A Search for Deep Energy Savings

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ABSTRACT

Over the next two decades a majority of the existing building stock will undergo a renovation or equipment upgrade. This represents a critical intervention event for capturing significant energy savings from existing buildings. Unfortunately, few building owners understand how much energy their buildings use or what aspects of building performance could be readily improved.

A search for deep savings in existing buildings found 50 projects that underwent a renovation or equipment upgrade since 2000 resulting in actual energy savings of 30%+ compared to national commercial building average EUI (CBECS). Nine buildings were investigated in more detail that, together, average 50%+ savings over CBECS. By focusing on the key takeaways from these successful projects, insight is provided into what is needed to help move the existing buildings market towards deep energy savings. This information is presented by covering the following three topics: 1) a national search for deep energy savings - the broad findings from 50 buildings, 2) a deep dive into deep savings – insights and data on nine projects a) building and efficiency measure characteristics, b) actual energy use and market positioning, and c) barriers and innovations encountered on these projects, and 3) Commonalities and Conclusions – how the research is being used in a large regional effort toward deep savings in existing buildings.

Through the careful examination of the deep retrofit process that these nine projects underwent, the key characteristics of their success are identified. It is these characteristics that demonstrate the true value of deep energy renovations and provide examples of success for market, program and policy makers.

Background

In the United States, there are approximately 5 million commercial buildings totaling a little over 70 billion square feet of building stock. This is significant because, according to McGraw Hill construction, new construction only accounted for approximately 2% of the total floor area in 2008. Although new commercial building stock is added each year built to updated energy codes and standards, the majority of existing commercial buildings (51 billion square feet) were built before 1980 with aging building equipment, systems and assemblies. Many of these inefficient buildings are prime candidates for a deep energy retrofit which could improve occupant satisfaction, provide energy savings for the owner and potentially reposition the building in a competitive real estate market.

A recently released report on the business case for building retrofits cites that 78% of survey respondents were planning on some energy efficiency upgrades in the next two years (McGraw Hill 2011). This represents a high level of commitment by building owners to improve their buildings as well as a significant opportunity to achieve deep energy savings through

focused market outreach, policy development and utility program involvement. Leveraging the expected $53 billion in commercial renovation investment anticipated by 2014 (McGraw Hill 2011) with proven technological packages and design best practices will ensure that these savings are achieved.

The research presented here was conducted to provide empirical data on existing commercial buildings accomplishing deep energy savings and to use this data to improve market confidence and inform program approaches toward low energy buildings. The report begins with a brief introduction to barriers, the NEEA Existing Building Initiative and the search method that led to the research findings. The findings are presented in the Deeper Dive section and begin with the actual energy performance of nine buildings compared to common benchmarks and highlighting variations in ranking when using different metrics. The energy performance section is followed by more detail on the buildings profiled, general project outcomes, barriers and innovations and the primary commonalities of their success.

Introduction

Summary of the Primary Barriers to Deep Renovations

Despite investment opportunities in the commercial retrofit market as well as documented success stories, there are numerous barriers that must be addressed in order to help move a larger percentage of existing building towards deep energy savings. The Preservation Green Lab (PGL 2011) points to "a lack of transparency in the retrofit market regarding measurable outcomes (that) makes it difficult to convince owners of the positive payback and benefits associated with retrofits". This lack of understanding of the retrofit process combined with the lack of available financing for such projects are the two primary barriers identified in a recent white paper (Pike Research 2010). Also acknowledged were "challenges in the project initiation/auditing and benchmarking phase as well as the measurement & verification phase".

A Pathway for Moving the Renovation Market

In 2010 the Northwest Energy Efficiency Alliance (NEEA) began planning a new market transformation initiative, tentatively called Existing Building Renewal, aimed at deep retrofits of commercial office real estate. As part of that planning effort, background research was conducted on barriers to both the demand (owners) side and supply (design and construction) side of the market (NEEA 2010). One of the initiatives that came out to this research included NEEA co-sponsoring a national search for examples of retrofit and renovation projects achieving significant savings (over 30%) undertaken by New Buildings Institute (NBI). Several outcomes from this research directly support the initiative design. These include:

- Understanding how some owners, developers and design teams have overcome the barriers to help lay the groundwork for providing guidance for others to follow, specifically leading to the development of an owner's Roadmap.
- Examples, prepared as case studies, to help inspire, motivate, and reassure others to take action.

- Seeing what levels of savings are possible to set a high but "achievable" target for a program and provide reference data to use for NEEA internal savings and cost-effectiveness analysis.
- Identifying specific technical solutions employed on the sampled projects to create a potential set of solutions for technical guidance or recommended measures.

A National Search for Deep Savings

NBI conducted a broad outreach and research effort which included communications with 47 organizations involved in the design, construction, green building and energy efficiency industries and review of over 500 projects from 29 websites. The focus was on obtaining general project information, descriptions of multiple efficiency measures and documentation of measured energy savings where available. The extensive nature of the search indicates the difficulty in gathering consistent and complete data sufficient to answer even a broad set of questions.

The search resulted in the documentation of 50 commercial retrofit, renovation and upgrade projects with demonstrated or predicted performance of 30% or better than the average for comparable buildings. The aggregate results of these 50 buildings were prepared into a Meta Report (NBI 2011). Working from this initial list NBI and NEEA selected nine buildings with the best opportunities for a deeper look into the measured energy performance, characteristics and motivations of existing building efficiency projects. These Project Profiles will serve NEEA's EBR initiative, in addition to addressing 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. The criteria to select the nine buildings for deeper analysis were:

1. **Willingness to participate** - a responsive contact(s) with sufficient knowledge of the project (this is the most critical factor).
2. **Northwest projects** – or representative building types in equivalent climates.
3. **Low energy use** – access to the measured results of energy performance after retrofit.
4. **Relevant example** – transferable information and lessons to other commercial building owners in the Northwest.
5. **Building type** - medium and large offices topped NEEA's list, followed by box retail, hospitals and lodging. The initial search was predominantly offices with some mixed use.
6. **Technical details** – on measures, design practices, operations and energy data.
7. **Business information** – information and perspective on the project's business rationale and financial factors.

A Deeper Dive: Nine Buildings

The projects selected for this portion of the study are all offices located in Northwest Climate Zones[1] (CZ) but offer a range of sizes, cities, uses, owner types and scope. Common to

[1] Department of Energy Climate Zones 1 - 6

all the projects is that during the past 10 years they significantly "renewed" an existing building to create an improved working environment prioritizing and accomplishing lower energy use.

Energy Performance Outcomes

Discovery of building measured energy performance data, even in the simple form of monthly utility bills is surprisingly hard to obtain, so these projects provide highly valuable and verified references. Increasing data on 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 also important to demonstrate retrofit results and to identify any shortcomings. As with energy efficiency, a market benchmark to compare changes such as tenant attraction, retention, lease rates and occupant satisfaction that relate more directly to the real estate industry 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

Basis of Data and Benchmarks. All energy performance information on these buildings is based on measured data. Their actual energy use, with Energy Use Intensity (EUI) ranging from 32–66 kBtu/sf/yr and over half at 40 or less, is well below other benchmark references. 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:

- EnergyStar Portfolio Manager (PM)
- USGBC LEED Energy and Atmosphere (EA1) Report
- Utility billing data
- Contractor Analysis
- USGBC Building Performance Partnership submittal
- Data and analysis by other researchers
- Review of data with NBI's FirstView tool

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

1. Energy Use Intensity (EUI) – an absolute number of kBtus/sf/yr
2. A percentage improvement relative to a benchmark
    a. Commercial Buildings Energy Consumption Survey (CBECS)[2]
    b. EnergyStar Portfolio Manager EUI
3. EnergyStar score

The benchmark of the greatest relevance to the market, the outcome compared to the building before retrofit. Pre-existing energy use is typically rare for deep energy savings since the nature of multiple measures and more extensive changes occur in renovations versus a simple lighting upgrade. Pre-existing data is only applicable if the building use, size, occupancy and hours remain reasonably consistent between pre- and post-retrofit. Since these buildings were

[2] CBECS is the primary benchmark source for commercial building energy use in the U.S.

primarily renovations, this was relevant or available in only two cases. Code comparisons are not done due to the variety of time periods and locations, the end-uses such as plug loads not addressed through codes, and the lack of consistent modeled results to generate a code baseline.

In Table 1 the nine buildings are labeled by A-I and are in order based on the EUI column from lowest to highest. Their absolute energy performance can be compared to each other and to nationally recognized benchmarks such as CBECS and Portfolio Manager and demonstrates that these projects have significantly better energy over these benchmarks. This documentation and comparison serves to bring recognition to these buildings, their owners and design teams that worked on them.

Table 1. Summary of Energy Performance for Nine Buildings

	Building Overview				Building Energy Metrics			
	Location	Activity Type	Owner Type	Size (sf)	**Building Measured EUI**	% Better Than CBECS EUI	% Better than PM EUI	Energy Star Score
A	Idaho (CZ 6)	Multi-use	Investor	28,000	32	66%	47%	90
B	Portland (CZ 4)	Medium Office	Non Profit	80,000	36	61%	50%	93
C	Seattle (CZ 4)	Small Office	Green Firm	8,000	36	61%	35%	94
D	Seattle (CZ 4)	Large Office	Investor	134,000	39	58%	64%	98
E	Portland (CZ 4)	Medium Office	Green Firm	13,000	40	57%	38%	92
F	Denver (CZ 5)	Medium Office	Non Profit + tenants	38,000	42	55%	39%	85
G	Montana (CZ 6)	Small Office	Non Profit	9,000	46	51%	72%	99
H	Portland (CZ 4)	Large Office	Investor	389,000	65	30%	30%	98
I	Michigan (CZ 5)	Medium Office	Green Firm	64,000	66	29%	35%	91

Energy performance, however, is not merely a representation of the absolute energy use as represented by EUI. Table 2 shows how viewing the performance across the three benchmarks of CBECS, Portfolio Manager developed EUI, and the ENERGYSTAR score can move a building's ranking significantly. Taking into account the location and use trends, as is done with the ENERGYSTAR score, create a much more even playing field for buildings across the country – but there is no possibility to be 'better than 100' despite EUIs than can possibly be

driven further down. Policy directions toward zero-net energy require we start to use zero as the very best 'score' and look at the EUI as an important indicator of the potential to display the balance of energy use with renewables. Rethinking percent savings (Eley 2009) is important since, as shown in Table 1 and 2, since the variations are wide and can be confusing as benchmarks change and the benchmark is not often referenced.

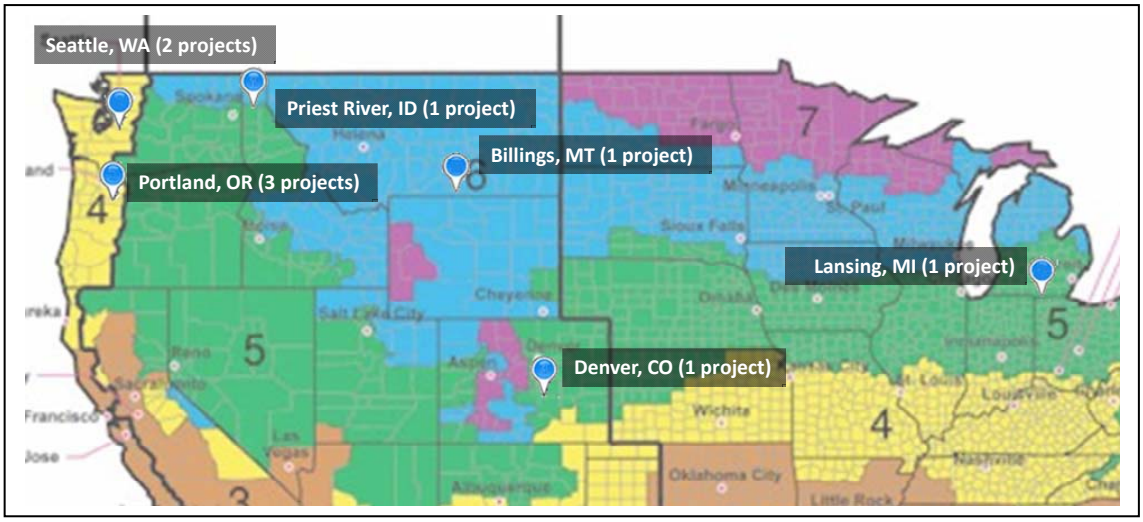
Table 2. Example of Ranking Two of the Nine Buildings

	Building Overview					Building Energy Ranking of 9 bldgs by:			
	Location	Activity Type	Owner Type	Size (sf)[2]	EUI	Building Measured EUI	% Better Than CBECS EUI	% Better than PM EUI	Energy Star Score
H	Portland (CZ 4)	Large Office	Investor	389,000	32	8	8	9	**tied for #1**
A	Idaho (CZ 6)[1]	Multi-use	Investor	28,000	65	**1**	**1**	4	8

The Buildings

Location and Size. The projects described in this report are located in six cities. In order for NEEA to apply this research, seven of the nine are in the three Pacific Northwest states and Montana, all of which are in Department of Energy (DOE) Climate Zones 4, 5 and 6. The projects in Colorado and Michigan are both located in DOE Climate Zone 5 as shown in Figure 1. The building set therefore provides an excellent cross-section of the three Northwest climate zones while exhibiting regional diversity.

Figure 1. Project Location DOE Climate Zones

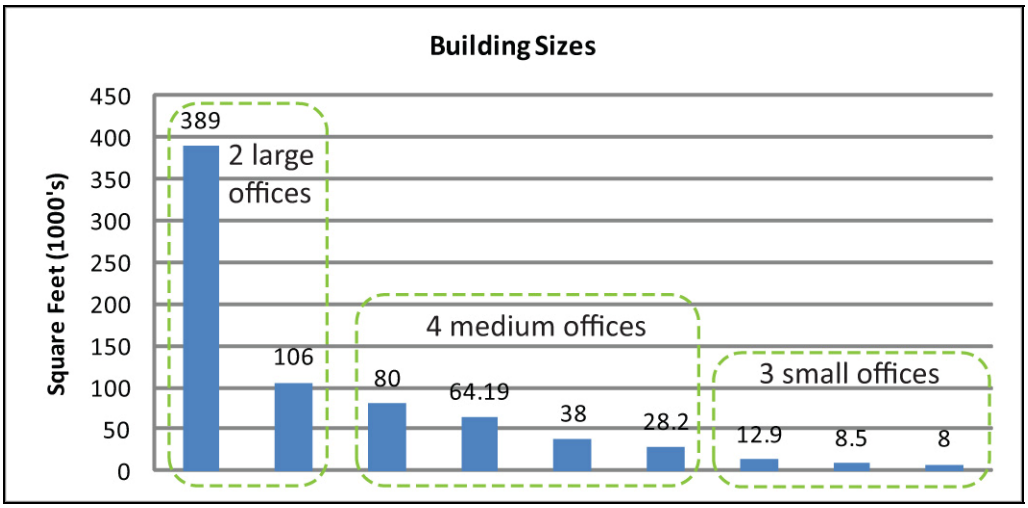


For the purpose of consistency with the energy review, the represented floor space areas are occupied office areas only. The buildings comprise a good mix of square feet (sf) of floor space, ranging from 8,000 sf to almost 390,000 sf (Figure 2). The building set includes three small (< 20,000 square feet), four medium (20,001 – 100,000 sf) and two large office buildings (>100,000 sf).

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 first out of the gate to help prove the concepts.

Figure 2. Type and Size of Buildings



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 the 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.

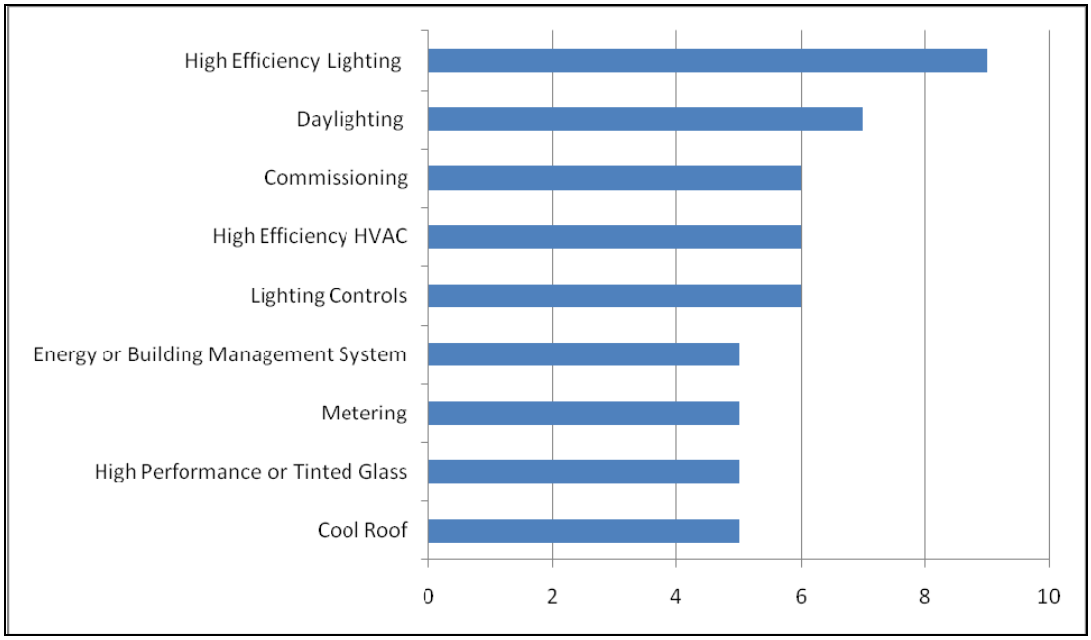
Table 3. Owner Categories

Owner Categories	Count
Owner Occupied: Private Green Firm	3
Owner Occupied: Non profit	2
Owner Occupied: Non-profit + 50% tenants	1
Private Investor: Tenant Occupied	3

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.

Figure 3 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 Heating Ventilation and Air-Conditioning (HVAC) equipment was included in more than half of the buildings, as was commissioning.

Figure 3. Frequency of Measure Application by Projects



An overview of some of the key measures in this high performance building set:

Lighting

- 100% of the buildings have high-efficiency lighting
- Integrated daylighting controls (automated dimming of electric lighting) were applied in whole or in part in 78% of the buildings

- Lighting Controls (occupancy sensors / timers) were included in 66% of the buildings

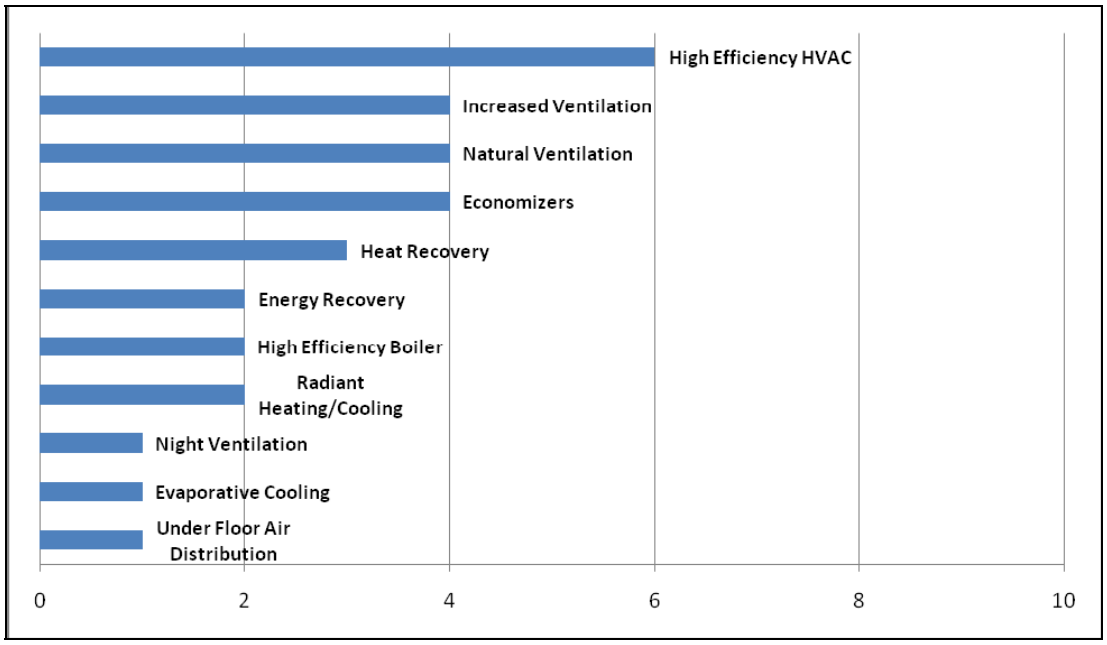
Daylighting

- 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

Figure 5. Count of HVAC Measures



Whole-Building Controls, Monitoring and Commissioning

- Tennant-level sub metering was used by two of the investor properties
- All projects submitted actual (not modeled) energy performance data for this research which was a result of a metering or Energy Management System or available in a commissioning report

Figure 6. Count of Monitoring, Metering and Commissioning Measures

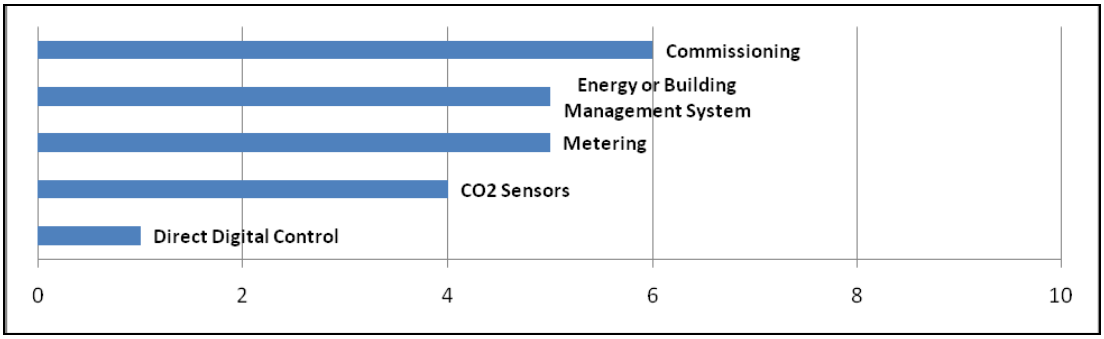
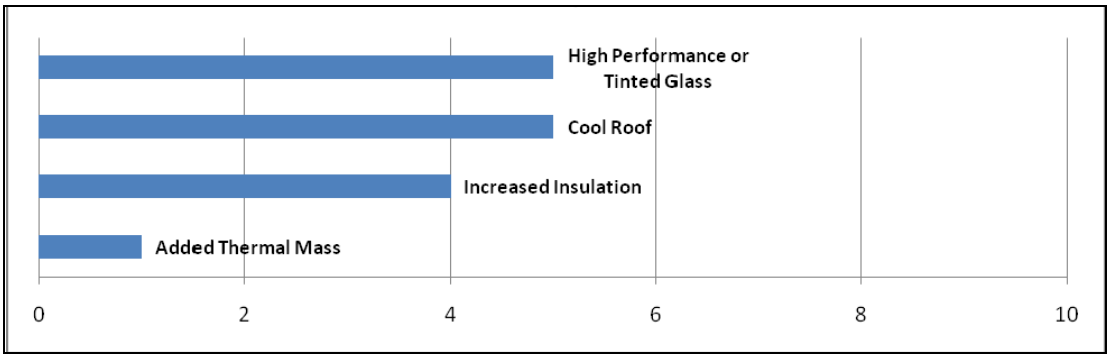


Figure 7. Count of Envelope Measures



Market Impact. Market outcomes – predicted and actual – were 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. These positive impacts can be partially attributed to the increase in awareness of ratings and label in the commercial building sector such as USGBC LEED certification and EnergyStar ratings. All nine buildings participated in a range of USGBC LEED programs covering four certifications and most projects experienced an increase in occupancy rate following the project completion.

Barriers and Innovations. These nine owners faced barriers and challenges similar to most construction projects with costs and maintaining historical attributes most often cited. As historic renovations, three project in particular 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.

Through interviews conducted with project owners and members of the design team there was a strong emphasis placed on taking an integrated approach to these projects. Such an

approach was most frequently cited in overcoming challenges associated with maintaining historic and structural elements of a project and ensuring that projects stayed on budget.

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.

Overview of financial and project scope barriers. Cost and the historic natures of the three of the buildings impeded pursuit of some energy efficiency. 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. Other challenges included the need to strategically stage the project around existing building tenants and the need to "transform" the design and construction team into believing in the project outcomes.

Innovative technologies. While most of the technologies applied to these projects are readily available to the market, some of the owners demonstrated a willingness to include new and emerging technologies in their projects. Examples included: electrochromic glass to reduce solar gain; a variable refrigerant flow (VRF) mechanical system and several novel heat recovery strategies.

Commonalities and Conclusions

In order to translate the success stories represented by these nine projects we have indentified the following commonalities as critical takeaways from this research:

- Integrated design, multiple measures and monitoring are more critical to low-energy building than any given technology.
- Ratings, labels and recognition appear to be valuable motivators for energy-efficient renewals.
- Commissioning, measurement and tracking and ongoing improvement are keys to low energy usage.
- All projects successfully leveraged incentives and tax credits.
- Strong leadership was exhibited in all cases including the desire to share their "stories".

The owners or managers of these buildings share five important characteristics that are keys to their success:

1. **"Green Link" Recognition** – they considered and valued the economic and environmental benefits (the "two greens") that make energy efficiency a wise investment.
2. **Measurement** – they track energy results and conduct continuous commissioning to maintain and improve performance.
3. **Vision** – they are goal-driven, pursue targets via LEED, have leadership mentalities, and the willingness and desire to be ahead of the curve in many aspects of their businesses.
4. **Money Leverage** – they maximize government, utility and organizational incentives and tax credits.

5. **Market Profile** – NBI "found" 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.

How These 'Commonalities' are Being Incorporated into the EBR Initiative

The ongoing development of the Existing Building Renewal Initiative is complex and involves numerous information resources, consultants and partner organizations. While the development phase is expected to continue through 2012, the commonalities from the findings of this research on conditions and actions frequently associated with successful deep retrofits, have been, and will continue to be, useful for the development in the following ways:

- Determination of pre-initiative baseline attitudes, practices and energy consumption
- Development of the Owner Roadmap (aka Playbook)
- Content for Education and Marketing efforts
- Supporting evidence for Integrated Measure Package development
- Assurance for NEEA funders and management on the EBR approach

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