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Deep Energy Savings in Existing Buildings

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ABSTRACT

This report describes nine existing buildings that underwent deep efficiency projects, including building characteristics, efficiency measures, motivations, money, measured energy performance, market and tenant outcomes, and barriers and innovations. These buildings are all low energy compared to other buildings of their kind; seven of the nine save 50% more energy than the national average, according to the Commercial Buildings Energy Consumption Survey (CBECS) and have an average energy use intensity (EUI) of just 39 kBtu/ft²/yr (0.44 GJ/m²/yr) (EIA 2003). Project details such as building characteristics, energy efficiency measures, business cases, and retrofit process notes are compared. The projects in this study are all offices, including three designated as historic buildings, with occupied floor space from 8,000–394,000 ft² (700–36,000 m²). Building ownership and occupancy falls evenly into three categories: (1) private investor-leased property, (2) nonprofit, and (3) firms in architecture or construction focused on green business. Eight of the nine projects included energy efficiency as part of a renovation when significant changes to the structure and/or use involved major construction. This optimized the opportunity for deeper savings. For firms involved in design, engineering, or consulting, showing leadership and experience in areas of effective green approaches and emerging technologies is a necessary part of doing business. In economic terms, the nonprofits gained funding based on being exemplary in their missions; the firms gained clients or expanded the scope of client projects based on demonstrating best practices. The investor property owners stated that tenant volume, rates, and terms were improved, and costs reduced, through their efficiency investments. Owners faced barriers and challenges similar to those seen in most construction projects, frequently citing costs and historical constraints. Lessons learned from individual projects and as a result of this overall research effort are shared in an effort to improve future deep energy-efficiency retrofits in existing buildings.

INTRODUCTION

Buildings use 40% of total energy consumed in the United States (EIA 2014). As building energy codes have become stricter, new buildings and major retrofits have become significantly more efficient. However, a cutting-edge efficient building from a few decades ago is probably now a middle-of-the road performer, and in another few decades will be inefficient compared with contemporary building stock. Major renovations account for approximately 2% of the total building stock every year (Nock and Wheelock 2010). The remaining building stock—98% of the total, on average—remains untouched or is only lightly renovated in any given year. The opportunity for energy savings in existing buildings is enormous and growing as buildings age and new technologies are implemented.

Defining Deep Savings

Even the small fraction of the total building stock that undergoes major renovation annually constitutes many buildings across the United States. However, only one-tenth of these renovations include a focus on state-of-the-art energy-efficiency measures (Nock and Wheelock 2010). For purposes of this research, deep energy retrofit projects are considered to be those with energy savings of at least 30% and at least two major energy-efficiency measures.

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Project energy savings can, and to achieve deep energy savings generally must, come from a variety of measure types across all end uses (including lighting, heating, cooling, ventilation, plug loads, water heating, refrigeration, cooking, and auxiliary loads such as pumping). The benefits of deep retrofit project extend far beyond energy to categories such as employee costs, nonenergy operating costs, risk mitigation, revenue increases, and more (Bendewald et al. 2014).

Existing Building Characteristics

Existing buildings are often considered to be the "gas guzzlers" of the built environment. This is often true: buildings constructed with minimal consideration to energy efficiency (as was common after World War II ended and continuing through the 1970s) or employing certain architectural elements such as all-glass exteriors (common in the 1980s) often use significantly more energy than the average (Denniston et al. 2010). However, even older buildings, such as those built before World War II and especially those built before 1920, can often perform better than their newer peers. Many technologies and architectural design features that today are considered cutting-edge hallmarks of green design were common in prewar buildings. For example, daylighting, passive heating and cooling, natural ventilation, operable windows, climate- and site-responsive siting, the arrangement of interior spaces, and window-to-wall ratios balanced to best meet the competing demands of daylighting and thermal insulation are all features that can help make some of these older existing buildings perform as well or better than relatively new energy-efficient construction. Of the approximately 160 net zero energy buildings in North America verified by New Buildings Institute (NBI), approximately one quarter (24%) were major renovations (Higgins and Cortese 2014), which demonstrates that transforming existing buildings to net zero energy buildings is eminently feasible.

Research Methodology: Building Identification and Selection

This paper builds on NBI's work with the Northwest Energy Efficiency Alliance (NEEA) regional Existing Building Renewal initiative to accelerate commercial market adoption of deep, integrated, energy-efficient retrofits. NBI identified 50 existing building projects showing improvement of at least 30% energy savings from two or more efficiency measures in the past ten years. Of those projects, NEEA and NBI identified nine buildings with the best opportunities for a deeper look into the measured energy performance, characteristics, and motivations of existing building efficiency projects (Higgins 2011). These examples are intended to help identify common technologies and practices, and to address barriers to deep retrofits, such as skepticism about performance and market outcomes, lack of knowledge on best practice strategies, and business rationale for pursuing energy efficiency.

This report includes a summary of the findings from the nine final project profiles including search methodology, building characteristics, efficiency measures, business and financial motivations, energy performance, market and tenant impact, and barriers and innovations. These buildings are all low energy compared to others of their kind. Seven of the nine saved 50% more energy than the Commercial Buildings Energy Consumption Survey (CBECS) national average and have an average energy use intensity (EUI) of just 39 kBtu/ft^2/yr (0.44 GJ/m^2/yr) (EIA 2003).

Five of the nine profiles were identified through personal contacts by NBI and Preservation Green Lab (PGL) staff, with the balance coming from follow-up on existing case studies or award documentation. Owner representatives were all willing to share with NBI and PGL staff the stories behind their projects, including energy data and financial information. In many cases, they spent a fair amount of time answering questions and following up with details.

Case Study Development

Case studies such as those presented here allow designers, contractors, policy makers, and others to learn from experiences in individual building projects. That information may be used to build from lessons learned in other projects or may be used to disseminate information about cutting-edge technology or practices. A valuable case study should present examples of exemplary performance in various applications and provide assistance to parties interested in applying the lessons learned in the project examined. NBI has assembled case studies on dozens of commercial buildings, both new and existing; this report focuses on nine of those in greater detail. These case studies followed a research and presentation approach. For a case study to be maximally useful, the following key characteristics should be present:

- Include basic identifying information such as location, building type, project description, building size, vintage, owner type, and basic occupancy information.
- Include key performance indicator information as available. Some common examples of key performance indicators for building performance include EUI, annual energy usage, and quantitative, comparable ratings such as an ENERGY STAR® score.
- Include validated and quantifiable estimates of energy impacts, including either comparisons to other buildings (e.g., the Environmental Protection Agency's (EPA) ENERGY STAR Portfolio Manager comparable buildings) or peer datasets (e.g., CBECS).
- Provide background information on project drivers, owner/tenant motivations, and rationales applied.
- List relevant building ratings, certifications, and awards earned by the building or project.
- Discuss barriers encountered by the project and how those barriers were surmounted.
- Provide detailed measure-level descriptions of the various technologies and design strategies applied. This informa-

tion is especially helpful when measure information is broken down into various end uses.

- Discuss financial aspects of the project. This can include information on overall project costs, incremental measure costs, incentives and other funding accessed, capital expenditure impacts, operating cost impacts, and more.
- Provide feedback from the project team and examine lessons learned from the design and construction process.
- When possible, list people involved in the project and provide contact information (in cases where the person has expressed a willingness to disseminate that information).

A sample case study that includes this information is included as an appendix to this report. The nine case studies are available on the Advanced Buildings (an NBI program) website.

OVERVIEW OF THE CASE STUDY BUILDINGS

The projects in this study are all offices but offer a range of sizes, locations, uses, owner types, and scope. Common to all is that during the past ten years they significantly renewed an existing building to create an improved working environment, prioritizing and accomplishing lower energy use. Table 1 provides an overview of the nine projects.

Building Characteristics

This section provides information on common real estate descriptors (location, type, size) and their ownership types, followed by a section focused on the energy-efficiency measures used in the buildings.

Retrofit Description. Terminology and definitions are a challenging aspect of research and reporting. The terms used by the energy industry are rarely those used by the market, despite the potential benefits of having common names and definitions for building improvements. According to many in the commercial real estate sector, the term *retrofit* is widely applied to any energy-efficiency improvement, regardless of other changes in the building. Also, *renovation* denotes a whole or partial building change involving major interior and often structural improvements. A renovation is often associated with a change in use and will typically trigger code due to the extensive nature of the improvements.

This research differentiates three types of projects that in turn can affect the extent of energy efficiency opportunities. Here the term *equipment upgrades or retrofits* indicates that efficiency improvements were made in the absence of other major construction projects or building changes. *Tenant improvement* helps to identify a change driven by a vacant space or a new tenant and may be coupled with the other terms. *Renovation* indicates much larger changes involving major construction that open more comprehensive efficiency opportunities than might a simple *retrofit*. NBI provided these definitions, summarized below, to the owner representatives to facilitate defining the types of improvements for this research.

Table 1. Overview of Buildings

Building Name	Location	Building Type	Owner Type	Renewal Description	Size, ft^2 (m^2)	Project Completed	Year Built
Vance and Sterling Buildings	Seattle, WA	Large office	Tenant occupied	Renovation	134,000 (12,400)	2007	1929
200 Market Building	Portland, OR	Large office	Tenant occupied	Renovation and retrofits	389,000 (36,100)	2009	1973
Beardmore	Priest River, ID	Medium office and multi-use	Tenant occupied	Historic renovation	29,000 (2700)	2008	1922
Mercy Corps Headquarters	Portland, OR	Medium office	Owner occupied	Renovation and addition	80,000 (7400)	2009	1892
The Christman Building	Lansing, MI	Medium office	Owner occupied	Historic renovation	64,000 (5900)	2008	1928
Alliance Center	Denver, CO	Medium office	Owner and tenant occupied	Historic renovation	38,000 (3500)	2006	1908
Lovejoy Building	Portland, OR	Medium office	Owner and tenant occupied	Renovation	13,000 (1200)	2004	1910
Home on the Range	Billings, MT	Small office	Owner occupied	Renovation	9000 (800)	2006	1941
Johnson Braund Design Group	Seattle, WA	Small office	Owner occupied	Equipment upgrade and retrofit	8000 (700)	Ongoing	1984

- *Equipment upgrades/retrofits:* Projects that involve non-structural improvements to an existing space and primarily target the building's efficiency systems. For this research, this must include two or more system improvements such as the upgrade of lighting, HVAC, controls, and kitchen and laundry equipment.
- *Tenant improvement:* An interior build-out for a new tenant of a commercial space that includes efficiency upgrades or redesign for systems such as lighting, HVAC, controls, and kitchen and laundry equipment.
- *Renovation or addition:* Major construction projects that include replacement of 50% or more of lighting, HVAC, and controls equipment, or projects that increase a building's total floor area and include efficiency upgrades such as lighting, HVAC, controls, and kitchen and laundry equipment.

For a project to be considered, there must have been two or more system changes and 30% minimum savings; the scale of the improvement was addressed through that screening.

Screening for projects for sufficient documentation and deep savings resulted in eight of nine projects labeled as *renovations* (Table 2), or about 90%—the same ratio of renovations from the initial list of 50 buildings identified for consideration in this phase. Retrofitting equipment is constrained only by building structure, wiring, and often tenant occupancy; it serves as an important intermediary step for procuring energy savings and provides cost savings and, usually, improved work spaces. Many of the projects have ongoing retrofit activities to ensure new technologies or practices can be rolled into their buildings to further drive down energy use.

A targeted search for equipment-only improvements would be valuable to inform the existing building market potential, since the majority of commercial buildings are in a fixed state and upgrades can yield high savings on a measured basis. For example, retrofitting the lighting in a building or space with high-performance lamps and ballasts, including daylight dimming and controls, could drop lighting energy use by 50% or more. However, this research focused on *deep savings*, defined as 30% or greater whole-building or whole-space improvements using an integration of two or more measures.

Table 2. Improvement Types

Improvement Type	Size, ft^2 (m^2)
Equipment upgrade/retrofit	8000 (700)
Renovation/historic	29,000 (2700)
Renovation/historic	38,000 (3500)
Renovation/historic	64,000 (5900)
Renovation	134,000 (12,400)
Renovation	13,000 (1200)
Renovation	9000 (800)
Renovation and ongoing retrofits	389,000 (36,000)
Renovation and addition	80,000 (7,400)

Renovations represent a repositioning or renewal of buildings in a slumping new-construction market. Renovating existing buildings can be a better investment than building new, as was found by some of the project owners and described in the "Business" section of this report. Energy efficiency was not the primary driver of renovations, but once the door was opened to major construction changes, owners considered energy efficiency an integral part of improving and updating their buildings.

Locations. The projects described in this report are located in six cities: Portland, Oregon (three projects); Seattle, Washington (two projects); Priest River, Idaho (one project); Billings, Montana (one project); Denver, Colorado (one project); and Lansing, Michigan (one project). This building set includes U.S. Department of Energy Climate Zones 3–5, which shows that deep energy retrofits can be completed in non-Mediterranean climates. Figure 1 shows building locations and corresponding climate zones.

Building Type and Size. All nine of the buildings are offices. Two buildings have some mixed use, with an unused theater, a spa area, and retail as small parts of the floor space. For the purpose of consistency with the energy review, the represented floor space areas are occupied office areas only. The buildings comprise a good mix of sizes, ranging from 8000 ft^2 (740 m^2) to almost 390,000 ft^2 (36,000 m^2) (Figure 2). The building set includes three small (< 20,000 ft^2 [< 1860 m^2]), four medium (20,001–100,000 ft^2 [1860 m^2–9300 m^2]), and two large office buildings (> 100,000 ft^2 [> 9300 m^2]).

Ownership. The initial search and this deeper-dive research both made clear that the majority of the buildings are owned by mission-driven organizations, firms, or individuals. Six of the nine buildings are owned by nonprofits or firms in the business of demonstrating and recommending green design practices; their buildings serve as extensions of their core missions. For the nonprofits, the buildings function as part of a larger environmental objective. The green firms' buildings serve as demonstration sites and labs on technologies and design that help to convey their green messages to clients.

Both nonprofits and green firms have strong self-interest in promoting the results of their building improvements. As a result, they comprise a high percentage of buildings with documented low-energy use. Due to their longer-than-average ownership and broader mandates, nonprofits and mission-driven organizations are able to take longer-term financial views and consider broader criteria when assessing upgrade options. These types of owners are typically the

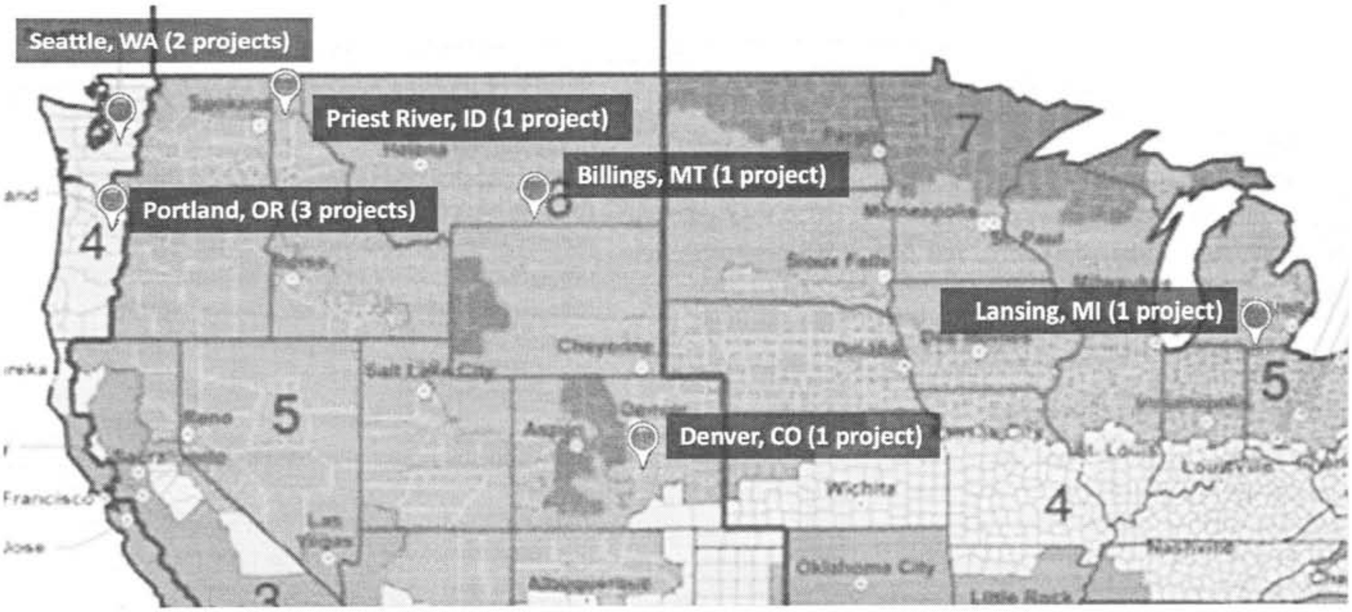

Figure 1 This figure shows building locations and climate zones of buildings examined.

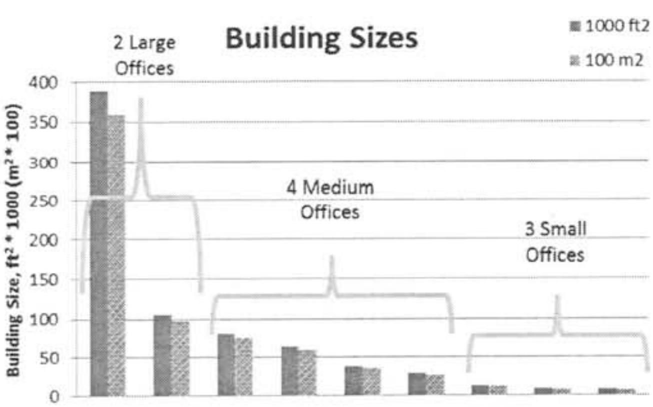

Figure 2 This figure shows the size of buildings examined.

first out of the gate to adopt new technologies and help prove concepts.

At this stage in moving toward deeper energy efficiency, the private real estate sector is an increasingly active player. One-third of these projects are owned by investors, as shown in Table 3. Of these three buildings, one is owned by an individual investor with a direct interest in the history of the building and two are owned by large private investor funds—both of which are strongly engaged in being leaders in high-performance buildings to the benefit of their business objectives.

Table 3. Owner Categories

Owner Type	Number of Projects
Owner occupied: private green firm	3
Owner occupied: nonprofit	2
Owner occupied: nonprofit and 50% tenants	1
Private investor: tenant occupied	3

Ratings and Awards

All nine buildings participated in a range of U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) Green Building Rating System programs covering four certifications: new construction (NC); existing buildings, operations, and management (EBOM); core and shell; and commercial interiors. Existing buildings often cross into several LEED categories, depending on the extent of the retrofits or renovations. USGBC is encouraging ongoing certification in EBOM to reflect continuous improvement and energy tracking. Together, the buildings achieved a total of 13 LEED certifications—all but one at the gold or platinum level. One building is rated triple-platinum, achieving the highest rating in three certification areas.

Although LEED certification was not a criterion for inclusion in this research (many of the initial set of 50 were not LEED certified), each project in this subset pursued and obtained a LEED rating. Some possible reasons for this are as follows:

- LEED provided a set of target criteria on a variety of environmental areas.
- In most cases, the building renewals were a one-time occurrence for the owner. With LEED providing a pre-

made framework, there was no incentive to explore or establish independent criteria.

- The owners perceived a strong value to the third-party certification and market recognition of the label.
- NBI's search more easily found projects that accomplish LEED or other green/energy ratings due to their higher public and industry news profiles.
- Building owners, operators, and design professionals more readily respond to requests for information because they have LEED submittal reports and are interested in the exposure for their work.

Energy-Efficiency Measures

The efficiency measures incorporated in these projects are more comprehensive than could be undertaken by a typical existing building absent a renovation, thus the larger energy savings results associated with these projects. High-efficiency lighting (lamps and ballasts) were a part of each project's upgrade; seven out of nine incorporated daylight dimming controls within the lighting system for their buildings. Table 4 shows the most frequent measures applied, with lighting-related measures as three of the top five: high-efficiency lighting, daylighting, and lighting controls. High-efficiency HVAC equipment was included in more than half of the buildings, as was commissioning. Measures performed in three or fewer projects are not shown in Table 4.

An overview of some of the key measure in this high performance data set follows:

Lighting:

- 100% of the buildings have high-efficiency lighting.

Table 4. Most Common Measure Types and Frequencies

Owner Type	Number of Projects
High efficiency lighting	9
Daylighting	7
Commissioning	6
High efficiency HVAC	6
Lighting controls	6
Energy or building management system	5
Metering	5
High performance glazing or tinted glass	5
Cool roof	5
Improved insulation	4
Ventilation	4
CO_2 sensors	4

- Lighting controls (occupancy sensors/timers) were included in six of the buildings.
- Integrated daylighting controls (automated dimming of electric lighting) were applied in whole or in part in six of the buildings.
- Architectural features to enhance daylight availability for improved indoor environment and/or to increase the potential for electric lighting reduction or to control daylighting for glare or heat reduction included exterior shades, motorized clerestory, automated interior shades, specialty glass, and skylights with automated dampers.

HVAC:

- 66% of the buildings upgraded to high-efficiency HVAC systems.
- Two buildings used radiant heating systems, an emerging trend for HVAC, selected (per owners) for energy efficiency and improved tenant comfort.
- Direct evaporative cooling was used in one building.
- HVAC controlled through an energy (or building) management system in five of the buildings.
- Heat recovery or energy recovery was installed in three of the buildings.

Envelope and General Building:

- Existing windows were restored for historic preservation on three buildings.
- Renovations allowed for improved envelope insulation in most projects.
- Operable windows were included as a ventilation and tenant comfort factor on at least two projects.
- CO_2 sensors provided some savings on ventilation in response to occupancy of spaces in four of the buildings.
- Six of the buildings have or are designed for solar electric photovoltaics.

Whole-Building Controls, Monitoring and Commissioning:

- Tenant-level submetering was used by two of the investor properties.
- Whole-building metering and monitoring via an energy (or building) management system is in place on five of the buildings.
- Commissioning was identified as a measure by six of the buildings.

Most buildings employed measures in more than two end-use categories. Figure 3 shows the counts of measures by end-use category.

THE BUSINESS RATIONALE

While creating low-energy buildings is not the primary business of most of these firms, the business rationale and financial

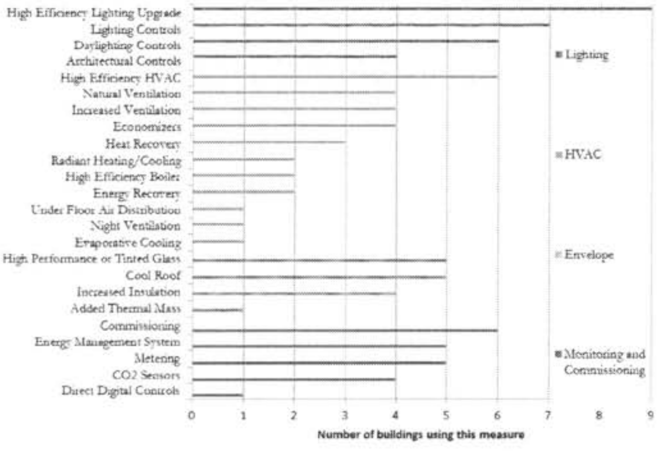

Figure 3 *Measure counts by end-use category.*

information these projects provide may inform and motivate others. This section addresses the motivations (as provided by the owners) and money aspects related to the existing building improvements and energy-efficiency choices.

Motivations

This set of projects largely represents owners with motivations partly driven by missions to "green" the built environment or to showcase their green businesses as a step toward carbon reduction or other environmental values. However, this statement alone is shortsighted and incomplete. The past ten years have seen a market trend that blurs the lines between altruistic and societal benefits and purely economic motivations. The "green" of money and "green" environmental and social motivations are primary and inseparable factors for the rationales for both low-energy buildings and the outcome to the owner.

In economic terms, the nonprofits gain funding based on being exemplary in their missions; the architecture firms gain clients or expand the scope of client projects based on demonstrating best practices; the investor property owners stated that tenant volume, rates, and terms are improved, and costs reduced, through their efficiency investments. Positive public exposure, strong building ratings and labels, and increased consumer awareness and interest in better buildings are other economic drivers in the decisions of investor-owned property managers.

For example, Beardmore, Lovejoy, Christman, and Johnson Braund Design Group (JBDG) are all architectural design and construction firms that wanted to incorporate energy efficiency into their own buildings to influence clients. Home on the Range, Mercy Corps, and Alliance wanted to be able to "walk their talk" as advocates for conservation, humanitarianism, and sustainability. Vance, 200 Market, and Beardmore have all found improved tenant draws and enhanced public profiles from the energy/green features of their buildings.

The following section provides some owner perspectives gained through interviews and some direct quotations from the projects.

Green Leadership. For firms involved in building design, landscaping, engineering, or consulting, showing leadership and experience in green approaches and emerging technologies is becoming a necessary part of doing business. These firms chose to use their buildings to demonstrate the technologies and practices they promote with clients; as they become models for green building, their abilities to influence other buildings and owners improves. Summaries of their energy-efficiency renewal measures follow.

[Beardmore] The owners restored the building using the sustainable and energy-efficient design principles that the owner incorporates into his own architectural practice. It also played an important part in revitalizing the Priest River, Idaho community and economy by restoring the building to its former grandeur.

[Lovejoy] The owners designed their space as a living laboratory to showcase and experience the various energy-efficiency and sustainable design features the building incorporates into their work.

[Christman] Christman's quest is to provide the best possible tools and expertise to customers in achieving its own green building and operations goals. As Gavin Gardi, Christman's sustainability manager, said, "What better way to learn how to do that than by taking ourselves through the process and experiencing it first-hand from an owner's perspective?"

[Alliance] Striving to meet its mission of achieving sustainability through collaboration, the Alliance converted a warehouse to a multitenant nonprofit center that would provide multiple organizations a "healthy, efficient, quality, mission-enhancing workspace." Pursuing energy efficiency supports its mission of sustainability and increases its access to a new tenant base of green-minded organizations and companies.

Money and Market. No owners or organizations approached the energy-efficiency upgrades with unlimited funds—all had to consider the options, costs, and trade-offs with other capital demands. Below are some of the motivations of these owners associated with money and the market for their buildings or services.

[Mercy Corps] Mercy Corps needed to be fiscally responsible with donor contributions throughout the construction process. After paying more than $34,324 in monthly rent at its previous location, Mercy Corps determined that owning a building was more cost-effective than renting. Lowering its operating costs through energy efficiency allows Mercy Corps to spend more money on humanitarian projects throughout the world. The organization was particularly interested in natural ventilation, so operable windows and motorized clerestory windows were included in the design.

[JBDG] JBDG established goals to reduce electrical and water grid consumption by 50%, receive a reasonable finan-

cial payback on all improvements, and improve occupant comfort.

[Vance] The owner, the Rose Smart Growth Investment Fund, was motivated to keep costs down by simplifying the energy system approach and to increase tenant draw by renewing the building's most attractive historical features. Peter Alspach, of Arup, the project engineer, stated the company wanted to "take the building back to its roots—architecturally by strategies such as exposing the terrazzo floor and the same principle for building systems, such as restoring natural ventilation. Pull back to the original systems, and then analyze how we could incrementally apply modern technologies to get best performance. Simplification was the general philosophy." The architect approached interior renovations with a focus on simplicity, which extended to the firm's creation of tenant improvement guidelines.

[200 Market] Keeping the occupancy rate high is a primary driver for improving energy efficiency and increasing this building's green profile. Working closely with the building management team, the owner has implemented a program of continuous improvement that not only serves to benefit the current tenants, but also attracts tenants that place a high value on environmental responsibility and a healthy work environment.

This motivation was reflected in 2006 when 200 Market became the first multitenant building in the nation to obtain its LEED for Existing Buildings 2.0 Gold certification. The owner, Russell Development, will only consider projects with payback periods of seven years or less; all improvements to date are well below that threshold. Russell's goal is to incorporate low energy use as a core part of a building's business management.

[Home on the Range] This organization consistently looked at costs and eliminated inefficiencies, but it incorporated most energy-efficiency measures into the project. The highest-priority measures of daylighting and radiant floors improved tenant comfort.

[Beardmore] A cost/benefit analysis determined the economic impact of green building practices in terms of design, documentation, material salvage, and construction.

[Christman] Using an integrated approach, Christman was able to incorporate energy efficiency into the project and proved it could be accomplished within a tight budget.

In all nine cases, the business views of the individuals or teams responsible for determining the building's energy efficiency aspects shared five key elements:

1. "Green link" recognition: Teams considered and valued the economic and environmental benefits (the "two greens") that make energy efficiency a wise investment.
2. Vision: Teams are goal-driven, pursue targets via LEED, have leadership mentalities, and have willingness and desire to be ahead of the curve in many aspects of their businesses.
3. Financial leveraging: Teams maximize government, utility, and organizational incentives and tax credits.
4. Measurement: Teams track energy results and conduct ongoing commissioning to maintain and improve performance.
5. Market profile: Building owners and managers publicize their energy-efficiency renewal results and pursue related public relations opportunities as a strategy to increase their buildings' values.

Money. The financial information gathered from owners, design teams, and property managers varied widely. Building owners currently have no reason to isolate costs of specific efficiency measures within larger projects. In addition, the effort would be time consuming and most likely futile due to the near-impossibility of separating labor time associated with, for example, wiring an office from that of wiring an extra connection to a specific control feature that improves efficiency; contractors bill for the full project. Even direct costs associated with efficiency features are rolled into broader invoices from distributors.

Only specific retrofits of efficiency measures can yield accurate cost information. Even then, the relevance is highly dependent on the physical constraints faced by the contractor, other building attributes, and the pricing and competitiveness of the locale.

This research experience highlights the fact that finding credible and transferable financial information on single projects is rare. Yet the level of openness with the data these owners did make available is also rare and worth presenting below.

Funding and Costs. Information on costs and financial details is aggregated below.

- The whole-project costs for eight of the full-building renovations ranged from \$100–\$176/ft^2 (\$1076–1894/m^2), with one building with an addition and the most extensive building de-and reconstruction running \$445/ft^2 (\$4790/m^2).
- Energy-efficiency measures were carefully documented by one nonprofit as \$3/ft^2 (\$32/m^2).
- The tenant improvement costs, including the efficiency measures, at the large Seattle office building were stated as \$26/ft^2 (\$280/m^2).
- The costs from the one project that consisted primarily of energy-efficiency upgrades with some smaller interior improvements was \$31/ft^2 (\$334/m^2).
- Specific efficiency-measure costs disclosed by 200 Market to benefit others pursuing improved energy performance include the following:
  - \$25,000,000 (1989) for boiler upgrade, variable-speed drives added to all pumps and fans, asbestos removal, reconfiguring of the ground floor, and upgrading of the life-safety systems.
  - \$11,000 (2000) for pressurized water tank/pressure sensor replacement of water pumps.

- $6,000,000 (2004) for elevator upgrade, including conversion to alternating current drives and new controls.
- $180,000 (2008) for garage lighting upgrade.

- Renovating yielded better economics for two of the buildings than did building or renting. For the Home on the Range building, the owners' cost analysis determined that demolishing the existing structure and building a new office building the same size to the model energy code would have cost approximately $325,000 more than the cost of renovating to LEED Platinum status (Figure 4).
- The methods used to access capital were also diverse, but only one project identified them as a barrier. In that instance the owner had to expend private funds due to a bank loan limit resulting from the national lending crisis. Here are the overview points:
    - No owners mentioned access to low-interest funds.
    - Conventional construction loans, private investor funds, public/private partnerships, and sponsor donations constituted the sources of money for these projects.
    - Owners took advantage of incentives and tax credits—historic, federal, state, and utility. All area-normalized costs shown above are after these incentives.

[Lovejoy] The owners decided against registering the building as an historic landmark, thus giving up the associated tax credits, in order to retain the flexibility to enlarge the exterior windows and add sunshades. The architect also chose to not move beyond LEED-NC Gold because of cost. According to one of the owners, James Meyers: "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."

Savings Estimates. Some owners were able to provide information from the original plans or from ongoing monitoring regarding the impact of efficiency on operating costs. The savings cited for the deeper energy renovations were near or beyond a 50% cost reduction in energy expenses, while the equipment retrofit project estimated 25% savings from the efficiency measures.

[Home on the Range] The owners realized an up-front cost savings of almost 20% in creating a building with operating costs estimated to be 23% lower over a ten-year period. The payback period was determined to be negative.

[Beardmore] The LEED modeling analysis estimated an annual cost savings at full occupancy of $23,370 (~$1/ft^2 [$11/m^2]), a reduction of more than 50% compared to the national average.

[Christman] The energy-efficiency upgrades incorporated into the project result in an estimated annual savings of $45,659 ($0.83/ft^2 [$9/m^2]). Implementation costs for the energy efficiency upgrades were $22,693, with a payback period of six months.

[JBDG] Improvements to this building reduced annual operating costs by $3840, or $0.48/ft^2 ($5/m^2). Note: typical energy costs are $1.50–2.00/ft^2 ($16–22/m^2), so this represents a ~25%–30% cost savings; however, this project was less deep than the approach available in the full renovations.

Conventional Approach (Estimates*)			Green Building Approach (Actual)		
Property	$	182,500	$	182,500	Property
Professional Services (10%)	$	127,290	$	122,000	Professional Services
Demolition	$	70,500	$	15,000	Deconstruction (partial)
New Construction	$	1,156,700	$	839,200	Renovation
			$	66,200	Alternative Energy Systems
Site	$	191,200	$	165,700	Site Improvements
			$	12,800	LEED related costs & fees
Total Capital Costs	$	1,728,190	$	1,403,400	Total Capital Costs
First Cost Savings - compared to building new:			$	324,790	
Capital + 10 years of Operational Costs**	$	1,855,683	$	1,429,813	Capital + 10 years of Operational Costs
10 Yr Cost Savings - compared to building new:			$	425,870	

*Estimates from 2006 RS Means Building Construction Cost Data based on 8,300 SF
** Baseline Office Building meeting Model Energy Code Ashrae 90.1-99
Operational Costs assume an annual 3% energy escalation rate

Figure 4 *Financial comparison of new construction versus retrofit (Home on the Range building).*

AGGREGATED ENERGY OUTCOMES

Identifying the performance outcomes of these buildings has been a unique and exciting part of this deep-dive research on a broad, whole-building level. Measured energy performance data is surprisingly hard to obtain, even in the simple form of monthly utility bills, so these projects provide helpful references. Educating the market on the value of benchmarking and tracking performance, together with the trend toward requiring energy performance disclosure and ratings in real estate transactions, will increase owners' abilities to understand and improve the current building stock. Determining performance following a retrofit or renovation is equally as important for market metrics as for energy efficiency. As with energy efficiency, a market benchmark to compare changes in typical industry metrics such as tenant attraction, retention, lease rates, and occupant satisfaction would be valuable in reviewing the project outcomes.

This section presents standard energy benchmarks as a basis for comparing the energy use of these nine buildings, and summarizes the owners' responses regarding the market impact (anticipated or actual) of their buildings.

Energy Performance

All energy performance information on these buildings is based on measured data. Their actual energy use is well below other benchmark references, with EUIs ranging from 32–66 kBtu/ft^2/yr (0.37–0.75 GJ/m^2/yr); five of the buildings have EUIs of 40 kBtu/ft^2/yr (0.46 GJ/m^2/yr) or less.

NBI reviewed a variety of data sources, in some cases multiple types for a single project, for reasonableness and consistency. Sources of energy performance information included the following:

- Portfolio Manager (PM)
- LEED Energy and Atmosphere report
- Utility billing data
- Contractor analysis
- USGBC Building Performance Partnership submittal
- Data and analysis by other researchers
- Review of data with NBI's First View tool

For this research, measured energy use is presented in three ways.

1. EUI—an absolute number of kBtu/ft^2/yr (GJ/m2/yr).
2. A percentage improvement relative to a benchmark (e.g., CBECS, PM EUI)
3. ENERGY STAR score

The CBECS database is the primary benchmark source for commercial building energy use in the U.S. NBI also had owner permission to access existing PM accounts, or was provided those results, for six of the buildings. NBI directly ran the energy data in PM for the remaining three. This provided an additional consistent benchmark EUI per building and also provided the third source of comparison by establishing an ENERGY STAR score for all nine buildings.

Preexisting energy use data is applicable only if the building use, size, occupancy, and hours remain reasonably consistent between pre- and postretrofit. Since these buildings were primarily renovations, this was relevant or available in only two cases. Those cases provide benchmarks of the greatest relevance to the market: the outcome compared to the building before retrofit.

These multiple methods of reviewing and comparing data are, understandably, confusing to all but the most serious of energy geeks. Since many in the efficiency industry embrace that label, this information offers sufficient variables from real field findings to benefit their work in the program area. For others seeking a more general overview of accomplishments, arrows in the following charts indicate the direction of *better*, to provide at-a-glance understanding when the metrics change, for example, from a goal of low energy to achievement of a high score.

Code comparisons are not done due to the variety of time periods and locations applicable to the projects upgrades as well as the amount of end uses not addressed through codes (unregulated areas such as plug loads).

Energy Comparisons. Table 5 shows the buildings' EUI compared to the two benchmarks of CBECS and PM; the ENERGY STAR score is provided as a summary of the building energy metrics. The table also shows activity type, ownership type and size.

Energy performance in the hundreds of case studies, articles, and information sources reviewed for this research is most commonly referenced as *percentage better* and *percentage saved*. Most instances included no *compared to...* references; percentages *better* or *saved* are very popular and easily-understood bases for presenting performance. Figure 5 shows building energy use as percentages better than the CBECS national average for offices, with an average savings of 52% better than CBECS.

The PM program allows a more specific comparison that determines the energy use of a building of like type, size, hours of use, and climate—determined from statistical analysis of the CBECS data set.

Figure 6 shows all buildings in this report that use less energy than the predicted comparable building. The buildings' EUIs (indicated by the squares in Figure 6) range from32–66 kBtu/ft^2/yr (0.37–0.75 GJ/m^2/yr), and, as shown in Figure 6, are 30%–72% lower than the PM benchmark, with an average savings of 46% better than the PM-calculated EUI.

Table 5. Building Energy Benchmark Comparisons

Activity Type	Owner Type	Size, ft^2 (m^2)	Building-Measured EUI	% Better than CBECS EUI	% Better than PM EUI	ENERGY STAR Score
Multi-use	Tenant occupied	29,000 (2700)	32	66%	47%	90
Medium office	Owner occupied	80,000 (7400)	36	61%	50%	93
Small office	Owner occupied	8000 (700)	36	61%	35%	94
Large office	Tenant occupied	134,000 (12,400)	39	58%	64%	98
Medium office	Owner and tenant occupied	13,000 (1200)	40	57%	38%	92
Medium office	Owner occupied	38,000 (3500)	42	55%	39%	85
Small office	Owner occupied	9000 (800)	46	51%	72%	99
Large office	Tenant occupied	389,000 (36,100)	65	30%	30%	98
Medium office	Owner occupied	64,000 (5900)	66	29%	35%	81

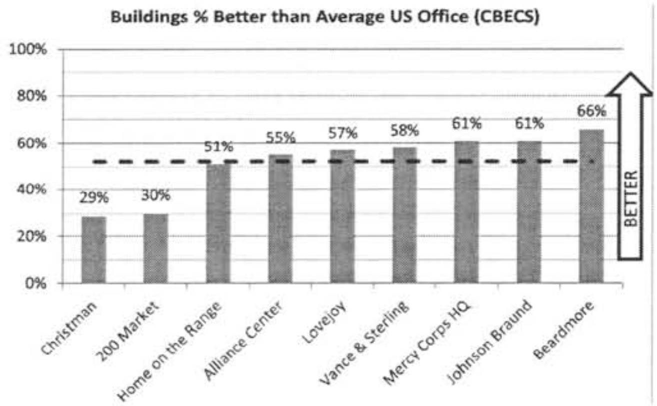

Figure 5 *Buildings percent better than CBECS.*

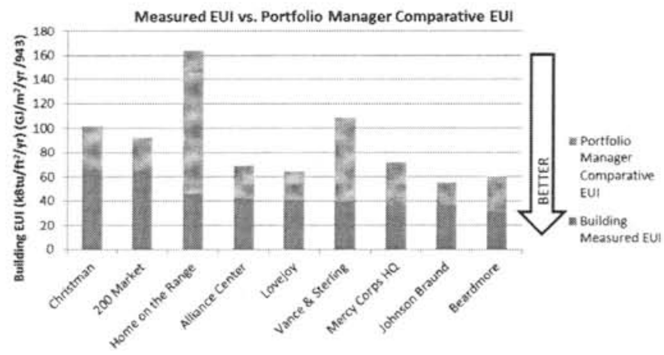

Figure 6 *Building EUI comparison to Portfolio Manager EUI.*

The metrics discussed above are represented in Figure 7 as an example of comparing a building's actual performance on the left side of the scale to other benchmarks on the right side of the scale. This scale helps direct energy use levels toward a "lower is better" vernacular based on ultimately striving for net zero energy buildings.

The ENERGY STAR label is a widely recognized performance rating available to any building through use of the PM tool. Scores range from 0–100, but the ENERGY STAR label is for buildings in the top 25th percentile of their class compared to others in the United States (a score of 75 or higher). The ENERGY STAR scores of these buildings are shown in Figure 8 as another metric to indicate the strong energy performance outcome achieved: all buildings scored above 80, and the majority scored 90 or above, placing them in the top 10% of office building energy performance in the U.S.

In addition to indicating building performance, ENERGY STAR scores are also the basis for the majority of energy disclosure requirements currently adopted by U.S. cities and states. Washington and Seattle already have these requirements, and Oregon is in the process of adoption. ENERGY STAR scores will be a new, visible metric required during real estate transactions and, in some cases, tenant lease negotiations. The high scores of the buildings in this set give these owners another positive feature recognized by the market.

A new partnership between the U.S. Department of Energy and The Appraisal Foundation will further influence labels as a means to higher value and is intended to encourage upfront investment in energy-efficiency upgrades. The partnership will work to ensure that appraisers nationwide have the information, practical guidelines, and professional resources they need to evaluate energy performance when conducting commercial building appraisals. This will enable investors, building owners and operators, and others to accurately assess the value of energy efficiency as part of the building's overall appraisal.

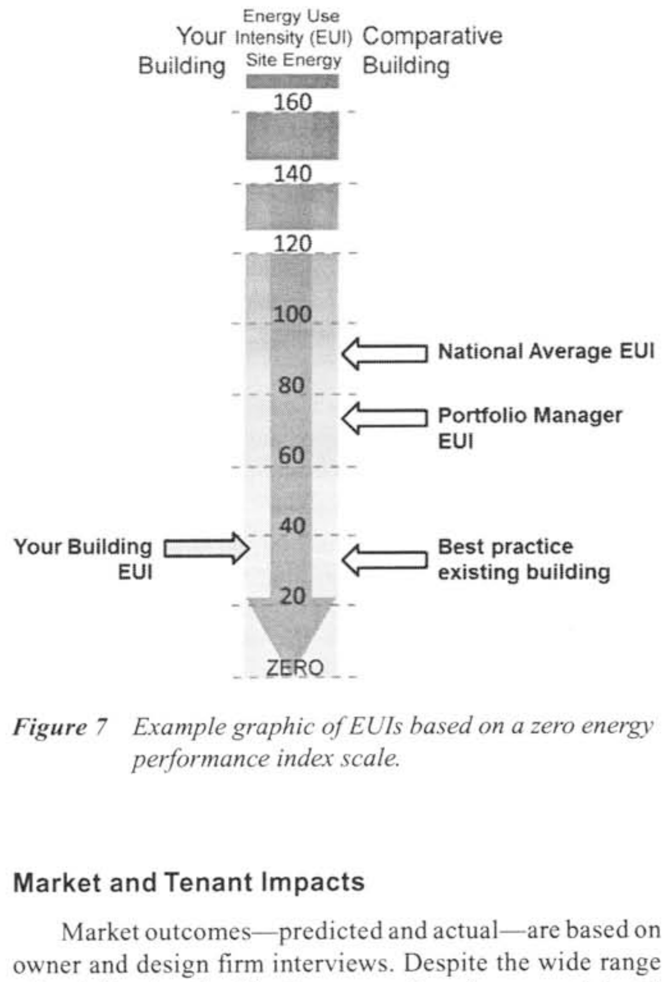

Figure 7 *Example graphic of EUIs based on a zero energy performance index scale.*

Market and Tenant Impacts

Market outcomes—predicted and actual—are based on owner and design firm interviews. Despite the wide range of variables involved in the economics of commercial real estate, all of these owners believe their buildings have positive impacts on business opportunities.

Market results. *[Beardmore]* Brian Runberg, owner, believes the building has "sparked new economic life into the community, giving it a renewed sense of pride and entrepreneurial spirit. Tenants saw the potential of what could happen in the building and came with business ideas." Due to the Beardmore's energy efficiencies and overall historic

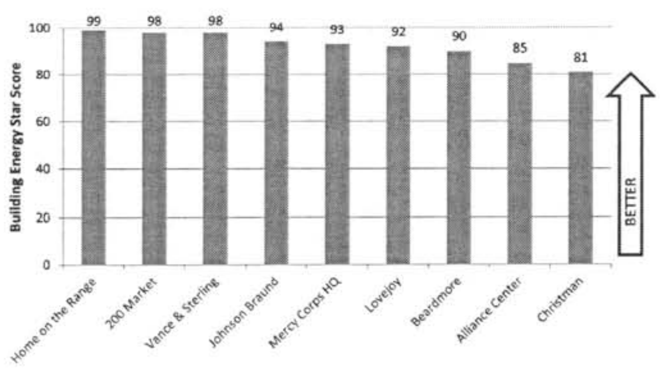

Figure 8 *Building ENERGY STAR scores.*

qualities, according to Runberg, rents average about 35% higher than other local properties.

[Vance] The owner believes the proof of concept is self-evident: Since completion of the renovation, the owner has increased occupancy from 68% to 96% and has seen increased rents, tenant retention, and net operating income, thus enhancing long-term value.

[Lovejoy] Because the building is LEED-Gold, the owner feels it is able to attract tenants committed to sustainability. This does not necessarily mean it has been able to charge more rent, but it has had no problem finding tenants, and the space has been continually occupied.

[Christman] Sustainability manager Gavin Gardi believes the building differentiates its company from others: "Tenants enjoy working here; the air feels fresh and is good for people with allergies; operating costs are low. People rave about the building."

[200 Market] "In my observation, tenants are willing to pay a premium for a building that is demonstrably better"—John Russell, owner representative. Much of this success has been credited to the owner's efficiency and sustainability investments. It has maintained a high level of occupancy (16 office tenants and 11 retail tenants) despite the economic downturn.

[Alliance] When asked to describe the direct benefits of association with the Alliance Center, owner responses included: "Added organization legitimacy and credibility, recognition to organization name, a sense of unification and prestige, added recognition for dedication to the environment, built-in fundraising and networking opportunities, an enhanced organization profile as a sustainability leader."

Involving the Tenant. Guidelines for tenants establish building-wide standards for new tenant improvements that align with the owner's energy and green targets. They can also require tenant-level metering or operational procedures that help reduce energy use. Occupant satisfaction surveys, while still rare, are gaining ground as a means of validating satisfaction with the indoor work environment and identifying areas of improvement that will help retain tenants.

[Vance] The owner and engineer worked with the architect to create guidelines for tenant retrofits to guide design decisions for daylighting, ventilation, and finishes. Tenant strategies include light shelves, automated window shading systems, and high-level transom vents where interior, enclosed offices are required.

[Lovejoy] A postoccupancy survey found the majority of employees in the building were "satisfied" or "very satisfied" with their renovated work environments. Daylighting received the greatest positive response from users.

[Vance] A 2010 occupant survey report showed that 77% of building occupants were satisfied with lighting levels, and 85% of occupants indicated general satisfaction with the overall building and individual work spaces.

[200 Market] A quarterly electronic newsletter is published by the building's management team to update tenants on ongoing green efforts and to provide tips on energy conservation measures.

DEEP RETROFIT BARRIERS AND INNOVATIONS

Barriers and Resolutions

These nine owners faced barriers and challenges similar to most construction projects, with costs and maintaining historical attributes most often cited. As historic renovations, Beardmore, Christman, and Mercy Corps offered additional challenges to aligning efficiency measures with historic preservation requirements, but some costs were offset with tax credits. An additional project chose not to pursue historic register status because its owners wanted flexibility to increase window heights.

[Vance] The design team began with an intention to apply higher-end retrofit measures, but the proposed design exceeded the project budget. The team had to rethink options and started focusing efforts on simplified approaches.

[Alliance] Some of the energy and atmosphere credits for which the Alliance Center qualified constituted "significant cost actions," but the Alliance was able to find funds and maintain its high level of commitment to promoting sustainable design approaches.

[Alliance] Because preserving the historic integrity of the building was a priority, only the more contemporary lobby windows received any kind of design treatment; the focus was shifted to improving the mechanical and electrical systems within the building.

[Home on the Range] The challenge was to get the architect, engineers, and contractors on board and transform them into "believers" in a low-energy building (they succeeded).

[Beardmore] Ground-floor retail glass transom windows provided almost no insulating properties; initial redesign concepts were rejected by the state historic preservation office. The approved solution allowed installation of a separate insulated glazing unit to the interior of the windows,

retaining the exterior character. The historic nature of the building did not allow for addition of a vestibule at the front doors, so ground-floor heat loss in the winter months is an issue.

[Lovejoy] The owners were willing to pay more for lighting controls, operable windows, and night flush than they would have for other standard efficiency improvements.

[Christman] The owners wanted to use a daylighting approach with controls and dimmable ballasts, but found the cost at the time was too high (estimated to add one-third to the price of the light fixtures). Note: dimmable ballast cost is dropping significantly.

[Vance] The building was occupied during renovation, presenting the challenge of implementing strategies while working around existing tenants, balancing the costs and benefits of green investments.

Innovations

Owners identified unique and innovative aspects of their processes and/or projects. All the items cited are readily available today and fit within project budgets, as well as contributing to their successful outcomes. Innovation is not defined here as on the fringe of practice, but rather reaching for ideas that pull the project to the top of its potential.

[Home on the Range] The owner representative 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."

[Lovejoy] The architects believe the most innovative aspect of their building is the in-floor hydronic heating and cooling, as it is not common practice to incorporate both. Although they agree that the daylighting strategy was not entirely high tech, they consider it a very successful and most enjoyable aspect of the project.

[Vance] The architect approached interior renovations with a focus on simplicity that extended to the firm's creation of tenant improvement guidelines. The owner's retrofit strategies go beyond building envelope and systems to include operations and maintenance. The project team continues to examine and fine-tune building performance through energy monitoring, post-occupancy surveys, and a re-greening effort.

[Alliance] This building provides tenant space for 38 sustainably-focused nonprofits, fosters communication and collaboration, and serves as a demonstration project of advanced design strategies in a rehabilitated historic building. In 2006, the Alliance Center was the recipient of a $25,000 grant from the Colorado Governor's Office of Energy Management and Conservation for installing informational and educational signs throughout the building and developing a self-guided tour and brochure. In an interview, Alliance Center director Phillip Saieg cited the direct digital controls installation as especially innovative. This system has allowed the building operators to continue to fine-tune the heating and cooling requirements in this historic structure.

[Christman] The owner representative describes the most innovative aspect of the project as "taking a historic building and transforming it into a high-quality, high-performance building at no additional cost within a tight budget."

[Mercy Corps] The owner representative believes the most innovative aspects of the building are the building management system and the method by which the clerestory windows exhaust air naturally.

[200 Market] 200 Market uses a gross lease structure in which savings in operational expenses, such as electrical and water usage, go directly to net operating income. This approach encourages owners to incorporate efficiency measures into existing buildings, ultimately improving the bottom line. The firm also believes improvements do not have to be massive capital-investment-type projects; success can be found through targeting small issues and implementing appropriate solutions. The owner representative and chief engineer found particularly innovative the use of existing smoke evacuation shafts to increase the building's ventilation rate, especially when it exceeded their initial expectations by improving occupant comfort and reducing fan energy.

CONCLUSIONS

Buildings

- Office buildings offered the most accessible information; this is likely due to their higher frequency of participation in green or utility efficiency programs and the more active nature of this sector in upgrades and building changes.
- Targeting projects looking to upgrade or renovate their buildings or spaces is a key market opportunity for deeper, more comprehensive efficiency opportunities in existing buildings.
- Deep efficiency retrofits are not limited to a specific size of building, but larger buildings are more likely investor-owned versus the small and medium buildings traditionally owned and occupied by nonprofits or private firms.
- Deeper energy efficiency projects were found in various states and in large and small cities. Although the numbers are low and information is difficult to find, the presence of these projects indicates some knowledge and skills are distributed throughout the region.

Measures

- Readily available technologies can be applied to accomplish deep energy savings.
- Integrated design, multiple measures, and monitoring are more critical to low-energy buildings than any given technology.
- Consistent inclusion of controls (lighting, HVAC, CO_2, and whole-building) is an important element of the move to greater savings.

- Other progressive measures such as radiant heating and cooling, evaporative cooling, motorized shading, and operable windows extend the potential for maximum savings and improve work conditions.
- Behavioral measures are increasingly recognized as valuable in creating energy-efficient green buildings with tenant-level metering and/or tenant guidelines in use by three projects.
- Building owners consistently mentioned commissioning, measurement and tracking, and ongoing improvement as keys to low energy usage.

Energy

- Energy and cost savings of 50% are clearly achievable and fit within the business parameters and motivations of these owners. Average savings among these buildings are 52% better than CBECS and 46% better than the PM-calculated EUI for a similar building. The average ENERGY STAR score of 92 puts them in the top 10% of office building energy performance in the U.S.
- Existing buildings can achieve zero-energy-capable energy use, currently considered 20–35 kBtu/ft^2/yr (0.23–0.40 GJ/m^2/yr). The actual energy usage of these nine ranges from 32–66 kBtu/ft^2/yr (0.37–0.75 GJ/m^2/yr); five of the buildings have EUIs of 40 kBtu/ft^2/yr (0.46 GJ/m^2/yr) or less.
- Owners considered innovative areas as transforming historic buildings: incorporating radiant heating and cooling, applying simplicity as a strategy, using tenant guidelines and gross leases to encourage behavioral change, natural exhaust through clerestories, and continuous monitoring of building management systems.

Business

- A link between the "two greens" drove motivations: (a) greenbacks—recognition and calculations of improved asset value, greater lease rates, and tenant occupancy; future-proofing for trends toward greener buildings and disclosure requirements; and operational cost savings, and (b) green leadership—exemplifying mission work, client interests, or owner values in green building and environmental benefits.
- Ratings, labels, and recognition appear to be valuable motivators for energy-efficient renewals. Projects seeking deeper energy efficiency tend to be involved and interested in third-party ratings and recognitions. The nine projects have earned a total of 13 LEED certifications and several other awards.
- ENERGY STAR scores are becoming a more visible metric required during real estate transactions and, in some cases, tenant lease negotiations. The high scores of the nine buildings in this set give these owners another positive feature recognized by the market.
- Access to capital was cited as a barrier by only one project, but several projects have donation-based funding or substantial internal private funding through investors. If the set had included more medium-size projects seeking conventional capital loans, this barrier may have been greater.
- Renovating provided better economics in two instances than would have building or renting.
- Renovations were completed within standard budget ranges for this level of work. One project documented the efficiency-only portion as just \$3/ft^2 (\$32/m^2).
- Good business results are important to these owners, as seen in the forms of higher rents (average about 35% higher than other local properties), increased occupancy from 68% to 96% post-renovation, better tenant retention and net operating income, ease in finding tenants, and continuous occupancy. These results enhance the long-term values for investment properties.
- Alternative lease structures (gross) and tenant guidelines were important business approaches for the private investors, distributing the responsibility for savings.
- Costs and the historic natures of three of the buildings impeded pursuit of some energy efficiency; creativity and project champions were integral to overcoming these barriers. When it comes to costs, a champion must defend efficiency as an embedded project cost inseparable from the renovation; in one case, the champion had to "transform" the design and construction team into believing in the outcomes. Creative team members for a large building also found more simplified approaches to efficiency at less cost.
- The owners or managers of these buildings share five important characteristics that are keys to their success:
  a. "Green link" recognition—they considered and valued the economic and environmental benefits (the "two greens") that make energy efficiency a wise investment.
  b. Vision—they are goal-driven, pursue targets via LEED, have leadership mentalities, and have the willingness and desire to be ahead of the curve in many aspects of their businesses.
  c. Money leverage—they maximize government, utility, and organizational incentives and tax credits.
  d. Measurement—they track energy results and conduct ongoing commissioning to maintain and improve performance.
  e. Market profile—NBI was able to find these buildings because publicizing their energy-efficiency renewal results, including the use of public-relations opportunities, is a part of the owners' strategies for increasing their buildings' values.

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Four project profiles were identified through case study research originating from the Urban Land Institute, ASHRAE's *High Performance Buildings* magazine, and American Institute of Architects—Seattle and the Committee on the Environment—2008 Top Ten Green Awards. The remaining profiles were identified through individual contacts already listed above.

APPENDIX: DETAILED BUILDING CASE STUDIES

Detailed building case studies discussed in this report may be downloaded at no charge from NBI's Advanced Buildings website.

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