a loan and grants from the Downtown Billings Partnership, and renewable energy incentives from Northwestern Energy. Northern Plains did a cost analysis comparing renting versus buying and found the cost of retrofitting was $147/sf, compared to new construction without energy efficiency and green measures at $186/sf. The property and existing building were purchased for $182,808.

Estimated annual cost savings: Demolishing the existing structure and building a new office building the same size to the model energy code (ASHRAE-90.1-1999) would have cost approximately $325,000 more than the cost of renovating to LEED Platinum status. Northern Plains realized an upfront cost savings of more than 20% to create a building with operating costs estimated to be 72% lower over a 20- year period. The payback period is negative.

Project Results

Staff Education/User Satisfaction: Northern Plains has implemented some staff education, but recognizes the need to do more. It requires employees to turn off computers, printers and lights when not in use. While it has not conducted formal user satisfaction surveys, Erickson said staff enjoys the daylighting and views: “Everyone loves the building, and the community has taken great pride in it.”

Innovation: Erickson believes the most innovative aspects of the project are the light shelves and the pulverized glass parking lot. “The fact that we were able to ‘walk our talk’ has given us an advantage point as an organization.”

Acknowledgements and Sources

Project Team:

- Owner Representative: Teresa Erickson, Northern Plains Resource Council
- General Contractor: Greg Hardy, Hardy Construction Company
- Architect: Randy Hafer and Ed Gulick, High Plains Architects
- Commissioning Agent: Ron Pecarina, Energy and Sustainable Design Consultants, Inc.
- Mechanical Engineer: Art Fust P.E., Energy A.D.

Sources:

- Northern Plains Resource Council: Teresa Erickson
- Western Organization of Resource Councils: Tim Ennis
- High Plains Architects: Ed Gulick
- Energy and Sustainable Design Consultants: Ron Pecarina
- Northern Plains Resource Council website
- USGBC LEED case study: http://leedcasestudies.usgbc.org/overview.cfm?ProjectID=902
- AIA Seattle 2010 Regional Top Ten Green Awards: "What Makes it Green?"

Photos: Courtesy of Northern Plains Resource Council and High Plains Architects

Research and Development:

- New Buildings Institute (NBI): Liz Whitmore, Cathy Higgins, Mark Lyles

Funding:

- The BetterBricks program of the Northwest Energy Efficiency Alliance (NEEA): Peter Wilcox, John Jennings and Mark Rehley
- NBI's work is also supported by the Doris Duke Charitable Foundation and the Kresge Foundation

Existing Building Renewal Initiative

This work is part of NEEA's regional Existing Building Renewal initiative to accelerate the market's adoption of deep, integrated energy efficient renovations. The initiative currently focuses on office buildings but will add other market sectors with large potential energy savings. This is one of the ways the region can rapidly revamp existing stock to achieve 30–60% energy savings — on the way to netzero-energy use by commercial buildings.

For more information on the Existing Building Renewal Initiative contact: Peter Wilcox pwilcox@neea.org or www.betterbricks.com

For additional case studies highlighting high performance commercial buildings, visit NBI's Getting to 50 Database:
buildings.newbuildings.org/

For more information about NBI's efforts to improve the energy performance of existing buildings, visit:
newbuildings.org/advanced-design/existing-buildings

New Buildings Institute

New Buildings Institute (NBI) is a nonprofit organization working collaboratively with commercial building professionals and the energy industry to improve the energy performance of commercial buildings.