

# VALUE BEYOND COST SAVINGS

*How to Underwrite  
Sustainable Properties*

**Expanded Chapter IV:  
Sustainable Property Performance**

SCOTT R. MULDAVIN, CRE, FRICS



GREEN BUILDING FINANCE CONSORTIUM  
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## About Expanded Chapter IV

This publication is Expanded Chapter IV of the Consortium's book: *Value Beyond Cost Savings: How to Underwrite Sustainable Properties*. *Value Beyond Cost Savings* presents the key findings and conclusions regarding the valuation and underwriting of sustainable properties based upon three years of independent research by the Green Building Finance Consortium.

Chapter IV is one of six "Expanded Chapters" from *Value Beyond Cost Savings: How to Underwrite Sustainable Properties* which provide 400 additional pages of in-depth research, analysis, and performance information, all available without charge to the public from the Consortium's website and other locations.

This Expanded Chapter has the same table of contents as the book, enabling readers wishing to delve into more depth on a topic to easily find the appropriate sections in the Expanded Chapters. This book also references many checklists, databases, documents, and resource links in the Expanded Chapters and in the Consortium's web-based Research Library. This Chapter and the book include some color, but the publications are designed to print in black without loss of information.

The Green Building Finance Consortium maintains a searchable Research Library and Industry Links database on its website: <http://www.GreenBuildingFC.com>. The Research Library and Industry Links databases include thousands of documents coded using the GBFC's unique index designed for the sustainable finance and investment industry. The structure of the index is consistent with the organization of *Value Beyond Cost Savings: How to Underwrite Sustainable Properties*. Future sustainable performance and related research updating the book on an ongoing basis will be available in the Research Library.

The mission of the Consortium is to enable private investors to evaluate sustainable property investments from a financial perspective. To accomplish this, we have identified and developed suggested modifications to valuation and underwriting methods and practices and are widely communicating the results of our work through our book, other publications, web-based research library, speeches, and collaborations.

The Consortium is financed independent of green building product or professional organizations, relying on funding from The Muldavin Company, Inc. and Consortium Members which include leading real estate industry trade associations and companies, governments, and non-governmental organizations. Trade association members include BOMA International, the Mortgage Bankers Association, the Urban Land Institute, the Pension Real Estate Association, and the National Association of Realtors.

## Acknowledgements

The Green Building Finance Consortium wants to acknowledge the leadership and support of its Consortium Members, Implementation Team, and Advisory Board, who together with the contributions of scores of other individuals and groups have made the Consortium's work possible.

### Founding Members of the Consortium

BOMA International  
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## Collaborators/Other Contributors

We are and have been involved in important collaborative efforts addressing database development, energy research, valuation practice, and many other areas critical to financial assessment of sustainable properties with at least the following organizations:

- **Lawrence Berkeley National Laboratory**—energy and health issues
- **CoreNet Global**—energy issues
- **Royal Institute of Chartered Surveyors**—valuation and policy issues
- **Appraisal Institute**—valuation issues, training
- **National Association of Realtors**—sustainability curriculum
- **North American Commission for Environmental Cooperation**—policy, finance
- **Vancouver Valuation Accord**—valuation and regulatory issues
- **Database for High Performance and Sustainable Buildings**—database design and development
- **Rutgers Green Building Research Center**—REIT valuation research, other
- **International Youth Leadership for a Sustainable Future**—youth education
- **World Business Council for Sustainable Development**—analytics and communications
- **California Energy Commission**—transaction disclosure documents

We also appreciate the scores of other individuals and companies who have provided significant input and assistance in the project through their research and data, review of Consortium work product, and participation in interviews and surveys.

## About the Author

Scott Muldavin is Executive Director of the Green Building Finance Consortium, a group he founded in 2006, and President of The Muldavin Company, Inc. For over 25 years, Mr. Muldavin has advised leading real estate companies including CalPERS, RREEF, Bank of America, Mitsui Trust and Banking, Great West Life, Prudential Real Estate, Ohio State Teachers Retirement System, Wells Fargo Bank, The Government of Singapore Investment Corporation, Catellus Development Corporation, Equitable Real Estate, and Standard Insurance Company.

Mr. Muldavin has been a lead real estate consulting partner at Deloitte & Touche, co-founded the \$3+ billion private real estate company Guggenheim Real Estate, served on the Advisory Board of Global Real Analytics, an advisor for \$2 billion of REIT and CMBS funds, and completed over 300 consulting assignments involving real estate finance, mortgage lending, investment, valuation and securitization. Mr. Muldavin's

engagements and work experience provide him with broad experience in equity and debt transaction structuring, underwriting, due diligence, investment fund design, and corporate real estate.

Mr. Muldavin has advised scores of equity investors and developers. As a co-founder of Guggenheim Real Estate, Mr. Muldavin has been involved in capital formation, investment strategy, due diligence and served on the investment committee. He has assisted pension funds including CalPERS, Ohio State Teachers, and Alaska Permanent Fund in their investment and organizational strategies. He has advised investment managers including RREEF, Prudential Real Estate, Amstar, Hunt Realty, and others on strategy, capital formation, organizational change, and due diligence practices.

Mr. Muldavin has been involved in the Real Estate Investment Trust (REIT) market since the early 1980s advising clients including Merrill Lynch, CalPERS, Kilroy Realty and others concerning new REIT securities offerings and investment issues. As an investment committee member of Guggenheim Real Estate, he monitored the REIT market and participated in investment decisions concerning the allocation of hundreds of millions of dollars of REIT investments.

Mr. Muldavin has been involved in mortgage underwriting for over 25 years. He was the lead consultant that developed the first commercial mortgage risk-rating system for Standard & Poor's Corporation in the early 1980's and was a national leader of the Real Estate Financial Institutions practice for Deloitte & Touché, where he worked with financial institutions to improve their underwriting and servicing systems, assess risks in their mortgage portfolios, and estimate loan losses. He also authored the quarterly "Real Estate Finance Update" in *Real Estate Finance*, for 16 years; developed the Real Estate Capital Flows Index, which was published quarterly for many years by the Pension Real Estate Association and Institutional Real Estate Inc.; and authored key articles and reports on mezzanine financing, mortgage servicing, risk management, capital volatility, and other topics.

Mr. Muldavin was also a leader of the corporate real estate practice at Deloitte and Touché and during his career has advised corporations such as Texaco, Phoenix American Corporation, Nissan Motors, Pacific Enterprises, Universal Studios, House of Blues Corporation, Johns Manville, and many others on their leasing, acquisition and real estate strategies.

Mr. Muldavin has been involved in the structuring and due diligence of real estate property and business transactions for over 25 years. He has completed due diligence engagements involving the acquisition of office buildings, retail properties, hotels, multi-family properties, industrial properties, large land parcels, mortgage portfolios, mortgage companies, commercial banks, real estate service companies and other real estate assets.

As an advisor and Investment Committee member of Guggenheim Real Estate, Mr. Muldavin reviewed hundreds of retail, office, industrial and multi-family investment

opportunities throughout the United States, as well as investments in mezzanine loans, B-piece investment funds, preferred equity, and REITs.

Mr. Muldavin is a frequent speaker on real estate finance, investment, valuation and sustainability. He has authored over 225 articles published in *Real Estate Finance*, RICS Property World, *Bankers Magazine*, *Urban Land*, *European Real Estate Yearbook*, *The Journal of Property Management*, *The Pension Real Estate Quarterly*, *Real Estate Issues*, *The Investment Property and Real Estate Capital Markets Reports*, *Institutional Investor*, *Builder and Developer*, *The Real Estate Accounting and Tax Journal*, and other industry publications.

Mr. Muldavin is a graduate of UC Berkeley and Harvard University, and has been recognized by the American Society of Real Estate Counselors and the Royal Institute of Chartered Surveyors, each of who have awarded him their highest level of professional certification. Mr. Muldavin is also on the Advisory Board of the Journal of Sustainable Real Estate and an Honorary Fellow of the Institute of Green Professionals.

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# Topical Index

This topical index is a guide to help locate information on select topics that are covered in multiple locations within the Book and six Expanded Chapters. Select other topics of interest are also identified.

## 1. Development Costs/Initial Cost Analysis

- Chapter IV, Section E-1: Building Performance, Development (“First” Costs)
- Chapter V, Section C-2c: Sustainability Sub-Financial Analysis, Comparative First Cost Analysis
- Appendix F: Financial Analysis Alternatives: Comparative First Cost Analysis
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## 2. Green Leases/Split Incentives

- Chapter V, Section C-2c: Sustainability Sub-Financial Analysis, DCF Lease-Based Cost/Benefit Allocation Models
- Appendix F: Financial Analysis Alternatives: DCF Lease-Based Cost/Benefit Allocation Models
- Chapter VI, Section G-3: Property Management, Leasing Agreement Review
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## 3. Energy Investment

- Chapter III, Section C-1: Sustainable Property Features
- Chapter III, Section C-2: Sustainable Property Resources
- Chapter III, Section C-3: Sustainable Property Features and Building Outcomes
- Expanded Chapter III, Appendix III-A, Sustainable Property Features List
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- Chapter IV, Section C-4: Process Performance, Energy Use Forecasting
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- Chapter IV, Section E-2: Whole Building Performance Studies
- Chapter IV, Section E-3: Building Energy Use (Performance)
- Chapter V, Section C-2: Financial Analysis Alternatives, Energy Star
- Appendix F: Financial Analysis Alternatives: Energy Star
- Chapter VI, Section E: Underwriting Energy-Carbon Reduction Investment

#### 4. Health and Productivity Benefits Analysis

- Chapter IV, Section D-2, Performance of Under floor Air Distribution and Daylighting
- Chapter IV, Section E-4: Occupant Performance, Health and Productivity
- Expanded Chapter IV, Appendix IV-C: Studies of Productivity and Health Cited by Industry
- Expanded Chapter IV, Appendix IV-D: Additional Studies of Productivity and Health
- Chapter IV, Section F: Market Performance, Space User/Investor Surveys and Tenant Demographics and Market Research
- Chapter V, Section C-2c: Sustainability Sub-Financial Analysis; Productivity Benefits Analysis; Health Benefits Analysis
- Appendix F: Financial Analysis Alternatives: Productivity Benefits Analysis; Health Benefits Analysis
- Chapter V, Section G-3: The Process for Determining Financial Model Inputs
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## 5. Key Trends in Performance Measurement

- Chapter III, Sections D-2 and D-3

## 6. Public Benefits of Sustainable Properties

- Expanded Chapter III, Appendix III-D, Measuring Sustainability: Assessment Systems/Tools
- Chapter IV, Section C-5: Process performance, Regulations and Code Compliance
- Chapter V, Section C-2d: Public Sustainability Benefits Analysis
- Appendix F: Financial Analysis Alternatives: Public Sustainability Benefits Analysis
- Chapter V, Appendix G, GBFC Sustainable Cost/Benefit Checklist, Public Benefits
- Chapter V, Section F-3: Assessing the “Net Impact” of Sustainable Costs and Benefits, Public Benefits

## 7. Risk Analysis and Mitigation

- Much of the book focused on this topic. Key sections include:
- Chapter IV, Section C: Process Performance
- Chapter IV, Section D: Feature Performance
- Chapter V, Section C-2, Financial Analysis Alternatives, Risk Analysis and Presentation
- Chapter V, Section E: Assess Costs/Benefits of Sustainability
- Chapter V, Appendix G: GBFC Sustainable Property Cost/Benefit Checklist
- Chapter V, Section H: Risk Analysis and Presentation
- Chapter VI: Sustainable Property Underwriting Guidelines

## 8. Service Provider Risks and Underwriting

- Chapter III, Section D: Measuring a Property's Sustainability, Service Provider Certifications and Assessments
- Expanded Chapter III, Appendix III-D: Measuring a Property's Sustainability, Service Provider Certifications and Assessments
- Chapter IV, Section C-3: Process Performance, Service Provider Quality and Capacity
- Chapter V, Appendix G: GBFC Sustainable Property Costs/Benefits Checklist
- Chapter VI, Section D: Underwriting Service Providers
- Chapter VI, Section E-9: The Impact of ESCOs on Underwriting Energy/Carbon Reduction Investment

## 9. Space User Demand- Enterprise Value

- See references above to Health and Productivity Benefits Analysis, a component of Space User Demand
- Chapter IV, Section E-4: Occupant Performance
- Chapter V, Section C-2c, Sustainability Sub-Financial Analysis, Enterprise Value Analysis
- Chapter V, Appendix F: Financial Analysis Alternatives, Enterprise Value Analysis
- Chapter V, Appendix G: GBFC Sustainable Property Cost/Benefit Checklist, Space User Demand Analysis
- Chapter VI, Section F: Underwriting Space User Demand
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## 10. Sustainable Features Choices and Analysis

- Chapter III, Section C-1: Sustainable Property Features
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- Chapter IV, Section D: Feature Performance
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- Chapter VI, Section C: Key Differences in Sustainable Property Underwriting
13. Valuation Issues for Sustainable Properties
- Chapter V, Section I: Valuing Sustainable Properties

## Sustainable Property Performance

<i>Underwriting Sustainable Property Investment</i>					
Chapter I Introduction	Chapter II Sustainable Property Investment Decisions	Chapter III Evaluating Property Sustainability	Chapter IV Sustainable Property Performance	Chapter V Sustainable Property Financial Analysis	Chapter VI Sustainable Property Underwriting Guidelines

### A. Introduction

Measuring and understanding sustainable property performance is the foundation of financial analysis and underwriting. While over 100 sustainable property performance and certification systems were identified in the Chapter III, all of them leave out critical performance information to financial analysis and valuation.

To address this deficit, we developed the GBFC Sustainable Property Performance Framework, a new framework for organizing and evaluating sustainable property performance that directly supports financial analysis, valuation and underwriting. GBFC's Framework introduces Market Performance, the "missing link" of sustainable property performance required to assess the financial implications of sustainable property investment.

Expanded Chapter IV presents a reasoned and practical approach to thinking about sustainable property performance and "value" that corresponds with traditional real estate property analytics and decision-making. **The Consortium's approach moves away from the quest to design and implement the "killer" quantitative study that proves the incremental value of sustainability, to focus on the process and data needed to assess the value of sustainable property investment for individual properties.**

In the rest of this chapter we present our assessment of sustainable property performance using the categories identified in GBFC's Sustainable Property Performance Framework:

- Process Performance;
- Feature Performance;
- Building Performance;
- Market Performance; and,
- Financial Performance.

We present evidence of both positive and negative performance as well as best practices that have been adopted to address problems that have arisen. Contrary to the belief of some, presentation of failure and underperformance, and related sustainable building risks, will not scare investors, but actually significantly increase sustainable investment due to improved confidence by capital sources in their ability to appropriately price and mitigate risk.

The performance assessment presented in this chapter, by its nature, is a point in time assessment, and by no means comprehensive given the huge volume of sustainable performance research available worldwide. Future reports and performance information will be available in the Consortium's Research Library and Industry Links, which have been organized consistent with the GBFC Sustainable Property Performance Framework.<sup>1</sup>

The analysis of risks and best practices outlined in this chapter supplement the more detailed GBFC Sustainable Property Cost-Benefit Checklist and risk analysis frameworks presented in Chapter V: Sustainable Property Financial Analysis. The underwriting of risk and risk mitigation is also fully covered in Chapter VI: "Sustainable Property Underwriting Guidelines."

It is important to understand when reviewing the contents of this chapter that conventional projects also fail and underperform. Accordingly, while this chapter focuses on sustainable properties, it should be understood that sustainable properties do not necessarily have a disproportionate level of problems.

## **1. Research Methodology**

The content for this chapter was generated through a process of interviews, literature reviews, and feedback from Consortium members and other industry experts.

We started by conducting initial interviews with a handful of experienced sustainable building professionals. We asked them to discuss their experience with failure and underperformance with sustainable properties. We used these interviews as a starting point for our own research. We used a variety of industry surveys, trade publications, journals, reports, and case studies to supplement the initial interviews as well as illuminate other key areas of risk. We have referenced our work in the following sections and provide hyperlinks for readers to access our sources and other research that complements our work.

We built on our initial interviews and literature review through interviews with a mix of sustainable property investors and developers and green building service providers and

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<sup>1</sup> GBFC's Research Library ([www.GreenBuildingFC.com](http://www.GreenBuildingFC.com)) provides a searchable database of key performance-related documents indexed and organized according to the structure of the GBFC Sustainable Property Performance Framework introduced in this chapter. Index codes 15.1 to 15.10 mirror the structure of Chapter IV, providing a source location to identify and access new process, feature, building, market, and financial performance evidence.



consultants. We believe the breadth and extensive experience of our interviewees was particularly important. Investors and developers view the risks associated with green building differently than consultants or service providers do, and we felt that the nuance that could be provided by seasoned professionals offered valuable perspectives. Most of our conclusions here are most applicable to sustainable buildings in the United States, but lessons learned should have broad applicability.

We also generated insights by “reverse engineering” some of the leading best practice guides, including the ASHRAE GreenGuide, the Whole Building Design Guide, the Sustainable Building Technical Manual, and Energy Design Resource Design Briefs, etc. These best practice guides were typically developed by using the combined experience of their authors to provide advice to other professionals on how to implement sustainability in buildings. This advice was largely based on lessons learned, which depend on a process of trial and error. We took these lessons learned to help us describe the key challenges and how to mitigate these risks. (A full selection of sustainable best practices guides is identified and many can be directly accessed in the Consortium’s Research Library and Industry Links section, index code 28.0)

We will selectively add nuance by property and project type where appropriate. We will group property types into three types: multifamily (which, for the purposes of this section, includes hotel), retail, and office. We will also group project types into three different categories, informed by the LEED rating system: new construction and major renovation (NC); existing buildings with a particular focus on maintenance and operations and minor upgrades (EB); and commercial interiors (CI), which focuses on tenant improvements and build out.

## 2. Applying Findings, Conclusions, and Methods

This chapter has broad applicability to sustainable property investment decision-making. However, the work is primarily directed to specific audiences and decisions in the private commercial real estate market as discussed below.

**Target Audiences:** The target audiences for this section are space users<sup>2</sup>, equity investors, lenders, developers, appraisers, and commercial property brokers. Sustainable service providers and groups seeking capital for sustainable property investment will also benefit from this section, as well as students and industry practitioners seeking to understand the financial underpinnings of sustainable property investment.

**Commercial Real Estate Properties:** The Consortium focuses on commercial and multifamily properties. While many of the frameworks and methodologies will have some applicability to the single-family market, single-family property issues are not addressed in detail. Select single-family resources are also available on the Consortium’s Research Library and Industry Links under code 19.2.

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<sup>2</sup> “Space user” is a term we use to describe the occupants or users of real estate. It is a term that includes corporate and non-corporate owner-occupants, tenants, retail customers or other non-owner or tenant users of space.

**Geographic Applicability:** Individuals and organizations throughout the world influence The Consortium’s work. Additionally, the Consortium’s focus on fundamental methods and practices make its work particularly transferable across national boundaries. However, this section has a North American bias.

**Property Specific Investment Decisions:** This chapter focuses on performance assessment and valuation of an individual property.

**Property Life Cycle:** This section will be applicable, in varying degrees, to sustainable property investment decisions involving new buildings, existing buildings, and tenant improvements.

**Private Investment Decisions:** The Consortium focuses on the underwriting of private investment decisions. However, understanding the types and magnitude of public benefits generated by a specific sustainable property investment is important to a private investor because of the potential to monetize public benefits by extracting the value they create for governments and tenants-investors.

Sustainable properties can have substantial social and environmental (public) value, and it is important to quantify and understand such benefits. Methodologically, public and private benefits should be assessed separately, and particularly from the perspective of valuation, it is critical to separate the concept of public and private value when evaluating a sustainable investment decision from a private sector perspective. This does not mean that public values and benefits cannot be considered by the private sector when making investment decisions, but only that such decisions should be made with a clear understanding of the differences between private and public values.

### 3. Organization

This chapter is organized as follows:

**A: Introduction.**

**B: GBFC Sustainable Property Performance Framework.** We present GBFC’s new framework for evaluating sustainable property performance.

**C: Process Performance.** We identify and describe those processes and services unique to sustainable properties, outline the associated challenges and risks that have led to underperformance, and identify select best practices for improving performance.

**D: Feature Performance.** We describe the key risks posed by sustainable features, systems, and materials unique to sustainable properties and how to best mitigate these risks.

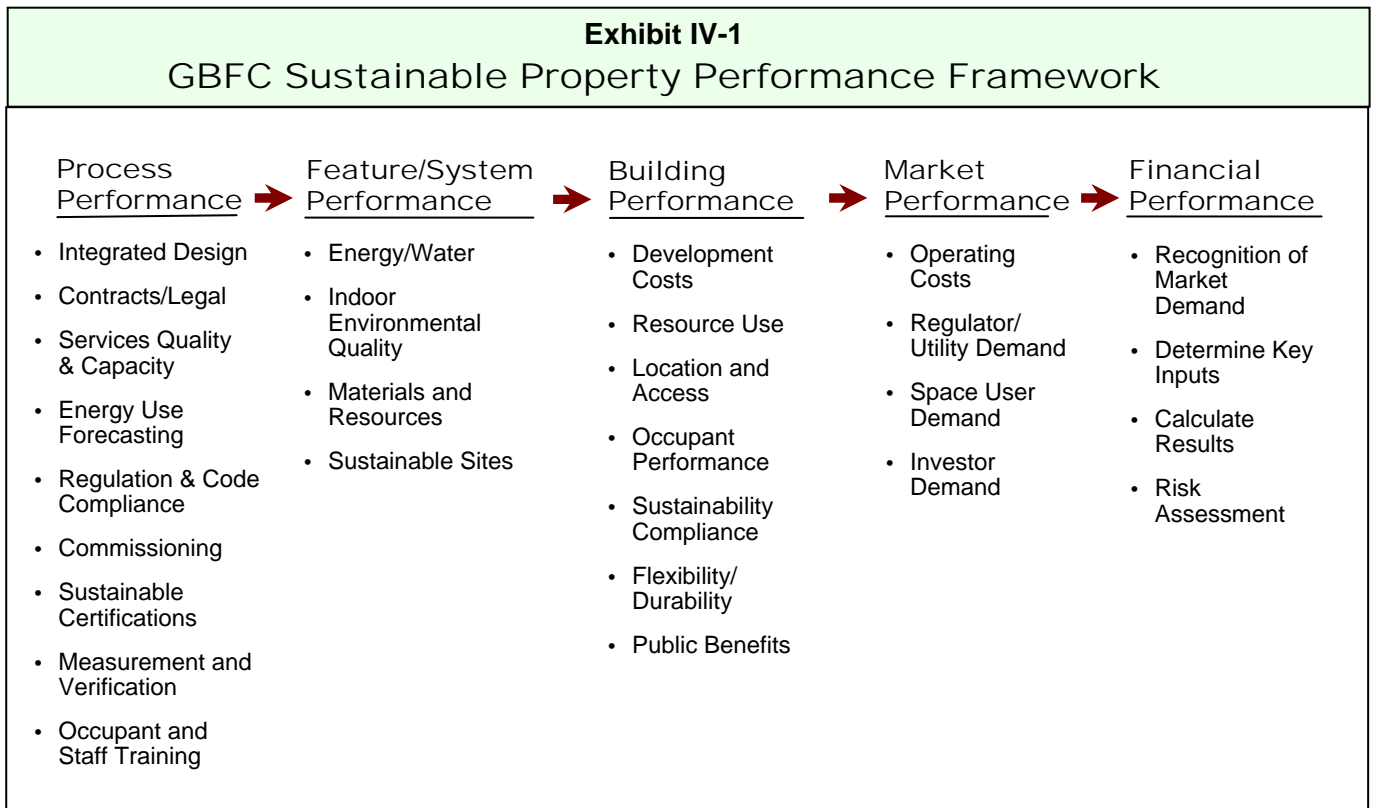
**E: Building Performance.** We identify and evaluate some of the best work to date that measures building and occupant outcomes with an eye to identifying key factors influencing building performance.

**F: Market Performance.** We present an assessment of the evidence of the market’s response to sustainable properties focusing on regulators, space users, investors, and the commercial brokerage and appraisal communities.

**G: Financial Performance.** We synthesize the work of sections D-G and show how performance at the process, feature, and building level flow through to financial performance and evaluate some of the key research that specifically addresses financial performance.

## B. GBFC Sustainable Property Performance Framework

GBFC’s Sustainable Property Performance Framework provides a new structure for organizing and evaluating property performance to enable improved financial analysis, valuation and underwriting. A graphic presentation of the framework is shown below in Exhibit IV-1 and presented in more detail in Appendix IV-A.



The genesis for GBFC's Sustainable Property Performance Framework was our interviews with scores of sustainable property service providers, investors and developers. In asking respondents about their experience with failure and underperformance in their sustainable property practice, we received a wide range of responses, including such comments as:

- “The integrated design process was not implemented correctly”;
- “We failed to address responsibilities appropriately in contracts”;
- “Our service providers either were too busy or did not have the specific qualifications needed”;
- “The daylighting solution seemed to bother occupants more than make them happy”;
- “Improper design of the underfloor air ventilation system resulted in temperature inconsistencies and occupant complaints”;
- “We exceeded our cost budget”;
- “Energy use was significantly greater than forecast”; and
- “We did not achieve the sustainability certificate that we had hoped for.”

We began to see a pattern where failure or underperformance occurred with specific processes, specific features or systems, or building performance. This differentiation between process performance, feature or system performance, and building performance was confirmed in our review of performance literature and case studies.

As our performance research continued, it became apparent to us that a sustainable property performance framework that included just process, features/system, and building performance was insufficient to assist underwriters and valuers in their assessment of financial performance. As shown in Exhibit IV-1, there is no direct way to go from building performance to financial performance. Even if you know how much a building costs, how much resources it uses, potential health or productivity benefits and related building performance statistics, the only way to assess financial performance (return on investment, value and risk) is to assess the market's response to the building's performance. Accordingly, the GBFC Sustainable Property Performance Framework introduces market performance as the fourth critical type of performance that must be measured at the property level to conduct proper financial analyses.

Finally, financial performance of sustainable properties is determined by evaluating how the market's response to the sustainable building will affect its financial inputs including rent, occupancy, absorption, discount rates, cap rates, operating costs, entitlement benefits, and other key variables. Financial performance is measured by the resulting rate of return or value that result from the input of the key financial inputs into a discounted cash flow or related model. Further, sustainable property financial performance must include a full assessment of risk. For example, is a 10% return always better than a 7% return? No, it depends on the nature of the risks undertaken to achieve each level of return.

The framework highlights the importance of separating the different elements of sustainable property performance in order to properly evaluate financial performance. Our

research shows that process performance drives the success of sustainable features and systems, which, in turn, determine building performance. To assess potential financial implications of a building with a specific level of sustainable performance, one must next measure the market response (regulators, space users, and investors) to the building's sustainable performance. Keeping the data and types of performance separate helps to assess the fit and relative importance of information.

GBFC's Sustainable Property Performance Framework also provides a structure for underwriters to use in their efforts to mitigate risks. GBFC's Framework prompts key lines of inquiry, including:

- Was the integrated design process implemented appropriately?
- Were contracts sensitive to the issues of sustainable properties?
- Did service providers and contractors have the requisite competence and capacity to get the work done?
- Have sufficient resources been spent on commissioning, measurement, and verification, as well as the training of occupants and staff?
- Are the features and systems specified in the building pioneering, or do they have proven track records? (Pioneering systems, features or materials are not necessarily bad because significant benefits can be achieved, but there may be some additional risk that will offset the benefits of their implementation unless property mitigated.)

Since most significant sustainable property investment decisions will be based on forecasted building performance (energy use, occupant performance, development costs, etc.) underwriters are, or should be, focused on reducing uncertainty and risk related to the forecasted performance. As has been proven in our research, risk and uncertainty around building performance can be significantly mitigated through underwriting of sustainable processes and features/systems. Fortunately, the sustainable property investment market is significantly more mature today than even a few years ago, enabling significant risk mitigation through proper attention to process and features performance issues.

## C. Process Performance

Strong performance at the process level is the foundation for successful sustainable property investment. As one green building expert noted, "sustainability" is not an add-on feature or technology. Building sustainably is fundamentally a process of best practices that leads to "sustainable" outcomes. It is critically important to get these processes right in order to deliver a successful high performance building. Poor execution of these processes can lead to a variety of negative consequences, including underperforming systems, uncomfortable environments, or increased cost.

Mitigating risk at the process level provides the most “bang for the buck”; that is, ensuring that processes are well executed has the additional effect of helping to mitigate risk at the feature and system level and ultimately at the overall building, market, and financial performance level. Strong performance at the process level is the foundation for successful sustainable property investment.

While valuers and underwriters of existing properties focus on actual building performance, this is not possible for new construction or major/moderate retrofits that would add certifications and/or change operating performance of a property. In these situations, valuers and underwriters must form judgments about forecast building performance, and the market’s response to it. Their job is to do as much research and due diligence as possible to reduce uncertainty in building performance forecasts.

The starting point for underwriting sustainable properties is to conduct due diligence on the key sustainable property processes to make sure that they are done in a way that reduces risk and increases the reliability and accuracy of forecasts. Specific research quantifying the financial benefits of strong sustainable process performance is available for some of the key processes like commissioning, however, the incremental contribution of each separate process to value or financial performance is not as important as understanding how strong performance in sustainable processes reduces risk.

Ultimately, financial performance is determined by the market’s response to sustainable building performance, which strong processes can contribute to. In many cases, failures in critical processes such as integrated design, contracts, or the selection of competent service providers can result in significant underperformance.

There are scores of different sustainable property processes. We focus on seven key sustainable property processes that have been identified by our survey, case studies, and the literature as important potential sources of sustainable property failure and underperformance:

The seven key processes that we will discuss in this chapter include:

- 1) Integrated design/Project delivery;
- 2) Contracts/Legal;
- 3) Services quality and capacity;
- 4) Energy forecasting;
- 5) Regulation and code compliance;
- 6) Commissioning; and
- 7) Measurement and verification.

For each of the seven-sustainable processes, we briefly describe each process, discuss the risks inherent with their implementation, provide a summary of best practices and identify key documents and web links. Information on sustainable property processes and performance can be found in the Research Library and Industry Links section of the

Consortium's website under index codes 15.4: Process Performance; 6.0: Sustainable Property Features; and 28.0: Sustainable Property Best Practice Guides.

## 1. **Integrated Design/Project Delivery**

Integrated design ("ID") is a design process that employs a collaborative, multidisciplinary project team throughout design in order to optimize the whole building. This is in contrast to conventional building design, where many individuals or teams are responsible for optimizing their own particular system with limited interactive collaboration.

ID is critical to successful sustainable projects, regardless of how a project is delivered. However, alternative project delivery models have evolved that incorporate a more collaborative process. These models will be discussed below.

### *Integrated Design*

Integrated design is an important tenet of sustainable building and a key process for keeping first costs in the same range as conventional buildings while maximizing environmental performance. Good ID should result in streamlined systems and eliminated redundancies, saving money and ensuring optimal performance. An example of this is the installation of certain high-efficiency systems, such as high-efficiency glazing or increased daylighting, which allow for downsizing the HVAC equipment while still providing equal or greater occupant comfort. This reduces both the capital cost *and* the operating costs of the HVAC system. These systems can only truly succeed with an integrated design approach.

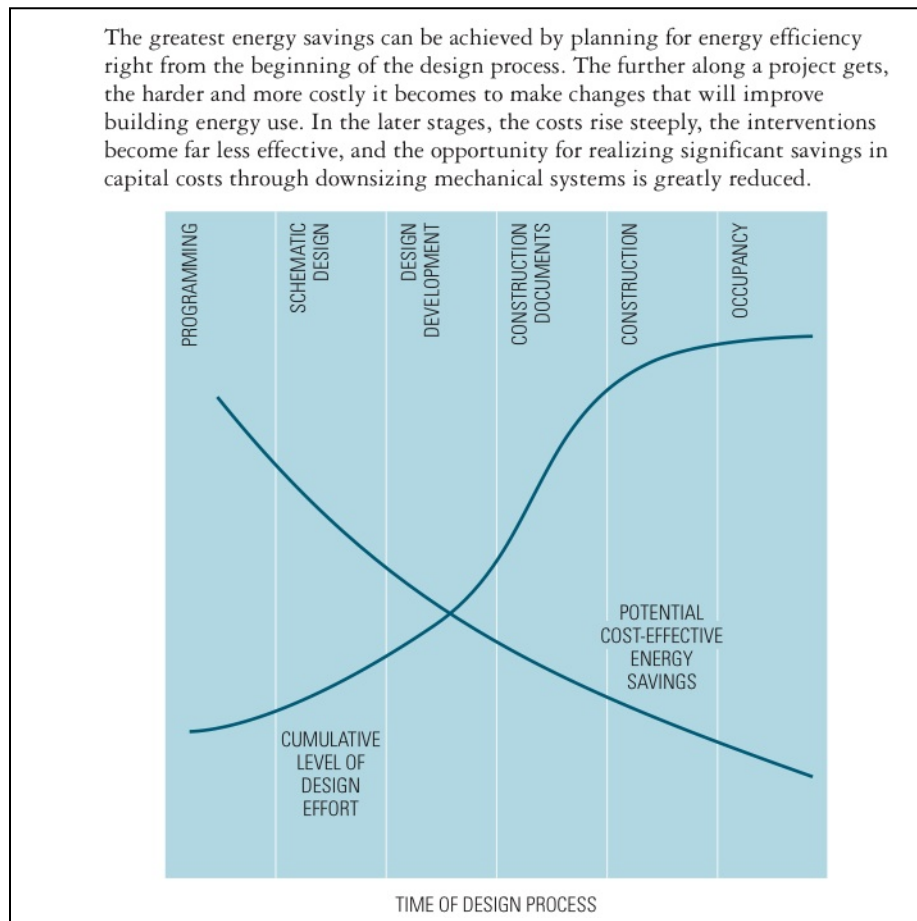
Moreover, since many sustainable building systems are inherently interdisciplinary, such as green roofs or daylighting, integrated design fits naturally with sustainable building systems. The integrated design process should be used on any sustainable property type and is most commonly used in new construction, but is also used effectively on major renovations or tenant build outs.

### *Risks*

Integrated design is one of the most challenging aspects of green design, as it depends on every member of the team participating and committing to it. A lack of buy-in from members of the team will severely hamper a good integrated design process. ID requires that all members of the team work collaboratively with each other, and this cannot occur if members of the team don't commit and participate.

One issue that can even affect teams who claim to have bought into ID is failing to maintain continual commitment to integration. Some team members think of buying into ID as attending one charette at the start of the process and then continuing with their standard design process. It takes vigilance to maintain commitment to the ID process.

Not getting everyone to the table early enough can also negatively affect property performance. If the process starts early enough, but not all the right players are involved, cost savings and sustainability increases can be missed or buy-in might not be sufficient. Moreover, even if all the right players are involved, but the design process is already advanced, cost savings will be missed and sustainability will be compromised. As one developer told us, in his experience it is important to have the maximum number of the project team at the table from the start, as the insights generated are worth the cost. Many of the lowest-cost sustainability solutions hinge on being incorporated into the process early. As the figure below shows, there is a tradeoff between time in the design process and the cost effectiveness of implementing sustainable solutions.



Source: *Design Brief: Integrated Building Design*, Sept. 2, 2002, p. 6, at. [www.energydesignresources.com](http://www.energydesignresources.com)

As one proponent of integrated design put it, “the impediment to integrated design can be summed up in one word: inertia.”<sup>3</sup> Integrated design techniques are not inherently more difficult than traditional design techniques; they are just different. Integrated design requires traditional design and construction teams to change the practices they are familiar with, and this is often met with resistance. Without this buy-in, ID is likely to underperform.

<sup>3</sup> John Boecker, “Integrated Design,” *Environmental Building News*, Nov. 1, 2004.



ID often requires a different fee structure. If the fee structure for a mechanical engineer, for example, is tied to the cost of systems, then they will have no incentive to downsize mechanical systems, a likely result of ID. Moreover, design fees may need to be distributed differently. The ID process will be more frontloaded than a standard design process, and the budget needs to reflect this. Good ID shouldn't cost more in total, but fees will be doled out earlier in the process. Real estate decision-makers need to understand this.

Undocumented design decisions also can stall the ID process. Most issues will be hashed out at early design charrettes, but if a new firm or project manager is brought on board, this can often lead to a rehashing of already settled issues. This is a waste of time and money. If decisions are properly documented, the team can refer to them easily.

If the ID process is not executed properly, this will result in missed opportunities for both upfront capital savings and downstream operational savings. If the architect and engineer are not properly coordinated, then it's quite possible to miss out on the capital savings that could have been achieved in an ideal collaborative environment. If for some reason the engineer is not properly kept in the loop of what the architect is doing to reduce the need for HVAC systems, the mechanical engineer might call for an unnecessarily large chiller, resulting in both higher upfront capital costs and also reduced operating efficiency down the line. Therefore, failed integrated design doesn't just result in additional upfront cost, but can continue to negatively affect financial performance of the project over its entire lifecycle.

Simply adding or overlaying systems will not result in optimal performance or cost savings. Sustainable building is not an add-on technology, but rather a method for rethinking the way system synergies interact. If, for example, a green building depends on high-efficiency light fixtures to reduce heat load to ultimately reduce cooling plant size, then changing the light fixtures will affect the cooling plant. The two systems are dependent on each other.

#### *Example*

The Chesapeake Bay Foundation's Philip Merrill Environmental Center provides an example of how not getting everyone to the table early can negatively affect performance. This project, the first LEED Platinum project, was primarily a product of solid integrated design. The team worked remarkably well together, and many project participants said this was due in part to an educational session and bonding experience for the team right at the outset. While the majority of the systems in the building performed extraordinarily well, one system did not: the plumbing system. The water treatment system was significantly oversized and pumps were improperly matched to the low water use of the facility. This led to unnecessarily high first costs and reduced water and energy efficiency. Interestingly,

the plumbing engineer did not take part in the team-building experience and did not buy in to the integrated design process, which may have contributed to this underperformance.<sup>4</sup>

### *Integrated Design Best Practices*

**1) Commitment from all parties.** It generally works best if the owner or tenant are committed. There seems to be a dichotomy between the “old school” and the “new school” on this one, a sort of bid-build mentality versus an integrated design mentality. According to one green building consultant, every “old line guy” they have worked with becomes a convert by the end of the process as they recognize that green is really just a set of best practices.

One way to ensure participation is to focus the sustainability consultant on the people who don’t “get it.” For an experienced sustainability consultant, this will not be the first time they’ve had to “prove it” to other members of the design team. But if the design team still doesn’t get it, it falls on the owner or developer to insist that the dissenters buy in to the process. At the end of the day, clear directives from the top are most effective. Without clear senior directives, it is too easy for design professionals to stick with what they’ve always done and hope to stay out of trouble. Hence the mechanical engineer’s line: “I’ve never been fired from a job for putting in too much cooling.” Perhaps if they *were* at risk of being fired, they would think more about the ID process.

Getting everyone to participate is not enough if you do not get the right people to participate. Of course, this is a platitude an owner/developer would use to describe any project, but it is actually extremely important to a good ID process. Professionals who are unwilling to try the new tactics that green buildings sometime require will slow the team and risk the synergies that are so important to effective green building.

In the selection process, the developers should ask tough questions to gauge a professional’s commitment to ID. Is it just lip service, or is it real commitment? Do they have the experience of successfully applying sustainable ID techniques to completed projects?

**2) Designating a member of the design team as the “integrated design coordinator.”** This person must be involved from the earliest stage of development and should have experience delivering certified sustainable projects with ID processes. Given the highly collaborative nature of this position, the coordinator must be an effective communicator and a good negotiator.

**3) Bringing the team together as early as possible.** This helps maximize opportunities for synergies and cost-savings and encourages the buy-in and team aspects that are critical to high performance.

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<sup>4</sup> John Boecker, “Integrated Design,” *Environmental Building News*, Nov. 1, 2004.

**4) Including a diverse set of parties on the team.** Include owners, all consultants who would typically be involved in a project, and a construction manager or cost-estimator. The construction team can provide critical knowledge to help hold down first costs. The team must also include the operations staff that will run the building after occupancy. Team members should be prepared and encouraged to think outside of their typical silo. The size and diversity of the team will, of course, vary by the size and type of project.

**5) Incorporating the requirements for an integrated building design process into the project documents.** Set the goals right from the start. For example, don't just say "we want LEED Gold," go credit by credit and agree on specific outcomes like X% savings in electricity, X% in water, and on down the line. This sets the context for the building and allows all consultants to start working toward achieving the goals of the project from the beginning. This type of thinking also creates a different approach toward sustainable certification ratings. With this type of design mentality, the sustainable rating won't be a target as much as a byproduct of the level of performance of energy, water, indoor environmental quality, etc. The optimal sustainability rating will then evolve from project decisions made to meet the performance targets.

**6) Consider structuring fees to reward the design team for the initial extra effort and risks of taking the integrated building design approach,** based on its achieving the desired results (see 2.7: Contracts for more information). However, this may not be necessary because the ID process often does not take any more time than a standard design process; it is merely distributed differently with more front-loading. As one sustainability consultant told us, their total invoice for jobs that bring them in early is usually smaller than those that bring them in later. Working from a clean slate often means consultants have to do less total work. Many owners/developers resist bringing in consultants until the last possible minute, often limiting meaningful financial savings.

**7) Be intentional about the design process.** One sustainability consultant told us that the design of the ID process could be even more important than the design of the building for delivering a successful green building.

**8) Maintain continued vigilance and commitment to the ID process during design and construction.** It's easy to fall back into the conventional design or construction process as the project progresses. This is especially true during construction, when change orders and product substitutions can be made based on first cost or scheduling considerations while ignoring the effect on the rest of the building systems.

**9) When possible and practical based on the size and type of property investment, do whole-systems analysis that treats the building as a system and takes into account the interactions and synergies between the different components.** This type of whole-systems analysis limits cost cutting designed as "value engineering" from the equation, since the systems are inexorably linked. "Simply adding, overlaying or deleting systems will not result in optimal performance or cost savings. Designers can obtain the most

effective results by designing various building systems and components as interdependent parts of the entire structure.”<sup>5</sup>

Whole-systems thinking focuses on downstream savings, which can be compounded as the design team moves upstream. A concrete example of this might start with reducing heat loads in a space through energy-efficient lighting fixtures and daylighting. These results in smaller required cooling supply-air flow rates, which mean smaller fans and cooling plants upstream. So a savings downstream, namely less heat load from lighting, worked its way upstream and saved both upfront capital costs as well as lifecycle operational costs since machinery works most optimally at or near full operational capacity. Whole-systems analysis generally relies on computerized design tools to simulate the effects of changing various design components. This type of analysis generally requires more time upfront than standard design processes, but can also maximize potential sustainable benefits.

**10) Remind yourself that sustainability isn’t rocket science.** Oftentimes, low-tech solutions can be combined to produce stunning efficiencies. Focusing on using state-of-the-shelf solutions in the proper way can often be more effective on a risk-adjusted basis than using state-of-the-art solutions. Teams with less experience should focus more on lower risk solutions and products.

### *Project Delivery*

The concepts of ID have contributed to the evolution of Construction/Development delivery models. The Design-Bid-Build process has been the most prevalent process historically, but Design-Build, Integrated Project Delivery, Intensive at Risk Construction Management, and hybrids of these processes have become more prevalent. These methods, and related risk mitigation ideas are presented below.

#### Design-Bid-Build

As might be expected, there are three main sequential phases to the design-bid-build delivery method: design, bidding, and construction. This process has some benefits in that the designer is solely representing the owner, bidding can result in more competitive pricing and costs, owners have choices, and bidders get to bid based on complete construction drawings.

The design-bid-build process can also be problematic due to the difficulty—costs, delays and disputes—arising out of changes that arise during the construction process. Development of a low-cost, rather than high value, mentality can be an issue. Most importantly for sustainable building, the contractor is typically brought in post design, limiting the quality of input and communications.

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<sup>5</sup> *Sustainable Building Technical Manual*, Public Technology, Inc., US Green Building Council, DOE and EPA, 1996, Ch. 3, p. 1.

### Design-Build

“Design-build focuses on combining the design, permit, and construction schedules in order to streamline the traditional design-bid-build environment. This does not shorten the time it takes to complete the individual tasks of creating construction documents (working drawings and specifications), acquiring building and other permits, or actually constructing the building, but can result in a more collaborative environment that can reduce change orders, enable a more value-oriented decision process, and improve communication.

By integrating design and construction in the same entity, input by contractors is provided early in the project, communication between key parties to the success of the project is enhanced, and responsibility for successful completion of the project is shared by the designer-builder. These benefits can be offset by a short-cut design process and reduced competition for the construction contract.

### Intensive at Risk Construction Management

This delivery method combines the traditional owner’s representative construction manager during the pre-construction phase and an “At Risk” construction manager during the construction that agrees to deliver the project at a “Guaranteed Maximum Price”.

### Integrated Project Delivery

Integrated Project Delivery is a new method where the owner, architect, and contractor enter into a multi-party contract up-front with incentives and penalties. This type of process links the three key service providers up front, forcing a more integrated approach to designing and delivering the project.

### Hybrid Arrangements

Hybrids of each of the four are also used in the industry today.

### *Project Delivery Best Practices-Risk Mitigation<sup>6</sup>*

Each of the processes discussed above has pluses and minuses. Best practices to reduce risks include:

- Clear contract specification is critical. Contractors limit risk by following construction contracts closely. Green or sustainability are not clear terms and should be clearly defined in the context of the project. Responsibility (ownership) of each LEED point should be spelled out in a separate exhibit.

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<sup>6</sup> This section is informed by a number of articles, experience, and presentations at GreenBuild 2009. See specifically “The Legal Risk in Building Green: New Wine in Old bottles?”, a USGBC Panel Discussion, April 2008. <http://www.greenrealestatelaw.com/2009/04/usgbc-paper-legal-risk-in-building-green/>

- Specific wants/needs of parties should be spelled out in the contract; performance or certification expectations should be clearly defined.
- Avoid over-reaching in marketing and representation.
- Do not accept standard contractor specification of “new materials without defects” if recycled products/materials will be used.
- Explicitly allocate the risks of new technology—consider performance testing of systems and technologies.
- Service provider “green damages” should be limited as to amount (liquidated damages) and amount of corrective work.
- Regardless of project delivery model, follow key Integrated Design best practices.
- Contractors can manage their obligations through use of quality control/assurance plans, a LEED action plan, Credit Management processes, and related project management techniques and documentation of work effort.
- Consider use of “At Risk” construction management process.
- Contractors/architects should stay away from, or only provide after careful consideration and definition, elevated standard of care guarantees/warranties—and carefully review implications of such warranties/guarantees on professional liability insurance.

### *Resources*

Green Building Finance Consortium Research Library and Industry Links (Index code 24.2: Integrated Design):

<http://www.greenbuildingfc.com/Home/ResearchLibrary.aspx>

Whole Building Design Guide:

<http://www.wbdg.org/>

Integrated Design for Sustainable Buildings:

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=188>

ASHRAE GreenGuide (2<sup>nd</sup> Edition):

<http://www.ashrae.org/publications/detail/16082>

Energy Design Resources Design Brief: Integrated Building Design:

<http://www.energydesignresources.com/Resources/Publications/DesignBriefs/tabid/74/articleType/ArticleView/articleId/110/Design-Briefs-Integrated-Building-Design.aspx>

Sustainable Building Technical Manual:

[http://www.wbdg.org/ccb/browse\\_doc.php?d=4156](http://www.wbdg.org/ccb/browse_doc.php?d=4156)

Environmental Building News: Integrated Design:

<http://www.buildinggreen.com/auth/article.cfm/2004/11/1/Integrated>

Market Transformation to Sustainability Guideline Standard - Whole System Integration Process:

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=908>

## 2. **Contracts/Legal**<sup>7</sup>

Sustainable properties introduce important legal and related contractual issues that increase development risk if not appropriately mitigated through improved contracts, training, and behavior. We address three key issues below:

- Design firm professional liability
- Construction contract risks
- Marketing Risk: misrepresentation and fraud in marketing and leasing protocols

### *Design firm professional liability*

#### *Risks*

Design firm professional liability is primarily an issue for architects and design firms who want to limit the potential for litigation, but improved and more clearly specified contracts will also help investors. For any owner or investor who has gone through litigation, they know that even the winners often do not “win.”

From the owner’s perspective, design and construction is already complex, and additional sustainability requirements and issues can make it even more so. Given the leadership of architects and designers in sustainability, it is natural and appropriate for owners to look to architects for education and guidance in this new field. However, it is important that the owner understand that their job is to communicate the importance of the economics, and the values that they are seeking in a project, and it is to their benefit to have contracts that clearly lay out the relative risks and responsibilities between architects and designers and owners.

The architectural community has stepped up their responsibilities to sustainable design in recent years:

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<sup>7</sup> This section provides an overview of select sustainability related issues but is not a complete or detailed treatment of these issues and appropriate legal advice is recommended when addressing these and other legal issues.

AIA B101-2007, the standard form of contract between architect and owner makes the architect's sustainable duties immediately apparent. That document provides, in pertinent part:

3.2.5.2 The architect *shall* consider environmentally responsible design alternatives such as material choices and building orientation, together with other considerations based on program and aesthetics that are consistent with the Owner's program, schedule and budget for Cost of the Work." (Emphasis added)

Thus under the AIA contract, for the very *first* time, the architect is actually required to consider and evaluate green or sustainable design alternatives as part of the base service.

The AIA Canons of Ethics create and impose similar duties, taken one step further. Under the modern Canons, the architect now actually has duties pertaining to the environment. In that regard, Canon IV – Obligations to the Environment, specifically provides:

Members should *promote* sustainable design...

E.S.6.1 Sustainable Design: In performing design work, members should be environmentally responsible and *advocate* the design, construction and operation of sustainable buildings and communities.

E.S.6.3 Sustainable Practices: Members should use sustainable practices within their firms and professional organizations, and they should *encourage* their clients to do the same. (Emphasis added.)<sup>8</sup>

Architects and owners need to be careful and understand the role of an “advocate” for sustainable design, and appropriately recognize their relative responsibilities and roles. Frederick Butters, in his article<sup>9</sup>, provides an example of this issue:

For example, the architect who takes the AIA documents' admonishment to “advocate” for sustainable design and sustainable products to heart and recommends to the owner an HVAC system based on a heat pump package that draws on a geothermal or water source. Unfortunately, the projections regarding the temperatures at which the geothermal or water source run are erroneous and the actual temperatures are warmer than projected. As a consequence, the system is less efficient and unable to maintain comfort on 10 percent of the warmest days in the summer. Tenants are angry and withholding rent. Vacant space remains vacant. The owner is faced with a complete retrofit of the HVAC system in order to resolve the problem at substantial expense. The owner looks to the design professional to correct the problem. While it may seem like a good idea, geothermal-based energy sources are unpredictable. If the architect does not clearly and sufficiently indicate the positives and negatives of the HVAC options, the client will be looking to the architect to make him or her whole. Becoming an advocate for many types of sustainable approaches may cause the

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<sup>8</sup> Frederick F. Butters, “Greening the Standard of Care: Evolving Legal Standards of Practice for the Architect in a Sustainable World,” *Real Estate Issues*, Counselors of Real Estate, Vol. 33, No. 3, 2008. ([http://findarticles.com/p/articles/mi\\_qa3681/is\\_200810/ai\\_n31170739/](http://findarticles.com/p/articles/mi_qa3681/is_200810/ai_n31170739/))

<sup>9</sup> Ibid.



design professional to overlook the messy reality for the sake of being a good advocate.

Other potential design risks include:

- Liability for the increased cost of certain types of damages, such as lost profits, lost business opportunities, increased tax burdens, and energy costs;
- Liability for warranting an outcome without having sufficient control over construction means, methods, operations, and maintenance;
- Liability for structural problems and leaks associated with green roofs;
- Lack of proper sustainable design experience and qualifications on the part of the design team; and,
- Lack of control over material specifications and substitutions on the part of the contractors.

A 2009 Marsh Report made the following observations:

As of May 2008, all markets surveyed acknowledged that it is premature to draw any conclusions or to offer new coverage. Much will likely depend on the claim activity or lack thereof.

Insurers already have experienced claim activity. Below are several examples:

- Claim by developer against architect because building did not achieve LEED Gold Certification.
- Claim against architect and structural engineer due to water infiltration from green roof.
- Claim against design team because the cork flooring they specified resulted in water retention and mold.
- Claim against architect because lack of green product availability caused project delays.
- Claim against architect because health problems of tenants' employees increased despite warranties that the indoor air quality would improve.

### *Best Practices*

The American Institute of Architects understands the importance of risk issues and has a series of 14 different memoranda in the risk management best practices strategies section on their website.

A 2009 Marsh Report made the following observations:

Most markets believe that traditional design professional liability policies provide a significant amount of coverage for the negligent performance of professional design

services. However, the general consensus is that a key difference between traditional design and green design involves enhanced performance expectations (i.e., energy savings, employee productivity, etc.) and an evolving standard of care, which may not be covered by traditional architects and engineers professional liability insurance policies.

As of the date of creating this report, no insurance companies surveyed have made changes to their underwriting criteria, pricing and/or coverage with respect to the design of green buildings. Several insurers do provide risk and contract management advice for their design firm clients. Focus is placed on the avoidance of performance guarantees, the appropriate standard of care, and a well-defined scope of services.<sup>10</sup>

### ***Construction Contracts***

#### ***Risk***

There are substantial risks in all construction, and it is important to remember in thinking through this issue that most of the risks occur in both sustainable and conventional construction. Key sustainability risks in construction contracts relate to specialized processes, requirements, and performance expectations, and related issues. Participation in the integrated design process, recycling and documentation of construction waste disposal, and specialized subcontractor requirements are a few of the areas where problems have been identified to occur.

Traditional contracts, while containing much of what is needed for sustainable construction, are not necessarily optimal. In many cases, design-build contracts do not have major incentives for building performance, leading some design-build professionals to ignore building performance as “not their problem.”

Even more troublesome is that some professionals’ fees are tied to the cost of the systems they install. This actually gives the professional an incentive to *not* downsize systems. It is also perverse, since it is harder for the designer to optimize the design than just oversize it. This skewed incentive structure creates a raw deal for the developer. The increased first costs of an oversized system will cut into a developer/owner’s financial return. Moreover, since oversized systems typically are less efficient and cost more to maintain than optimally sized systems, NOI will be lower than it otherwise should have been. Therefore, the owner/developer is getting doubly hit, since her first costs are increased while her NOI on the back end is reduced, reducing the capitalized building value. Such a scenario reduces overall financial returns to the project.

The surety markets have not yet responded to potential risk issues. Based on a survey by Marsh published in early 2009, the surety markets (that provide payment, completion and performance bonds) have not specifically responded to the green industry. They noted key concerns revolving around onerous contract provisions and the risk of inadvertently guaranteeing a specific performance or efficacy for energy usage, water consumption,

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<sup>10</sup> Extracted from “The Green Built Environment in the United States, 2008 Year-end Update of the State of the Insurance Market,” Marsh, February 2009.

and/or LEED certification. Surety markets are looking at green contracts more closely, and it is possible, as more positive experiences are achieved, that new products will be available in this area.<sup>11</sup>

### *Best Practices*

The primary way that construction risk is mitigated is through higher equity requirements, fixed price construction contracts, retainage, budget contingencies, and payment, completion, and performance bonds. These practices are still at the heart of risk mitigation for sustainable properties, but legal counsel should review for sustainable nuances and risks as noted above.

Importantly, sustainable properties have both positive and negative risks related to the construction process. Best practice to mitigate risks that do arise is to make sure projects accrue the positive risk benefits that are available. A specific assessment of the key factors that can reduce cost volatility, entitlement risk, and legal risk should be made for the subject property

To assess potential benefits due to reduced construction risk, as a result of sustainability, it is important to evaluate the specific sustainability experience of the contractor, subcontractors, design team and other project participants. Given the added potential communication problems from having additional participants, team experience working together, or a plan to mitigate lack of prior team experience can be important.

### ***Marketing Risk: Misrepresentation and Fraud***

#### *Risk*

Sustainable property investors and developers are subject to claims of misrepresentation and fraud resulting from property marketing. These risks arise largely because the marketing process begins well before a project is certified, a lack of knowledge about the studies and data they cite, insufficient consideration of the specific application of studies and data to their project, and the actual variability in sustainability outcomes achieved by properties to date. As a result, sales and leasing brokers or principals marketing their projects have the potential to make claims that are untrue at the time that they make them.

There is also a substantial risk in presenting or promoting a project with unsupported claims. Capital providers, as part of their due diligence, often will uncover poorly supported or misleading facts and statistics, thus undermining the credibility of all of the appropriately argued and supported information in a funding request.

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<sup>11</sup> “The Green Built Environment in the United States, 2008 Year-end Update of the State of the Insurance Market,” Marsh, February 2009.

### *Best Practices*

Many in the market are confused about the difference between pre-certification, registration, certification, and other varying levels of sustainability. It is also important to be careful in making “first in market” claims or other claims that are not carefully researched. Given the long time frame in which marketing documentation often exists, these kinds of claims can also become untrue over the life of a document.<sup>12</sup>

It is particularly important not to cite industry studies without appropriate caveats and/or limitations. Many studies show that actual energy performance is quite volatile with a wide divergence among the individual results that make up an average energy savings. Consequently, if an owner cites averages in marketing their project, there is a high likelihood that they will be wrong.<sup>13</sup>

Project promotion risks can be mitigated through staff training and the development of protocols for reviewing marketing and promotion materials. A good discussion of these and other issues can be found in “Selling and Governing the Green Project: Owner Risks in Marketing, Entitlement and Project Governance,” Paul D. Arelli, *Real Estate Issues*,” Counselors of Real Estate, Vol. 33, No. 3, 2008. On a similar note, unsubstantiated or over-stated claims made during the entitlement process can also lead to problems, and potentially be turned around on a developer by becoming part of the requirement(s) of the development agreement.

The Federal Trade Commission has published a brochure, “Complying with the Environmental Marketing Guides” that provides the FTC staff’s view of the law’s requirements. The FTC Act gives the Commission the power to bring law enforcement actions against false or misleading marketing claims, including environmental or “green” marketing claims.

The FTC issued its Environmental Guides, often referred to as the “Green Guides,” in 1992, and revised them most recently in 1998. The Guides indicate how the Commission will apply Section 5 of the FTC Act, which prohibits unfair or deceptive acts or practices, to environmental marketing claims. Like other industry guides issued by the FTC, the Environmental Guides “are administrative interpretations of laws administered by the Commission for the guidance of the public in conducting its affairs in conformity with legal requirements.” Conduct that is inconsistent with the positions in the Environmental Guides may result in corrective action by the Commission, if after investigation, the Commission has reason to believe that the conduct violates prohibitions against unfair or deceptive acts or practices.

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<sup>12</sup> Paul Arelli, “Selling and Governing the Green Project: Owner Risks in Marketing, Entitlement and Project Governance,” *Real Estate Issues*, Counselors of Real Estate, Vol. 33, No. 3, 2008.

<sup>13</sup> Cathy Turner and Mark Frankel, “Energy Performance of LEED® for New Construction Buildings,” New Buildings Institute Final Report, March 2008, pp. 1-4.

The Environmental Guides apply to all forms of marketing for products and services: advertisements, labels, package inserts, promotional materials, words, symbols, logos, product brand names, and marketing through digital or electronic media, such as the Internet or email. They apply to any claim, express or implied, about the environmental attributes of a product, package or service in connection with the sale, offering for sale or marketing of the product, package or service for personal, family or household use, or for commercial, institutional or industrial use. See the complete text of the Environmental Guides.

<http://www.ftc.gov/bcp/edu/pubs/business/energy/bus42.shtm>

#### *Resources*

Energy Design Resources Design Brief: Performance-Based Compensation:

<http://www.energydesignresources.com/Resources/Publications/DesignBriefs/tabid/74/articleType/ArticleView/articleId/47/Design-Briefs-PerformanceBased-Compensation.aspx>

“Phrasing Is Key To LEED Projects”, by Jim Zehren:

<http://www.stoel.com/articletypes.aspx?Type=1230>

### **3. Service Provider Quality and Capacity**

#### *Introduction*

The quality and capacity of service providers was identified by our sustainable performance survey respondents as one of the key factors leading to failure or underperformance, and also a significant opportunity for risk mitigation through retention of qualified and experienced service providers.<sup>14</sup> While experienced service providers are critical to any real estate project, issues of service provider quality and capacity take on particular importance in the sustainable property investment marketplace. Rapid growth of the sustainable property marketplace and a disproportionate level of new products, materials, systems and processes enhance the opportunity for service provider underperformance when dealing with sustainable properties.

#### *The Sustainable Property Services Markets*

The services required to successfully complete a sustainable project will generally differ from a conventional project in two key ways: 1) the core service providers will have specialized knowledge about sustainability; and 2) the project will likely require several additional specialized services. Specialized services are required on many sustainable projects because they often have systems, features and verification requirements that conventional buildings do not have.

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<sup>14</sup> The Consortium conducted a survey of experienced sustainable consultants, developers and investors to assess those sustainable features and processes that had the highest level of failure and underperformance. The results of this survey and related research are presented in Chapter IV in the sections on sustainable process and feature performance.

For the purpose of this section and the broader purposes of the “*Value Beyond Cost Savings: How to Underwrite Sustainable Properties*” book, we define the service provider markets broadly, incorporating a full range of real estate and construction/development services as shown in Exhibit IV-2 below.

<b>Exhibit IV-2</b>	
<b>Service Provider Markets*</b>	
Real Estate Services	Construction-Development Services
1. Diversified national real estate service firms	<b>1. LEED /sustainability consulting</b>
2. Real estate consulting	<b>2. Sustainability/strategy consulting</b>
3. Appraisal	3. Systems/management consulting
4. Commercial property brokerage	<b>4. Commissioning</b>
5. Tenant rep brokerage	<b>5. Energy/other performance contracting</b>
6. Residential property brokerage	<b>6. Energy modeling/consulting</b>
7. Commercial mortgage/equity brokerage	<b>7. Energy audits/assessments</b>
8. Residential mortgage brokerage	<b>8. Renewable energy consulting</b>
9. Property/asset management	<b>9. Daylighting consulting</b>
10. Real estate law	10. Cost estimation
11. Real estate tax consulting	11. Construction management/consulting
12. Real estate accounting	<b>12. IAQ analysis and consulting</b>
13. Planning	13. Urban design
14. Property condition due diligence	14. Landscape design and architecture
15. Environmental due diligence	15. Project architecture
	16. Interior design
	17. General contracting/building
	<b>18. Specialized sub-contracting (HVAC, roofs, plumbing, electrical, etc.)</b>
	<b>19. Specialized equipment/ product installer</b>
	<b>20. Renewable energy contracting</b>
	21. Engineering: general
	22. Engineering: electrical
	23. Engineering: mechanical
	24. Engineering: civil
	25. Engineering: soils/geotechnical
	26. Engineering: other specialties

\* “New” sustainable property focused services are highlighted in bold.

The issues of service provider quality and capacity will vary significantly by property type, market, and the specific type of service. Given the rapid growth in the sustainable marketplace, some of the specialty consulting services such as daylighting consultants, commissioning agents, and other sustainable specialists are typically the hardest to find.

Many of the most experienced service providers focus their attention on their long-term clients and larger, more complicated projects, making it particularly difficult for smaller, less sophisticated projects, and new owners/developers who have not been big consumers of services in the past. A more detailed analysis of the real estate service provider market and key underwriting issues is presented in Section D: “Underwriting Service Providers” in Expanded Chapter VI: “Sustainable Property Underwriting Guidelines.”

### *Service Provider Risks*

Service provider capacity and quality are linked. When the capacity of experienced service providers is more limited, the quality of service provider options can suffer. Key failures or underperformance due to service provider capacity and quality problems include:

- Project delays that disrupt potential occupants and/or increase costs to the project development process.
- Insufficient or inadequate commissioning, leading to startup delays and additional occupant complaints and longer-term costs.
- Less experienced service providers may have more difficulty in “buying-in” to the integrated design process and create team problems due to less sophisticated communications.
- Reduced willingness to implement more pioneering or sophisticated sustainability approaches, which could result in long-term reductions in operating performance. What is pioneering or sophisticated to a less experienced service provider may be understood to be less risky to a more experienced service provider.
- Higher cost is a definite potential result of poor service provider capacity or quality. When demand exceeds supply, price will, and has, gone up for most experienced service providers. More importantly, those service providers with experience significantly reduce the relative cost disadvantages of sustainable property investment. Major builders like Swinerton, Webcor, Turner and many others assert publicly that construction of projects that are certified LEED should cost little or no more than a conventional project.

### *Service Provider Underwriting Best Practices*

As discussed before in the legal/contract risks area of this section, one of the ways to address potential service provider quality problems is to carefully design contracts, carefully review warranties, and move towards performance-based compensation, at least for some parts of service provider compensation. Greater specification of goals and outcomes, as well as the specific process and approach that a service provider will follow, can also be important.

Credentials and education can assist in the “vetting” process of evaluating service providers, but it will be important to understand the specific course of study and requirements of accreditations, certifications or other professional labels that people acquire. A credential does not mean that a specific individual or firm will be better than an individual or firm without such accreditation, but it shows a focus and willingness to understand the unique aspects of sustainable property investment that could make your project run smoother.

Given that the service provider undersupply problem is not likely to be rectified in the short term, owners and developers should also invest to train in-house staff in sustainable

building principles and practices. Some owners/developers complain that if they spend a lot of money to train their people in sustainability they will just leave and get another job. This does happen, but owners/developers must remember that the alternative is that you don't train them and they stay.

Another critical best practice element to understand is that sustainable practice is only a portion of what a real estate or a construction/development services provider needs to know. Depending on the specific area of specialty, it is critical that owners/developers do not over-emphasize sustainable training or focus to the detriment of fundamental real estate and construction/development skills. For example, fundamental leasing, construction, or architecture skill, independent of sustainable knowledge, is critical to successful projects. Owners/developers need to be careful trading off experience in the fundamental skill sets required to complete a project for a firm or individual's specialization on sustainable practice.

Retaining service providers with specific experience in the property type and challenges anticipated for a specific project is perhaps the most important practice to mitigate risk. Accordingly, spending sufficient time to develop a "vetting" process for the different sustainability specialties, and/or hiring LEED consultants or other team leaders with significant experience in this vetting process is important.

In this section, we briefly present three key service providers and what decision-makers should look for in selecting these professionals and organizations:

- Design Team;
- Contractor; and
- Asset Manager.

The role of each of these groups and suggested key questions to ask in selecting each are presented in the subsections that follow.

### The Design Team

The design team includes various professionals including architect, mechanical engineer, lighting designer, professional engineer and others. The decision-maker should consider the following questions to assess the experience level of the development team, individually and together, as it pertains to energy efficiency.

- Is the professional LEED accredited or accredited with similar credentials internationally? Are they experienced with LEED, Green Globes, ENERGY STAR or other certifications sought on the project?
- On how many properties?
- What were their results? Successes? Failures? Can they articulate lessons learned from past projects?
- Do they (the design team) have any experience working together?
- Do they have the willingness to work together collaboratively?



- Who will act as the lead to facilitate collaboration and to ensure that integrated design principles are employed?
  - Set a clear alignment of interests.
  - Ensure that interests are aligned throughout and incentives to completion support alignment.
- Who has final decision-making authority?
- Who bears ultimate responsibility for meeting objectives?
- Who covers over budget items?
- Who reaps the benefits of meeting objectives?

### Contractors

The contractor is ultimately responsible for executing the sustainable design. Experience in installing new-technology components and in sustainable construction practices is highly desirable. Some of the key questions to ask in selecting an energy efficiency contractor are as follows:

- How much experience does the contractor have in sustainable building?
- How early has the contractor been brought into the design process?
- Does the contractor understand the objectives?
- Is the contractor being incentivized on the basis of these objectives?
- Do the sustainable design features increase construction complexity?
- Will bringing the team together early on minimize these complexities?
- How reliable is the construction budget?
- Are materials readily available?
- Have the materials been tried and tested?
- Do the construction methods have a proven track record?
- Does the contractor have experience in the particular methods being proposed?
- Should contingency reserves be increased due to sustainable features or should they be decreased due to integrated design input?
- How will building codes and regulation either limit possibilities or create complexities?
- Are there any hurdles in getting insurance or bonding due to non-traditional construction materials or methods?
- Do sub-contractors have experience in sustainable building?
- Is it necessary to develop, communicate and train contractors on new protocols or building methods?

### Asset /Property Managers

Increasing reliance is being placed upon asset managers to help building owners achieve energy cost savings for individual buildings and portfolios. Asset managers have broad discretion to undertake a wide variety of measures ranging from re-lamping to retrofits. Demonstrated experience and competence in energy cost management, including implementation of energy efficiency upgrades, have become crucial qualifications for such professionals and organizations.

- What experience have managers had in implementing energy conservation projects (low-cost/no-cost, upgrades, retrofits, etc.)?
- What were the payback periods of those projects?
- What training has staff had in ENERGY STAR benchmarking for properties and portfolios?
- What is the experience or training specific to sustainable operating and maintenance practices?

Additional information on service providers and the process for implementing a sustainable office retrofit is available in “*Retrofitting Office Buildings to be Green and Energy-Efficient*”, a book published in late 2009 (see Chapters 2 and 4)<sup>15</sup>.

## **4. Energy Use Forecasting**

A key ingredient in the energy investment underwriting process is a forecast or projection of the dollar savings that the investment is likely to yield over time. For new construction or major renovations, this projection typically relies on some sort of energy use forecasting model to analyze how the interaction of the specific design features of a property affects overall energy use. This model output of energy use can then be compared to a “baseline” building, typically one that meets minimum building code requirements for the jurisdiction in which the property is located or in the case of a retrofit can also be compared to existing energy use or use presuming conventional improvements.

In this section, we trace the logical steps from understanding how energy performance is measured to the basis of comparison for assessing energy cost savings to the reasons why energy efficient buildings don’t perform as expected. We conclude with an analysis of energy prices, which are a critical component of any estimate of energy cost savings. More detailed background information and a repeat of some of the information in this section is presented in Expanded Chapter VI, Section E: Underwriting Energy-Carbon Reduction Investment.

A crucial aspect of the comparisons of forecast energy consumption between baseline and sustainable designs is that they only assume certain energy end uses for systems that the design team can control (so-called regulated energy components)<sup>16</sup>, such as:

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<sup>15</sup> “*Retrofitting Office Buildings to be Green and Energy-Efficient*”, principal authors Leane Tobias and George Vavaroutsos, Urban Land Institute, 2009.

- HVAC
- Building envelope insulation
- Service hot water systems
- Percentage glazing
- Solar shading
- Fan and pump motor efficiency
- Installed lighting power density
- Other specified systems

The baseline and sustainable comparisons do not include the impacts of process energy, which has to do with the actual use of the building and can cause wide discrepancies between forecast and actual energy consumption. Process energy has a specific definition in ANSI/ASHRAE/IESNA Standard 90.1-1999, *Energy Standard for Buildings Except Low-Rise Residential Buildings*: “energy consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for the occupants of a building.” Examples of process energy components are presented below and may include some of the biggest end uses in new commercial buildings<sup>17</sup>.

- Server rooms
- Lab equipment
- Cooking or restaurant equipment
- Security systems
- Building control systems
- Fire safety systems
- Computers
- Printers
- Copiers
- Other plug loads

As discussed in more detail below, process energy can be a major reason why a sustainable building’s energy performance may fall short of expectations.

#### *The Distinction Between Intended Design, As-Built Design and Actual Performance*

As a prerequisite to understanding how to assess an energy forecast’s reliability and accuracy, it is crucial to understand the differences between the intended design of a new

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<sup>16</sup> These items are referred to as “regulated” energy components, because they are regulated by applicable building codes.

<sup>17</sup> “The Proof is Performance: How Does 4 Times Square Measure Up?”, High Performance Buildings, Winter 2008, p. 31.

construction project or upgrade, the as-built design and the actual operating performance of the building. This subsection addresses these concepts in turn.

**Intended Design:** The intended design is a set of physical property specifications for building orientation, lighting, HVAC and other mechanical components, for a building of a given size. The periodic (e.g., monthly or annual) energy consumption for such a design can be simulated through the use of energy forecasting models, based on assumptions for a given use and occupancy of the project such as:

- Floor plan
- Construction type
- Number of occupants
- Number of computers
- Hours of operation
- Building use (offices, computer rooms, lunch rooms, copy rooms, etc.)
- Lighting loads
- Plug loads
- Other

Energy consumption can be forecast in the baseline case (meeting minimum building codes) and for various combinations of energy efficiency features constituting various levels of sustainability, always using the same set of assumptions for building use and occupancy.

*Forecast energy savings is the difference between a) the energy consumption forecast in the baseline design and b) the energy consumption forecast under a sustainable design, both for a given set of assumptions for building use and occupancy.*

**As-Built Design:** The as-built design is the design of the building as actually constructed. The as-built design may deviate from the intended design for several reasons:

- Changes in project budget
- Integrated design opportunities revealed during construction
- Problems with implementing new technologies
- Poor construction
- Other

The as-built design may have more or less energy efficient features or different combinations of energy efficient features than the intended design.

Similar to the intended design, periodic energy consumption for the as-built design can be simulated through the use of energy forecasting models, based on assumptions for a given use and occupancy of the project.

**Actual Operating Performance:** After the building has been placed in service, the actual use and occupancy become known. Furthermore, the actual energy consumption becomes known and, typically after at least a year of operations, a baseline measure of actual annual energy consumption for the building can be developed.

*Actual energy savings is the difference between a) the energy consumption forecast under the baseline design, given the actual building use and occupancy, and b) the actual energy consumption.*

So who should be concerned with what? An Owner/User evaluating energy efficient designs for a new building, is going to be concerned with forecast energy savings, i.e., is the additional investment (if any) justified by the forecast energy savings? An investor considering designs for a new building (as well as a lender or appraiser) is going to be concerned more with the absolute level and cost of energy consumption, as this will translate directly to NOI and value.

Once the building is built and occupied, the occupancy and use profile represent the actual requirements of the Owner/User or Tenant. Whether or not these requirements were foreseen during the planning stages of the project, the Owner/User will benefit directly from the implementation of the energy efficient features.

#### *Energy Forecasting Risks*

The key risk of energy models and their forecasts is that the actual building fails to live up to the performance indicated in the model. A significant underperformance of expected energy savings would have a negative impact on net operating income (NOI), reducing expected building value and the owner/ investor's rate of return (ROI). In an extreme scenario, this underperformance could even cause the building to breach a debt service coverage ratio covenant, or at a minimum drastically alter Simple Payback or Simple ROI calculations upon which investment decisions may have been based.

Another broad risk related to energy models is that other investors may begin to perceive all models overstate energy savings. If an energy model of a green building indicates significant savings over a baseline design, future investors may discount this performance if they perceive energy models to be historically unreliable. If the developer or redeveloper of a property is looking to sell it before the project is complete or before full occupancy has established the actual level of energy use, this uncertainty over the future level of energy use could result in reduced value to the building.

Below, we discuss the reasons why 1) energy forecasts differ from actual energy performance and 2) energy savings forecasts may differ from (i.e., fall short of) actual energy savings. These findings are based on a review of key literature and interviews with ten top energy-forecasting specialists.

1. Inherent inaccuracy of energy models. Energy forecasting models, while generally considered fairly accurate, are subject to some level of intrinsic error

ranging from 10% to 20%. This forecasting error is interpreted as the percentage error between actual energy consumption and forecasted energy use based on a building's actual design characteristics and use profile, including actual process energy.

Examples of whole building energy simulation models include eQuest, DOE-2, Trane Trace, EnergyPlus, 700, and GB Studio. There are many modeling and evaluation tools for individual energy efficient features that provide estimates of energy consumption and energy savings. The U.S. Department of Energy website provides an assessment of numerous energy modeling tools, and the Center for the Built Environment website <http://www.cbe.berkeley.edu/> contains various assessments of energy forecasting models as well.

2. The accuracy of the forecasts closely depends upon the skill level of the modeler. Skilled modelers can tweak or trick the model to adjust for factors that might otherwise be outside the capabilities of the model. In some instances, highly skilled modelers will write and validate new algorithms to address specific design features. However, sometimes the tedious task, including making decisions on many assumptions, is assigned to newer, less-skilled staff members. Energy modeling is part art and part science, and energy-modeling practices are not consistent.
3. Given the proliferation of new building technologies, it has been increasingly difficult for modeling software to keep up. For example, it can be difficult for a model to accurately integrate the effects of daylighting and natural ventilation.
4. The design parameters of the building fall outside of the range that the model can adequately handle. For example, while models account for window area, building design may include a particularly large amount of window area. Another example is a model's ability to simulate daylighting effects for a 15-foot deep room, while the design calls for a 30-foot deep room.
5. The model or modeler does not adequately address property type issues that arise, for example, in big-box retail, laboratories, hospitals or other specialized property types, or does not address unusual design features such as building arms, wings or projections.
6. There are design flaws in energy efficiency components that may be relatively new and/or untested. The components do not perform as expected.
7. Thermal massing causes cooling loads to be greater than anticipated. Thermal massing results from the absorption by building components of heat generated from solar, machinery, human and other sources.
8. The building is not built to the original design specifications: energy efficient features have been omitted or improperly installed.

9. The building is not built to the original design specifications: space design has changed, like adding lunchrooms, additional copy rooms, etc.
10. The building is not operated in the same manner as the assumptions used in the design phase:
  - Process energy (described above) was not taken into consideration in the design phase;
  - Occupants or facility managers override energy saving features;
  - Longer hours of operation; and
  - More occupants.
11. Sustainable O&M techniques are not employed. Research has indicated that buildings with sound O&M practices may outperform other buildings that have more energy efficient features.
12. Sufficient time was not allowed for the building to “settle down” after being put in service and before measuring energy consumption. A rule of thumb is that it takes about one year for a newly constructed building to settle down or stabilize in terms of its energy consumption.
13. Fundamental commissioning was not performed. If energy efficient systems have not been commissioned to operate as designed, expected performance levels would not be obtained.
14. Actual variations in weather. Energy models are based on assumptions about local historical weather patterns. In the first year a new building is benchmarked against modeled performance, weather may be more severe than assumed during the design phase.
15. Improper weather benchmarking. In locations that are subject to micro-climate variations (such as the San Francisco Bay Area), weather at the site may differ from the weather at the location from which historical data was taken in the modeling process, for example, at an airport.
16. For existing buildings, prior deferred maintenance in relation to upgrades leads to increased energy use. For example, replacing broken light fixtures that used no energy with energy efficient fixtures that use some energy will increase energy consumption and energy costs.
17. Actual energy prices may differ from those used to forecast energy cost savings. Energy models typically include forecasts of energy costs for the building as well as consumption. Total energy consumption for the year is based on an hour-by-hour simulation of energy consumption. Energy costs are based on assumptions about energy prices, which are usually assumed to be the prices in effect at the

time the modeling is done, including peak, off-peak, shoulder and other utility pricing mechanisms. If energy prices are higher or lower than assumed in the modeling process, actual energy cost savings will differ from the forecast. A more detailed analysis of the importance of energy prices in underwriting energy efficiency investments is provided below.

#### *Assessing the Reliability and Accuracy of Forecasts of Energy Performance*

Given the importance of assessing the reliability and accuracy of energy forecasts, we have prepared a list of questions that will assist the underwriter in this process.

- What benchmark data is available from comparable conventionally designed properties?
- Have clear and aggressive energy use targets been identified?
- Which combination of energy efficiency strategies would be most effective for this project?
- Are there any design features that are outside the range of the energy model's capabilities?
- How reliable is energy modeling?
  - How much experience does the engineer modeling have with this type of project?
  - Have their modeling results on other projects been reviewed to compare modeled vs. actual results?
  - What benchmarks can be utilized to track accuracy and highlight variances to the norm?
  - What data is available to support modeling results in similar projects with similar systems?
- Have different design alternatives been modeled?
  - Model and analyze energy efficiency strategies collectively, not independently (e.g. a project such as upgrading an inefficient chiller that may have a 3-year payback when analyzed in isolation could have a 5-month payback when coupled with load-reducing strategies such as high-efficiency lighting or high-performance glazing. Combining a lighting retrofit and high-performance glazing with a new smaller chiller might have the same capital cost as a larger chiller. Additional benefits may be derived from more efficient operations and consequently lower operating costs.)
- How will you ensure that the alternatives will meet the objectives?
- How will building performance be monitored over time?
  - Does the design allow for operational enhancements as needed?
  - How will adjustments be made and subsequently measured?



- Has the design team fully vetted potential negative design elements and identified appropriate mitigants? For example, daylighting can have the unintended consequence of glare and excessive heat. Mitigants may include proper glazing, or the use of outside design features to block direct sun from work surface.

Many of the risks to reliable and accurate forecasts above can be effectively mitigated with three important steps: using an experienced energy modeler, hiring a competent commissioning agent, and ensuring proper measurement and verification.

Experienced energy modelers can often tweak the modeling software packages to more accurately reflect cutting-edge features and building nuance that less-experienced modelers may miss. They will also have a track record of modeling projects and can provide the owner with a reasonable idea of the range of variation to expect from the predicted results based on experience.

Competent commissioning agents will work with the building systems to ensure that they perform as designed, thereby providing more accuracy to energy forecasts. They will also run functional tests of the buildings systems before occupancy and check how close these systems come to their expected performance. If they underperform significantly, a good Cx agent will also be able to develop solutions to the problem.

Proper measurement and verification (M&V) will also provide the O&M staff with live data to verify that the building is performing as expected. This way, if they see actual energy use significantly higher than predicted energy use, they can diagnose the systems in order to bring actual energy use more in line with the predicted values, assuming that they are trained in how to interpret and act upon the M&V data.

### *Resources*

Substantial resources are identified and discussed in this chapter in Section F-3: “Building Energy Use” and in Chapter VI, Section E: “Underwriting Energy/Carbon Reduction Investment” as well as in the Consortium’s Research Library and Industry Links under codes 9.0, 15.63, and 24.7.

## **5. Regulation and Code Compliance**

Sustainable property investments, whether they are new construction, retrofits, or commercial interiors, often encounter regulation and code compliance problems. Regulation and code compliance problems can occur in meeting broader regulations that require LEED and/or other levels of environmental certification, or a more micro building code level involving fire and safety regulations, plumbing codes, and operational issues regarding the use of elevators, tenant behavior, management practices, and related issues.

Problems often arise due to conflicting goals between sustainable performance and life and safety requirements, the ability to measure and document performance, and failure in

communications. Regulation and code compliance problems can occur even when local municipalities, building owners and tenants are all committed to sustainability due to the chasm that often exists between the aspirational statements of city leaders or building owners and the realities of the day to day implementation of regulation and code compliance with specific building code and building operations personnel.

### *Risks*

The key risks related to regulation and code compliance problems include delays in project completion, additional costs due to delays or design modifications, reduced environmental or financial benefits, and finally the inability to obtain expected rebates or other financial incentives.

To better understand the risks related to regulation and code compliance, it is important to understand the fundamental difference in thinking between a sustainable property that is based on an integrated combination of features and systems and the code compliance process, which has historically been based on a feature-by-feature or system-by-system compliance assessment. The priority and importance of fire and safety requirements also makes compromise and innovation more difficult.

The magnitude of regulation and code compliance risks varies significantly by country, state or province, and municipality. Risks will vary based on the regulating authority's commitment to sustainable principles, the level and complexity of code compliance, the administrative requirements to address regulatory or code compliance problems, and related factors.

### *Examples*

Some examples of regulation and code compliance problems include:

- Plumbing codes and union requirements often make waterless urinals more difficult to implement, or more costly if redundant plumbing systems are required.
- Rooftop water storage and other water savings or reclamation strategies often must address and overcome municipal code issues.
- Key fire and safety requirements often affect various energy-saving strategies or materials choices.
- Internal tenant bike racks, showers, green cleaning strategies, and related sustainable design features can conflict with building operating strategies and/or space use limitations in leases.
- Rebates and related financial incentives can be difficult and expensive to document, limiting their value and use.

### *Regulation and Building Code Best Practices*

The most important best practice is to be fully aware of the nature of regulation and code compliance problems that can arise and appropriately research and communicate with local and state officials critical to achieving compliance. It is particularly important to not rely upon the assertions or statements of city leaders or building owners in determining the importance of addressing these issues, given the chasm that often exists between leaders and the people responsible for compliance implementation on the ground.

If potential problems appear possible, then efforts need to be undertaken as soon as possible to address potential solutions, particularly if they involve action in the political realm. Experienced consultants or other service providers should be aware of the key issues that are likely to arise, but if new or pioneering technologies or systems are contemplated, it is important to address their potential implications on regulations and codes at an early stage.

To the extent that potential operational issues exist that may be addressed in leases, they can be addressed through key clauses in newly designed green leases that address behavioral and operational issues that can arise. Depending on the number of tenants and the complexity of the particular property situation, these issues can also be addressed with existing tenants if dealt with early.

## **6. Commissioning**

Commissioning (Cx) is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.<sup>18</sup> A professional commissioning agent appointed by the owner carries out the process. Commissioning is a more comprehensive version of standard mechanical system testing, adjusting, and balancing (TAB). Although commissioning was originally created to ensure that HVAC systems were correctly specified and properly installed in building projects, the process can and often should be applied to nearly any building system.

Commissioning for existing buildings (sometimes referred to as retro-commissioning) is a systematic process for investigating, analyzing, and optimizing the performance of building systems by improving their operation and maintenance to ensure their continued performance over time. This process helps make the building systems perform interactively to meet the owner's current facility requirements.<sup>19</sup>

A basic commissioning process is a prerequisite for LEED certification. The cost of commissioning is usually between \$0.30 and \$0.90 per square foot, though this varies depending on the size of the project, the types of systems being commissioned, etc. One

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<sup>18</sup> "Design Briefs: Building Commissioning," Energy Design Resources (<http://www.energydesignresources.com/>)

<sup>19</sup> Building Commissioning Association (<http://www.bcx.org/>)

study estimated that the cost of a whole building commissioning could cost from 0.5% to 3% of the total construction cost.<sup>20</sup> Cost will vary based on the comprehensiveness of the engagement, when the agent is brought in to the project, the type of property, and other factors. Properties like apartments and hotels, with a substantial volume of individual units to check, can be substantially more expensive.

In one of the most comprehensive evaluations of the outcomes from commissioning, Lawrence Berkeley National Laboratory found evidence of the effectiveness of commissioning.<sup>21</sup> This analysis of the benefits of commissioning was conducted on 224 buildings in 21 states representing 30.4 million sf of commissioned space (73% existing buildings, 27% new construction). The review resulted in the following observations<sup>22</sup>:

- An average of 11 deficiencies were found in existing buildings, 28 in new buildings. HVAC systems represented the bulk of problems.
- For existing buildings, median commissioning costs were \$0.27/sf; energy savings came to a median of 15% resulting in payback times of less than nine months.
- For new buildings, commissioning costs were \$1.00/sf (0.6% of total construction costs), yielding a median payback of 4.8 years.
- Reduced change orders and other non-energy benefits accounted for \$0.18/sf savings in existing buildings and \$1.24/sf in new construction – “comparable to the entire cost of commissioning” the researchers note.

The value of commissioning was confirmed in a July 2009 study by Evan Mills: “Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions”. Based on data from 37 commissioning providers representing 643 buildings comprising 99 million sq. ft. of floor space from 26 states, the study made the following key findings:

- Median commissioning costs: \$0.30 and \$1.16 per square foot for existing buildings and new construction, respectively (and 0.4% of total construction costs for new buildings).
- Median whole-building energy savings: 16% and 13%.
- Median payback times: 1.1 and 4.2 years.
- Cash-on-cash returns: 91% and 23%.
- Very considerable reductions in greenhouse-gas emissions were achieved, at a negative cost of -\$110 and -\$25/ton CO<sub>2</sub> equivalent.

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<sup>20</sup> “Design Briefs: Building Commissioning,” Energy Design Resources (<http://www.energydesignresources.com/>)

<sup>21</sup> Evan Mills, PhD and colleagues at Lawrence Berkeley National Laboratory, “The Cost-Effectiveness of Commercial-Buildings Commissioning: A Meta Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States,” Portland Energy Conservation and Texas A&M University research, 2006.

<sup>22</sup> Ibid p. 36-37.

- High tech buildings are particularly cost effective, and saved large amounts of energy and emissions due to their energy intensiveness.
- Projects employing a comprehensive approach to commissioning attained nearly twice the overall median level of savings.
- Non-energy benefits are extensive and often offset part or all of the commissioning cost.

An article by Michael English provides a useful primer on commissioning and reported the following conclusion:<sup>23</sup>

Organizations such as the NYS Energy Research & Development Authority (NYSERDA), US Green Building Council and Portland Energy and Conservation, Inc. (PECI) have calculated anywhere between 15%-30% energy reduction for buildings that are commissioned [compared] to buildings that are not. (Page 121)

The article also makes note of another link between commissioning and value in that commissioned buildings typically receive a certificate of operation sooner. This allows them to convert their construction loan to a conventional loan sooner, thereby saving on interest costs. It is further suggested that the commissioning provider be involved throughout the project from the pre-design phase through the warranty phase.

Carnegie Mellon reports positive findings on commissioning:

CMU's BIDS™ has identified seven retro-commissioning case studies indicating an average annual savings of 8.1% in total building energy consumption. These seven studies demonstrate that retro commissioning results in annual energy cost savings of approximately \$0.15 per square foot.

While the benefits of retro commissioning will diminish over an average of four years, the initiative is more than paid for in the first year of savings, and the four-year net present value of the savings averages \$0.64 per square foot.

CMU's BIDS™ has also identified four building case studies that demonstrate an average of 17.4% total building energy savings annually due to continuous commissioning. These four studies demonstrate that continuous commissioning yields average annual savings of \$0.30 per square foot for energy alone, with facility management and failure costs not yet quantified.

Additional commissioning benefits that are difficult to quantify include better indoor air quality and environment, reduced occupant complaints, increased occupant comfort and productivity, and reduced facility management costs.<sup>24</sup>

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<sup>23</sup> Michael C. English, PE, CCP, LEED, "Commissioning (Cx) 101, The Cost and Benefits of High-Performance Buildings," Horizon Engineering Associates, 2007.

<sup>24</sup> Carnegie Mellon Energy Related Investment Decision Support (eBids website, July 2009.)

### *Commissioning Risks*

A key risk factor influencing cost and quality is the availability of competent/experienced commissioning agent(s). Survey respondents have experienced problems in retaining quality commissioning agents due to a lack of qualified commissioning agents. Since commissioning has historically been used on only approximately 1% of buildings, the number of experienced people has been limited. Good commissioning is sort of like being a good auto mechanic: the best ones can properly diagnose complicated problems based on the year, model and make of the car and noises it makes, while less experienced mechanics may spend more money and not really solve the problem.

The lack of generally accepted industry standards for a general scope of commissioning work leads to widely varying proposals in terms of scope and costs. Settling for little more than a test and balance procedure, which is done in all new buildings, will likely result in systems that don't work as designed. This could result in a lower performing building, since the energy savings and occupant comfort forecasts assume the systems are performing at a high level.

Moreover, if the owner is unwilling to pay for the heightened level of coordination between design, construction and commissioning teams, which takes extra time, this will lead to a lack of buy-in for commissioning, making effective commissioning difficult. The commissioning agent must be able to coordinate and collaborate with the architect, contractors and engineers in order to complete commissioning. If the owner fails to incorporate commissioning into the project requirements, the construction or design team may not be interested in helping, as they may feel that time spent with the Cx agent was not properly compensated. However, most professionals are happy to work with a Cx agent as long as they know from the start.

Sometimes commissioning problems arise due to the identity of the commissioning agent. Contractors or the engineer of record may have conflicts of interest if they also serve as Cx agents. Since the Cx agent essentially checks the work of the contractor, if they see something lacking or not up to the owner's design requirements, they will ask the contractor to redo it. This additional expense will come out of the contractor's fee and reduce the contractor's margin on the job. Without proper management and disclosure, these conflicts of interest could result in underperformance. One commercial real estate owner also told us that the size of the Cx agent's shop is important. If the Cx agent runs a one-man shop and gets sick for four weeks or goes on vacation, that can result in project delays.

Commissioning can also run into problems when the Cx agent is brought on too late in the process. Since the Cx agent serves as a check on the work of others to ensure the project meets the design intent and performs up to expectations, bringing a Cx agent on too late may result in more expensive change orders if they find something not up to par. Bringing the Cx agent on later also increases the likelihood that the project team doesn't buy into commissioning, potentially reducing the effectiveness of the process.

Another problem with commissioning of a core-and-shell building is that the Cx agent usually only commissions the main building systems, not tenant improvements (“TI”). Therefore, TI often lacks the same sort of quality control process that the core and shell systems receive. This is an issue of allocating the costs and benefits of Cx, and should be worked out by tenants and owners/ developers.

Commissioning of the building envelope is seen as an increasingly important issue with sustainable properties.<sup>25</sup> Uncontrolled rainwater penetration, condensation and moisture ingress are three of the most common threats to the long-term durability of a property. Heat transfer through the building envelope is a critical design issue, particularly in buildings with floorplates less than 15,000 square feet, and when trying to achieve energy efficiency and related sustainability goals.

Since Cx is often perceived as a big and/or additional cost item, it sometimes gets skipped by owners of sustainable buildings that are designed to LEED standards but do not actually pursue the rating. The risk of this approach is that the building may not perform up to expectations. Getting the Cx agent’s independent stamp of approval that the building works as intended is a significant risk mitigation tool for the owner. The commissioning agent can also reduce uncertainty around the variation between actual and modeled energy performance by confirming a property is operating as designed, which should result in higher NOI’s in the underwriting process.

#### *Commissioning Example*

The following case study is an excerpt from the Energy Design Resources Design Brief on Commissioning. It shows what can happen when the commissioning process is not properly executed:

When the University of Montana constructed a new building for its Gallagher School of Business Administration, the university contracted with the mechanical and electrical engineer to facilitate the commissioning process. Unfortunately for the university, even though commissioning requirements were included in the specifications, the commissioning contract was executed so late in the construction process that commissioning tests did not begin until the building was nearly completed. When the university moved into the building, serious flaws became evident. The building controls were so unstable that temperatures and airflows varied widely from their intended values. Some rooms were too cold, some rooms were too hot, and odors were so prevalent in one lecture hall that the class had to be moved. Some air handlers were inaccessible, and the filters could not be properly maintained. The filter in one air-handling unit was found to be so dirty that it was being sucked into the fan by the airflow.

#### *What Went Wrong?*

First, the commissioning requirements in the specifications were incomplete. Although commissioning information for the mechanical and electrical systems had

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<sup>25</sup> Daniel Lemieux, AIA, “Trust, But Verify... Building Enclosure Commissioning in Sustainable Design,” *Real Estate Issues*, Volume 33, Number 3, 2008.

been added during the design process, the overall commissioning process had not been described in a specific commissioning section. In addition, commissioning was not listed as a requirement for substantial completion (payment), so once the building was occupied, the contractors departed—leaving behind many problems that still needed to be resolved.

Second, the commissioning process was initially underfunded and was restricted to an unreasonably short schedule. As a result, the commissioning agent tried to reduce his costs by relying on contractors to perform many of the checks. Unfortunately, because the contractors did not understand the commissioning requirements, the tests and inspections that did get done were often done incorrectly—and were therefore not very useful.

Third, commissioning tests were not started until construction was nearly complete. Even then, poor communication between the commissioning agent and the contractors led to misunderstandings—many inspections either were not done or were not witnessed by the commissioning agent. Problems that could have been identified and corrected during the construction phase went unnoticed until it was too late for efficient solutions.

After it became apparent that the initial building commissioning effort had been inadequate, a specialized commissioning firm was hired to do the job properly. At considerable cost, a detailed commissioning plan was developed that included static inspections as well as functional performance tests. The second commissioning agent found hundreds of discrepancies, including incorrectly programmed controls, misplaced sensors, standard- efficiency motors provided where high-efficiency motors were specified, and incorrectly set outside-air damper stops. Most of these problems were ultimately corrected, but it would have been far less expensive—and more effective—to have done the commissioning right the first time.<sup>26</sup>

### *Commissioning Best Practices*

Commissioning can be valuable for most building types and situations, but is particularly valuable for the following types of buildings:

- Large or complex buildings (size and complexity not always linked);
- Buildings with very large loads on the mechanical equipment, such as laboratories;
- Buildings with highly variant occupancy levels; and
- Buildings in extreme climates.

While the best practices for commissioning can get detailed, six straightforward steps can go a long way to improving commissioning:

**1) Clear Definitions:** Clearly define roles and responsibilities of commissioning participants, the scope of work goals, and the current facility requirements.

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<sup>26</sup> “Design Briefs: Building Commissioning,” Energy Design Resources (<http://www.energydesignresources.com/>), pg. 19.



**2) Bring the Cx agent on early.** As one commissioning expert notes, “any owner who has done commissioning at some point during the construction phase will say: ‘next time we want to start sooner (Karl Stum- Environmental Building News: Building Commissioning: The Key to Buildings That Work).’” Bringing the Cx agent on in the predesign phase will ensure that any problems that arise can be fixed during the design stage at minimal cost to the owner.

**3) Make sound compensation and quality decisions.** Work to match the quality and experience of the commissioning agent(s) with the complexity and sophistication of the job. Paying for quality and sufficient involvement of commissioning agents is important. Credible groups, such as ASHRAE and the Building Commissioning Association, offer commissioning agent certification.

**4) Manage conflicts of interest.** If the owner has a specific reason for appointing the architect, engineer of record, or contractor rather than an independent Cx agent, ensure that processes are established to manage conflict of interest. A Cx agent with no conflicts of interest may be in a stronger position to advocate solely for the building owner.

**5) Get buy-in from the team.** Incorporate commissioning requirements into specifications so the design and construction teams know what they’re getting into. Ensure that the budget will cover the up-front cost needed to pay designers for extra time spent coordinating with the Cx agent.

**6) Continuous commissioning or annual re-commissioning.** Annual recommissioning can supplement a good monitoring and verification program to improve O&M and keep the building running optimally. According to the ASHRAE GreenGuide, building performance generally declines two to five years after being commissioned.

*Resources:*

For a complete selection of key commissioning guides, articles and related documents go to the Consortium’s Research Library and search index sub-code 24.3: Commissioning. Additional commissioning websites and additional documents are available in the Consortium’s Industry Links section index code 24.3. Select resources are identified below.

A detailed 19-page guide to best practices for existing building commissioning is: “Best Practices in Commissioning Existing Buildings,” Building Commission Association, August 18, 2008.

<http://www.bcxa.org/resources/index.htm>

Building Commissioning Handbook, Second Edition, BCA

<http://www.bcxa.org/resources/pubs/index.htm>

Trust, But Verify... Building Enclosure Commissioning in Sustainable Design, Daniel Lemieux, Real Estate Issues, 2008

<http://www.entrepreneur.com/tradejournals/article/192452486.html>

Energy Design Resources Design Brief: Building Commissioning:

<http://www.energydesignresources.net/Resources/Publications/DesignBriefs/tabid/74/articleType/ArticleView/articleId/109/Design-Briefs-Building-Commissioning.aspx>

Environmental Building News: Building Commissioning: The Key to Buildings That Work:

<http://www.buildinggreen.com/auth/article.cfm/2000/2/1/Building>

A new database and analysis service collects information from users on facility costs and sustainability, and allows facility manager to compare their buildings to others using more than 30 data filters that ensure meaningful comparisons to similar buildings. The tool, FM Benchmarking from FMLink and Facility Issues, uses cost data on utility usage, maintenance, and cleaning. The program assesses sustainability-using measures from the LEED for Existing Buildings rating system. FM Benchmarking generates graphs and tables that show the user's building in relation to comparable facilities, LEED certification requirements, and best practices appropriate for the building.

Currently the database has information for more than 800 million square feet (74 million square meters) of building space. Access to the service is by annual subscription; full use of FM Benchmarking costs \$375 for one building; there are discounts for additional buildings.

FM Benchmarking, FMLink and Facility Issues

<http://www.fmbenchmarking.com/>

## **7. Measurement and Verification**

*Introduction:*

Measurement and verification (M&V) is an important process for monitoring resource consumption after construction or major retrofit. Did the building or system perform to expectations? Better? Worse? M&V is a set of procedures and testing methods that can help answer these questions. M&V most often is applied to energy use, but also can be used to analyze consumption of any resource, including water, materials, and indoor air quality. Standard energy M&V assesses energy use in a few different ways, including dedicated metering with data logging, utility bill analysis, or energy modeling.

Essentially, after a new project is completed or an upgrade is undertaken, energy bills may still go up. This could be because the project failed, but most likely it is due either to higher electricity prices or changed facility conditions that lead to increased energy use unrelated to the project. For example, if an energy retrofit is completed successfully, but electricity prices rise and while the retrofit was being completed a large number of new server computers were added to the building, it will naturally have higher electricity bills. All this could apply in reverse, too. Good M&V, therefore, is a method for comparing the

before and after energy bills on an apples-to-apples basis and removing the effect of higher (or lower) electricity prices and changing conditions driving energy use.

*Risks:*

M&V is a complex process and a definitive accepted industry standard has not emerged on how to implement the process. This is an area that has, and is, receiving a lot of attention due to renewed focus on energy issues, labeling initiatives, and the realities about the information needs of facility managers faced with managing energy use.

M&V design and implementation can be suboptimal if the O&M team is not part of the process. M&V must reflect the realities of the O&M of that particular building, and O&M will provide key input in this regard.

One common risk is a lack of follow through after the project is completed. The developer will spend a good deal of money and time developing a functioning M&V system, but the operations side somehow drops the ball and doesn't fully implement the system. This can even occur when the construction and design teams collaborate with operations people. Ultimately, it is up to developer/owner to make it clear to O&M team how important follow through is on M&V. You can't reduce or control what you can't measure.

Another problem with M&V is installing or designing the necessary systems too late in the design process. If a building is pursuing energy saving strategies, M&V should be programmed into design from the start. It is easier and cheaper to set up the meters properly if the design team plans for them from the start. For example, if the electrical engineer knows that the intent is to measure all lighting and HVAC energy separately, they can appropriately structure the building's electrical system to accommodate this.

If engineers or building managers are not properly trained on how to run the building at optimal levels, then even a good M&V process may fail to result in high performance as the staff will not know how to interpret the M&V data or fine tune the building after data starts coming back indicating underperformance.

M&V can also be a risk-mitigating tool. It provides owners with a scorecard of how well the building performs from an energy perspective. This allows the owner to have a better idea of whether the design team has met their contractual obligations and also allows the owner to market the building and provide the data to prove it. This will become more important in the future as requirements for labeling and reporting building performance become more widespread.

*Measurement and Verification Best Practices:*

While detailed best practices can be complex, and vary significantly by project type, three simple best practices are identified below:

- 1) Introduce the M&V concept early in the project, as it's least expensive and most efficient to design the necessary M&V equipment into the systems from the start. One sustainability consultant mentioned that this has the added benefit of focusing the design team on the operations side of the building.
- 2) Develop an M&V plan that incorporates the goals of the building, the protocol for using the M&V data, and establishes who is responsible for the management of the process. This helps bridge the gap from construction to O&M.
- 3) Train the O&M staff to read and interpret the M&V data. This ensures that the staff will be able to fine-tune the building to minimize energy use.

*Resources:*

Energy Measurement and Verification —The Key to Quantifying Real Savings:

<http://www.fmlink.com/ProfResources/Sustainability/Articles/article.cgi?USGBC:200510-01.html>

Environmental Building News: Measurement and Verification:  
Monitoring Building Systems for Optimal Performance:

<http://www.buildinggreen.com/auth/article.cfm/2006/6/7/Measurement-and-Verification-Monitoring-Building-Systems-for-Optimal-Performance/>

International Performance Measurement and Verification Protocol:

[www.ipmvp.org](http://www.ipmvp.org)

Federal Energy Management Program's M&V Resources:

[http://www1.eere.energy.gov/femp/financing/superespcs\\_mvresources.html](http://www1.eere.energy.gov/femp/financing/superespcs_mvresources.html)

## D. Feature Performance<sup>27</sup>

The focus of this section is on sustainable property feature performance and risks. The importance of feature performance, relative to financial analysis and valuation, is how it contributes to the overall building performance, which can then, through an assessment of the market's response, be translated into financial performance. Additionally, underwriting of feature selection and performance is an important part of risk analysis and mitigation.

The performance of specific features, systems or strategies has been a critical focus of financial analysis historically in energy efficient/sustainable properties. While this focus can be appropriate when replacing a particular system or feature in a building, or when making decisions about the relative financial merits within a particular feature (type of light bulbs, windows, or glazing, for example), the industry has grown to understand that a

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<sup>27</sup> We use the term "features" to refer to the broad array of features, products, systems and strategies employed in the sustainable property industry to address key building functions like lighting, water savings, indoor air quality, etc.

more holistic analysis of buildings, rather than a feature by feature analysis, is the preferred overall design and financial analysis strategy.

Feature based performance analysis have typically focused on cost savings, and, in select cases, a simplified capitalization of operating cost savings, to develop simple pay-back or simple return on investment conclusions. However, as the sustainable investment challenge has moved to determining the maximum technically and economically feasible level of sustainable investment, such cost-based feature-by feature models have become less reliable and accurate. More holistic financial models, like the discounted cash flow analysis discussed in Chapter V, are needed to accurately reflect all benefits and risks that result from investment decisions.

Practically, a complex DCF financial model is not possible, or necessary, for all decisions, but even simple feature-based financial analysis can be supplemented with an independent and intelligently organized assessment of revenue and risk implications that can assist decision-makers. These types of supplementary analyses need to be property specific, address both positive and negative risks, clearly articulate risk mitigating facts and circumstances, and be organized to support an assessment of financial implications through conceptual linkages to the discounted cash flow model. (This is the focus of Chapter V).

Decision-makers should be cautioned that in many cases the specific structure of these financial models, as well as the data on both costs and benefits, are often supplied, either directly or indirectly, from product suppliers and manufacturers, and thus must be appropriately screened and considered.

## **1. Feature-Based Financial Performance**

The sustainable property industry has focused on research that demonstrates the financial performance of specific features. For example, there are many specialized financial models to calculate the financial benefits of green roofs, daylighting, HVAC systems, specialized water saving systems, occupancy and lighting controls, acoustical tiles, etc.

These feature-based financial models are discussed in detail in Section C, Step 1: Select the Financial Model, of Chapter V: “Sustainable Property Financial Analysis.” Additionally, Appendix F: “Financial Analysis Alternatives,” presents 40 pages of financial models and provides links to websites with many more. These types of financial models can also be found in the Consortium’s Research Library and Industry Links sections of the Consortium’s website under index code 1.2: Traditional Sustainability Financial Analyses.

While there are scores of feature-based financial analyses, below we present information from a select few sources that we find are illustrative, and provide interesting input and insights, in general, about the cost-based reasonableness of certain features and systems. “*Retrofitting Office Buildings to be Green and Energy-Efficient*”, a book published in late

2009, provides a detailed Chapter on the elements of Green Office Retrofits and related case studies and implementation advice that is also helpful.<sup>28</sup>

When applying such general studies to a particular property, it is important to carefully assess the applicability of the research (time of study, property type, comparability of sustainable features/outcomes, geography, etc.), its quality, and key underlying assumptions. In general, particular care must be observed when combining cost and benefit calculations from separate feature analysis due to double-counting and related issues.

Features or systems do not always perform as expected. Sometimes underperformance will require replacement of a feature or system or a significant redesign or re-engineering. In fact, based on our survey of practitioners and experience, feature or system problems are more often than not an issue of a mis-use or misapplication, rather than a complete product or system failure. For example, green roofs that are applied when the slant is too severe will often have problems. Materials like cork, which might be great for lower intensity use might not be as effective in a school or highly traveled lobby.

#### *Rocky Mountain Institute*

Based on research from the Rocky Mountain Institute, the following financial payback is typical for eight key energy features:

<b>Exhibit IV-3</b>			
<b>Typical Feature-Based Financial Analysis</b>			
Energy Measure	Cost (\$)	Savings (\$)	Payback (yrs)
<b>Daylighting</b>	\$4,900	\$1,560	3.14
<b>Glazing</b>	\$5,520	\$1,321	4.18
<b>Energy Efficient Lighting</b>	\$1,400	\$860	1.63
<b>Energy Efficient HVAC</b>	\$3,880	\$739	5.25
<b>HVAC Controls</b>	\$2,900	\$506	5.73
<b>Shading</b>	\$4,800	\$325	14.77
<b>Economizer Cycle</b>	\$1,200	\$165	7.27
<b>Insulation</b>	\$1,600	\$101	15.84

*Source: CoreNet Global, Rocky Mountain Institute, January 2007*

Another interesting example from a features-based analysis in an existing building, which has been highly publicized, is the results from the Adobe Corporation buildings, which were converted to the first LEED EB Platinum certified buildings. Interestingly, while Adobe eventually decided to get the LEED EB certification, their asset manager, Cushman Wakefield, started five years earlier with inexpensive projects and continued to initiate new projects, with documented results along the way. In the end, Adobe spent \$1.2 million

<sup>28</sup> “Retrofitting Office Buildings to be Green and Energy-Efficient”, Principal Authors Leane Tobias and George Vavaroutsos, Urban Land Institute, 2009.

on 53 separate projects, which together save \$1 million per year in energy costs and received \$349,000 in rebates.<sup>29</sup>

What is particularly interesting about the results shown below from the Adobe building retrofit are the numerous small expenditures that can be done on a highly profitable financial basis that can contribute significantly to energy savings:

Exhibit IV-4 Energy Efficiency Projects at Adobe						
Energy Efficiency Measure	Capital Cost (\$)	Annual Cost Savings (\$)	Annual Energy Savings (kBtu)	Annual Energy Savings (kWh)	Payback Period	Return on Investment
Modified Cooling Tower Staging and Sequencing	\$575	\$12,272	322,092	94,400	Immediate	2,134%
Modified Boiler Control Programming	\$600	\$41,779	94,162	27,597	Immediate	6,963%
Corrected Chilled-Water Pump Controls	\$1,200	\$43,000	96,915	28,404	Immediate	3,583%
Changed Corridor Lighting Override to Control and Program	\$4,500	\$27,327	717,229	210,207	2 months	607%
Added Real-Time Electric Meters	\$19,969	\$39,938	90,013	26,381	6 months	200%
Retrofitted Indoor Lamps	\$21,088	\$52,530	118,393	34,700	5 months	249%
Provided Motion Sensors for HVAC in All Conference Rooms	\$37,500	\$40,357	310,438	90,984	8 months	140%
Reprogrammed Garage Lighting	\$55,267	\$34,037	76,713	22,483	11 months	115%
Installed VFD on Chiller	\$65,000	\$38,719	87,265	25,576	7 months	163%
Provided Surge Protectors and Motion Sensors for Every Office	\$104,750	\$65,887	148,498	43,522	5 months	253%
Retrofitted Garage Lighting	\$157,775	\$138,544	312,254	91,516	10 months	118%

Source: "Adobe: Outsource Energy Efficiency Upgrades and Reap the Benefits," Rocky Mountain Institute, CoreNet Global, April 2007.

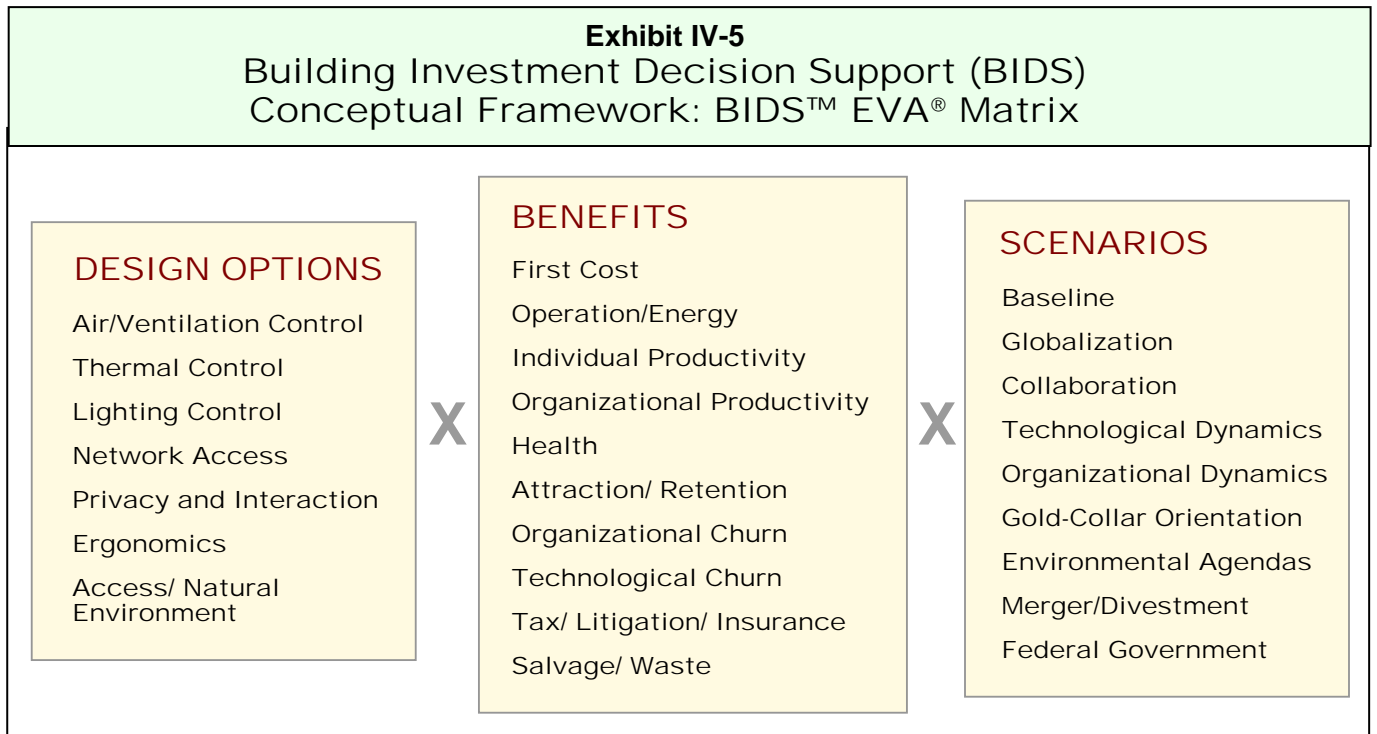
#### *Carnegie Mellon Building Investment Decision Support (BIDS™)*

One of the most comprehensive sources for feature/system-based performance analysis is the Carnegie Mellon BIDS program. Carnegie Mellon's BIDS (trademark for Building Investment Decision Support) is a case-based decision support tool that generates a calculation of the economic value added of investing in high performance building systems, based on the findings of building owners and researchers around the world.

BIDS™ has a comprehensive collection of building performance case studies organized in their database in a variety of ways with key categories being Air, Thermal, Lighting

<sup>29</sup> "Adobe: Outsource Energy Efficiency Upgrades and Reap the Benefits," Rocky Mountain Institute, CoreNet Global, April 2007.

Control, Network Access, Privacy and Interaction, Ergonomics, Access/Natural Environment, and Whole Building. For each of these areas, a whole range of cost-benefit factors can be analyzed including First Cost, O& M Energy, Churn, Productivity, Health, Attraction/retention, Tax, Litigation and Insurance, and Salvage/Waste. The conceptual framework is shown graphically below:



Source: *Building Investment Decision Support (BIDS) Presentation, Buran Gurtekin-Celik, PhD, undated*

BIDS™ can provide an excellent starting point for thinking about how sustainable features and systems can add value to a property over the full life cycle of the building. However, access to BIDS™ is limited to financial contributors. Summary information and findings on energy-related topics can be found publicly at e-BIDS™ (Energy Related Building Information System) <http://cbpd.arc.cmu.edu/ebids/>.

One of the key features of BIDS™ is its life-cycle assessment of the value of features or systems. The results are calculated for each feature or system utilizing case study/research findings and BIDS™ “life cycle assumptions” which factor in average salaries, building size, health data, and other demographics to calculate the benefits that can be compared to cost for the feature or system.

Generally, calculations and conclusions from BIDS™ or e-BIDS™, and other analyses of this type, need to be carefully interpreted and used. First, study results are presented in aggregation to draw general conclusions, but aggregated studies often deal with separate property types, features, measures of productivity or health, and cover time periods more than 20 years apart from various regions and countries. Each of the individual scientific



studies typically have a page or more of caveats to their analyses, and the studies are highly variable in quality and reliability, yet it is difficult if not impossible for the user of the summary information to discern the difference. Additionally, the use of “general averages” from reference data on worker compensation, health costs, demographics, etc., renders the results not directly applicable to individual buildings with their unique characteristics.

BIDS™ style calculations and conclusions have the most applicability to owner-occupied buildings, since BIDS™ return on investment (ROI) and related financial performance conclusions presume owners fully value the health, productivity, energy or related savings. BIDS™ calculations are not directly applicable to multi-tenant or non-owner occupied buildings because of the variable costs and benefits accruing to the owner and tenants based on leases in place.

A key to interpretation and use of BIDS™ results, or similar analyses, is to not oversell or overplay the accuracy and reliability of the actual numbers and general conclusions. It is important to understand that the studies for each feature/system are conducted separately, and that any attempt to add productivity, health, or related benefits from features or systems can lead to nonsensical results. Through selective and more property specific adjustment of the studies and methodologies, important quantitative support can be generated to improve the ability to prove and argue for enhanced space-user demand through the introduction of certain features-sustainable strategies.

Even with the noted caveats and cautions, many of the BIDS™ features/systems analyses that we have reviewed are an improvement from the historic norm in the industry because of the aggregation of research and inclusion of life cycle costs. However, BIDS™ calculations and analyses we have reviewed do not appropriately consider risk and revenue issues, particularly for investors who must assess the market’s response to a building’s overall sustainability outcomes in the context of other factors.

BIDS™ offers the following “Declaration” on the front page of the e-BIDS™ website:

Declaration: e-Bids is the first attempt to merge the benefits of field and laboratory case studies that link the quality of specific building components and systems to measurable financial gains in both quantitative and human performance areas. There is no question that a critical mass of case studies is still needed before definitive conclusions can be drawn. However, when a threshold of five case studies emerged related to a specific building innovation, a decision was made to merge the benefits from these case studies into a single argument for consideration by building decision-makers. **In addition to limitations related to the small number of case studies and their confidence ratings (an area that needs significant increase in funding), caution should be taken in translating the conclusions beyond office buildings or across a range of climate conditions without careful building science resolution.** (Emphasis added)

Based on our review of select studies and knowledge of the nature of the conclusions, and caveats in scientific studies upon which BIDS™ conclusions are drawn, we would recommend caution when applying the numerical summary conclusions, although the

direction and support for positive contributions of the features/systems discussed appear reasonable in many cases.

A summary of conclusions from the eBIDS™ website (July 2009) provides some insight into the five key features/systems for which they offer specific financial conclusions related to energy issues.

**Cool roofs pay!** CMU's BIDS™ identifies seven case studies indicating a link between reflective light-colored roofs and 2.3% to 46% reductions in annual cooling energy consumption, with an average savings of 11% or \$0.02 per square foot. Reflective roofing has also been associated with an average peak cooling demand reduction of 14%. Given energy savings alone, the average ROI for an investment in reflective roofing is 11%

From a series of energy simulations, one study concludes that green roofs provide 48% average cooling energy savings, 8% average total energy savings, and an average 48% peak load reduction. With estimated annual energy savings of \$0.18 per square foot, the average ROI for an investment in a green roof is 15%.

**Daylighting pays!** Eleven studies have shown that innovative daylighting systems can pay for themselves in less than one year due to energy and productivity benefits.

CMU's BIDS™ demonstrates that daylighting yields annual energy cost savings of \$112 per employee (\$0.99 per square foot) and annual productivity gains of \$2,475 per employee, for total savings of up to \$2,587 per employee annually.

With an estimated one-time first cost premium of \$600 per employee (\$1 to \$7 per square foot) in new construction, the ROI for an investment in daylighting is over 185%.

CMU's BIDS™ identifies three case studies that demonstrate an average 44% reduction in overall energy consumption, and six case studies indicating 52% average lighting energy savings due to high performance daylighting systems. Five case studies demonstrate individual productivity benefits from daylighting, with an average improvement of 5.5% annually. Finally, one case study identifies a 40% improvement in organizational productivity due to daylighting, through higher retail sales in a "big box" chain retail store."

**High Performance Lighting Pays!** Twenty-five studies have shown that high performance lighting systems can pay for themselves in less than one year due to energy, productivity and health benefits.

CMU's BIDS™ demonstrates that high performance lighting yields annual total energy cost savings of \$82 per employee (0.41 per square foot), annual productivity gains of \$1,600 per employee, and annual health cost savings of \$20 per employee, for total savings of up to \$1,702 per employee annually.

With a median first cost of \$720 per employee for lighting retrofits (\$3.60 per square foot, range \$0.63 - \$7.45), and a median first cost increase of \$200 per employee for high performance lighting systems in new construction (\$1 per square foot, range \$0.26 - \$10.65), an investment in high performance electric lighting results in an ROI of 236% for retrofits and 851% for new construction!"

CMU's BIDS™ has identified 15 case studies linking improved lighting design with a median of 60% savings in annual lighting energy worth approximately \$80 per employee per year.

Six case studies identify a link between improved lighting design and total annual energy savings, including reductions in lighting, cooling and other HVAC energy consumption, with a median savings of 18% or \$82 per employee per year. The average lighting energy savings is 4.9 KWh per square foot annually, and the additional cooling energy savings averages 0.2 KWh per square foot per year.

Nine case studies identify a link between improved lighting design and individual productivity gains, with a median improvement of 3.2% or \$1,600 per employee per year. Productivity is evaluated by a range of measures including improved working speed, reduced error rate, improved reading comprehension, improved short-term memory and logical reasoning, or self-reported increases in productivity.

Finally, a 1998 controlled experiment by Aaras et al. identifies a link between improved lighting design and a 27% reduction in the incidence of headaches, which accounts for 0.7% of overall employee health insurance cost at approximately \$35 per employee annually.

**Under floor air distribution pays!** Twelve studies have shown that UFA systems can pay for themselves in less than one year due to energy, productivity, churn, and facility management benefits.

CMU's BIDS™ demonstrates that UFA yields annual energy cost savings of \$30 per employee (\$0.14 sq. ft.), productivity gains of \$254 per employee, churn cost savings of \$154 per employee, and facility management savings of \$38 per employee (\$0.19 sq. ft.), for total savings of up to \$486 per employee annually.

With a one-time first cost premium of \$54 per employee for new construction and \$422 per employee to modify existing buildings, the average ROI for an investment in UFA is 900% for new buildings and 115% for retrofits.

CMU's BIDS™ identifies four case studies that indicate an average 15% reduction in annual HVAC energy consumption due to UFA systems. Five studies demonstrate an average 80% reduction in annual churn cost due to UFA. (Churn cost is the cost of office moves and changes.) Two studies report first cost savings of \$0.43 to \$2.00 per square foot for UFA systems, as compared to ceiling-based systems. One case study identifies annual facility management staffing cost savings of \$0.19 per square foot and one study shows an individual productivity improvement of 0.7%, given underfloor air delivery.”

**Mixed-Mode Conditioning Systems Pay!** Eight studies have shown that natural ventilation and mixed-mode systems can pay for themselves in less than one year due to energy and productivity benefits.

CMU's BIDS™ demonstrates that natural ventilation and mixed-mode systems yield annual energy cost savings of \$110 per employee (\$0.53 per sq. ft.), health cost savings of \$60 per employee, and annual productivity gains of \$3,900 per employee, for a total savings of \$4,070 per employee annually. (Using BIDS™ baseline assumption)

With an estimated first cost premium of \$1,000 per employee (\$5 per sq. ft.) in new construction and a documented first cost of \$3,400 per employee (\$17 per sq. ft.) to modify an existing building, the average ROI for an investment in natural ventilation or mixed-mode conditioning is 407% for new construction and 120% for retrofits.

CMU's BIDS™ identifies three case studies that demonstrate HVAC energy savings due to mixed-mode conditioning or natural ventilation, with average energy savings of over 59% annually. Two case studies show health cost reductions, with an average savings of 1.1% annually. Six case studies show individual productivity improvements due to mixed-mode or natural ventilation, with an average improvement of nearly 9% annually.

## **2. Performance/Risk Assessment of Six Key Features/Systems**

A key purpose of this section is to provide the basis for due diligence/underwriting questions investors should ask consultants and vendors concerning features and strategies they recommend, both today and in the future. The answers to such questions can significantly mitigate risk and uncertainty and provide context for interpreting the results of financial analyses.

Our focus on failure or underperformance in this chapter is based on our belief that a full and straightforward discussion of failure and underperformance provides a critical supplement to the positive feature performance studies and reports that are published and promoted by sustainable building advocates, product suppliers, vendors, and others. It should also be noted that many buildings have installed these features and systems with little or no trouble.

Moreover, as this work is just a snapshot in time, some of these features and strategies, and risks related to them, may be quite different in a few years' time. Not only will technology change, but also service providers, owners, tenants and other occupants will become more experienced, changing the mix of risks and returns.

To better understand feature risks, and identify key features to focus on, we interviewed a score of top consultants, developers, and investors, and corporate real estate professionals to determine those features with a history of failure and underperformance. Based on this survey, case studies and other research, we made the decision to focus on six important features that were repeatedly mentioned during our survey of respondents as having experienced failure or underperformance. For each features discussed below, we provide an introduction to the system, the problems that most commonly occur, some real world examples and solutions, and best practices to mitigate the risks described.

Substantial additional information on sustainable features is presented in Expanded Chapter III, Section C: "Sustainable Property Features" and in Appendix III-A of Expanded Chapter III: "Sustainable Property Features Menu" as well as in the Research Library under index codes 6.0, 12.0, 15.5, and 28.0.

The six features/systems discussed in this section are:

- a. Underfloor Air Distribution
- b. Green Roofs
- c. Daylighting
- d. Lighting Controls
- e. Waterless Urinals
- f. Materials

### **a. Underfloor Air Distribution**

#### *Introduction*

Underfloor air distribution (UFAD) is an approach to ventilation in commercial and institutional buildings in which conditioned air is distributed through a plenum or cavity created by raised floors, which also typically carry electrical and communications cabling. UFAD is commonly used in green buildings because it has the potential to improve ventilation efficiency and indoor air quality; improve occupant comfort, productivity and health; and reduce energy use reduce and life-cycle building costs. The raised floors required for UFAD can also improve flexibility for building services and decrease floor-to-floor height in new construction.

#### *Risks of Underfloor Air Distribution*

One common cause of problems related to UFAD is plenum leakage, either through the plenum into other building cavities or from the plenum into the occupied space via the floor. This leakage can result in many problems, including loss of thermal comfort, wasted energy, ventilation noise, and condensation in the plenum. Such condensation can ultimately lead to growth of biological material or mold, which can seriously impair air quality and may result in liability for the building owner.

One cause of these problems in UFAD buildings has been the many trades involved in working in the plenum.

Construction of an airtight plenum requires strict coordination of 10 to 12 trades and special construction techniques that have not yet been developed for concrete, masonry, drywall, millwork, sealant and joint specialists, raised-access floor installers, carpenters, sheet metal, plumbing, electrical, communications, etc.<sup>30</sup>

This has led to a lack of communication that has contributed to leakage problems in some projects. One developer also noted that the raised floors required for UFAD systems felt somewhat “hollow” or “insubstantial” relative to slab construction typical in Class A office buildings. This is certainly a trade-off, but many Class A tenants are still willing to

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<sup>30</sup> James Woods, *Ecostructures*, Jan.-Feb. 2008.

accept raised floors just for the flexibility and related “churn” costs savings, let alone the sustainability benefits.

Other risks with the thermal mass of the slab and plenum walls were identified:

The thermal mass of the slab and plenum walls is a significant issue for energy management and control. Observations revealed that longer-than-expected operational periods of the HVAC systems were required to maintain plenum temperatures. Head and moisture transmission and condensation in the plenum also are issues because gradients across the plenums resulted in non-uniform temperatures in the occupied spaces, and surfaces within the plenums were more likely to support condensation.<sup>31</sup>

#### *Examples of Underfloor Air Distribution*

In one building, occupant complaints of thermal discomfort due to variable temperatures throughout a space arose when a designer tried to implement a UFAD system that worked in one building to a building with a larger floorplate. Due to the larger floorplate, the use of centrally located forced air systems that worked in a building with smaller floorplate was insufficient to serve, offices on the exterior of the building, which experienced temperature differentials of nearly six degrees Fahrenheit. Redesign that included multiple forced air systems distributed different parts of the floor, and additional insulation in underfloor ducts provided a solution, although at additional cost.

In another building, problems arose due to air vents being covered up by desks or other internal tenant furniture or equipment. It is important that the duct design and floor vent location is closely coordinated with interior tenant improvements. This is most difficult in multi-tenanted buildings, but can be solved through coordination and planning.

The United States General Services Administration (GSA), the nation’s biggest landlord and also a champion of green building, was moving toward banning or modifying their design standards for UFAD after problems with leakage. The GSA has nearly 8 million square feet of UFAD installations nationwide. The leakage rates from the plenum in these installations were found to be between 60 and 100% in GSA testing. These incredibly high leakage rates resulted in higher energy costs, occupant complaints and condensation in the underfloor plenum.<sup>32</sup> Modifications to design requirements and other actions were eventually implemented.

#### *Underfloor Air Distribution Best Practices*

To counter leakage problems, one approach is to use a ducted system rather than just letting the airflow freely through the plenum. This can reduce leakage, but will also reduce many of the benefits of UFAD, most notably reduced energy use and user controllability. Another possible approach for mitigating plenum leakage is to stagger the carpet tiles over the floor tiles, so that the carpet can provide a type of seal. This, however, has concerns of

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<sup>31</sup> James Woods, *Ecostructures*, Jan.-Feb. 2008.

<sup>32</sup> Tristan Roberts, “GSA Moving Towards Ban on Underfloor Air,” *Building Green*, August 7, 2007.

its own relating to the ease of reconfiguration and material waste. Sealant can also be applied in between floor tiles in buildings where carpet is not used.

According to the UC Berkeley Center for the Built Environment, a key researcher of UFAD systems, the key factors to the success of UFAD design are:

1. The experience of the project team
2. Appropriate location and climate
3. Proper integrated design process
4. HVAC control strategies
5. Sufficient training of building management staff.

One developer who successfully installed UFAD told us that vendor input is essential during the design and construction phase for a successful under floor air distribution system. The construction team met with the vendor and sub-contractors prior to installation of the raised floor. Other unsuccessful projects that the developer was aware of did not have this collaboration. When using UFAD, developers should make a construction meeting with the vendor mandatory.

One vendor had this advice:

After commissioning, building owners and occupants assume responsibility for the optimal operation of the UFAD system. The owner or facility manager should secure a complete set of as-built drawings, establishing the grid system and locating all UFAD components and controls. It is recommended that you revise the grid system whenever changes are made to the system.

It is also important for the owner to train maintenance people to operate the UFAD system. Begin by providing them with applicable service manuals that explain the operation and maintenance of the system, and reviewing the manuals with them.

Pay special attention to the impact of room-temperature stratification on comfort and control, as well as the control functions to reset the relative humidity, supply-air temperature and floor SP, as needed. If applicable, explain any control options, such as providing a pocket digital assistant as a maintenance tool.

Finally, it is important to inform the building occupants about the UFAD system. You should stress the importance of periodic vacuuming of the underfloor airway as well as cleanup from spills. In addition, explain the benefits of the system, including comfort, improved IAQ, flexibility and energy efficiency.

Furthermore, point out the location of the diffusers and the availability of individual diffusers to meet special needs. Identify the location of thermostats and sensors for individual work areas or zones, their functions and how to use them. Finally, provide contact information to register comfort complaints.<sup>33</sup>

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<sup>33</sup> Jack Goertner, "Getting a handle on UFAD" *RSES Journal*, York FlexSys Underfloor Air Systems, Dec. 2005.

Since so many trades are involved in building the plenum, it requires a skilled and experienced team leader to have oversight of the plenum as a system. In a successful application of UFAD in the New York Times Building in New York City, the mechanical engineering team worked closely with the architect to detail the leakage requirements during the design process and conducted numerous tests throughout the building process to ensure compliance.

It should also be acknowledged that UFAD systems are a more difficult challenge for existing buildings, typically much more costly than in new construction, and in many cases are not possible due to physical limitations.<sup>34</sup> However, some creative UFAC solutions to existing buildings have been implemented.

#### *Underfloor Air Distribution Resources*

Environmental Building News: Access Floors- A Step-up For Commercial Buildings:  
<http://www.buildinggreen.com/auth/article.cfm/1998/1/1/Access-Floors-A-Step-Up-for-Commercial-Buildings/>

HPAC: Underfloor-Air-Distribution Design Concepts:  
<http://hpac.com/news/underfloor-air-distribution-design-0506/>

Energy Design Resources Design Brief: Underfloor Air Distribution and Access Floors:  
<http://www.energydesignresources.com/Technology/HVACDesign/tabid/97/articleType/ArticleView/articleId/127/Default.aspx>

Center for the Built Environment: Hype Vs. Reality: New Research Findings on Underfloor Air Distribution: <http://www.cbe.berkeley.edu/research/publications.htm>

#### **b. Green Roofs**

Relevance: Multifamily, Retail, Office; New Construction, Existing Buildings

##### *Introduction*

While there are many variations, two primary types of green roofs are extensive and intensive. An extensive green roof is a lightweight; vegetated roof installed on top of conventional or slightly sloping roofs and is a strategy used in many green buildings. Extensive roof systems require minimal ongoing maintenance and typically do not allow occupant access.<sup>35</sup> The roof is covered with thin layer of soil that supports light vegetation with no irrigation. Due to its lightweight; an extensive green roof can be retrofitted to most structures.

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<sup>34</sup> The Center for Building Performance at Carnegie Mellon stated that UFAD systems cost \$54 per employee for new construction and \$422 per employee for retrofits. "Guidelines for High Performance Buildings", 2004.

<sup>35</sup> "FAQ's on Green Roofs," Greenroofs.com, <http://www.greenroofs.com/Greenroofs101/faqs.htm>



Intensive roof systems are fully landscaped roofs intended for human access and use. These roofs require deeper soil depth to allow landscape material to develop and irrigation for ongoing maintenance. In many cases they are rooftop gardens created for the building occupant's enjoyment. Often they include shrubs, trees, water features, and irrigation systems. For healthy plants, anywhere between 9 inches and 3 feet of soil is required.<sup>36</sup>

There are many potential public and private benefits of green roofs. The public benefits for the surrounding community include stormwater control, pollutant removal and improved outdoor air quality, reduced urban heat island effect and increased habitat for wildlife. The private benefits for the building include noise reduction, smaller cooling loads, and enhanced roof membrane durability.<sup>37</sup>

Select conclusions from "An Assessment of Green Roof Benefits" by Charlie Miller, PE in 2003 are presented below. These comments were particularly insightful, if somewhat dated, due to its assessment of practices in Germany, a green roof leader.

Thirty-five years of experience with green roofs in Germany has demonstrated their value in protecting waterproofing materials. A roof assembly that is covered with a green roof can be expected to outlast a comparable roof without a green roof by a factor of at least two, and often three. Although modern green roof systems have not yet been in place longer than 35 years, many researchers expect that these installations will last 50 years and longer before they require significant repair or replacement.

For a building owner with a long-term investment in the roofing system, this benefit factor goes a long way toward paying back the initial investment in a green roof. Taken by itself, this factor may not be sufficient to fully compensate the owner for the higher installation cost of a green roof; however, other benefits close the gap.

The value of a green roof will depend upon many factors that are specific to a particular application. In many instances a \$7 per square foot investment in a green roof will easily be justified.

European experience demonstrates that a uniformly vegetated 'extensive' green roof with three inches of media will provide the highest benefit-to-cost ratio. Improvements associated with thicker and more intensively landscaped systems are marginal.

Generally, green roofs provide greater benefit in the summer than in the winter. However, their capacity to virtually eliminate the daily variation in temperature is a year-round phenomenon. Furthermore, green roofs are up to twice as efficient as white or reflective roof surfaces in reducing thermal gain. Quantitative analysis of energy benefits can be conducted on a project-specific basis.

Green roofs can be used as effective sound attenuation systems. In one dramatic application, they have been used to address sound impacts from air traffic at the

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<sup>36</sup> AIA Best Practices: Green Roof Design

<sup>37</sup> "Green Roofs: Using Roofs for More Than Keeping Dry," *Environmental Building News*, Nov. 1, 2001. <http://www.buildinggreen.com/auth/article.cfm/2001/11/1/Green-Ro>

Frankfurt airport. In this case, green roofs were installed on buildings that lie below the approach flight path to mitigate impacts associated with expansion of the airport.

A German article referring to this project asserts that the plants alone reduce reflected noise by two to three decibels and that the media (soil layer) further reduces sound reflection and transmission. A simple three-inch thick green roof can be expected to reduce sound transmission by a minimum of five decibels.

For projects where abatement of ambient noise is important, green roofs may be a better solution than other alternatives, such as baffles and textured surfaces. The savings afforded by eliminating these ancillary features is properly an added value of the green roof.

### *Green Roof Risks*

A key potential problem for extensive green roofs is the vegetation. Weeds can overrun roofs or the drains can clog. Other problems can occur that prevent the plants from taking hold, such as a lack of irrigation during the establishment phase.

Some extensive roof installations have seen the membrane warranty voided. Certain manufacturers have partnered to fix this problem, but this issue needs to be addressed before deciding on a green roof. Since roofs often have a 15-year life cycle, a voided warranty could present a serious financial risk to an owner.

Too much moisture is a common culprit to green roof vegetation problems.

Common mistakes made in green roof design include:

**Installing peg-type drain panels or sheets in an ‘inverted’ configuration.** When a peg-type drainage panel is installed in the inverted (“cups up”) position, water percolates less easily to the drainage zone of the panel than if the panel had been inserted with the cups facing down. Inverted, “cups up” installations actually compromise the drainage function of the panel. When the goal is to capture water and the drain panels are installed with the cups facing up, and then a layer of coarse-grained drainage material should be installed to cover the panel prior to installing the growth media to restore drainage properties to the profile.

**Incorporating drainage layers with inadequate water carrying capacity.** Standard procedures for predicting the drainage capacity of both synthetic and granular drainage layers have been published by ASTM<sup>38</sup>

It is important to note that in our research we found limited evidence that currently employed green roofs are prone to leakage or membrane failure.

### *Green Roof Example*

The company whose “green roof” dried up atop The Rapid bus station blames the transit system for the \$220,000 mistake, saying it failed to care for it. The transit

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<sup>38</sup> “MythBusters,” Roofscapes, Inc., June 2009.

system allowed the roof's live sedum to dry because it watered with only a hose and sprinkler instead of spending a few thousand dollars on an irrigation system, a company official said Thursday. Transit system officials, however, said they were led to believe the roof was maintenance-free. 'I'm surprised to hear that,' Rapid spokeswoman Jennifer Kalczuk said. 'We felt we worked very well with them to address this problem.' Xero Flor America LLC, based in North Carolina, said it has installed thousands of green roofs on buildings around the world, including the Ford Motor Co.'s River Rouge plant. The Rapid's roof, installed in 2004, is the only one that has failed, said company manager and technical director Clayton Rugh.<sup>39</sup>

### *Green Roof Best Practices*

The following answers to Frequently Asked Questions by Roofscapes Inc. from their website ([www.roofscapes.com](http://www.roofscapes.com)) provide some general ideas regarding best green roofs practices.<sup>40</sup>

#### **What are the most important factors in designing a green roof?**

There are many complex, interactive factors that a green roof design engineer takes into account, balancing many considerations for optimal performance, including:

- Climate, especially temperature and rainfall patterns
- Strength of the supporting structure
- Size, slope, height, and directional orientation of the roof
- Type of underlying waterproofing
- Drainage elements, such as drains, scuppers, and drainage conduits
- Accessibility and intended use
- Visibility, fit with architecture, and owner's aesthetic preferences
- Fit with other 'green' systems, such as solar panels
- Costs of materials and labor

#### **What kind of waterproofing do I need?**

Many types of waterproofing are compatible with green roofs. Worldwide, polyvinyl chloride (PVC) and polymer modified bituminous membranes is the most common. Many of these installations have now been in place for over 30 years and continue to perform as designed. PVC, EPDM and thermal polyolefin (TPO) are, in most cases, inherently root-resistant; other common waterproofing materials require a root barrier between the waterproofing materials and the vegetated cover.

Surprisingly, leaks in the waterproofing layer are less likely when it is protected from the elements by a green roof. If a leak does occur, it can readily be located through new electronic technology, such as electric field vector mapping (EFVM), which can rapidly and accurately pinpoint even minute holes. This system is more reliable than the older flood testing method, need not be installed in advance, and can even be used

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<sup>39</sup> "Company blames Rapid as green roof dries out," *Grand Rapids Press*, Feb. 29, 2008.

<sup>40</sup> I have selected a few of their responses to FAQs and provided them here. Roofscapes provides these answers for education purposes and the Consortium has not evaluated their responses from a technical perspective, and also provide them here for educational purposes. We recommend reviewing the details in the citations for more information. The Consortium acknowledges Roofscapes' lack of independence from the green roof industry and readers should factor this in as they read this information.

on steeply sloped surfaces. Repairs to the waterproofing are quick, and disturbance of the green roof is minimal.

#### **In what climates do green roofs work?**

Green roofs have been built most widely in temperate climates, but special techniques allow them to thrive in semi-arid, tropical, and even windy coastal areas. Roofscapes, Inc. has designed and built green roofs across the continent, and from hot, moist Florida to the cold, windy Boston harbor.

#### **Is irrigation required? If so, what kind?**

With thoughtful engineering, *irrigation is rarely necessary*. When irrigation is required, the water should be delivered deep under the surface—where the roots will seek it and it will not be lost to evaporation. Surface irrigation systems (drip or spray systems) are wasteful and require more maintenance than subsurface irrigation methods.

#### **Why is drainage important?**

Proper drainage ensures that the growing medium will be maintained in an aerated condition suited to healthy plant growth. Basal drainage must also be designed with large rainfall events in mind. The goal is for all rainfall to percolate to the base of the system. The portion that is not absorbed should move ‘underground’ toward roof drains or scuppers. During very large storms, brief episodes of surface runoff may occur. In a Roofmeadow® system, such surface runoff can enter the roof drains at gravel surfaced areas that surround the drain access chambers. Surface ponding, even during large storms, is evidence of a poorly designed green roof.

#### **What kinds of plants should be used on a green roof?**

In frost zones 4 through 8, at least half of the plants installed on an extensive green roof should be varieties of *Sedum*. In colder climates grass-dominated covers are recommended. Reliable tropical plant lists are not currently available. However, in cooperation with the Florida Department of Environmental Protection, Roofscapes, Inc. has installed three green roof prototypes to evaluate candidate plants for un-irrigated extensive systems.

Many other plants can be incorporated to provide habitat value or visual interest. Appropriate auxiliary plants will vary by region, but generally, the deeper the green roof, the more complex the plant community that can be sustained. They range from *Sedum* and herbs on the thinnest systems, to meadow grasses and perennials on mid-weight roofs, to turf and small trees on the deep, ‘intensive’ roofs.

Hundreds of different species have been used by Roofscapes, Inc. in American projects. The experience gained from these projects allows us to confidently recommend plant communities for green roofs. Their selections will depend on many factors: depth of growing media, seasonal temperature ranges, average rainfall, and the aesthetic preferences of the owner.

*For optimal plant growth and health, the plants should be selected, installed, and maintained by experienced horticulturalists or landscape contractors who understand the local environment and climate, in consultation with the design engineer.*

### **What kind of maintenance is required?**

Generally, after the plants have become established, most extensive green roofs only need weeding and occasional infill transplanting twice a year. Maintenance visits should be timed to intercept any weeds before they go to seed. This level of maintenance is sufficient to maintain the health of the plants and protect the underlying roofing materials. Some owners enjoy greater involvement and choose to ‘garden’ in their green roof more frequently. Intensive green roofs will require the same care and maintenance as a similar garden situated on the ground.

### **Avoid using surface irrigation, if at all possible.**

Surface drip and spray systems are expensive to maintain, do not deliver water efficiently to the roots, where it is most needed—and waste enormous amounts of water through evaporation. Also, on surface-irrigated green roofs plant roots tend to develop nearer the surface. This makes the covers increasingly dependent on irrigation and vulnerable to lapses in the watering schedule.

#### *Green Roof Resources:*

GreenRoofs.com:

<http://www.greenroofs.com>

Environmental Building News: Green Roofs: Roofs for More than Keeping Dry:

<http://www.buildinggreen.com/auth/article.cfm/2001/11/1/Green-Roofs-Using-Roofs-for-More-Than-Keeping-Dry/>

King County Green Roof Case Study Report:

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=1098>

Design Guidelines for Green Roofs:

<http://www.greenroofs.com/Greenroofs101/how-tos.htm>

AIA Best Practices: Green Roof Design:

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=772>

Additional information is available on the Consortium website in the Research Library or Industry Links sections under codes 6.0, 12.0, 15.5 and 28.0.

### **c. Daylighting**

Daylighting is the practice of using natural light to illuminate building spaces.<sup>41</sup> Rather than relying solely on electric lighting during the day, daylighting brings indirect natural light into the building through windows or skylights. Daylighting is a common green building strategy, as it can allow for significant energy savings due to avoided energy use

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<sup>41</sup>“What/Why>What,” Daylighting Collaborative, <http://www.daylighting.org/what.php>

for lighting and heating while also improving occupant comfort and potentially increasing worker productivity.

Daylighting systems typically involve a combination of architectural and other building elements that can include skylights, atriums, clerestories, light shelves, light pipes, window glazing technologies, solar shading systems, and interior lighting systems with sensors and dimmable ballasts. A well-designed daylighting system minimizes thermal gains and excessive brightness due to direct sunlight.

Daylighting systems will be more important to the issue of sustainability in some property types versus others. Since daylighting is linked to worker productivity and health, these elements will be more important for property types where more people are effected (e.g. more important to retail, office and apartment properties than warehouse/distribution properties)

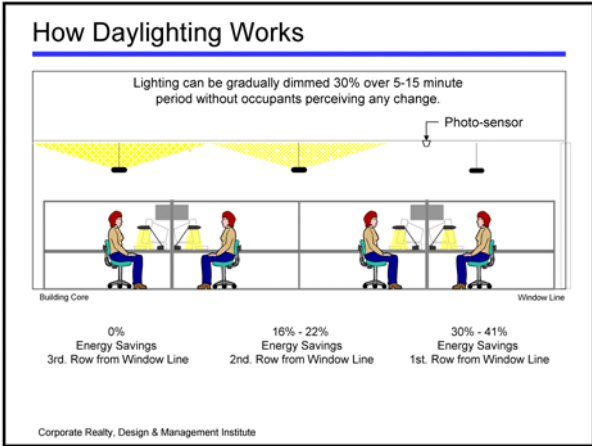
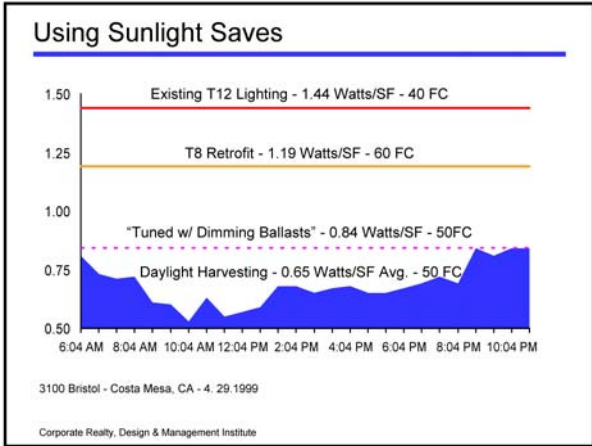
Daylighting systems are more challenging to evaluate in new buildings than in existing buildings because they do not yet exist. While an existing daylighting system can be evaluated to determine whether it is functioning as designed, a to-be-built system cannot be evaluated in this manner. Some daylighting elements may not be physically possible or cost effective when retro-fitting an existing building versus building a new building, making daylighting upgrades to an existing building more challenging and requiring more scrutiny on the part of underwriters.

Owner/users are likely to have the greatest incentives to include daylighting systems in their buildings. They incur the costs of these systems but also receive the benefits. Investors/speculative developers' incentives to include daylighting systems will depend on the nature of the lease agreement with tenants. To the extent that there is an equitable sharing of the costs and the benefits related to daylighting systems, the more incentive exists for investors to include these elements in the building. While tenants may have an incentive to invest in daylighting systems because they receive many of the benefits, they generally don't have much control over many of the daylighting elements that are included in the building because the owner makes these decisions.

To better understand daylighting, I present below some graphics and information provided to me by Alan Whitson, from his seminar "Lighting for Profit, Unlocking Hidden Energy Savings."<sup>42</sup>

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<sup>42</sup> Alan Whitson, RPA, is a leading researcher and educator on sustainable real estate practices and financial analysis through the Corporate Realty Design and Management Institute (<http://www.squarefootage.net/>).



### The Stokeley Office Building

- Base Case
  - ASHRAE 90.1-1999
- Scenario 1:
  - Perimeter Zone Daylighting
  - Interior Zone Dimming
- Scenario 2:
  - Perimeter Zone Daylighting
  - Interior Zone Dimming
  - Occupancy Sensors in all private offices, common areas and conference rooms
- Test Cities
  - New York, Chicago, Houston, Los Angeles

Five Story Office Building  
66,500 Square Feet  
"Standard" Lighting & HVAC  
Lights Off 10 pm to 6 am - Time clock  
DOE 2.1 Energy Modeling by:  
- Sieben Energy Associates

Corporate Realty, Design & Management Institute

### Scenario 1

	Los Angeles	Houston	Chicago	New York
Demand - kW	396	583	827	768
Total Usage - kWh	940,855	1,132,945	1,194,277	1,111,412
Electricity Costs	\$142,029	\$165,504	\$157,451	\$179,190
Savings - Electricity	\$35,550	\$38,557	\$15,709	\$35,127
Percent Reduction	29%	29%	28%	29%
Incremental Investment	\$119,153	\$119,153	\$119,153	\$119,153
State/Utility Incentives	(\$15,274)			(\$28,801)
EPAAct 2005	(\$8,725)	(\$8,725)	(\$7,806)	(\$8,266)
Net Investment	\$95,154	\$110,428	\$111,347	\$82,086
ROI - Without Incentives	28%	32%	13%	29%
ROI - With Incentives	35%	35%	14%	42%
Increased Building Value	\$458,710	\$497,510	\$202,697	\$453,252
ROI - Building Value	482%	451%	182%	552%

DOE 2.1 Energy Modeling by: - Sieben Energy Associates

Corporate Realty, Design & Management Institute

### Daylighting in Warehouses

- Use diffusing skylights
  - Maximize light transmission
  - Space skylights no more than 1.5 times the ceiling height apart.
- Use photo sensors to dim or turn off lights when interior levels are high.
- Paint ceiling, walls and structural elements white; use light-colored floor materials.

Corporate Realty, Design & Management Institute

The case studies presented by Mr. Whitson demonstrate electricity savings of 29% due to daylighting and interior zone dimming, and up to 33% when the use of occupancy sensors was added. Interestingly, the results were consistent in the four geographically distinct cities.

*Links to Sustainability Ratings or Certifications (From Consortium Research in 2007)*

With respect to the LEED rating system, daylighting can potentially impact property certification in two ways: 1) Energy & Atmosphere; and 2) Indoor Environmental Quality. Under the Energy & Atmosphere category, daylighting can help to optimize energy performance, which can earn a building owner or sponsor up to 10 points towards LEED certification. Under the Indoor Environmental Quality category, daylighting can earn a building owner or sponsor up to two points for daylight & views, depending on the percentage of space affected, towards LEED certification.

With respect to the Green Globes (Design v.1 – Post Construction Assessment) rating system, daylighting can potentially impact property certification in two main categories: 1) Energy (360 potential points); and 2) Indoor Environment (200 potential points). Within the Energy category, daylighting has the potential to add points towards certification in the Energy Consumption sub-category (110 potential points), and the Energy Demand Minimization sub-category (135 potential points).

Under the Green Globes Indoor Environment category, daylighting has the potential to add points towards certification in the Lighting Design and Integration of Lighting Systems sub-category (45 potential points). Within this sub-category the Green Globes systems awards points for minimum daylight illumination levels, the percentage of primary interior spaces with views to the building exterior or to an atrium, and the existence of shading devices to control glare from direct sunlight.

While ASHRAE Standard 189P (2007 Draft) is not a rating system, it does specify certain mandatory provisions that a building must meet in order to be considered a “High-Performance Green Building.” The two main sections of ASHRAE 189P that impact daylighting systems and specific elements of these systems are: 1) Section 7 – Energy Efficiency; and 2) Section 9 – Indoor Environmental Quality.

One example of mandatory requirement impacting daylighting systems is found under the Energy Efficiency Section of ASHRAE 189P (Section 7.4.6 (e) - Lighting), which indicates that: “In addition to ASHRAE/IESNA Standard 90.1, automatic controls for lighting in daylight zones: Lighting in all daylight zones, both daylight zones under skylights and daylight zones adjacent to vertical fenestration, shall be provided with controls that automatically reduce lighting power in response to available daylight....”

Another example of a mandatory requirement impacting daylighting systems is found under the Indoor Environment Section of ASHRAE 189P (Section 9.3.7 (a) – Minimum Daylight Zone by Toplighting), which indicates, for certain large enclosed spaces, that: “A minimum of 50% of the floor area shall be in the daylight zone. Areas that are day lit shall have a minimum toplighting area to daylight zone area ratio as shown in Table 9.3.7.”



### *Daylighting Risks*

The primary problem with daylighting is too much light entering the building interior. This may actually lead to decreased occupant comfort and productivity, ultimately harming financial performance of the building. The problem of too much light could manifest itself either in glare or uneven distribution of light, as well as excessive cooling loads from the direct solar gains. The upshot is either lost energy savings or occupant discomfort.

One developer told us that the sunshade coordination, fabrication, and installation proved to be a challenging process resulting in a much greater cost to the contractor than those included in its contract. The point is that daylighting can be a complicated process, even though it is one of the most widely used green design features.

Other risks to consider include:

- Advanced lighting and/or shading systems used for daylighting are likely to be more expensive to install, repair and maintain than conventional systems.
- Cost estimates for daylighting systems may be more difficult to pin down due to the customized nature of these systems.
- Incorporating daylighting elements such as skylights increases the risk of unwanted glare from direct sunlight and higher energy costs as a result of increased building temperatures.
- Additional openings (skylights, clerestories, roof monitors, etc.) in the building envelope increase the risk of leaks that can result in water damage or heat loss.
- Photo sensors for daylighting can have problems due to miscalibration, or improper positioning. This can result in missing energy savings, as daylighting typically accounts for about 10% of lighting savings in energy models.
- Another risk in implementing daylighting can occur by spending too much on technology. In offices, which are typically vacant half the time, dimmers may not be needed. Consider also putting daylighting sensors only on the sunny side of certain buildings.

At a session on “Daylighting and Beyond” at GreenBuild in 2007, the following additional daylighting issues were identified by speakers on the panel:

- Form does not follow function--shading was on the wrong side;
- Architectural detail with no purpose--form with no function;
- The orientation of the property was wrong, so shading did not work;
- Excessive thermal gains due to window orientation, resulting in overheating;
- Insufficient daylighting: 40% daylighting is not good enough—you need 60% or energy use can increase because people will still use lights;

- Unwanted contrast: if one part of the space is light and the other significantly darker, the contrast will make it seem too dark, even if there should be enough light for occupants;
- Insufficient internal shading and related excessive daylight on computer monitors;
- Manual shades can often be problematic;
- Proper selection of window glazing can be important, and is often done sub optimally;
- Improper calculation of the glass to floor area ratio;
- Exterior shading from roofs can underperform due to ceiling cavities being too deep;
- East-west shading is very difficult, so shading solutions on buildings with these orientations can be ineffective;
- Excessive overhang on the south side of buildings;
- Perhaps the most important problem—problems with lighting controls, including lack of compatibility between the ballast and the lamp, and other issues.<sup>43</sup>

#### *Daylighting Examples*

The San Francisco Federal Building uses extensive daylighting but has experienced problems from glare.<sup>44</sup> This has reportedly resulted in significantly reduced occupant comfort as occupants struggle to read their computer monitors.

CTG Energetics struggles with daylighting photo sensors in their renovated office building. Mitigation requires significant set-up calibration and ongoing fine-tuning to ensure high performance.

#### *Daylighting Best Practices*

Three important daylighting best practices include:

- 1) Carefully placed windows — It is best to avoid direct sunlight on critical tasks and excessive brightness. This calls for bringing the daylight in at a high location and bouncing it off of surrounding surfaces in order to filter the daylight. This creates much greater visual comfort for occupants.
- 2) Shading devices — In general, light, which reaches a task indirectly (such as having bounced from a white wall), will provide better lighting quality than light, which arrives

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<sup>43</sup> Mike Nicklas, “Daylighting and Beyond,” Innovative Design, Green Build, 2007.

<sup>44</sup> Amy Westervelt, “San Francisco Federal Building’s green building blues,” Sustainable Industries, June 29, 2007. <http://www.sustainableindustries.com/greenbuilding/8238217.html>

directly from a natural or artificial source.<sup>45</sup> As one developer told us, the window shades need to be installed as part of the base building and need to be integrated with the daylighting components of the building. The developer had received several complaints due to overheating and glare, which could have been mitigated if shading devices were in place.

3) Low-transmission glass — one developer told us that most of his LEED projects required some form of post-construction window treatment to reduce glare.<sup>46</sup> The design challenge is to manage the “daylight factor”, which is a product of the visible light transmittance of the glass and the area of the glass. It typically needs to be smaller than is assumed, but this needs to be validated in design using daylighting-modeling techniques (either computerized or physical models).

#### *Daylighting Risk Mitigating Factors*

Attention to the practices discussed below can also help mitigate risks:

- The design team has prior experience with daylighting systems containing elements similar to the one proposed.
- The contractor has prior experience installing daylighting systems containing similar elements.
- The building owner or project sponsor has provided a cost estimate from the sub-contractor responsible for installing and/or maintaining the various daylighting elements in the building.
- The building owner or project sponsor has provided adequate support for any rent premiums being forecast including evidence of such premiums from either inside or outside of the market.
- The building owner or project sponsor has provided adequate support for any increases in retail sales being forecast.
- The building owner or sponsor has provided evidence (“commissioning”) that the daylighting system is operating as designed.
- The daylighting system incorporates special window glazing or shading elements to mitigate unwanted glare?

#### *Key Daylighting Due Diligence Questions*

Key questions to assist in assessing whether best practices were followed include:

- Does the design team have prior experience with daylighting systems?
- Did the design team employ an integrated approach to designing the daylighting system, considering/incorporating both passive (e.g. skylights, clerestories, roof

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<sup>45</sup> Gregg D. Ander, “Daylighting,” National Institute of Building Sciences, Nov. 5, 2008. <http://www.wbdg.org/resources/daylighting.php>

<sup>46</sup> Sustainable Building Technical Manual, Chapter 9

monitors, etc.) and active (automated shading and/or lighting systems) daylighting elements?

- Does the daylighting system incorporate any special window glazing or shading systems to mitigate unwanted glare?
- Does the contractor/sub-contractor have prior experience installing daylighting systems into buildings?
- Does the owner and/or property manager have experience operating buildings with daylighting systems?
- Was commissioning performed on the daylighting system?
- Were any increases in retail sales due to daylighting included in the revenue forecast? If so, how were these estimated?
- Were any rent premiums due to daylighting included in the revenue forecast? If so, how were these rent premiums estimated?

#### *Daylighting Resources*

LBNL Windows & Daylighting Group

<http://windows.lbl.gov>

LBNL Lighting Systems Research Group: Controls and Communications

[http://eetd.lbl.gov/btp/lsr/1\\_controls.html](http://eetd.lbl.gov/btp/lsr/1_controls.html)

IEA Task 31, Daylighting Buildings in the 21<sup>st</sup> Century

<http://www.iea-shc.org/task31/>

USDOE Daylighting Information Resources

<http://www.eere.energy.gov/buildings/info/design/integratedbuilding/passivedaylighting.html#shelves>

Building Envelope Design Guide/Fenestration Systems Whole Building Design Guide Website

[http://www.wbdg.org/design/env\\_fenestration.php](http://www.wbdg.org/design/env_fenestration.php)

Design Objectives/Sustainable/Enhance Environmental Quality (IEQ)/Daylighting, Whole Building Design Guide Website

<http://www.wbdg.org/design/daylighting.php?r=ieq>

Sustainable Industries: San Francisco Federal Building's green building blues:

<http://www.sustainableindustries.com/greenbuilding/8238217.html>

Tips for Daylighting with Windows: The Integrated Approach:

<http://windows.lbl.gov/pub/designguide/default.html>

Energy Design Resources: Daylight in Buildings

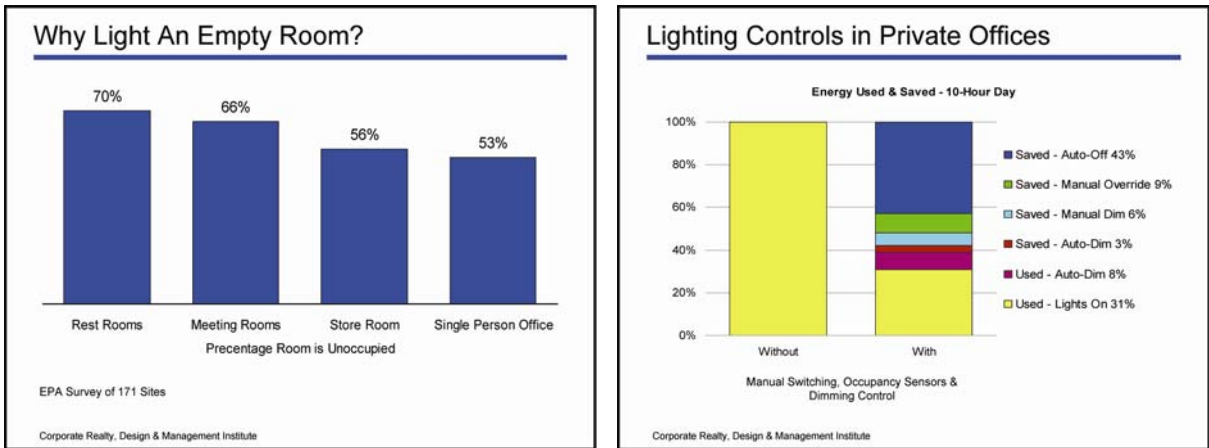
<http://www.energydesignresources.com/Resources/Publications/DesignGuidelines/tabid/73/articleType/ArticleView/articleId/8/Design-Guidelines-Daylighting-Guidelines.aspx>

Whole Building Design Guide:  
<http://www.wbdg.org/resources/daylighting.php>

**d. Lighting Controls**

An essential element of lighting and daylighting in green buildings is effective control of the operations of the electric lighting systems. This requires that controls enable the lights in a room to automatically turn off when the room is unoccupied. Further, it requires that the level of electric lighting be automatically adjusted in response to available daylight in the room.

As shown below in two charts from Alan Whitson’s seminar presentation “Lighting for Profit: Unlocking the Hidden Energy Savings,” there are significant opportunities for savings from lighting controls. Rest rooms are unoccupied 70% of the time, and even single-person offices are vacant 53% of the time. Energy savings can reach 60%, due primarily to automatic off sensors, but also due to dimming.



The potential energy savings are further supported by research reported by the US EPA in their September 2007 report: “Putting Energy in Profits: ENERGYSTAR® Small Business Online Guide.”<sup>47</sup>

<sup>47</sup> “Putting Energy Into Profits: ENERGYSTAR® Small Business Online Guide, US EPA, September 2007.

<b>Energy-Savings Potential With Occupancy Sensors</b>	
<b>Application</b>	<b>Energy Savings</b>
Offices (private)	25–50%
Offices (open spaces)	20–25%
Rest rooms	30–75%
Corridors	30–40%
Storage areas	45–65%
Meeting rooms	45–65%
Conference rooms	45–65%
Warehouses	50–75%

Note: Figures listed represent maximum energy-savings potential under optimum circumstances. Figures are based on manufacturer estimates. Actual savings may vary.

Source: California Energy Commission/U.S. Department of Energy/  
Electric Power Research Institute

### *Occupancy Sensors*

In typical office buildings, there are many spaces (closed offices, conference rooms, storage rooms, rest rooms, etc), which are occupied sporadically. Such rooms are perfect candidates for the use of occupancy sensors, which detect the presence of people in a space and turn the lights on. If the space becomes unoccupied, the sensor detects that condition and shuts off the lights after a suitable time delay period. Such controls are relatively inexpensive and are mandated by most energy codes for new construction.

### *Risks of Occupancy Sensors*

The risks with occupancy sensors relate to type of sensor, location of the sensor, and adjustment of the sensor. Sensors are typically either ultrasonic (using changes in high frequency sound waves, not unlike a bat, to detect occupancy) or infrared (using changes in an infrared beam, similar to that on a TV remote control, to detect occupancy). If ultrasonic sensors are located too close to an open door, a passerby may trigger the sensor and cause the lights to turn on even when no one is actually in the room. Thus, location of the sensor is important relative to nuisance tripping.

The entire area controlled by the sensor should be able to be detected by the sensor (which is a function of its range and its angle of sensing). Finally, it is important to assure that there is an appropriate time delay between when the last person leaves the room and the lights are shut off: if it is too long, excess energy will be used; if it is too short, it may result in excessive cycling of the lights during normal use of a room.

### *Occupancy Sensors Best Practices*

Substantial detail on lighting controls and sensors can be found in the referenced sources. A few simple practices include:

- Make sure you have the proper sensor for each location type. (See the Design Brief on Lighting Controls pgs 6-8 for more information.)
- Make sure you have the sensors in the proper location. (See the Design Brief on Lighting Controls pgs 8-9 for more information.)
- Decide on the proper delay time. Owners must balance the energy savings of a short time delay with the occupant nuisance factor.

#### *Automatic Daylight Dimming Sensors*

Automatic daylight dimming, or "daylighting," uses a light sensor to measure the amount of illumination in a space. Then, light output from dimming ballast is adjusted to maintain the desired level of illumination. The combination of daylight dimming with appropriate task lighting is often a very effective and energy-efficient way to light space.

#### *Risks of Daylight Sensors*

Poorly calibrated daylight sensors can result in little or no energy savings from daylighting. If the daylight sensors do not properly adjust the lights in response to ambient day lit conditions, it may over-provide light resulting in wasted energy. A poorly calibrated sensor may also under-provide light to an area, which can annoy occupants and in most cases lead occupants to manually override the system, resulting in wasted energy. Poor calibration could be due to miscalibration after installation or improper positioning. This can seriously damage energy performance, as properly functioning daylight dimming sensors can in some cases account for up to 30% of lighting savings.<sup>48</sup>

#### *Examples of Daylight Sensors*

CTG Energetics, a green building consultancy who has recommended and installed daylighting sensors for many of their clients, struggled with automatic daylight dimming sensors in their own office. The systems were initially improperly calibrated and annoyed users, resulting in users often manually overriding the system, leading to wasted energy and utility expense.

#### *Daylight Sensors Best Practices*

Initial commissioning and calibration of light sensors and controls is critical for effective daylighting.<sup>49</sup> In addition to significant setup calibration, daylight-dimming sensors also require on-going fine-tuning to ensure highest performance. Building O&M staff should be trained by the commissioning agent to test the systems on an ongoing basis.

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<sup>48</sup> <http://www.energydesignresources.com/resource/22/>

<sup>49</sup> [http://www1.eere.energy.gov/femp/procurement/eep\\_light\\_controls.html](http://www1.eere.energy.gov/femp/procurement/eep_light_controls.html)

### *Daylight Sensors Resources*

Energy Efficient Products:

[http://www1.eere.energy.gov/femp/procurement/eeep\\_light\\_controls.html](http://www1.eere.energy.gov/femp/procurement/eeep_light_controls.html)

Energy Design Resources Design Brief: Lighting Controls:

<http://www.energydesignresources.com/Technology/LightingDesign/tabid/94/articleType/ArticleView/articleId/134/Design-Briefs-Lighting-Controls.aspx>

### **e. Waterless Urinals**

In an office building, the water used for flushing urinals is the largest use of water inside the building. Waterless urinals are a commonly used water saving strategy in sustainable design. These urinals use no water for flushing, but instead allow the urine to flow down the drain and into a trap that contains a fluid that allows urine to pass through it and drain off, while keeping odors trapped inside. The urinal is still connected to the plumbing sanitary sewer drainage system but not to the water supply.

#### *Risks of Waterless Urinals*

The problems associated with waterless urinals primarily come from improper maintenance. Improper maintenance is generally a result of either using too much water during cleaning or using an alkaline cleaning solution, both of which result in sediment build up and break down the sealant that traps odor. This ultimately results in having to replace the cartridge more often, an unnecessary expense, or in user complaints regarding odor.

Some owners have also reported that filters were more expensive than advertised and required changing more frequently than advertised.

Another risk is the build-up of uric acid crystals in the sewer lines, due to the pure urine flowing through the pipe rather than being diluted by flush water. This can cause increased maintenance of the plumbing system, and can be combated by periodically running some water through the drains.

Another risk is the acceptance of waterless urinals by regulators, unions and building owners. There has been a risk of approval by some local code authorities. Many jurisdictions have been unwilling, partially due to plumbing union concerns, to allow waterless urinals, or allow them without a redundant water plumbing alternative, which increases costs. In addition, some owners have found them objectionable due to the more focused maintenance requirements.

#### *Waterless Urinals Examples*

The US Merchant Marine Academy has begun removing waterless urinals from their dorms due to excessive calcium build-up in the piping that led to odor. The main cause of



this sedimentation was improper maintenance. The merchant marines were required to clean their own urinals, which would take place at night when the fully trained maintenance staff was unavailable to supervise. In the public area urinals where the maintenance staff was responsible for maintenance and cleaning, no problems were experienced.

The office of *Environmental Building News* installed an early generation waterless urinal in their office, but ultimately discovered a leak from the connection between the urinal and the drain line. The line was also clogged with a gooey substance, which was caused because that the drain line was not pitched away from the urinal.<sup>50</sup>

In a hospital in North Carolina, water closets were replaced with low-flow and waterless urinals. However, the slope of the plumbing was designed for the old toilets, and the new systems did not push enough water through to work effectively.

#### *Waterless Urinals Best Practices*<sup>51</sup>

One green building consultant put the problems with waterless urinals into perspective: “If there is improper maintenance on conventional urinals, they’ll have odor problems, too.” It is really just an issue of the building owner committing to properly train the staff to maintain the waterless urinals. In particular, maintenance staff should be trained to use small amounts of water and a slightly acidic cleaner during cleaning.

In general, waterless urinals are most appropriate for buildings with large, dedicated maintenance staffs and frequent high volume use, such as large Class A office buildings, stadiums and convention centers, hotel lobbies, etc. Avoid waterless urinals in situations where a reliable pitch in the drain line cannot be insured and the maintenance staff is unwilling to learn new procedures.

One alternative to waterless urinals are new low-flow urinals, which use less water than a conventional urinal but can be cleaned in the same way. Such low-flow urinals typically use about 1/8<sup>th</sup> of a gallon per flush, significantly less than traditional urinals. This will eliminate the problems that sometimes afflict waterless urinals.

#### *Waterless Urinals Resources*

EBN: Why Non-Flushing Urinals Fail (And How to Prevent Those Failures):  
<http://www.buildinggreen.com/auth/article.cfm?fileName=131104b.xml>

Waterless Urinals and LEED WEcr3:  
<http://www.usgbcnorthtexas.org/articles/WaterlessUrinals/>

Waterless Urinals: Technical Evaluation:

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<sup>50</sup> <http://www.buildinggreen.com/auth/article.cfm/2004/11/1/Why-Non>

<sup>51</sup> [www.cecer.army.mil/techreports/ERDC-CERL\\_TN-06-03/ERDC-CERL\\_TN-06-03.pdf](http://www.cecer.army.mil/techreports/ERDC-CERL_TN-06-03/ERDC-CERL_TN-06-03.pdf)

[www.cecer.army.mil/techreports/ERDC-CERL\\_TN-06-03/ERDC-CERL\\_TN-06-03.pdf](http://www.cecer.army.mil/techreports/ERDC-CERL_TN-06-03/ERDC-CERL_TN-06-03.pdf)

## **f. Materials**

Building materials choices are extremely important in sustainable design, as construction and demolition waste constitute about 40% of the total solid waste stream entering landfills in the United States<sup>52</sup>. Several LEED credits call for materials different from conventional building materials. Examples of the types of materials eligible for LEED credits include reused or salvaged materials; materials with recycled content, locally manufactured materials, rapidly renewable material, and certified wood. Credits are also available for use of non-toxic adhesives, sealants, paints and coatings; low emitting carpets; and formaldehyde-free wood and agrifiber products.

### *Materials Risks*

The increasing number of buildings seeking LEED ratings has had a strong impact on the building materials industry. This has resulted in products that are either new or untested or are traditional products being used in new and untested ways. As one developer noted, “It’s good to be a pioneer as long as the pioneer understands he’s headed for the wilderness.” The risks of sustainable materials include underperformance and possible replacement, and “greenwashed” materials that fail to meet sustainable standards or expectations.

One risk is that materials procured for projects will not perform as expected and may even need, in extreme cases, to be replaced. This is not only a financial risk to the owner, but also compromises some of the environmental benefits of the building. After all, durable products with a long useful life are considered to be more sustainable than less durable products because they do not have to be manufactured as often, lessening the demands on natural resources, reducing transportation of goods, and also reducing the waste otherwise created in the manufacturing process. Another problem with the underperformance of some building materials is that, in many cases, the underperformance is not always symptomatic of any one building material, but rather a hit-and-miss phenomenon. This makes the risk harder to mitigate.

Another risk is that the documentation relating to the green features of a product may be incomplete. Since some sustainable certification credits are no-tolerance credits, like the LEED “no formaldehyde” credit, if a product unknowingly contains formaldehyde no points from that LEED credit are earned for the building. This can happen if manufacturers do not control every single aspect of the production process, which can sometimes lead to the discrepancy described herein.

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<sup>52</sup> USGBC

### *Materials Examples*

The owner of a Class A office development had to replace the building's cork floor. The owner told us that the flooring appeared to move, and created an uneven appearance. The construction team was never able to pinpoint the root cause of the problem. Potential problems were that some of the environmentally friendly adhesives such as those used for the cork flooring, resilient flooring, and rubber flooring did not possess the strength that previous adhesives contained. The same project had no problem in procuring good, competitively priced materials locally to achieve other sustainable objectives.

In another example, and one often mentioned, sustainable adhesives underperformed in holding down carpets, and in other applications.

### *Materials Best Practices*

The best approach is to work with specifiers and contractors who are familiar with the range of green materials products available for particular applications. This may vary by locality, as well as by building type.

Nationally recognized information resources that screen new green products, such as those listed below can be helpful, but the rapid growth in new products and materials, and sophisticated sales efforts behind such products and materials, will make it important to retain experienced assistance in this area.

As an example of the detailed knowledge necessary to make materials recommendations, the following "Top Ten Methods to Solve Problems by Avoiding Them," from the November 2007 issue of *PSI Green Bulletin* are instructive:<sup>53</sup>

After many years of dealing with architects, designers, and general contractors, we have seen literally hundreds of problems created because of projects that specified specific wood products with specific environmental features that are extremely hard to supply, and very expensive to support. These top 10 suggestions cover the most common problems we see, along with some alternative items that make it easier to supply, and less expensive.

#### #1: Long Length FSC Plywood

FSC plywood in lengths longer than 8' is very difficult to find, and very expensive. Option: Specify long length FSC Certified. OSB-PSI offers this product with no price premium to regular lengths.

#### #2: FSC Tropical Hardwoods

Not only are FSC Certified tropical hardwoods hard to find, the product selection and grade options are very restricted. Option: Stick with domestic hardwoods.

#### #3: Framing Lumber

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<sup>53</sup> We realize we cite only nine methods, but this is consistent with the article. We cite these methods for illustrative purposes and are not commenting on the technical merit of the conclusions, which in many cases—recommendations based on supply constraints—may be very time sensitive.

While all species of framing lumber are available in FSC Certified, some are more plentiful than others. Stick with FSC Certified Western Hem/Fir and FSC Western SPF. Go easy on FSC Douglas Fir, and avoid Southern Yellow Pine as much as possible.

#4: Framing Plywood

Like framing lumber, some types of framing plywood are far easier to find than others. Specify FSC Fir plywood in US Grades, avoid Southern Yellow Pine plywood (hard to find), and totally avoid Canadian FSC Certified framing plywood (NONE AVAILABLE)

#5: Watch the Roof

Tempted to specify FSC Certified cedar shakes and shingles? If you are—don't do it! The supply of this product is very limited, very unreliable, and very expensive.

#6: "Engineered Wood"

While you may not have a choice, try to avoid specifying FSC Certified LVL or PSL lumber—very tough to find. Option: FSC gluelams are easier, or specify FSC framing and build up your required percentage in this manner.

#7: Get Two for One

Specify panel products that are both FSC Certified and urea formaldehyde free. For example, PSI's line of "Platinum" grade panels are available in plywood, particleboard, MDF, and PB door core. All these products offer both credits, and are available in large volumes.

#8: FSC Certified Veneers

Finding that FSC Certified veneers are expensive, hard to find, and of lower quality? Consider specifying Platinum MDF—with 100% FSC content. You can go with non-FSC veneers and still earn the FSC credit.

#9: Consider Your Options

Are you specifying a lot of FSC Certified interior millwork? Consider specifying more FSC Certified lumber and plywood as part of the rough construction. You can build of big volumes of FSC content this way, and not "break the bank" on expensive FSC hardwood millwork.<sup>54</sup>

*Materials Resources*

Environmental Building News

<http://www.buildinggreen.com/>

California Integrated Waste Management Board- Green Building Materials

<http://www.ciwmb.ca.gov/greenbuilding/Materials/>

Oikos Green Product Gallery:

<http://www.oikos.com/products/>

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<sup>54</sup> "Top Ten Methods..." *PSI Green Bulletin*, Panel Source International, Vol. 1 Issue 11, Nov. 2007.  
<http://www.panelsource.net>

## E. Building Performance

Sustainable property performance at the building level is the foundation for valuation and financial analysis. Understanding development costs, resource use, occupant performance, the level of sustainability achieved, and the location and flexibility of a building is critical to being able to assess potential demand for “sustainability” from the market. However, while whole building performance is necessary to value a sustainable property, it is not sufficient. The specific market response by regulators, space users, and investors to a building’s actual, or projected, performance is a necessary prerequisite to understanding value or financial performance.

Building performance, and how to measure and monitor it, is a big topic and a growing focus of the real estate industry. Building labeling and related energy directives are a reality in Europe and a growing legislative reality at the state and federal levels in the United States. ASHRAE’s proposed Building Energy Quotient program is designed to enable both asset and operational ratings for all building types, except residential.<sup>55</sup> ASTM’s Building Performance and Energy Disclosure Task Force is working on an ASTM standard to guide the practice of building energy performance assessment and disclosure.

In June 2009, as part of LEED v3, the latest version of the US Green Building Council’s program for green building design, construction, operations and maintenance, buildings seeking LEED certification will be required to submit operational performance data on a recurring basis on a precondition to certification.

While numerous, government and trade group efforts in building performance assessment are dwarfed by the thousands of corporate and institutional investors worldwide who are endeavoring to rationalize the process for measuring and monitoring the performance of the buildings in their portfolios. In the United States, EnergyStar benchmarking has become a critical component of many asset managers’ sustainability programs.

Measuring building performance and sustainability, and its importance to valuation and underwriting, were fully discussed in Chapter III: Evaluating Property Sustainability. We identify and categorize 100 different assessment systems in six categories of sustainability/performance measures, as shown below in Exhibit IV-6:

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<sup>55</sup> ASHRAE’s labeling program differs from existing labeling programs in that it focuses solely on energy use. ASHRAE intends for its proto-type labeling program to become a model for mandatory labeling programs that are being considered legislatively.

Exhibit IV-6 Six Categories of Sustainability Measures		
Type	Level	Examples
1. <b>Environmental assessments</b>	Building	LEED, BREEAM, GreenStar, CASBEE
2. <b>Occupier-focused assessments</b>	Building; company	Global Reporting Initiative, IPD Environmental Code, Leased Space Leadership Consortium Guidelines
3. <b>Government regulations/codes/ incentives</b>	Building; building features; products; procurement	European Directive on the Energy Performance of Buildings, Local government initiatives
4. <b>Other building performance assessment standards</b>	Building; building features	ASTM Sustainability Standards, SB Tools 07, ASHRAE Building Quotients
5. <b>Product/material assessments/certifications</b>	Products, materials, features	GreenGuard, Green Seal, Forest Stewardship Certification
6. <b>Service provider certifications/assessments</b>	Companies; individuals	ASHRAE Certifications, Green Building Certification Institute, LEED AP

In this section of Chapter IV, we identify and review the key evidence documenting sustainable property building performance for the following categories:

1. Development (“First”) Costs
2. Whole Building Performance Studies
3. Building Energy Use
4. Occupant Performance
5. Durability/Adaptability/Flexibility

## 1. Development (“First”) Costs

An important input into the financial performance of a building project is its initial development/construction cost (“first cost”). Since first costs are not discounted (they occur immediately), increased (decreased) upfront building costs can cause significant financial underperformance (outperformance).

### *Summary of Development Cost Research*

The evidence from key research and case studies analyzing the performance of sustainable properties regarding development costs (often referred to as “first costs”) is that a certified sustainable property costs 0-2% more, with higher levels of certification costing up to 10% more. Many major construction companies (Swinerton, Webcor, Turner, etc.) promote

publicly that sustainable construction should cost no more, and the research shows that in many cases it does not.

Perhaps the biggest cost barrier for sustainable property investment is not measured in dollars, but in implementation time and risk. For example, you can show a developer that studies have shown that a sustainable building will only “cost” 2% more, but they still have legitimate “cost” concerns. The sustainable building process will require new types of contracts, leases, insurance, subcontractors, and contractors, and will require a more integrated design and project management process, different than what the developer has been used to. What is the cost of these required changes? Sophisticated discussions of costs and proper interpretation of the surveys that are done in the marketplace require consideration of this question.

#### *Considerations in Evaluating Development Cost Performance Research*

In answering the comparative cost question, it is important to understand the significant differences between existing buildings and new construction. Many of the most prominent studies looking at comparative costs are based on new construction, and do not fully consider existing buildings. Comparative cost analysis for existing buildings is significantly more difficult due to the wide variety of building types, the varying ways sustainability is achieved, and the significant underlying variances in the age, construction type, and other variables that will affect comparative cost.

Another key factor in first costs for green buildings is the geographic market that the building is located in. If the contracting trades in that area have no experience with green buildings, then they will likely increase their prices in the bidding process, bringing cost up. Moreover, proper execution of green building design and construction processes requires experience, without which a project is likely headed for disappointing performance. Thus, it is very important that developers consider the context of their market (designers, contractors, suppliers, and prospective tenants) when pursuing sustainable development.

Just as important as the market context is the experience of the project team, particularly from the developer’s side. Many developers see a cost premium for the first sustainable property they build, but will see this disappear after 2 or 3 projects as they learn how to adapt their traditional processes to reflect the realities of sustainable property development.

Conducting a comparative first cost analysis should be done very carefully to avoid making bad decisions. Fundamentally, sustainability should not be viewed as something to be added, versus an integrated part of building design. Most importantly, a first cost analysis that compares initial buildings costs of a sustainable building to a “non-sustainable” building ignores potential operating cost savings or any value implications. However, despite the logic that the question does not make a lot of sense, procurement officers, CFOs, developers, and facility managers are often confronted with short-term budget constraints and the anticipated “premium” for sustainable building still gets cited

as one of the most important barriers to further adoption of sustainable property investment.<sup>56</sup>

The question of comparative cost is also very difficult to answer on a general basis. However, it is much more feasible to address the question of how much sustainability will cost on a specific project. In answering the question for a specific project, you must specify explicitly the level of green or sustainability goals and consider the role of integrated design in promoting trade-offs that enable reduced costs in some areas to offset increased costs of some sustainable features. For example, improved energy efficiency due to improved insulation, window replacements, improved controls, or management changes can offset the new or replacement costs for HVAC systems.

The next part of the analyses is to determine what you are going to compare sustainable costs to. One approach is to compare the cost of green to the original budget or the original anticipated cost. A limitation to this approach is that it assumes that the original budget was adequate and that no other changes or enhancements were made. Is it reasonable to assume that the building would have been designed to a minimum energy standard, or would some of the “sustainable” features have been designed in anyway? As the marketplace has become more accepting of sustainable property investing, the base for an original building budget has been moving. Equally important, investors’ and space users’ assessment of building quality is also changing as sustainable features and outcomes become more important than other expensive building features that used to be required for a top quality building.

Another method of comparing cost is to look at the individual cost of added green features. Again, this approach fails to consider offset costs and assumes that features or outcomes can be separately priced. Perhaps most importantly, doing a comparison of initial costs for specific sustainable materials or features ignores important advantages in life cycle operating costs and value due to improved appeal to tenants and investors, as well as regulators.

#### *Key Development Cost Research*

It is important to carefully interpret the studies presented below. Each has pros and cons. For example, the Davis Langdon study, arguably the most comprehensive study, focuses on construction hard costs. Other project costs including interest costs, design costs, and contingency costs can also be important. Design and consulting costs can be both more expensive and more front-loaded, resulting in higher interest costs as well. On the other hand, a solid green building process could reduce contingency, in addition to several of the other soft costs associated with building. The planning process may provide incentives for green that would reduce carrying cost; insurance providers may offer lower rates; lenders may offer lower interest rates or higher LTV ratios.

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<sup>56</sup> Much of the information in this section is derived from conversations with Peter Morris of David Langdon and a review of his article, “What Does Green Really Cost?” published in the PREA Quarterly in the summer of 2007. This article is available on the Green Building Finance Consortium website at [insert web link here].



Many of the ideas in this section relating to comparative first cost-analysis emanated from Peter Morris at Davis Langdon. His article in the *Pension Real Estate Quarterly* provides the best concise summary we have seen on some of the issues that need to be considered in thinking about this question. “What Does Green Cost”, PREA Quarterly, Summer 2007. <http://www.davislangdon.com/upload/images/publications/USA/Morris%20Article.pdf>

**In November 2009, Davis Langdon completed a Cost Study for the Urban Green Council**, which found that LEED certified high rises came in at an average cost of \$440 per square foot compared to \$436 per square foot for non-LEED projects. On commercial interiors, the cost of \$191 per square feet was actually \$6 dollars lower than for non-LEED projects. This study was based on construction costs for 38 high-rise multi-family buildings and 25 commercial interiors in New York City.

**A July 2009 Study by Davis Landgdon: “Cost of Affordable Green Housing in Portland and Seattle”** looked specifically at the costs for affordable green housing and reached the following conclusions:

1. There is no statistically significant difference in construction cost between the green-rated and standard populations within this study.
2. The mandatory aspects of current funding-related building requirements and standard building practices for affordable housing within the cities of Seattle and Portland would normally lead to buildings achieving a LEED score in the range of 5-7 points; 10-15 total points could be earned with minimal additional effort and 20-24 total points could be earned with proper planning, documentation, and early setting of goals & thresholds.
3. Projects meeting the mandatory aspects of current funding-related building requirements in Seattle and Portland can achieve somewhere in the range of 45-60 points in the Built Green system, which would potentially earn either a 1-Star or a 2-Star certification level.
4. Among the respondents to the interviews, most indicated a belief that adding sustainable features increases the cost of projects; however, two key priorities for affordable housing projects are longevity and resident comfort, resulting in incorporation of green building features despite a frequent lack of direct focus on environmental sustainability as a program goal.
5. The green-rated projects were typically pursuing strategies related to site, water, and materials issues; and reduction of VOC content for finish materials

The affordable housing projects in the study are all three to five stories of wood frame residential construction. Most have one to two stories of concrete parking and retail shell below; nine of the projects are residential wood frame construction on grade. All but three projects started construction between 2004 and 2008, the remaining are scheduled to start before August 2009. The projects range in size from 21,000 ft.<sup>2</sup> to 218,000 ft.<sup>2</sup>, with a

median area of 57,000 ft.<sup>2</sup>. 75% of the population fell between 40,000 ft.<sup>2</sup> and 90,000 ft.<sup>2</sup>.  
<http://www.davislangdon.com/USA/Research/ResearchFinder/2009-Cost-of-Green-Analysis-for-Affordable-Housing-in-Portland-and-Seattle/>

One of the best analyses of comparative cost to date is shown in: **“The Cost of Green Revisited: Reexamining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption,”** Lisa Matthiessen, Peter Morris, David Langdon, 2007.

<http://www.davislangdon.com/USA/Research/ResearchFinder/2007-The-Cost-of-Green-Revisited/>

This study is an update of Davis Langdon’s July 2004 study entitled “Cost of Green: A Comprehensive Cost Database and Budgeting Methodology”. The updated study comes to essentially the same conclusion as the earlier study – “there is no significant difference in average costs for green buildings as compared to non-green buildings.”

The study methodology was to analyze a total of 221 buildings, 83 of which were designed with a goal of achieving some level of LEED certification and 138 of which did not have a goal of sustainable design. The authors note “it is important to keep in mind that the difference between these groups is simply that the LEED-seeking buildings were designed with LEED certification in mind, while this was not one of the goals for the non-LEED buildings.” They further note that most of the non-LEED-seeking buildings would have achieved 10 to 20 LEED points had they applied. The study included an analysis of academic buildings; laboratory buildings, library buildings, community centers and ambulatory care facilities.

Other key findings from the study are as follows:

- In many areas of the country, the contracting community has embraced sustainable design, and no longer sees sustainable design requirements as additional burdens to be priced in their bids.
- Cost of documentation remains a concern for some project teams and contractors, although again, as teams become accustomed to the requirements, the concern is abating somewhat.
- There is such a wide variation in cost per square foot between buildings on a regular basis, even without taking sustainable design into account. . . comparing the average cost per square foot from one set of buildings to another does not provide any meaningful data for any individual project to assess what—if any—cost impact there might be for incorporating LEED and sustainable design.

The 2007 Davis Langdon report updates a prior report in 2004 and examined a larger sampling of buildings and additional building types. The report demonstrates that costs for LEED and non-LEED projects are quite variable, and that LEED certification is not correlated with higher costs.

<http://www.davislangdon.com/USA/Research/ResearchFinder/2004-Costing-Green-A-Comprehensive-Cost-Database-and-Budgeting-Methodology/>

Greg Katz and a group of contributing authors have recently completed a study, **“Green Buildings and Communities: Costs and Benefits 2009,”** that looked at 150 buildings from the U.S. and ten other countries and concluded that the additional cost for building sustainable versus conventional non-green buildings was approximately 2% (median of 1.6%, mean of 2.5%). The detail necessary to analyze the relevance and applicability of this work to specific properties is not publicly available, but may become available when the findings are published in a book in 2009. For example, given that thousands of green buildings have now been built, the specific randomness of the selection of the 150-building sample will be key to interpreting the results. (The 150 buildings were located in 33 states and 10 countries and built from the period 1998 to 2008.)

<http://www.goodenergies.com/news/-pdfs/Web%20site%20Presentation.pdf>

Mr. Katz’s more recent work confirms his important earlier work: **“The Cost and Financial Benefits of Green Buildings: A Report to California’s Sustainable Building Task Force,”** was completed in 2003 and found that the green premium on average was about 2% of the original cost of a building. This study consisted of an analysis of 33 actual green buildings across the United States, including a comparison of the actual constructed cost with a cost estimate based on similar, non-green building design. All of the buildings were LEED with 8 certified, 18 silver, 6 gold, and one LEED platinum building. The primary conclusion of the study is that the cost premium for all but the LEED platinum building is about 2% or less.

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=398>

**The GSA commissioned a study by Steven Winters on LEED costs (“GSA LEED Cost Study, 2004”)**, which was generally supportive and consistent with other findings. This study provided an analysis and comparison of standard building prototypes, rather than actual buildings, that were modified to reflect different LEED ratings. The study analyzed costs for a new courthouse and an office building modernization under conventional building techniques and for various LEED certification levels.

- The authors concluded that sustainable building can be achieved at the LEED silver, and sometimes gold, levels for a cost increase of less than 2.5%.
- New green building costs range from a 0.4% reduction to an 8.1% increase depending upon the LEED level achieved.
- Major renovation costs to achieve the various LEED ratings ranged from a 1.4% to 7.8% increase.
- Uniformly, the attainment of higher LEED levels was associated with higher costs.

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=1007>

Evidence from a European cost study is consistent with findings from the US:

**A study undertaken by BRE and Cyril Sweett** investigated the marginal increases in construction costs required to achieve different BREEAM ratings. Using a typical building for each of the categories studied, the analysis explored the marginal increase on capital cost to achieve BREEAM and EcoHomes ratings at the time of the study (2003-4) for three different types of building:

- A house
- A naturally ventilated office
- An air-conditioned office

The study concluded that, subject to certain conditions, the environmental performance of a new building can be increased by 1-3 ratings for less than 2% additional capital cost, provided the conditions are optimum and the most cost-effective measures are implemented. In the case of a naturally ventilated office a negative increase (i.e. a net saving) was achieved due to the reduced cost of plant compared with standard build cost.

Higher environmental standards cost more. The development of projects that command the higher ratings between “good” and “excellent” incur costs up to 7% higher than those of conventional buildings.<sup>57</sup>

A somewhat outdated study by the David and Lucille Packard Foundation in October of 2002 provides an interesting methodological approach, looking at six different sustainability scenarios and evaluating costs and benefits. This study resulted in higher premiums for the first cost for sustainable buildings, although life cycle analysis provided a positive conclusion about sustainable investment.

<http://www.greenbuildingfc.com/Home/DocumentDetails.aspx?id=485>

## **2. Whole Building Performance Studies**

The three studies we summarize here offer evidence of building performance across a number of categories including resource use, occupant performance and operational efficiency.

### **a. “Innovative Work Places: Benefits and Best Practices,” GSA Office of Government-Wide Policy, January 2006**

The US General Services Administration (GSA) has been one of the leading researchers and promoters of improved design and efficiency for federal buildings. The GSA describes this publication as a “...milestone workplace publication.” The GSA’s findings and conclusions in this report are based on years of conducting extensive workplace research and tracking industry-wide best practices.

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<sup>57</sup> BRE Information Paper 4/05 (2007), “Costing Sustainability: How Much Does It Cost to Achieve BREEAM and EcoHomes Ratings?” Quote extracted from Richard Ellis, “Who Pays for Green? The Economics of Sustainable Building,” CB EMEA Research, 2009.

An interesting observation about the reported benefits of innovative workplaces from the GSA study is that while sustainability-related attributes like improved health and productivity benefits and energy efficiency were cited as key benefits, ergonomic furniture, flexibly designed workspaces, and improved occupant control of their space—issues that are inconsistently considered sustainability issues, were also cited as key contributors to superior performance. These findings reinforce the importance of careful interpretation of the incremental benefits of the sustainable attributes of a building due to the many confounding factors that contribute to performance and define results. A select few of GSA’s conclusions are presented below:<sup>58</sup>

According to a two-year workplace study by DYG, Inc. for Knoll, Inc., consisting of 1,500 interviews with 350 full-time office workers, people increasingly believe the workplace affects their productivity and job satisfaction.... The study also showed that satisfaction is crucial to staff retention. Employees planning to leave the organization were 25% less satisfied with their physical workplace than those who planned to stay<sup>59</sup>

The GSA’s research found the following as key descriptors of poor workplace conditions:

- **Space as status**—space is assigned based on status rather than the type of work completed in the space.
- **Indoor air quality**—poor indoor air circulation can lead to people feeling lethargic or having eye, nose, and throat irritations.
- **High churn costs**—significant time, cost, and effort is required to reconfigure space to match organizational changes.
- **Environmental complaints**—people complain about noise and odors or being too hot or too cold.
- **Outmoded technology**—outdated or aging phone and computer systems impact productivity in the workplace, as well as the ability to work from remote locations.
- **Nagging service calls**—building management response to emergency repairs or repetitive maintenance calls on a frequent basis.
- **Anonymous space**—it is difficult to locate other employees within the building; the workspace lacks variety and has no focal points.”

The following key qualities are found in sustainable workplaces:

- **Integrated design process**—focused on adaptability and mobility, environmental issues, ergonomics, collaboration, privacy, and noise control.
- **Healthy environment**—with more daylight, outside views, and fresh air
- **Flexible systems**—such as ergonomic equipment, chairs, and keyboards; flexible monitor location; and moveable task lighting.
- **Occupant control** of lighting, heating, and cooling systems

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<sup>58</sup> The conclusions presented are those of the General Services Administration, and reflect their position as an occupant of the space they own or lease, and the underlying assumption that the government accrues all the benefits that would accrue from innovative and/or sustainable workplaces.

<sup>59</sup> DYG, Inc., 1998.

- **Alternative work strategies**—including telework programs and centers, desk sharing, touchdown space, and remote information access
- **Flexible workplace strategies**—such as community space and ample private space; cell phones and laptops.
- **Reduced absenteeism.** Healthier indoor environments reduce sick building symptoms and absenteeism. A Canadian study revealed that approximately one-third of employees' sick leave can be attributed to symptoms caused by poor indoor air quality. The same study found that communication and social support enabled by open office plans are strong contributors to healthy workplaces and lowered absenteeism.<sup>60</sup>

According to a study by Carnegie Mellon University (CMU) for the Department of Energy (DOE), improving indoor air quality and providing natural light reduces illness and stress. The CMU study<sup>61</sup> showed that occupants closer to windows reported fewer health problems.

In addition, a survey of three case studies by the Rocky Mountain Institute proved that better lighting and HVAC systems could reduce absenteeism from 15 to 25 percent.<sup>62</sup>

- **Improved recruitment and retention:** The workplace is a proven factor in hiring and keeping a world-class workforce, resulting in improved recruitment and retention rates and decreasing expenses to replace staff. Knoll reports that a Hay Group study found that half the people planning to leave their current employer were dissatisfied with their workplace, while only one-quarter of those staying were dissatisfied.<sup>63</sup> A study commissioned by the American Society of Interior Designers also found that 51 percent of employees surveyed said the physical workplace would impact their decision to leave their job.<sup>64</sup>

Similar studies show that employees are happier when they have control over how and where they work, resulting in a better work-life balance and higher retention rates. This finding is particularly important given that Boston College's Sloan Work and Family Research Network found that 54 percent of the current workforce is part of a dual-earner couple—meaning that employees are increasingly responsible for caring for children and parents.<sup>65</sup>

- **Increased productivity and performance:** Flexible, adaptable work settings allow people to customize their workspace to suit their individual needs, providing improved comfort. When given control over their environment, workers are less distracted and more productive and satisfied with their jobs. They also report fewer complaints to building management. For example, Public Works and

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<sup>60</sup> K.E. Charles, et al., "Workstation Design for Organizational Productivity," 2004.

<sup>61</sup> Advanced Building Systems Integration Consortium, Center for Building Performance and Diagnostics, 1995.

<sup>62</sup> J.D. Romm and W.D. Browning, 1998.

<sup>63</sup> Knoll and The Hay Group, 1998.

<sup>64</sup> American Society of Interior Designers, 1999.

<sup>65</sup> Sloane Work and Family Research Network, 2005.

Government Services Canada found that when people were given individual ventilation control, the number of trouble calls decreased significantly.<sup>66</sup>

Healthier, more ergonomic workplaces can also improve performance and reduce expenses. The Occupational Safety and Health Administration (OSHA) reports that repetitive strain injuries caused by poor ergonomic design, including computer use, cost business and industry as much as \$54 billion annually in workers compensation and other costs.<sup>67</sup>

In addition, effectively planned work spaces allow workers to interact on an informal basis as needed, increasing collaboration, teaming, and social ties, which can create more cohesive groups and more creative problem solutions. Research has shown that supportive co-worker relationships help people in dealing with stress.<sup>68</sup> Herman Miller found that enabling teams to collaborate and share information improved work group process quality by three percent and decreased project cycle times.<sup>69</sup>

- **Greater flexibility of building services:** Improved flexibility in workplace design reduces the time and expense required for reconfigurations and daily operations and maintenance. The GSA Adaptable Workplace Lab showed that using easily reconfigured furniture could save 90 percent of reconfiguration costs, and reduce reconfiguration time from days to hours. In another example, the Pennsylvania Department of Environmental Protection reduced average churn costs from \$2,500 to \$250 per workstation by using more flexible building and furniture systems in their high-performance green buildings.<sup>70</sup>
- **More effective space utilization:** Workplace strategies such as telework and hoteling support better space-use alternatives. The U.S. Patent and Trademark Office eliminated three floors of office space and saved \$1.5 million per year in rent by incorporating telework and office sharing into its new building program.
- **Efficient operations and maintenance:** Innovative workplaces help decrease facility management, operating, and technology expenses. Vivian Loftness et al. at Carnegie Mellon have compiled case studies that show that improved lighting efficiency and control can save up to 40 percent in total building energy costs.<sup>71</sup>

**b. “Assessing Green Building Performance, A Post-Occupancy Evaluation of Twelve GSA Buildings,” Kim M. Fowler and Emily M. Rauch, Pacific Northwest National Laboratory, July 2008**

The intent of this whole building performance measurement analysis was to inform GSA on how its sustainably designed buildings were performing in comparison to traditionally designed buildings. In contrast to LEED-NC, which is focused on design and

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<sup>66</sup> K.E. Charles, et al., 2004

<sup>67</sup> Occupational Health and Safety Administration (OSHA), Dept. of Labor, 1999.

<sup>68</sup> K.E. Charles, et al., 2004.

<sup>69</sup> L. Gee and H. Miller, 2003.

<sup>70</sup> J. Toothacre and Pennsylvania Dept. of Environmental Quality, 2001.

<sup>71</sup> Center for Building Performance and Diagnostics, 2005.

specifications for new construction projects, “whole building performance measurement” (WBPM) assesses how well sustainably designed buildings are actually operating.

The authors offered this summary of their study:

In summary, this study shows that for these 12 GSA buildings, the aggregate operational costs, the energy performance, and the waste costs are better than those of an average baseline building. Additionally, the building occupants are more satisfied with the buildings than occupants of baseline buildings, and the environmental impact with respect to carbon emissions of the study buildings are less than a baseline building.

Because this study involves a small number of buildings, data on many more buildings are needed before any of the findings can be generalized to a larger population of sustainably designed buildings. Detailed analysis on individual buildings would offer a better understanding as to why each of these buildings is performing as it is.

The study focused on twelve buildings, seven that were US Green Building Council LEED Certified buildings, and one that was LEED registered, one that used Green Building Challenge, but has a LEED equivalent score for the report, and three buildings that emphasized energy efficiency during design. Based on the selection criteria outlined in the report, and the fact that the GSA had only 19 LEED Certified buildings as of the summer of 2007, and the fact that the buildings are located in five different geographically dispersed GSA regions, it is reasonable to presume that the results of this study represent a random selection of sustainable buildings in the GSA portfolio. This is particularly critical to sustainable building performance studies, because so much of sustainable building research is seriously compromised because of the “cherry picking” of buildings that included in studies.

While the study’s design appears reasonable, potential issues that need to be considered when applying conclusions from the work are that it is likely that the first wave of sustainable properties at the GSA might be expected to be strong performers. Additionally, willingness to provide information was the final selection criteria for properties included in the study, indicating potential self-selection bias. Offsetting these concerns is the well established fact that lessons learned in initial sustainable property experiences can be quite valuable in improving the quality of sustainable property investment in the future, thus suggesting that this initial sample of GSA buildings may actually not perform as well as future projects.

The whole building performance metrics analyzed in this study include:

- Water use
- Energy use
- Maintenance and operations costs
- Waste generation and recycling
- Occupant self-reported satisfaction and productivity



- Transportation (regular commute miles per week)

In most cases, data were only available for 12 consecutive months, which was generally collected for the time period between April 2005 and March of 2007. Other key information about the buildings include:

- Four of the buildings are leased, eight are GSA-owned.
- Five of the buildings had major renovations; seven are new construction.
- Half of the buildings are four stories tall or fewer.
- Three of the buildings have GSA personnel co-located with the occupants.
- Four buildings have underfloor air distribution systems.
- Four buildings purchase central steam.
- Three buildings purchase central chilled water.

Key conclusions are summarized below:

- **Water:** The average water use of the GSA buildings in this study was three percent less than the calculated water use indicated for baseline buildings. The conclusions on water use are not clear because domestic water use had to be estimated. Sub-metering and more detailed information about each of the buildings' water use would be needed before definitive conclusions could be drawn.
- **Energy:** All of the buildings performed better than the Commercial Buildings Energy Consumption Survey (CBECS) averages and most performed better than the GSA goal. On average the office buildings in this study performed 29% better than the CBECS national average for office buildings.

When compared to the GSA national goals for energy performance, these buildings performed 14% better. Consistent with prior studies, while the average improved performance for office buildings was 29%, there was wide variability among the 12 buildings studied.

- **Maintenance and operations:** Average maintenance costs (general maintenance, ground maintenance and janitorial costs) for the sustainable buildings was 13% less than the average baseline cost. More than half of the buildings fell within or below the baseline range. Several buildings had noticeably higher general maintenance costs per square foot. All but one of the buildings fell within or below the baseline range for grounds maintenance. Janitorial costs for a third of the buildings were above the baseline costs, with two-thirds at or below the baseline. The study notes a number of difficulties and issues related to the data, but the numbers appear to clearly show that sustainable property maintenance costs are not higher in most cases, and on average lower than for conventional buildings.
- **Waste generation and recycling:** All of the buildings were below the baseline for waste costs per occupant per year. However, based on site visits it was observed that recycling was not a strong expectation of the building occupants

for at least some of the buildings. Data availability also made a clear and definitive understanding of this issue difficult.

- **Occupant satisfaction:** All of the GSA buildings in this study scored above the 50<sup>th</sup> percentile for general building satisfaction based on the Center for the Built Environment (CBE) survey (reformatted by GSA for this study as the Sustainable Places and Organizational Trends (SPOT) survey.) On average, these buildings scored 22% better than the CBE 50<sup>th</sup> percentile.
- **Transportation:** The commute distance traveled and emissions from the identified transportation modes result in lower emissions than the average office worker commute.

**c. “The Economics of LEED for Existing Buildings,” Leonardo Academy Inc., April 21, 2008**

The survey data presented in this report was gathered in 2006-2007. The survey was sent to the owners or managers of 53 LEED-EB certified buildings and 23 of them returned the survey. This represented a response rate of 43 percent.

The survey form gathered the overall costs of the LEED-EB implementation and certification process. Out of 23 survey respondents, 14 (61%) provided this information. The information gathered included the internal staff time and internal staff costs in achieving LEED-EB certification, the amount spent on LEED-EB consultants (if any), total soft costs of the process, and the total hard costs (for any building improvements made). This report includes analysis of the total costs, costs on a square foot basis and costs for the level of LEED-EB certification achieved (LEED-EB, LEED-EB Gold, LEED-EB Silver, or LEED-EB Platinum). For operating costs comparisons, the LEED-EB certified building operating cost data was compared to the operating costs in BOMA’s *Experience Exchange Report*.

For the operating cost survey form, 13 of the 23 (57%) of the respondents provided the requested building operating cost data. Of these 13 responses with building operating cost data, 11 were included in this analysis because incomplete information was provided for one building and another building was of a building type very different from the others. All of the buildings included in this analysis have a significant component of office space.

The following key conclusions were extracted directly from the report:<sup>72</sup>

- The costs for LEED-EB implementation and certification varied significantly from building to building. The total costs were a mean of \$2.71 per square foot, with a median of \$2.31 per square foot. The results did not follow expectations of higher costs for higher certification levels, but this may be due to the very small sample size available.

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<sup>72</sup> While not reported in this report, the study does provide an assessment of the cost to achieve specific LEED-EB points.

- In all the categories of operating costs, more than 50% of the LEED-EB buildings had expenses less than the BOMA average for the region. Total expenses per square foot of the LEED-EB buildings were less than the BOMA average for seven of the eleven buildings (64%).
- The median cleaning cost in LEED-EB buildings was \$1.24 per square foot compared to \$1.14 per square foot for BOMA buildings. Repair/maintenance in LEED-EB buildings had a median cost of \$1.17 per square foot compared to the BOMA median of \$1.52 per square foot. Roads and grounds expenses in LEED-EB buildings had a median of \$0.33 per square foot compared to \$.08 per square foot for BOMA buildings. Utility expenses in LEED-EB certified buildings were at a median of \$1.45 per square foot compared to the BOMA median of \$2.11 per square foot (indicating 31% less utility expense in LEED buildings). Total expenses in LEED-EB certified buildings had a median of \$6.07 per square foot, 13% less than the \$6.97 average for BOMA buildings.

### 3. Building Energy Use

In this section, we focus on evidence of building energy performance given its critical role in financial analysis.

#### *Summary Conclusions on Building Energy Use*

In summary, evidence from the key studies to date looking at actual energy-use savings from LEED certified buildings<sup>73</sup> suggests such buildings use 15% to 40% less site energy than non-LEED buildings, consistent with the anecdotal evidence the Consortium has accumulated from numerous case studies.<sup>74</sup> Actual energy savings in EnergyStar buildings has also been found to be in the 30% range.

While average site energy savings range from 15% to 40% in key studies, there is an even wider variability in performance around the mean. More importantly for real estate investors, actual energy performance was not closely correlated with modeled performance at the property level, increasing uncertainty and risk in forecast savings. Many factors are cited to explain the variability in forecasts including the occupancy type and energy intensity of the users.

The most widely cited source of energy performance evidence, the February 2008 New Building Institute study, has been challenged by subsequent research. The 2008 NBI study concluded that LEED certified buildings on average use 25-30% less energy than non-LEED buildings. An initial follow-up study refining the NBI data and analysis concluded that energy savings were as low as 18%, ranging from 18% to 39%, but that 28% to 35% of the LEED buildings actually used more energy than similar conventional buildings. A

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<sup>73</sup> It should be noted, and considered in evaluating the results, that even the studies cited here published in 2008/2009 only evaluate buildings certified through 2006.

<sup>74</sup> Most building managers are familiar with site energy, the amount of heat and electricity consumed by a building as reflected in utility bills. Source energy represents the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, thereby enabling a complete assessment of energy efficiency in a building. More detail on the differences and their importance can be found at [http://www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_benchmark\\_comm\\_bldgs](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs).

second follow-up study reported as its main conclusion that LEED office buildings on average used 17% less site energy, but total source energy for LEED buildings was actually higher than the corresponding average for similar commercial stock.

Each of these three key studies brings up a myriad of complex statistical and energy measurement issues, and offers conclusions that suggest investors/valuers need to be careful in applying any general statistics to specific property analysis, and be skeptical concerning forecast energy savings or links between environmental certification and energy savings. However, as LEED and other environmental certifications are becoming more energy sensitive, and energy technologies and strategies become more tested, results and commentary from properties certified in the first five years of this century will not define what is possible or likely with energy efficiency and renewal strategies. The key is to be an informed consumer of “scientific” research.

#### *Summary of Key Building Energy Use Research Studies*

This rest of this section contains an overview of select reports, articles, academic studies and case studies that provide evidence of the link between sustainable certification, energy efficiency, and real estate returns and value. Its purpose is to provide decision-makers with a general sense of how these linkages are assessed and the order of magnitude of what one can expect from energy efficiency investment.

#### **a. “Evaluating the Energy Performance of the First Generation of LEED-Certified Commercial Buildings,” Rick Diamond, Mike Opitz, Bill Von Neida, and Shaun Herrera, 2006.**

One of the first studies of 21 buildings certified under the LEED program between December 2001 and August 2005 concluded:

The mean savings modeled for the sample was 27% compared to their modeled baseline values. For the group of 18 buildings for which we have both modeled [as designed] and billed [actual] energy use, the mean value for actual consumption was 1% lower than modeled energy use, with a wide variation around the mean.

While, on its face, this conclusion may provide some level of comfort concerning the reliability of energy forecasts in the aggregate, the results are more variable on a building-by-building basis. For individual buildings, the ratio of actual to modeled energy use ranged from 18% to 225%, with a mean of 99% and a standard deviation of 46% (a mean of 99% implies that as a group the actual buildings use about the same amount of energy as modeled.) The study discusses some of the many reasons for the discrepancy between modeled and actual performance, such as occupancy and use patterns, which are discussed in detail below.<sup>75</sup> The study also found “...no correlation between energy efficiency points and actual normalized performance for the buildings, with a similar finding for the total

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<sup>75</sup> The study also documents other caveats—small sample size, concentration in federal buildings in the Pacific Northwest, and “likely to be an unrepresentative sample.”

LEED energy points.” It should be noted that this study was based on a different LEED rating system—less energy focus—than exists today.

**b. “Energy Performance of LEED NC Buildings,” Kathy Turner and Mark Frankel, New Building Institute, Feb. 29. 2008; G.R. Newsham, S. Mancini, and B. Birt**

Key conclusions:

**1. On average, LEED buildings are delivering anticipated savings.** Each of the three views of building performance show average LEED energy use 25-30% better than the national average, a level similar to that anticipated by LEED modeling. Average savings increase for the higher LEED levels, with Gold/Platinum buildings approaching the interim goal of Architecture 2030.

**2. Within each of the metrics, measured performance displays a large degree of scatter, suggesting opportunities for improved programs and procedures.** Measured EUIs for over half the projects deviate by more than 25% from design projections, with 30% significantly better and 25% significantly worse. (Page 5)

Background information on the data and research methodology as stated by the authors:

All 552 LEED NC version 2 buildings certified through 2006 were invited to participate in this study. The only requirement for inclusion was the ability to provide at least one full year of measured post-occupancy energy usage data for the entire LEED project. Twenty-two percent (121) of currently certified buildings were able to provide the requested information and are included in the results. (Page 1)

For all modeled whole building results, this study assumed plug loads equal to 25% of the total 90.1 baseline energy usage. This is the default value currently used by LEED in modeling energy use. (Page 9)

Even with 121 participating buildings, data volume can be insufficient for statistically credible differences when subdivided among multiple variables, particularly with high variability in individual performance results. Thus, the study is a beginning, not the final definitive analysis. (Page 9)

What this study is not

- This study is not a statistically robust evaluation of the precise energy savings of LEED buildings. The results show a level of spread within building types and certification levels that can't be explained solely by the buildings characteristics data available. While differences in averages suggest possible relationships, the variance in the data is too large for statistically significant confidence in the size of those differences.” (Page 10)
- The median is appropriate to reflect the average for small sets of widely scattered results, as is true for several of the subset views presented here. It is less skewed by extreme results than are mean averages (which are calculated as the total of all observations divided by the number of observations). Comparing these study medians to the *mean* averages published for the CBECS database creates one imprecision in the quantitative savings estimates here. (Page 34/35)

**c. “Do LEED-certified buildings save energy? Yes, but...,” The National Research Council of Canada, Aug. 2008**

Key conclusions and caveats in the author’s words are cited below:

The study reported that the median EUI of the LEED buildings was 32% lower than the mean EUI in the CBECS database. For office buildings, the most common and easily-comparable activity type, the median EUI of the LEED buildings was 33% lower than the mean EUI in the CBECS database.” (Page 4: Commentary on February 29, 2008 NBI Study)<sup>76</sup>

In fact, the average ratio between measured and designed EUI was remarkably close to unity, at 0.92, suggesting that modeled results over populations of buildings might represent a reasonable estimate of actual energy performance. However, the ratio for individual projects ranged from less than 0.25 to >2.75, suggesting that experts’ caveats for individual buildings are well-founded, and that energy modeling can be a poor predictor of project-specific energy performance. The median predicted energy saving (relating to the code baseline) for the LEED buildings was 25%, whereas the median measured saving was 28%. However, again the range for individual buildings was wide, with one-in-five buildings using more energy than their baseline.” (Page 5: Commentary on February 29, 2008 NBI Study)

The results for all medium energy use buildings and for offices only are similar. Average savings are in the range 18-39%, depending on the parameters of the comparison.” (Page 14: Reporting results from the author’s study of revised/ adjusted data from NBI study)

However, despite average savings, 28-35% of LEED buildings used more energy per floor area than their individually matched CBECS building. Further, there was no statistically significant relationship between LEED certification level and energy use intensity, or percent of energy saved vs. baseline. In other words, LEED Silver buildings did not exhibit better energy performance than LEED Certified buildings, and LEED Gold/Platinum buildings did not exhibit better energy performance than LEED Silver buildings. This runs counter to the popular assumption, and although we found that “higher” certification level was positively correlated with number of energy credits received, certification level does depend on many other credit categories. There were, for example, Certified buildings that received more energy credits than Gold/Platinum buildings.” (Page 14/15: Reporting on results from author’s study of revised/adjusted data from NBI study)

It is important to recognize that these conclusions are drawn from a dataset with many limitations. First, the LEED building data comes from early years of operation, perhaps the first year, during which “teething problems” or unusual start-up operations will inevitably occur. Second, we have a relatively small sample size, particularly when looking at office buildings only, or in the more conservative comparisons to the CBECS database. The CBECS comparisons are further complicated by differences in building/climate/performance descriptors. Sample size is a particular concern when there is large variability in the data, as there inevitably is in building energy data. Building-to-building comparisons, as well as comparisons

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<sup>76</sup> EUI = Energy Use Intensity, as measured in KBtu/ft<sup>2</sup>/year, was derived by summing the purchased energy from all fuel types.

between buildings and their own baselines and modeled performance, can be clouded by a host of on-the-ground design and operational issues. The studies referred to in the Introduction suggest the following key (but by no means inclusive) factors:

- The occupancy hours differ from those in the initial design assumptions
- The final as-built building differs from the initial design
- Experimental technologies do not perform as predicted
- Plug loads are different than assumed
- The building has not been commissioned property, and a knowledge transfer gap exists between the design team and end users.” (Page 16)

One criticism that we do not have the data to address is that of self-selection in the LEED sample. Building owners/operators participated voluntarily (of 552 LEED certified buildings that could have been in the sample, data for only 121 was provided), and it is possible that those who thought they exhibited better performance would be more likely to participate. Therefore, we recommend that these findings should be considered as preliminary, and the analyses should be repeated when longer data histories from a larger representative sample of green buildings are available.” (Page 17)

**d. “A Re-examination of the NBI LEED Building Energy Consumption Study,” John H. Scofield, Oberlin College, OH, August 2009**

Key conclusions from this study are presented below:

Here we identify several critical flaws in the NBI analysis and, upon re-examination of the data, reach different conclusions. We find that the average energy consumption by LEED certified buildings is actually higher than the corresponding average for the US commercial building stock. This difference is shown to be largely due to the over-representation of “high-energy” principle building activities (PBA’s) such as laboratories and the under-representation of “low-energy” PBA’s such as non-refrigerated warehouses in the LEED building data set, relative to their occurrence in the U.S. commercial building stock. Eliminating high- and low-energy PBA’s from both data sets yields “medium-energy” building subsets free of these disparities. **Comparing these we find that LEED medium energy buildings, on average, use 10% less site energy but no less source (or primary energy) than do comparable conventional buildings. LEED office buildings achieve 17% reduction in site energy, but again, no significant reduction in primary energy use relative to non-LEED office buildings.**

In the U.S. SiteEI is commonly used as the metric for building energy consumption. In contrast, the EPA has adopted source energy intensity (SourceEI) as the metric for the ENERGY STAR national energy performance rating.<sup>77</sup> Building source energy, which accounts both for on-site building energy use and off-site losses in bringing the energy to the building site, is a good measure of the primary energy use and emissions associated with building operation.<sup>78</sup>

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<sup>77</sup> For more information see [http://www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_portfoliomanager](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager).

<sup>78</sup> For a discussion of site and source energy intensities see [http://www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_benchmark\\_comm\\_bldgs](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_benchmark_comm_bldgs).

Are we to call a building “more efficient” if it lowers SiteEI while actually causing primary energy consumption (on and off site) to increase? This is ludicrous—yet it is exactly what is going on today with many “high performance” buildings and, as is a significant problem with LEED buildings. Building SourceEI accounts for the off-site losses in the electric sector by weighting the on-site electric use by a factor of three.”<sup>79</sup>

The author used the database used in the 2008 NBI study as a starting point, but made some adjustments:

Following NBI’s lead we now divide the LEED-121 buildings into two sets: (1) 21 ‘high-energy’ buildings and (2) 100 ‘medium energy’ buildings. Our goal is to compare the ‘medium energy’ buildings with a comparable subset of CBECS. As was the case for the full LEED-121 data set, we do not have fuel-type information enabling us to calculate SourceEI for all the LEED-100 (M) buildings. Instead, SourceEI may be calculated for 89 of these—what we will refer to as the LEED+89(M) medium energy data set.

To proceed with our analysis we must extract a medium energy building subset from CBECS that is comparable to the LEED medium energy subset. Looking at Table 2 we first remove laboratories ((PBA=4), food sales (PBA=6), food service (PBA=15), and inpatient health facilities (PBA=16), as these are analogous to high-energy uses that have been eliminated in forming the LEED+89(M) data set. On the low energy side we remove vacant buildings (PBA=1), non-refrigerated warehouses (PBA=5), and religious worship buildings (PBA=12) on the grounds that these low-energy buildings are not represented in the LEED data set.

Consider then another comparison. Focusing on Office buildings yields smaller data sets but ones that are more homogenous with regard to building activities. The LEED-121 data set contains 35 office buildings. LEED+32(O) is the subset for which we have been able to determine source energy. Office buildings correspond to a specific PBA in CBECS, so it is easy to extract data for Office buildings of all vintages or just the most recent vintage (constructed between 2000-3). Comparing these subsets we find that LEED offices have mean SiteEI 17% lower than that for CBECS offices of all vintage, but that both sets have insignificantly different SourceEI means. The same conclusion is reached in comparing LEED offices with the newest vintage CBECS offices.

There is no question that the method for gathering data for this study is flawed. Ideally data would be gathered from all 552 LEED certified buildings and verified by independent audits—gathering energy data directly from utilities rather than filtered through building owners. Alternately, data from a subset of randomly selected LEED buildings could serve in its place. Neither method was employed, nor could be, as LEED certification has no monitoring or reporting requirement.”

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<sup>79</sup> Here we employ a simple definition of *source energy* to be *site energy* plus twice the *electric energy* (used on site). This is equivalent to weighting the electric energy used on site by a factor of three. The EPA uses a more complicated formula that weights electric energy by 3.34, natural gas by 1.047, and other fuels by factors slightly greater than unity. Changing to EPA numbers would raise SourceEI figures for both CBECS and LEED by 7-10%, but have no significant impact on their comparison.



**e. “The Financial Benefits of ENERGY STAR Labeled Office Buildings,” Greg Katz and Jeff Perlman, February 2007**

The authors analyzed data on office buildings that earned the ENERGY STAR label between 1999 and 2004 and compared the performance of those buildings to that of a national subset of buildings (baseline “average” building) derived from the Department of Energy’s Commercial Buildings Energy Consumption Survey (CBECS). The baseline data set consisted of buildings from the 1999 CBECS that were similar to the ENERGY STAR labeled buildings in terms of size and use. The performance measure employed was the energy intensity of the buildings, which is thousands of BTUs consumed per square foot per year (kBtu/ft<sup>2</sup>/yr).

Since the ENERGY STAR program is a performance-based rating system, ENERGY STAR labeled buildings may have any combination of energy efficient features or none. They may be well-managed properties that employ a series of energy efficient O&M practices.

The key findings are as follows:

- ENERGY STAR labeled office buildings are one-third more energy efficient than average U.S. office buildings, consuming 61.6 kBtu/ft<sup>2</sup>/yr as compared to an average of 103.2 kBtu/ft<sup>2</sup>/yr.
- A conservative estimate of energy savings of 35 kBtu/ft<sup>2</sup>/yr coupled with assumed energy price of approximately \$0.014 equates to about \$0.50 per square foot per year in lower energy costs. For a 100,000 square foot office building, this translates into \$50,000 per year in energy savings when compared to an average building.
- “Buildings that receive the ENERGY STAR label in multiple years consistently outperform comparable non-labeled buildings, and the performance margin increases over several years of relabeling.” (Page 5)
- The study cites anecdotal evidence, derived from interviews with REIT managers, that ENERGY STAR labeling is positively correlated with higher occupancy.
- The study offers anecdotal evidence that energy efficient buildings are generally actively managed and have better operations and maintenance (O&M) procedures, personnel and equipment. The authors state qualitatively that one approach to achieving the Energy Star label is to include sophisticated energy management and control systems (EMCS) in the design of the building. By monitoring energy performance management can detect drops in efficiency that

otherwise go undetected, thereby contributing to longer equipment life and reduced O&M cost.

- Given the trend by utilities to use new pricing systems that include demand, peak and tiered charges, energy efficient buildings may be able to lower peak demand and qualify for a lower rate structure that actually lowers the average price paid per kilowatt-hour. In addition to overall energy consumption, energy costs will depend on the timing of the demand for energy.

It is not possible to determine a rate of return for achieving the ENERGY STAR label from this study. As noted above, a building can earn the label in any number of ways, and initial costs to achieve the label were not considered. It is possible to generally attribute value to having the label in that, all other things being equal, \$0.50 per square foot per year in reduced operating expenses will translate into property value directly by applying a cap rate to the resulting increase in NOI. This conclusion holds true for an owner/user but may depend upon lease structures for investor/landlords.

**f. “Participation in Voluntary Programs, Corporate Reputation, and Intangible Value: Estimating the Value of Participating in EPA’s ENERGY STAR® Program,”  
Lou Nadeau, Jeff Cantin and Richard Wells, June 24, 2003**

This study estimated the intangible market value of companies that participated in the ENERGY STAR building program and also the intangible market value associated with energy efficiency in general. The following synopsis is taken from the summary and conclusions of the study:

This paper looks at the relationship between participation in the EPA ENERGY STAR® program and a firm’s intangible value. We used a sample of [124] REITs measured quarterly from 1999 to 2001. We constructed models of the relationship between Tobin’s  $q$ , a measure of intangible value, and participation in the ENERGY STAR® program. Our models controlled for a number of factors, including self-selection into the ENERGY STAR® program by companies, market conditions, firm characteristics, and firm-level financial factors.

- We found that the REITs involved in the ENERGY STAR® program received a return of \$16,026 for every million in assets above the amount they would have earned had they not joined the program. Based on the modeling procedure that we used, we attribute this return to the ENERGY STAR® program.
- We also found that ENERGY STAR® partners that benchmark a small number of buildings (1.9 percent of their total floor space in a quarter) earn a [further] return of \$6,437 per million in assets. We attribute this benefit to activities that are associated with building benchmarking, such as efficient building operation.
- Finally, we found that energy efficiency, as proxied by participation in the ENERGY STAR® program [and representing the combined effects of ENERGY STAR® partnership, the reputational effect associated with partnership, and the effect of a company’s propensity for being energy efficient] earned partners a return of \$45,564 per million in assets. This return translated into 10.4 percent of

the market share of these companies. Thus, for REITs, where energy is a substantial concern, energy efficiency represents 10.4 percent of the market share of the energy efficient companies.

**g. “Energy Management & Investor Returns: The Retail Merchandising Sector,”  
Innovest Strategic Value Advisors, February 2003**

Innovest Strategic Value Advisors conducted a study analyzing the relative energy efficiency and management performance in the retail-merchandising sector of the equity markets. Their data set included 12 of the largest retail merchandizing companies representing over 70% of the market capitalization of the Dow Jones Broadline Retail Index. Innovest used a comprehensive rating model consisting of over 30 quantitative and qualitative metrics to rank the companies from 1 to 12.

The study then made a comparison between the top six companies and the bottom six companies in terms of several financial performance measures with the following results:

- The six companies with above average energy management performance as a group outperformed the six below average companies by 71 percentage points over the past five years in terms of stock market performance (total return).
- Above average companies outperformed in terms of price-to-earnings ratio by 13%.
- Above average companies outperformed in price-to-book-value by 26%.
- Above average companies outperformed in return-on-assets by 49%.
- Above average companies outperformed in return-on-equity by 52%.
- Above average companies outperformed in return-on-invested capital by 16%.
- Above average companies outperformed in a measure of intangible value (Tobin’s Q) by 8%.

**h. “The Proof is Performance: How Does 4 Times Square Measure Up?” Adam W. Hinge, P.E. and Donald J. Winston, P.E., High Performance Buildings, Winter 2008**

The article provides a candid analysis of how and why actual energy performance may not meet expectations for new buildings. The property in question is the Conde Nast Building at 4 Times Square, the first green high-rise in the United States. The authors note that “across the high performing building industry, these unrealistic energy performance goals have come from (among other things) inadequate modeling practices, failure to include operation staff in goal setting or accurately communicate the design intent to the staff and

lack of adequate budgets for commissioning, evaluation and ongoing benchmarking.”  
(Page 30)

The case study made a comparison of the energy performance of the 4 Times Square building to the ENERGY STAR 50<sup>th</sup> percentile and other Durst buildings. The basis of comparison is energy intensity (kBtu/sf/yr), measured as both source energy and site energy. This metric does not control for the use, operation or other characteristics of the property. The authors make note of several factors contributing to the higher energy intensity of the building, some of which relate to energy efficiency technologies and other unanticipated factors:

- The ventilation system provides twice the prior New York City industry standard amount of outside air delivered by a dedicated outside air system thereby requiring additional consumption of fan and chiller energy. Additionally, the outside air is filtered to a higher level than other buildings, resulting in additional filter resistance and fan energy consumption.
- The process energy for exterior signage and lighting (to achieve minimums required by the Times Square Redevelopment District) was not taken into consideration while setting performance goals.
- The principal tenants of the building have significant after-hours operations, and the building is available for tenants 24/7.

A broadcast antenna atop the building consumes • Additional process energy with transmitter facilities for radio and television stations, some of which operate 24/7 and require continuous operation of the building cooling plant.

Two corporate cafeterias consume • Additional process energy with commercial kitchen facilities.

- The direct gas-fired absorption chillers did not turn out to be the most efficient choice with respect to overall net site or source energy use. They had been chosen primarily for their lack of impact on the electrical grid, favorable operating costs and lack of harmful refrigerants. (Page 32)

The authors share the lessons learned at 4 Times Square and how these lessons will be incorporated into their next project, the Bank of America Tower at One Bryant Park. Some of these lessons are described below:

...though fuel cells work, from a fiduciary standpoint this application and design was not the best use of the technology. The two fuel cell units consume a large amount of space that is out of proportion to the actual amount of power being produced. In midtown Manhattan, the price of this office space is at a premium. Also, the units have turned out to be very maintenance intensive, and installation costs were much higher than expected. Finally, the waste heat recovered from them is low-grade and not very useful. At One Bryant Park, instead of a fuel cell, a gas turbine is being used to achieve energy production goals in a more dramatic way.

After seeing that installation costs were much higher than expected and that production rates were much lower than expected due to the vertical orientation of the

Photovoltaics in the building's facade, we realize that this technology was not best applied in a Manhattan high-rise office building. At One Bryant Park, we resisted the desire and pressure to include building-integrated Photovoltaics.

Because the [commissioning] team was engaged during the final stages of construction, the process was less efficient than it could have been. At One Bryant Park, we engaged the commissioning team much earlier during the design process and before construction began... the commissioning team is also much larger than the team at 4 Times Square, allowing for increased system testing, surveillance and inspection. (Page 35)

**i. “Energy Management & Investor Returns: The Real Estate Sector,” Innovest Strategic Value Advisors, October 2002**

This study is similar to the above Innovest Strategic Value Advisors study; only this study focuses on 12 REITs instead of the retail sector. The energy consumption performance of the 12 REITs was analyzed using a comprehensive rating model consisting of over 25 quantitative and qualitative metrics. The six companies with above average energy management performance, taken as a group, outperformed the below average companies by 34 percentage points in the stock market over a two year period.

Energy performance was also assessed by comparing the stock market performance of 13 less active ENERGY STAR partners, 11 active ENERGY STAR partners and 12 non-partners. The study concluded that active partners outperformed less active partners by over six percentage points in the stock market, and active ENERGY STAR partners outperformed non-partners by over 12 percentage points over a two-year period from June 2000 to June 2002. (Page 3). Active ENERGY STAR partners consistently outperformed both of the other groups over the relevant time period. However, it should be noted that the performance of the less-active partners in relation to the non-partners was sensitive to the selection of the end point of the analysis, and the non-partners actually outperformed the less active ENERGY STAR partners if the assessment were to be made during the February to November 2001 time period.

Based on the Tobin's Q measure of intangible value, active ENERGY STAR partners outperformed less active partners by 29% and non-partners by 18%. (Page 3) The study alludes to other Innovest research indicating that in nearly every one of 50 stock market sectors analyzed, companies with above average environmental performance, taken as a group, out-perform the below average companies by amounts ranging from 3 to 30 percentage points per year. (Page 4)

**j. “Core Performance Guide,” New Buildings Institute, Inc., July 2007**

<http://www.newbuildings.org>

The New Buildings Institute, Inc. recently published its *Core Performance Guide*, which is “a prescriptive program to achieve significant, predictable energy savings in new commercial building.” The following excerpts are taken from the Guide's introduction:

The program describes a set of simple, discrete integrated design strategies and building features. When applied as a package, they result in energy savings of at least 20 to 30% (depending on climate) beyond the performance of a building that meets the prescriptive requirements of ASHRAE 90.1-2004, and at least 25 to 35% beyond a building that meets ASHRAE 90.1-2001. This program is the revised and updated version of the *Advanced Buildings Benchmark* program released previously.

The program is based on the results of an extensive energy modeling protocol used to identify consistent strategies that lead to anticipated energy savings across climates... The program also includes guidelines on implementing improved design processes to foster design integration, thereby improving overall building performance opportunities... A key aspect of the *Core Performance* program is that the strategies that make up the program represent ‘state of the shelf’ technologies and practices that are broadly available in the building industry, and have been demonstrated to be cost-effective. (Page 11)

It is important to note that the projected energy savings described above are based on over 3,000 energy model simulations run on prototype buildings, rather than actual implementation and measurement of the effects of energy efficient features. Even so, the methodology has the highly useful capability to generate an ordered ranking of energy efficiency measures or features. This is accomplished by sequentially adding energy performance measures to a baseline case to determine, at each stage, which one has the most significant energy savings impact.

#### **4. Occupant Performance**

The fourth key component of sustainable building performance that we cover in this section is occupant performance. Occupants (tenants, owner-occupants, or visitors/customers) are the most critical component of building performance. Individuals and/or enterprises that are healthy, productive, profitable, and happy as a result of their buildings should respond favorably from a market perspective, enabling higher revenues, reduced risk, and improved financial performance for building owners.

##### *Measure of Occupant Performance*

Occupant performance has two key components of measurement, as shown below in Exhibit IV-7:

- The actual occupant: individuals working in or using space; and
- Enterprises that lease or own the space.

<b>Exhibit IV-7</b> Measuring Building Performance: Occupants	
<b>Individual</b>	<p><b>Health</b></p> <p><b>Productivity</b></p> <p><b>Satisfaction</b></p>
<b>Enterprise</b>	<p><b>Reduction in Resource Use</b></p> <ul style="list-style-type: none"> <li>• Reduction in energy and water use</li> <li>• Reduction in building waste</li> <li>• Reduction in pollution emissions</li> <li>• Reduction in carbon footprint</li> </ul> <p><b>Improved Reputation / Leadership</b></p> <ul style="list-style-type: none"> <li>• Recruiting</li> <li>• Employee retention / satisfaction</li> <li>• Public relations / brand management</li> <li>• Retain “social license” to operate</li> <li>• Improved marketing and sales</li> <li>• Increased company market value</li> <li>• Increased company market liquidity</li> <li>• Shareholder concerns addressed</li> </ul> <p><b>Compliance With Internal / External Policies / Initiatives</b></p> <ul style="list-style-type: none"> <li>• Corporate energy / sustainability requirements</li> <li>• Corporate social responsibility reporting</li> <li>• Global Reporting Initiative</li> <li>• Carbon Disclosure Project</li> <li>• Minimum requirements of socially responsible investment funds</li> </ul> <p><b>Reduced Risk to Future Earnings</b></p> <ul style="list-style-type: none"> <li>• Legal risks—sick building syndrome and mold claims, business interruptions, building remediation costs, etc.</li> <li>• Reduced sub-leasing risk if downsizing, relocating, etc.</li> <li>• Reduced operating cost volatility</li> <li>• Reduced risk to reputation</li> <li>• Improved defense of competitive advantages</li> <li>• Reduced risk of future compliance costs</li> </ul>

While most researchers and industry analysts have focused on individual occupant performance (health, productivity and satisfaction), enterprise-level occupant performance is also critical to measure and understand. As shown above in Exhibit IV-7, enterprise-level occupant performance consists of reductions in resource use, improved reputation/leadership, compliance with internal/external policies or initiatives, and reduced risk to future earnings. Individual occupant performance—health, productivity and satisfaction are part of enterprise level occupant performance.

Reductions in resource use have been discussed in the prior section. The key focus of occupant performance is the occupant’s share of potential reductions in resource use/cost, relative to property owners.

Improved reputation/leadership can be measured directly by surveys, stock analyst reports, and indirectly through assessment of how sustainable property investment has influenced

recruiting, employee retention or satisfaction, marketing and sales, and brand awareness. This “evidence” of occupant performance relative to improved reputation and leadership may be found in the surveys and market research done for other parts of an occupant’s business, and not typically in a traditional building measurement or monitoring program.

Occupant performance relative to compliance with internal/external policies and initiatives can be measured through an examination of trends in the importance of owned or leased real estate to the Global Reporting Initiative, the Carbon Disclosure Project, the requirements of socially responsible investment funds, government agencies, or a corporation’s own Corporate Social Responsibility reporting strategy and communications. At a property level, the question is how important is sustainable owned or leased real estate to the types of tenants expected to be leasing in the building.

The final measure of enterprise-level occupant performance is reduced risk to future earnings. This type of performance can be measured through monitoring of litigation and legal costs, subleasing trends relative to sustainable property, energy cost volatility, and changes in the level of importance of sustainability to key employees, customers, capital providers, vendors, and other stakeholders. If the importance of sustainability increases to the stakeholders, the risks to future earnings, on either a positive or negative basis, could be significantly influenced by sustainable property investment.

#### *Summary Conclusions on Occupant Performance*

In summary, based on all of the Consortium’s research, including its review of over 200 individual health and productivity studies identified in Appendices IV-C and IV-D, its review of resource reduction in sustainable properties, its detailed analysis of the costs and benefits of sustainable properties in Chapter V, and its evaluation of corporate sustainability policies and trends towards sustainable buildings, **there is a clear positive relationship between sustainable property investment and occupant performance.** Occupant performance measurement is in its infancy, as is the occupant market’s response to improved occupant performance, but the trends are supportive of further close attention and analysis.

The key scientific studies that support the Consortium’s summary conclusion above and more detailed conclusions on health and productivity presented below are presented in Appendices IV-C and IV-D. In Appendix IV-C, we first documented as many of the different alleged health or productivity benefits cited by the industry as we could find, then found the specific research study where the alleged benefit was cited. In this process, we identified over 100 additional, as yet uncited research reports that may also be of interest. For Appendices IV-C and IV-D, the studies were categorized as follows:



Study Categories	Number of Studies	Percentage
Indoor Environmental Quality	64	27%
Temperature Control	15	6%
Lighting	19	8%
Privacy and Interaction	13	6%
Ergonomics	17	7%
Access to Natural Environment	36	15%
Whole Building	40	17%
Other References	33	14%
<b>Total</b>	<b>237</b>	<b>100%</b>

As will be discussed in more detail below, care must be taken in citing and using specific numerical conclusions from many of the studies, but existing research has established a clear positive relationship between certain sustainable building outcomes and positive health benefits.

Two good additional resources for looking at Indoor Environmental Quality and Productivity issues from a more practical real estate based perspective are a recent study: “*Green Buildings and Productivity*” published in the Fall 2009 Journal of Sustainable Real Estate, and a series of articles and studies presented at the Yourbuildings.com web site under “Indoor Environmental Quality”:

<http://www.yourbuilding.org/Article/News.aspx?p=82&c=4>

*Green Buildings and Productivity*, by Norm Miller and Dave Pogue, addresses the question of whether green buildings improve productivity, with a focus on office properties. They provide interesting insights on measurement and summarize the results of scientific and more practical studies. They then went further to test the hypothesis that LEED and EnergyStar buildings increased productivity by surveying over 2000 tenants who had moved into 154 LEED or EnergyStar buildings managed by CB Richard Ellis. They received 534 responses and found that 55% agreed or strongly agreed that employees were more productive, while 45% suggested no change. As to sick days, 45% thought there were fewer sick days taken, 45% thought it was the same and 10% thought there were more sick days.

#### *Summary of Health and Sustainable Property Conclusions*

Sustainable buildings that control moisture, control pollutant sources, improve ventilation and access to outside air, promote access to the natural environment, and pay attention to ergonomic furniture and interiors have been documented to improve health. Reduction of sick building syndrome, improved respiratory health, headache reduction, reduction of colds, reduction of asthma, stress reduction, and improved emotional functioning and cognition are some of the positive health outcomes that are possible.

The key findings and conclusions for occupant performance cited below provide excellent starting hypotheses that need to be tested for an individual property. For example, while improved ventilation and moisture control has a positive relationship with health, and daylighting and temperature control has been shown to improve productivity, the analytic

challenge is to determine if these conclusions, even directionally, let alone quantitatively, apply to the particular property that is subject to valuation or underwriting.

The specific property type, size, age, location, and description needs to be considered when applying findings from the key scientific studies. Are the indoor air quality, lighting, temperature control and other outcomes projected for a building similar to the outcomes on which the health and productivity studies were based? Given that most health and productivity studies isolate the effects of a specific outcome like temperature control, it is important not to double count health or productivity gains, and consider the implications of the quality of the scientific studies and the ability to control for factors independently in the analysis of health and productivity benefits. In particular, given the very limited knowledge on the dose-response relationship in many studies, very specific quantitative conclusions may not be reliable.<sup>80</sup>

Fortunately, in the real estate investment community, perfect science or knowledge about the potential health or productivity benefits of sustainable property investments is not required. What is required is appropriate caution in the use of health and productivity studies so as not to mislead decision-makers based on incorrect or incomplete presentation of results and caveats.

Real estate investors are used to dealing with uncertainty. Accordingly, even if it is not scientifically possible to provide a specific quantitative estimate of health or productivity benefits that would result from a particular investment in sustainable property, a thoughtful and independent analysis of the potential benefits to occupants, and how potential occupants for the specific building would react to such information, is particularly important. What has been shown with significant anecdotal evidence, and in occupant surveys, is that due to the “precautionary principle,” even a potential for improved health or productivity by occupants will be more than sufficient to justify any additional cost to create the potential benefits.<sup>81</sup>

The best, and most scientifically sound summary of the potential health benefits of sustainable properties is available on Lawrence Berkeley National Laboratory’s Indoor Air Quality Scientific Findings Resource Bank website (<http://eetd.lbl.gov/ied/sfrb/>). A select

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<sup>80</sup> While the scientific studies have been fairly conclusive in establishing relationships between outcomes like low ventilation rates and adverse health, the studies have been less successful in clearly establishing a dose-response relationship that would enable more precise understanding of how the level of ventilation rate, or the level of daylighting affects health or productivity.

<sup>81</sup> The *precautionary principle* is a moral and political principle which states that if an action or policy might cause severe or irreversible harm to the public or to the environment, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action [Raffensperger C. & J. Tickner (eds.), *Protecting Public Health and the Environment: Implementing The Precautionary Principle*, Island Press, Washington, DC, 1999]. The principle implies that there is a responsibility to intervene and protect the public from exposure to harm where scientific investigation discovers a plausible risk in the course of having screened for other suspected causes. The protections that mitigate suspected risks can be relaxed only if further scientific findings emerge that more robustly support an alternative explanation. In some legal systems, as is the law of the European Union, the precautionary principle is also a general and compulsory principle of law [Recuerda, Miguel A., “Risk and Reason in the European Union Law,” *European Food and Feed Law Review*, 5, 2006]. (Wikipedia, August 2009)

summary of their conclusions on ventilation rates, dampness, and indoor volatile organic compounds is presented below:

### *Ventilation Rates and Health*

Ventilation rates vary considerably from building to building and over time within individual buildings. Throughout the normal range of ventilation rates encountered in buildings, increased ventilation rates are, on average, associated with fewer adverse health effects and with superior work and school performance. There is also some limited evidence that occupants of buildings with higher ventilation rates have lower rates of absence from work or school.

Substantially higher rates of respiratory illness (e.g., 50% - 370%) in high density buildings (barracks, jails, nursing homes, and health care facilities) have been associated with very low ventilation rates, presumably because lower ventilation rates are likely to result in higher airborne concentrations of infectious viruses and bacteria. Only a few studies have been performed.

In offices, a 35% decrease in short term absence was associated with a doubling of ventilation rate from 25 to 50 cfm per person. In an elementary grade classroom study, on average, for each 100 ppm decrease in the difference between indoor and outdoor CO<sub>2</sub> concentrations there was a 1% to 2% relative decrease in the absence rate.

Many studies have found that occupants of office buildings with above-average ventilation rates (up to 40cfm per person) have 10% to 80% fewer sick building syndrome (SBS) symptoms at work. A statistical analysis of existing data has provided a central estimate of the average relationship between SBS symptom prevalence in office workers and building ventilation rate. This analysis indicates a 15% increase in symptom prevalence as the ventilation rate drops from 17 to 10 cfm per person and a 33% decrease in symptom prevalence rates as ventilation rate increases from 17 to 50 cfm per person. The uncertainty in these central estimates is considerable.

### *Building Dampness and Health*

Much research has been conducted on building dampness. Topics investigated include the causes of excess building dampness, and the effects of dampness and of dampness-related indoor contaminants on people's health.

Based on a review by the Institute of Medicine (IOM) of the National Academy of Sciences, dampness and mold in homes is associated with increases in several adverse health effects including upper respiratory symptoms, cough, wheeze, and asthma exacerbation. The available data were sufficient to suggest, but not confirm, that dampness and mold in houses were associated with increases in development of the disease of asthma. The IOM indicated that the specific agents, e.g., molds, bacteria, or organic chemicals, causing these effects were uncertain and that insufficient scientific data were available to draw conclusions about the association of dampness and mold with several other health effects.

Since completion of the IOM review, two new related analyses were completed for this Scientific Findings Resource Bank. A quantitative statistical evaluation of the

available scientific literature produced estimates and uncertainty bounds for the average magnitudes of increases in various respiratory health effects in homes with dampness and mold. Building dampness and mold were determined to be associated with 30% to 50% increases in a variety of respiratory and asthma-related health outcomes

Based on review of eight studies, the evidence supporting an association of dampness or mold in offices and institutional buildings with respiratory or other health effects of occupants is reasonably robust.

### *Volatile Organic Compounds and Health*

Some VOCs and SVOCs are odorous and some are suspected causes of adverse health effects.<sup>82</sup> The suspected health effects cover a broad range including, but not limited to, sensory irritation symptoms, allergies and asthma, neurological and liver toxicity, and cancer.

In summary, additional research is needed before firm conclusions can be drawn about the effects of indoor VOCs or SVOCs on allergy or asthma. The existing evidence of risks is sufficient to indicate that such research is a high priority.

Sensory irritation symptoms involve irritation of the eyes, nose and throat. Skin irritation is also sometimes considered. While it is clear that numerous VOCs can cause sensory irritation symptoms when airborne concentrations are sufficiently high, at the concentrations typically found in normal buildings the contribution of most indoor VOCs and SVOCs to sensory irritation remains uncertain.

In summary, the evidence for an association of higher TVOC (**T = total**) (emphasis added) concentrations with sensory irritation symptoms is equivocal, with most studies not finding an association. Today, some indoor air researchers believe that measurements of TVOC have minimal value because the composition of individual VOCs within the indoor TVOC mixture varies widely among buildings and because the odor thresholds and potencies of the individual VOCs to cause sensory irritation also vary a great deal.

Some of the VOCs present in indoor air have caused cancer in animal studies when the animals were exposed to high concentrations. A few of these VOCs, for example formaldehyde and benzene, are considered by many authorities to be proven or probable human carcinogens.

In summary, some indoor VOCs are designed by multiple authorities as human carcinogens. Estimates of the magnitudes of cancer risks posed by these VOCs vary widely. The cancer risks posed by indoor-generated VOCs appear to be comparable in magnitude to the cancer risks of exposures to VOCs from outdoor air. Given the uncertainties in cancer risk assessment, particularly the uncertainties of extrapolating from occupational-level concentrations (e.g., 500 to 2000 ppb for formaldehyde) to typical indoor concentrations (e.g., a few 10s of ppb for formaldehyde), the magnitude of the cancer risks posed by indoor VOCs will continue to have a high level of uncertainty.

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<sup>82</sup> SVOCs are semi-volatile organic compounds with higher vapor pressures than VOCs (Volatile Organic Compounds) and therefore are released as gas more slowly.

Given that indoor VOCs, as discussed above, may significantly increase the risks of cancer, it is useful to maintain an awareness of the indoor sources of the VOCs posing the greatest risk. Table 2 lists the VOCs indicated as the largest sources of cancer risk and their main indoor sources. Reducing or eliminating these sources, when feasible, is an option for those who wish to minimize cancer risks from indoor VOCs.

VOC	Examples of Indoor Sources
Formaldehyde	Some manufactured wood products used as building materials, in cabinets, and in furniture (e.g., medium density fiberboard, particle board, plywood with urea formaldehyde resin; urea formaldehyde foam insulation (no longer used but still present in some buildings); tobacco smoking; ozone-initiated chemical reactions with common indoor VOCs, unvented combustion appliances
Naphthalene	Pesticides (moth balls)
Para dichlorobenzene	Pesticides (moth crystals); toilet bowl deodorizer
Chloroform	Pesticides; showering; washing clothes and dishes
Acetaldehyde	Tobacco smoking; water-based paint; unvented combustion appliances; leakage from wood stoves, furnaces, and fireplaces; (outdoor air also an important source)
Benzene	Tobacco smoke; some furnishings, paints, coatings, wood products, gasoline from attached garages (outdoor air also an important and sometimes predominant source)

### *Summary of Productivity and Sustainable Building Conclusions*

Substantial research has established a positive relationship between occupant productivity and improved indoor air quality (IEQ), temperature control, lighting/daylighting, and noise reduction. As summarized in the scores of studies identified in Appendices IV-C and IV-D, productivity benefits for individual IEQ, temperature control or lighting attributes range from 1 - 2% to over 20% in some cases.

Again, these studies provide a strong basis for development of hypotheses about potential gains from productivity that need to be tested at an individual building level. Does the building being valued or underwritten have the features or sustainable outcomes cited in the most important studies? Are the building's property type, time period, type of occupant, and other details similar to the key important studies?

For productivity studies in particular, it is important to understand the specific measure of productivity used. Productivity measures used in these studies include the speed and accuracy of office work tasks, the speed of completing academic work, the speed and accuracy of typical office tasks, test scores, improved proofreading or creative thinking, etc.

It is also important to understand that most of the studies are independently evaluating a particular attribute, like temperature control, and it is not proper to directly add productivity gains from different features. In fact, given the many different factors that affect productivity, including scores of issues that major companies have been studying and working on for over a hundred years, there are significant statistical problems in controlling for all the factors that affect productivity. Additionally, as with health studies,

it is difficult to conduct good studies given the problems in getting cooperation from workers, companies, worker unions, etc.

A thoughtful two-page summary of the impacts of indoor environments on human performance and productivity can be found at the Lawrence Berkeley National Laboratory's Indoor Air Quality Scientific Findings Resource Bank website (<http://eetd.lbl.gov/ied/sfrb/>). They summarize their findings in this way:

The performance of office and schoolwork is affected by indoor environmental conditions and by the features of buildings that influence indoor environmental conditions. Work performance may be improved from a few percent to possibly as much as 10% by providing superior indoor environmental quality (IEQ).

Interestingly, while they find clear measurable relationships between temperature, ventilation rates, and indoor pollutant sources and work performance, they reach the following conclusions concerning daylighting and lighting levels:

- Daylight, View, and School and Work Performance: There is some evidence that more daylight or a view to outdoors improves office and school work performance, but the available data are limited and findings are inconsistent.
- Lighting Levels, Lighting Quality, and Work Performance: Available data are too limited to draw conclusions about the impacts of typical changes in indoor lighting levels and lighting quality on performance of office and school work. Significant impacts on performance are most likely for subjects with poor or uncorrected vision.”

#### *Key Considerations in Assessing Occupant Performance Information*

Identifying, evaluating, and applying the results of research testing the relationship between sustainable building features/ outcomes and health and productivity benefits is challenging. Fortunately, the challenge is not dissimilar to the difficulties the business world faces in the application of any scientific or academic study. And, as discussed above, perfect studies or knowledge about the relationship between buildings and health or productivity is not required in order to be useful.

Measuring building occupant performance is also important and beginning to get more attention. For example, the National Australian Built Environment Rating System's (NABERS) latest benchmark tool is set to provide building managers with the means to identify potential issues within their buildings, as well as compare how they are performing against their peers. Developed by the NSW Department of Environment and Climate Change, the NABERS Base Building Indoor Environment rating tool will allow you assess the air quality, acoustic and thermal comfort of your building. The rating tool can be used to rate tenancies, the base building or the whole building.<sup>83</sup>

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<sup>83</sup> From article posted 11-25-09 at Yourbuildings.org:  
<http://www.yourbuilding.org/Article/NewsDetail.aspx?p=83&id=2350>

Some of the key issues to be considered in assessing and applying the results of health and productivity studies include:

*Identification of and access to key research.*

It is difficult and time consuming to identify and access the key scientific research related to health and productivity benefits. While Appendices IV-C and IV-D are a start, as well as the Consortium's Research Library and Industry Links sections (see index code 10.1 and 10.2), scientific research is ongoing. As with the selection of comparable properties, it is difficult to know if someone advocating the potential health and productivity benefits of a property has identified the key studies, or just included those that support their point. The best way to address this issue is to seek independent sources, and rely upon meta-studies<sup>84</sup>

*Understanding how and why sustainable property outcomes affect health and productivity.*

While there has been a significant amount of research, as presented in Appendix IV-C and IV-D, that test whether sustainable outcomes like indoor environmental quality, temperature control, lighting, privacy and interaction, ergonomics, and access to the natural environment affect health or productivity, the science on how and why these sustainable outcomes influence health and productivity is still not well understood in many cases. What are the physiological and psychological characteristics of light, temperature control, or noise that influence health and productivity. Better understanding and articulation of these linkages will result in improved hypotheses and better, more logical testing and presentations that will be more convincing to the business community.

*Linking specific features/strategies to sustainable outcomes.*

While studies demonstrating a relationship between ventilation, dampness, daylighting, etc. and health and productivity outcomes are well established, the volume and quality of research that links specific sustainable features or strategies to specific ventilation, dampness or daylighting outcomes is often not as robust. Importantly, even when the linkages are well understood, many scientific studies do a poor job describing sustainable features or strategies, making application of these studies to specific buildings with a defined set of features or strategies difficult.

*Statistical/data problems.*

The reliability and accuracy of the specific quantitative results from many of the health and productivity studies is questionable. This is due to the extreme difficulty in the collection of data, and controlling for the scores of variables that influence occupant health

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<sup>84</sup> Meta-studies are those completed by an expert in a particular field that provide a summary assessment and analysis based on a review of key studies. The review is based on a qualitative, and often quantitative, assessment of the results of studies that have been done in the field. The websites of key research organizations like the Lawrence Berkeley National Laboratory, Carnegie Mellon and others can also be helpful in this regard.

or productivity. Since health and productivity studies tend to focus on a particular sustainable feature or outcome, the problem of evaluating a whole building, with a combination of sustainable features and outcomes, is also difficult.

One framework that we particularly like that assists in understanding the statistical relationship between building science and health is one created by Mark Mendall, an epidemiologist working at Lawrence Berkeley National Laboratories, and a board member of the Consortium. Dr. Mendall has created a “layman’s” framework for categorizing the basis for believing something causes an adverse affect. His “What We Know” framework is summarized below.

<b>Documented causal relationships</b>
Significant, replicated, consistent, unbiased, dose-related, plausible
<b>Persuasive scientific findings</b>
Replicated, significant findings, and alternate explanations seem unlikely
<b>Suggestive scientific findings</b>
But “correlation does not prove causation”
<b>Beliefs based on informal observations</b>
Sometimes guides and predicts future science, but sometimes based on error, coincidence, or hidden factors

Dr. Mendall’s framework is based on a related framework used by the Institute of Medicine in their official reviews of health issues.

*Dose-response relationships*

While the studies linking indoor environmental quality, lighting, daylighting, temperature control, noise, and other sustainable outcomes to building health or productivity are robust in many cases, the studies are often insufficiently specific to enable a clear relationship between the amount of the sustainable outcome (lighting, noise, etc.) and building health or productivity. Accordingly, it makes it difficult to assess whether a particular building, with its sustainable outcomes or designed outcomes, will be sufficient to achieve the results identified in the studies.

**5. Durability/Flexibility/Adaptability**

Durability is an important component of a sustainable building. Durable buildings, and the materials and products that go into them, maximize the time available to benefit from environmental benefits the buildings provide. Additionally, given the substantial embedded energy in existing buildings, more durable buildings reduce energy consumption and carbon output significantly, as well as reduce waste in landfills.<sup>85</sup>

<sup>85</sup> The energy required to build a building is approximately 10-20% of a buildings total energy used during its lifetime. This is an estimate from specialists I have talked to, but is highly variable based on the building type, buildings energy use, etc.



Building durability is significantly influenced by its flexibility and adaptability to changing tenant and investor demands. Buildings are frequently torn down or substantially retrofitted due to functional or economic obsolescence, not just structural, product or material failures. Flexibility of space has been studied in the corporate real estate sector for years and is a key attribute sought by corporations. Flexibility and adaptability can be aided by underfloor air distribution and many other design and construction techniques.

One of the problems with durability is that it is difficult to define. Should it be defined as the lifespan of a building, the durability of its components, the level of operations and maintenance required, or some combination of the three? In the GreenSpec Directory®, durability and low maintenance are considered together as a criterion for product selection.<sup>86</sup> Durability can be defined or rated through review of specific building or product requirements, evidence of performance, or through documentation of a process to promote durability.

“LEED Canada has directly addressed durability for a few years. LEED Canada’s Materials and Resources Credit 8 – Durable Building requires building designers to develop a Building Durability Plan to ensure that the predicted service life of the building and its components exceeds the design service life. The credit draws from Canadian document CSA S478 – Guideline on Durability in Buildings to establish requirements and minimum benchmarks to achieve the point. A project team is required to demonstrate that the building has been designed to achieve the established service life by “documenting effectiveness, modeling, or testing in accordance with Clauses 7.3, 7.4, and 7.5 of CSA S478” and by completing several tables within the Guideline.

A thoroughly more convincing set of recommendations and guidelines for increasing the durability of buildings can be found in Building Science Digest 144, “Increasing the Durability of Building Constructions,” written by renowned building scientist Joseph Lstiburek. In this paper, the author describes building failure mechanisms, what we already have in codes and federal requirements to minimize failures, what we cannot control and design for, and the four remaining things that we can design and plan for: water, heat, ultraviolet radiation and insects. These four “damage functions” are the main focus of the document and arguably address more than 90 percent of current industry durability issues.”<sup>87</sup>

Key elements of durability include<sup>88</sup>:

**Moisture control:** Moisture problems, due to problems in building envelope design—partially as a result of the sustainability goals of more outside air and daylighting—are a significant cause of durability problems. This is particularly true for residential, but also an issue with some commercial properties.

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<sup>86</sup> Durability, a Key Component of Green Building, Environmental Building News, November 2, 2005.

<sup>87</sup> Straight Green: Green Building Rating Systems and Building Durability, “Walls and Ceilings” Chris Dixon, June 24<sup>th</sup>, 2008.

<sup>88</sup> This list is summarized from the article “Durability, a Key Component of Green Building, Environmental Building News, November 2, 2005.

**Thermal Stress:** Heat can cause materials to expand and contract, affecting durability.

**Sunlight:** Ultraviolet light degrades most materials.

**Ozone and Acid Rain:** Ozone and Acid rain degrade materials.

**Insects:** Insects, mostly termites, cause billions of dollars of damage annually.

**Material Failure:** Materials wear out at different rates.

**Building Function:** A building's ability to adapt to changing needs is key to its durability. Functionality has been shown to be more important to durability than physical issues.<sup>89</sup>

**Style:** Similar to building function, buildings with “timeless” style tend to last longer and are better maintained.

**Natural Disasters:** Durable buildings must meet the design requirements of their localities—hurricanes, earthquakes, tornados, floods, and fires.

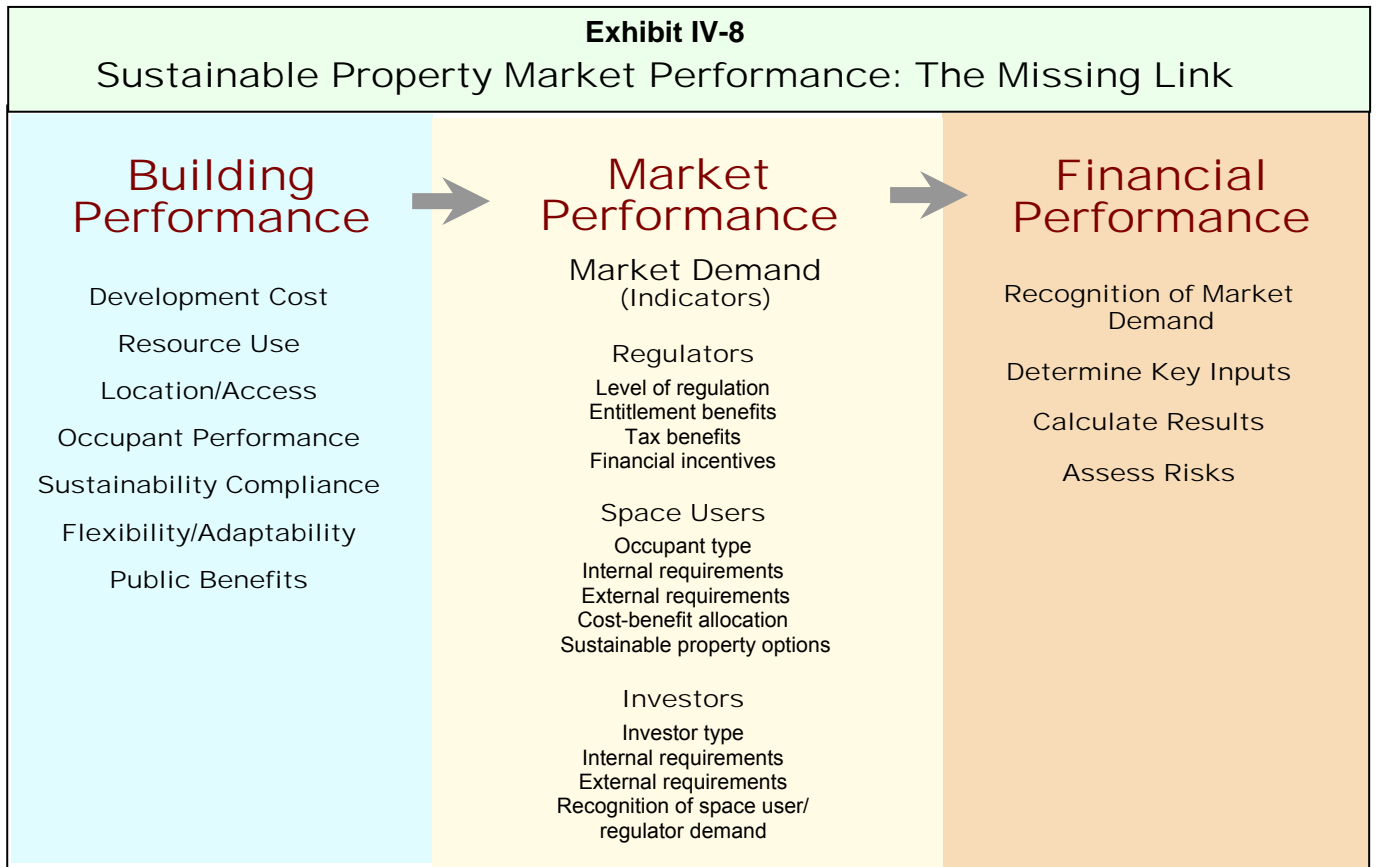
## F. Market Performance

There is substantial evidence to support enhanced regulator, space user, and investor demand for sustainable properties. The significant demand for sustainable properties is evidenced by expert-based financial analyses, statistical based analysis, survey/market research, and well-reasoned valuation theory.

Market performance is the missing link that ties building performance information to financial performance. Historically, the green building industry has done a poor job of articulating the value of sustainable property investment because they have equated building performance (energy/water savings, health and productivity benefits, etc.) with financial performance, without taking the critical intermediary step of assessing of the response of the market to the building's performance (see Exhibit IV-8 below). Full consideration of the market's response to a building's performance ensures proper consideration of revenues, risks and the allocation of costs and benefits of sustainability between owners and tenants.

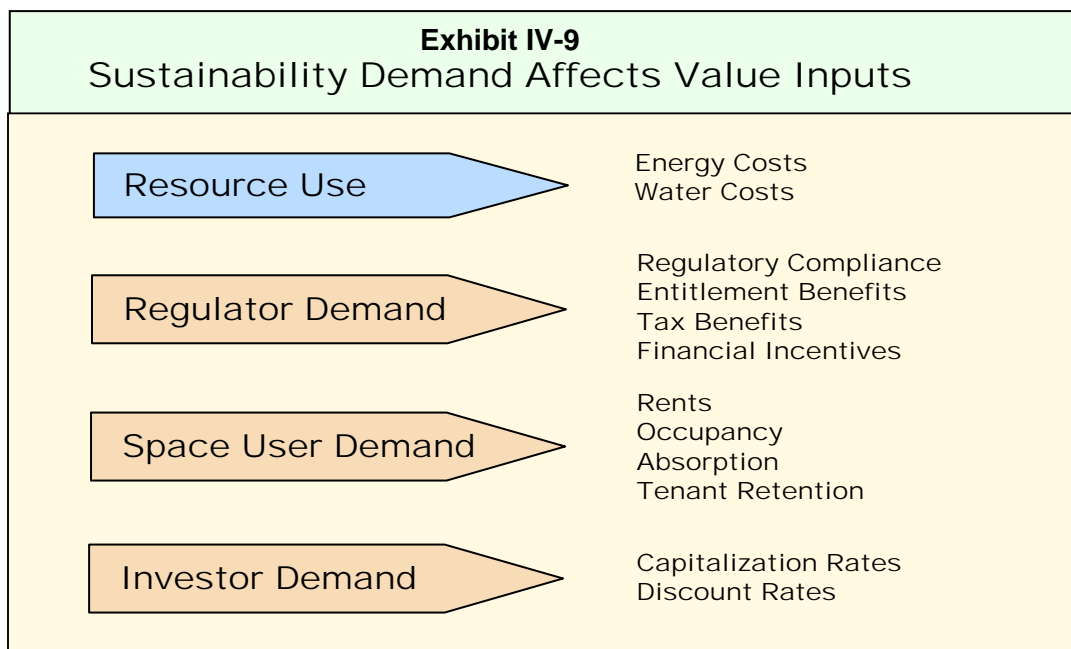
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<sup>89</sup> Athena Institute Study for Forintek Canada in 2004 examined 277 commercial and residential buildings demolished between 2000 and 2003 in St. Paul Minnesota and found 31% were torn down due to physical condition and 57% due to redevelopment or buildings were not suited for intended use. 63% of the structural concrete buildings, 80% of the steel buildings and only 14% of the wood frame buildings were less than 50 years old.



While downplaying market performance issues is a critical problem in general performance or cost-benefit studies, it is a fatal error in the ability to assess the financial implications of sustainable property investment for an individual property. As shown in Exhibit IV-8, to get from building performance to financial performance for a specific property, you must evaluate the market demand for sustainable property by regulators, space users, and investors, then assess whether brokers, appraisers, and lenders in the specific markets where the property is located recognize the sustainable market demand. Finally, you must determine key financial model/valuation inputs factoring in both sustainable and non-sustainable issues.

Regulator, space user, and investor demand are critical to value, as shown below in Exhibit IV-9. If valuers only considered resource use (energy costs, etc.) and ignored market performance, as measured by demand, key value issues affecting entitlements, rents, cap rates and other issues would be ignored. In essence, revenue and risk considerations would not factor into decision-making, a recipe for long-term underperformance.



To better understand and ease the interpretation of sustainable property market and financial performance research, we segment and categorize the research into four key types:<sup>90</sup>

1. **Expert-based financial analyses.** Conducted primarily by valuers/market analysts on a property-by-property basis following traditional valuation practices.
2. **Statistics/modeling-based financial analyses.** Conducted primarily by academics applying statistical modeling techniques to large databases of properties.
3. **Surveys and market research.** Surveys and related market research studies addressing regulator, space user, and/or investor demand.
4. **Foundational background and theory.** Foundational research and theoretical studies that address key issues in sustainable property valuation and financial analysis.

## 1. Three Principles for Applying Sustainable Property Market Performance Research

Prior to the presentation of the market performance evidence for sustainable properties, it is important to have guiding principles to assist in understanding how market performance evidence can be used to aid decision-making. Three important principles are discussed below:

- **Principle One:** Different decisions require different types of market data.

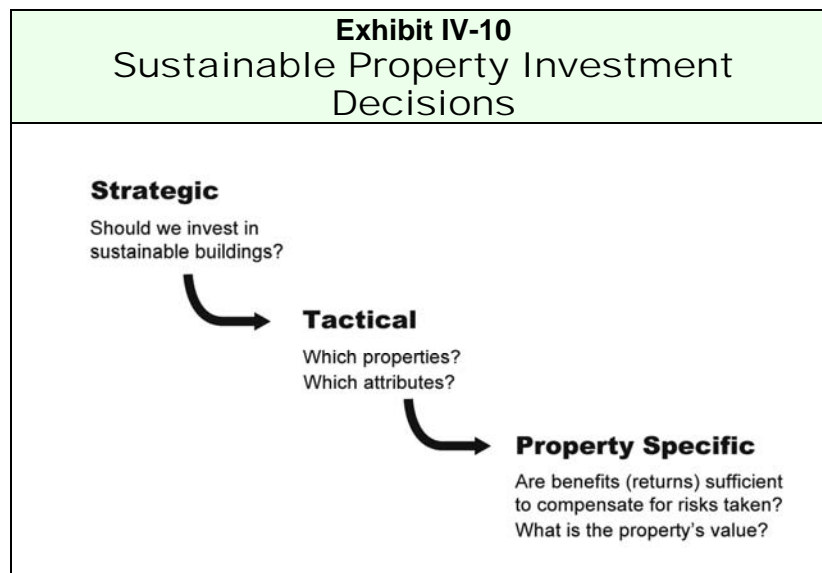
<sup>90</sup> We combine sustainable market and financial performance research together because much of the research in the field covers both these topics in their studies.

- **Principle Two:** Failure to understand types of market research will lead to failure in interpretation and application.
- **Principle Three:** Sweat the details when applying market research to property level decisions.

***Principle One: Different decisions require different types of market data***

Sustainable property market performance research can be interpreted and applied in many different ways. Unfortunately, if a user of market research does not understand the details of the market research, or the types of decisions that it is most applicable to, research results and conclusions can be misused and misunderstood, as happens frequently regarding sustainable properties in the industry and media.

One particularly important framework for differentiating sustainable property investment decisions is illustrated in Exhibit IV-10 below. This framework, based on traditional management consulting practice, differentiates strategic or enterprise decisions from business unit or operating decisions.



Strategic decisions are those made by pension fund boards, corporation boards, CEOs, and other leaders who must make decisions about how they are going to respond to the broader issue of sustainability, and the more specific issue of sustainability within their real estate portfolios. Statistics/modeling-based research, surveys, valuation theory and other market/performance research that “generally” addresses the importance of sustainable property is important and applicable to these decisions.

Once a strategic decision is made that sustainable real estate is an important consideration, implementation is passed down to corporate real estate heads, pension fund portfolio managers, asset managers, and others who are charged with the tactical responsibility to

determine the nature of the organization's response. Should sustainability investments be phased? How should they be phased? Should we just work on our office portfolios, or are all property types of concern? Which properties should we focus on? Which sustainability attributes? How do we measure and assess where we currently stand and track progress moving forward? The types of research applicable to strategic decisions can help here in developing portfolio strategies, but more detailed "sustainability options analysis" (See Chapter V, Section C-2) and property level analysis become more important.

Property specific decisions are quite different than either tactical or strategic decisions. Key questions include: How do we underwrite the risks and returns of specific investments in sustainable features for a given property? Are the benefits (returns) sufficient to compensate for the risks taken for investment in a particular property? How will the market respond to sustainable property improvements?

Making property specific decisions requires different types of data and analytics than strategic or tactical decisions. As fully described in Chapter V: "Sustainable Property Financial Analysis," general statistics/modeling-based research, surveys, and expert-based research can be helpful, but much more detailed and granular data and analysis is required. It is improper and inaccurate to directly apply the numerical results of statistics/modeling-based research done at a general level to any particular property-level analysis.

For a specific property, the selection of comparables, for either setting rents in a discounted cash flow analysis, or for making adjustments in the market comparables approach, is a much more detailed and specific analysis of those key competitors to a specific property. The selection, weighting, and adjustment of comparables to determine what a subject property will rent or sell for involves scores of qualitative judgments by professional real estate appraiser or due diligence analyst with experience in the market and a clear understanding of the factors influencing the tenants specific to a particular building.

Finally, property level decisions require appreciation of the fact that rent, value risk and other key financial performance and modeling assumptions require explicit consideration of non-sustainable demand factors, as highlighted below in Exhibit IV-11.

<b>Exhibit IV-11</b>	
Sustainability Just Part of Factors Influencing Tenant Demand	
<p><b>Location Specific</b></p> <ul style="list-style-type: none"> <li>• <b>Proximity to executive housing</b></li> <li>• Proximity to qualified employees</li> <li>• Proximity to nearby amenities (restaurants, shops &amp; services)</li> <li>• Proximity to public transportation</li> </ul> <p><b>Building Specific</b></p> <ul style="list-style-type: none"> <li>• Paid versus free parking</li> <li>• Age of building</li> <li>• How modern is building</li> <li>• Adequacy of building systems</li> <li>• Operating expense costs</li> <li>• Building ceiling heights</li> <li>• <b>Floor plate size &amp; configuration</b></li> <li>• Level of property mgmt service</li> <li>• Level of building security</li> </ul>	<p><b>Space Specific</b></p> <ul style="list-style-type: none"> <li>• <b>Location of space (lower, middle or upper floors)</b></li> <li>• Open versus built-out floor plan</li> <li>• Common versus dedicated restrooms</li> </ul> <p><b>Tenant Specific</b></p> <ul style="list-style-type: none"> <li>• <b>Rental rate (cost) for space</b></li> <li>• Perceived building prestige</li> <li>• Other tenants located in the building</li> <li>• Proximity to clients/customers</li> <li>• Adequate parking ratio</li> <li>• Adequacy of lobby</li> <li>• Curb appeal of building</li> </ul> <p><b>Sustainability Specific</b></p> <ul style="list-style-type: none"> <li>• Potential health benefits</li> <li>• Potential productivity benefits</li> <li>• Reduced energy/water cost volatility</li> <li>• Improved recruiting</li> <li>• Improved employee retention</li> <li>• Leadership—improved corporate market value</li> <li>• Reduced subleasing risk</li> </ul>

Full appreciation of all the factors influencing value enables market performance research users to appreciate the relative importance of sustainable property investments.

***Principle Two: Failure to understand types of market research will lead to failure in interpretation and application.***

The strengths, weaknesses and purpose of sustainable property market research guide proper interpretation and application.

Expert-based financial analyses provide the most reliable results because the general conclusions offered by such studies are based on detailed property-by-property analysis following traditional real estate market analysis practices. Unfortunately, for those who still seek the “killer” study that will provide the “answer” to the question of whether sustainable properties are more valuable, the quantitative specificity of the conclusions of expert-based studies often fall short of what advocates desire.

The caveats and hedging of conclusions often found in these studies reflect a recognition by experts that general conclusions based on detailed property analysis are difficult and always subject to caveats. Failure to acknowledge forecasting risk makes research more difficult to interpret by decision-makers.

Expert-based valuers and market analysts are used to providing very definitive, and in the case of an appraisal, a specific single value estimate, for individual property analysis. Because of this discipline, and the recognition of the uniqueness of each property,

valuation and market research experts are always rightfully concerned about drawing general property conclusions.

Statistics/modeling-based financial analyses are primarily applicable to strategic decisions, where general conclusions about markets and properties can be quite valuable in moving enterprise level decision-makers to invest resources to better understand sustainable property investment, but have very limited use for property level decisions. In fact, due to the substantial difficulties in the data and modeling methodologies of these types of market performance studies, their primary benefit to date has been in establishing a strong relationship between superior financial performance and sustainability, while the numerical accuracy or applicability of the results is much more problematic.

Surveys and market research are different from expert-based or statistics/modeling-based performance studies because they typically focus on segments of market demand, rather than on predicting the specific financial contribution of sustainability on rents, occupancies or sales prices. Surveys and market research help valuers/underwriters understand key factors driving sustainable market demand by type of occupant, demographic or geographic characteristics, type of sustainable property attribute and other factors. This work is critical to enabling market demand estimates for specific properties.

Foundational background and theoretical research provides the necessary linkages and intellect required to develop sound market research methodologies and properly apply results.

***Principle Three: Sweat the details when applying research to property level decisions.***

The most important guidance in interpreting and applying any of the four types of sustainable property market performance research to property level decisions is to sweat the details. As discussed above and in more detail below, if one is to attempt to apply statistics/modeling-based financial analyses to a property level decision, it is critical to fully understand the data, sample size issues, control factors, and other details. At best, these types of studies will provide general confirmation for financial assumptions that should be derived from more property-specific methods, and may affect the risk or uncertainty of a particular financial assumption.

Sweating the details does not only apply to statistics/modeling-based financial studies but also to surveys and expert-based financial analyses. For surveys, it is critical to understand the date the survey was conducted, the specific context for the survey, the specific job classifications of the respondents, the date the survey was administered, the geographic regions and property types that were discussed, and the quality (lack of bias in its structure) of the survey questions and vehicle. For expert-based financial analyses, it is particularly important to understand potential researcher bias, the nature of researchers' expertise, and the depth and comprehensiveness of the analytic procedures that they performed in coming to their conclusions.



*Data Issues: Statistics/Modeling-Based Research*

Data problems are so significant; they limit the accuracy and reliability of most statistics/modeling-based studies. Data is not typically consistently available to allow the proper model specification of the key factors that would influence rent or sales price.

Sample size is also a significant problem, particularly if one is trying to draw statically significant conclusions for specific property types, markets, types of sustainable certification, for almost any smaller segment.<sup>91</sup> Fortunately, through the “marking” of properties that are LEED and EnergyStar certified in large databases such as the CoStar database, the sample size for non-certified properties is quite large. The most difficult sample size issues occur with certified property. While the number of EnergyStar certified properties is relatively large, LEED certified properties is a much smaller sample size. There is also the difficulty that the number of LEED certified properties was very small in the 2000 to 2005/2006 time period before becoming larger in more recent years. LEED existing building certifications, an important classification of study, is currently a significantly smaller sample, with LEED EB only really taking off as recently as 2006.<sup>92</sup>

Finally, any data voluntarily provided directly from building owners could be subject to self-selection bias. Since many of the early owners and developers of sustainable properties were promoters of sustainability, and have a financial stake in the market appreciating the value of sustainable investment, there is significant potential for any voluntary sample of certified buildings to include those buildings that performed best, and if the data is not audited or provided for an independent purpose, questions about the potential bias of the data need to be considered.

*Control Issues: Statistics/Modeling-Based Research*

Closely related to understanding the data and sample used in a study, is to understand the way the study authors control for the critical factors that would affect rent or sales price. The general structure of statistics/modeling-based studies is that they have a dependent variable (typically rent, occupancy, or sales price) that is dependent upon a whole series of independent variables including location, access, property age, property size, property quality, market conditions, and LEED or EnergyStar certification.<sup>93</sup> The basic idea in these

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<sup>91</sup> The way sample size works, when you try to specify a more specific conclusion, it significantly reduces sample size. Accordingly, if you wanted to look at a statistically significant conclusion for community shopping centers in a particular geographic area, the sample size of certified properties, particularly if you were looking for sales information, would typically be so small (based on sales to date) as to make conclusions unreliable.

<sup>92</sup> LEED EB registrations have taken off during the last two years but some time will have to elapse to improve the ability to draw conclusions.

<sup>93</sup> In our discussion and analysis in this section, we typically refer to LEED, the US Green Building Council’s environmental certification, and EnergyStar, an energy certification and rating system promulgated by the US Environmental Protection Agency. The reason to focus on these certifications is that most of the statistics/modeling-based market performance studies have been completed using the CoStar database, which is a large comprehensive US-based property level database that began “marking” its properties for their LEED or EnergyStar certification in recent years. Accordingly, due to the size of the database, and marking of certification level on properties that are certified, it enables statistics/modeling-based studies to be completed.

studies is that by including LEED or EnergyStar certification as one of the independent variables, you can estimate the contribution of the LEED or EnergyStar certification to the dependent variable (rent, sales price, or occupancy). The trick is to properly specify the model (include the key factors that would influence rent or sales price) and control for all the key factors such as age, size, time, location, market condition, and other factors, so you can get an accurate estimate of the contribution of a LEED or EnergyStar certification.<sup>94</sup>

In practice, it is very difficult to properly specify the model and control for important factors that might affect rent and sales price. You can only specify and include a factor as an independent variable if you have the appropriate granular data over the proper time period to include in the analysis. This is not possible for much key data used in real estate analysis. Given the unique nature of each property, micro location issues including the access, quality and mix of tenants in a building, lobby quality and security, access to transportation, and many other factors can affect rent or sales price. This information is not available on a building-by-building basis in a consistent fashion. Statistically, the problem this presents is less significant when trying to predict sales prices or rents, but more difficult when trying to reliably estimate the contribution of an independent variable like LEED or EnergyStar status.

Control becomes even more problematic when dealing with asking rents for specific spaces within a building. The specific asking rent for a particular space in a building can be significantly influenced by the configuration and flow of the space, the interior tenant improvements, co-tenancy issues, and other factors. For large office buildings, it is a well-accepted fact that lease rates vary as much as 30% within buildings based on floor height and views. Without specific controls or other statistical adjustment for these factors, which is difficult, if not impossible, significant control issues can arise.

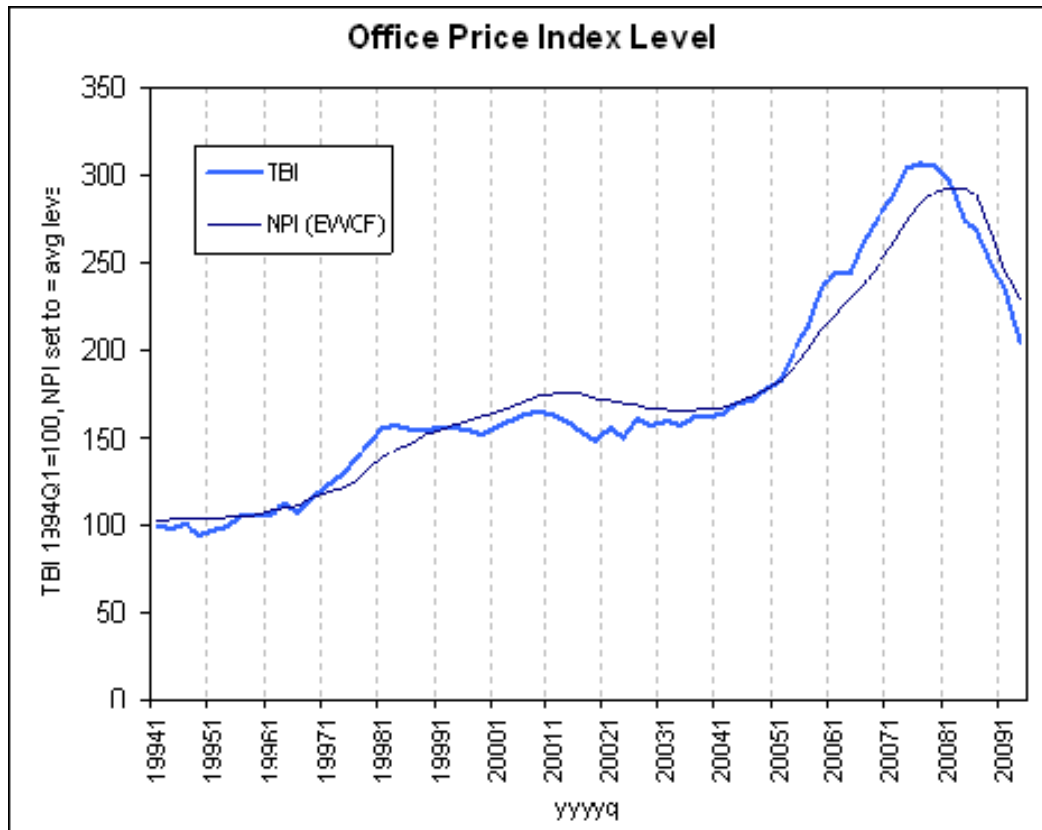
One of the most significant statistical issues involves time. As mentioned earlier, the distribution of certified buildings, particularly sales of certified buildings, is spread over just a few years, limiting strong time series analysis. More importantly, without a very explicit and effective control for time, on as frequent as a monthly basis, significant problems can exist in the numbers that come out of these type of analyses. As shown in Exhibit IV-12 below, property prices moved dramatically on a quarterly, and even a monthly basis during the last five years, the time period in which most sustainable property market performance studies are limited to. Office building sales prices increased approximately 100% from 2004 to 2007, and then just as dramatically declined in value. Prices are down nearly 40% from their peaks through the second quarter of 2009.

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<sup>94</sup> These types of models are typically referred to as hedonic regressions. The term *regression* relates to the idea that when large amounts of data are examined, statistical measures of various characteristics should tend to regress to the true parameter values for the underlying populations. When applied to real estate valuation, regressions analysis is often called *hedonics* or *hedonic regression*. Auto industry analyst A.T. Courts coined the term *hedonic* in the late 1930s, borrowing from a psychological term suggesting pleasant states of mind, to convey the idea that an item's value is associated with features that give its users pleasure or utility. (Footnote language extracted from "Expert Testimony: Regression Analysis and other Systemic Methodologies," Peter Colwell et al., *The Appraisal Journal*, Summer 2009.)

Rents moved equally dramatically, with rents in New York City down 50% or more in many sub-markets from their peaks in recent years. Accordingly, without a very specific and conscientious control for time on a frequent interval basis, statistics/modeling-based market performance studies are difficult to rely upon, given the dramatic variability in rents and sales prices as a result of time.

Exhibit IV-12



Source: MIT/NCREIF Commercial Real Estate Transaction Based Index (TBI). NPI (EWCF) = NCREIF National Property Index equal weighted cash flow based returns.

Please note that the TBI is a statistical methodology that produces estimates of price movements and total returns based on transactions of properties sold from the NCREIF Index database. The purpose of this index is to measure market movements and returns on investments based on transaction prices of properties sold from the NCREIF Index database. This is a new type of index that offers advantages for some purposes over the median-price or appraisal-based indexes previously available for commercial real estate in the U.S.

#### *Dependent Variable Issues: Statistics/Modeling-Based Studies*

While not as frequently discussed as independent variable control and model specification problems, the dependent variables (typically rent or sales price) also have issues that must be considered.

Perhaps the most difficult is the issue of rent. As is fully discussed in Chapter V: “Sustainable Property Financial Analysis,” rent is not the only, or typically even the most important, variable that is influenced by increased demand by space users for sustainable

properties. Other critical financial assumptions that have a significant influence on value that are also influenced by space user demand include tenant retention, speed of absorption, equilibrium occupancy, vacancy loss at turnover, and lease terms. Accordingly, by focusing solely on rent, statistics/modeling-based market performance studies may be underestimating the influence of sustainable property investment on financial performance.

Other issues relate to what the term “rent” actually represents. If it is asking rent, there are sometimes significant differences between asking rent and actual negotiated lease rent. Asking rent may only represent an average for the rent on the type of space that is available in a property, and not fully reflect the true average value of all space in a building. If actual rent from signed leases is used as the dependent variable, then all the issues related to the specific configuration of the space, tenant improvements, floor height, and other issues become important. In down markets, effective rents (adjusted for free rent that comes in many forms) can be significantly below asking or even stated lease rent.<sup>95</sup> While researchers are sometimes aware of these micro issues that are the bread and butter of expert-based valuation analysis, and sometimes endeavor to make adjustments to the data to compensate for these issues, the adjustments are often difficult to make and not possible in many cases, even if they do try.

Another key issue in looking at rents relates to the type of lease, whether it is a net lease, a gross lease, or one of the scores of hybrid variations of lease types. These issues are important because they influence tenants’ actual and perceived value relative to energy or related cost savings, and other issues.

Beyond the type of lease are the actual terms of the lease, lease length, lease options, tenant improvement budgets, and many other clauses affecting the use and flexibility of space affect the rent charged.

#### *Problems With Environmental Certifications as Independent Variables: Statistics/Modeling-Based Studies*

Another key consideration in evaluating statistics/modeling-based studies are the definitions of the environmental (LEED and EnergyStar) certifications, which are the focus of these studies. For example, due to the intricacies of the certification process, LEED building A is not the same as LEED building B. For example, building A may have gone after different points to achieve the LEED rating than building B, and therefore possesses a very different set of design elements and technologies, which in turn may impact the building’s environmental and economic performance in different ways. By focusing simply on a LEED rating generally, without differentiation for the level or type of LEED certification, or the specific sustainable features within a building, limits the applicability of these types of studies.

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<sup>95</sup> It should be noted that Eichholtz, Kok, and Quigley use the term “effective rent” in their studies to reflect their adjustment of asking rent for occupancy level, but the industry does not define effective rent the way they do.

The substantial changes in LEED ratings, due to the release in 2009 of LEED 3.0, further highlights the difficulty in interpreting generally what a LEED rating is. This problem is less a concern for EnergyStar certification. However, because most studies have not specifically addressed varying EnergyStar scores, care must be taken in interpreting and applying these results, because all EnergyStar certifications are not the same.<sup>96</sup>

Keeping the three principles in mind, we present a summary of the evidence of sustainable property market and financial performance to date.

## **2. Presentation of Market Performance Evidence**

### *Expert-Based Financial Analyses*

Real estate valuers and/or market/financial specialists conduct Expert-Based Financial Analyses. The basis for conclusions in these studies is typically drawn from specific analyses of buildings, following a process that is similar to a traditional market analysis process, although typically more cursory. Key studies of this type draw general conclusions based on detailed property-by-property analysis of a portfolio of properties. Strong single-property case studies, if independently done by a specialist using appropriate practices, would be considered Expert-Based Financial research.

In this section, we review and present the findings from seven important expert-based financial analyses:

1. “Do Green Buildings Make Dollars and Sense?” Norm Miller and Dave Pogue USD-BMC Working Paper 09-11, Draft: November 6<sup>th</sup>, 2009
2. “High Performance Green Building: What’s It Worth? Investigating the Market Value of High Performance Green Buildings,” Theddi Wright Chappell, Chris Corps, May 2009.
3. “Green Value: Green Buildings, Growing Assets,” Royal Institute of Chartered Surveyors, Canada, 2005, Oct. 2005<sup>97</sup>
4. “Valuing Green: How Green Buildings Affect Property Values and Getting the Valuation Method Right,” Richard Bowman, John Wills, Green Building Council of Australia, 2008; and,
5. “Financial Analysis of LEED EB Implementations,” Craig Sheehy, Envision Realty, 2008.
6. “Energy Efficiency Improvements: Do They Pay?” Brian A. Ciochetti and Mark D. McGowan, MIT Center for Real Estate, February 2009.
7. “Towards a Green Building Infrastructure Investment Fund,” Trent Berry, Compass Resource Management, February 2007.

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<sup>96</sup> EnergyStar certification is awarded for all properties that achieve the 75% percentile of results, or better.

<sup>97</sup> This study is also sponsored by BC Hydro, the British Columbia government, English Partnerships, Greater Vancouver Regional District, Green Buildings BC, the Canada Green Building Council, Natural Resources Canada, Resources naturelles Canada, and Realpac.

*Reasoning Supporting the Priority and Importance of Expert-Based Studies*

Understanding how the real estate industry assesses market performance is instructive in understanding why we believe expert-based studies offer the best evidence of sustainable property market performance. Industry standard for investors when seeking a property valuation or market due diligence is to select market analysts or valuers to do a detailed quantitative/qualitative analysis of the market.

For example, if a sophisticated real estate investor wants to understand a specific property's market demand and potential value, they typically hire a market feasibility consultant, valuer/appraiser, or internal staff that are trained in these specialty areas. These analysts follow well-recognized procedures in data collection and analysis; focusing on direct comparable properties in the sub-market, market and economic trends for the local and regional markets, detailed assessment of tenant demands and preferences in the marketplace, and many other analyses. At the end of the analysis, they select specific inputs for their financial models (rents, vacancy rates, tenant retention, capitalization rates, discount rates, etc.) and make a determination about the potential financial performance of their properties.

These well recognized procedures include a substantial number of quantitative analyses including forecasts of supply and demand, structured analysis of comparable properties, and numerous other financial analyses of specific operating expense inputs, occupancy or absorption trends, and other key information that is then integrated qualitatively by the valuation or market analyst in determining final financial model assumptions.

This reasoning was confirmed at a meeting of pension real estate investors with over a trillion dollars of real estate invested among the 60 participants. We asked whether any of the participants had “ever” relied upon a statistics/ modeling-based approach to generate rents, occupancies, or sales price for the valuation or underwriting of any property. The answer was “No.”

The reason the industry relies upon a more quantitative/qualitative approach to market analysis and valuation is that it is the best way, given the numerous factors that must be considered simultaneously, and the inability to obtain reliable results at a property level using statistics/modeling based analysis.

*Summary Conclusions From Expert-Based Analyses*

**These types of studies and research provide the best evidence of sustainable property market and financial performance.** These studies are typically conducted by experts in real estate valuation or market analysis, and follow in form, if not always in depth, the process used by valuers and market researchers to generate rents, cost, and related real estate property financial assumptions.

In summary, the Expert-Based Financial Analyses support the following conclusions:

- Faster absorption of tenants—improved pre-leasing;
- Achieve competitive rents—in some cases higher than competitors;
- Reduced tenant turnover;
- Higher equilibrium occupancies;
- Competitive lease terms;
- Reduced operating and maintenance costs;
- Attract superior grants, subsidies and other inducements; and,
- Achieve high or moderately high tenant satisfaction scores.

The expression of increased occupant demand was not consistent across properties or studies, with some projects experiencing faster absorption and higher occupancy, but not significantly higher rents or better lease terms. Investor and tenant interviews on specific projects supported increased value conclusions and suggested trends of increased tenant and investor demand moving forward. As to the magnitude of potential value increases, this was not specifically quantified, but on average incremental value increases of around 10% was suggested.

The working draft study by Dave Pogue and Norm Miller is particularly interesting in that they draw upon the results of a survey of over 750 occupiers from 154 of LEED or Energy Star buildings. They supplemented their survey with a survey of CBRE property managers of the buildings who provided detailed operations and expense data for each of the subject properties. They found that green buildings were operated more intensively, and overall total operating expenses were not that different. Separate metering was found to be almost as important as a significantly improved EnergyStar score in saving energy. Green buildings had higher wage tenants who indicated they felt more productive, but were not yet willing to say they would pay more.

In one important study of investors in Australia, the majority of investors indicated that they would pay more for a Green Star building. The improved marketability of Green Star buildings is their main current competitive advantage: they are easier to sell and lease, which reduces vacancy times and hence income losses. Many investors and owners/managers believe Green Star buildings are “future proofed” against the risk of rising energy costs, market rejection of non-Green Star buildings and tightening regulations on building sustainability performance.

Another interesting analysis of 59 LEED Existing Building (EB) implementations showed that returns were robust, with an average payback of 1.5 years and a simple return on investment of 69%. Perhaps more important, all of the 59 projects demonstrated positive returns, with a minimum return of 11% and maximum payback period of 9 years. Returns were strong across geographies and for Certified, Silver and Gold LEED certifications. Implementation cost per square foot averaged a minimal \$0.23 and ranged from \$0.08 to \$0.95 per square foot. The office properties in the analysis averaged 406,000 square feet

and were geographically dispersed through much of the United States. Ownership was typically institutional or large private investor.<sup>98</sup>

The results of the study of 59 buildings above is most likely influenced by selection bias, making the results more robust than the average results for a typical portfolio of buildings. Selection bias arises because service providers and owners are more likely to prioritize the properties they convert to LEED, with the easiest and most profitable the first to convert. Offsetting the potential selection bias is improvement over time due to experience.

Another observation is that for these buildings, the decision to obtain LEED EB was not a significant investment, suggesting more robust investment and sustainability goals might be warranted based on the high level of return that was achieved, even prior to considering any risk or revenue benefits.

The six studies we summarize above are discussed below.

**Report 1: “Do Green Buildings Make Dollars and Sense?” Norm Miller and Dave Pogue USD-BMC Working Paper 09-11, Draft: November 6<sup>th</sup>, 2009**

The working draft study by Dave Pogue and Norm Miller is particularly interesting in that they draw upon the results of a survey of over 750 occupiers from 154 of LEED or Energy Star buildings. They supplemented their survey with a survey of CBRE property managers of the buildings who provided detailed operations and expense data for each of the subject properties. They found that green buildings were operated more intensively, and overall total operating expenses were not that different. Separate metering is almost as important as a significantly improved EnergyStar score in saving energy. Green buildings had higher wage tenants who indicated they felt more productive, but were not yet willing to say they would pay more.

**Report 2: “High Performance Green Building: What’s It Worth? Investigating the Market Value of High Performance Green Buildings,” Theddi Wright Chappell, Chris Corps, May 2009**

The key findings and conclusions in the author’s own words are presented below.

*Background*

Are high performance green buildings really worth more than traditional buildings?

To explore this question, two of the leading experts in valuing high performance green properties in the United States and Canada (see bios below) were recruited to analyze and ascertain whether high performance green attributes contributed to market values. The consultants approached the owners of three high performance green commercial office buildings (200 Market Place in Portland, OR; Alley24 East

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<sup>98</sup> Envision Realty, June 2009.



in Seattle, WA; and the Vancouver Centre in Vancouver, British Columbia) who were willing to make their data available for analysis. The results of this work are three detailed case studies on green buildings written from a financial/investment perspective. The owners of the three subject properties gave the research team access to lease rates, operational expense data, and other financial performance information that is rarely shared with outside observers.

The authors are experts in real estate valuation and financial analysis. Theddi Wright Chappell is the managing director of Cushman & Wakefield of Washington Valuation Services, Capital Markets Group and national practice leader of the firm's National Green Building and Sustainability Valuation and Advisory Practice and a Counselor of Real Estate and Fellow of the Royal Institute of Chartered Surveyors. Chris Corps is a chartered surveyor and principal of Asset Strategics in Victoria, British Columbia. Chris instigated and co-led the Vancouver Valuation Accord and Summit, an initiative linking sustainability and value that was signed by BC's Premier and valuation professionals from 20 countries. Chris has nearly 30 years of experience in real estate and complex business cases in the UK and Canada.

#### *Alley24 East, Seattle, Washington*

While the long-term implications of the various high performance green strategies employed at Alley24 East can only be quantified via specific and detailed analysis over time, it is clear that the property:

- experienced a comparatively quick absorption period;
- attracted and has retained high quality tenants;
- achieved competitive rents;
- and has a higher-than-average level of occupancy.

When the building was delivered it was 90% preleased. This is an impressive amount of preleasing under any circumstances.

Leases signed at Alley24 East were competitive with other properties in terms of rental rates, escalations, and tenant improvement allowances. Specific data indicate that Alley24 East held a strong competitive position relative to its peers, at the same time exceeding industry averages for both rent and occupancy.

Tenant rankings of Alley24East in the New Building Institute's Building Performance Review reflected *high* or *moderately high* scores in tenant satisfaction related to building temperature, air quality, acoustics, lighting, and general health and productivity factors."

#### *200 Market Place, Portland, Oregon*

200 Market Place leads its competition in tenant occupancy statistics with a current occupancy of 99.6%. While this high level of occupancy is most likely the result of a variety of factors, it is indisputable that the building is marketed and run as a high performance green property.

Based on comparisons of the lease rates achieved, tenant improvement allowances offered, and escalation factors, the leases signed at 200 Market Place are similar to and competitive with those signed at comparable properties in the Portland central business district.

Prior to LEED-EB certification, energy consumption escalated each year from 2004 through 2006. However, since the building's LEED certification in 2006 and implementation of a variety of energy strategies, energy use declined in 2007 by 3.45% and in 2008 by 8.73%, reflecting increasing year-over-year reductions.

From 2007 to 2008, overall operating expenses declined by 0.64%, and they are projected to decline by an additional 3.29% in 2009.

#### *Vancouver Centre, Vancouver, Canada*

The energy retrofit project achieved a 19% return on investment (ROI). While a payback of four years was anticipated, the extended implementation to minimize tenant disruption meant that the returns took longer but were successful. It also meant that the benefit was directed less towards cash flow and more towards improving vacancy, absorption, tenant retention, and other factors.

This review concludes that the nature of the retrofit and savings were not pivotal in determining the purchase price of the building to the buyer. The value of the retrofit was known and contributory, but of insufficient size to change the decision to buy the building.

An incidental finding relates to lease structures and how the relationship between landlord and tenant might be structured to support a sustainable retrofit for mutual profit. It was identified that the same attributes that gave a 19% approximate return on investment (ROI) could increase to 197% provided both parties agree to a lease term and structure more closely matching the life cycle of the retrofit costs and savings; a redistribution of costs aligned with debt retirement; a reallocation of total occupancy payments (e.g., rent, operations, and maintenance costs), without raising the tenant's total costs; and an apportionment of benefits. If handled carefully, this has the potential to encourage more retrofits by motivating landlords and tenants through mutual profit.

#### **Report 3: "Green Value: Green Buildings, Growing Assets," Royal Institute of Chartered Surveyors, Canada, Oct. 2005**

Valuation experts conduct this study and its conclusions are based on detailed property-specific analysis of 12 individual buildings. The results of this study are based primarily on detailed interviews with owners, property managers, tenants, service providers, and others associated with the project, rather than relying upon a detailed review of competitive properties. Importantly the expert surveys and interviews addressed specific properties.

**Green is good for asset value.** This, contrary to a view frequently held by many builders, developers, lenders and some valuers/appraisers, is the picture that emerges from new research.

These conclusions came through interviews with developers, owners and occupiers at green office, industrial, retail, residential and educational buildings across Canada, the United Kingdom and the United States. The findings are also borne out by an extensive review of academic and industry literature.

With this new research, however, green buildings are also shown to improve asset value. Green buildings can:

- Be quicker to secure tenants
- Command higher rents or prices
- Enjoy lower tenant turnover
- Cost less to operate and maintain in most cases
- Attract grants, subsidies and other inducements to do with stewardship of the environment, increasing energy efficiency and lessening greenhouse gas emissions.
- Improve business productivity for occupants, affecting churn, renewals, inducements and fitting out costs amongst others
- Resulting from business productivity benefits, benefit occupants more than the underlying asset cost or value.

Because comparatively few green buildings have been completed, however, the extent of value benefit is still hard to quantify. So, too, is the effect on market value of green building rating systems, as well as the degree to which the benefits of green buildings go to the occupier rather than the owner or developer.”

While the general conclusions presented above are interesting and important, the results of the interviews from six of the 12 case studies are particularly helpful in identifying costs, benefits, lessons learned, and other insights. A summary of the key interview findings is presented in Appendix IV-B at the end of this chapter.

**Report 4: “Valuing Green: How Green Buildings Affect Property Values and Getting the Valuation Methodology Right,” Richard Bowman, John Wills, Green Building Council of Australia, 2008**

This report is classified as an expert-based financial report because it was completed by real estate experts and incorporates detailed property-by-property analysis and face-to-face interviews with over 50 real estate practitioners/owners.

The lead authors of the report were:

- Mr. Richard Bowman, AAPI, Principal and Representative, Real Estate Advisory Services, Ernst & Young.
- Mr. John Wills, MIMC, AAPI, AIMM, Director, The Property Lab.

### *Summary of Report Findings*

It is based on an extensive literature search, case studies of eight recently completed Green Star buildings and interviews with some 50 of Australian property owners, valuers and developers, responsible for some 30% of total property fund assets with Australia, with a combined value of \$85 billion.

The majority of investors indicated that they would pay more for a Green Star building. The improved marketability of Green Star buildings is their main current competitive advantage: they are easier to sell and lease, which reduces vacancy times and hence income losses. While some tenants are willing to pay the rental cost of achieving Green Star, a rental premium is not yet proven in all cases. Corporate and government demand for improved lifecycle economic and environmental performance are key drivers of green, but these tenants can negotiate green as a bonus for long rentals with predetermined review patterns, rather than paying an up front direct premium.

In the longer term, however, the industry expectation is that rental growth; tenant retention and operating cost savings will become the key drivers for the market value of Green Star buildings, relative to non-Green Star buildings. Green Star buildings also claim improvements in productivity, wellbeing, and occupational health and safety, but market acceptance of these intangible values is limited.

Many investors and owners/managers believe Green Star buildings are 'future proofed' against the risk of rising energy costs, market rejection of non-Green Star buildings and tightening regulations on building sustainability performance."

### *Summary of Survey Findings*

The industry survey taken as part of the report (pages 16-19) was insightful:

The survey was undertaken by Ernst & Young and involved:

- Representatives of five leading property advisory and valuation firms; and,
- Representatives of fourteen fund managers and developers.

The surveys comprised face-to-face interviews based on a standard set of questions to obtain both quantitative and qualitative responses. Key conclusions are set out below.

1. All respondents believed that the investment performance of a Green Star building would outperform traditional buildings over the medium to long term, but not necessarily the short term.
2. Forty-five percent of survey respondents indicated that tenant demand is driving the need for their organizations to implement green building practices.
3. A Green Star rating is important in reaching an investment decision, but financial return cannot be compromised

4. The majority of respondents indicated that they would pay more for a Green Star building. About two-thirds of interviewees would pay more for a Green Star building. Some reported that they already pay more if convinced of the value. Most also said they would not undertake refurbishment of a building without considering a Green Star rating.
5. The overwhelming majority of respondents would be prepared to invest in a Green Star building despite the possibility of incurring a short-term loss.
6. The improved marketability of green buildings is highly regarded by the respondents. The key marketing instrument nominated was the Green Star rating rather than any particular green feature in the building.
7. Long-term rental growth, tenant retention and operating cost savings are the key drivers of the increasing market value of green buildings. The operational cost savings for Green Star buildings typically quoted by respondents were approximately \$5 per square meter (3-6% of total outgoings).
8. All respondents identified the DCF approach as being the most suitable method to assess the valuation of green buildings.
9. All fund managers and developers interviewed are developing an internal sustainability capability.

#### *Summary of Case Study Findings*

Case study findings were consistent with the interviews:

Eight case studies were chosen to provide a cross section of Green Star buildings, covering owner-occupiers and investors with public and private tenants

- Construction costs were equal to, and in two instances lower than, budget expectations. A slight cost premium still exists for delivering buildings with a 6 Star Green Star rating.
- Operating costs (including salaries) are below expectations.
- From examples in Canberra and Adelaide, Green Star buildings have achieved a reduced capitalization rate to the order of 0.25-0.50% when compared with the rest of the market.
- Green Star rated buildings appear easier to sell—it is not possible yet to infer whether this also adds a price premium, but a faster sale potential alone should infer value via a tighter capitalization rate.
- Let up periods were reduced by improved exposure and marketing from being 'green'.

- Attraction of ‘blue chip’ tenants was improved by meeting tenant requirements and briefs. Importantly, the case studies reveal that these tenants are prepared to pay for ‘green.’

**Report 5: “Financial Analysis of LEED EB Implementations,” Craig Sheehy, Envision Realty, 2008.**

This analysis is presented as an expert-based analysis because a real estate expert performs it with substantial building operating experience. The analysis is also important because it is not a sample, but the results of 59 initial EB implementations undertaken by Envision Realty. The 59 office properties averaged 406,000 square feet and were geographically dispersed through much of the United States. Ownership was typically institutional or large private investor.

LEED EB retrofits can be done cost effectively, as demonstrated from the results of the 59 LEED EB retrofits reported by Craig Sheehy of Envision Realty Services as of the summer of 2009 (Exhibit IV-13). The analysis focuses on the investment return created by operating cost savings associated with the retrofit of existing buildings.

As the 605 properties in the data set show, returns were robust, with an average payback of 1.5 years and a simple return on investment of 69%. Perhaps more important, all of the 59 projects demonstrated positive returns, with a minimum return of 11% and maximum payback period of 9 years. Returns were strong across geographies and for Certified, Silver and Gold LEED certifications. Cost per square foot averaged \$0.23 and ranged from \$0.08 to \$0.95 per square foot.

The analysis by Envision Realty, while important, focuses on one measure of financial performance—net financial benefits of operating cost savings. Accordingly, while the results were impressive, they fail to take into consideration potential increases in revenue due to increased tenant demand, government incentives, reduced risk, and increased investor demand. While these benefits may not accrue to every project, dramatic changes by governments, tenants and regulators make an analysis of these potential benefits important.

Exhibit IV-13 Implementation Costs and Benefits - LEED EB Retrofits							
City	State	Level	Sq. Ft.	Cost	Savings	Payback	ROI
Walnut Creek	CA	Gold	249,391	\$88,808	\$96,100	11 months	108%
Los Angeles	CA	Gold	317,058	\$58,437	\$33,000	1.7 years	56%
Atlanta	GA	Gold	410,357	\$116,812	\$89,000	1.3 years	76%
Minneapolis	MN	Gold	621,193	\$191,130	\$186,238	1.01 years	97%
Los Angeles	CA	Silver	587,022	\$71,700	\$55,000	1.3 years	77%
Fort Lauderdale	FL	Gold	261,676	\$108,641	\$77,000	1.5 years	71%
Los Angeles	CA	Silver	137,369	\$51,084	\$13,000	3.9 years	25%
Charlotte	NC	Silver	324,305	\$53,777	\$60,000	9 months	112%
Charlotte	NC	Certified	298,371	\$52,910	\$58,000	8.8 months	110%
Denver	CO	Certified	263,716	\$108,097	\$102,750	1.05 years	95%
Vienna	VA	Silver	346,618	\$53,700	\$32,000	1.6 years	60%
Atlanta	GA	Silver	625,071	\$91,520	\$50,000	1.8 years	55%
Oakland	CA	Silver	273,355	\$59,033	\$25,000	2.3 years	42%
Dallas	TX	Silver	1,113,575	\$291,136	\$237,400	1.4 years	82%

Exhibit IV-13 Implementation Costs and Benefits - LEED EB Retrofits							
City	State	Level	Sq. Ft.	Cost	Savings	Payback	ROI
Billerica	MA	Certified	353,242	\$54,281	\$35,000	1.5 years	64%
Greenwood Village	CO	Silver	317,218	\$68,530	\$30,000	2.2 years	44%
Greenwood Village	CO	Silver	115,408	\$47,885	\$10,000	4.7 years	21%
Denver	CO	Certified	150,673	\$48,766	\$15,000	3.2 years	31%
Chicago	IL	Gold	800,000	\$114,950	\$75,000	1.5 years	65%
Atlanta	GA	Certified	312,000	\$72,990	\$31,000	2.3 years	42%
Dallas	TX	Certified	515,388	\$64,460	\$50,000	1.2 years	78%
Atlanta	GA	Certified	670,000	\$57,950	\$40,000	1.4 years	69%
Atlanta	GA	Certified	670,000	\$78,110	\$40,000	1.9 years	51%
Denver	CO	Silver	435,672	\$67,821	\$40,000	1.6 years	59%
Dallas	TX	Silver	843,650	\$65,950	\$75,000	11 months	114%
Atlanta	GA	Silver	695,707	\$91,520	\$50,000	1.9 months	55%
Los Angeles	CA	Gold	904,459	\$170,000	\$175,000	11 months	103%
Los Angeles	CA	Silver	980,000	\$244,185	\$190,000	1.2 years	78%
Irving	TX	Silver	364,336	\$61,558	\$34,000	1.9 years	55%
Irving	TX	Certified	369,659	\$74,691	\$35,000	2.1 years	47%
Atlanta	GA	Gold	310,194	\$131,418	\$138,000	11 months	105%
San Francisco	CA	Silver	281,000	\$127,725	\$80,000	1.6 years	63%
Beverly Hills	CA	Silver	162,643	\$81,666	\$84,000	11 months	103%
San Francisco	CA	Silver	286,182	\$80,405	\$20,000	4 years	25%
San Francisco	CA	Silver	661,950	\$92,950	\$30,000	3 years	32%
Atlanta	GA	Silver	531,000	\$57,950	\$35,000	1.6 years	60%
Oakland	CA	Gold	548,188	\$242,450	\$197,000	1.3 years	81%
Atlanta	GA	Silver	670,000	\$178,000	\$174,000	1 year	98%
San Francisco	CA	Certified	347,147	\$90,179	\$36,000	2.7 years	40%
San Francisco	CA	Silver	310,777	\$56,670	\$35,000	1.6 years	62%
S. San Francisco	CA	Silver	454,054	\$60,354	\$35,000	1.6 years	58%
San Francisco	CA	Silver	365,000	\$173,525	\$94,000	1.9 years	54%
San Francisco	CA	Silver	201,000	\$131,955	\$60,000	2.2 years	45%
San Francisco	CA	Silver	346,162	\$69,704	\$50,000	1.3 years	72%
Washington DC		Silver	240,000	\$71,156	\$40,000	1.8 years	56%
Santa Monica	CA	Certified	320,000	\$60,000	\$30,000	2 years	50%
Burbank	CA	Certified	448,720	\$67,708	\$50,000	1.2 years	74%
New York City	NY	Certified	594,600	\$61,950	\$135,000	5 months	218%
San Francisco	CA	Gold	596,059	\$72,110	\$50,000	1.5 months	69%
San Francisco	CA	Silver	795,500	\$64,950	\$50,000	1.2 years	77%
Atlanta	GA	Certified	410,571	\$59,694	\$25,000	2.3 years	42%
Irvine	CA	Certified	346,684	\$92,317	\$10,000	9 years	11%
Austin	TX	Certified	250,000	\$125,080	\$60,000	1.1 years	48%
Austin	TX	Silver	154,939	\$106,183	\$48,000	2.2 years	45%
Portland	OR	Gold	101,553	\$96,014	\$27,000	3.5 years	28%
New York City	NY	Silver	589,651	\$62,950	\$70,000	11 months	111%
Seattle	WA	Silver	255,818	\$55,385	\$9,000	6.1 years	16%
Portland	OR	Silver	279,000	\$127,265	\$74,000	1.7 years	58%
Portland	OR	Certified	363,000	\$57,525	\$25,000	2.2 years	43%
			<b>Avg. Sq. Ft.:</b> <b>406,082</b>	<b>Avg. Cost:</b> <b>\$93,825</b>	<b>Avg. Savings:</b> <b>\$64,585</b>	<b>Avg. Payback</b> <b>1.45 years</b>	<b>Avg. ROI:</b> <b>69%</b>

Source: Envision Realty Services, Craig Sheehy, August 2009

It is important to understand when interpreting data like that presented above that the implementation results are likely to be more robust than the average results for a portfolio of buildings, because of selection bias. Selection bias arises because Envision Realty, and other service providers and owners, are implementing increasingly sophisticated screening tools to select buildings to retrofit first. Logically, money should be spent on those buildings with the highest return on investment, thus any analysis in the early years of LEED EB implementation need to be carefully examined for their general applicability to future decisions. At the same time, the Sheehy results suggest that green building retrofits can offer attractive returns to property owners and, if selected prudently, can represent

attractive financing options for lenders. Offsetting the potential selection bias is improvement due to experience.

**Report 6: “Energy Efficiency Improvements: Do They Pay?” Brian A. Ciochetti and Mark D. McGowan, MIT Center for Real Estate, February 2009.**

This study is categorized as an expert-based report because it is conducted by real estate academics, but more importantly relies on a detailed analysis of properties and interviews, rather than a statistics/modeling-based methodology.

The results of the detailed analysis of one building are consistent with Sheehy’s analysis presented above, with an 86% ROI and total payback of 14 months. The case study diverged from Sheehy’s work in that the total EB implementation cost was \$1,011,526 compared to an average of \$93,000 in Sheehy’s work, indicating more capital-intensive LEED EB conversions may be able to compete financially with less aggressive approaches.

More detail, in the author’s words (select experts), is presented below. It is instructive to note how difficult the job of locating and digging into the details of actual projects can be.

One of the challenges with this study was the shortage of data that were available for analysis. As shown earlier in Figure 11, the stock of certified buildings at the end of 2008 stood at 106. While many buildings are registered for certification, the number available for analysis is very small. Over the course of this study, we were able to access owners of 38 of these properties. Eleven were willing to share and/or discuss details of their projects. Of these we were able to secure enough information for some level of discussion on six, which are presented in this section. We will focus on one building and provide discussion on four others.

A real estate investment firm that develops, owns, and manages properties throughout the U.S. and Europe owns the property used in this example. We believe it is typical of urban Class A projects and is a good representative of the type of project that would be well suited for investment in EEI upgrades.

The building is a multi-tenant Class A office tower in a central business district in the Northeast, was completed in 1972, and is comprised of approximately 1,015,000 square feet.

As described in Figures 12-15, total costs for the LEED-EB certification project were \$1,011,562 (including the cost of the consultant, registration and certification) and the total savings were \$868,908. This results in an overall economic performance of:

Total Return on Investment (ROI) = 86%  
Total Payback = 14 months

Gathering additional data on building upgrade projects has proven difficult. The following five LEED-EB project summaries are an assemblage of information gathered from owners, published news information, and posted presentations. For these, we highlight components of each project dealing with, or related to, investment in energy efficiency improvements.



The results from the five additional case studies indicated strong positive ROIs and payback periods for the initiatives undertaken.

**Report 7: “Towards a Green Building and Infrastructure Investment Fund,” Trent Berry, Compass Resource Management, February 2009.**

This report was initiated by the City of Vancouver and other parties interested in launching a Green Building and Infrastructure Investment Fund as a legacy of the 2010 Olympic Games. The goal of their “scoping” study was to examine a typical premium for green construction, potential investor returns, the best means of recouping investment, the magnitude of available opportunities, and challenges and opportunities for an investment fund.

As part of their work, Compass Resource Management completed an investment analysis based on construction costs and utility rates from Vancouver and Whistler as modeled for an 11-storey multi-unit residential building with 146 units and a total size of 12,800 square meters.<sup>99</sup> They used data collected by Natural Resources Canada from building developers and calculated industry- average building costs. They assumed an average construction cost of \$1,200 per square meter for the investment analysis in this study. The total construction cost of the representative building modeled in this study is \$15.4 million.

Further detail on the data and their findings is presented in their own words below:

We used building energy consumption profiles developed by EnerSys Analytics for the Lower Mainland region of British Columbia in this study. This study shows energy consumption for standard construction practice, for MNEC-B, and simulates packages of measures that achieve reduction of energy consumption of 25% compared to MNEC-B. We adjusted these base building profiles to account for the cooler climate in Whistler compared to Vancouver.

We did not find detailed data on building water consumption in Vancouver and Whistler. Building indoor water consumption profiles were based on a study of multi-unit residential buildings by the Canadian Mortgage and Housing Corporation. Building outdoor water consumption is based on a survey conducted by the Pacific Institute. There is considerable uncertainty in the value adopted for outdoor water consumption.

We used a simple cash flow analysis to calculate the internal rate of return and payback on incremental costs and savings associated with different levels of LEED. The following figure shows the 15-year and 25-year real internal rate of return for incremental green building measures associated with various levels of LEED in MURBs. The results show:

- The rate of return on green buildings is higher in Whistler than Vancouver. Whistler has higher natural gas prices, which means that reduction in energy consumption translates into bigger cost savings in Whistler than Vancouver.

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<sup>99</sup> While an internal rate of return was calculated, the return did not incorporate potential revenue or risk benefits, nor was it compared to returns for a similar building without sustainable features.

Whistler also has a colder climate (more heating degree days) and so incremental energy savings measures show a faster return than in Vancouver.

- The rate of return for LEED Certified buildings is high. In both Vancouver and Whistler, LEED Certified buildings appear to be a profitable investment, with a 15-year rate of return above 35%
- The rate of return for LEED Silver, Gold, and Platinum buildings is much lower. The 15-year rate of return on LEED Silver buildings in Vancouver is 18%, while in Whistler it is 29%. For LEED Gold buildings, the 15-year rate of return ranges from 11% in Vancouver to 19% in Whistler. For LEED Platinum, the 15-year rate of return ranges from 2% in Vancouver to 8% in Whistler.
- The payback for LEED buildings ranges from 3.0 years (LEED Certified) to 12.8 years (LEED Platinum) in Vancouver and from 2.2 years (LEED Certified) to 8.7 years (LEED Platinum) in Whistler.”

### *Statistics/Modeling-Based Financial Analyses*

Statistics/modeling-based studies typically will involve a large number of sustainable and non-sustainable properties, with statistical modeling focused on determining the incremental contribution of a sustainable certification or rating on rent levels, sales prices, occupancies, or other specific financial variables. These studies are typically completed by academics with real estate and/or finance backgrounds.

In this section, we review and present the findings from the following statistics/modeling-based financial analyses<sup>100</sup>:

1. “The Investigation of the Effects of Eco-Labeling on Office Occupancy Rates, Frank Furst and Patrick McCallister, *Journal of Sustainable Real Estate*, Fall 2009
2. “New Evidence on the Green Building Rent and Price Premium”, Frank Fuerst and Patrick McAllister, presentation to ARES conference; April 3, 2009.
3. “Doing Well by Doing Good? Green Office Buildings,” Piet Eichholtz, Nils Kok, and John M. Quigley, UC Berkeley Fisher Center for Real Estate & Urban Economics working paper, January 2009.
4. “Does Green Pay Off?” Norm Miller, Jay Spivey, Andy Florance, *Journal of Real Estate Portfolio Management*, Fall 2008.
5. “Green Design and the Market for Commercial Office Space,” Justin Benefield, Jonathan Wiley and Ken Johnson, *Journal of Real Estate Finance and Economics*, forthcoming.

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<sup>100</sup> Select additional statistics/modeling based studies have been completed and published in the *Journal of Sustainable Real Estate*

6. “The Greening of US Investment Real Estate—Market Fundamentals, Prospects and Opportunities,” Andrew Nelson, RREEF Research, November 2007.

*Summary of Consortium Conclusions on Statistics/Modeling-Based Financial Analyses*

The statistics/modeling-based financial analyses cited above provide **general** support for a positive relationship between a green building certification (LEED or EnergyStar) and improved rents and sales prices for commercial properties. However, all of the studies have significant methodological, data, and statistical limitations that limit the reliability/applicability of the numerical conclusions to specific property valuations.

While the specific numerical results may be of limited reliability, it does not imply that the rent and sales price premiums are necessarily overstated, just that methodological and data limitations make it difficult to rely upon the numerical results. For example, one of the limitations of the studies is that they tend to focus on rents, while many other important value increasing attributes, like faster absorption, better lease terms, higher tenant retention rates, and lower risks (discount and cap rates) are also possible indicators of tenant preference, but these variables are not evaluated in the existing studies.

An observation about most of the research reports cited above is that they are all the second, or in one paper, the third research reports on the same topic. Accordingly, the papers cited above and reviewed in this section include many of the most recent papers completed (as of the publication of this chapter) and provide the most refined data and statistical approaches. In the case of the three studies where we were able to review the earlier reports, rent and sales price premiums had declined significantly from prior study versions.

In reviewing and applying the information from the six studies cited above, it is critical to know what they are, and what they are not. The methodologies in the studies do not reflect industry practice to assess rent and price premiums in individual properties, and methodology and data limitations are significant, and in most cases acknowledged by authors in their work. Use of the statistics without appropriate understanding of the caveats and the coverage of the studies is not appropriate. In most cases, the studies cover only office buildings in the United States, so any application to other property types or regions needs to be carefully considered.

Small sample size, problems in controlling for time, and numerous other statistical problems are particularly relevant for the sales price premium analysis, but also apply to the rent premium analysis in the cited studies. A detailed analysis of the kinds of methodological and statistical review that is needed in applying this kind of information can be found in the Consortium’s special report titled “Quantifying ‘Green’ Value: Assessing the Applicability of the CoStar Studies,” Scott Muldavin, Green Building Finance Consortium, June 2009. <http://www.greenbuildingfc.com/>

Keeping the caveats and application cautions in mind, what do the four statistical studies actually show?<sup>101</sup> As shown in Exhibit IV-14 below, with the exception of the Wiley and Johnson paper, which I was not able to review in detail, rent premiums from LEED properties were shown to be from 0% to 6%, and EnergyStar premiums ranged from 3.3% to 5%. These results, while subject to significant statistical and methodological issues, at least appear plausible, based on the Consortium's assessment of scores of tenant surveys and discussions with many more tenants and investors. The Fall 2009 study by Fuerst and McCallister reported occupancy rates in LEED buildings 8% higher, and in EnergyStar buildings 3% higher.

While the rent and occupancy premiums reported appear plausible, to date the Consortium's research suggests that the increasing space user demand for sustainable properties is more likely to be reflected in absorption rates, tenant retention, and adjustments to risk, rather than a direct rental price premium. It should be noted that many types of tenants, in different markets and property types, have reported that they would not pay more, suggesting caution in applying any average figures to any particular building.

<b>Exhibit IV-14</b>				
<b>Statistics/Modeling-Based Sustainable Property Financial Analysis</b>				
	<b>Rent Premiums</b>		<b>Sales Price Premiums</b>	
	<i>EnergyStar</i>	<i>LEED</i>	<i>EnergyStar</i>	<i>LEED</i>
Fuerst & McAllister, April 2009 <sup>1</sup>	5%	6%	31%	35%
Eichholtz, Kok & Quigley, January 2009 <sup>2</sup>	3.3%	0%	16% <sup>2</sup>	0%
Miller, Spivey & Florance, Fall 2008	N/A <sup>3</sup>	N/A <sup>3</sup>	5.8%	9.9%
Wiley & Johnson (forthcoming)	7%-9%	15%-17%	\$30/sq.ft.	\$130 sq.ft.

<sup>1</sup> Fuerst & McAllister disclose many of the problems with their methodology and data, and conduct a more robust statistical analysis on a smaller, more comparable sample of office properties that results in a 3.7% rent and 19.6% sales price premium for LEED.

<sup>2</sup> The authors make an adjustment for occupancy level, which changes results to show a 6% premium for EnergyStar. The premium for LEED in this adjusted approach was 9%, but not statistically significant. The sales price calculation is not independently derived, but rather based on rent premium and cap rate assumptions using direct cap sales method.

<sup>3</sup> No statistical analysis of rent premium included as part of their analysis.

Sales price premiums range from 5.8% to 31% for EnergyStar properties and 9.9% to 35% for LEED certified properties. Due more severe statistical, methodological, and data problems in sales price analyses, the Consortium places little confidence in these specific numerical results.

Based on interpretation of the statistical models, these results imply that LEED or EnergyStar certifications, independent of all the other factors that would affect sales price,

<sup>101</sup> The analysis in "The Greening of US Investment Real Estate—Market Fundamentals, Prospects and Opportunities," by RREEF Research in November of 2007 does not do a controlled statistical study, but rather compares occupancies and rents between certified and non-certified properties, and thus does not meet the statistical rigor that is attempted by the other four studies listed above.

are responsible for very significant sales price premiums, well beyond plausible premiums detected in tenant and investor surveys and case studies. We are particularly concerned about potential distortions due to insufficiently granular control for time, with value change during the time period studied increasing rapidly, with certified property sales, due to their very limited time series, happening during the periods of the most rapid value growth.<sup>102</sup>

The Consortium's work confirms that sustainable properties can be more valuable, due to the increases in regulator, space user and investor demand and positive "net" risks, but do not believe that the numerical results from these studies of sales price premiums are reliable indications of potential value increases at this time.

### ***Surveys and Market Research***

This category includes a broad array of research including tenant/occupant surveys, investor surveys, general surveys of corporate sustainability trends, sustainable related market or demographic research, tenant segmentation analysis, and other research that would contribute to an understanding of space user and investor demand and its implications on their willingness to pay more for sustainable real estate. Studies of churn costs, space flexibility, occupant satisfaction, and health and productivity are critical to space user demand, but are really aspects of building performance. The focus of the research categorized here is on work that assists in interpreting how space users or investors would respond to such building performance.

One of the difficulties in presenting market performance evidence for sustainable properties is that market analysis is inherently microanalysis, involving detailed property-specific analysis. For example, assessing the demand by regulators for a sustainable property is difficult to express generally, because demand for a property is a function of the regulations and incentives offered by municipal, state or federal governments, as well as the utilities and other specialized regulators for a specific property, based on its geographic location, property type, and the nature of the type of sustainable property investment.

Similarly, general statements about space user demand are also difficult because the analysis of the market demand by potential occupants for sustainable space is a function of the type of property, the particular geographic market, the profile of actual or potential property occupants, and other factors such as existing lease structures and market conditions.

Investor demand is somewhat easier to address generally, given the more regional, national, or even international capital markets for many real estate properties, but the type, size, quality and other attributes of a property will significantly influence a particular

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<sup>102</sup> Sustainable Real Estate Development: The Dynamics of Market Penetration by John Goering, published in the Fall 2009 Journal of Sustainable Real Estate, provides a good summary of statistics-modeling based research, and the issues involved in applying the conclusions of this research. He also looks at the key issues influencing the adoption of sustainable building in the industry.

property's investor demand due to its sustainability. Most importantly, regulator and space user demand drive investor demand, which are unique to specific properties.

Surveys and related market research make up the bulk of what actual valuers and underwriters use to value and underwrite the risks of sustainable properties. Expert-based research has been very limited to date, with only a handful of credible studies. Statistics/modeling-based market performance research has never been used by the industry to implement detailed property-specific valuation and due diligence. Accordingly, valuers and underwriters must collect and integrate many different sources of quantitative and qualitative research to assist them in deriving their opinions about key financial inputs including rents, occupancies, tenant retention, cap rates, discount rates, and expenses.

Surveys and market research are part of a broader array of supportive "Sustainable Sub-Financial Analyses" that we define and describe in significant detail in Expanded Chapter V-C and Appendix V-A. Sustainable sub-financial analyses are those analyses and models that provide quantitative insights/data that is typically combined with other information and analyses to aid valuers/underwriters in their specification of key financial assumptions in a discounted cash flow analysis, or a related traditional real estate financial model.

For the purposes of this section, we highlight and discuss three key types of surveys and market research, as shown below:

- Space user and investor surveys;
- Corporate sustainability surveys and research; and
- Tenant demographics and market segmentation.

#### *Space User and Investor Sustainability Surveys*

Space user and investor sustainability surveys provide insight into the potential magnitude and/or direction of sustainability demand by type of tenant or investor. Further segmentation by geography and/or property type and other categories is often possible.

The keys to extracting value and insight from these more general surveys is to look at the survey trends over time, the questions asked, the date the survey was taken, the independence of the survey organization, and most importantly, as much specificity as possible about the types of tenants, investors, or other respondents that are surveyed. If detailed information from these surveys is used in the interpretation of the results, important hypotheses about potential market demand for a particular property can be established, which valuers and underwriters can then test through more detailed market research and property-specific tenant, investor, and broker surveys, as is customary practice for valuers and underwriters.

A list of important tenant and investor surveys (and related respondents) is presented below in Exhibit IV-15.<sup>103</sup> These surveys, which became more frequent starting in 2005 and 2006, demonstrate an increasing trend of tenant and investor understanding of, and interest in, sustainable property. Generally, space users indicate an interest in sustainability, and in some cases a willingness to pay, but also reinforce the importance of cost savings and related financial concerns. While space user demand has continued during the economic crisis, select surveys report an even greater focus on cost savings or value, with a priority on organizational survival, rather than sustainability.

Space user demand is not consistent across types of space users. Government organizations, larger corporations, space users with an affiliation or relationship with the sustainable industry, high technology organizations, and certain other tenant groups tend to show the strongest interest and demand for sustainable properties. Larger, more sophisticated properties and owners are more focused on sustainability generally, but enhanced demand in the multi-family and smaller building segments appears to be growing, though it is hard to pin down based on surveys done to date.

Surveys of investors, which tend to be mixed with other respondents, or part of larger surveys, are beginning to show a stronger interest in sustainable properties. Investors are responding to increased regulator and space user demand, indicating, at least for the larger institutional or private investors, aggressive programs of evaluating the energy efficiency and/or sustainability of their properties, and trying to figure out strategies for measuring, monitoring and improving their portfolios.

Evidence based on our discussions with scores of institutional investors, and as confirmed by select surveys, suggests that many investors are developing acquisition screens and criteria to assist in evaluating the potential economic or functional obsolescence, and the cost to cure such obsolescence in new properties that they buy. These trends are quite important, because they suggest concrete investor response to increased regulator and space user demand.

#### *Corporate Sustainability Surveys and Research*

Corporations and other owner-occupants are significant players in the commercial real estate markets. Corporations own approximately half of the commercial real estate market. Additionally, they lease a substantial portion of space owned by others.<sup>104</sup> Corporate

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<sup>103</sup> This chronological list of survey research includes space user and investor surveys, surveys of other real estate industry professionals, and surveys of corporations regarding their general preferences for sustainability. Many of these surveys are available on the Consortium's website under index code 15.73 in the Research Library or Industry Resources sections.

<sup>104</sup> This estimate is very approximate, based on a 20-year history of capital markets research by Scott Muldavin, and review of the "Non-residential Buildings Energy Consumption Survey" (CBECS) of the Energy Information Administration. According to the EIA and CBECS research as of 1999, there were 4.7 million commercial buildings in the United States, of which 89% were privately owned and 60% of those were owner occupied. A detailed breakout and analysis of the commercial building industry is provided in "Who Plays and Who Decides, The Structure and Operation of the Commercial Building Market, US Dept. of Energy, Innovologie, LLC, John Reed et al., March 2004.

sustainability surveys and research incorporate a broad array of work evaluating the corporate sustainability movement and related issues.

The focus of this research from a real estate perspective is to understand how potential corporate space users “value” sustainability, and how important their real estate sustainability strategy is as part of their overall sustainability initiatives. Research looking at the real estate components of the Global Reporting Initiative, Carbon Disclosure Project, or corporate social responsibility reporting is some of the types of work that would be included here, as well as general surveys of corporate sustainability interests, and any comments they have specifically on real estate.

Additionally, more specialized studies of how corporations value sustainability-related benefits like reduced churn cost, increased space flexibility, or improved health and productivity of employees could also be included here. Again, the focus of the research categorized here is not on whether a building produces health and productivity or churn benefits, but in how different types and segments of the space user market react to buildings with such sustainable features or outcomes.

The results from the many surveys and research studies we have reviewed show a clear trend of increasing focus by corporations on sustainability, with growing emphasis on the key role real estate plays in sustainability and climate change. (See Research Library index codes 15.73 and 15.74.

A key component of corporate sustainability research is not only to develop hypotheses of the types of space users that have a greater demand for sustainable real estate today, but also to understand the trends in which future tenants may demand such services. Any investor buying a multi-tenant building today, with leases rolling over years into the future, must be sensitive not only to today’s demand, but also to underlying changes in the market that could affect future demand and performance.

#### *Tenant Demographics and Market Segmentation*

This category of market research covers any kind of academic research or related study that provides a detailed understanding of space user demand for sustainability. An example of this kind of survey would be demographic research, such as has been done in the hotel industry, which assesses the demand for sustainability by potential hotel occupants based on their age. This research, which is still in its infancy, shows substantially greater demand for sustainability by hotel occupants that are 35 years or younger, compared to middle and older age hotel users. Of course, geographic, income, and other demographic characteristics could also be important in defining sustainability demand, enabling more informed decisions to be made by valuers and underwriters relative to the financial impacts of sustainability on key financial variables like rents, occupancies, cap rates, etc.

Important research that evaluates tenant market segmentation and related issues is being conducted utilizing CoStar’s Tenant Module that enables analysis of the types of tenants



leasing, or not leasing, in sustainable properties. “Why Do Companies Rent Green? Real Property and Corporate Social Responsibility,” published on June 4, 2009, authored by Piet Eichholtz, Nils Kok, and John Quigley and further work of this type is underway by the authors.

“Why Do Companies Rent Green” is an update of a similar paper from a year ago, focuses on the most critical question of every sustainable property valuation assignment—what drives the leasing of potential occupants of “this” building, and how important is sustainability to them? By providing descriptive and statistical analysis of tenant preferences for sustainability from over 1000 sustainable office properties and 3000 tenants of those buildings, Eichholtz, Kok and Quigley have provided invaluable insight to valuers and underwriters trying to understand how different types of tenants will respond to a building’s sustainability. Their results on tenant preferences provide excellent hypotheses that valuers can now test through traditional market research and interviews at the property-submarket level.

Pages 3-13 of their study provide an excellent discussion of the theory of tenant choice, factors driving corporate space leasing and other issues critical to addressing tenant demand for green space. The six “propositions” that they set out to test, based on their theoretical foundation are also insightful:

Proposition I: Firms in the tertiary sector, i.e. the service industry, profit most from the cost savings and the improved working environment of green office buildings. Therefore, they will have a higher likelihood of renting green office space.

Proposition II. As stakeholder pressure regarding CSR is mainly directed at the largest and most visible firms in an industry, these are more likely to act in a social and environmentally responsible manner and will therefore have a higher likelihood of leasing green office space.

Proposition III. Firms with environmentally sensitive operations will be more likely to leasing green office space, as this can help to offset otherwise more negative corporate images.

Proposition IV. Firms in industries that are dependent on high levels of human capital and high wage workers are more likely to rent office space in green buildings.

Proposition V: Government, government-related organizations, and non-profit institutions are more likely to act in socially responsible ways, and thus to lease green space, as monetary factors are of less importance. The possibly higher cost of leasing green space can be more easily passed on to the taxpayer or sponsors.

Proposition VI: Firms that are concerned about customer responses will adjust their CSR actions to their industry peers.

Their testing of the propositions is also interesting in that it is based on four different types of descriptive analysis: 1) which specific tenants (and SIC codes) leased the most green space; 2) how concentrated were tenants in green buildings versus nearby conventional buildings; 3) the propensity of industries to choose green buildings over nearby

conventional buildings, and 4) finally, the fraction of office space by industry sector in green buildings versus the fraction of all buildings they occupy.

Their key conclusions included:

The descriptive results show that the oil industry is a major occupier of green office space, which is in line with the proposition that firms in environmentally sensitive industries will actively incorporate sustainability in strategic decisions such as headquarters selection, which may well be to enhance reputation. Firms in the legal and financial services industry lease a substantial share of green office space as well. For some of these firms, further investigation shows support for our proposition that firms in the tertiary sector acknowledge the productivity benefits of green buildings. However, it is likely that for other firms, leasing green is a result of the preference for high quality buildings, rather than an act of responsible behavior, since green buildings are usually higher-quality buildings.”

We then address tenant composition in green buildings as compared to a matched set of conventional office buildings. We find that, controlling for differences in quality and unobserved locational characteristics, tenants are more concentrated in green buildings, occupying larger shares of the buildings. This may indicate the desire to use a building as a flag to signal commitment to CSR.

In general the descriptive evidence confirms some of our propositions, to the extent that the expected industries each have a few ‘green’ leaders. However, the results of the regression and Tobit-analyses are less clear: a statistically significant commitment to green space usage currently only exists for the manufacturing and mining industry and for public administration, respectively. These findings confirm the proposition that companies with socially challenging operations may use green buildings to offset negative reputation effects. Moreover, the government and government-related organizations, for which non-financial utility is of major importance, are significantly more likely to rent green office space than other sectors do. The most prominent example is California’s Environmental Protection Agency, with all of its activities located in a highly sophisticated environmental-friendly office building.

Besides, it turns out that the concentration and size of establishments, as well as the extent to which human capital is available in certain metropolitan areas, has a distinct positive influence on the fraction of environmentally labeled space that is leased by particular industries.

Significant good work continues to come from Australia. In *Benchmarking Sustainability*, published June 2009 at [Yourbuilding.org](http://www.yourbuilding.org):

(<http://www.yourbuilding.org/Article/NewsDetail.aspx?p=83&mid=1587>, the results of a Building Use Study, which compared an Australian building (The Szencorp Building) against 55 other Australian and 81 international buildings, and incorporated a follow-up survey of tenants, three years after an initial survey was done, were dissatisfied with some of the promised sustainable benefits, but showed a high level of tolerance towards achieving solutions due to the buildings sustainability. Tenant education and behavior modification were identified as critical investments to maximize potential productivity benefits.

Key findings included:

- The Szencorp Building was the highest scoring Australian building in the international sustainable buildings benchmark dataset, achieving a ‘Good Practice’ rating for overall performance.
- Perceived productivity was in the top 9 percent of Australian buildings, but this was actually a 1.5 percent decrease from the 2006 results, which showed a 13 percent increase in productivity. Building use studies research shows only 30 percent of buildings have positive productivity ratings.
- Tenants rated the Szencorp Building’s image and design as very positive, placing it fourth in the Australian dataset for image.
- The speed at which problems such as temperature were addressed rated better than the national benchmark.
- The 2006 study revealed tenants were very happy with the level of artificial and natural light, but the 2009 study showed that the tenants believed there was not enough natural light.
- 86 percent of staff were dissatisfied with ventilation, 70 percent were dissatisfied with cooling and 79 percent dissatisfied with heating. However, forgiveness for these matters was also high.
- 54 percent of tenants said they felt “more healthy” working in the Szencorp Building.
- The building’s overall performance rating improved from 76 to 80 out of 100.
- Travel to work by bicycle increased from 5 percent in 2006 to 11 percent in 2009, but 61 percent of occupants travel to work by car, showing the importance of behavior programs alongside good building design.

<b>Exhibit IV-15</b>			
<b>Space User and Investor Sustainability Surveys</b>			
<b>Name/Source</b>	<b>Publication Date</b>	<b>Date(s) Survey Taken</b>	<b>Respondent Description</b>
McGraw-Hill Smart Growth Reports	Ongoing	Ongoing	Wide range of sustainable building and construction industry participants
Jones Lange LaSalle / CoreNet Sustainability Survey	Late 2009	Sept.-Oct. 2009	Corporate real estate executives
"Doubling Down on Green," National Real Estate Investor 2009 Green Building Survey	Nov./Dec. 2009	Aug.-Sept. 2009	E-mail invitation to developers, corporate and government planners, subscribers, involved with office, retail or mixed-use properties. 337 responses: 175 government officials, 105 commercial developers, 57 corporate real estate users.
CB Richard Ellis and Burnham-Moores Center for Real Estate, University of San Diego, "Do Green Buildings Make Dollars and Sense?"	Nov. 2009	May 2009/ Summer 2009	534 responses from tenants in 154 Class A or A-LEED office buildings. Follow-up survey obtained 221 respondents, or EnergyStar
National Association of Home Builders	Oct. 2009	Aug. 2009	Homebuilders
National University of Singapore, Journal of Sustainable Real Estate	Fall 2009	Not provided	400 occupiers of commercial buildings in Singapore; survey on importance of green building benefits and willingness to occupy
RICS/CPE Global Commercial Property Sustainability Survey	Aug. 2009	June-July 2009	Property professionals worldwide. "Leading international real estate organizations and local firms." No further detail provided.
Kingsley Assoc. "Insight" Newsletter	June 4, 2009	N/a	Office tenants.
"Energy Efficiency Indicator Survey" (EEI), Johnson Controls	May 2009	N/a	1,400 N. American executives responsible for managing, reviewing, or monitoring energy use in their organization.
"The Economy's Impact on Corporate Real Estate," CoreNet Global	May 2009	April 2009	400 respondents from the occupier and service provider sides of the corporate real estate industry, many of who have global responsibilities.
"Global Compact Annual Report," Survey by United Nations	Apr. 8, 2009	N/a	700 respondents from 1,500 global businesses signed on to UN's "Global Compact."
Center for Research on Environmental Decisions, Columbia and Yale Universities	Mar. 19, 2009	N/a	New Yorkers.
Allen Matkins 3 <sup>rd</sup> Annual Green Building Survey	Early 2009	Dec. 2008	900 respondents including 42% design professionals, 21% contractors/subcontractors, 12% construction planning managers, 11% consultants, 10% owners/developers, 4% other
"Central London Occupier Survey," Knight Frank	Jan. 2009	Sept. 2008	Corporate real estate directors in London, UK.
"Green Building Market Barometer," Turner Construction Company	Jan. 2009	Aug.-Sept. 2008	754 executives in the United States real estate industry: developers; building owners; brokers; architectural, engineering, and construction firms; corporate owner-occupants; and tenants. Unclear if 754 was respondents or those surveyed.
Turner Green Building Market Barometer	Year-end 2008	Aug.-Sept. 2008	754 green building executives, 37% developers, 31% owners, 27% brokers/real estate service providers, 22% architects and engineers, 10% corporate users
"Sustainability in Corporate Real Estate," CoreNet Global & Jones Lang LaSalle	Dec. 5, 2008	Oct. 2008	402 senior corporate real estate executives, global survey (75% N. America, 12% Europe, 13% other); 78% of respondents from companies with over 1,000 employees.
"The 2007 Sustainability Survey Report," Leonardo Academy	Dec. 10, 2008 (updated)	Fall 2007	408 respondents from a variety of businesses and international locations.
"The Green Survey," <i>Real Estate Forum</i> , GlobeSt.com, the Building Owners & Managers Assoc. Int'l., US Green Bldg. Council	Nov. 2008	2008	Over 250 respondents in the U.S. to on-line poll included property owners, property managers, developers, asset managers, REIT executives and "other" (some respondents have international reach).
"Quarterly Sustainability Tracking Study," Panel Intelligence	Nov. 25, 2008	Early Nov. 2008	65 "sustainability executives" of Fortune 500 companies in North America.
Verizon and IR Magazine Study	Sept. 10, 2008	N/a	150 respondents -- Investor relations professionals Drawn from global readership of IR Magazine.
"From Green to Gold 2008," GVA Grimley	Fall 2008	Summer 2008	"Leading" UK income property investors. Survey focused solely on investors.
Experience, Inc.	Aug. 6, 2008	N/a	2,500 college students and recent graduates.

<b>Exhibit IV-15</b>			
<b>Space User and Investor Sustainability Surveys</b>			
<b>Name/Source</b>	<b>Publication Date</b>	<b>Date(s) Survey Taken</b>	<b>Respondent Description</b>
"Energy Efficiency Indicator," Johnson Controls	Apr. 15, 2008	N/a	Survey conducted by International Facility Management Association.
"Future of the Workplace Survey," CoreNet Global	May 2008	N/a	Global corporate real estate: consultants/academics, service providers, end-users. 85% respondents based in China/Asia/Pacific.
Carbon Disclosure Project	May 1, 2008	N/a	144 supply chain companies from around the world.
"2008 IBT Market Pulse Survey"	N/a	Apr. 2008	On-line survey: 124 financial institution executives in the U.S.
"Green Shopping Centres," GVA Grimley	Spring 2008	Oct. 7, 2007–Feb. 8, 2008	20 UK shopping centers plus interviews with their managers, investors, developers, architects and cost consultant, covering both existing and new centers.
"The State of Sustainability in Asia", Jones Lang LaSalle, CoreNet Global	Mar. 4, 2008	2007	300 corporate real estate professionals at the CoreNet Global Asia Summit.
Survey on green employment, MonsterTRAK.com	Feb. 8, 2008	N/a	"Young professionals", "students and entry-level hires".
"CSR Jobs Rank High for Newly Minted MBAs," Net Impact and Ellen Weinreb Recruiting	Jan. 15, 2008	2005-2008	Job listings in major cities globally
"Global Sustainability Survey," CoreNet Global & Building Design + Construction Magazine	Jan. 2008	N/a	A wide range of industry sectors was surveyed about trends in the design-and-build side of the industry.
"Sustainability Perceptions and Trends in the Corporate Real Estate Industry," CoreNet Global & Jones Lang LaSalle	Jan. 2008	Mar.-Sept. 2007	Global Summit audiences—"corporate real estate and workplace executives"—in Singapore, Denver, London and Melbourne. 2,300 were queried; 414 responded.
Valuing Green, Australian Green Building Council, 2008	2008	2008	Detailed face-to-face interviews with representatives of five leading property advisory and valuation firms and 14 fund managers and developers (pgs. 16-19).
"Australian Sustainability Survey 2007," Jones Lang LaSalle	2008	2007	Australian real estate industry.
"Global Green Building Trends," McGraw Hill Construction	2008	April/May 2008	The global construction industry: 1,503 surveyed, with 700 respondents from construction industry professionals in 45 countries.
Survey on corporate responsibility by The Conference Board	Nov. 9, 2007	N/a	198 medium to large multinational companies.
"2007 Green Index," AIA and Autodesk, Inc.	Nov. 13, 2007	Oct. 2007	347 practicing architects in the U.S.
"2007 Green Survey: Existing Buildings," Real Estate Media, the Building Owners & Managers Assoc. Int'l. and the US Green Building Council"	Nov. 2007	2007	392 property owners, property managers, developers, asset managers, REIT executives and "other" in the U.S. (some respondents have international reach).
"European Landlord & Tenant Survey," Cushman & Wakefield	Nov. 2007	N/a	825 senior executives representing major corporations in Europe. 1/3 were property landlords; 2/3 <sup>tenants</sup> .
"2007 Green Building Survey," National Real Estate Investor and Retail Traffic	Nov. 2007	Aug. 2007	24,943 subscribers of participating publications were e-mailed survey invitations. Subscriber categories: corporate users of real estate, developers of commercial real estate, government officials. 384 respondents.
"The Workplace Performance Survey," Tritaga	Oct. 2007	Sept. 2007	Over 100 workplace organizations primarily in government, financial services, and professional services. Medium to large organizations.
"2007 Canadian Office Tenant Survey," Colliers International	Sept. 26, 2007	July 2007	181 Canadian office tenants who lease over 10,000 sf of space.
"15 <sup>th</sup> Business Leaders Survey," Grant Thornton and <i>Business Week</i>	Sept. 2007	June 2007	Online survey: 510 corporate executives from Business Week's Market Advisory Board.
"State of the Outsourcing Industry," Brown-Wilson Group	Aug. 20, 2007	N/a	Results based on a green-related sub-survey as part of its larger survey of 20,000 global outsource users for its book <i>State of the Outsourcing Industry</i> ."
"Corporate Social Responsibility Survey," RSM Erasmus University	July 25, 2007	N/a	200 large European companies across a broad range of sectors.
"From Green to Gold," GVA Grimley	Summer 2007	June 2007	UK's leading real estate investors.

<b>Exhibit IV-15</b>			
<b>Space User and Investor Sustainability Surveys</b>			
Name/Source	Publication Date*	Date(s) Survey Taken	Respondent Description
Johnson Controls	June 13, 2007	Mar. 2007	"employees across a wide range of industries and locations" identified as decision makers for energy management issues.
"The Greening of Corporate America SmartMarket Report," McGraw-Hill/Siemens	May 14, 2007	N/a	190 of the largest companies in US, all with revenues over \$250 million. 85% of the respondents were CEOs or CFOs or senior vice presidents in environmental or investor-relations positions.
GVA Grimley/ CBI survey	Spring 2007	June 2006	"Office occupiers".
"Australian Office Tenant Survey 2006," Colliers International	2007	Latter half of 2005	205 corporate tenants in a broad cross-section of industries occupying more than 500 sq. m. located in CBD and metropolitan markets of Sydney, Melbourne and Brisbane, Australia
"Financial Consequences of Worker Absences," Cornell U., U. of Pennsylvania, Dow Chemical & Merck	Feb. 25, 2006	N/a	800 managers in 12 industries.
"US Workplace Survey," Gensler	2006	Mar. 2006	2,013 American office workers, covering eight industries and with equal regional representation across the continental US.
"Office Tenant Needs Study," CBE and Fisher Ctr. of Real Estate & Urban Economics/ Spieker Properties	Oct. 1999	July/Aug. 1999	Focus groups of 8 to 15 from various business sectors and types of companies (small, medium, large; public/private).

\* Information came from a third party source. Publication date is the date the source reported on the survey, not necessarily the date survey results were published.

### ***Foundational Background and Theory***

This category includes foundational background research and theoretical studies that address key issues in sustainable property valuation and financial analysis. Academics and/or leading industry specialists and/or trade groups/government typically complete this work. Theoretical research on valuation and financial performance of sustainable properties has received contributions from around the world since about 2000.<sup>105</sup>

Sarah Sayce, Louise Ellison, and Judy Smith from the United Kingdom began publishing papers around 2003 and early 2004 that began to integrate sustainability into the appraisal of property worth. Their work was part of the Sustainable Property Appraisal Project<sup>106</sup> and was the first we reviewed that specifically addressed the theoretical foundation for linking sustainable property attributes and property performance.<sup>107</sup>

Chris Corps and a team consisting of Cushman Wakefield, LePage, Busby Perkins + Will BuildGreen Consulting, and DTC (UK) led a collaborative project and published "Green Value" in late 2005, still one of the best theoretical and empirical pieces of work linking sustainable property attributes and value. Chris Corps continued his work in the valuation arena through his founding of the Vancouver Valuation Accord and his continuing

<sup>105</sup> We identify a number of key researchers working on sustainable valuation and financial performance, but the list is by no means comprehensive; we apologize in advance for leaving out key researchers and look forward to hearing from others working in the field.

<sup>106</sup> This research project was made possible through the financial support of the Department of Trade and Industry, Prudential Property Investment Mangers, Investment Property Forum, Boots Properties, and the ongoing support of Drivers Jonas, IPD, Universities Superannuation Scheme and Forum for the Future.

<sup>107</sup> Sarah Sayce has been publishing papers on these and related topics since the 1990s.

authoring of important theoretical and empirical works, including his May 2009 co-authorship with Theddi Wright Chappell of “High Performance Green Buildings: What’s It Worth?” and “Valuing Sustainability,” which he wrote as a special report of the Commission for Environmental Cooperation in the fall of 2007.

David P. Lorenz and Thomas Lütztendorf of Germany, who have written a series of papers that explore in detail the relationship between sustainability and market value and risk, have made substantial contributions. Simultaneous with the work by Lorenz and Lütztendorf, a number of Australians, including Richard Reed, John Robinson, Georgia Myers, Phillip Kimmet, and Stefan Trück, began developing additional theoretical support for the relationship between sustainability and the value of buildings. Their work and the work of many other important Australian sustainability authors was formalized into the YourBuilding.org website (<http://www.yourbuilding.org/>), which today is one of the best organized and most accessible websites providing a foundation for the linkage between sustainable property attributes and financial performance and value, written from a commercial real estate perspective.

Researchers in Japan have also made important contributions. Since 2005, Sumitomo Trust has been studying environmental added value. The Japan Real Estate Institute is studying sustainable valuation practices internationally. Professor Tomonari Yashiro of the Institute of Industrial Science at the University of Tokyo has been actively involved in key valuation research and has helped to tie together the relationship between sustainability and value. Kei Owada, of the Mitsubishi Research Institute and Masato Ito, of the Sumitomo Trust and Banking Company, Ltd., have also been publishing more recently on the critical relationships between sustainability and value. Mr. Ito’s 2005 award-winning paper, “A Note On Environmental Added Value for Real Estate,” can be found at:

<http://www.sumitomotrust.co.jp/csr/innovation/real-estate/pdf/200511.pdf>

Sumitomo Trust's research on environmental added value is available at:

<http://www.sumitomotrust.co.jp/csr/innovation/real-estate/01english.html>

It is also important to acknowledge the significant theoretical and background research contributions of all of the authors of the research studies discussed earlier in this chapter. These researchers include Norm Miller, Dave Poque, Jay Spivey, Andy Florance, Piet Eichholtz, Niles Kok, John Quigley, Franz Fuerst, Patrick McAllister, Brian Ciochetti, Mark McGowan, and Jonathan Wiley, Justin Benefield and Ken Johnson. While the focus of the statistics/modeling-based research is on proving an empirical relationship between sustainable certification and rent or value, each of the key papers authored by these individuals also provided important theoretical and background research that built off the foundation that had been established by earlier authors.

The Royal Institute of Chartered Surveyors and the Appraisal Institute have also provided leadership in developing the theoretical foundation for sustainable valuation. The Royal Institute of Chartered Surveyors, an international organization (operates out of 146 countries) of over 100,000 property professionals, has been a key sponsor and promoter of much of the work done to date in the industry. In addition to organizing and sponsoring

meetings of sustainable valuation professionals, sponsoring specific research in Canada, United States, United Kingdom, Australia, Germany, and other countries, and supporting groups like the Green Building Finance Consortium and others working on these issues, the Royal Institute of Chartered Surveyors has an active sustainability publication program, publishing special reports and surveys on sustainable property issues. In addition to their specific work on sustainable property valuation, they are active worldwide in many other aspects of the relationship between sustainability and property.

The Appraisal Institute, a global membership association of professional real estate appraisers with 25,000 members in 91 chapters throughout the world, has supported publication of green valuation articles and sponsored the development of a green valuation educational seminar, created by Theddi Wright Chappell and Timothy Lowe, which provides a strong introduction on the key green value issues confronted by valuers.<sup>108</sup>

CoStar ( <http://www.costar.com/> ), the largest provider of real estate information, marketing and analytics in the United States and the United Kingdom, has also demonstrated strong leadership by making its data useable and available for sustainable property research, providing financial support for research, and contributing significant staff time to support better research and analysis.

*Identification of Sustainable Valuation Background and Theoretical Research*

Substantial work has been completed providing an emerging theoretical foundation linking sustainable property investment and improved financial performance and value. A chronological listing of some of the key work is presented below in Exhibit IV-16. In many cases, the research presented below can be found in the Green Building Finance Consortium’s Research Library or in the Industry Links section under index code 7.2.

The Green Building Finance Consortium’s “*Value Beyond Cost Savings: How to Underwrite Sustainable Properties*” builds off the theoretical foundation presented in the publications below. The Consortium’s work expands beyond valuation to the broader context of sustainable property investment decision-making.

Key theoretical research and background articles on sustainable property valuation and financial performance are organized and presented chronologically below:

<b>Exhibit IV-16</b>			
<b>Foundational Background and Theoretical Research</b>			
<b>Sustainable Property and Valuation Chronological List</b>			
Title	Author(s)	Publication/Publisher Name	Publication Date
Green Design and the Market for Commercial Office Space	Jonathan A. Wiley, Justin D. Benefield and Ken H. Johnson	Journal of Real Estate Finance and Economics	forthcoming (2010 or 2011)

<sup>108</sup> Theddi Wright Chappell and Tim Lowe are pro bono members of the Green Building Finance Consortium’s implementation team. Chris Corps is a member of the Consortium’s Advisory Board.



<b>Exhibit IV-16</b>			
<b>Foundational Background and Theoretical Research</b>			
<b>Sustainable Property and Valuation Chronological List</b>			
<b>Title</b>	<b>Author(s)</b>	<b>Publication/Publisher Name</b>	<b>Publication Date</b>
A New Competitive Advantage: Connecting the Dots between Employee Health and Productivity	Nina Taggart	Benefits and Compensation Digest	2009
Green Buildings and Productivity	Norm Miller and Dave Pogue	Journal of Sustainable Real Estate	2009
Greening Our Build World: Costs, Benefits and Strategies	Greg Kats	Island Press	Nov. 2009
The Costs and Benefits of Green	Greg Kats	A Report to California's Sustainable Building Task Force, Capital E Analytics	Oct. 2003 and 2007
Is LEED Certification Worth It?	K. McCormick	Multifamily Trends, The Urban Land Institute	April 2008
Increasing Commercial Real Estate Returns With Energy Risk Management	Jerry Jackson	Working paper presented at ARES	April 2008
Do Green Buildings Make Dollars and Sense?	Norm Miller, David Pogue	USD-BMC Working Paper 09-11, Draft	Nov. 6, 2009
Sustainable Real Estate Development: The Dynamics of Market Penetration	John Goering	Journal of Sustainable Real Estate	Fall 2009
An Investigation of the Effect of Eco-Labeling on Office Occupancy Rates	Franz Fuerst and Patrick McAllister	Journal of Sustainable Real Estate	Fall 2009
Effect of LEED Ratings and Levels on Office Property Assessed and Market Values	Sofia V. Dermisi	Journal of Sustainable Real Estate	Fall 2009
Green Design and the Market for Commercial Office Space	Justin Benefield, Jonathan Wiley and Ken Johnson	Journal of Real Estate Finance and Economics, forthcoming	2009
Why Do Companies Rent Green? Real Property and Corporate Social Responsibility	Piet Eichholtz, Nils Kok, & John Quigley	Working Paper	July, 2009
High Performance Green Building: What's It Worth? Investigating the Market Value of High Performance Green Buildings	Chris Corps, Theddi Wright Chappell	Special Report	May 2009
Thinking About the Value of a Property From a Sustainable Perspective	Lynne Armitage	API Journal	May 2009
New Evidence on the Green Building Rent and Price Premium	Frank Fuerst & Patrick McAllister	Presentation to ARES Conference	Apr. 3, 2009
Investment Returns From Responsible Property Investments: Energy Efficient, Transit-Oriented and Urban Regeneration Office Properties in the US from 1998-2008	Gary Pivo and Jeffrey Fisher	Working Paper	Oct. 11, 2008; revised March 2009
Energy Efficient Investments: Do They Pay?	Brian Ciochetti and Mark McGowan	MIT Conference for Real Estate	Feb. 2009
How Green a Recession? Sustainability Prospects in the US Real Estate Industry	Andrew J. Nelson	RREEF Research	Jan. 2009
Doing Well By Doing Good? Green Office Buildings	Piet Eichholtz, Nils Kok and John M. Quigley	Working paper, Fisher Center for Real Estate & Urban Economics, UC Berkley	Jan. 2009
Sustainability: Measurement and Valuation? Insights From Australia and New Zealand	Georgia Warren-Myers, Richard Reed	15 <sup>th</sup> Annual Pacific Rim Real Estate Society (PRRES) Conference	Jan. 2009
The Impact of Sustainability on the Investment Environment: A Case Study of Australia	Deborah Levy & Anthony De Francesco	Royal Institute of Chartered Surveyors Research Report	Nov. 2008
Globalization and Global Trends in Green Real Estate Investment	Andrew Nelson	RREEF Research	Sept. 2008
Next Generation Decision Support Instruments for the Property Industry: Understanding the Financial Implications of Sustainable Building	David Lorenz & Thomas Lütendorf	Paper for World Sustainable Building Conference	Sept. 2008
Sustainable Property Investment and Management: Key Issues and Major Challenges	David Lorenz, et al.	Royal Institute of Chartered Surveyors	Sept. 2008

<b>Exhibit IV-16</b>			
<b>Foundational Background and Theoretical Research</b>			
<b>Sustainable Property and Valuation Chronological List</b>			
<b>Title</b>	<b>Author(s)</b>	<b>Publication/Publisher Name</b>	<b>Publication Date</b>
Valuing Green Buildings: An Australian Perspective	Philip Kimmert and Victoria Popova	School of Urban Development, Queensland Univ. of Technology	Sept. 2008
Quantifying 'Green' Value: Assessing the Applicability of the CoStar Studies	Scott R. Muldavin	Green Building Finance Consortium Special Report	June 2008
Does Green Pay Off?	Norm Miller, Jay Spivey & Andy Florance	Journal of Real Estate Portfolio Management	Fall 2008
Does It Pay to Be Green? Correcting Economic and Environmental Performance in Commercial Real Estate Markets	Franz Fuerst and Patrick McAllister	Draft Paper	June 3, 2008
Breaking the Vicious Cycle of Blame—Making the Business Case for Sustainable Buildings	Royal Institute of Chartered Surveyors	Royal Institute of Chartered Surveyors	June 2008
Why Companies Rent Green: CSR and the Role of Real Estate	Piet Eichholtz, Nils Kok, John M. Quigley	Working Paper	June 2008
Does Green Pay Off?	Norm Miller, Jay Spivey and Andy Florance	Working Paper	April 2008
Doing Well By Doing Good? Green Office Buildings	Piet Eichholtz, Nils Kok and John M. Quigley	Working paper, Fisher Center for Real Estate & Urban Economics, UC Berkley	April 2008
Pricing Sustainability: An Empirical Investigation of the Value Impacts of Green Building Certification	Franz Fuerst and Patrick McAllister	Working paper presented at ARES	April 2008
Valuing Green: How Green Buildings Affect Property Values and Getting the Valuation Method Right	Richard Bowman, John Wills	Australian Green Building Council Special Report	Feb. 2008
RICS EU Advisory Group on Sustainable Property Investment and Management	RICS Advisory Group Action Plan	Royal Institute of Chartered Surveyors	Jan. 2008
An Introduction to Valuing Green	Tim Lowe & Theddi Wright Chappell	Appraisal Institute Education Seminar	2008 (updated regularly)
Climate Change: The Risks for Property in the UK	Patrick Austin	Hermes Special Report	2008
The Greening of US Investment Real Estate: Market Fundamentals, Prospects and Opportunities	Andrew Nelson	RREEF Research	Nov. 2007
Integrating Sustainability Into Property Risk Assessments for Market Transformation	Thomas Lütendorf & David Lorenz	Building Research and Information	Nov. 2007
Does Green Pay Off?	Norm Miller, Jay Spivey and Andy Florance	Working Paper	Nov. 19, 2007
Valuing Sustainability	Chris Corps	Special Report of the Commission for Environmental Cooperation	Fall 2007
Office Productivity: A Theoretical Framework	B.P. Haynes	Journal of Corporate Real Estate	Fall 2007
Valuation of Sustainable Commercial Properties	Richard Reed	Your Building Website	Aug. 30, 2007
A Strategic Response to Sustainable Property Investing	Scott Muldavin	PREA Quarterly	Summer 2007
Financing and Valuing Sustainable Property: We Need to Talk	The Royal Institute of Chartered Surveyors	Presented at the "Rethinking Sustainable Construction" Conference	April 2007
The Relationship Between Sustainability and the Value of Office Buildings	Georgia Myers	Presented at the 13 <sup>th</sup> Annual Pacific Rim Real Estate (PRRES) Conference	Jan. 21-24, 2007
Socially Responsible Property Investment: Quantifying the Relationship between Sustainability and Investment Property Worth	L. Ellison, S. Sayce and J. Smith	Journal of Property Research	2007
Understanding Investment Drivers for UK Sustainable Property	Sarah Sayce, Louise Ellison and P. Parnell	Building Research & Information 35 (6)	2007
The Application of Sustainable Development Principles to the Theory and Practice of Property Valuation	David Lorenz & Thomas Lütendorf	Working Paper	Dec. 2006
The Sustainable Property Appraisal Project: Outline of Collaborative Research Programme	Sarah Sayce, et al.	School of Surveying, Kingston University	Aug. 3, 2006

<b>Exhibit IV-16</b>			
<b>Foundational Background and Theoretical Research</b>			
<b>Sustainable Property and Valuation Chronological List</b>			
<b>Title</b>	<b>Author(s)</b>	<b>Publication/Publisher Name</b>	<b>Publication Date</b>
Addressing Risk and Uncertainty in Property Valuations: A Viewpoint from Germany	David Lorenz, Stefan Trück & Thomas Lütendorf	Journal of Property Investment and Finance	June 2006
Exploring the Relationship Between the Sustainability of Construction and Market Value	David Lorenz, Stefan Trück & Thomas Lütendorf	Property Management, Vol. 25, No. 2	April 2006
Sustainability in Property Valuation: Theory and Practice	David Lorenz & Thomas Lütendorf	Property Management, Vol. 25, No. 2	April 2006
Assessing the Value of Sustainability	Jones Lang LaSalle	Jones Lang LaSalle	2006
Toward Sustainability Indicators for Commercial Property Occupies and Investors	Sarah Sayce & Louise Ellison	Research Paper; Kingston University	2006
Green Value: Green Buildings, Growing Assets	Chris Corps, Cushman & Wakefield LePage, Busby Perkins + Will, Build Green, DTZ (UK)	Royal Institute of Chartered Surveyors	Oct. 2005
The Value of Green Buildings: A Study for the RICS	DTZ Research	Royal Institute of Chartered Surveyors	April 2005
Property Valuation and Analysis Applied to Environmentally Sustainable Development	J. Robinson	Paper presented at the 11 <sup>th</sup> Pacific Rim Real Estate Society Conference	Jan. 2005
A Note on Environmental Value Added for Real Estate	Masuto Ito	The Sumitomo Trust & Banking Co. Ltd. Real Estate Consulting Dept.	2005
The Reporting of Risk in Real Estate Appraisal Property Risk Scoring	A. Adair and N. Hutchison	Journal of Property Investment and Finance, Vol. 23, No. 3	2005
Sustainable Property Investment: Valuing Sustainable Buildings Through Property Performance Assessment	Thomas Lütendorf & David Lorenz	Building Research and Information	2005
Incorporating Sustainability in Commercial Property Appraisal: Evidence From the UK	Sarah Sayce, Louise Ellison and Judy Smith	Presented at the 11 <sup>th</sup> European Real Estate Conference	June 2, 2004
How Green Is Your Building? An Appraiser's Guide to Sustainable Design	Krisandra Buidry	The Appraisal Journal (Appraisal Institute)	Winter 2004
Integrating Sustainability Into the Appraisal of Property Worth: Identifying Appropriate Indicators of Sustainability	Sarah Sayce & Louise Ellison	Presented at the American Real Estate and Urban Economics Association Conference	Aug. 21, 2003
The Quest for Sustainable Buildings: Is Longevity the Key?	Sarah Sayce	Proceedings of the 2002 International Sustainable Development Research Conference	Apr. 8-9, 2002
An Aggregated Weighting System for Evaluating Sustainable Urban Regeneration	L. Hemphill, S. MacGreal & J. Berry	Journal of Property Research, 19 (4)	2002
Sustainability Checklist for Developments	D. Brownhill and Rao	Watford: BRE Centre for Sustainable Construction	2002
Stalking the Elusive Business Case for Corporate Sustainability	Donald J. Reed	World Resources Institute	Dec. 2001
Environmental Benchmarking for Property Portfolio Managers	D. Brownhill and A. Yates	Watford: BRE Centre for Sustainable Construction	2001
What About Demand? Do Investors Want 'Sustainable Buildings?'	M. Keeping	The Cutting Edge, RICS Research Foundation	2000
Attitudes Towards Financial Incentives for Green Buildings	P. Parnell and S. Sayce	Kingston University School of Surveying and Drivers Jonas Property Consultants	1999
Sustainability Indicators: Measuring the Immeasurable	S. Bell and S. Morse	Earthscan, London	1999
Financial Analysis of LEED EB Implementations	Craig Sheehy	Envision Realty	2008

## G. Financial Performance

Sustainable property financial performance is not a simple concept, and needs to be clearly defined and articulated when presenting financial performance evidence. For example, when talking about sustainable property financial performance, you must first clearly specify whether you are talking about value or returns for the property overall, or the incremental rate of return or value contribution of incremental investments in sustainable features and strategies.

Sustainable property financial performance can also refer to feature-based financial performance measured by simple payback and rate of return analyses. These types of analyses are conducted for individual sustainable features or strategies like green roofs, daylighting, underfloor air distribution, etc. It is also important to keep clear whether one is talking about projected or actual financial performance.

The scores of different types of sustainable property investment decisions, including minor retrofits, major retrofits, commercial interiors, new acquisitions, new construction, and many variations in between, further highlight the complexities of sustainable property financial performance. The appropriate measurement and analysis for determining sustainable property financial performance will vary by the type of decision and other factors.

The key focus of the Consortium is to enable private sector investors to properly integrate revenue and risk considerations into their decision-making. Accordingly, simple payback and simple return on investment analyses, and other feature- or strategy-based financial analyses, are not the focus of our work.

As is detailed in Expanded Chapter V, to understand the implications of sustainable property investment on financial performance, one must consider, at least conceptually, a discounted cash flow analysis. The DCF produces specific financial performance measures including an internal rate of return and value. Of course, no estimated rate of return or value estimate can be properly interpreted, and incorporated into a sustainable property investment decision, without a full and comprehensive understanding and consideration of risk.

### *Summary of Sustainable Property Financial Performance Evidence*

The evidence for sustainable property financial performance was presented in prior sections of this chapter. Section D: “Feature-Based Financial Performance” of Expanded Chapter IV presents further evidence for specific features or strategies. Evidence of the implications of sustainable property investment on property rates of return and value were presented in the “Market Performance” section, under the Expert-Based and Statistics/Modeling-Based Financial Analyses headings.

In summary, the volume of sustainable property financial performance evidence is still small. The significant dearth of sales and leasing transactions, and substantial value and rent declines since 2008, and rapid value increases prior to 2008, will also continue to make it difficult to generate statistics/modeling based empirical evidence. However, evidence from the key expert-based financial analyses and statistics/modeling-based financial analyses presented in the prior sections shows a clear trend towards improved rents, occupancies, risks, and resulting rates of return and value. Additionally, by fully identifying and assessing the positive and negative sustainability risks of specific properties, and carefully evaluating surveys/market research, there is hope for more intelligent assessments of the value contributions of sustainable property investment.

Not unexpectedly, enhanced rate of return and value performance evidence to date has been more incremental than dramatic. This result is reasonable given that sustainable features and strategies are just one part of the rate or return or value equation for any particular property. Additionally, the key forces driving value—enhanced regulator, space user and investor demand—have only recently been increasing measurably.

## H. Conclusions

Sustainable property performance measurement and monitoring must evolve to include market performance to enable the full value of sustainable properties to be more easily quantified. Process and feature performance assessment need to be modified to focus more on their contribution to risk mitigation, than incremental payback. Building performance measurement needs to sharpen its focus on the key things occupiers' value including resource use, carbon footprint, and the potential health, productivity and satisfaction of building users. Property owners must also be wary of changing social attitudes and regulatory changes that could negatively affect even “high performance” buildings that are auto dependent.

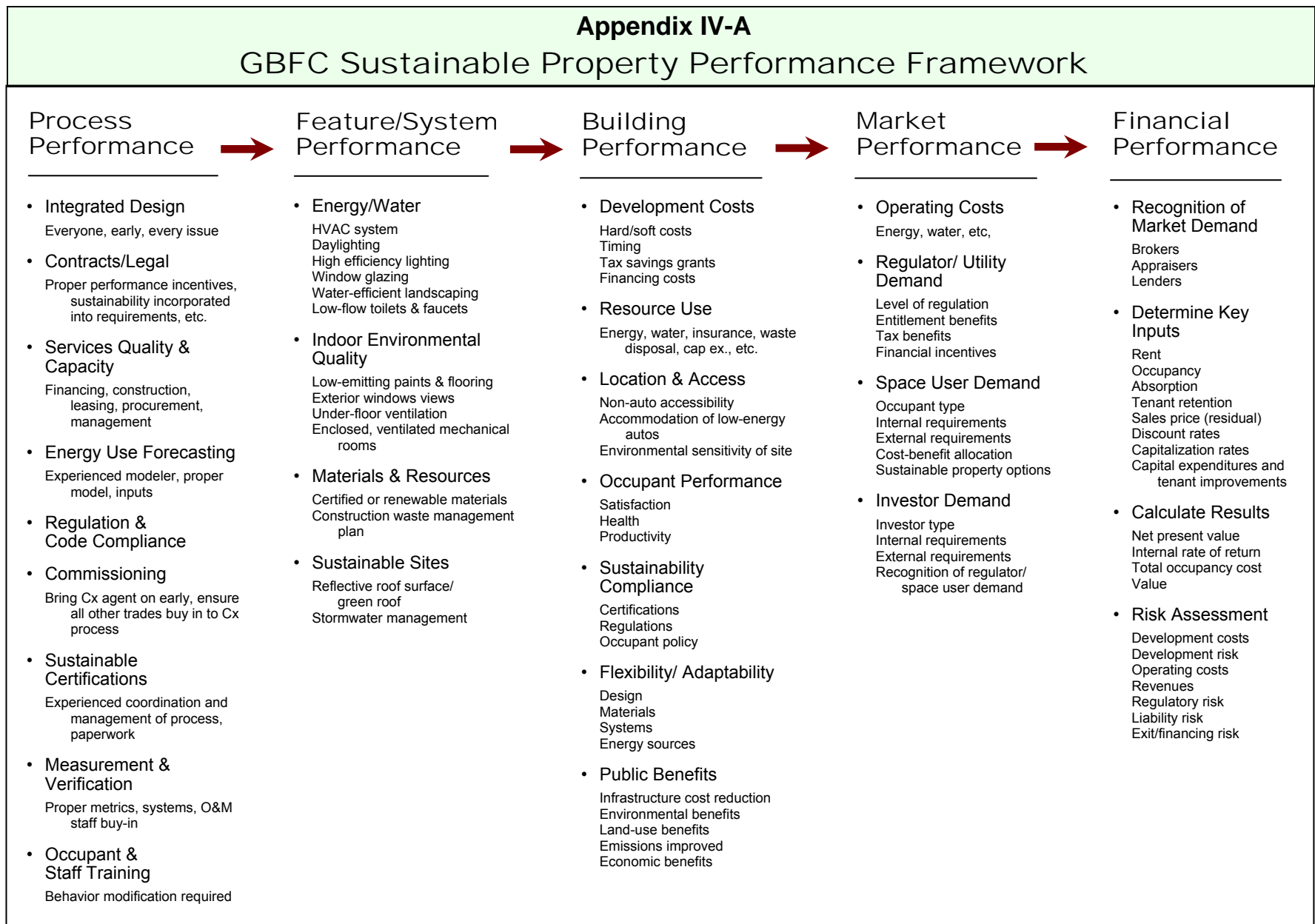
Fortunately, even if measurement efforts lag, and data availability (number of sustainable property sales, for example) remains constrained, real estate valuers and underwriters can still assess potential market response to a property's sustainability, and incorporate revenue and risk considerations into value. Real estate valuers and underwriters often work with significant data constraints and highly qualitative information, but traditional valuation and underwriting processes have evolved with these limitations and can accommodate them.<sup>109</sup> In many cases, less than perfect information—potential health and productivity information for example—can provide important insights that can reduce the uncertainty in a forecast, adding significant value.

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<sup>109</sup> For example, real estate markets around the world frequently have gone through periods of volatility. Markets are down today, and were previously as a result of the Internet bust of the early 2000s, the Asian debt crisis, the Russian debt crisis, and other events or market changes. During such times, the number of sales and leasing transactions reduces dramatically and those transactions that are completed are often distressed and or from a few months earlier when market conditions may have been quite different. Valuers adjust to these limitations through more detailed focus on tenants, market forecasts, leases, and risk analysis.

For those people designing performance measurement and monitoring programs, it is important to consider explicitly the financial models and decision-making processes that capital sources are employing to insure that measurement and monitoring systems are delivering what decision-makers need. To reinforce the key point above, accurate and timely information on energy-use and related resources is a key base, but ignoring more qualitative measures like tenant-occupant satisfaction surveys and sustainable focused “peer group” comparables market surveys may undercut the ability to properly assess the building’s market performance.





## Appendix IV-B

### RICS Green Value Interview Summaries<sup>110</sup>

#### Select Extracts of Positive and Negative Interview Comments

Project <sup>111</sup>	Description/ Costs	Interview Date/Type	Positive Features <sup>112</sup>	Underperformance/ Lessons Learned
1. Green on Grand, Ontario, Canada (pages 4-13)	<p>2-story office rebuilt in 1995 to high level of green standard.</p> <p>Based on “hard” construction costs only (i.e. excluding land, tenant leasehold improvements, design fees, landscaping and site services) the total was \$67.08 per square foot (\$722 per sq. m.) compared to \$66.70 per square foot (\$718 per sq. m.) for conventional construction.</p>	<p>December, 2004</p> <p>Owner, lead tenant</p>	<ol style="list-style-type: none"> <li>1. <i>Building envelope</i> – this represents a similar cost to conventional construction but yielded the biggest benefit from the standpoint of operating cost benefit.</li> <li>2. <i>Lighting</i> – natural daylight workspaces represent significant benefit for occupants and reduces electricity consumption.</li> <li>3. <i>Ventilation</i>– (the building has both natural and mechanical ventilation) better than the heating and cooling system, with a low cost and relatively high benefit</li> <li>4. <i>Lack of ambient noise</i> – there is good quality sound in the office (although noise does carry through the floor).</li> <li>5. <i>Operable windows</i> – this is a popular feature with the tenants. The only complaint is that not all the offices have operable windows.</li> </ol> <p>A comparison of predicted utility costs between the Green on the Grand and conventional construction was provided. This demonstrated savings of 58% relative to conventional construction, which was prior to the significant increases in energy costs experienced in the last two years.</p>	<p><i>Pond</i> – this aesthetic feature is popular with the tenants but has created maintenance headaches for the landlord.</p> <p><i>Mechanical system</i> – this has created the biggest challenge for the owner. If they could reconfigure the building mechanical systems they would have it piped differently with a modular system, not centrally controlled, allowing for the varying loads associated with multi-tenant buildings (i.e., better zone control).</p> <p>Initial construction costs, operating costs and ongoing maintenance costs all exceeded expectations, but in a negative way (i.e. they were more expensive than expected).</p> <p>However with regards to the impact on the initial construction costs and ongoing maintenance costs the higher cost of these items was felt to be directly related to the greening of the building. Both of these latter two items were felt to have exceeded initial expectations, in terms of additional cost, by 11-20%.</p>
2. Vancouver Island Technology Park (pages 28-36)	<p>184,000 sq. ft. office/R&amp;D property; completed in 2002, 95% occupied, 21 tenants. First US LEED Gold building in Canada.</p> <p>No comparative cost</p>	<p>January 2005</p> <p>Developer/ owner; property manager</p>	<ol style="list-style-type: none"> <li>1. <i>Air quality</i> – the cleaner air in the facility as a result of the low VOC materials and the HVAC system has benefited the tenants in terms of higher levels of productivity.</li> <li>2. <i>Park-like Setting</i> – this campus type property has a drainage system which relies on swales and ponds rather than filters and separators.</li> <li>3. <i>Lighting</i> – there is subdued lighting on the property both on</li> </ol>	<p>Biggest concerns/issues were not budgeting enough for LEED CI and leaving this up to tenants; and not putting in operable windows or a “green roof,” which would have reduced energy use further.</p>

<sup>110</sup> Content for this chart extracted from interviews of private investors documented in “Green Value,” Royal Institute of Chartered Surveyors, October 2005, Case Studies [link]

<sup>111</sup> Page numbers from Green Value Case Studies publication.

<sup>112</sup> The numbered features are in the order that the interview respondents cited from the most financially and non-financially beneficial to the least.



**Appendix IV-B**

**RICS Green Value Interview Summaries<sup>110</sup>**  
**Select Extracts of Positive and Negative Interview Comments**

Project <sup>111</sup>	Description/ Costs	Interview Date/Type	Positive Features <sup>112</sup>	Underperformance/ Lessons Learned
	<p>data cited; initial costs met expectations within 0-2%</p>		<p>the interior and exterior. The abundance of natural light has also benefited the tenants in terms of higher levels of satisfaction and productivity.</p> <ol style="list-style-type: none"> <li>4. <i>Heating and cooling</i> – the property is serviced by an oversized ground source heat pump system in the space which allows for considerable flexibility in directing the heating and cooling of the building. Gas boilers in series are also easier to manage, save on energy costs and also provide flexibility.</li> <li>5. <i>Water usage</i> – lower water usage as a result of the indigenous plants and waterless urinals has resulted in a 30% reduction in operating costs compared to conventional buildings.</li> <li>6. 98% of materials used recycled content; saved \$1,000,000 million by using materials from prior building on site.</li> </ol> <p>The lighting and the HVAC system (and air quality) all had an extremely important impact in attracting the tenants to the project. The site features (including the park-like setting) had a neutral impact in attracting tenants.</p>	
<p>3. 260 Townsend St., San Francisco, USA (Pages 37-44)</p>	<p>7 storey office with 95,126 gross sq. ft., built in 1984 and renovated to LEED EB Gold by year-end 2004</p> <p>Detailed cost premium assessment showed 2.01% premium over the entire project cost.</p>	<p>December 2004 Owner/ occupier</p>	<ol style="list-style-type: none"> <li>1. <i>Building Management System</i> – the premium cost of this item was tracked at \$37,000. The building management system and mechanical upgrades were expected to result in a 20-30% improvement in energy usage.</li> <li>2. <i>Low Volatile Organic Compounds (VOCs) in building materials</i> – a premium was paid for better air quality (e.g. no (VCT) vinyl tile in the cafeteria, no VOC paint and low VOC carpet). The owners speculate that the results of better indoor air quality are at least partly reflected in both higher productivity and higher occupant satisfaction.</li> <li>3. <i>FSC Wood</i> – there is paneling on the 7th floor and laminated doors.</li> <li>4. <i>Daylighting/ views</i> – this was inherent in the original design. The private offices have glass partitions and the workstations have half height walls to allow for more natural light.</li> <li>5. <i>Other</i> – the 3rd party certification, the level of attention, the visibility of the building, and the educational displays in the</li> </ol>	<p><i>Water conservation</i>, as it related to the waterless urinals. The San Francisco plumbing department indicated at the time that the waterless urinals did not comply with the code and therefore they weren't included.</p> <p>The grey water/stormwater collection on-site which was not allowed by the San Francisco building code and would otherwise have been included.</p>

**Appendix IV-B**

**RICS Green Value Interview Summaries<sup>110</sup>**  
**Select Extracts of Positive and Negative Interview Comments**

Project <sup>111</sup>	Description/ Costs	Interview Date/Type	Positive Features <sup>112</sup>	Underperformance/ Lessons Learned
			<p>building are thought to have had an impact on the employees' moods, performance and morale.</p> <p>ES rank of 51.1 KBTUs per sq. ft. versus 3 direct peers averaging 73.8, a 31% savings.</p>	
<p>4. Phillips Eco-Enterprise Centre, Minneapolis, USA (Pages 45 to 53)</p>	<p>64,000 sq. ft. office/industrial property built in 1999 to LEED Gold standards—although did not apply for certification given cost.</p> <p>According to the developer, construction costs were approximately 3% higher than they would have been for conventional construction.</p>	<p>December 2004 Developer</p>	<ol style="list-style-type: none"> <li>1. <i>Skylights</i> - warehouse area where skylights were used with sun tracking mirrors to reflect the sunlight resulted in up to 10 times more Lumens during the morning and the late afternoon compared with passive skylights.</li> <li>2. <i>Ground Source Heat Pump system</i> – shallow bedrock required the installation of more wells around the property, resulting in higher upfront costs and a longer payback – initially estimated at 7 years. Actual payback has been more rapid (3-4 years) due to spikes in natural gas costs for comparable projects. Heat pump system runs entirely on low-cost electricity.</li> <li>3. <i>30 kilowatt Photovoltaic system</i> – four years after the project's commissioning, the owner installed 30-kilowatt photovoltaic array on the building's warehouse roof. This array constitutes the largest single solar energy installation in the region.</li> </ol> <p>Property consumes 40% less energy than a conventional project.</p> <p><i>Rental Rates</i> - net rental rates achieved were \$12 - \$14.00 per square foot per annum for premium office space, and \$4.50 and \$9.00 per square foot for warehouse and warehouse office spaces, respectively. These figures represent a 5-10% premium over the market for conventional buildings.</p>	<p><i>Reuse of building materials</i> – 60% of the steel joists in the warehouse, and the office building's bricks were from salvaged sources. There were some subsequent construction challenges relating to the steel joists in the warehouse area.</p> <p>The developer indicated that they would not reuse structural steel again as they had to re-weld every connection of the steel joists as otherwise the contractor would not have warranted the construction.</p> <p>The developer considers the green roof, which cost \$50,000, a luxury that could have been omitted without compromising the property's stormwater retention capabilities.</p>
<p>5. Mountain Equipment Co-op Store, Montreal, Canada (Pages 54 to 61)</p>	<p>48,438 sq. ft. retail outlet opened in May 2003. Complied with Natural Resources Canada C2000 Standard.</p> <p>No comparative cost data cited.</p>	<p>December 2004 Owner/ occupant; facility manager</p>	<ol style="list-style-type: none"> <li>1. 69.2% below Canadian Model National Energy Code for Buildings (MNECB), based on the first year's operating data. Energy costs are estimated to be only \$50,000 per annum for MEC compared to \$150,000 per annum for a comparable conventional building.</li> </ol> <p>Annual first year costs were \$52,347, an estimated savings of \$99,865 for a conventional building.</p> <ol style="list-style-type: none"> <li>2. <i>Photovoltaic panel</i> – two PV panels power the circulation pump for the solar domestic water system and the irrigation</li> </ol>	<p><i>Financial cost of PV panel</i> – the up-front capital costs associated with the PV panel, relative to the energy savings benefits were considered to be difficult to justify based on a strict financial payback.</p> <p><i>Cistern to feed toilets/irrigation</i> – this commodity was not valued correctly (in terms of the initial cost versus the benefits).</p> <p><i>High fly-ash concrete</i> – 27% fly ash in concrete.</p>

**Appendix IV-B**

**RICS Green Value Interview Summaries<sup>110</sup>**  
**Select Extracts of Positive and Negative Interview Comments**

Project <sup>111</sup>	Description/ Costs	Interview Date/Type	Positive Features <sup>112</sup>	Underperformance/ Lessons Learned
			<p>system.</p> <p>3. <i>Stormwater management</i> – this was designed to go beyond the municipal requirements to accommodate a 100-year event with no discharge to the sewage system.</p> <p>MEC did not track benefits—project built to fit strategic alignment with corporate goals</p>	<p>Due to the cost premium of this product in Québec there was a financial penalty associated with this as it related to incorporating this material into the project.</p> <p>Additional time and cost required looking at approaches to commissioning the building (there were very few comparable projects which could be considered at the time).</p> <p>Challenges associated with the development model that requires speedy design/build to generate income as soon as possible. This often means opening a building, which isn't finished (from MEC's perspective) with building systems not in line and commissioned. This market issue matched with the complex building systems and controls made for a very difficult start up. In MEC's view it is important to take the time to build the knowledge about how to get the building to work effectively.</p>
<p>6. Solaire, New York, USA (Pages 62 to 68)</p>	<p>27-storey residential apartment property with 293 units, 357,000 sf. and a parking garage. Property completed August 2003 and designated LEED Gold</p> <p>No data on relative construction costs</p>	<p>January 2004 Developer/ owner</p>	<p>1. <i>Energy efficiency</i> – the photovoltaic (PV) panels and the bulkhead have a very long payback period of over 50 years compared to the usual 3-5 years which is considered reasonable for other features. The variable frequency drives which pump hot and chilled water through the building has a reasonable payback period. The other energy efficient feature is the gas fired cooling with the double effect absorption chiller.</p> <p>2. <i>Indoor air quality</i> – the mechanical ventilation and low VOC content has resulted in better indoor air quality in the building which has led to the project being able to achieve a very positive public perception and premium rents in the market.</p> <p>3. <i>Lighting</i> – there is energy efficient lighting throughout the project as well as occupancy sensors to control the lighting.</p>	<p><i>On-site wastewater treatment plant</i> – the collection of stormwater, its treatment and reuse in the building does not provide a reasonable payback to the owners. Since the project was developed, and as a result of lobbying efforts, the local Water Board now provides a reduced water rate if savings of over 25% water usage can be demonstrated.</p> <p><i>Green features you would not replace or add that were not included</i> – two items were identified and have been addressed in another building adjacent to The Solaire, which is being built by the same developer. First, there was no room in the mechanical room to add heat recovery ventilators, which would otherwise have been added. Second, the ventilation systems in The Solaire worked better than expected. This raised the question as to how much ventilation is actually required and the ability to manage this. The lessons learned are now being applied in other projects. This in comparison to typical buildings new "tighter" building envelopes without mechanical</p>

**Appendix IV-B**

RICS Green Value Interview Summaries<sup>110</sup>  
 Select Extracts of Positive and Negative Interview Comments

Project <sup>111</sup>	Description/ Costs	Interview Date/Type	Positive Features <sup>112</sup>	Underperformance/ Lessons Learned
				ventilation, the exhaust systems are less effective.  <i>Ability to achieve lower insurance premiums – there was no evidence that lower insurance premiums could be achieved.</i>

### Appendix IV-C

## Studies of Productivity and Health Cited by Industry<sup>113</sup>

Productivity	Number of Documents	Health	Number of Documents
Productivity Gains from IEQ	6	Health Gains from IEQ	33
Productivity Gains from Temperature Control	14	Health Gains from Temperature Control	1
Productivity Gains from Lighting Control	18	Health Gains from Lighting Control	1
Productivity Gains from Privacy and Interaction	5	Health Gains from Privacy and Interaction	0
Productivity Gains from Ergonomics	1	Health Gains from Ergonomics	2
Productivity Gains from Access to Natural Environment	1	Health Gains from Access to Natural Environment	8
Productivity Gains from Whole Building	16	Health Gains from Whole Building	7
<b>Subtotal</b>	<b>61</b>	<b>Subtotal</b>	<b>52</b>

Health and Productivity	
Other Studies	<b>6</b>

Total Number of Studies	119
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<sup>113</sup> The bulk of the studies described in this Appendix were identified through an extensive search of key industry studies, sustainable business case and cost-benefit studies, private placement memorandums and other documents. Studies were cited in support of the benefits of sustainability.

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Productivity Gains from IEQ		
GSA Office of Government-wide Policy, "Productivity and the Workplace: Featuring the Productivity Playback Model" <a href="http://cbpd.arc.cmu.edu/bids/pages/description.aspx?category=list&amp;index=1">http://cbpd.arc.cmu.edu/bids/pages/description.aspx?category=list&amp;index=1</a>	2001	"When employees do not have control over their individual work environment, it negatively affects their physical health and mental disposition leading to increased absenteeism, employee dissatisfaction, inferior work products, and unsatisfactory customer service"
Pawel Wargocki, "Making the Case for IAQ," <i>ASHRAE IAQ Applications</i> , Fall 2002	2002	5% increase in productivity with improvements to the IAQ
Romm, J.D., & Browning, W.D., "Greening the Building and the Bottom Line – Increasing Productivity Through Energy-Efficient Design," <i>Colorado: Rocky Mountain Institute</i>	1998	"Three case studies by The Rocky Mountain Institute proved that better lighting and HVAC systems can reduce absenteeism from 15 to 25%"
Wyon, "Individual Microclimate Control: Required Range, Probable Benefits, and Current Feasibility," Proceedings of Indoor Air '96, Nagoya, 7th International Conference of Indoor Air Quality and Climate, Vol.1	1996	"Increased productivity can be valued at \$2.4 billion annually based on two studies showing that better control of workplace comfort conditions produces a 3% productivity increase"
Milton, Glencross and Walters, "Risk of Sick Leave Associated with Outdoor Air Supply Rate, Humidification, and Occupant Complaints," <i>Indoor Air 10(4)</i>	2000	Absenteeism decreased 35% with higher ventilation rates
Kroner, Stark-martin & Eillemain, "Using Advanced Office Technology to Increase Productivity--The Impact of Environmentally Responsive Workstations on Productivity and Worker Attitude," West Bend Study, New York: Center for Architectural Research, Rensselaer Polytechnic Institute	1992	"Increased productivity can be valued at \$2.4 billion annually based on two studies showing that better control of workplace comfort conditions produces a 3% productivity increase"
Productivity Gains From Indoor Temperature Control		
Rowe, David. 2002. Pilot Study Report: "Wilkinson Building, The University of Sydney," Sydney, Australia.	2002	15% productivity gain from improved temp. controls
Niemala, R., M. Hannula, S. Rautio, K. Reijula, and J. Railio "The effect of air temperature on labor productivity in call centers—a case study" <i>Energy and Buildings</i> , 34	2002	4.1-7% productivity gain from improved temp. controls
Tham, KW, HC Willem, SC Sekhar, DP Wyon, P Wargocki, PO Fanger "Temperature and ventilation effects on the work performance of office workers" In Proceedings of Healthy Buildings, Singapore.	2003	4.9% productivity gain from improved temp. controls
Mendell, MJ, WJ Fisk, MR Petersen, CJ Hines, M Dong, D Faulkner, JA Deddens, AM Ruder, D Sullivan, MF Boeniger "Indoor Particles and Symptoms among Office Workers: Results from a Double-Blind Crossover Study." <i>Epidemiology</i> , v.13	2002	4.1% productivity gain from improved temp. controls
Hannula M., Niemela R., Rautio S., and Reijula K. "The effects of indoor climate on productivity." In Proceedings of Healthy Buildings 2000,	2000	2.8% productivity gain from improved temp. controls
Kroner, W., Stark-Martin, J., and Willemain, T. "Using Advanced Office Technology to	1992	2.7% productivity gain from improved desktop temperature control

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Increase Productivity – The Impact of Environmentally Responsive Workstations (ERWs) on Productivity and Worker Attitude.” <i>The West Bend Mutual Study</i> . Center for Architectural Research, Rensselaer Polytechnic Institute, Troy, NY		
Bauman, F., Baughman, A., Carter, G., and Arens, E. “A Field Study of PEM (Personal Environmental Module) Performance in Bank of America’s San Francisco Buildings.” <i>Publication #CEDR-01-97, Center for Environmental Design Research, University of California, Berkeley, CA.</i>	1992	2.8% productivity gain from improved desktop temperature control
Hayashi, J., T. Akimoto, S. Lee, N. Iesaki, T. Yokota, S. Tanabe. “Thermal preference of the task environment and its influence on productivity.” In <i>Proceedings of Healthy Buildings 2003, December 7-11, 2003, Singapore.</i>	2003	0.2% productivity gain from improved desktop temperature control
Pilcher, J., Nadler, E., and Busch, C. “Effects of hot and cold temperature on performance: a meta-analytic review.” <i>Ergonomics, 45:10</i>	2002	0.8% productivity gain from individual temperature control
Witterseh, T. “Environmental Perception, SBS Symptoms and the Performance of Office Work under Combined Exposures to Temperature, Noise and Air Pollution.” Ph.D. Thesis, Technical University of Denmark, Denmark.	2001	0.6-0.7% productivity gain from improved individual temperature control
Wyon, D.P. “Individual microclimate control: required range, probable benefits, and current feasibility.” In <i>Proceedings of Indoor Air '96: 7th International Conference of Indoor Air Quality and Climate, Nagoya, Vol. 1,</i>	1996	2-20% increase in small tasks with small temperature changes 3-7% increase when provided with about 3°C individual temp. control
Olli Seppanen and William Fisk, “A Method to Estimate the Cost Effectiveness of Indoor Environments in Office Work”	2005	The optimum temperature for workers to be content at is 72 degrees
Tanabe, S. “Indoor Temperature, Productivity and Fatigue in Office Tasks,” <i>Proceedings of Healthy Buildings, Lisbon, Portugal</i>	2006	Productivity dropped 2.1% for each degree above 83.4 degrees inside, Air velocity control reduces mental fatigue
Alan Hedge, “Linking Environmental Conditions to Productivity,” <i>Eastern Ergonomics Conference and Exposition, New York, June 2004.</i>	2004	Lower temperatures also have a bad effect on workers, it made them work slower, costing more money
Productivity Gains from Lighting		
Romm, J.J., and W.D. Browning, “Greening the Building and the Bottom Line - Increasing Productivity Through Energy-Efficient Design.” <i>Rocky Mountain Institute.</i>	1994	13.2% productivity gain with T8/T5 lamps, electronic ballasts, and/or high performance fixtures
National Lighting Bureau, “The NLB Guide to Office Lighting and Productivity”	1988	6% productivity gain with T8/T5 lamps, electronic ballasts, and/or high performance fixtures
Kuller, Rickard and Laike, Thornbjorn. “The impact of flicker from fluorescent lighting on well-being, performance and physiological arousal.” <i>Ergonomics 41(4)</i>	1998	3.2% productivity gain with T8/T5 lamps, electronic ballasts, and/or high performance fixtures
Katzev, R. “The Impact of Energy-Efficient Office Lighting Strategies on Employee Satisfaction and Productivity.” <i>Environment and Behavior, 24:6</i>	1992	26.1% productivity gain with indirect lighting

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Hedge, A., Sims, W. and Becker, F. "Effects of lensed-indirect and parabolic lighting on the Satisfaction - Visual health and Productivity of Office Workers," <i>Ergonomics</i> , 38:2	1995	3% to 8.5% productivity gain with indirect lighting
Romm, J. J. "Cool Companies: How the best businesses boost profits and productivity by cutting greenhouse gas emission." Washington D. C.: <i>Island Press</i>	1999	6% productivity gain with indirect lighting
National Lighting Bureau. "High Benefit Lighting: San Diego Federal Building and Courthouse Save Taxpayers Money." <a href="http://www.nlb.org/publications/csh_federal.html">http://www.nlb.org/publications/csh_federal.html</a>	N/A	3% productivity gain with T8/T5 lamps, electronic ballasts, and/or high performance fixtures
Barnaby, J.F. "Lighting for Productivity Gains." <i>Lighting Design and Application</i> , 10(2)	1980	0.7-2% productivity gain from increased light levels
Boyce, P.R., Beckstead, J.W., Eklund, N.H, Strobel, R.W., and Rea, M.S. "Lighting the Graveyard Shift: The Influence of a daylight-simulating skylight on the task performance and mood of night-shift workers." <i>Lighting Research and Technology</i> 29(3)	1997	1.8% productivity gain from daylight simulating skylight
Rocky Mountain Institute, Romm, J.D.	1998	15-25% decrease in absenteeism from better lighting and HVAC
Romm, J.J., and W.D. Browning "Greening the Building and the Bottom Line - Increasing Productivity Through Energy-Efficient Design." <i>Rocky Mountain Institute</i> .	1994	Employees preferred working under the skylights, which in turn boosted sales
Heschong Mahone, "Day lighting in Schools: An Investigation into the Relationship Between Daylight and Human Performance"	1999	Student' learning increased 20% in math 26% faster reading with most daylight
Benton & Fountain, "Successfully Daylighting a Large Commercial Office Building: A Case Study for Lockheed Building 157, <i>Progressive Architecture</i>	1990	15% reduction in absenteeism results in a cost benefit valued at \$432 million annually
Naomi Miller and Terry McGowan, "How Will Light and Health Research Affect Electrical Lighting and Lighting Design"	Sep. 30 – Oct. 2, 2004	Improvements in worker health and productivity with changes to lighting
Nicklas, M. and Bailey, G., "Student Performance in Daylit Schools," Innovative Design, Raleigh, North Carolina	1995	Compared daylit schools to typical schools, 5% better test scores in daylit classrooms
Heschong Mahone Group "Skylighting and Retail Sales. An investigation into the relationship between daylight and human performance." Detailed Report for Pacific Gas and Electric Company. Fair Oaks, CA	Aug. 20, 1999	Sales increase 40% in daylit stores with skylights with the most favorable conditions
Heschong Mahone Group, "Daylight and Retail Sales"	Oct. 2003	Sales increase 0-6% for average daylight conditions
Romm, J., "Cool Companies – How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions," <i>Island Press</i> : Washington D.C.	1999	Sales in the daylit half were higher than in the non daylit side, sales in the daylit half we higher than sales in the same departments in other Wal-Mart stores



## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Productivity Gains from Privacy and Interaction		
E. Sundstrom, J.P. Town, R.W. Rice, D.P. Osborne, and M. Brill, "Office Noise, Satisfaction, and Performance"	1994	Study on lower-decibel noise found that over 50% of office workers disturbed by noise
Evans, G., & Johnson, D. "Stress and Open-Office Noise." <i>Journal of Applied Psychology</i> , 85(5): Glass, D. C., & Singer, J. E. (1972). "Urban Stress: Experiments on Noise and Social Stressors." <i>Academic Press</i> : New York and London.	2000	66% higher level of task motivation given three hours of quiet conditions, as compared to subjects exposed to 55dBA office noise conditions for three hours
S.P. Banbury and D.C. Berry, "Office Noise and Employee Concentration: Identifying Causes of Disruption and Potential Improvements," <i>Ergonomics</i> 48	2005	93% increase in accuracy on short-term memory tasks and a 21.7% increase in accuracy on mental-arithmetic tasks in quiet environments
Phil Leather, Diane Beale, and Lucy Sullivan, "Noise, psychosocial stress and their interaction in the workplace," <i>Journal of Environmental Psychology</i> 23	2003	Noise affecting productivity and communication, frustration tolerance, group cohesiveness, and job satisfaction
Glee, L., & Miller, H., Presentation; "The Marketplace at Herman Miller"	2003	Enabling Teams to collaborate and share information improved workgroup process quality by 3% and decreased project cycle times
Productivity Gains from Ergonomics		
Toothacre, J & Pennsylvania Department of Environmental Protection, Presentation: "Sustainable Federal Facilities Conference," <i>U.S. Green Building Council</i>	2001	"The Pennsylvania Department of Environmental Protection reduced average churn costs from \$2500 to \$250 per workstation by using more flexible building and furniture systems in their high-performance green buildings"
Productivity Gains from Access to Natural Environment		
Heschong, L., Wright, R. L., and Okura, S. "Daylighting Impacts on Human Performance in School." <i>Journal of the Illuminating Engineering Society</i> , 31:2	2002	Students in schools with the largest window surface progressed 15% faster in math and 23% faster reading
Productivity Gains from Whole Building		
Paladino & Company "Washington High Performance School Buildings: Report to Legislature"	Jan. 31, 2005	15% absenteeism reduction, 5% test score increase with green school building 5% reduction in teacher turnover in green schools
Heschong, Mahone Group Inc. "Windows and Offices: A study of worker performance and the indoor environment"	October 2003	Multiple statistics on lighting, views, glare, ventilation etc.
Lockheed Remodel Study, Joseph Romm "Greening the Building and the Bottom Line"	1999	15% decrease in absenteeism, 15% rise in productivity
William R. Pape, "Healthy, Wealthy, and Wise," <i>Inc. Magazine</i>	1998	Absenteeism reduced 40%, productivity up 5%
Steven W. Lockly, "Light and Human Circadian Regulation"	Sep. 30 – Oct. 2, 2004	Potential improvements in performance measures that relate to green buildings

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Kaczmarczyk, S., & Murtiugh, J. "Measuring the Performance of Innovative Workplaces," <i>Journal of Facilities Management, Volume 1 Number 2</i> ,	2002	Outlines the basics to figure out the performance of an innovative workplace
GSA Office of Government-wide Policy, "Real Property Performance Results"	2002-2003	Shows the performance of GSA federal buildings
Knoll & DYG, Inc., "The Second Bottom Line: Competing for talent Using Innovative Workplace Design"	1998	1500 Interviews with 350 full-time office workers: "People increasingly believe the workplace affects their productivity and job satisfaction"
Schriefer, A.E., "Workplace Strategy: What is it and Why You Should Care", <i>Journal of Corporate Real Estate, Volume 7, Number 3</i>	2005	"Forward-Thinking organizations of all sizes and across all industries have come to recognize that <i>innovative workplaces</i> can enhance employee and business performance - resulting in long-term cost savings and/or improved organizational performance. They are seeking ways to use their space and technology investments to enable rather than inhibit progress toward their objectives."
Knoll & The Hay Group, "The 21st Century Workplace," PowerPoint Presentation	2000	"Half the people leaving their current employer were dissatisfied with their workplace, while only one-quarter of those staying were dissatisfied"
American Society of Interior Designers, "Recruiting and Retaining Qualified Employees – By Design"	1999	51% of employees surveyed said the physical workplace would impact their decision to leave their job
Sloane Work and Family Research Network, Retrieved from <a href="http://wfnetwork.bc.edu/index.php">wfnetwork.bc.edu/index.php</a>	2005	"Similar studies show that employees are happier when they have control over how and where they work, resulting in a better work-life balance and higher retention rates. Boston College's Sloan Work and Family Research Network found that 54% of the current workforce is part of a dual earner couple meaning that employees are increasingly responsible for caring for children and parents"
Bjarne Olsen, "Indoor Environment-Health, Comfort and Productivity,"	2005	5-10% gain in productivity with improved thermal comfort, less pollutants, and better ventilation
Morton, S., "Business case for Green Design," from <a href="http://www.facilitiesnet.com">http://www.facilitiesnet.com</a>	N/A	ING bank in Switzerland found that absenteeism decreased 15% in a green building compared to an older existing building
Heschong Mahone Group, "Windows and Classrooms: A Study of Student Performance and the Indoor Environment"	Oct. 2003	Good views support student learning, Direct sun penetration and glare negatively impact student learning, The acoustic environment is important for learning, Poor ventilation
Health Gains from IEQ		
Drinka, P, P. Krause, M. Schilling, B. Miller, P. Shult, S. Gravenstein "Report of an Outbreak: Nursing Home Architecture and Influenza- Attack Rates." <i>Journal of the American Geriatrics Society, v. 44</i>	1996	87.3% reduction of flu with increased outside air
Jaakkola, J and Miettinen, P. "Ventilation rates in office buildings and sick building syndrome." <i>Occupational and Environmental Medicine</i>	1995	67% reduction of SBS (sick building syndrome) with increased outside air

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Brundage, J.F., McNeil, R., Lednar, W.M., Smith, D. and Miller, R. "Building-Associated Risk of Febrile Acute Respiratory Diseases in Army Trainees." <i>Journal of the American Medical Association</i> , 259(14)	1988	46% increase in respiratory health with increased outside air
Fisk, W.J. and Rosenfeld, A.H. "Estimates of Improved Productivity and Health from Better Indoor Environments." <i>Indoor Air</i> , 7	1997	35% reduction of SBS with increased outside air, 20% reduction of respiratory illness
Kaczmarczyk, J. "The effect of a personalized ventilation system on perceived air quality and SBS symptoms."	2002	23.5% reduction of headaches with individual control or task air
Menzies, D., Pasztor, J., Nunes, F., Leduc, J., and Chan, C.H. "Effect of a new ventilation system on health and well being of office workers." <i>Archives of Environmental Health</i> , 52:5	1997	20% reduction of headaches with individual control or task air
Cox-Ganser, Jean M., et al. "Respiratory Morbidity in Office Workers in a Water-Damaged Building," <i>Environmental Health Perspectives</i> , vol. 113, no. 4, Last accessed from <a href="http://ehp.niehs.nih.gov/members/2005/7559/7559.pdf">http://ehp.niehs.nih.gov/members/2005/7559/7559.pdf</a>	2005	72.5% reduction of asthma with moisture control
Husman, T. "Indoor Air 2002: Respiratory Infections Among Children in Moisture Damaged Schools." <i>National Public Health Institute</i> , Kuopio, Finland.	2002	15% reduction of colds with moisture control
Liu, J. Z., Y. X. Tao, L.Y. Hao "The Relationship between Sick Building Syndrome and Indoor Decoration." Proceedings of the 7th International Conference on Indoor Air Quality and Climate, v. 2	1996	85% reduction of colds with pollutant source controls
Garrett, MH, MA Hooper, and BM Hooper "Low levels of formaldehyde in residential homes and a correlation with asthma and allergy in children." In Proceedings of Indoor Air 96, vol. 1.	1996	61.5% reduction of asthma and allergies with pollutant source controls
Wargocki, Pawel "Human Perception, Productivity, and Symptoms Related to Indoor Air Quality." Doctoral Thesis. Center for Indoor Environment and Energy, Technical University of Denmark.	1998	47% reduction of SBS with pollutant source controls
Wieslander, G., D. Norback, E. Bjornsson, C. Janson, G. Boman. "Asthma and the Indoor Environment: the significance of emission of formaldehyde and volatile organic compounds from newly painted surfaces." <i>International Archives of Occupational and Environmental Health</i> . v. 79	1997	23.6% reduction of asthma with pollutant source controls
Bourbeau, J., C. Brisson, S. Allaire "Prevalence of the sick building syndrome symptoms in office workers before and six months and three years after being exposed to a building with an improved ventilation system." <i>Occupational and Environmental Medicine</i> , v. 54	1997	33.6% reduction of SBS symptoms with increased outside air
Sundell, J. "What We Know, and Don't Know, About Sick Building Syndrome." <i>ASHRAE Journal</i>	Jun. 1996	33% reduction of SBS symptoms with increased outside air

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Jaakkola, JJK, P Tuomaala, O Seppanen. "Textile Wall Materials and Sick Building Syndrome." <i>Archives of Environmental Health</i> , 49(3)	1994	21.4% reduction of asthma and mucosal with better pollutant source controls
Jouni J. K. Jaakkola, Leif Oie, Per Nafstad, Grete Botten, Sven Ove Samuelson, Per Magnus. "Interior Surface Materials in the Home and the Development of Bronchial Obstruction in Young Children in Oslo, Norway." <i>American Journal of Public Health</i>	1999	13.5% reduction of asthma and bronchial symptoms with better pollutant source controls
Fisk, Bill, "Indoor Air Quality Handbook," <i>McGraw Hill</i> , Lawrence Berkeley National Laboratory	1999	9-20% reduction of flu and colds with better ventilation and indoor air quality, 16-37 million fewer cases, and annual savings of \$6-14 billion
William J Fisk "Health and Productivity Gains from Better Indoor Environments and Their Implications for the U.S. Department of Energy," Referenced in "The Business Case for Sustainable Design in Federal Facilities," US DOE(2003)	Feb. 2000	9-20% reduction in healthcare costs for communicable respiratory diseases 18-25% from reduced allergies and asthma 20-50% from non-specific health and discomfort effects
Satish Kumar and William Fisk, " The Role of Emerging Energy Efficient Technology Promoting Workplace Productivity and Health"	Feb. 13, 2002	23-76% reductions in acute respiratory infection with higher ventilation rates 8-25% reduction in allergy and asthma symptoms with improved IAQ
M.J. Mendell, " Indoor Environments and Health: What do we Know?" PowerPoint Presentation, Lawrence Berkeley National Lab	Mar. 3, 2004	People spend about 85% of their time indoors, and indoor pollutant release is 1000X more effective in causing human infection
J.J. Jaakkola and O.P. Heinonen, "Sick Building Syndrome, Sensation of dryness and thermal comfort in relation to room temperature in an office building: Need for individual control of temperature," <i>Environmental International</i> 15	1989	Many things contribute to air quality such as ventilation, temperature, mold, VOC's and communicable biological agents
O. Seppanen and W.J. Fisk, " Some Quantative Relations Between Indoor Environmental Quality and Work Performance and Health," <i>ASHRAE Research Journal</i>	2006	Many things contribute to air quality such as ventilation, temperature, mold, VOC's and communicable biological agents
Institute of Medicine, "Damp Indoor Spaces and Health," Institute of Medicine website	2006	Many things contribute to air quality such as ventilation, temperature, mold, VOC's and communicable biological agents
P. Wolkoff, C.K. Wilkins, P.A. Clausen, G.D. Neilsen, " Organic Compounds in Office Environments – Sensory Irritation, Odor, Measurements and the Role of Reactive Chemistry," <i>Indoor Air</i> 16	2006	Many things contribute to air quality such as ventilation, temperature, mold, VOC's and communicable biological agents
O.A. Seppanen, W.J. Fisk, and M.J. Mendell, "Association of Ventilation Rates and CO2 Concentrations with Health and Other Responses in Commercial and Institutional Buildings"	1999	States that there is more research to be done to compare the ventilation rates and pollutants in the air
U.S. EPA, "Program Needs For Indoor Environments Research (PNIER),"	2005	The research path of the EPA to study indoor air
"Improving the Health of Workers in Indoor Environments: Priority Research Needs for a National Occupational Research Agenda," M.J. Mendell, W.J. Fisk and more	2002	The research agenda to study indoor environments
U.S. EPA, "Indoor Air Quality"	Jan. 6 2003	Concentration of pollutants indoors is 10 – 100 times higher than outdoors

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Charles, K.E., et al, "Workstation design for Organizational Productivity," Ottawa, Ontario: Public Works and Government Services Canada, <i>National Research Council Canada</i> ,	2004	"A Canadian study revealed that approximately one-third of employees' sick leave can be attributed to symptoms caused by poor indoor air quality. The same study found that communication and social support enabled by open office plans are strong contributors to healthy workplaces and lowered absenteeism"
U.S. DOE, "The Business Case for Sustainable Design in Federal Facilities"	Aug. 2003	IAQ is one of the top five environmental health risks
"Issue Brief: Green Building Design." Business for Social Responsibility	Dec. 2003	"Researchers with the Lawrence National Laboratory note that businesses could save nearly \$58 billion each year by preventing SBS. Better indoor air quality could save companies an additional \$200 billion per year by improving worker performance and productivity. Improving indoor air quality can yield financial benefits 8-17 times greater than the cost to make the improvements."
<i>Building Design and Construction</i> , p. 52	Apr. 1997	50-70% lower airborne VOC's with new HVAC, after one year, absenteeism dropped 6-10%
LEED Certified Project Case Study: Genzyme Center, <i>U.S. Green Building Council</i>	2003	With no VOC's or formaldehyde, employee sick time dropped 5%
Health Gains from Temperature Control		
Judith Heerwagen, Ph.D., " Investing in People: The Social Benefits of Sustainable Design," Paper Presented at Rethinking Sustainable Construction '06	Sep. 19-22, 2006	Humans need to have control over things in their lives and having control of things at your desk will help worker health and productivity
Health Gains from Lighting		
Edwards, L., & Torcellini, P., "A Literature Review of the Effects of Natural Lighting on Building Occupants," Colorado: <i>National Renewable Energy Laboratory</i> , A U.S. Department of Energy Laboratory	2002	With properly installed and maintained daylighting systems, natural light has proved to be beneficial for the health, productivity, and safety of building occupants
Health Gains from Privacy and Interaction		
None	N/A	N/A
Health Gains from Ergonomics		
National Institute for Occupational Safety and Health (NIOSH) Study	N/A	Ergonomic furniture reduced health complaints by 50% and increased productivity by 23%
OSHA, Department of Labor, <i>Ergonomics Proposed Rules</i> , Federal Register No. 64:65769-66078	1999	"OSHA reports that repetitive strain injuries cause by poor ergonomic design, including computer use, cost business and industry as much as \$54 billion annually in workers compensation and other costs"

## Appendix IV-C

### Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
Health Gains from Access to Natural Environment		
Judith Heerwagen, Ph.D., " Investing in People: The Social Benefits of Sustainable Design," Paper Presented at Rethinking Sustainable Construction '06	Sep. 19-22, 2006	Workers with a view of nature have less stress and improved emotional functioning, attention and cognition.
S. Kaplan, "The Restorative Benefits of Nature: Toward an Integrative Framework," <i>Journal of Environmental Psychology</i> 15: 169-182	1995	States that nature causes less fatigue which then replenishes attentional system
R.S. Ulrich, "Biophilia, Biophobia, and Natural Landscapes," in The Biophilia Hypothesis	1993	Viewing nature is a positive mood enhancing cognitive activity
A. Isen, "The Influence of Positive and Negative Affect on Cognitive Organization: Some Implications for Development' in Psychological and Biological Approaches to Emotion	1990	Seeing nature during work helps moods
J. LeDoux, "The Emotional Brain", <i>Simon &amp; Schuster</i>	1996	Nature boosts moods through cognitive activity
T. Hartig, M. Mang, and G. Evans, "Restorative Effects of Natural Environment Experiences," <i>Environment and Behavior</i> 23: 3-26	1991	Real contact with the outdoors during work boosts moods, not just a plant or a picture
R.S. Ulrich, "A View Through a Window May Influence Recovery From Surgery," <i>Science</i> 224: 420-421	1984	Real views of nature help a person in many ways
E.O. Wilson, "Biophilia: The Human Bond with Other Species"	1984	There is a connection between humans and nature which needs to be fulfilled
Health Gains from Whole Building		
Mendell, et al, "Improving the Health of Workers in Indoor Environments: Priority Research Needs For a National Occupational Research Agenda"	N/A	Health problems are costing building occupants tens of billions of dollars a year
U.S. GSA, "Frequently asked questions: Space management"	2006	\$50 billion divided by 15 million affected occupants and multiplied by the ration of 1occupant to 230 sq.ft., about \$14.50 per sq.ft. could be saved
Vivian Loftness, Volker Hartkoph, Lam Khee Poh, " Sustainability and Health are Integral Goals for the Built Environment," <i>Healthy Buildings</i> 2006	June 4-8, 2006	High-performance ventilation cut respiratory illness 10-90%, Better temperature control improved performance 0.2-7%, 74% Reduction of headaches by replacing magnetic fluorescent lamps.
Advanced Building Systems Integration Consortium, Center for Building Performance and Diagnostics, "Flexible Grid – Flexible Density – Flexible Closure Officing: The Intelligent Workplace," <i>Pittsburgh; Carnegie Mellon University</i>	1995	"The CMU study showed that occupants closer to windows reported fewer health problems"

### Appendix IV-C

## Studies of Productivity and Health Cited by Industry

Document Citation	Article Date	Alleged Benefit / Issue Cited
"Reduce Your Risk." National Resources Defense Council, 2006, <a href="http://www.nrdc.org/buildinggreen/bizcase/own_risk.asp">www.nrdc.org/buildinggreen/bizcase/own_risk.asp</a>	2006	"According to various estimates, approximately one-third of all government and commercial office buildings in the U.S. may be regarded as unhealthy"
Heerwagen, Judith, "Sustainable Design can be an Asset to the Bottom Line—Expanded Internet Edition," <i>Environmental Design &amp; Construction</i>	Jul. 2002	"Two studies of 11,000 workers in 107 European buildings analyzed the health effect of worker-controlled temperature and ventilation. These studies found significantly reduced illness symptoms, reduced absenteeism and increased productivity relative to workers in a group whose workspace lacked these features."
Study described in a valuable review of green building productivity issues in: Alex Wilson, "Productivity in Green Buildings," <i>Environmental Building News</i>	Oct. 2004	10-20% better on tests with improved views Workers in offices without glare outperformed workers in offices with glare by 15% or more
Other References		
Anderson, R, "Mid-Course Correction: "Toward a Sustainable Enterprise: The Interface Model," White River Junction," Vermont: <i>Chelsea Green Publishing Company</i>	1998	
Becker, F., & Fritz, S., "Workplace by Design: Mapping the High-Performance Workscape," San Francisco: <i>Jossey-Bass Publishers</i>	1995	
Becker, F., & Joroff, M., "Reinventing the Workplace," Norcross, Georgia: <i>International Development Research Council</i>	1995	
Federal Facilities Council, "Federal Facilities Beyond the 1990's: Ensuring Quality in an Era of Limited Resources, Technical Report #3," Washington, DC: <i>National Academy Press</i>	1997	
Heerwagen, J., Kampschroer, K., Powell, K., & Loftness, V., "Collaborative Knowledge Work Environments," London: <i>Building Research and Information</i>	2004	
Kampschroer, K., & Heerwagen, J., "The Strategic Workplace: Development and Evaluation," London: Building and Research Information		

## Appendix IV-D

### Additional Studies of Productivity and Health<sup>114</sup>

Productivity	Number of Documents	Health	Number of Documents
Productivity Gains from IEQ	16	Health Gains from IEQ	9
Productivity Gains from Temperature Control	0	Health Gains from Temperature Control	0
Productivity Gains from Lighting Control	0	Health Gains from Lighting Control	0
Productivity Gains from Privacy and Interaction	8	Health Gains from Privacy and Interaction	0
Productivity Gains from Ergonomics	10	Health Gains from Ergonomics	4
Productivity Gains from Access to Natural Environment	21	Health Gains from Access to Natural Environment	6
Productivity Gains from Whole Building	7	Health Gains from Whole Building	10
<b>Subtotal</b>	<b>62</b>	<b>Subtotal</b>	<b>29</b>

Health and Productivity	
IEQ Occupant Satisfaction	11
Other Studies	16
<b>Subtotal</b>	<b>27</b>

Total Number of Studies	118
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<sup>114</sup> The bulk of the studies described in this Appendix were identified through an extensive search of key industry studies, sustainable business case and cost-benefit studies, private placement memorandums and other documents. Studies were cited in support of the benefits of sustainability.



## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Productivity Gains from IEQ		
Wargocki, P., Wyon, D., Sundell, J., Clausen, G., and Fanger, P.O. "The Effects of Outdoor Air Supply Rate in an Office on Perceived Air Quality, Sick Building Syndrome (SBS) Symptoms, and Productivity." In <i>Proceedings of Indoor Air 2000, Vol. 10</i>	2000	1.7-4.6% increase in productivity with better ventilation rates
Shendell, D, R. Prill, W. Fisk, M. Apte, D. Blake, D. Faulkner "Associations between classroom CO2 concentrations and student attendance in Washington and Idaho." <i>Indoor Air, v. 14</i>	2004	0.7% reduction in daily attendance per 1000 ppm of CO2
Menzies, D., Pasztor, J., Nunes, F., Leduc, J., and Chan, C.H. "Effect of a new ventilation system on health and well being of office workers." <i>Archives of Environmental Health, 52:5</i>	1997	20% decrease in headaches and 11% increase in productivity from better ventilation
Wargocki, Pawel, "Human Perception, Productivity, and Symptoms Related to Indoor Air Quality." Doctoral Thesis. Center for Indoor Environment and Energy, Technical University of Denmark.	1998	6.5% decrease in typing performance and 15-22% increased SBS with introduction of old carpet
Lagercrantz, L., Wistrand, M., Willen, U., Wargocki, P., Witterseh, T. and Sundell, J. "Negative impact of air pollution on productivity: previous Danish findings repeated in new Swedish test room." In <i>Proceedings of Healthy Buildings 2000, Vol. 1, Espoo, Finland</i>	2000	1.8% improvement in typing speed and 1.6% improvement in typing accuracy with removal of old carpets
Wargocki, P., D. Wyon, P.O. Fanger "Call-centre operator performance with new and used filters at two outdoor air supply rates." In <i>Proceedings of Healthy Buildings 2003, Singapore</i> .	Dec. 7-11, 2003	6.7-10% decrease in talk time with new filters and 80% outside air
Hedge, A, GE Mitchell, JF McCarthy, J Ludwig "Effects of a Furniture-integrated Breathing-zone Filtration System on Indoor Air Quality, Sick Building Syndrome, and Productivity." <i>Indoor Air. v. 3</i>	1993	47% reduction in sick building syndrome symptoms, 49% decline in lethargy, 43% decline in dry skin, 31% decline in headaches with furniture-integrated breathing zone filtration system
Myatt, TA, SL Johnston, Z Zuo, M Wand, T Keadze, S Rudnick and DK Milton "Detection of Airborne Rhinovirus and Its Relation to Outdoor Air Supply in Office Environments." <i>American Journal of Respiratory and Critical Care Medicine, v169</i>	2004	Better air filters reduce pollutants resulting in less sick occupants

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Smedje, G and Norback, D. "New ventilation systems at select schools in Sweden—Effects on Asthma and Exposure." <i>Archives of Environmental Health</i> , 35(1)	2000	69% reduction of asthma with improved ventilation systems
Menzies, D, J Popa, J Hanley, T Rand, D Milton "Effect of ultraviolet germicidal lights installed in office ventilation systems on workers' health and wellbeing: double-blind multiple crossover trial." <i>The Lancet</i> , v. 362	2003	25% reduction in reported respiratory symptoms with drip pans and cooling coils within ventilation systems.
Åhman, M., Lundin, A., Musabašić, and Söderman, E. "Improved Health After Intervention in a School with Moisture Problems." <i>Indoor Air. Vol 10</i>	2000	36% reduction in sick building syndrome with ventilated floor slab and repair of water damaged walls
Fisk, W., P. Price, D. Faulkner, D. Sullivan, D. Dibartolomeo, C. Federspiel, G. Liu, and M. Lahiff, "Productivity And Ventilation Rate: Analyses of Time-Series Data for a Group of Call-Center Workers" <i>Proceedings, Indoor Air 2002</i> , Monterey, CA	June 2002	Describes that very high ventilation rates per occupant (very low □CO2) may lead to lower AHT, or faster work rates.
Federspiel, C., G. Liu, M. Lahiff, D. Faulkner, D. Dibartolomeo, W. Fisk, P. Price, and D. Sullivan, "Worker Performance and Ventilation: Analyses of Individual Data for Call-Center Workers." <i>Proceedings, Indoor Air 2002</i> , Monterey, CA	June 2002	Ventilation rates less than 100% outdoor air are associated with lower work performance, high temperature (> 25.4 C) is associated with lower work performance, higher occupant density is associated with lower work performance, understaffing is associated with lower work performance, longer shifts are associated with lower work performance.
U.S. EPA "I-BEAM Computer programs"	2001	A computer program that shows what different green building systems do to IEQ
Knoll, DYG, "The 21st Century Workplace"	1998	Describes the new innovative workplace features and they're benefits
Gensler, "The Gensler Design + Performance Index," <i>The U.S. Workplace Survey</i>	2006	Lays out many benefits of different features added to buildings to make the more efficient
Productivity Gains From Indoor Temperature Control		
None	N/A	
Productivity Gains from Lighting		
None	N/A	
Productivity Gains from Privacy and Interaction		
Salter, C. and R. Waldeck, "Designing Acoustically Successful Work Places: A Case Study Assessment of the Speech Privacy and Sound Isolation of Spaces Having Underfloor Air Distribution Systems." <i>CBE Summary Report</i> , April.	2006	Describes wall types and how they affect noise

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Jensen, K., and E. Arens, "Acoustic Quality in Office Workstations, as Assessed by Occupant Surveys." <i>Proceedings, Indoor Air 2005</i> , Sept. 4-9, Beijing, China.	2005	50% of workers in cubicles say that poor acoustics effect their work, 30% in private offices
Salter, C., K. Powell, D. Begault, and R. Alvarado, "Case Studies of a Method for Predicting Speech Privacy in the Contemporary Workplace." <i>CBE Summary Report</i> , January.	2003	Workers don't like open office floor plans because they don't have a sense of privacy, which means less productivity
Armstrong Ceiling Systems, "Office Acoustics: Attaining speech privacy in open and closed plan environments," <i>AWI Licensing Company</i>	2006	Shows many examples to stop noise from traveling around the office distracting people
S. Dorgan, J. Dowdy, T. Rippin, "The Link Between Management and Productivity" <i>McKinsey and Company</i>	February 2006	Improving management quality makes workers be more productive and makes the company as a whole more productive
Mark Mendell, William Fisk, "Is Health in office buildings related only to psychosocial factors," <i>BMJ Publishing Group</i>	2006	A letter written by Mendell and Fisk disproving the article "Building Health: An Epidemiological Study of Sick Building Syndrome in the Whitehall II Study"
Steve Johnson, "Office Acoustics are Important to Productive Work Atmosphere," <i>The Denver Business Journal</i>	January 30, 2006	Describes how walls in large open spaces are important to the privacy of workers
Andrew Blum, "Work and the Workplace in 2006," <i>Gensler Publications</i>	2006	Describes how working as groups in the workplace gets things done faster
Productivity Gains from Ergonomics		
University of Texas Health Science Center at Houston, "Leap Productivity and Health impact Study," <i>Steelcase.com</i>	February 25, 2006	17.8% productivity gain from occupants using Leap chair and office ergonomics training
Dressel, D.L. and Francis, J. "Office Productivity: Contributions of the Workstation" <i>Behavior and Information Technology</i> , 6:3	1987	20.4% increase in productivity with new layout and new furniture
Brill, M. "Using Office Design to Increase Productivity. Buffalo Organization for Social and Technological Innovation (BOSTI)," <i>Workplace Design and Productivity</i>	1986	9.5% increase in productivity with better workstations that improve noise, glare, comfort, and enclosure conditions
Dainoff, M.J. "Ergonomic Improvements in VDT Workstations: Health and Performance Effects In the Workplace"	1990	17.6-23.3% improvement of quality with ergonomic workstations
Sauter, S.L, Dainoff, M.J., and Smith, M.J. "Promoting health and productivity in the computerized office: models of successful ergonomic interventions." <i>London: Taylor &amp; Francis</i>	1990	17.6-23.3% improvement of quality with ergonomic workstations
Occupational Safety and Health Administration, US Department of Labor "Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis for the Occupational Safety and Health Administration's Proposed Ergonomics Programs Standard," (Chapter III-V and Appendix III-A, Scenario No. OGI-4, pp. 422-423).	1999	5% increase in output with better monitor position 5-20% increase in output with ergonomic chairs 82% reduction of recordable cumulative trauma with ergonomic chairs and keyboards
Zecevic, A.; Miller, D. I.; Harburn, K.; "An evaluation of the ergonomics of three computer keyboards." <i>Ergonomics</i> , 43:1	2000	11-20% decrease in productivity with split keyboards without proper training

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Silverstein, B.; Vilkkari-Juntura, E.; Kalat, J. "Work-related Musculoskeletal Disorders of the Neck, Back, and Upper Extremity in Washington State," 1990-1988, Technical Report Number 40-4a-2000, Safety and Health Assessment & Research for Prevention, Washington State Department of Labor and Industries.	2000	11-20% decrease in productivity with split keyboards without proper training
Mackenzie, S.; Kauppinen, T.; Silfverberg, M.; "Accuracy measures for evaluating computer-pointing devices." <i>In Proceedings of CHI 2001 Conference on Human Factors in Computing Systems</i> , Seattle, Washington	March 31- April 5 2001	63% improvement in throughput with a mouse as opposed to a trackball, a touchpad, and a joystick.
Amick, B., M. Robertson, K. DeRango, L. Bazzani, A. Moore, T. Rooney, R. Harrist "Effect of Office Ergonomics Intervention on Reducing Musculoskeletal Symptoms." <i>SPINE</i> , 28(24)	2003	48% reduction of end-of-day rating of symptom intensity with fully-adjustable ergonomic chairs
Productivity Gains from Access to Natural Environment		
Heschong, Mahone Group, Inc. "Windows and Offices: A study of office worker performance and the indoor environments," <i>California Energy Commission Technical Report</i>	2003	6-12% productivity gain from better views
Mendell, Mark J. "Risk Factors for Work-Related Symptoms in Northern California Office Workers."	1991	4.3% productivity gain from having windows near workstations
Sterling, E. and Sterling, T. (1983) The Impact of Different Ventilation Levels and Fluorescent Lighting Types on Building Illness: an Experimental Study. <i>Canadian Journal of Public Health</i> , Vol. 74,	November December 1983	71% reduction in absenteeism with operating windows
Skov, P., Valbjorn, O. and Pedersen, B.V. "Influence of indoor climate on the sick building syndrome in an office environment." <i>Scandinavian Journal of Work Environmental Health</i> , 16	1990	46% less SBS symptoms with naturally ventilated systems
Kroeling, P. "Health and well-being disorders in air conditioned buildings; comparative investigations of the "building illness" syndrome." <i>Energy and Buildings</i> , 11	1988	33% fewer headaches, 28% fewer colds and 31% fewer circulation problems with natural ventilation
Schwartz et al "Lost Workdays and Reduced Work Effectiveness Associated with Headache in the Workplace." <i>Journal of Occupational and Environmental Medicine</i> . 39(4)	1997	33% fewer headaches, 28% fewer colds and 31% fewer circulation problems with natural ventilation
Fendrick et al. "The economic burden of non-influenza-related viral respiratory tract infection in the United States." <i>Archives of Internal Medicine</i> . V163	February 24, 2003	33% fewer headaches, 28% fewer colds and 31% fewer circulation problems with natural ventilation
Bramley et al. "Productivity Losses Related to the Common Cold." <i>Journal of Occupational and Environmental Medicine</i> . (44) 9	2002	33% fewer headaches, 28% fewer colds and 31% fewer circulation problems with natural ventilation
Finnegan, MJ, Pickering, CAC, Burge, PS. "The Sick Building Syndrome: prevalence studies." <i>British Medical Journal</i> . Vol. 289	1984	70% fewer SBS symptoms, 66% fewer nasal problems, 67% fewer eye symptoms and 60% fewer headaches, 71% fewer incidence of chest

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
		tightness
Preziosi P, S Czerniichow, P Gehanno, S Hercberg. "Workplace air-conditioning and health services attendance among French middle-aged women: a prospective cohort study." <i>International Journal of Epidemiology</i> , 33(5)	2004	16.7% reduction in the rate of medical services use and a 57.1% reduction in sickness absence with naturally ventilated buildings
Vincent, D, I Annesi, B. Festy, J. Lambrozo "Ventilation system, indoor air quality, and health outcomes in Parisian modern office workers." <i>Environmental Research</i> , v. 75	1997	59% less nasal discomfort when waking up and 52% less migraines with naturally ventilated buildings
Hu, XH, LE Markson, RB Lipton, WF Stewart, ML Berger "Burden of Migraine in the United States." <i>Archives of Internal Medicine</i>	1999	59% less nasal discomfort when waking up and 52% less migraines with naturally ventilated buildings
Edmeads, J and J Mackell "The Economic Impact of Migraine: an analysis of direct and indirect costs." <i>Headache</i> , v. 42	2002	59% less nasal discomfort when waking up and 52% less migraines with naturally ventilated buildings
Schwartz, BS, WF Stewart, RB Lipton "Lost Workdays and Decreased Work Effectiveness Associated with Headache in the Workplace." <i>Journal of Occupational and Environmental Medicine</i>	1997	59% less nasal discomfort when waking up and 52% less migraines with naturally ventilated buildings
Fjeld T "The Effect of Plants and Artificial Daylight on the Well-being and Health of Office Workers, School Children and Health Care Personnel." <i>Proceedings of Plants for People International Symposium Floriade</i> , Netherlands	2002	With plants present, 21% reduction of sickness symptoms, and a 23% reduction of head sickness symptoms
Apte, M.G. and C.A. Erdmann. "Indoor Carbon Dioxide Concentrations, VOCs, Environmental Sensitivity Association with Mucous Membrane and Lower Respiratory Sick Building Syndrome Symptoms in the BASE Study" Analyses of the 100 Building Dataset. <i>Indoor Environment Department, Lawrence Berkeley National Laboratory, Berkeley, CA</i>	2002	With plants present, 21% reduction of sickness symptoms, and a 23% reduction of head sickness symptoms
Lohr, V.I., C. Pearson-Mims, and G. Goodwin "Interior Plants may Improve Worker Productivity and Reduce Stress in a Windowless Environment." <i>Plants-for-People</i> . <a href="http://www.plants-in-buildings.com/documents/Lohretal-plantsandproductivity.pdf">http://www.plants-in-buildings.com/documents/Lohretal-plantsandproductivity.pdf</a>	1990	12% increase in reaction time with plants around leading to increased productivity
Marmot, AF, J Eley, M Stafford, SA Stansfeld, E Warwick, MG Marmot "Building Health: an epidemiological study of "sick building syndrome" in the Whitehall II Study." <i>Occupational and Environmental Medicine</i> , v. 63	2006	14% fewer symptoms but not significant because so many different things studied at once
Graudenz, G.S, Oliveira, C.H., Tribess, A., Mendes, Jr, C., Latorre, M. Kalil, J. "Association of Air Conditioning With Respiratory Symptoms in Office Workers in Tropical Climate." <i>Indoor Air</i>	2005	37% decrease of persistent cough and 74% lower rate of building-related worsening of symptoms
Hedge, A. et al "Indoor Air Quality and Health in Two Office Buildings With Different Ventilation Systems," <i>Environmental International</i> , Vol15	1989	14.8% average reduction in symptoms with a naturally ventilated building

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Laverne, R and Winson-Geldman, K "The influence of trees and landscaping on rental rates at office buildings." <i>Journal of Arboriculture</i> 29(5)	2003	7% average increase to rental rates with aesthetically pleasing landscaping and shade
Health Gains from Whole Building		
Michael Brill, Sue Weidman and the BOSTI Associates, "Disproving widespread myths about workplace design," <i>Kimball International</i>	2002	Disproves multiple myths about the cost and effectiveness of innovative workplace designs
"Workplace Matters," <i>General Services Administration</i>	2006	Shows how important layout of offices are to productivity and satisfaction of occupants
Judith Heerwagen, "Green Buildings, Organizational Success, and Occupant Productivity," <i>Building Research and Information Vol. 28</i>	N/A	6.5% better on a text entry task without 20 year old carpet, workers with SBS worked 7.2% slower
"Queensland University of Technology Research Week International Conference," <i>Queensland University of Technology</i>	July 4-5 2005	Describes how every factor of a building affects the workers inside of it doing work and how office settings can be improved
"Integrated Systems: Increasing Building and Workplace Performance," <i>BOMA International Foundation</i>	2000	Lays out the ways that integrating a building can increase productivity
Karen Niemi, "Employee productivity taking precedence over luxury in law firms," <i>Trade Press Publishing Company</i>	September 2004	Law sacrificing traditional ways to make their offices encourage worker productivity
Steve McLinden, "Q&A with Mark Golan, Vice President, Cisco Systems"	April 16 2007	Some questions about workplace efficiency with detailed answers
Health Gains from IEQ		
"Commentary: Air Conditioning as a Risk for Increased Use of Health Services" By M. J Mendell	Aug. 19, 2004	Air conditioning systems causing health problems for occupants.
M. J. Mendell and G. A. Heath, "Do Indoor Pollutants and Thermal Conditions in Schools Influence Student Performance? A Critical Review of the Literature" <i>Indoor Air 2004</i>	Sep. 15, 2004	Indoor pollutants and indoor temperatures affecting student performance.
M.J. Mendell, "Indoor Residential Chemical Emissions as Risk Factors for Respiratory and Allergic Effects in Children: A Review" <i>Indoor Air 2007</i>	Jan. 1, 2007	Residential air quality causing children to have allergies and respiratory problems.
O. Seppanen, W.J. Fisk, "Association of ventilation system type and SBS symptoms in office workers," <i>Indoor Air 2002</i>	Mar. 5 2001	Treating SBS by taking care of the ventilation systems or replacing the HVAC.
O. Seppanen, W.J. Fisk, Q.H. Lei, "Ventilation and performance in office work," <i>Indoor Air 2005</i>	Aug.2 2005	How ventilation affects workers in office buildings.
Carnegie Mellon Center for Building Performance and Diagnostics Guidelines for Air Quality and Ventilation Control	N/A	Maps out different ways to set up air and ventilation systems as opposed to the conventional way.

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Baughman, A., and E. Arens. "Indoor Humidity and Human Health - Part I: Literature Review of Health Effects of Humidity-Influenced Indoor Pollutants." <i>ASHRAE Transactions</i> , Vol. 102	1996	Shows the relation of indoor humidity and health problems
Arens, E., and A. Baughman. "Indoor Humidity and Human Health - Part II: Buildings and their Systems." <i>ASHRAE Transactions</i> Vol. 102	1996	Shows the relation of indoor humidity and health problems
William Esposito, "Indoor Air Quality Testing fir LEED," <i>The Costs and Benefits of High Performance Buildings</i>	N/A	Tells ways that air gets tested and also how to help the air in a building have less pollutants
Health Gains From Temperature Control		
None	N/A	
Health Gains From Lighting		
None	N/A	
Health Gains From Privacy and Interaction		
None	N/A	
Health Gains from Ergonomics		
United State General Accounting Office "Worker Protection: Private Sector Ergonomics Programs Yield Positive Results," <i>GAO/HEHS-97-163</i>	August 1997	80% reduction of costs for workers comp. claims from \$9,100 per claim to \$1,700 per employee
Ignatius, E. and Fryer, B. "The High Cost of Keyboard Injuries." <i>PC World</i> , 12:3	1994	63% reduction of overall costs of repetitive strain injuries with ergonomic chairs and workstations
Occupational Safety and Health Administration, US Department of Labor. "Success with Ergonomics"	1991	Reduced cumulative trauma disorder-related compensation costs by 80% with ergonomic workstations
Choi, HJ, J Schwartz, DK Milton, HA Burge "The Work Environment and Workers' Health in Four Large Office Buildings." <i>Environmental Health Perspectives</i> , 111(9)	2003	42% decrease of non-specific symptoms, and 31% for upper respiratory symptoms. The little number of participants didn't make a significant study, but with more participants it would be better
Health Gains from Access to Natural Environment		
"Biophilia in Practice: Buildings That Connect People with Nature"	Jul. 2006	Describes what Biophilia is and how buildings can help bring nature to people inside.

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
CBPD / DOE "Field Studies of the Major Issues Facing Existing Building Owners, Managers and Users." <i>Department of Energy Building Studies, Center for Building Performance and Diagnostics (CBPD), Carnegie Mellon University, Pittsburgh, PA.</i>	1994	23.5% reduction in self-reported SBS symptoms for employees near windows
Wargocki, P, Wyon, D, and Fanger, P.O. "Pollution Source Control and Ventilation Improve Health, Comfort and Productivity." In Proceedings of <i>Cold Climate HVAC 2000</i> , Sapporo, Japan	November 1-3, 2000	1.1% increase in productivity with every 10% reduction of SBS complaints
Ulrich, R. "View Through a Window May Influence Recovery From Surgery." <i>Science</i> , 224(4647)	1984	8.5% less recovery time when viewing trees as opposed to a brick wall
Mendell, M.J., W. Fisk, J. Deddens, W. Seavey, A. Smith, D. Smith, A. Hodgson, J. Daisey, L. Goldman "Elevated Symptom Prevalence Associated with Ventilation Type in Office Buildings." <i>Epidemiology</i> , 7(6)	1996	53-57% reduction of SBS symptoms with natural ventilation and 5.8-6.3% productivity increase
Beauchemin, K.M. and P. Hays. "Sunny Hospital Rooms Expedite Recovery form Severe and Refractory Depression." <i>Journal of Affective Disorders</i> , v.40	1996	Patients in bright rooms stayed an average of 16.9 days, while patients with dimly lit rooms stayed an average of 19.5 days.
Health Gains from Whole Building		
"Current Knowledge About Buildings – Related Symptoms" By M. J. Mendell	Nov. 2, 2006	Sick Building Syndrome, how it is caused and how it can be prevented.
"Preventing Building-Related Symptom Complaints in Office Buildings" By M. J. Mendell	Jan. 13, 2006	Preventing SBS by fixing excessive building moisture, inadequate outdoor air, excessive dust, pollutant gasses and odors, inadequate thermal control, and inadequate attention by management to indoor environments.
M. J. Mendell , "Non-Specific Symptoms in Office Workers: A Review and Summary of the Epidemiologic Literature" <i>Indoor Air 1993</i>	1993	Non-specific symptoms and how they relate to the effect buildings have on workers.
"Mold: Steps Toward Clarity" By The Mold Working Group	Jun. 2005	The effect that mold has on businesses and people working in the building.
"Moisture Management Market Opportunities Situation Analysis" By George Benda	Sep. 15, 2005	Describes the problems that mold causes in terms of money and complaints.
"Mold Remediation in Schools and Commercial Buildings" By The U.S. EPA	Mar. 2001	How to find, identify and clean up mold in schools and commercial buildings.
"Ten Tips to Construct a Mold-Free Building" By GreenBiz.com	Aug. 29, 2006	How to build a building while keeping it mold free.
Federspiel, C., G. Liu, M. Lahiff, D. Faulkner, D. Dibartolomeo, W. Fisk, P. Price, and D. Sullivan, "Worker Performance and Ventilation: Analyses of Individual Data for Call-Center Workers." <i>Proceedings, Indoor Air 2002</i> , Monterey, CA, June.	Jun. 2002	<ol style="list-style-type: none"> <li>1. Ventilation rates less than 100% outdoor air are associated with lower work performance, but the results are not conclusive.</li> <li>2. High temperature (&gt; 25.4 C) is associated with lower work performance.</li> <li>3. Higher occupant density is associated with lower work performance.</li> </ol>



## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
W. J. Fisk, Q. Lei-Gomez, M. J. Mendell, "Meta-analyses of the associations of respiratory health effects with dampness and mold in homes," <i>Proceedings, Indoor Air 2007</i>	February 7, 2007	Dampness and mold are associated with increases of 30–50% in a variety of health outcomes
D. Mudarri and W. J. Fisk, "Public health and economic impact of dampness and mold," <i>Indoor Air 2007</i>	February 7, 2007	4.6 million cases of asthma in the USA result from exposure to dampness and mold and that the resulting economic cost of this health impact is approximately \$3.5 billion annually
Abbaszadeh, S., L. Zagreus, D. Lehrer and C. Huizenga, "Occupant Satisfaction with Indoor Environmental Quality in Green Buildings." <i>Proceedings, Healthy Buildings 2006</i> , Vol. III, 365-370, Lisbon, Portugal	June 2006	Compares the different green building features to satisfaction
Huizenga, C., S. Abbaszadeh, L. Zagreus and E. Arens, "Air Quality and Thermal Comfort in Office Buildings. Results of a Large Indoor Environmental Quality Survey." <i>Proceedings, Healthy Buildings 2006</i> , Vol. III, 393-397, Lisbon, Portugal,	June 2006	Only 11% of buildings had 80% or more satisfied occupants. The mean building satisfaction rate is 59%
Heerwagen, J. and L. Zagreus., "The Human Factors of Sustainability: A Post Occupancy Evaluation of the Philip Merrill Environmental Center." Summary Report for U.S. Department of Energy, Center for the Built Environment, University of California, Berkeley, CA	April 2005	Describes the Philip Merrill environmental center, its features and what the occupants think about it
Zagreus, L., Huizenga, C., E. Arens and D. Lehrer, "Listening to the Occupants: A Web-based Indoor Environmental Quality Survey." <i>Indoor Air 2004</i> ; 14 (Suppl. 8)	December 2004	A survey of occupants of buildings and what they think of their IEQ
Huizenga, C., L. Zagreus, E. Arens and D. Lehrer, "Measuring Indoor Environmental Quality: A Web-based Occupant Satisfaction" Survey. <i>Proceedings, Greenbuild 2003</i> , Pittsburgh PA	November 2003	A survey to see how the occupants think the sustainable feature are helping them improve
Huizenga, C., K. Laeser, and E. Arens, "A Web-Based Occupant Satisfaction Survey for Benchmarking Building Quality." <i>Proceedings, Indoor Air 2002</i> , Monterey, CA	June 2002	A survey used to evaluate the effectiveness of a design and the way it is operated
Fountain, M., E. Arens, R. de Dear, F. Bauman, and K. Miura. "Locally Controlled Air Movement Preferred in Warm Isothermal Environments" <i>ASHRAE Transactions</i> , Vol. 100	1994	A study in which occupants were tested with different temperatures to see which one was the most comfortable
Brager, G.S., G. Paliaga, and R. de Dear, "Operable Windows, Personal Control and Occupant Comfort." <i>ASHRAE Transactions</i> , 110 (2)	June 2004	A study in which the ASHRAE Standard 55 is tested to see if it applies
David Lehrer, "Do Green Buildings Provide Better Workplace Environments?" <i>Center for the Built Environment</i>	June 28 2005	Conducted a survey in which occupants of green and non green building participated and showed what they liked and didn't like about their buildings
Jay W. Schnieder, "Focus on Workplace Design," <i>Building Design and Construction</i>	March 1 2007	67% of occupants more efficient when working with others, 65% of occupants desired private offices, 64% of occupants want to have input into the design of the office layout

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
Leaman, Adrian "Productivity Improvement. Buildings in Value," Vol. 3, Ch. 19. <i>Building Use Studies Ltd.</i>	2001	9.75% increase in productivity with a well-designed natural ventilation system
Other References		
Olesen, B. W. and G.S. Brager, "A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004." <i>ASHRAE Journal</i>	August 2004	Studies ASHRAE Standard 55 and how to make more people satisfied with it
Martin, R. M., C. Federspiel, and D. Auslander, "Responding to Thermal Sensation Complaints in Buildings." <i>ASHRAE Transactions</i> , 108(1)	January 2002	Studies ASHRAE Standard 55 and shows how to make occupants happier with it
Webster, T., C. Benedek, and F. Bauman, "Underfloor Air Distribution (UFAD) Cost Study: Analysis of First Cost Tradeoffs in UFAD Systems." Report to U.S. General Services Administration	September 2006	A regular system and a top quality system resulted in the differential change from a \$3.5/gsf UFAD premium to a ~\$6-\$8/gsf UFAD savings over OH
Jung, A., and M. Zeller, "Analysis and Testing of Methods to Determine Indoor Air Quality and Air Change Effectiveness." Original technical paper from Rheinisch-Westfälische Technical University of Aachen, Germany, English translation by Wolfgang Lukaschek, Center for the Built Environment (CBE). Executive Summary by Fred Bauman, PE, Center for the Built Environment (CBE)	October 2005	Studies the different air systems, how air can get trapped in some spaces and what systems work the best to completely exchange air
Lehrer, D. and F. Bauman, "Hype vs. Reality: New Research Findings on Underfloor Air Distribution Systems." <i>Proceedings, Greenbuild 2003</i> , Pittsburgh PA	November 2003	Improved flexibility for building services Improved ventilation efficiency and indoor air quality Improved occupant comfort, productivity and health Reduced energy use Reduced life-cycle building costs Reduced floor-to-floor height in new construction
Bauman, F., A. Baughman, G. Carter, and E. Arens, "A Field Study of PEM (Personal Environmental Module) Performance in Bank of America's San Francisco Office Buildings." University of California, Berkeley,	April 1998	Preference for higher air motion within the PEM group also decreased from 54% in the baseline survey to only 15% in the post-PEM survey
Bauman, F., "Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building." <i>Proceedings, World Workplace 1999</i> , Los Angeles,	October 1999	Task or ambient conditioning improve thermal comfort, improve ventilation efficiency, reduce energy use, reduce life cycle costs, improve maintaining building services, reduce floor to floor height and improve worker satisfaction and productivity
Huizenga, C., H. Zhang, P. Mattelaer, T. Yu, E. Arens, and P. Lyons, "Window Performance for Human Thermal Comfort. Final Report to the National Fenestration Rating Council," Center for the Built Environment, University of California, Berkeley,	February 2006	Shows how windows and thermal comfort affect occupants of buildings
Federspiel, C., R. Martin, and H. Yan, "Thermal Comfort Models and Complaint Frequencies." CBE Summary Report	April 2003	The re-calibrated model predicts higher minimum complaint rates than the original model. The re-calibrated model is more asymmetrical than the original model. The hot complaint rate increases faster with increasing temperature than the cold

## Appendix IV-D Additional Studies of Productivity and Health

Document Citation	Article Date	Alleged Benefit / Issue Cited
		complaint rate increases with decreasing temperature.
Murray, S., and K. Powell, "Office Tenant Needs Study" CBE Summary Report	October 1999	Where cost is high for buildings, companies want Sustainable features to cut down costs of other things
"NAREIM: Senior Executive Strategic Issues Discussion forum," <i>Cisco Systems</i>	June 24, 2003	How interaction is becoming a bigger part of work and linking everyone in the company no matter where they are in the world-non green
Becky Ham, "Depression Treatment Boosts Employee Productivity" <i>Health Behavior New Service</i>	November 22, 2004	High-Quality care for depression can improve productivity at work and lower rates of workplace absenteeism
Darryl Demos and Les Dinkin, "Productivity Metrics Not Just for Factories," <i>American Banker Online</i>	November 5, 2002	Disproves three "myths" about productivity in businesses other than factories
Mark V. Pauly, "Multiplier Effect: The Financial Consequences of Worker Absences," <i>Wharton Health and Economics</i>	December 14, 2005	When employees are gone it takes more money and effort to get replacements to do the job
Environmental Protection Agency, National Institute of Occupational Safety and Health, "Building Air Quality Action Plan"	June 1998	A guideline of how to create better air quality in a building
Occupational Safety and Health Administration, US Department of Labor "Preliminary Economic Analysis and Initial Regulatory Flexibility Analysis for the Occupational Safety and Health Administration's Proposed Ergonomics Programs Standard," (Chapter III-V and Appendix III-A, Scenario No. Scenario No. OGI-5, OGI-9, OGI-19, pp. 424-425, 434-435, 461-463).	1999	Many studies on ergonomics relating to health and productivity



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