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Case Study

Deep Energy Savings in Existing Buildings

Overview

Site Details

- Owner: Lovejoy Building LLC
- Location: Portland, OR
- Building Type: Office
- Project Description: Major Renovation
- Size SF: 20,000
- Stories: 2
- Project Completion: 2004
- Year Built: 1910

Recognition:

- LEED-NC Gold

THE LOVEJOY BUILDING

Originally built in 1910 as the stables for the Marshall-Wells Hardware Company, the Lovejoy Building is the home of Opsis, an architectural design firm practicing sustainable design. The building is located in Northwest Portland in an area known as "Slabtown," formerly home to early lumber mill workers. The owner architects purchased and renovated the historic building in 2003 to house their growing business and to provide ground-floor office lease space and second-floor offices for their firm. Retrofit of the existing load-bearing brick structure required a major seismic upgrade. The architects used this as an opportunity for an integrated response to advanced structural upgrades, enhanced user thermal comfort and improved energy savings.

Opsis wanted to use the building to experience and demonstrate the technologies and practices it promotes with clients. Creating an open, comfortable and resource-efficient office space was a priority; incorporating upgraded efficiency features was considered an integral part of the normal project budget.

The building's actual energy use is 40 kBtu/sf/yr, 57% better than the average for office buildings in the U.S. The building also qualified for the U.S. Green Building Council's Leadership in Energy and Environment (LEED) certification at a Gold level in 2006.

Motivations

Project goal: The goal of the project was to create a building that aligned with the culture and professional objectives of Opsis. The owners designed their space to formulate a living laboratory to showcase, and experience, the various energy-efficient and sustainable design features they incorporate into their work.

Creating an open, comfortable and resource-efficient office space was a priority.

According to one of the owners, James Meyer:

"There can be a disconnect for architects to understand the real world and what it means to be the one to write the check. We wanted to 'walk the talk' as proponents of green building design for our clients."

Rationale and economic criteria for selecting energy efficiency options: The architects at Opsis placed priority on a large uninterrupted office space supporting an open collaborative work environment. An in-floor hydronic heating and cooling system was chosen to optimize open space as well as to provide greater individual thermal comfort. Vertical and horizontal glazing offered everyone access to an effectively daylit work environment and enhanced views to the outside. Opsis recognized the common tendency to consider energy efficiency measures as "add-ons" that can be value-engineered out during cost-cutting sessions. The firm's design approach demonstrated a holistic integration of all components, with efficiency as an imbedded part inseparable from the design and project program.

Barriers and resolutions to energy efficiency measures: Opsis wanted to incorporate as many energyefficient measures into the building as possible, and it was able to include almost everything it considered. Lighting controls, operable windows and night flush were some of the measures for which the owners were willing to pay more. Radiant concrete walls were studied but were determined to be cost-ineffective.

Technologies and Design Strategies

The project included a whole-building envelope upgrade (the building was not occupied during the renovation). The additional efficiency strategies outlined below were incorporated into the 13,660 sf occupied by Opsis. A subtenant

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leases the remaining area, which has three different mechanical systems; the owners currently have efficiency or green tenant lease requirements.

HVAC: An in-floor PEX pipe hydronic system provides the building's primary heating and cooling, coupled with an integrated natural ventilation strategy using windows, skylights and ventilators. In the winter, water runs through the thermal mass, creating a stable temperature range while introducing heat low in the space. In the summer, the building is set for a night purge: cool night air introduced into the building removes the heat gains of the previous day, leaving the space cool for the next morning. In addition, the radiant slab hydronic system collects heat out of the slab, running the water through a rooftop chiller where the heat is removed; the cool water is then recycled back through the in-slab piping system. The radiant floor strategy requires significantly less space for equivalent heating and cooling than a material- and energy-intensive forced air system, with the additional benefit of less recirculated air, resulting in improved air quality and human comfort.

Envelope: A seismic upgrade required adding to the thermal mass of the building. New high fly-ash concrete perimeter walls and a concrete floor system were poured in place, with the added benefit of improving the efficiency of heating and cooling the building by increasing its thermal mass. The original windows were enlarged to improve views and bring light deep into the space. The addition of 14 skylights provides additional natural light to the top floor of the building. Low-E high-efficiency glass is used to minimize heat, and operable windows are controlled by the building management system to maintain temperature and air quality. Automated sunshades on the west face of the building block unwanted light and heat gains.

Lighting: The primary lighting system is suspended direct/indirect T8 fixtures with dimmable ballasts. The lighting system includes integrated daylighting controls to automatically dim electrical light.

Daylighting: The office space was modeled for uniform natural balanced daylight using a heliodon at the Energy Studies and Buildings Laboratory in Portland. Daylighting strategies include open office space, enlarged windows, skylights and a white ceiling for reflective purposes. Daylight controls reduce electric lighting, and west facing exterior automated sunshades reduce glare and heat gain.

Controls: The lighting and HVAC systems are controlled by a wholebuilding Energy Management Control System (EMCS) and sensors. The digital system modulates lighting according to daylight levels with zoned photocell sensors located on the open office ceiling. Automated sunshades on the west face of the building are controlled by photocells set to an astronomical clock. Rather than using the standard fixed ventilation rates per person based on assumed full occupancy, Opsis uses carbon dioxide (CO^2)

Efficiency Measures

- High thermal-mass envelope
- In-floor radiant slab with hydronic heating and cooling
- Night cool air purge
- Low-E glazing
- Automated sunshades
- Skylights
- Dimmable ballasts with integrated daylight controls
- Demand control ventilation with CO^2 sensors
- Open office with light surfaces
- Energy management control system

Daylight controls reduce electric lighting, and west facing exterior automated sunshades reduce glare and heat gain.

sensors in the office to interpret occupancy density. This system of CO^2 sensors, known as Demand Control Ventilation (DCV), sends data to the building management system to modulate ventilation air (which requires energy for conditioning) to accommodate actual occupancy needs.

Plug Load Management: When the staff at Opsis moved into their new space, they replaced their old CRT monitors with more energy-efficient flat screens. Opsis recently installed an electricity management monitoring system to review plug loads and energy usage in real time.

Commissioning: The project included enhanced commissioning, and the electricity management monitoring system allows for feedback to direct ongoing commissioning.

Monitoring systems: The building has two electrical meters, one for Opsis and the other for its tenant.

Post-Renovation Additional Measures: The original Direct Digital Controls (DDC) purchased for the building were reasonably-priced, but they lacked clear feedback and guidance. After three years, Opsis bought higher-end, more user-friendly controls.

Renewables: A photovoltaic system on the roof provides 2,500-watt maximum output – enough to power six workstation computer environments.

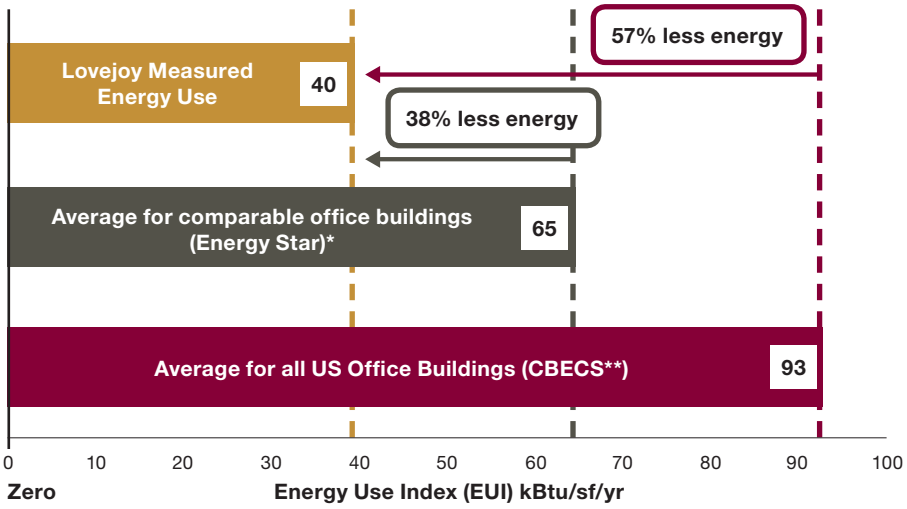
Energy Performance

Energy Performance

% Better than Baseline	57%
Baseline	**Average for U.S. Offices***
Measured Energy Use (KBtu/SF/yr)	40
Energy Star Score	92

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

Energy Use per square foot Comparison



* 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)

During 2010 the owners calculated a cost savings of over $5,000 in energy (gas and electric) compared to the predicted energy costs for the renovated building through the LEED design model.

Energy performance/savings: Opsis has been tracking its monthly gas and electric bills since 2008. In 2010, energy use was 40 kBtu/sf/yr (EUI[1]) for the Opsis office space area – 57% less energy per square foot than the average for offices in the U.S.[2] The U.S. office energy average is a good basis for quickly comparing buildings of the same type. A more specific comparison can be made through the Energy Star Portfolio Manager program, which determines the energy use of comparable buildings of like type, size, hours of use and climate. In this example, the Energy Star program calculation showed that comparable buildings would use less energy than the average U.S. office building, yet the Lovejoy performs even better – using 38% less energy than the Energy Star estimate.

The Lovejoy Building earned an ENERGY STAR score of 92 (out of 100), placing it in the top 10% of office buildings in the U.S. for energy performance. During 2010 the owners calculated a cost savings of over $5,000 in energy (gas and electric) compared to the predicted energy costs for the renovated building through the LEED design model.

The Lovejoy Building showcases the energy efficiency potential of an older building upgraded with readily-available energy technologies and thoughtful design. The owners' interest in the energy features and continual monitoring increases the likelihood of success and provides a real-world example to their clients.

Financial

Total project cost: $2,300,000, $115/sf

Funding: The owners used a construction loan to finance the building, receiving an Oregon Business Energy Tax Credit (BETC), but felt they were not as aggressive as they could have been in pursuing additional tax credits. They decided against registering the building as a historic landmark, thus giving up the associated tax credits, in order to retain the flexibility to enlarge the exterior windows and add sunshades. Opsis also chose not to go beyond LEED-NC Gold due to cost. According to James Meyer:

"We took everything as far as we could within a tight budget and were able to prove that if you are smart with the design, you can achieve LEED-Gold cost-effectively."

Project Results

Competitive positioning in the market: Because the building is LEED-Gold, Opsis has been able to attract tenants committed to sustainability. While this does not necessarily mean higher rents, the space has been

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

continuously occupied since it was constructed. The current tenant is an open source web design software company.

Staff education/user satisfaction: Opsis has a staff policy regarding turning off lights and computers when not in use. They did a Post- Occupancy Survey and found the majority of their employees were “satisfied” or “very satisfied” with their renovated work environment. Daylighting received the most positive response from users. When asked their levels of satisfaction with the quality of daylighting in the building, 70% of employees responded “very satisfied” and 30% “satisfied.” Eighty percent of employees surveyed “strongly agreed” that working in a building that uses less energy and fewer resources was important to them, and the balance (20%) “agreed” that it was important.

Innovation and Lessons Learned: The architects at Opsis believe the most innovative aspect of their building is the in-floor hydronic heating and cooling system, as it is not common practice to incorporate both. The energy efficiency of the system has matched their high expectations and the user comfort has exceeded them. Although the straightforward daylighting strategy is not high-tech, they consider this aspect of the project very successful and most enjoyable.

Acknowledgements and Sources

Project Team:

- Owner and Architect: Opsis Architecture LLP
- General Contractor: Gray Purcell
- Mechanical Engineer: Interface Engineering, Inc
- Electrical Engineer: Greenway Electric
- Sustainability Consultant: Brightworks

Sources:

- Opsis: James Meyer, owner and principal
- Opsis: Randall Heeb and Chris Brown, architects
- Lovejoy Opsis Building case study
- Integrated Design in Contemporary Architecture by Kiel Moe

Photos: Courtesy of Opsis Architecture/Gene Faulkner

Research and Development:

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

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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

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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.