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The **Journal of Sustainable Real Estate** (1949-8276) is published annually by the American Real Estate Society at Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC 29634-1323. Postmaster, please send address changes to: Diane Quarles, Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC 29634-1323. Changes of address, claims and all correspondence dealing with subscriptions should be sent to Diane Quarles, Manager of Member Services, Clemson University, School of Business and Behavioral Science, Department of Finance, 424 Sirrine Hall, Clemson, SC, 29634-1323. Phone 864-656-1373, Fax 864-656-7519 or email equarle@clemson.edu. For more information, visit our website: www.ARESnet.org.
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Preface

Journal Changes and Key Contacts

This is the second volume and full issue of the Journal of Sustainable Real Estate. Beginning with this edition, we will print a small number of copies, although the bulk of our distribution will be electronic. Seasoned professionals like myself often have concerns with a real journal that is purely electronic, so let me assure you that the academic review process, editing process and copy-editing process is identical to that of the traditional ARES print journals. There are a few significant differences, including some advantages. First, with an online publication, we have the ability to produce a four-color publication. Second, we can also accept links embedded into the papers or footnotes that provide additional information. If you do provide a link, it must not be to promote or sell a product or service, but simply to offer additional information or resources. An exception might be a book link, i.e., where to buy a book mentioned in the paper or a non-profit organization event. Third, we eliminate the need to use vast amounts of paper and incur other printing and shipping costs.

A new feature of this Journal is the posting of “Industry Perspectives” at www.josre.org. This is a compilation of papers that are worth reading and have been reviewed, but are not typical academic papers with literature reviews and empirical testing. They provide advice, strategy discussions, and synthesis. We expedite the process of publication by not copy-editing and typesetting these papers. Rather, we publish them as edited and formatted by the authors. Note that not all submitted papers are accepted in this section. We received about three times as many papers as we accepted in Volume 2, and we expect that over time we will receive even more submissions.

This journal has now been accepted in Econ Lit, the American Economic Association’s prestigious electronic bibliography. This will mean that citations of work published here are more likely than before when we were a relatively unknown publication.

The CoStar Group continues to fully fund this Journal including editing and prizes. The University of San Diego Burnham-Moores Center for Real Estate continues to manage the journal with the dedicated help of Myla Wilson and editorial assistance by Jeryldine Saville. The American Real Estate Society (ARES) continues to support the journal as one of its official publications, and we have three very capable associate editors who work with me to review papers and determine which papers are accepted. They are: Nico B. Rottke (Europe), European Business School, email: rottke.ebs@rem-institute.org; Robert Simons (North America), Cleveland State University, email: r.simons@csuohio.edu; and Kwame Addae-Dapaah (Asia), National University of Singapore, email: rstka@nus.edu.sg.

Submissions should still be sent to greenjournal@sandiego.edu or to nmiller@sandiego.edu with a copy to mwilson@sandiego.edu.
Acknowledgements

We thank the CoStar Group and the support of CEO and President Andrew Florance for funding this journal in full. We want to make it clear that while CoStar has provided the funding to us and data to many researchers, they have always provided complete independence and never asked to see any results prior to publication. I am also deeply indebted to Myla Lorenzo-Wilson, who has worked tirelessly on communications with authors, provided content and cover designs and otherwise managed the entire review process of the journal and to the University of San Diego’s Burnham-Moores Center for Real Estate for their support of this journal.

This is what we hope will be the second of many issues until such time that sustainable real estate becomes so mainstream that a separate journal is no longer needed.

We also want to thank our Editorial Board, especially the Associate Editors who deserve the red pen award for reviewing so many papers. Some members of the Advisory Board participated in a discussion in the Industry Perspectives section, and they continue to provide vital links by cheerleading submissions from those involved in sustainable real estate research.

CoStar

On behalf of the CoStar Group, I am very pleased to welcome the publication of the second issue of the Journal of Sustainable Real Estate (JOSRE), and to congratulate the authors whose original research is presented in this second issue.

CoStar Group continues to be an active supporter of academic research involving the built environment. As part of our ongoing efforts to increase awareness of energy efficiency and sustainability issues in real estate, CoStar has joined with the ARES to sponsor JOSRE with the goal of provoking thought and encouraging discussion by publishing a collection of research papers addressing sustainable real estate issues. CoStar has also undertaken a series of quarterly webinars with the U.S. Green Building Council and may soon start teaming up with the Environmental Protection Agency to provide information on trends and best practices.

Of all the core categories of energy consumption in the United States, the built sector is the least efficient and has the largest potential for cost-effective improvement. Addressing the impact that sustainability practices can have on this major business sector is critical.

And yet, businesses and public sector organizations face a daunting task in confronting the fundamental challenges presented by climate change, population growth, and resource constraints. If successful, their decisions may lead to the development of market-leading innovations and technologies and drive changes in business practices and consumer behavior needed to integrate sustainability on a large scale and achieve the economic rewards and long-term viability that sustainable principles offer. However, if we are unsuccessful in meeting those challenges, we collectively face increased costs, diminished opportunities, and a very real risk to our future.
Above all, confronting what I believe to be one of the greatest challenges of our time requires innovative thinking and fundamentally questioning the accepted status quo in our real estate and business practices. It requires careful consideration of alternatives, clear-eyed analysis of risks, and thoughtful debate on the merits of pursuing different strategies for securing our future and achieving our long-term goals.

This rationale motivates CoStar to proudly sponsor independent research into sustainable real estate. In doing so, the goal is to help in a small but meaningful way those investors, developers, appraisers, lenders, asset managers, government, and land use regulators gain a better understanding of the issues associated with sustainable real estate practices.

As more and more providers and occupiers of business real estate integrate sustainability into their business strategies, we believe there will be competitive advantages for innovative companies to unlock opportunities and capture profitable growth. Through our support of this *JOSRE*, our hope is that independent research in this area can spur additional interest and provide the insight and recognition that helps bring about those needed changes.

In addition to sponsoring academic research, CoStar offers qualified university professors and their students access to CoStar’s comprehensive online information services for use in their research and in their educational endeavors. More than 1,100 professors and students at more than 150 universities are currently enrolled in the program. To learn more about this program and the research resources available through CoStar, I encourage you to visit www.costaruniversity.com. More information on *JOSRE* can be found at www.josre.org.

Andrew Florance  
Chief Executive Officer  
CoStar Group  

*The U.S. Green Building Council*

Buildings represent a nexus of impacts and opportunities for people and the environment. We have ample documentation of the far-reaching consequences of buildings for energy use, water consumption, greenhouse gas emissions, human health, occupant productivity, and myriad other factors. The magnitude of these impacts means that the design, construction, and operation of buildings also provide far-reaching opportunities to reduce negative impacts and ultimately strive to make active, positive contributions. This convergence of impacts and opportunities means that buildings must be central to any effort to address the sustainability of human activities.

Understanding this confluence of impacts and opportunities requires new interdisciplinary approaches and strong connections between theory and practice. As with so many new fields of study, the issues associated with green buildings and real estate do not fit neatly into existing academic categories. Rather, the most pressing and potentially rewarding intellectual challenges are arising at the boundaries and interfaces between disciplines. *JOSRE* provides an urgently needed vehicle for rigorous, peer-reviewed communication for the growing green building research community that strives to bridge these boundaries and create novel
scholarship at the confluence of disciplines. Over time *JOSRE* has the potential to become a critical outlet for new work and, consequently, an essential part of the intellectual foundation for this rapidly growing research community.

*JOSRE* can fulfill this potential by providing a forum for the rigorous exchange of ideas and seeking an editorial balance that blends concepts and empirical observations to advance both the theory and practice of green building. In this issue, the editors and contributors have demonstrated this balance with an exceptional collection of papers. Going forward, I encourage the research community to reflect on the example set herein and the broader goals and aspirations of this fairly new publication. *JOSRE* provides an important outlet for findings that will help shape the future of all building.

**Chris Pyke**  
Director of Research  
U.S. Green Building Council
Foreword

The first paper, by Eugene Choi, focuses on the effects of municipal policies on seeking green building designations. In this follow-up from Volume 1, Choi continues to address important questions about effective policies for encouraging green development or retrofits. We need more work on this topic as we balance the carrot versus stick approach of incentives versus regulations.

The second paper, by Steven Laposa and Sriram Villupuram, provides a comprehensive examination of corporate sustainability policies. There are an increasing number of scorecards for reporting corporate sustainability, and the authors provide some insights into the issues yet to be resolved, along with some clear and valuable advice. The third paper, by Norm Miller, Dave Pogue, Jeryldine Saville, and Charles Tu, discusses the operations and management of green buildings. This study is a continuation of the ongoing collaboration between the University of San Diego and CB Richard Ellis, which looks at the portfolio of green properties managed by the company. Insights on the benefit of separate metering and the impact of ENERGY STAR ratings are discussed, along with a review of green building management and operating practices. The fourth paper, by Aaron Binkley and Brian Ciochetti, covers carbon markets and whether they provide hidden additional value for real estate owners making green improvements beyond energy savings and/or rent impacts. The fifth paper is by Kwame Addae-Dapaah, Tham Kok Wai, Mohd Jaafar Bin Dollah, and Yvonne Foo, who examine the impact of indoor air quality and office property value using a sample from Singapore. The sixth paper is written by Stephanie Rauterkus, Grant Thrall, and Eric Hangen, who discuss locational efficiency, mortgage default, and risk as tied to the sustainability of location, as well as a host of other demographic/social control factors. The remaining papers cover responsible investing, valuation, sustainable community development, barriers to sustainable development, wind farm impacts, reducing greenhouse gases, solar panels and tree regulations, corporate governance affecting sustainable investment or leasing policies, teaching sustainability, and the pay-off from energy improvements.

We hope that you find the papers in Volume 2 to be interesting and thought-provoking. We appreciate your sharing JOSRE’s website (www.josre.org) with as many appropriate individuals and organizations as possible. Thank you.

Norman G. Miller
Senior Editor
University of San Diego and CoStar
Green on Buildings: The Effects of Municipal Policy on Green Building Designations in America’s Central Cities

Author: Eugene Choi

Abstract: This study quantitatively examines the effect of municipal policies on commercial green office building designations. Many states and cities have adopted green building requirements and incentives as policy instruments. This study conducts an OLS regression analysis using American central cities as a unit of analysis and codes municipal green building regulations and incentives for separate dummy variables. The findings reveal that municipal regulatory policy has been a strong tool to promote green office building designations as expected, but incentive-based policies have not been effective except for administrative incentives.

“Green on Real Property” has emerged as a major tool to increase sustainability in urban areas. It is believed that greening real estate has improved overall energy consumption (Rajgor, 2005; Fellows, 2006; Pan, Yin, and Huang, 2008), indoor air quality (James and Yang, 2005; Matela, 2006; Borrelli, 2007; Richardson and Lynes, 2007; Prasow, 2008), occupants’ satisfaction and office occupancy rate (Paul and Taylor, 2008; Prasow, 2008; Fuerst and McAllister, 2009), and rental and sales revenues (Fuerst and McAllister, 2008; Miller, Spivey, and Florance, 2008; Dermisi, 2009). Under the assumption that these externalities can be generated by being “green,” city and state level decision makers have adopted various green building requirements as policy instruments. In addition, many non-profit sectors have significantly influenced the green building movement. The grass-roots level push for green building was heard by politicians and the response has been an increase in public policies to encourage these types of developments. As a result, the green building movement continues to grow rapidly. According to the U.S. Green Building Council (USGBC), since the 2000 Leadership in Energy and Environment Design (LEED) green building rating system, the U.S. experienced a 50% increase in cumulative LEED-registered projects and nearly a 70% increase in LEED-certified projects in 2006. The USGBC is a non-profit organization dedicated to sustainable building design and construction; it is the developer of the LEED building rating system.

This study tests the impact of both regulatory and incentive-based green building policies at the city level on the increase in green office building designations, particularly for the private sector. Perhaps there is less need to implement green
building policy through the larger units of government, such as the federal and the state levels; however, fear of increased costs and regulation may foster reluctance among local governments to implement any policy that would discourage building in smaller cities or those in weaker economies that compete with each other for businesses.

In this study, a green office building refers to an office building registered in the LEED green building rating system or ENERGY STAR. The USGBC developed LEED standards in 1998. LEED is a green building rating system that considers the design, construction, and operation of buildings in accordance with environmental considerations. LEED was developed from a checklist of recommended construction practices to include development; the LEED rating system is an ongoing collaborative process between architects, builders, and building owners and operators (Simons, Choi, and Simons, 2009). ENERGY STAR is also a “green” measurement, developed in 1992 through the efforts of the United States Environmental Protection Agency (USEPA). The focus of the ENERGY STAR program is to reduce energy consumption, thereby lowering greenhouse emissions. ENERGY STAR measures energy efficiencies for operating buildings, building systems, and equipment used inside buildings and homes. ENERGY STAR is incorporated into LEED standards for the renovation of existing buildings (Simons, Choi, and Simons, 2009). There are other green building rating systems in the U.S., such as Green Globe and Green Seal. Green Globe is a set of international standards initially endorsed by 182 heads of state at the United Nations Rio de Janeiro Earth Summit in 1992. Founded in 1989, Green Seal is a non-profit entity helping to set standards for the service industry and individual products (Simons, Choi, and Simons, 2009). This study does not include office buildings designated under either the Green Globe or Green Seal standards because the number of office buildings registered in these two systems in each central city cannot be obtained.

This study looks at the effects of municipal green building policies obtained from web research as of October 2009. Public policies at the municipal level are divided into two sub-categories: municipal regulatory policy and municipal incentive-based policy. In addition, municipal incentive-based policy can be divided into three sub-categories: administrative incentive, financial incentive, and technology support incentive. For the statistical model, therefore, these four public policies including regulation policy and three sub incentive-based policies are coded as separate dummy variables. An Ordinary Least Squares (OLS) regression analysis is conducted using central cities in the U.S. as the unit of analysis. The market penetration of commercial green office buildings in each central city is the dependent variable while the policy dummy variables serve as independent variables. Eight control variables are used to account for demand and supply side factors of green buildings, as well as to control for environmental factors. Factor analysis is used to reduce the nine control variables into three factors because the sample size (n=103) is not large enough to run the regression model with an array of 13 explanatory variables (four policy dummy variables and nine control variables). An additional OLS regression analysis is conducted to test whether a city that has used both regulation policy and incentive-based policy experiences
an effect on market penetration that is different than a city that has used only a regulation policy or an incentive-based policy alone.

Literature Review

Although American cities have experienced a rapid increase in the number of green buildings, there have been few empirical studies that have analyzed the factors that may affect green building development. Several motivators for private sector “greening” have been discussed by previous literature: supply-side factors such as increased property value and rents (Fuerst and McAllister, 2008; Miller, Spivey, and Florance, 2008; Dermisi, 2009), demand-side factors (Clemens and Douglas, 2006; Richardson and Lynes, 2007; Paul and Taylor, 2008; Simons, Choi, and Simons, 2009), environmental condition and public policy (Simons, Choi, and Simons, 2009). How an entity values each of these motivators depends on whether the entity is the operator, tenant, owner, or developer of a building.

Supply-Side Factors

Real estate deals are strongly affected by supply-side factors. Green office building initiatives may also be affected by supply-side factors of the existing office market. These supply-side factors include: availability or vacancy of existing office stock, rents or sales prices of existing or planned office buildings, and current condition of existing office stock (Rosen, 1984; Tse and Webb, 2003). Higher vacancy and availability rates will motivate the developer not to invest in green office building because these two proxies indicate that either the office market is down for new construction (meaning that it is hard to find office building buyers or tenants) or competition with other offices is too tough to warrant added investment costs for new green office building construction. Current building conditions may influence owners or operators of older office buildings to convert their properties to green buildings because the costs for rehabbing and converting their properties to green buildings simultaneously can be less if than if done separately.

Previous studies of rents or sales prices of green buildings are important because the existence of a rent or sales price premium for green office buildings indicates that markets can price the benefits of investment in ENERGY STAR and LEED certification (Simons, Choi, and Simons, 2009). In other words, developers or building owners can derive more benefit through green investment. Two papers presented at the American Real Estate Society annual meeting in 2008 investigated the difference between ENERGY STAR or LEED designated buildings (i.e., green buildings) and conventional buildings (Miller, Spivey, and Florance, 2008; Fuerst and McAllister 2008; Dermisi, 2009) in terms of rents and building sales prices. They both found market premiums for green building.

Demand-Side Factors

Who wants to buy or work in green office buildings? Buyers and tenants who think green office buildings are more comfortable than conventional office
buildings generate demand (Paul and Taylor, 2008). Paul and Taylor’s study compared occupant comfort and satisfaction between a green building and a conventional building. They collected the comfort and satisfaction perceptions of the occupants of a green university building and two conventional university buildings with a questionnaire that asked occupants to rate their workplace environment in terms of aesthetics, serenity, lighting, acoustics, ventilation, temperature, humidity, and overall satisfaction.

Buyers and tenants who consider public perception or who think “it is the right thing to do” generate demand for green office buildings as well (Simons, Choi, and Simons, 2009). Under this assumption, it is logical that if a city has more educated people, the city is likely to possess more green office buildings. Many times a lack of internal leadership among stakeholders is very important for green office building development because this assumption is not related to tangible benefits. Richardson and Lynes (2007) pointed out the importance of internal leadership and communication between participants of green office building development. They explored the barriers to and motivations for the construction of green buildings at the University of Waterloo. The authors conducted 13 in-depth interviews with key university individuals and found that a lack of internal leadership among stakeholders with decision-making power, a lack of quantifiable sustainability targets, an operational structure that does not reward building designs with lower energy costs, and a lack of communication between professional designers, facilities management, and faculty were all barriers to constructing green buildings at the university.

Environment Conditions

Simons, Choi, and Simons (2009) pointed out that various climate environments serve as motivators for green building initiatives: cities that experience many days of sunshine are able to utilize solar panels; cities with less water access and higher water costs motivate water conservation; and warmer climates use more electricity for air conditioning, motivating building users to provide shade and green roofs.

Green building developments can be motivated by environmental protection. Green building developments have been used in the context of local commitment to the U.S. Mayors Climate Protection Agreement and other climate change programs (Retzlaff, 2009). Although some environmental benefits are not easily quantified, it is believed that green building generates less pollution and landfill waste. According to the U.S. Department of Energy (2008), buildings in the U.S. contribute 38.1% of the nation’s total carbon dioxide emissions, including 20.6% from the residential sector and 17.5% from the commercial sector. For the public side, green buildings can be a good tool to reduce air and water pollution by using eco-friendly building materials, recycling or reusing old materials, and using eco-friendly energy sources such as fuel cells.

Public Policy

Simons, Choi, and Simons (2009) qualitatively investigated the impact of public policies on the market penetration of green commercial office buildings. The
research had limited generalized findings because the results were drawn from case studies. They researched policies at both the state and city level through various methods, such as website research and interviews with public officials. They found that many local municipalities in California have adopted green building codes that were mandated for public funding of projects. They also noted that some financial incentives were originally established but these programs are no longer are funded in California. Moreover, mandates initially were not required for private developers but private developers were encouraged to follow suit. According to their research, Chicago not only encourages LEED design for all new buildings, but since green does not stop at new buildings, Chicago also works with existing building owners and operators to incorporate ENERGY STAR efficiencies into rehab projects. The authors concluded that the most common form of public policy is to require LEED for all public buildings. Several states call this “Lead by Example” and specify that government buildings and/or school buildings be LEED certified, ENERGY STAR rated, or both. They also pointed out that starting with publicly financed new buildings such as schools is the best way to “Lead by Example” and gain knowledge about the green building process.

Retzlaff (2009) divided municipal policies impacting use of the LEED building assessment system into three categories: policies for buildings that are funded or owned by municipalities, private development requirements, and incentives. According to her, the inclusion of LEED in municipal policies is a new trend; prior to 2000, only two cities—Austin, Texas and Scottsdale, Arizona—had adopted green building policies. She found in the private side, which is a fuse of this paper, that no jurisdiction enacted a policy that requires all buildings to use LEED; however, some places require multiple types of buildings, all buildings in certain zoning districts, or those that meet minimum size requirements to use LEED.

The National Association of Industrial and Office Properties (NAIOP) Research Foundation retained Yudelson Associates in 2007 to investigate local government incentive programs specifically for green buildings. Yudelson Associates identified and characterized local and state incentives for green building construction by the private sector through several case studies and survey research. From their survey, “incentive payment from a utility energy-efficiency program” and “direct monetary payment from a city or county (grant, rebate or reimbursement)” were two most popular incentives for green building construction by the private sector. Yudelson Associates also listed current government programs at the local level by city or state. They found that local governments have increasingly instituted policies, programs, and incentives in the effort to encourage sustainable buildings (Yudelson Associates, 2007).

Profiles of Municipal Green Building Policies: Web-Based Research

Based in part on information derived from a review of the academic literature, websites for central cities that possess more than one green office building were
reviewed. The intent was to ascertain whether or not city governments apply green building policies. The search phrases used were “green building requirement” and “green building incentives.” The table in the Appendix lists all central cities that have implemented municipal green building policies.

Green policies can be adopted through either executive orders or legislative enactment. Executive orders are a quicker method for implementing policy. Legislation often gets bogged down by politics. Working through different political agendas often results in green legislation going nowhere (Simons, Choi, and Simons, 2009). The general concept for implementing green building techniques through regulatory policies is straightforward: some of newly constructed or renovated buildings or all of buildings in certain zoning (Retzlaff, 2009) must meet LEED or LEED-equivalent requirements. Municipalities have mandated that all or some of their buildings must meet LEED or equivalent requirements (Yudelson Associates, 2007), while state governments have mandated their “public buildings” to utilize some green building techniques (May and Koski, 2007). Regulation is viewed as the most powerful policy tool for promoting specific development activities because a city or a state can conduct disciplinary action for non-compliance.

Central cities also utilize various incentive-based policies to encourage green building. Such policies can be divided into the three main categories previously mentioned: administrative incentives, financial incentives, and technical support (Retzlaff, 2009; Simons, Choi, and Simons, 2009). With administrative incentives, green building projects will pass through the plan review and approval process faster so that developers can save time and money. With financial incentives, green building developers can get various tax credits, funds, and rebates. With technical support, a municipality provides every effort for the developers who want their properties to be green certified; this support is very useful since green building requirements are often new or unfamiliar for private sector initiators.

Public Policy: State or City?

The provisions of state green requirements include incentives for constructing green buildings, mandates for adherence to LEED provisions for new facilities, and requirements for LEED provisions for renovated buildings that meet specified size or value requirements (May and Koski, 2007). As Simons, Choi, and Simons (2009) and May and Koski (2007) point out, most state policies promote the utilization of green building techniques in state buildings, schools, and other public facilities, while municipal policies more often focus on promoting green construction in the private sector. In other words, the state requirements do not affect single-family homes or commercial structures. Therefore, this study assumes that municipal policies may be more effective on the market penetration of green buildings than state policy because municipal policies deal with commercial developers’ investment. In addition, municipalities may be the best place for green policies because they have the organizational structures to adopt and enforce development regulations, they can respond best to local government conditions and issues, and because public sustainability activism is more meaningful and
Green on Buildings: The Effects of Municipal Policy

Exhibit 1
Number of Existing ENERGY STAR Office Buildings since 2001

Data Source: www.costar.com.
2001, 2,215 office buildings were certified as ENERGY STAR, and in the second quarter of 2009, 2,468 office buildings were certified as ENERGY STAR, showing an increase of over 10% during this period. There were 564 green office buildings certified as LEED in 2000 and 1,311,137 green office buildings certified as LEED in 2009.

Exhibit 2 depicts new constructions of green office buildings certified by ENERGY STAR or LEED since 2001 in the U.S. The exhibit shows that approximately 200 green office buildings were constructed around 2000. It appears that after USGBC developed LEED standards in 1998, many efforts in the private sector have been made to meet LEED standards. However, new constructions of office green buildings have experienced a rapid decrease since 2008; the continuing economic crisis may explain this reversal (Exhibit 3).

Exhibit 4 lists the top 20 states in terms of the distribution and density of green office buildings. There are 2,801 green office buildings in the CoStar database in the U.S., as of March 26, 2009; each building in the database was listed as having rental vacancy and “green” status. The exhibit indicates state rankings by concentration of buildings on the left side and the availability of green office buildings per million state residents on the right side.

In terms of the number of green office buildings, California was ranked as the top with 691 green office buildings, followed by Texas (285), Colorado (155), Illinois (113), and Massachusetts (96). The top 10 states possess approximately 70% of the green office buildings. For the availability rankings of green office buildings per million people in each state, Colorado was at the top with approximately 31 green office buildings per million people (excepting the District of Columbia), followed by California (19), Oregon (17), Minnesota (16), and Massachusetts (15). The average of green office buildings per million people was approximately 8.26, yet only 13 states exceeded the average green office buildings per million people.
Exhibit 5 shows the distribution of green office buildings expressed as the number of buildings per million. Western states such as Texas, Colorado, Washington, Oregon, and California have more than 10 office green buildings per million people. On the other hand, no office green buildings were found in states located in northern states such as Montana, North Dakota, South Dakota, and Wyoming. This result seems to be due to cold weather in these states. In addition, no office green buildings were found in Vermont or New Hampshire. This result seems to be due to small office markets in these states.

Exhibits 4 and 5 show that the green building movement is not a uniform nationwide trend. It has been concentrated in several states, especially in the western states (Simons, Choi, and Simons, 2009).

Exhibit 6 shows the market penetration rates for green office buildings in the top 10 central cities in the U.S. The market penetration rate is calculated by dividing the number of green office buildings in a city by the city’s total office buildings. San Francisco has the highest market penetration rate, with approximately 6.23% market penetration, followed by Houston (5.89%), Washington D.C. (4.63%), Denver (4.32%), and Duluth (4.32%).

In San Francisco, both incentive-based and regulatory policies are in place and seem to be working. According to San Francisco’s Department of the Environment, projects that commit to LEED Gold certification are eligible for priority permit processing through coordination with the Planning Department, Department of Building Inspection, and Department of Public Works. There are also rebates for installation of photovoltaic systems, water efficiency and energy efficiency measures available from the San Francisco Public Utilities Commission. Coupled with the California Solar Initiative state rebates and federal tax credits, incentives can pay half the cost of a solar power system installed in an office.
### Exhibit 4 | Top 20 States by the Number of Green Office Buildings

<table>
<thead>
<tr>
<th>Ranking</th>
<th>State</th>
<th>Number of Offices</th>
<th>State</th>
<th>Per Million People</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>California</td>
<td>691</td>
<td>District of Columbia</td>
<td>135.17</td>
</tr>
<tr>
<td>2</td>
<td>Texas</td>
<td>285</td>
<td>Colorado</td>
<td>31.38</td>
</tr>
<tr>
<td>3</td>
<td>Colorado</td>
<td>155</td>
<td>California</td>
<td>18.80</td>
</tr>
<tr>
<td>4</td>
<td>Illinois</td>
<td>113</td>
<td>Oregon</td>
<td>16.89</td>
</tr>
<tr>
<td>5</td>
<td>Massachusetts</td>
<td>96</td>
<td>Minnesota</td>
<td>15.52</td>
</tr>
<tr>
<td>6</td>
<td>Washington</td>
<td>88</td>
<td>Massachusetts</td>
<td>14.77</td>
</tr>
<tr>
<td>6</td>
<td>Florida</td>
<td>88</td>
<td>Hawaii</td>
<td>14.75</td>
</tr>
<tr>
<td>8</td>
<td>Minnesota</td>
<td>81</td>
<td>Washington</td>
<td>13.44</td>
</tr>
<tr>
<td>9</td>
<td>New York</td>
<td>80</td>
<td>Texas</td>
<td>11.72</td>
</tr>
<tr>
<td>9</td>
<td>District of Columbia</td>
<td>80</td>
<td>Virginia</td>
<td>10.04</td>
</tr>
<tr>
<td>11</td>
<td>Virginia</td>
<td>78</td>
<td>Arizona</td>
<td>8.77</td>
</tr>
<tr>
<td>12</td>
<td>Pennsylvania</td>
<td>73</td>
<td>Illinois</td>
<td>8.76</td>
</tr>
<tr>
<td>12</td>
<td>Georgia</td>
<td>73</td>
<td>Connecticut</td>
<td>8.28</td>
</tr>
<tr>
<td>14</td>
<td>Oregon</td>
<td>64</td>
<td>Maryland</td>
<td>7.63</td>
</tr>
<tr>
<td>15</td>
<td>Michigan</td>
<td>63</td>
<td>Georgia</td>
<td>7.54</td>
</tr>
<tr>
<td>16</td>
<td>Arizona</td>
<td>57</td>
<td>Kansas</td>
<td>6.78</td>
</tr>
<tr>
<td>17</td>
<td>North Carolina</td>
<td>51</td>
<td>Michigan</td>
<td>6.30</td>
</tr>
<tr>
<td>18</td>
<td>New Jersey</td>
<td>50</td>
<td>Pennsylvania</td>
<td>5.86</td>
</tr>
<tr>
<td>19</td>
<td>Ohio</td>
<td>48</td>
<td>New Jersey</td>
<td>5.76</td>
</tr>
<tr>
<td>20</td>
<td>Maryland</td>
<td>43</td>
<td>Delaware</td>
<td>5.73</td>
</tr>
</tbody>
</table>


Building in San Francisco. In terms of regulations, the city enacted private sector green building requirements that became effective November 2008. Chapter 13C of the San Francisco Building Code will require new buildings constructed in the city to meet green building standards, which were developed by the Green Building Task Force. In addition, all municipal projects, both new construction and major renovations over 5,000 square feet, are required to achieve LEED Silver certification from the USGBC.

### Methodology

#### Study Area

This study uses America’s central cities as a unit of analysis. Central cities are defined as core urban areas; they often have higher poverty and crime rates with
Exhibit 5 | Distribution of Green Office Buildings

Exhibit 6 | Market Penetration; Top 10 Central Cities in 2009

<table>
<thead>
<tr>
<th>Central City</th>
<th>State</th>
<th>Green Office Buildings</th>
<th>Total Office Buildings</th>
<th>Market Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>CA</td>
<td>102</td>
<td>1,638</td>
<td>6.23%</td>
</tr>
<tr>
<td>Houston</td>
<td>TX</td>
<td>129</td>
<td>2,189</td>
<td>5.89%</td>
</tr>
<tr>
<td>Washington D.C.</td>
<td>DC</td>
<td>81</td>
<td>1,750</td>
<td>4.63%</td>
</tr>
<tr>
<td>Denver</td>
<td>CO</td>
<td>56</td>
<td>1,296</td>
<td>4.32%</td>
</tr>
<tr>
<td>Duluth</td>
<td>MN</td>
<td>5</td>
<td>118</td>
<td>4.24%</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>MN</td>
<td>23</td>
<td>593</td>
<td>3.88%</td>
</tr>
<tr>
<td>Seattle</td>
<td>WA</td>
<td>47</td>
<td>1,266</td>
<td>3.71%</td>
</tr>
<tr>
<td>Honolulu</td>
<td>HI</td>
<td>11</td>
<td>300</td>
<td>3.67%</td>
</tr>
<tr>
<td>Burlington</td>
<td>NC</td>
<td>4</td>
<td>112</td>
<td>3.57%</td>
</tr>
<tr>
<td>Chicago</td>
<td>IL</td>
<td>62</td>
<td>1,790</td>
<td>3.46%</td>
</tr>
</tbody>
</table>

Note: The data source is CoStar, Inc. (www.costar.com).
lower median household incomes than the surrounding Metropolitan Statistical Area (MSA). It is believed, moreover, that central cities have relatively poor environmental conditions, such as lower air and watershed quality, than suburban cities (Warner, 2001; Harner, Warner, Pierce, and Huber, 2002; Rast, 2006; Chambers, 2007). On the other hand, many job generators including commercial offices are concentrated in the central cities. This study assumes that green building policies are more common in central city areas than suburban areas. The principal cities of each MSA are considered the central cities, but not all central cities in the U.S. have green office buildings. Central cities without green office buildings are not included in the sample, leaving 103 central cities in the study. California has the most central cities (14) where such buildings exist, followed by Florida, North Carolina, and Texas, each with six central cities possessing green office buildings.

Data

The dependent variable is the market penetration rate of green office buildings in each central city (Exhibit 7). The market penetration of green office buildings is measured as the ratio of green office buildings to total office buildings. These data were obtained from CoStar, Inc.’s database (www.costar.com).

Each category of green building policies, including regulatory policy, administrative incentive, financial incentive, and technical support are coded as separate dummy variables. The policy categories are based on the following criteria:

- **Regulatory Policy**: New/rehabbed commercial buildings must Meet LEED or LEED-equivalent;
- **Administrative Incentive**: Priority building permit process, expedited development plan review, and marketing materials;
- **Financial Incentive**: Various tax incentives including tax credits and refunds, as well as various grants and rebates for green building development; and
- **Technical Support Incentive**: Technical support for construction or rehab methods, building preparation, site evaluation, material selection, and training.

This study uses average office rent expressed in dollars per square foot per year and average of office age to control effects of supply-side factors on green building development. The percentage of white population and the median household income are used to control the effects of demand-side factors on green building development. To account for the environmental motivations of green building initiatives, controls for the density of the carbon are integrated into the analysis. Since a significant number of sunny days may affect green building development (Simons, Choi, and Simons, 2009), it is reasonable to include the average temperature in July for last 30 years as a control variable.

Exhibit 8 shows basic statistics for the factors used as dependent variables and used for factor analysis in this study. The mean of market penetration of green
Exhibit 7 | Descriptions of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP</td>
<td>The market penetration rate of green office buildings (green office buildings/total office buildings).</td>
<td><a href="http://www.costar.com">www.costar.com</a></td>
</tr>
<tr>
<td>LNOFFICERENT</td>
<td>The natural logarithm of average office rent per year per square foot.</td>
<td><a href="http://www.costar.com">www.costar.com</a></td>
</tr>
<tr>
<td>LNOFFICEAGE</td>
<td>The natural logarithm of average office age.</td>
<td><a href="http://www.costar.com">www.costar.com</a></td>
</tr>
<tr>
<td>LNRBA</td>
<td>The natural logarithm of the average rentable building area.</td>
<td><a href="http://www.costar.com">www.costar.com</a></td>
</tr>
<tr>
<td>WHITE</td>
<td>The percentage of white population.</td>
<td>Census 2000</td>
</tr>
<tr>
<td>GRADUDEGREE</td>
<td>The percentage of graduate or professional degree.</td>
<td>Census 2000</td>
</tr>
<tr>
<td>LNINCOME</td>
<td>The natural logarithm of median household income.</td>
<td>Census 2000</td>
</tr>
<tr>
<td>LNCARBON</td>
<td>The natural logarithm of carbon density.</td>
<td><a href="http://www.airnow.gov">www.airnow.gov</a></td>
</tr>
<tr>
<td>LNOZONE</td>
<td>The natural logarithm of ozone density.</td>
<td><a href="http://www.airnow.gov">www.airnow.gov</a></td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>Average temperature in July since last 30 years.</td>
<td><a href="http://www.city-data.com">www.city-data.com</a></td>
</tr>
<tr>
<td>REGULATION</td>
<td>A dummy variable indicating the presence of the regulation policy.</td>
<td>Web Research</td>
</tr>
<tr>
<td>ADINCENT</td>
<td>A dummy variable indicating the presence of the administrative incentive.</td>
<td>Web Research</td>
</tr>
<tr>
<td>FINAINCENT</td>
<td>A dummy variable indicating the presence of the financial incentive.</td>
<td>Web Research</td>
</tr>
<tr>
<td>TECHINCENT</td>
<td>A dummy variable indicating the presence of the tech support incentive.</td>
<td>Web Research</td>
</tr>
</tbody>
</table>

Note: www.costar.com is the website of a commercial real estate information company. www.airnow.gov is a cross-agency government website that provides air quality information for the U.S.

Exhibit 8 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Penetration</td>
<td>0.04%</td>
<td>6.23%</td>
<td>1.38%</td>
<td>1.41%</td>
</tr>
<tr>
<td>Office Rent</td>
<td>$10.19</td>
<td>$52.82</td>
<td>$20.33</td>
<td>$7.01</td>
</tr>
<tr>
<td>Office Age</td>
<td>19.50</td>
<td>89.40</td>
<td>43.66</td>
<td>16.02</td>
</tr>
<tr>
<td>Rentable Building Area (SF)</td>
<td>809,261.00</td>
<td>494,050,780.00</td>
<td>36,360,186.74</td>
<td>59,707,504.82</td>
</tr>
<tr>
<td>White Percentage</td>
<td>7.00%</td>
<td>92.00%</td>
<td>52.91%</td>
<td>21.40%</td>
</tr>
<tr>
<td>Graduate Percentage</td>
<td>2.00%</td>
<td>49.00%</td>
<td>10.63%</td>
<td>6.61%</td>
</tr>
<tr>
<td>Median Household Income</td>
<td>$23,234</td>
<td>$99,102</td>
<td>$37,496</td>
<td>$9,852</td>
</tr>
<tr>
<td>Carbon Density</td>
<td>1.00</td>
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<td>Ozone Density</td>
<td>.04</td>
<td>.10</td>
<td>.08</td>
<td>.01</td>
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<tr>
<td>Temperature</td>
<td>62.80</td>
<td>92.80</td>
<td>76.78</td>
<td>5.94</td>
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office buildings is 1.38%. The mean of office rent square foot per year was approximately $20 and the mean of office age was approximately 44 years old. The highest temperature was 93 degrees while the lowest temperature was approximately 63 degrees. On the mean, cities included in this study have 77 degrees.

Exhibit 9 shows a distribution of central cities’ green building policies: 30 central cities have regulatory policies, 11 central cities use administrative incentives, 9 central cities have various financial incentives, and 6 central cities use technical support.

The Models

This study runs simple Ordinary Least Squares (OLS) regressions to determine which factors affect the market penetrations of green office buildings including public policies. The baseline OLS model in this study is expressed as in the reduced form:

\[
y = \beta_0 + \beta_1 \text{Supply} + \beta_2 \text{Demand} + \beta_3 \text{Env} + \beta_4 \text{Policy} + \epsilon \quad (1)
\]

Where:

\[\begin{align*}
y & = \text{Green building market penetration;} \\
\text{Supply} & = \text{A vector indicating supply-side variables;} \\
\text{Demand} & = \text{A vector indicating demand-side variables;} \\
\text{Env} & = \text{A vector indicating environmental variables} \\
\text{Policy} & = \text{A vector indicating policy variables; and} \\
\epsilon & = \text{The error term}
\end{align*}\]

However there is a crucial issue to run the OLS model with 14 variables in four factors because of the small sample size and possible correlation between independent variables. To minimize this issue in this study the baseline Model (1) is specified into four sub-models. Exhibit 10 presents model specifications in this study. All variables except public policy dummy variables are checked at least twice in the analysis.

<table>
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<tr>
<th>Policy</th>
<th>Frequency</th>
<th>Percentage</th>
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<td>Regulatory Policy</td>
<td>30</td>
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<tr>
<td>Administrative Incentive</td>
<td>11</td>
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<td>Financial Incentive</td>
<td>9</td>
<td>8.74%</td>
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<tr>
<td>Technical Support</td>
<td>6</td>
<td>5.83%</td>
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</table>

Note: Total central cities in sample is 103.
**Empirical Results**

Exhibit 11 presents estimation results of OLS regression analyses. Model 1 includes `LNOFFICERENT`, `WHITE`, `LNCARBON`, and `TEMPERATURE` with policy dummy variables. This model has a 0.636 adjusted $R^2$, which means that the variables explain approximately 64% of the total variation. In this model, `WHITE` is statistically significant at the 5% level with a negative sign, and `TEMPERATURE` is statistically significant at the 1% level with a positive sign, which means that cities with higher temperatures are more likely to show higher market penetration rates of green buildings. In this model, `REGULATION` is statistically significant at the 1% level, with a positive sign meaning cities adopted regulation policy are more likely to show higher market penetration rates while other incentive-based policies are not statistically significant.

Model 2 included `LNOFFICEAGE`, `LNINCOME`, and `LNOZONE` with policy dummy variables. This model has a 0.567 adjusted $R^2$, which means that variables explain approximately 57% of total variation. `LNOFFICEAGE` is statistically significant at the 1% level, with a positive sign, which means that cities with older office properties are more likely to have higher market penetration rates. In this model, both `REGULATION` and `ADINCENT` are statistically significant at the 1% level with positive signs, which mean that cities that adopted regulation or administrative incentive program are more likely to have higher market penetration rates.

Model 3 included `LNRBA`, `GRADUDEGREE`, and `LNOZONE` with policy dummy variables. This model shows a 0.543 adjusted $R^2$, which means that the variables
### Exhibit 11 | Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
<th>Model 3</th>
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<td>t-value</td>
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<td>0.359</td>
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<tr>
<td>REGULATION</td>
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<td>Adj. R²</td>
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Notes: N = 104.
*Significant at the 10% level.
**Significant at the 5% level.
***Significant at the 1% level.
explain approximately 54% of total variation. In this model, \textit{REGULATION} is statistically significant at the 1% level with a positive sign and \textit{ADINCENT} is statistically significant at the 5% level with the positive sign. Such results confirm the estimation results of Model 2.

\section*{Conclusions and Policy Implications}

Only recently have local governments started to look at their regional needs, as well as strengths and weaknesses to help develop individualized standards for implementing green building policies (Simons, Choi, and Simons, 2009). Numerous public policies have been implemented in the last ten years to promote green building in the private sector. Focusing on municipal policies, this study divided policies into two main categories: regulatory policy and incentive-based policy. In addition, this study also divided incentive-based policy into three sub-categories: administrative incentive, financial incentive, and technical support. Under regulatory policies, newly constructed or rehabbed buildings must meet LEED or LEED-equivalent requirements. Under administrative incentives, green building projects will pass through the plan review and approval process faster so that developers can save time and money. Using financial incentives, green building developers can get various tax credits, funds, and rebates. Technical support occurs when a municipality provides every effort for the developers to get their properties as green certified.

Using American central cities as the unit of analysis, this study conducted OLS regression analyses. In the regression models, the municipal regulatory policies, the municipal administrative incentive, the municipal financial incentive, and the municipal technical support were coded as four distinct dummy variables. The model controlled for the effects of various external factors driven by the literature review.

Strong effects of the municipal regulatory policy on green building development have been pointed out (Simons, Choi, and Simons, 2009). In fact, many central cities with higher market penetration rates of green buildings have mandated regulatory policies; such policies are found in the top three central cities (San Francisco, Houston, and Washington, DC). Not surprisingly, the effects of regulatory policy on green building developments were found by estimation of this study.

It is interesting that the municipal administrative incentive has a significant impact on green building development. Through “priority building permit process” and “expedited development plan review” developers can save time and money. Green building projects pass through the process faster and will be approved more quickly through the plan review phase (Yudelson Associates, 2007). This result suggests that developers consider permit and approval processes as barriers to building development. Simons, Choi, and Simons (2009) pointed out that difficulties involved with identifying appropriate architects, construction firms, construction materials, legal counsel, and other development necessities can
lengthen the project schedule. Delays often lead to greater risks and higher costs that developers would rather avoid, given tight budgets and time frames. In this context, faster building approvals and permitting processes for green building projects lower the risks for the private sector developers with the added benefit of promoting greener construction.

On the other hand, financial incentives have not worked as a tool for green office building developments. Yudelson Associates (2007) listed municipal financial incentive programs for the private sectors. These programs include tax credits, refunds/abatements, bond funds, loan/loan funds and various fees as mentioned. It is quite interesting that, although many central cities are under these financial incentive programs, monetary supports have not worked for private sector green building developments. This result may imply that financial incentives have been in name only or developers have not shown interest in such incentive programs because they could not offset construction or rehab costs due to greening properties. Simons, Choi, and Simons (2009) found that in many cases, particularly in California, existing financial incentives were rarely disbursed to developers. This does not eliminate the possibility that the monetary incentives provided by central cities cannot offset greening costs.

Future researches will focus on the role of green buildings in urban sustainability in the U.S. These research topics will enumerate positive externalities of green building development in urban areas in terms of suitability.

**Appendix**

**Green Building Policy Profile of America’s Central Cities**

<table>
<thead>
<tr>
<th>States</th>
<th>Central City</th>
<th>Regulation</th>
<th>Incentive-Based</th>
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### Appendix (continued)

#### Green Building Policy Profile of America's Central Cities

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## Appendix (continued)

### Green Building Policy Profile of America’s Central Cities

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Note: Policies obtained from the web-based search done by the author. Some cities may be omitted from the table, therefore, if they implemented green building regulations or incentives since the web-based search was completed in October 2009.

## References


Corporate Real Estate and Corporate Sustainability Reporting: An Examination and Critique of Current Standards

Authors
Steven P. Laposa and Sriram Villupuram

Abstract
This article examines Global Reporting Initiative’s (GRI) corporate sustainability reporting standards and identifies existing and missing linkages with corporate real estate disclosures. Based on an analysis of the GRI reporting standards, results of corporate real estate content analysis in the 45 corporate sustainability reports examined, along with the low explanatory power of the models, there is evidence that establishes a lack of clear and consistent coverage of corporate real estate in corporate sustainability reports. There is a strong need for further disclosure, standardization of several corporate real estate-related reporting benchmarks, and increased transparency with respect to corporate owned or leased properties in corporate sustainability reports.

There is a growing body of literature on corporate sustainability accounting and reporting standards. Yet within this body of literature and policies, specific standards do not necessarily reflect the direct or indirect relationships of corporate real estate assets, practices, and strategies to corporate sustainability, social responsibility, or citizenship actions or reporting standards. As more private and public corporations, non-government organizations (NGOs), and government entities prepare and report on sustainability, citizenship, or social responsibility actions, it is important to independently examine and critique existing and underlying standards that form the basis of these reports especially in limited, but critical subject areas such as corporate real estate, which includes such assets as a firm’s facilities, headquarters, manufacturing plants, mines, office or retail locations, corporate campuses, or industrial sites.

Corporate sustainability, corporate citizenship, and social responsibility reporting standards and practices do not include sufficient data and management discussion regarding the operations, acquisitions, dispositions, or abandonment of corporate real estate assets, whether owned or leased, to produce meaningful and transparent stakeholder information and knowledge. Reporting standards do not necessarily include requirements or recommendations on how or where to include relevant disclosure and discussion between the roles of an entity’s corporate real estate owned, leased, or managed assets to sustainability standards or practices within a corporate report. Thus it is reasonable to expect inconsistency, minimal transparency, and a lack of specific corporate real estate-oriented discussion in corporate sustainability, citizenship, or social responsibility reports.
There are two basic questions addressed in this study. The first question is why corporate real estate is a critical subject that requires significant discussion in corporate sustainability reporting, and second, how do current sustainability and social responsibility global reporting standards generally address corporate real estate, and more specifically the sustainability characteristics of a firm’s commercial corporate real estate assets such as offices, industrial warehouses, facilities, plants, or other non-residential property types. If there is a significant relationship between management and operations of corporate real estate assets to sustainability, then is it not rational to expect sufficient detail and disclosure in corporate sustainability or social responsibility reports?

There are two reasons that confirm a direct linkage between corporate real estate and corporate sustainability actions and strategies. First, corporate real estate represents a sizeable universe and large segment of corporate balance sheets and expenses (Rodriguez and Sirmans, 1996; Roulac, 2003), and an integral part of corporate strategy (Roulac, 2001). Commercial property types are necessary for the production of goods and services as economic activity does not exist in a spatial vacuum. Corporations include property, plant, and equipment on their respective balance sheets. For example, ExxonMobil’s annual report for December 2009 included approximately $139.1 billion of property, plant, and equipment (net) out of total assets of $233.3 billion. ExxonMobil’s corporate citizenship report (2008), which follows the reporting guidelines of the International Petroleum Industry Environmental Conservation Association (IPIECA) and the American Petroleum Institute (API)’s guidelines, includes respectful coverage topics such as facilities and greenhouse gas emissions, waste discharge, and energy usage, but limited discussion on properties or facilities that are abandoned, scheduled for decommissioning, or locations where the sustainability of the local community is negatively affected by the firm’s decision such as the recent BP oil disaster in the Gulf of Mexico. When firms downsize operations and abandon properties, close operations, and cancel leases, this has a spillover impact on economic vitality and sustainability in local markets. The recession in the United States has caused Blockbuster to cancel leases in 545 stores in 2010 and Circuit City closed 567 stores in 2009, leaving long-term physical assets abandoned and dark. Corporations can abandon previously owned properties creating high-impact temporarily obsolete abandoned derelict sites (HI-TOADS), as discussed by Hollander (2009), which impact the sustainability and economic vitality of local communities.

Corporate sustainability reporting standards need to recognize that corporations require various property types, whether owned or leased, to operate their business. There are environmental and sustainability differences of various property types based on the operation and management of such assets. The distributions of commercial real estate property types, identified as corporate real estate assets on a balance sheet, are somewhat unique to various economic sectors. For example, service-oriented firms such as financial institutions and banks, generally use office buildings to conduct business, whereas a utility firm or manufacturer will use industrial plants, warehouses, and distributions centers. Differences exist in the number of locations, property types, and sizes of corporate owned non-residential
assets required to produce an economic good or service. Manufacturing firms differ from information service, retailers, and other service-oriented firms in the demand for property, just as significant differences exist between similar industrial sectors based on the nationality of firms (Laposa and Charlton, 2002).

The second reason to elevate corporate real estate disclosure in corporate sustainability reporting is the relationship between commercial real estate, greenhouse gases (GHG), energy consumption, waste management, and sustainability. If the operation and management of corporate real estate is a significant negative or positive factor in social responsibility, citizenship, or sustainability actions, then global sustainability reporting institutions need to review existing standards and modify as necessary to address the critical environment role of corporate real estate assets. Commercial real estate is a depreciating asset in functionality without continued maintenance and capital improvements. The U.S. Department of Energy, Energy Information Administration estimates that the median lifetime for an office building is 73 years, warehouses 80 years, and lodging 80 years. As corporate real estate assets age so too the requirement of periodic capital improvements to maintain operation efficiencies and to mitigate structural obsolesces that potentially create negative environmental impacts.

Academic, industry, and governments produce reports on energy usage in the commercial real estate sector. Variations in such reports depend on several factors such as definitions of the building sector or whether direct, indirect, or total energy consumptions are separately indicated. For example, the U.S. Department of Energy, Buildings Energy Data Book reports that the building sector, including residential and commercial sectors, “...consumed 39% (38.77 Quads) of U.S. primary energy in 2006,” (D&R International, 2009) with residential accounting for approximately 20% and commercial 18% of primary energy consumption in 2006. Global GHG related to residential and commercial buildings are also estimated at 7.9% in 2004⁵ and the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report estimates that “...when including the emissions from electricity use, energy-related CO₂ emissions from the buildings sector were 8.6 Gt/yr, or 33% of the global total in 2004.”⁶ The IPCC also reports that “…the largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry, while residential and commercial buildings, forestry (including deforestation) and agriculture sectors have been growing at a lower rate,” (Pachauri and Reisinger, 2007).

Cost-effective retrofits of existing commercial buildings have been recommended as a critical component of reducing GHG emissions in the U.S. (Brown, Southworth, and Stovall, 2005; McKinsey & Company, 2007). Urge-Vorsatz, a contributor to the IPCC report, claims that commercial buildings offer “…the largest low-cost potential in all world regions by 2030” to reduce GHG (Urge-Vorsatz, 2007). According to another study, there are three options of reducing greenhouse gas emission; one option identifies the real estate sector. Levine identifies: “...reducing energy consumption and embodied energy in buildings, switch to low-carbon fuels including a higher share of renewable energy, or
controlling the emissions of non-CO$_2$ GHG gases,” (Levine, Urge-Vorsatz et al., 2007).

The hypothesis explored in this article is that corporate sustainability reporting standards, such as the Global Reporting Initiative (GRI), do not include corporate real estate disclosure requirements commensurate with corporate real estate’s role and impact in sustainability and the environment. Other prominent international agreements such the U.N. Global Compact do not specifically address corporate real estate’s role in corporate citizenship; rather there are important, yet limited factors including environmental guidelines for suppliers, corporate environmental policies, and greenhouse gas inventory of operations (Fussler, 2004). Triple bottom line (TBL) reporting standards and even the word ‘sustainability’ is an emerging trend, still evolving in definition in the industry, the scope and application of sustainability, and finally acceptance for firms, whether public or private, large or small. Surveys find that even in the institutional real estate investment arena, acknowledgement of sustainability is still not a significant role in investment decisions (GVA Grimley, 2007; Sustainable Facility, 2007), but is slowing showing signs of acceptance with real estate companies (Mattson-Teig, 2007).

Despite the limited requirements in corporate sustainability reporting standards and similar broad-based international agreements, a sample of corporations include corporate real estate management and operations in corporate sustainability reports. Exhibit 1 highlights selected text from a sample of corporate sustainability reports that include corporate real estate or facilities references.

This research bridges an existing gap in the literature between corporate real estate and corporate sustainability reporting. Corporate real estate is a critical asset and a sizeable universe that directly and indirectly impacts the environment. The Literature Review briefly highlights the role of corporate real estate in a corporation and then discusses recent research on corporate real estate and environmental and sustainability issues. There are three bodies of literature relevant to corporate real estate and corporate sustainability reporting: corporate real estate, corporate sustainability reporting standards and practices, and corporate sustainability reporting analysis and research. A separate section examines existing Global Reporting Initiative standards and how they address corporate real estate or how, with minor modifications, can improve corporate real estate disclosure in corporate sustainability reports. The Methods and Data introduces the academic standards applied to the collection and analysis of corporate real estate content in the sample 45 corporate sustainability reports, which is followed by the Results. Finally, the Conclusion summarizes the findings, outlines limitations of this research, and presents ideas for further research.

Literature Review

The management and operations of corporate real estate were initially identified as ‘undermanaged’ (Veale, 1989), but eventually evolved to include corporate real estate as an integral part of corporate strategy (Nourse and Roulac, 1993). Later
Exhibit 1 | Sample Corporate Real Estate References in Corporate Reports

<table>
<thead>
<tr>
<th>Company, Report Title, Year</th>
<th>Reference Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergan, Sustainability Performance Report (2009)</td>
<td>Reduce the amount of electrical energy used by 5% from 2006 to 2010 using 2005 as the baseline year both on an absolute and normalized to square footage basis. Implement existing technologies such as cogeneration and photovoltaic systems. Implement new technologies such as fuel cells. Change the fuel types used from fuel oil to natural gas. Increase the fuel efficiency. Increase the use of renewable energy sources.</td>
</tr>
<tr>
<td>Bristol-Myers Squibb, Sustainability Website Contents (2009)</td>
<td>We are setting land aside for conservation in a wide range of our operations worldwide. Our campuses for manufacturing, R&amp;D, distributions and administrative offices are able to conserve habitats, including forests, grassland, marshes, bogs and reefs. We are planting trees, installing birdhouses and more. Many of our facilities worldwide have adopted and support a local endangered or threatened species, in many cases with direct involvement of site employees.</td>
</tr>
<tr>
<td>SAS Institute, Corporate Social Responsibility Report (2008)</td>
<td>Our Austin office is the only other SAS-owned facility in the United States. It is located on 94 acres of mostly undisturbed land and features grounds where deer and other wildlife freely roam. Only about three acres are used for facilities and access roads. It has intentionally been left wild and features a long, winding driveway and natural walking trails surrounding the more landscaped areas around the building. The property is home to several types of endangered birds and spiders, which are protected by landscaping and conservation guidelines to include the Balcones Canyonlands Conservation Plan (BCCP). The BCCP is a joint venture of the City of Austin and Travis County that protects habitats for several locally occurring species protected under the federal Endangered Species Act. SAS works closely with BCCP managers in a joint effort to maintain the natural integrity of these important habitats.</td>
</tr>
</tbody>
</table>
### Exhibit 1 | (continued)
Sample Corporate Real Estate References in Corporate Reports

<table>
<thead>
<tr>
<th>Company, Report Title, Year</th>
<th>Reference Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pfizer, Corporate Responsibility Report (2009)</td>
<td>In 2008, as part of our Plant Network Strategy productivity initiative, eight plants were sold or closed in Canada, Germany, Italy, Sweden, Puerto Rico and the U.S. We plan to continue reducing our internal network of plants worldwide to 41 by 2010. It should be noted that often facilities are divested to other companies with an agreement to supply Pfizer for several years. This allows the acquiring company to develop additional business to make the plant sustainable. We never make these decisions lightly, realizing how difficult they are for our colleagues and their families who are impacted. However, we believe that the cumulative benefit to Pfizer will be a more focused, streamlined and competitive manufacturing operation.</td>
</tr>
<tr>
<td>Dell Corporation, Inspire &amp; Innovate, Achievements in Corporate Responsibility (2009)</td>
<td>Incorporated LEED design elements into global design standards Dell is a corporate member of the U.S. Green Building Council, a nonprofit organization dedicated to expanding green building practices and education and promoting the use of its LEED…Green Building Rating System…Our long-term goal is to double the “greenness” of our buildings and operations, using the scoring system created by the U.S. Green Building Council’s LEED program. A few of the related activities undertaken in fiscal year 2008 include: (a) our manufacturing facility in North Carolina adopted a green cleaning program; it mandates cleaning products and techniques designed to be gentler to the environment and promote improved indoor air quality. We composed a new Dell global design guide that incorporates many of the LEED requirements for sustainable building design, construction and operation.</td>
</tr>
<tr>
<td>Coca Cola, Live Positively, Sustainability Review (2008/2009)</td>
<td>As we build new facilities, we seek to make them as energy efficient as possible. In Great Britain, our new Automated Stock Retrieval System at our Edmonton facility…has eliminated the need for separate warehousing and distribution. Meanwhile, our new warehouses in Toulouse, France, and Ghent, Belgium, have eliminated the need for heating through the use of better insulation. In the United States, we are working toward attaining Leadership in Energy and Environmental Design (LEED™) Certified status from the U.S. Green Building Council for our new sales center in Coachella, California. This requires meeting targets for reducing non-process water and energy use, using recycled and regional materials, and diverting 75 percent of construction waste.</td>
</tr>
</tbody>
</table>

*Source: Company reports.*
studies estimated that corporate real estate represents approximately 25% to 40% of total corporate assets (Rodriguez and Sirmans, 1996) and the body of literature on corporate real estate research continues to expand in topics and (Manning and Roulac, 2001).

The role of corporate real estate in corporate sustainability strategies is an emerging body of literature. New studies confirm the benefits of green buildings on energy savings, with one study showing 26% less energy use, 13% lower maintenance costs, 27% higher occupant satisfaction, and 33% fewer CO₂ emissions (Powell, Fowler and Parman, 2009). A multiple case study using life cycle analysis concepts estimated that facilities activities caused over 50% of environmental impact of service firms although facility-related expenses account for 5% of total expenses (Junnila, 2004). Another survey of corporate real estate executives indicated that 57% are now involved in funding sustainability investments, 49% are adding sustainability staff, 44% rate suppliers’ sustainability, and 53% indicate improved communications with senior management due to sustainability issues (Bloomfield and Kadzis, 2009). Numerous surveys indicate a trend toward sustainability or environmentally-friendly practices in the real estate industry (Mattson-Teig, 2007; Sustainable Facility, 2007; Environmental Design & Construction, 2008), and also integrating corporate social responsibility with property investment (Roberts, Rapson, and Shiers, 2007). The role of corporate real estate executives to justify management and operations of properties to benefit the environment is challenging (Roper and Beard, 2006) just as the limited universe of environmentally-accredited properties impact corporate location decisions to support strategies to increase the percentage of leased space in such certified locations (St. Lawrence, 2004). There is a complex system of environmental ratings for the built environment (Reed, Bilos, Wilkinson, and Schulte, 2009), and the importance of incorporating building efficiency into capital improvements for properties is gaining respect (Reed and Wilkinson, 2005).

Early research on corporate social responsibility and financial performance dates back to the 1960s (Cochran and Wood, 1984). Cochran and Wood (1984) found a significant relationship between the average age of corporate assets to corporate social responsibility rankings, specifically finding that “Asset age and asset turnover are related with Moskowitz’s CSR categories.” In particular, asset age is strongly and significantly negatively correlated with the “worst” CSR firms. In addition, asset turnover is weakly correlated to Moskowitz’s ratings. Thus, one impediment to disclosing critical information on corporate real estate assets is the potential stigma that as the average age of corporate assets increases for buildings, plants, and facilities, the lower potential for corporate social responsibility ranking and requirements for environmental mitigation strategies. Furthermore, if industry standards such as Global Reporting Initiative do not require significant discussion or metrics for corporate real estate assets, then the motivation to report on corporate real estate assets at a critical level of age or functional obsolesces is diminished. Research has shown that the service sector compared to chemicals, manufacturing, and the oil and gas sectors, has the least social pressure regarding those stated (e.g., published reports vs. actual or implemented environmental strategies) (Ramus and Montiel, 2005). Corporate real estate portfolios of service
sector firms generally include property types as office, retail, or flex properties that are less susceptible to impacting the environment, such as refineries, large-scale manufacturing plants, and processing facilities.9

Corporate sustainability reporting continues to increase in the number of reporting entities, academic research, and acceptance in the industry although less than 100 U.S. firms produced sustainability reports in the early 1990s (White, 2005). The continued increase in the number of firms publishing corporate sustainability reports has caused a complimentary increase in reporting sustainability standards, research, and auditing guidelines (O’Dwyer and Owen, 2007). O’Dwyer and Owen (2007) provide a synopsis of recent history and trends in the corporate sustainability accounting literature. The authors use a sample of 51 award-winning sustainability reports and compare them by AA1000, FEE, and GRI reporting standards. Growth in corporate sustainability reporting has significantly increased in the largest 100 global firms (Milne and Gray, 2008) and the Fortune Global 250 (Kolk, 2003). Yet, there are questions on the one-size-fits-all concept to corporate sustainability practices across geographies, sectors, and maturity of firms (Marrewijk and Were, 2003) including standards for corporate real estate reporting standards. Paul (2008) shows minimum corporate real estate discussion based on website content of the Global 100 Most Sustainable Companies.

Corporate sustainability assurance reporting is an emerging field of practice by corporations. Current practices across geographies, governments, and stakeholder participation are not necessarily the same in quantity or quality (Kolk and Perego, 2008). Environmental, social, or citizenship reporting has improved the social responsibility of corporations, yet current practices lack sufficient disclosure, dialogue, or development of sustainable issues (Hess, 2008). Models have been proposed to improve the communication framework and moral discourse between corporations and stakeholders as corporate sustainability reporting continues to evolve (Reynolds and Yuthas, 2008). Several studies question the relevance of corporate environmental policies, even claiming they may be a form of greenwashing (Ramus and Montiel, 2005), rhetorical or disingenuous (Aras and Crowther, 2009), or ‘self-laudatory’ communications (Holder-Webb, Cohen, Nath, and Wood, 2009). Ramus and Montiel (2005) find that service companies are more likely to commit to sustainable development policies rather than manufacturing, hinting at a potential moral hazard issue in corporate real estate as manufacturing firms are more likely to own and operate facilities with environmental issues than service-oriented firms.

Global Reporting Initiative Analysis

Corporate sustainability reporting standards are still evolving. Organizations such as the Global Reporting Initiative10 (GRI) originally published corporate sustainability guidelines in 2000 (G1), 2002 (G2), and 2006 (G3). According to a KPMG report, corporate sustainability reports following the GRI standards account for 77% of global Fortune firms.11 According to GRI, the purpose of “Sustainability reporting is the practice of measuring, disclosing, and being accountable to internal and external stakeholders for organizational performance
towards the goal of sustainable development.” Furthermore, GRI provides guidance on report content, protocols such as indicators, sector supplements, and technical and standard disclosures.

GRI’s reporting standards are summarized by three standard disclosures: (1) strategy and profile, (2) management approach, and (3) performance indicators. Real estate, property, or the built environment terms are not found in the latest reporting standard recommendations (2006). Although corporate real estate’s characteristics fit well in the performance indicators such as how much space is used in the business (year-over-year changes), number of international, national, regional, and local offices, plants, or places of business operations, such performance indicators do not exist in current GRI standards. The standards do address locations, limited to reporting significant changes in a company’s locations or, under the environmental performance indicators (section EN11) on biodiversity, GRI standards recommend the “Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.” Overall, there is not even a requirement to include a simple lifecycle matrix of corporate real estate assets by such factors as location, age distributions, energy-ratings, operating or abandoned, or property types.

Global Reporting Initiative is recognized as the leading international organization setting forth reporting standards for environmental reporting for corporations. The rise of GRI, from two individuals in the late 1990s, to the leading global sustainability guidelines entity is a classic case of institutional entrepreneurship (Brown, de Jong, and Lessidrenska, 2009). GRI’s sustainability guidelines have evolved since the initial standards in 2000 with recent standard edition of 2006 known as the G3 reporting guidelines. Exhibit 2 briefly identifies several GRI sections and expands the description of sections to include direct and indirect corporate real estate implications not specifically recommended in current standards. Included in this exhibit there are suggested modification of existing standards to address and accommodate corporate real estate disclosures. Based on the analysis and review of numerous corporate sustainability reports, the corporate real estate implications listed in Exhibit 3 are lacking in the majority of sustainability reports.

In addition to the general reporting guidelines, GRI produces sector guidelines for such industries as apparel and footwear, airports, food processing, community impacts, and the construction and real estate sector. One of the top five topics for community impacts listed in the GRI guidelines is community expenditures that includes the number of projects developed and completed. According to the GRI analysis and research, “The practice of sustainability reporting is not as well established in the Construction and Real Estate (C&RE) compared to other sectors, such as the financial services or the electric utilities sectors.” Although GRI recognizes the lack of sustainability reporting in the construction and real estate industries, an examination of GRI 2006 standards clearly indicates a lack of corporate real estate disclosures and transparencies for the non-construction and real estate industries regarding current and future operations and management of corporate real estate assets.
### Exhibit 2 | GRI Standards and Real Estate

<table>
<thead>
<tr>
<th>GRI Section</th>
<th>Description</th>
<th>CRE Implications Not Specifically Addressed in GRI Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization profile, section 2.9 (Reporting Guidelines)</td>
<td>The location of, or changes in operations, including facility openings, closings, and expansions.</td>
<td>Direct property linkages, yet no requirement on corporation’s summary square footage or square meter data, properties and certification status or strategies for new construction properties, matrix of properties by lifecycle stage, table of owned properties, size of properties, type of properties, age of properties especially list of at-risk properties due to functional obsolesce, environment contaminants, or subject to national or local changes in building or certification codes.</td>
</tr>
<tr>
<td>EN11</td>
<td>Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.</td>
<td>Does not include land owned or leased not adjacent to protected areas; not required if corporation’s real estate assets listed under section 2.9.</td>
</tr>
<tr>
<td>EC1</td>
<td>Economic Value Generated and Distributed (EVG&amp;D); monetary value to local economies.</td>
<td>Identify revenues from sale or donation of property and other assets that benefit local economies.</td>
</tr>
<tr>
<td>EC2</td>
<td>Financial implications and other risks and opportunities for the organization’s activities due to climate change.</td>
<td>List significant scheduled or planned capital improvements to maintain, rectify, or certify corporate owned properties.</td>
</tr>
<tr>
<td>EN3, EN4, and EN5</td>
<td>Direct energy consumption by primary energy source. Indirect energy consumption by primary source. Energy saved due to conservation and efficiency improvements.</td>
<td>Standardize direct and indirect energy consumption according to corporate real estate inventory of properties; discuss energy savings due to efficiency improvements for corporate owned properties.</td>
</tr>
<tr>
<td>EN13</td>
<td>Habitats protected or restored.</td>
<td>Discuss the role of corporate real estate properties or facilities in protecting or restoring habitats.</td>
</tr>
<tr>
<td>EN16, EN17, and EN18</td>
<td>Total direct and indirect greenhouse gas emissions by weight. Other relevant indirect greenhouse gas emissions by weight. Initiatives to reduce greenhouse gas emissions and reductions achieved.</td>
<td>Standardize direct and indirect greenhouse gas emissions according to corporate real estate inventory of properties, e.g., GHG per square foot or square meter; discuss initiatives to reduce greenhouse gas emissions relative to efficiency improvements for corporate owned properties.</td>
</tr>
<tr>
<td>SO1</td>
<td>Nature, scope, and effectiveness of any programs and practices that ...manage the impacts of operations on communities, including entering, operating, and exiting.</td>
<td>Identify corporate owned properties scheduled for disposition, abandonment, or closing; identify significant corporate leased properties scheduled for closure or nonrenewal that may negatively impact local communities.</td>
</tr>
</tbody>
</table>
**Methods and Data**

Although existing GRI standards do not adequately or consistently address corporate real estate in corporate sustainability reporting as shown in Exhibit 2, Exhibit 1 shows that several corporations include corporate real estate disclosures in CSRs. In order to test the hypothesis that corporate real estate content is deficient in CSRs, a diverse sample of CSRs were initially collected and reviewed, which focused on the corporate real estate disclosures related to the GRI sections listed in Exhibit 2. Content analysis methodologies were used as in previous research to further empirically test for corporate real estate coverage in the 45 sample CSRs.

This study recognizes the limitations and consistent reliability issues associated with the application of content analysis and corporate reporting. In order to mitigate potential bias, all corporate sustainability reports were obtained from a single source, the CorporateRegister.com\textsuperscript{15} website, a site devoted to collecting corporate sustainability reports produced under the Global Reporting Initiative, AccountAbility AA1000, or Global Compact standards and guidelines. All reports used in this study were produced under the GRI guidelines and included reports...
from 2008 or 2009. Thus, the restricted use of the sample reports from one source, developed under the same guidelines, limits content analysis problems due to inconsistency of documents as identified by Unerman (2000). Unerman’s review of 25 articles on the use of content analysis of corporate reporting also highlights various measurement methods employed in the literature.

Content analysis has been used for over 30 years in analyzing corporate audit reports (Fisher, Oyelere, and Laswad, 2004), chairman’s statements (Smith and Taffler, 2000), web-based triple bottom line reporting according to GRI indicators (Gill and Dickinson, 2008), developing economies and country level sustainability reporting (Belal, 2001; Skouloudis, Evangelinos, and Kourmousis, 2010), and social, environmental, and accounting reports (Guthrie and Abeysekera, 2006). Early research applied content analysis to identify minor relationships between environmental disclosures and social performance indicators (Ingram and Frazier, 1980). Milne and Adler (1999) provide a significant list of content analysis used in social and environmental accounting report analysis and find general correlation between content analysis results by experienced and non-experienced users. In the real estate sector, content analysis has recently been used to compare commercial versus residential brokerage websites (Henderson and Cowart, 2002) and used to examine corporate social responsibility reporting via websites, annual reports, and social responsibility reports of the top 10 hotel firms (Holcomb, Upchurch, and Okumus, 2007).

Content analysis methodologies found in the literature are employed and applied using a computer-assisted quantitative software application (NVivo 8.0). Initially, over 100 reports were randomly selected from the Corporate Register website. According to its website, Corporate Register is the largest online depository of corporate sustainability reports, whereas GRI lists 1,251 corporate sustainability reports covering over 35 industry sectors for 2009. Final sample selection was impacted by security and password protections of the Adobe Acrobat corporate sustainability files, which limited complete importing of the CSR files into NVivo (see Exhibit 3 for list of 45 companies). If NVivo was not able to successfully import the entire CSR file, then the respective firm was excluded from the final sample. Sectors represented by the 45 final firms include several of the top sector rankings as identified by GRI and include the following number of firms by sectors: healthcare and healthcare products (6), energy and energy utilities (7), technology and computer hardware (6), consumer (11), manufacturing (5), financial services (6) and other (4).

Exhibit 4 shows the textual queries initially used in the analysis with descriptions and limitations. Wildcards and other criteria such as ‘corporate within 10 words of property’ were used to expand and identify potential CRE-related content. Each text or phase was individually searched in all corporate sustainability reports in the sample. Once a query identified a text or phrase in the respective report, the entire sentence was highlight and coded. There are debates in the literature on the measurement methods used in content analysis and corporate reporting. For example, the literature shows a broad and diverse set of methods from counting words or whole sentences relevant to a set of codes or themes. Sentences were used as the unit of analysis measurement and pictures of corporate real estate were
Exhibit 4 | CSR Textual Queries

<table>
<thead>
<tr>
<th>Text Queries</th>
<th>Description, Objectives, and Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land, lands</td>
<td>Corporate land, not including landfill usage</td>
</tr>
<tr>
<td>CASBEE, BREEAM, ENERGY STAR, LEED, USGBC, ISO 14001, Green building or green buildings</td>
<td>Facility certifications, inclusion of standard industry associations that certify the environmental characteristics of commercial properties</td>
</tr>
<tr>
<td>Corporate property, corporate properties, or corporate real estate, property or properties, facility or facilities, property near within 10 words of corporate, office, plant or plants, headquarter, location or locations, square feet or square meters</td>
<td>General references to inclusion of corporate properties, facilities, plants, locations, measurements of corporate properties</td>
</tr>
</tbody>
</table>

excluded, although there are several reports in the sample that included photographs of buildings and facilities. NVivo summarized each text or phrase’s coverage in a report by dividing the selected sentence or sentences that included the text or phrase by the overall report area.

Once a specific text or phrase was identified in the CSR, the relevant sentences containing the text or phrase were coded into one of 20 nodes in NVivo. A node is a classification structure that collects similar results from textual queries. For example, in Exhibit 4, there are numerous texts and phrases associated with general references to corporate properties and other queries associated with facility certifications. Therefore, selected texts identified within all corporate sustainability reports coded by the various general corporate property phrases were coded to the corporate properties reference node. As previously mentioned, pictures and graphs were not included in any textual query. Facilities and sustainability (136.69 average words per report) and LEED references (125.73 average words per report) ranked first and second respectively as top nodes by average words per report. Exhibit 5 lists the 20 nodes with the average number of words per report per node.

After all text or phrases were identified and coded, the 20 nodes were summarized into four primary variables. The four variables essentially clustered similar nodes. As Exhibit 5 illustrates, several nodes had minimal average number of words and thus coverage percentages were minor. For example, the codes beginning with ‘EN’ collectively identified content areas in the CSRs associated with GRI guideline references. We combined the ‘CASBEE, BREEAM, or ENERGY STAR,’ ‘ISO 14001 and corporate properties,’ and ‘LEED references’ nodes into a facility certifications variable to estimate the coverage corporations include in corporate sustainability reports and not necessarily individual LEED, CASBEE, or ENERGY STAR references. Exhibit 6 illustrates the relationships between the 20 nodes to the four summary variables.

Although the primary focus of this research is to highlight and examine corporate real estate coverage in corporate sustainability reports, the typical list of corporate
variables is extended such as firm size, industry sector, and profitability as outlined by Raar (2007) that attempt to explain content analysis results. This study introduces three new real estate-related financial benchmarks as independent variables to explain variances of corporate real estate content in corporate sustainability reports. The three CRE benchmarks are shown in Exhibit 7 and proxy the ratios of corporate owned or leased real estate-related assets. The
Exhibit 7 | Corporate Real Estate Financial Benchmarks

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Description and Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property, Plant, and Equipment (net)/Total Assets (OWN)</td>
<td>Proxy for a firm’s corporate real estate ownership intensity.</td>
</tr>
<tr>
<td>Rental commitments five years/Net income (RENT)</td>
<td>Proxy for a firm’s corporate real estate leasing intensity.</td>
</tr>
<tr>
<td>OWN/RENT (OwnRent)</td>
<td>Ratio of owned versus leased properties used by the firm.</td>
</tr>
</tbody>
</table>

Rational is that if a corporation has a higher ratio of property, plant, and equipment to total assets, then the quantity of reporting on corporate real estate assets is theoretically more likely and higher than for a firm with low property, plant, and equipment ratio that leases more than owns properties. Conversely, corporations that primarily rent real estate assets are less likely to include corporate real estate disclosures in corporate sustainability reports. As tenants and users of properties owned and managed by others, corporations find that they are occupiers, not owners of real estate and thus sustainability is someone else’s problem as noted as one of the myths of corporate real estate and corporate sustainability in CoreNet Global’s survey (Kadzis, 2007).

Based on the calculated corporate real estate content percentages ($CRE_p$) in a CSR and the three corporate real estate financial benchmarks, the following models were constructed to test the hypotheses that $OWN$, $RENT$, and $OwnRent$ explain variances of corporate real estate coverage in corporate sustainability reports:

Exhibit 8 | Descriptive Statistics 45 CSRs

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>4.83</td>
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<td>CRE references (%)</td>
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<td>3.16</td>
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<td>GRI CRE references (%)</td>
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<td>Facility and sustainability (%)</td>
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<td>0.00</td>
<td>29.63</td>
<td>3.362</td>
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<tr>
<td>CRE coverage as % of total ($CRE_p$)</td>
<td>45</td>
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<td>31.01</td>
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<td>CRE coverage total words</td>
<td>45</td>
<td>0.00</td>
<td>4159.00</td>
<td>717.844</td>
<td>918.633</td>
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<tr>
<td>Net PPE to Total Assets (OWN)</td>
<td>45</td>
<td>0.01</td>
<td>0.777</td>
<td>0.271</td>
<td>0.227</td>
</tr>
<tr>
<td>Rent 5 yrs to Net Income (RENT)</td>
<td>40</td>
<td>-16.01</td>
<td>4.867</td>
<td>0.046</td>
<td>3.051</td>
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<tr>
<td>PPE to Rent ratio (OwnRent)</td>
<td>40</td>
<td>-0.56</td>
<td>9.685</td>
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<td>Valid N (listwise)</td>
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**Exhibit 9 | CRE Coverage and Four Factors Correlations**

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<tr>
<th></th>
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<th>CRE References</th>
<th>GRI References</th>
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<th>CRE Coverage as % of total</th>
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<td>CRE references</td>
<td>Pearson Correlation</td>
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<td>Sig. (2-tailed)</td>
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<td>45</td>
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<td>GRI CRE references</td>
<td>Pearson Correlation</td>
<td>-0.151</td>
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<td>Sig. (2-tailed)</td>
<td>0.322</td>
<td>0.482</td>
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<td>N</td>
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<td>Facility and sustainability</td>
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<td>N</td>
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<td>CRE coverage as % of total</td>
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<td>0.268</td>
<td>0.288</td>
<td>-0.019</td>
<td>0.958**</td>
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<td>Sig. (2-tailed)</td>
<td>0.075</td>
<td>0.055</td>
<td>0.900</td>
<td>0.000</td>
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*Note:*

**Correlation is significant at the 0.01 level (2-tailed).**
### Exhibit 10 | CRE Benchmarks vs. CRE Factors Correlation

<table>
<thead>
<tr>
<th>Net PPE to Total Assets (Own)</th>
<th>Rent 5 yrs to Net Income (Rent)</th>
<th>Facility Certifications</th>
<th>CRE References</th>
<th>Facility and Sustainability</th>
<th>GRI References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net PPE to Total Assets (Own)</strong></td>
<td><strong>Pearson Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>N</strong></td>
<td><strong>Pearson Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
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<td>Net PPE to Total Assets (Own)</td>
<td>1</td>
<td>0.786</td>
<td>45</td>
<td>-0.044</td>
<td>0.328*</td>
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<tr>
<td>Rent 5 yrs to Net Income (Rent)</td>
<td>-0.044</td>
<td>0.760</td>
<td>40</td>
<td>0.047</td>
<td>0.194</td>
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<td>Facility certifications</td>
<td>-0.047</td>
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<td>40</td>
<td>0.332*</td>
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<tr>
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<td>0.332*</td>
<td>0.226</td>
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<td>0.047</td>
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<td>Facility and sustainability</td>
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<td>0.045</td>
</tr>
<tr>
<td>GRI references</td>
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<td>0.045</td>
<td>45</td>
<td>0.047</td>
<td>0.151</td>
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</table>

**Note:**
* Correlation is significant at the 0.05 level (2-tailed).
**Exhibit 11** | Equation Summary Results

<table>
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<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
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</tr>
<tr>
<td><strong>F</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>1.345</td>
<td>0.789</td>
</tr>
<tr>
<td></td>
<td>(0.252)</td>
<td>(0.380)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>6.425</td>
<td>5.298</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td><strong>OWN</strong></td>
<td>−4.999</td>
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</tr>
<tr>
<td></td>
<td>(0.252)</td>
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<tr>
<td><strong>RENT</strong></td>
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<td>0.321</td>
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<tr>
<td></td>
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<td>(0.888)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>OwnRent</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Adj. R²</strong></td>
<td>0.008</td>
<td>−0.005</td>
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</tbody>
</table>

\[
CRE_p = \alpha + \beta_1 \text{OWN} + \varepsilon. \quad (1)
\]
\[
CRE_p = \alpha + \beta_2 \text{RENT} + \varepsilon. \quad (2)
\]
\[
CRE_p = \alpha + \beta_3 \text{OwnRent} + \varepsilon. \quad (3)
\]

**Results**

Exhibit 8 includes descriptive statistics for the four factors and corporate real estate financial benchmarks. For the sample CSRs, the average corporate real estate coverage percentage is 5.07%, with a wide variance from 0.00% to a high of 31.01% (the median is 3.42% for corporate real estate coverage percentage). The highest average for the four factors is ‘facility and sustainability’ at 3.36% (1.34% median) and the lowest average ‘GRI CRE references’ at 0.13% (0.00% median).

Correlations between the four factors and corporate real estate coverage percentages are generally insignificant with the exception of CRE coverage percentage to the facility and sustainability factor (Exhibit 9). Regardless of the CRE coverage percentage in a CSR, the results for the 45 CSRs indicate a higher focus on facilities and sustainability than any other factor. At a 10% significance level, facility certifications and CRE coverage as a percentage of the total are slightly significant whereas the correlation of CRE coverage percentage to GRI CRE references is essentially zero.

Exhibit 10 extends the previous correlation matrix and includes the Own and Rent CRE benchmarks and four primary factors. CRE references (%) to OWN is
significant at the 5% level, with a 0.332 correlation indicating a positive relationship between the intensity of net property, plant, and equipment assets to corporate real estate references in CSRs. Paradoxically, there is also a positive correlation between RENT and facility certifications (%) at 0.328, significant at the 5% level. The latter referenced relationship supports corporate real estate surveys that indicate a preference for corporations to lease LEED-certified properties and mention it in CSRs (Mattson-Teig, 2007; Sustainable Facility, 2007; Environmental Design & Construction, 2008).

Results of Equations 1, 2, and 3 are shown in Exhibit 11 and confirm insignificant relationships between each independent variable (OWN, RENT, and OwnRent) to the dependent variable (CREr). Such results are not surprising due to several reasons. First, GRI guidelines do not require significant discussion of CRE ownership or operations in CSRs, and second, there are non-linear relationships of the dependent and independent variables with large standard deviations for all variables. Alternative transformations such as logs and squaring variables also resulted in low explanatory outcomes. Until CRE content in CSRs is consistently improved and increased across industry sectors and geographies, increasing the sample size of CSRs is likely to show similar insignificant results based on the three CRE benchmarks.

**Conclusion**

This article argues for increased transparency and disclosures on corporate real estate assets, whether leased or owned, in corporate sustainability reports. There are three reasons to support this argument. First, commercial real estate is a significant asset class globally, whether owned, leased, operated, abandoned, or managed by corporations. Second, research and environmental studies identify the direct and indirect impacts and contributions of commercial real estate operations to climate impacts and greenhouse gas emissions. Third, although current GRI (2006) guidelines do not sufficiently address corporate real estate disclosures in CSRs, minor modifications and extensions of existing GRI guidelines have the potential to correct the gap of CRE reporting. The results of the content analysis research of the sample 45 CSRs based on GRI (2006) guidelines indicate that corporate real estate disclosures in corporate sustainability reporting are limited in scope, consistency, transparency, and coverage.

Exhibit 2 illustrates how existing GRI standards can be modified to address corporate real estate disclosures in corporate sustainability reports. The requirement (EN11) to disclose corporate locations adjacent to high biodiversity valued areas or protected areas is reasonable and understandable. There are, however, critical questions about corporate locations adjacent to non-protected areas in urban, rural, developing counties, or corporate locations in less developed countries too. For example, the geographic landscape of cities and rural areas is littered with abandoned commercial and industrial real estate properties just as inner cities are littered with abandoned and non-inhabitable residential properties.

GRI standards need to account for the vast role of the operations and management of corporate real estate assets in corporate sustainability reporting. Research
confirms the relationship of commercial real estate to GHG emissions and energy usage. Research also confirms the significant financial value and risks of corporate owned real estate assets to corporations, and yet, this research proves that corporate real estate disclosure is limited and inconsistent in corporate sustainability reporting. Do corporations account for owned and leased property changes such as divestitures, disposition, or reductions in leased space when reporting changes in CO₂ or GHG emissions? Why are CO₂ emissions not reported on a square footage or square meter basis over time in an attempt to standardize analysis? Do firms disclose significant differences in corporate real estate sustainable management strategies regardless of local geographies, economics, or demographics (Gouldson, 2006)? Is there an agency problem with corporate real estate, whereby companies that lease more than they own, view corporate real estate and sustainability as someone else’s problem (Kadzis, 2007)?

A majority of corporate real estate executives in 2009 already believe that sustainability is an important issue. There is, however, a continuing debate on the role of corporate real estate within the overall corporate strategies and the lifecycle of the firm. Are corporate real estate executives adequately viewed, organized, and empowered within the firm as relevant managers of corporate assets and integrated in corporate sustainability strategies (Manning and Roulac, 1996, 1999)? Another factor is the level of corporate real estate assets and the financial structures that facilitate whether a firm owns or leases the necessary space for the production of goods and services. Are corporations that own most of their properties more likely to link corporate real estate with sustainability strategies than corporations who primarily lease commercial properties?

There are several limitations to this research and areas for further research. CRE content percentages in the sample reports did not include photographs and graphics that may alter content analysis results due to areas in the reports that feature pictures or illustrations of corporate properties and facilities. Thus further research using the measurement methods espoused by Unerman (2000) may result in different results. Corporate real estate coverage and content in corporate sustainability reports written under non-GRI guidelines may produce alternative results. Furthermore, evidence of a lack of corporate real estate content in CSRs may not necessarily portray the extent of sound corporate real estate sustainability strategies employed and implemented by firms and reported in other media than CSRs. The authors recommend further research, expanding the sample size, geographic coverage, and industry representations of corporations in order to empirically prove a dissonance exists as identified by (Adams and Whelan, 2009). In summary, this research recommends that GRI and other international institutions developing CSR standards need to consider developing new standards and guidelines that encourage transparency and significant discussion of corporate real estate assets in corporate sustainability reporting. As Exhibit 2 illustrates, many of the existing GRI sections offer the opportunity to expand relevant discussions and content to address the empirical evidence and research linking commercial real estate to greenhouse gas emissions, climate impacts, and environmental and community sustainability challenges.
### Exhibit 12 | CRE Coverage % by Four Factors

<table>
<thead>
<tr>
<th>Company</th>
<th>Facility Certifications</th>
<th>General CRE References</th>
<th>GRI References</th>
<th>Facilities and Sustainability</th>
<th>Total CRE % Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>12.29</td>
<td>12.29</td>
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<td>Abbott</td>
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<td>0.00</td>
<td>1.34</td>
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<td>0.44</td>
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<td>3.53</td>
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### Exhibit 12 | (continued)
**CRE Coverage % by Four Factors**

<table>
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<th>Company</th>
<th>Facility Certifications</th>
<th>General CRE References</th>
<th>GRI References</th>
<th>Facilities and Sustainability</th>
<th>Total CRE % Coverage</th>
</tr>
</thead>
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<td>OfficeMax</td>
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<td>0.00</td>
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<td>0.00</td>
<td>0.16</td>
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<td>Pfizer</td>
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<td>0.36</td>
<td>0.00</td>
<td>1.73</td>
<td>2.17</td>
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<tr>
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<td>1.78</td>
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<td>3.97</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>3.97</td>
</tr>
<tr>
<td>The Kroger Company</td>
<td>0.65</td>
<td>0.00</td>
<td>0.00</td>
<td>2.08</td>
<td>2.73</td>
</tr>
<tr>
<td>Unitedhealth Group</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Wainwright</td>
<td>4.12</td>
<td>0.00</td>
<td>0.00</td>
<td>1.22</td>
<td>5.34</td>
</tr>
<tr>
<td>Xerox</td>
<td>4.83</td>
<td>2.31</td>
<td>0.00</td>
<td>1.64</td>
<td>8.78</td>
</tr>
<tr>
<td>Average</td>
<td>1.02</td>
<td>0.56</td>
<td>0.13</td>
<td>3.36</td>
<td>5.07</td>
</tr>
</tbody>
</table>

### Exhibit 13 | CRE coverage vs. Independent Variables

<table>
<thead>
<tr>
<th>Correlations</th>
<th>CRE Coverage as % of Total</th>
<th>Net PPE to Total Assets (OWN)</th>
<th>Rent 5 yrs to Net Income (RENT)</th>
<th>PPE to Rent Ratio (OwnRent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRE coverage as % of total</td>
<td>Pearson Correlation</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net PPE to Total Assets (Own)</td>
<td>Pearson Correlation</td>
<td>−0.174</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Sig. (2-tailed)</td>
<td>0.252</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rent 5 yrs to Net Income (Rent)</td>
<td>Pearson Correlation</td>
<td>0.143</td>
<td>−0.044</td>
<td>1.000</td>
</tr>
<tr>
<td>N</td>
<td>Sig. (2-tailed)</td>
<td>0.380</td>
<td>0.786</td>
<td></td>
</tr>
<tr>
<td>PPE to Rent ratio (OwnRent)</td>
<td>Pearson Correlation</td>
<td>−0.064</td>
<td>0.292</td>
<td>0.031</td>
</tr>
<tr>
<td>N</td>
<td>Sig. (2-tailed)</td>
<td>0.694</td>
<td>0.067</td>
<td>0.848</td>
</tr>
</tbody>
</table>
Endnotes

1 There are several definitional issues that need to be addressed. Corporations, NGOs, municipalities, and other entities produce and publish reports under a variety of names. For purposes of this paper, social responsibility, citizenship reports, and sustainability reports are collectively referenced as corporate sustainability reports (CSR). References to the generic term corporation also include other institutions, firms, and entities such as municipalities, public and private firms, and non-government organizations unless otherwise noted.

2 ExxonMobil, December 31, 2009 Annual Report.


4 Haynes (2009).

5 See Figure 2.1 (c) in Climate Change 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change, United Nations (http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm) [March 28, 2010].


8 For further information, see Moskowitz (1972, 1975).

9 See Exhibit 14 in the Appendix; note that many of the firms with high ratios of net property, plant, and equipment to total assets that have low corporate real estate coverage percentages in corporate sustainability reports are in the oil and gas industries.


See http://www.globalreporting.org [March 28, 2010]; “The environmental dimension of sustainability concerns an organization’s impacts on living and non-living natural systems, including ecosystems, land, air, and water. Environmental Indicators cover performance related to inputs (e.g., material, energy, water) and outputs (e.g., emissions, effluents, waste). In addition, they cover performance related to biodiversity, environmental compliance, and other relevant information such as environmental expenditure and the impacts of products and services.”


See http://www.corporateregister.com/ [March 26, 2010].


A full list of GRI reporting firms from 1999 to 2010 is available in an Excel spreadsheet at http://www.globalreporting.org [July 16, 2010].

Bristol-Myers Squibb reports that “We include facilities in our data collection and reporting systems for full calendar years only. Newly opened facilities are included in the first full calendar year of operation. New acquisitions are included within two full calendar years. If a facility is divested or closed, data from the facility are included through the last full calendar year it was part of Bristol-Myers Squibb.”

For example, Allergan reports that the firm “…has seen generally a decline in total energy consumption on a per square foot basis since 2000. This trend demonstrates Allergan’s effective energy program. The reduction in 2008 versus 2007 was approximately 6% on a per square footage basis. Using 2000 as a baseline, the decrease was 20% in 2008. When energy consumption is normalized per sales, in 2008 a decrease of 11% in energy consumption occurred versus 2007. The normalized trend demonstrates Allergan’s commitment and results regarding energy conservation and management.”

See Jones Lang LaSalle, Perspectives on Sustainability, 2009.

References


Steven P. Laposa, Colorado State University, Fort Collins, CO 80523-1272 or steve.laposa@colostate.edu.

Sriram Villupuram, Colorado State University, Fort Collins, CO 80523-1272 or Sriram.Villupuram@colostate.edu.
The Operations and Management of Green Buildings in the United States

Authors
Norman G. Miller, Dave Pogue, Jeryldine Saville, and Charles Tu

Abstract
This study examines the performance of green buildings from the operation and management perspective. Specifically, we look at the utility expenses, cleaning practices, use of energy-saving devices, and other building operation procedures of a national sample of office properties managed by CB Richard Ellis. The findings indicate that green buildings in the sample are more energy-efficient than their non-green counterparts. Surprisingly, the average total operating expenses of the green building group is higher than the non-green building group, albeit insignificantly. Additionally, a building’s operating performance is more highly correlated with its ENERGY STAR score, and not the ENERGY STAR label.

Green is not a fad, but a future way of doing business. We expect the term “green” to fade as it becomes mainstream, but for now we remain early in the process of conversion. A large part of this conversion will involve existing buildings since no more than 2% of the existing stock is built in any one year. While we do not have the luxury of replacing all existing buildings with new, green construction overnight, we do have a tremendous opportunity to incorporate green practices into the management of existing buildings. This approach will actually move us forward faster in the sustainability sphere since the operation of a building can prove even more critical than its design in making a difference.

Yet the research so far has been lacking on the operations and management of green buildings, leaving building owners and managers, who are driven by economics, not altruism, to wonder what the actual costs are and how their bottom line would be impacted. This study begins to fill that gap by comparing the operating performance and sustainability-related practices of a group of ENERGY STAR/LEED buildings with those that do not have such labels. Specifically, we look at their operating expenses (including electricity, gas, water, and waste removal), cleaning practices, use of energy-saving devices, and other building operation procedures.

The remainder of the paper is organized as follows. The next section reviews recent studies on sustainable real estate and green buildings. We then discuss the data used in this study, including the source and summary statistics. The section after that presents the results of comparative analyses between buildings with and without green labels, in terms of operating expenses and green practices. The conclusions are discussed in the final section.
Recent Studies on Sustainable Real Estate

The academic research community has made continued efforts to study the impact of green buildings on rents, values and more, focusing mostly on ENERGY STAR and LEED as the standard bearers. Studies using data from 2005 through late 2009 have consistently found that green buildings on average have higher rental premiums, higher occupancy levels, and higher values than buildings with otherwise similar characteristics. Examples include Miller, Spivey, and Florance (2008), Fuerst and McAllister (2009), Eichholtz, Kok, and Quigley (2010), and Wiley, Benefield, and Johnson (2010), all of whom found premiums in rents and occupancy rates for green buildings. Rental premiums and higher occupancy rates should lead to higher values generally by more than the extra costs to go green; however, data on LEED-certified property sales has been particularly difficult to come by as there have been few sales over the past few years. The same holds true for ENERGY STAR-labeled properties. This may imply that owners of green buildings are oriented more toward the long term and less likely to sell as quickly as merchant builders who care less about long-term values.

Other studies have investigated the cost of going green. Bubny (2009) asserts that there are no significant incremental costs at all for new construction to hit the Silver level of certification, as long as the developer starts early and has an experienced team. In a recent review study, Kats (2009) suggests that, “Green buildings cost roughly 2% more to build than conventional buildings,” which is quite nominal compared to the benefits found in the empirical studies. In a report prepared for the Urban Green Council, Langdon (2007) looks at construction costs for 38 high-rise multifamily buildings and 25 commercial interiors in New York City. He finds that the cost differential is less than 1% for new buildings, and for commercial interiors, the cost for LEED construction is actually 6% lower than for non-LEED. The report concludes that, “We must prioritize greening our cities, and cost is not the barrier some have made it out to be.”

But if the cost differential to produce better buildings is modest, why is the overall office stock percentage of green buildings—not to mention other property types—so low? Blame this on the fact that real estate lasts a long time. As we see existing building owners ramp up with retrofits, the percentage will grow rapidly. The iconic Empire State Building, for example, is receiving a $20 million energy-efficiency retrofit, which is expected to save $4.4 million in annual energy costs, reduce its energy consumption by close to 40%, repay its net extra cost in about three years, and cut its overall carbon output. Perhaps the Empire State Building retrofit will serve as an inspiration for others.

A number of studies have examined the relationship between worker productivity and the work environment, and certain improvements such as better lighting, cleaner air, and the lack of volatile organic compounds (VOCs) are shown to improve employee productivity or reduce sick time. But few studies focus on the impact of green buildings. Kats (2003) reviews a sample of 33 green building projects and suggests present value benefits of US$37 to US$55 per square foot as a result of productivity gains from less sick time and greater worker
productivity. These results stem primarily from better ventilation, lighting, and the general environment. Miller and Pogue (2009) conduct a survey of over 500 tenants in green buildings and find present value benefits that could equal hundreds of dollars, depending on the time horizon for discounting. These early results beg the question why more corporations are not putting greater effort into insisting upon better worker environments.

A paper by Eichholtz, Kok, and Quigley (2009) identifies four determinants of the penetration of corporate social responsibility in real estate decision-making. They develop six propositions about which firms or industries are willing to rent green space and to pay a rental premium. The results show that the oil industry is a major consumer of green office space, indicating that firms in environmentally sensitive industries will actively incorporate sustainability in strategic decisions, such as headquarters selection. Firms in the legal and financial services industries lease a substantial share of green office space as well. For some of these firms, further investigation shows support for the notion of productivity benefits from green buildings; however, the authors conclude it is likely that many firms lease green space simply because green buildings are usually higher-quality buildings.

Going green and sustainability has also been a topic of interest in the planning profession recently. In 2008 the Journal of the American Planning Association published a special issue on green communities. Berke (2008) reviews the major visions of urban form evolved over the last century, and examines how they have affected the planning practices associated with developing green communities. Retzlaff (2008) compares nine building assessment systems and discusses which one is the most appropriate for planners to utilize for their purposes. The systems analyzed in the study have very diverse themes, scales, and scopes. For example, 85% of the points in the LEED-NC are related to building and site features, while over 60% in the LEED-ND focus on the community/regional level. None of the systems, however, place a strong emphasis on the maintenance and operations of buildings.

The study at hand examines green buildings from the operations and management perspective, an area that has not been addressed in the growing literature of sustainable real estate. The purpose is to compare the operating performance and green practices between buildings with and without green labels.

Data

The data utilized in the current study was collected from a Spring 2009 survey of a portfolio of office properties managed by CB Richard Ellis (CBRE). The property manager of each building filled out an online questionnaire. In addition to descriptions of the property (such as its location, submarket, class, rentable area, etc.), the manager was also asked questions regarding the building’s operating performance and sustainability-related practices. A copy of the questionnaire is presented in the Appendix.

The portfolio surveyed includes 154 buildings with the ENERGY STAR label (four of them also have LEED certification) and 105 without a green label. Some
of the property managers started but did not complete the questionnaire, or chose not to answer all of the questions. Surveys without valid information have been removed from the dataset. A subject group of 139 green buildings and a peer group of 103 properties are included in the analyses. These properties are located across the country in 10 different geographical areas, with Southern California having the most observations. Exhibit 1 shows the distribution of both green and traditional buildings across geographical locations.

Overall, the green buildings in the sample are larger and of better quality. The average size of green buildings is slightly over 360,000 square feet (SF), while the peer group of traditional buildings is approximately 260,000 SF. The majority of the green buildings (73%) are Class A properties; in contrast, 60% of the peer group are Class A. The average occupancy is 87% for green buildings and 84% for the peer group. The average current ENERGY STAR score of the subject group is 84.0; in the peer group, 63 buildings have an ENERGY STAR score, with an average of 71.9.

In a number of recent empirical studies, LEED and ENERGY STAR labels are both used as proxies for green buildings, in contrast to traditional buildings. However, these two rating systems have very different emphases. ENERGY STAR focuses almost exclusively on a building’s energy performance. A building that is among the nation’s top 25% in terms of energy efficiency and maintains a healthy indoor environment can qualify as an ENERGY STAR building. The U.S. Green Building Council’s (USGBC) LEED designation, on the other hand, measures a building’s greenness based on a wider variety of features, including site planning, energy, water management, indoor environmental quality, and material use. Based

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Exhibit 1 | Geographical Distribution of Survey Sample

![Distribution of Survey Sample](image-url)
on its overall score, the building may qualify for one of the four levels: Certified, Silver, Gold or Platinum.

Of the 139 ENERGY STAR buildings in the sample, only four currently have LEED certification. Among the non-LEED buildings, 52 have registered with the U.S. Green Building Council, and 64 have completed a gap analysis to assess what needs to be done to achieve LEED certification (Exhibit 2). A considerable number of ENERGY STAR buildings in the sample (62, or 44%) are neither LEED-certified nor working toward LEED certification.

### Analyses of Survey Results

#### Operating Performance

With the survey data, we first compare the performance of the subject group of green buildings with the peer group in terms of their operating expenses. Because a building with ENERGY STAR certification is by definition more energy-efficient than an average building, we expect the electricity and gas costs of green buildings to be lower than the peer group. Exhibit 3 shows the expenses per square foot (PSF) of the subject group and the peer group, including electricity, gas, water, waste removal, and the total. As expected, ENERGY STAR buildings have significantly lower electricity ($1.84 PSF vs. $2.19 PSF) and gas expenses ($0.14
**Exhibit 3** | Comparison of Operating Expenses PSF between ENERGY STAR and Non-ENERGY STAR Buildings

<table>
<thead>
<tr>
<th>Operating Expense</th>
<th>Electricity</th>
<th>Gas</th>
<th>Water</th>
<th>Waste Removal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Subject Group: ENERGY STAR Buildings</td>
<td>1.84</td>
<td>0.14</td>
<td>0.13</td>
<td>0.07</td>
<td>10.73</td>
</tr>
<tr>
<td>The Peer Group: Non-ENERGY STAR Buildings</td>
<td>2.19*</td>
<td>0.22*</td>
<td>0.15</td>
<td>0.07</td>
<td>10.34</td>
</tr>
</tbody>
</table>

*The number is significantly different from the Subject Group at the 10% level.

PSF vs. $0.22 PSF). Water consumption and waste removal costs are also lower for the subject group, but the difference is not statistically significant.

When we compare the total operating expenses between the two groups, the results show that the green buildings have higher overall operating expenses ($10.73 PSF vs. $10.34 PSF), albeit insignificantly. This finding suggests that ENERGY STAR buildings may incur additional non–energy-related expenses. Further investigation is necessary to explain this unexpected result.

As many of the buildings in the peer group have an ENERGY STAR score higher than the minimum certification requirement of 75, we further analyze the data by separating the sample into three subgroups: Group 1 includes all properties with the ENERGY STAR label; Group 2 includes buildings without the label but with an ENERGY STAR score of 75 or higher; and Group 3 includes all other properties. Exhibit 4 presents the average operating expenses PSF of the three groups. When Groups 1 and 2 are compared, the results show that Group 1 has

**Exhibit 4** | Comparison of Operating Expenses PSF Based on Both ENERGY STAR Label and Score

<table>
<thead>
<tr>
<th>Operating Expense</th>
<th>Electricity</th>
<th>Gas</th>
<th>Water</th>
<th>Waste Removal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: ENERGY STAR Buildings</td>
<td>1.84</td>
<td>0.14</td>
<td>0.13</td>
<td>0.07</td>
<td>10.73</td>
</tr>
<tr>
<td>Group 2: Non-ENERGY STAR Buildings with Score ≥75</td>
<td>2.07</td>
<td>0.14</td>
<td>0.13</td>
<td>0.06</td>
<td>10.28</td>
</tr>
<tr>
<td>Group 3: Non-ENERGY STAR Buildings with Score &lt;75</td>
<td>2.26*</td>
<td>0.25*</td>
<td>0.16</td>
<td>0.08</td>
<td>10.38</td>
</tr>
</tbody>
</table>

*The number is significantly different from Group 1 at the 10% level.
lower electricity costs, but Group 2 has lower total expenses. Neither difference is statistically significant. This suggests that there is no significant difference in the operating performance between Groups 1 and 2, even though one has the ENERGY STAR label and the other one does not. Group 3, however, has significantly higher energy costs (including electricity and gas) than Group 1.

To assess which factor—ENERGY STAR label or ENERGY STAR score—is a better indicator of a property’s energy performance, we run correlation analyses between each factor and operating expenses. Both the ENERGY STAR label and score are negatively correlated with a building’s electricity and gas costs, although the correlation coefficient is higher and more significant for the ENERGY STAR score. This is because some of the buildings without the ENERGY STAR label are quite energy-efficient. In terms of total operating expenses, the correlation with the ENERGY STAR label is positive but insignificant, while it is significantly negative with the ENERGY STAR score. These results further confirm that the ENERGY STAR score is a better indicator of a building’s energy efficiency.

**Green Practices**

In terms of operations and management, one of the measures of a building’s greenness is the utilization of green leases, which are becoming more common. The U.S. General Services Administration (GSA) requires prospective landlords to deliver a structure that satisfies LEED Silver standards. Many states, such as California, have similar, if not more stringent requirements. Green lease provisions may require a tenant to separate trash for recycling, maintain operational limits for thermostat temperature controls, use occupancy sensors for lighting, use window blinds, limit water or electrical consumption per square foot, and require landlords to have cleaning staff use only green-certified products. Consequences for failure on the part of the tenant or the landlord to live up to these provisions are not always clear, and enforceability will be determined by the courts in cases yet to be heard. Awareness of the provisions and communication of green management requirements and/or tenant obligations is an evolving process.
Although we cannot directly measure whether a building’s management has implemented green leases, several related factors are taken into account. Among the ENERGY STAR buildings in the sample, 19 (including two LEED buildings) have established a policy that requires new tenant improvements to be constructed to meet the LEED Commercial Interiors (CI) standards. In the meantime, 15 ENERGY STAR buildings currently have interior space receiving LEED CI certification, ranging from 6,000 SF to 180,000 SF (or approximately 2% to nearly 60% of the rentable area in the building). It is interesting that there is not much overlap between the two factors, given that 11 of the 15 LEED CI buildings do not currently have a tenant improvement requirement.

We then compare the ENERGY STAR buildings in the sample with non-ENERGY STAR buildings based on a number of other features. Exhibit 6 shows the comparison in terms of cleaning practices. Janitorial staff in almost 90% of the

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**Exhibit 6 | Comparison of Cleaning Practices (% of Buildings)**

<table>
<thead>
<tr>
<th></th>
<th>Green Cleaning Practices</th>
<th>Day Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Subject Group:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR Buildings</td>
<td>89.9%</td>
<td>7.9%</td>
</tr>
<tr>
<td>The Peer Group:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-ENERGY STAR Buildings</td>
<td>84.8%</td>
<td>5.7%</td>
</tr>
<tr>
<td>With Score ≥ 75</td>
<td>97.1%*</td>
<td>3.0%</td>
</tr>
<tr>
<td>With Score &lt; 75</td>
<td>78.6%**</td>
<td>8.6%</td>
</tr>
</tbody>
</table>

Notes:
*The number is significantly different from the Subject Group at the 10% level.
**The number is significantly different from the Subject Group at the 5% level.
***The number is significantly different from the Subject Group at the 1% level.

---

**Exhibit 7 | Comparison of Use of Energy-Saving Devices (% of Buildings)**

<table>
<thead>
<tr>
<th></th>
<th>Restrictive Plumbing Devices</th>
<th>Motion-Controlled Lighting Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Subject Group:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY STAR Buildings</td>
<td>84.9%</td>
<td>33.8%</td>
</tr>
<tr>
<td>Non-ENERGY STAR Buildings</td>
<td>68.6%***</td>
<td>26.7%</td>
</tr>
<tr>
<td>With Score ≥ 75</td>
<td>91.4%</td>
<td>40.0%</td>
</tr>
<tr>
<td>With Score &lt; 75</td>
<td>57.1%***</td>
<td>20.0%**</td>
</tr>
</tbody>
</table>

Notes:
*The number is significantly different from the Subject Group at the 10% level.
**The number is significantly different from the Subject Group at the 5% level.
***The number is significantly different from the Subject Group at the 1% level.
Exhibit 8 | Comparison of Building Operation Procedures (% of Buildings)

<table>
<thead>
<tr>
<th>The Subject Group:</th>
<th>Integrated Pest Management Program</th>
<th>No-Cost/Low-Cost Best Practices Plan</th>
<th>Recycling Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR Buildings</td>
<td>64.0%</td>
<td>89.9%</td>
<td>95.7%</td>
</tr>
<tr>
<td>Non-ENERGY STAR Buildings</td>
<td>59.1%</td>
<td>64.8%***</td>
<td>82.9%***</td>
</tr>
<tr>
<td>With Score ≥ 75</td>
<td>80.0%**</td>
<td>71.4%**</td>
<td>100.0%**</td>
</tr>
<tr>
<td>With Score &lt; 75</td>
<td>48.6%**</td>
<td>61.4%***</td>
<td>74.3%***</td>
</tr>
</tbody>
</table>

Notes:
*The number is significantly different from the Subject Group at the 10% level.
**The number is significantly different from the Subject Group at the 5% level.
***The number is significantly different from the Subject Group at the 1% level.

ENERGY STAR buildings have utilized green cleaning practices, compared with 85% in non-ENERGY STAR buildings. Since the difference is not statistically significant, we investigate further based on the ENERGY STAR score (i.e., Groups 1, 2, and 3 as defined previously). It turns out that a much higher percentage of Group 2 buildings have put green cleaning into practice than Group 1, while a lower percentage of Group 3 buildings have done so. A very small number of properties have implemented day cleaning, so a meaningful comparison between day and evening cleaning cannot be made.

We consider two green devices—restrictive plumbing and motion-controlled lighting—in the survey. The patterns are very similar to that of green cleaning. When the subject group is compared with the peer group—regardless of the ENERGY STAR score—a higher percentage of ENERGY STAR buildings have installed these inexpensive devices. However, when the subject group (i.e., Group 1) is compared with the subgroups of non-ENERGY STAR buildings, these devices have been installed in slightly more Group 2 buildings and significantly fewer Group 3 buildings.

Three building operation procedures are also compared between the subject and the peer groups, including: (1) an integrated pest management program to reduce/remove toxic chemical pesticides; (2) a no-cost/low-cost best practices plan to conserve energy and water; and (3) a recycling program. The patterns are similar to the comparative analyses of green cleaning and energy-saving devices. The only difference is that a higher percentage of ENERGY STAR buildings have implemented a best practices plan than the peer groups (both Groups 2 and 3).

Conclusion

This research examines green buildings in the United States from the operations and management perspective—a perspective that has so far been lacking in the growing field of sustainable real estate research and one that is critical to
commercial market participants who have expressed skepticism on the topic. With a national sample collected from a survey of office buildings managed by CBRE, we compare the operating expenses and management of 139 green buildings with 103 buildings that do not have a green label. Since all properties are managed by the same company, this is not a random sample and, therefore, may not be representative of the entire stock of the U.S. office market. The benefit, on the other hand, is that the subject and control groups are comparable in terms of management style and quality.

Not surprisingly, the results show that green buildings are more energy-efficient—with savings on electricity, gas, and water costs—when compared with their non-green counterparts. What is surprising, however, is that the average total operating expenses of the green building group is higher than the non-green building group, albeit insignificantly. This suggests that ENERGY STAR buildings may incur additional non-energy-related expenses. It is possible that green buildings are more intensively managed and/or they require a learning curve for what is often a more sophisticated building system. This result merits further investigation.

Even more striking are the findings that point to the importance of the ENERGY STAR score—over the ENERGY STAR label—in judging the “greenness,” or even the energy efficiency, of a building. The results reveal that a building’s operating performance is more highly correlated with its ENERGY STAR score, and not the ENERGY STAR label. Thus, the higher a building’s score, the lower its operating expenses. It is essential, then, that tenants searching for green space or investors interested in buying a green building look beyond the plaque on the wall when making their decisions.

Likewise, in terms of green practices—implementing green cleaning, installing restrictive plumbing devices, and motion-controlled lighting—we find that a higher percentage of buildings that meet the ENERGY STAR standards but have no label have implemented green practices, compared with those that do carry the ENERGY STAR label. This seems to suggest that the ENERGY STAR label is not a good indicator of the “greenness” of a property and that all green buildings are not, in fact, created equal.

We further analyze the sample of ENERGY STAR buildings that are not currently LEED-certified to find out if the management is working toward LEED certification. Slightly less than half of these buildings have completed a gap analysis, and about 40% have registered with the USGBC. We find no correlation between a property’s current ENERGY STAR score and its intention to pursue LEED status. A higher percentage of the buildings that have completed a gap analysis or registered with the USGBC have implemented green practices.

This research begins to shed light on the critical role that the operations and management of green buildings plays. Regardless of how many bells and whistles it has, a green building will not be green unless it is operated green. It is the manner in which the green features are utilized that makes all the difference.
Appendix

Real Estate Managers Survey—Users of Green Space Questionnaire

This survey is a research project combining the efforts of the Burnham-Moores Center for Real Estate at the University of San Diego, CBRE Information Management, and CBRE Sustainability Group. Information gathered through the survey is completely confidential and will only be released in an aggregate form. It will be analyzed by staff and faculty at the Burnham-Moores Center for Real Estate at the University of San Diego to identify trends and attitudes. Once the study is completed the results will be made available to you. This survey will take approximately 10 minutes of your time. Your input will be greatly valued.

1. Would you like a copy of the results sent to you? If yes, enter your email address:
   Email Address:

2. Please provide the name of your Asset Manager.

3. Please provide the contact email address of your Asset Manager.
   Email Address:

4. Where is the building located?
   City/Town: ______________
   State: ______________
   ZIP: _____________

5. Building Information
   Client Name ________________
   i-Track ID Number ________________

6. Building Footage
   Building size (rentable square feet) _______________

7. Geographic market of your space
   ○ Central Business District
   ○ Suburb

8. Quality Class of Building
   ○ A
   ○ A−
   ○ B
   ○ C

9. Building Type
   ○ Single Tenant
   ○ Multi-Tenant

10. Current Occupancy Rate (%) ________________

11. Please identify the scheduled lease expirations by number of leases and total square footage in 2009.
Number of leases __________________
Total square footage __________________

12. **2008 Operating Expenses ($)**
   - Overall Total Expense ________________
   - Electricity _________________________
   - Gas _______________________________
   - Water _____________________________
   - Waste Removal _____________________

13. **ENERGY STAR**
   - Current ENERGY STAR Score __________
   - Original ENERGY STAR Score __________
   - What was the baseline period? ________

14. Please indicate, has:
   - A preliminary study been completed?
     - YES
     - NO

   - A gap analysis been completed?
     - YES
     - NO

   - The building registered with USGBC?
     - YES
     - NO

15. If gap analysis has been completed, check which level is anticipated
   - Certified
   - Silver
   - Gold
   - Platinum

16. Has the building already achieved LEED Certification?
   - YES
   - NO

17. Please indicate the level achieved:
   - **LEED Existing Building O&M**
     - Certified
     - Silver
     - Gold
     - Platinum

   - **LEED Core & Shell**
     - Certified
     - Silver
     - Gold
     - Platinum

   - **LEED New Construction**
     - Certified
     - Silver
     - Gold
     - Platinum
18. Has a building policy been established requiring Tenant Improvements be constructed to LEED CI standards?
   - YES
   - NO

19. Have any tenant build-outs been certified under LEED CI?
   - YES
   - NO

20. If yes, how much square feet in total is certified under LEED CI?

21. Please indicate, are:
   - Green cleaning practices utilized by the janitorial staff?
     - YES
     - NO
   - All cleaning chemicals used in the building Greenseal certified?
     - YES
     - NO
   - All wipes used by the cleaning staff Micro Fiber towels?
     - YES
     - NO

22. Is all floor equipment utilized by the cleaning staff Green Label certified by the CRI?
   - YES
   - NO

23. Has DAY cleaning been implemented?
   - YES
   - NO

24. If yes, how many hours per week was the building lighting runtime reduced as a result of implementing day cleaning?

25. Please indicate all that apply:
   - Restrictive plumbing devices (aerators) installed in common area restrooms?
     - YES
     - NO
   - Motion-controlled lighting devices installed in ALL tenant spaces?
     - YES
     - NO
   - A lighting retrofit performed at the building in the last three years?
     - YES
     - NO

26. Has an integrated pest management program been implemented to reduce or remove toxic chemical pesticides?
   - YES
   - NO
27. Has a no-cost/low-cost best practices plan been implemented to conserve energy and water?
   ○ YES
   ○ NO

28. Please check all that apply:
   The building has a recycling program in place for: Please check all that apply:
   ○ Paper
   ○ Aluminum
   ○ Glass
   ○ Cardboard
   ○ Other (please specify)

29. Has a waste audit been conducted and a written plan put in place?
   ○ YES
   ○ NO

30. Do paper products used in the common area restrooms meet the standards of the EPA Comprehensive Procurement Guidelines?
   ○ YES
   ○ NO

—End of Survey—
THANK YOU FOR YOUR PARTICIPATION!

Endnotes

1 LEED stands for Leadership in Energy & Environmental Design and was created by the U.S. Green Building Council (USGBC). ENERGY STAR is a label verified by the U.S. Environmental Protection Agency (EPA) based on meeting a set of ongoing energy-saving standards.

2 While recent studies have focused primarily on ENERGY STAR and LEED, other standards of green features exist, including BREEAM, CASBEE, Green Star, Green Globes, and many more which we do not review here (see Reed, Bilos, Wilkinson, and Schulte, 2009).

3 On those few sales that have occurred, we estimate about a 50 basis point lower cap rate compared with similar non-green sales. As of October 29, 2009, there were 3,608 LEED or ENERGY STAR Class A or B office buildings in the CoStar database and of these, only 43 were for sale. With sales activity low, it is unlikely that all for sale will sell quickly; therefore, it is a challenge to provide a significant sample of LEED or ENERGY STAR property sales in 2009.

4 We acknowledge that there remain some certification processing costs, which may deter some owners from applying. For example, in 2010 the cost of new construction certification fee for a 100,000 square foot building is $5,500, plus $10,000 for an expedited process for design and construction review, along with fees for a LEED consultant to assist in the process, which could run several thousand dollars.


6 For a comprehensive review of the literature on worker productivity, see Miller and Pogue (2009).
This is based on an assumption of a 1.5% increase in productivity for state of California employees. The annual productivity benefit is then discounted at 5% for a 20-year period. The present value is $37 for Certified and Silver level buildings and $55 for Gold and Platinum level buildings.

The systems reviewed in the study include Green Globes, the Green Communities Criteria by the Enterprise Community Partners, the Health House program by the American Lung Association, the Green Building Guidelines by the National Association of Home Builders, two EarthCraft programs (Communities and House), and three LEED programs (Home, Neighborhood Development and New Construction).

Because all the properties in the study are managed by CBRE, this cannot be considered a random sample and, therefore, may not be representative of the entire stock of the U.S. office market. The benefit is that the subject and control groups are comparable in terms of management style and quality.

In this study, the Southern California region includes Los Angeles, Orange, and San Diego counties.

The range of the current ENERGY STAR score for the subject group is 45 to 96. Five of the buildings with the ENERGY STAR label currently have a score below the certification requirement of 75.

In fact, 35 of the 63 properties have an ENERGY STAR score equal to or greater than 75. For whatever reasons, however, they have not been certified as ENERGY STAR buildings.

One of them was certified as Core & Shell (CS) at the Gold level; the other three were certified as Existing Buildings Operations & Maintenance (EBOM), with one Certified, one Silver, and one Gold.

Of the gap analyses, 17% targeted the LEED Certified level, 42% LEED Silver, and 19% LEED Gold (with the remaining unspecified).

Whether a building has an ENERGY STAR label is represented by a binary variable, which has a value of 1 if it is an ENERGY STAR building, or 0 otherwise.

Survey respondents were asked if motion-controlled lighting devices had been installed in all tenant spaces and if restrictive plumbing devices had been installed in common area restrooms.

For example, NAIOP, the Commercial Real Estate Development Association, has been a leader in providing resources on sustainable development in the United States, but also has been an opponent of regulations and design burdens that impose new costs on building owners and tenants. See www.naiop.org/resourcecenter/gr.cfm.

References


Carbon Markets: A Hidden Value Source for Commercial Real Estate?

Authors
Aaron G. Binkley and Brian A. Ciochetti

Abstract
Real estate is one of the largest contributors to CO₂ emissions yet the industry knows very little about this topic. This paper provides a background on carbon markets and their potential role in a proposed strategy for energy efficiency improvements (EEI). It compares the relationship between an investment decision based solely on electricity prices to one that incorporates the monetary benefit associated with carbon offsets. The findings suggest that a regulated carbon ‘cap and trade’ system could provide additional value to property owners who pursue EEI strategies. Moreover, carbon offset value differs significantly by geographic location and method by which electrical energy is produced. EEI strategies that take into account carbon offset value could significantly reduce the impact that commercial real estate has on the environment.

Momentum is growing within the United States to better understand the causes and consequences of climate change, commonly referred to as “global warming.” While debate continues as to what the best course of action may be to deal with this phenomenon, one fact remains clear: activities that consume fossil fuels such as manufacturing, transportation, energy production, building operations, and food production are contributing to a rapid rise in carbon emissions (IPCC, 2007; Harvey, 2010). Continued reliance on fossil fuels as a primary source of energy will have dire environmental consequences. Atmospheric CO₂ levels have increased as much in the past 30 years as they have in the prior 200 years. This rate of increase has been especially pronounced in recent years (Exhibit 1).

In a seminal research report, The Stern Review has argued that the financial implication of attempting to stabilize global greenhouse gas emissions could be approximately 1% of global GDP, and this figure is expected to grow over time (Stern, 2006).

In the U.S., major industrial sectors are increasingly facing questions about their role in global warming, and it is likely that regulation associated with carbon emissions will be adopted in the near future. At present, the commercial real estate industry does not have a clear understanding of the magnitude or potential value of carbon emissions—either as a liability or as an opportunity (Llewellyn, 2007). This in turn may impact investment decisions and operational strategies of commercial real estate owners and investors.

This paper provides an introduction to carbon emissions and the commercial real estate sector’s current level of awareness of its emissions footprint. It identifies
Exhibit 1 | Trend in Atmospheric CO₂ Concentration over the Industrial Era

![Trend in Atmospheric CO₂ Concentration over the Industrial Era](image)


the operational carbon footprint of investable U.S. commercial real estate and estimates the emissions reduction potential within the industry to be nearly $3 billion on an annual basis. A scenario is proposed where carbon emission reductions from investments in energy efficiency improvements (EEI) in both existing and new construction can be monetized in a regulated carbon market.¹ This creates a new revenue stream that justifies greater investment in energy conservation projects, which in turn, reduce carbon emissions. A geographical comparison of the relative value of emission reductions is made that allows for a location-based model of emission reducing EEI investment. The paper concludes with a discussion of major opportunities and barriers to realizing carbon emissions value given current industry practices and lack of regulatory certainty.

The academic literature linking carbon emissions to commercial real estate operations has been limited to a discussion of potential emission reductions (Binkley, 2007; Nauclé and Enkvist, 2009). There is however a growing body of research and policy documents that identify and address energy efficiency potential, building performance, and energy conservation in the commercial building sector (e.g., Ashford, 1999; Huovila, Ala-Juusela, Melchert, and Pouffary, 2007; Llewellyn and Chaix, 2007; Nelson, 2007; DiBona, 2008; Fuerst, 2008;
Carbon Markets

Miller, Jay, and Florance, 2008; Eichholtz, Kok, and Quigley, 2009). Research conducted by organizations have also examined this topic (United Nations Foundation, 2007; World Business Council on Sustainable Development, 2009), and policy implications to support energy efficiency investments have also been discussed (Reed, Johnson, Riggert, and Oh, 2004).

Carbon Emissions: Perception and Reality

Many real estate professionals believe that carbon emissions come primarily from vehicles and power plants; yet few recognize the magnitude of the contributions from real estate. A survey of building industry professionals globally shows that when asked the question: “What percentage of CO₂ emissions do you think buildings give rise to—directly and indirectly?” respondents reported a range of 12% to 30% depending on country of origin (Exhibit 2). Respondents in the U.S. reported the lowest estimates of all countries surveyed, at 12%, less than one-third the actual level of approximately 34% globally and 40% in developed economies (Price et al., 2006; World Business Council on Sustainable Development, 2009).

In the U.S., residential and commercial buildings account for more than 39% of all carbon emissions, more than either the transportation or industrial sectors. Commercial buildings account for 18% of total carbon emissions, whereas residential structures account for 21% (Exhibit 3). While carbon emissions for the economy as a whole are expected to grow at 1.2% annually, emissions from commercial real estate are expected to rise at nearly double that rate (McKinsey and Company, 2007). This is despite the recent awareness and increase in construction of “green” buildings in many countries throughout the world.

Fortunately, building energy conservation projects (EEI) represent some of the lowest cost, highest return investments available to reduce energy use and

Exhibit 2 | Perceived Emissions Generated by Real Estate

simultaneously reduce carbon emissions. The commercial real estate industry has a valuable opportunity to monetize emission reductions while simultaneously reducing operating expenses and modernizing their property portfolios.

**Background on Greenhouse Gases and Carbon Emissions**

Carbon emissions are greenhouse gases, produced largely by the burning of fossil fuels. They are generated either directly by the conversion of fuel such as natural gas into energy and heat in a building’s central plant, or indirectly by a power company burning coal to generate electricity for building use. In either case, the exhaust gases released into the atmosphere—primarily carbon dioxide (CO₂) and nitrogen oxides—trap heat from the sun. The accumulation of these gases in the atmosphere is believed to alter global climate patterns, leading to extreme weather events and changes to regional climates. This is what is commonly referred to as ‘global warming.’ These events and changes negatively impact global gross domestic product, as well as affecting mankind’s health and safety (CIER, 2007). Commercial real estate can also be affected through business interruption, higher insurance costs, and increased regulation that leads to higher construction costs or prohibits development in certain areas. Long-term shifts in customer demand to less risk-prone markets are also possible.

The standard measure of greenhouse gas emissions is one metric ton of carbon dioxide equivalent (CO₂e), the global warming impact of one metric ton of atmospheric carbon dioxide. The “e” is an equivalent measure by which certain gases other than CO₂ are converted to a common unit of measure. This is referred
to as the global warming potential (GWP) of a gas. Exhibit 4 lists several greenhouse gases and their relative GWP compared to CO₂.

When the global warming CO₂e of these gases is compared, fluorocarbons have a very high CO₂e; however, they are produced in much smaller quantities than CO₂. For example, fluorocarbons studied by the U.S. EPA account for only 2.2% of the total annual CO₂e emissions in the U.S.

Fossil fuel combustion produces several greenhouse gases including carbon dioxide, nitrogen oxides (NOx), sulfur oxides, and carbon monoxide. Utility-based power production is responsible for 27% of total NOx emissions in the U.S., second only to motor vehicles, which produce 49% of all NOx emissions (EPA, 1998). Avoiding the emission of one ton of N₂O (a common oxide of nitrogen) from fossil fuel combustion is equivalent to avoiding the emission of 310 tons of CO₂.

Carbon emissions from buildings accounted for more than 39% of all U.S. carbon emissions. The U.S. building sector was found to be responsible for direct and indirect emissions of 2.2 gigatons of CO₂e per year (U.S. EPA, 2010; author’s calculation). Globally, buildings have been estimated to contribute to 34% of CO₂ emissions, which is somewhat higher for developed countries at approximately 40% (Price, et al., 2006; World Business Council on Sustainable Development, 2009).

**Efforts to Reduce Carbon Emissions**

Over the past 15 years, there has been a global call to slow the impact of mankind’s contribution to climate change. Meetings in Kyoto, Japan in 1997 provided the first significant recognition of the global impact of carbon emissions and globally warming. The Kyoto Protocol, adopted by 187 countries, established a framework for several non-U.S. carbon emission trading systems currently in operation. One of the most comprehensive programs is represented by the European Union Emission Trading Scheme (EU ETS), which was created in 2003 and took effect in January 2005. This multi-country, multi-sector Greenhouse Gas

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**Exhibit 4 | Global Warming Potential of Various Gases**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Global Warming Potential</th>
<th>% of U.S. Emissionsᵃ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>1</td>
<td>85.1%</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>21</td>
<td>8.2%</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
<td>310</td>
<td>4.6%</td>
</tr>
<tr>
<td>Fluorocarbons (HFCs, PFCs, SF₆)</td>
<td>11,700</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Note: The source is U.S. EPA (2010).

ᵃmmtCO₂e.
(GHG) emission trading scheme is intended to allow member countries to meet their carbon emission reduction goals set forth by the Kyoto Protocol. In this program, emissions are capped on a country-by-country basis, and each country then allocates their allowances to large emitters across the range of regulated industries. Large emitters are assigned emissions allowances by their national government’s National Allocation Plan (NAP). This allocation is accomplished through study of industry efficiency, economic development levels, anticipated growth, and industry input. These companies are required to reduce their emissions to meet their allocated cap within the compliance period. There are over 10,000 such facilities throughout the European Union and include such industries as electrical generation, pulp and paper, smelting and refining, and the production of iron and steel, cement, and chemicals.

Large emitters are required to reduce their emissions to meet their cap within a series of compliance periods. This activity provides the basis for what is known as a ‘cap and trade’ system, and can be illustrated through a generic example: Let’s look at two power companies in Europe. A coal-fired power generating utility in Germany is required to reduce greenhouse gas emissions from 120 units to 100 units. In Spain, a power producer generates electricity from wind turbines, and has an allowance of 80 units but only uses 60 units because of the non-polluting wind energy. The Spanish company has excess offsets and can sell them via the cap and trade market to the German company to meet their emission reduction obligations.

Cap and trade markets work by setting a ceiling, or ‘cap’ on total emissions and allowing market forces to determine the price of emission reductions to comply with the cap. Entities participating in the cap and trade system can choose to reduce emissions internally or they can go to the market to buy or sell emission reductions to manage their obligations at a lower cost. Costly fines are levied for non-compliance, and emission reductions are required even if fines are levied.

One can gain a sense of the economics of a cap and trade system by looking at historical prices from the EU ETS market. The prices at which carbon offsets trade on the EU ETS index have ranged from €8.5 ($12.23) to €29 ($41.80) per metric ton in the 2008–2012 compliance period (Exhibit 5). The EU ETS accounts for nearly 70% of all global carbon trading, with nearly 8.2 gigatons of CO₂e traded in 2009 (Mouawad, 2010).

While the U.S. has not ratified the Kyoto Protocol and does not have a national carbon emission market, regulated markets have been created on a regional level. The Regional Greenhouse Gas Initiative (RGGI), a coalition of ten New England and Mid-Atlantic states, established a regional cap and trade system with similarities to the EU ETS. This market regulates only power sector emissions and quarterly emission allowance auction proceeds have totaled $662.8 million across eight auctions since September 2008. Prices have ranged from $2.00 to $3.50 per ton since initiation, and reflect an over-allocation of emission allowances to utilities and a weak economy in the U.S., which has resulted in lower-than-anticipated demand for electricity.
California, along with ten other Western states and four Canadian provinces have created a similar cap and trade system, with stringent emissions reduction goals known as the Western Climate Initiative (WCI). The WCI applies to many sectors of the economy, not only power generation. The WCI is planned for full implementation by 2015 when it will cover 90% of all regional carbon emissions. The Midwestern Greenhouse Gas Reduction Accord (MGGRA) is another example of an emerging multi-state emission reduction plan.

The federal government has been debating various cap and trade systems to regulate greenhouse gases, although legislation has yet to be enacted. In February 2009, the Obama Administration released its proposal for the first nationwide carbon cap and trade market. Initial targets sought to reduce overall carbon emissions by 14% below 2005 levels by the year 2020 and 83% by 2050.

In 2010, further federal progress appears to have slowed due to a lack of bipartisan political support in the U.S. Congress for a comprehensive climate and energy legislation. In response, the Clean Energy Jobs and American Power Act (Senate bill S.1733) was proposed in July 2010. This legislation would create a limited cap and trade program that applies only to the electric power sector and proposed to take effect in the year 2013. If a national cap and trade market is enacted in the U.S., it is not unreasonable to assume that over time, as caps are lowered, the price for emission reductions in the U.S. will rise toward levels seen in the EU ETS. This will likely accelerate if a functional global carbon cap and trade system is agreed-upon by the U.S., the European Union, and other major carbon-emitting countries.

Voluntary carbon markets also exist in the U.S. One example is the Chicago Climate Exchange. Compared to a regulated market, the voluntary market is small...
and carbon offset prices are considerably lower. Historic prices in the $2 to $3 per metric ton range have fallen to under $0.50 per emission reduction allowance in 2009 and 2010, due in large part to the recent global economic slowdown.

Thus far in the U.S., regional efforts to regulate carbon emissions have utilized a cap and trade approach. It is likely that a cap and trade solution will continue to be preferred over other options such as a carbon tax. Cap and trade programs that are currently operating or planned are constrained by limited geographic reach and also by a focus on only certain sectors of the economy. Until there is a comprehensive national carbon reduction program that encompasses all major sources of carbon emissions, it is unlikely that EU ETS-level pricing for carbon emissions will occur in the U.S.

**Carbon Offset Additionality**

In order to understand the impact of carbon-related improvements in commercial real estate, one needs to identify the level of activity that could occur, and which would qualify for inclusion in a functioning cap and trade market. This is referred to as *additionality*, and it is a complex term that pervades the carbon markets.\(^{13}\) It refers to a specific, prescribed activity or investment that must take place in order to prove that emission reductions are a result of a conscious activity, and one that would have *not* occurred through business-as-usual practices. The retrofit of a functionally obsolete 30-year-old boiler in a commercial building illustrates the concept of additionality. Due to advancements in boiler technology over the past 30 years, all new boilers will likely be more efficient than the one being replaced. Because of this improvement, carbon emission reductions associated with this boiler retrofit that bring it up to current standards would be considered business-as-usual and therefore would *not* have additionality. If, on the other hand, the new boiler was one of the most efficient models available and perhaps utilized other systems to further boost its efficiency (e.g., co-generation), many of the emission reductions for the level of efficiency beyond the business-as-usual case would have additionality. This concept can be thought of like a sales quota plan in marketing. Only by exceeding the quota will a salesperson receive a bonus. Carbon offsets work in a similar manner. Investments in buildings that do not exceed a carbon market-recognized threshold of emission reductions (i.e., have additionality) will not receive a bonus—they will not be able to monetize the carbon offsets that could result from such activity. As a result of this concept of additionality, it is likely that a limited number of larger and highly energy-efficient properties will capture a disproportionate level of carbon offsets relative to their peers.

**Emission Reduction Potential in Commercial Real Estate**

Commercial real estate electricity use accounts for three quarters of all electricity consumption in the U.S. A conservative approximation of the level of carbon emissions from commercial real estate activity can be made by using federal electricity consumption information for commercial real estate and multiplying it
by the U.S. average carbon emissions rates per unit of electricity production (pounds of CO\textsubscript{2} equivalent emissions per kilowatt-hour). Other forms of energy use in buildings, such as natural gas, also present carbon emission reduction opportunities. However, natural gas use in commercial buildings comprises only 8.2% of all natural gas use in the U.S. By comparison, natural gas used in residential buildings accounts for 21% of total yearly U.S. natural gas consumption (EIA, 2009). Due to the lower percentage consumption, as well as for clarity and simplicity, only emission reductions associated with electricity consumption are considered in our discussion.

Secondary carbon reductions that are a by-product of energy conservation measures are also excluded. An example of this would be more efficient lighting that, as a by-product, also reduces indoor heating loads, thereby reducing air-conditioning power consumption. In this case, secondary savings from the air-conditioning have been ignored even though they may be quantifiable and additional in a real world carbon emission reduction project. Excluding secondary sources of emission reductions also provides for more conservative assessment of economic value.\textsuperscript{14}

Investable commercial buildings in the U.S. consume approximately 1.7 trillion kWh of primary electricity per year.\textsuperscript{15} The average U.S. carbon emissions rate from the production of primary energy average 2.06 pounds per kilowatt-hour of electricity. Multiplying primary energy consumption and the average carbon emission rate and dividing by 2,204.6 (the number of pounds of CO\textsubscript{2} per metric ton) yields 1.6 billion metric tons. This is a gross (and conservative) approximation of the carbon emissions generated from U.S. investable commercial real estate on an annual basis.

In order to arrive at the net monetizable emission reduction potential, carbon offset additionality must be considered. As discussed, most emission reduction investments will not meet additionality requirements, although they will still generate significant operating cost reductions. For purposes of this research, it is assumed that industry-wide, commercial real estate emissions can be reduced by 30%.\textsuperscript{16}

Of this 30% reduction, the assumption is that only a relatively small subset would be classified as having additionality. The actual percentage will be a result of many factors including regulations and energy codes, emission reduction schedules, incentive levels, and the rate of adoption of new technology. For purposes of the current discussion, approximately 1/6 of these reductions (or 5% of total carbon emissions) will qualify as having additionality.\textsuperscript{17} This results in an annual level of tradable carbon emissions of approximately 79.8 million metric tons (Exhibit 6).

While the choice of additionality level may appear to be somewhat vague, there are some guidelines as to how it may be interpreted. In the U.S., there is a voluntary carbon market, which operates on the Chicago Climate Exchange (CCX). The CCX uses the EPA ENERGY STAR rating system to determine additionality, and an ENERGY STAR rating of 75 has been set as the threshold.
Exhibit 6 | Emission Reduction Potential for Commercial Real Estate

<table>
<thead>
<tr>
<th>CO₂ Emissions Generated by Electricity Consumption</th>
<th>Million Metric Tons of CO₂e</th>
</tr>
</thead>
<tbody>
<tr>
<td>All commercial buildings</td>
<td>3,754</td>
</tr>
<tr>
<td>Investable commercial buildings</td>
<td>1,596</td>
</tr>
<tr>
<td>5% of investable commercial buildings emissions</td>
<td>79</td>
</tr>
</tbody>
</table>

Note: The source is EIA 2008; author’s estimates.

for what constitutes additionality. Emission reductions that result from efforts required to bring a building up to an ENERGY STAR 75 rating cannot be monetized, while those associated with exceeding the ENERGY STAR 75 rating pass the CCX prescribed additionality test.

Value of Carbon Emission Reductions

To determine the value of potential carbon savings, a range of carbon prices is assigned to the quantity of offsets generated in Exhibit 6. The range of offset prices is shown in Exhibit 7. The range of prices for carbon offsets are derived from a low of $3 per ton (RGGI market prices) to a high of $35 per ton (EU ETS prices). As shown, the annual value of emission reductions ranges from a low of $240 million to a high of $2.80 billion. Assuming no growth in this market, the total capitalized value of carbon offsets for U.S. investable commercial real estate would range from approximately $3.43 billion to $40.0 billion.

While many emission reduction projects will not exceed the additionality threshold, a subset of assets will thus constitute the universe of properties that represent the values shown in Exhibit 7. The average impact of carbon offsets for these buildings could reasonably fall between $0.01 and $0.08 per square foot per year, assuming monetizable energy savings of 2.5 kWh per square foot per year.

Exhibit 7 | Value of Carbon Offsets for Commercial Real Estate

<table>
<thead>
<tr>
<th>Price per Ton of CO₂</th>
<th>Annual Market Value of Emission Reductions ($ billion)</th>
<th>Capitalized Value at 7% ($ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3</td>
<td>$0.24</td>
<td>$3.43</td>
</tr>
<tr>
<td>$15</td>
<td>$1.20</td>
<td>$17.1</td>
</tr>
<tr>
<td>$35</td>
<td>$2.80</td>
<td>$40.0</td>
</tr>
</tbody>
</table>

Note: The source is author’s estimates.
In the case of a 1 million square foot building, this would represent an annual monetized value of between $7,000 and $82,000. In low carbon price scenarios, carbon offsets are unlikely to be monetized, as even modest transaction costs would likely consume any marginal revenue. Yet as shown in this example, higher carbon prices (such as those experienced in the EU ETS market) could result in a value enhancement of $1.2 million. In a high carbon price scenario, this revenue should become a consideration when underwriting the scope and energy savings level to be attained by EEI investments. Note, this value is in addition to the value created through the reduction of electricity costs achieved by making EEI investments to the building.

**Carbon Emissions, Physical Location, and Fuel Source**

Property location will have a significant effect on emission reduction potential for EEI investments. Within the U.S., carbon emissions vary between electric utilities due to their power generation fuel sources and generation efficiencies. Carbon emissions per kilowatt-hour (kWh) of electricity vary by more than 550% from highest to lowest emitting states (Exhibit 8). North Dakota and Wyoming lead the nation in emissions, while Vermont and Idaho have the lowest. This suggests, ceteris paribus, investing in states with high levels of emissions will maximize the monetary impact of carbon offsets. This is evidenced by the fact that North Dakota has 55 times greater effective emissions (per kWh) than Vermont.

In the prior 1 million square foot building example, the carbon offset value was based on a carbon emissions rate equal to the U.S. average of 2.06 pounds of CO₂e per kWh of electricity. If the same EEI investment were implemented in North Dakota with its much higher emissions rate, annual revenue would exceed $153,000 and the capitalized value would approach $2.2 million, which is nearly double the prior example.

**Price of Carbon**

Given the level of average carbon emissions per kWh by states, the monetary value of savings associated with the offset of these emissions can be derived on a kWh basis. These results are shown in Exhibit 9. In the exhibit, there are two values: one based on a carbon offset price of $3 (RGGI market) and the other at $35 (EU ETS market). The dollar value of CO₂ emissions at a $3 price ranges from a low of nearly zero per kWh in Vermont, where the average level of emissions is very low, to a high of $0.005 kWh in North Dakota, where a higher level of emissions has marginal value at this offset price. As discussed earlier, transaction costs would likely preclude the decision to undertake a carbon-motivated improvement by itself at these price levels. However, at an offset price of $35 per ton, the savings become more significant, ranging from $0.001 per kWh in Vermont to $0.061 per kWh in North Dakota. While these values may seem low, recall that they are based on a single kWh, and when scaled up for actual carbon savings associated with the operations of commercial real estate, could offer monetary benefit to a well-planned EEI investment strategy.
### Exhibit 8 | Comparison of CO₂ Emissions by State

<table>
<thead>
<tr>
<th>State</th>
<th>Effective CO₂ Emissions&lt;sup&gt;a&lt;/sup&gt;</th>
<th>State</th>
<th>Effective CO₂ Emissions&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT</td>
<td>0.070</td>
<td>U.S. AVERAGE</td>
<td>2.056</td>
</tr>
<tr>
<td>ID</td>
<td>0.188</td>
<td>MI</td>
<td>2.057</td>
</tr>
<tr>
<td>WA</td>
<td>0.491</td>
<td>MS</td>
<td>2.155</td>
</tr>
<tr>
<td>OR</td>
<td>0.612</td>
<td>AK</td>
<td>2.195</td>
</tr>
<tr>
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<td>0.802</td>
<td>NV</td>
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</tr>
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<td>NE</td>
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</tr>
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<td>NJ</td>
<td>1.008</td>
<td>MT</td>
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</tr>
<tr>
<td>ME</td>
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<td>WI</td>
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<td>MN</td>
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<td>NY</td>
<td>1.221</td>
<td>SD</td>
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</tr>
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<td>DE</td>
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</tr>
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<td>MO</td>
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</tr>
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<td>IA</td>
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<td>KY</td>
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<tr>
<td>FL</td>
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<td></td>
</tr>
</tbody>
</table>

Notes: The sources are EPA (2007) and author's calculations.
<sup>a</sup>lbs/kWh.

### Price of Electricity

Traditionally, the investment decision for energy conservation measures has been based on energy cost reductions and their relation to the capital cost of implementation. Investment is made when an acceptable return on investment is expected. Notwithstanding the value of carbon offsets, the cost of electricity significantly impacts the attractiveness of EEI investments in certain markets. For
### Exhibit 9 | $ Value of CO₂ Emissions per kWh at $3 and $35 per Ton Carbon Prices

<table>
<thead>
<tr>
<th>State</th>
<th>$ Value of Carbon Emissions per kWh at $3</th>
<th>$ Value of Carbon Emissions per kWh at $35</th>
<th>State</th>
<th>$ Value of Carbon Emissions per kWh at $3</th>
<th>$ Value of Carbon Emissions per kWh at $35</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.003</td>
<td>0.032</td>
</tr>
<tr>
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<td>0.003</td>
<td>MI</td>
<td>0.003</td>
<td>0.033</td>
</tr>
<tr>
<td>WA</td>
<td>0.001</td>
<td>0.008</td>
<td>MS</td>
<td>0.003</td>
<td>0.034</td>
</tr>
<tr>
<td>OR</td>
<td>0.001</td>
<td>0.010</td>
<td>AK</td>
<td>0.003</td>
<td>0.035</td>
</tr>
<tr>
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<td>0.013</td>
<td>NV</td>
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<td>0.037</td>
</tr>
<tr>
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<td>0.015</td>
<td>NE</td>
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<td>0.038</td>
</tr>
<tr>
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<td>0.016</td>
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<td>0.038</td>
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<td>0.017</td>
<td>WI</td>
<td>0.003</td>
<td>0.040</td>
</tr>
<tr>
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<td>0.001</td>
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<td>0.040</td>
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<tr>
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<td>0.026</td>
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<td>0.044</td>
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<td>KS</td>
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</tr>
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<td>0.052</td>
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</tr>
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<td>ND</td>
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<td>0.061</td>
</tr>
</tbody>
</table>

Those who have performed energy audits of their properties in several markets, this will not come as a great surprise, and countless energy conservation businesses exploit this to target customers in high energy cost markets.

What is rather surprising is the lack of awareness by many (if not most) real estate investors about the variation in commercial electricity prices from one market to another. For example, average commercial electricity prices per kWh in 2006 range from a low of $0.052 in Idaho to a high of $0.214 in Hawaii, with a U.S. average of $0.095 (Exhibit 10). Put another way, base electricity prices vary 415% from lowest to highest cost states.²²
### Exhibit 10 | Commercial Electricity Price by State

<table>
<thead>
<tr>
<th>State</th>
<th>Electricity Price(^a)</th>
<th>State</th>
<th>Electricity Price(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>$0.051</td>
<td>TN</td>
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</tr>
<tr>
<td>WV</td>
<td>$0.056</td>
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<td>$0.081</td>
</tr>
<tr>
<td>MO</td>
<td>$0.061</td>
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<td>$0.084</td>
</tr>
<tr>
<td>UT</td>
<td>$0.061</td>
<td>OH</td>
<td>$0.085</td>
</tr>
<tr>
<td>VA</td>
<td>$0.062</td>
<td>MI</td>
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</tr>
<tr>
<td>NE</td>
<td>$0.062</td>
<td>PA</td>
<td>$0.089</td>
</tr>
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</tr>
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<td>$0.091</td>
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<tr>
<td>SD</td>
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<td>U.S. AVERAGE</td>
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</tr>
<tr>
<td>WA</td>
<td>$0.066</td>
<td>FL</td>
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</tr>
<tr>
<td>AR</td>
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<td>NV</td>
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<td>KS</td>
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<td>$0.103</td>
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<td>DE</td>
<td>$0.109</td>
</tr>
<tr>
<td>MN</td>
<td>$0.070</td>
<td>VT</td>
<td>$0.117</td>
</tr>
<tr>
<td>NC</td>
<td>$0.072</td>
<td>AK</td>
<td>$0.117</td>
</tr>
<tr>
<td>IN</td>
<td>$0.072</td>
<td>NJ</td>
<td>$0.118</td>
</tr>
<tr>
<td>OK</td>
<td>$0.072</td>
<td>ME</td>
<td>$0.124</td>
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<tr>
<td>IA</td>
<td>$0.073</td>
<td>CA</td>
<td>$0.131</td>
</tr>
<tr>
<td>CO</td>
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<td>RI</td>
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<td>IL</td>
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<td></td>
</tr>
</tbody>
</table>

Notes: The source is EIA (2007).
\(^a\) $ per kWh.

---

**Electricity Prices and Carbon Emissions**

If one considers the value of carbon emissions in *addition* to the value of energy cost reductions when making an EEI investment decision, alternative outcomes from an energy-cost-only perspective may be warranted. Carbon offset value could make EEI investment in low-cost power states *more* attractive while spurring greater conservation efforts in virtually all locations.
Electricity prices and carbon emissions exhibit negative cross-correlation. This suggests that states with higher CO₂ emissions are associated with lower electricity cost (Exhibit 11). For example, Utah has the fourth highest level of emissions per kWh (Exhibit 8) while its electricity prices are the fourth lowest (Exhibit 10). This is driven in part by the fact that places with lower electricity costs are likely to have power created by coal-fired electricity plants, which are typically a cheaper source of power, but associated with higher levels of carbon emission.

Until there is a national policy for dealing with carbon emissions, EEI investment will likely remain concentrated in higher electricity price regions; regions that correlate to lower carbon emissions. In this case, energy use reductions will be achieved, but industry-wide emission reductions will not be maximized. As a result, the role that commercial real estate investment (and corresponding EEI) will play in the reduction of greenhouse gases may be limited.

One can examine the relative economics of carbon value with electricity value in EEI investments by comparing the ratio of carbon emission value per kWh divided by electricity value per kWh. The ratio indicates the relative attractiveness of EEI investment value when considering a given carbon offset price and electricity price. For a ratio less than 1, this means the value of electricity reductions is greater than the value of emission reductions. From a relative economic perspective, the closer the ratio is to zero suggests that EEI investment will be driven more by electricity costs than carbon offset value. However, even with a ratio less than one, some level of carbon offset value will be generated, depending on the state location of the property. Exhibit 12 presents this ratio for a carbon offset price of $3 per ton.

In Utah, for example, at a $3 per ton offset price, the ratio of carbon savings to energy savings is 0.066. Subject to the earlier discussion on additionality, this can be interpreted as follows: for every dollar of electricity savings per kWh on commercial real estate in Utah due to EEI, there will also be 6.6 cents of savings from carbon offsets. While these numbers are not large, they come in addition to the electricity savings already being received, and can thus be thought of as an additional value that is associated with EEI investment. While there is carbon offset value in nearly all states at the offset price of $3 per ton, in most locations it is relatively small and unlikely to shift investments away from higher electricity price markets. This implies that carbon offsets priced at levels observed in the

---

**Exhibit 11** | Correlation between CO₂ Emissions and Electricity Cost

<table>
<thead>
<tr>
<th>CO₂ Emissions by State (Lb/kWh)</th>
<th>Electricity Cost ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Emissions by State (Lb/kWh)</td>
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</tr>
<tr>
<td>Electricity cost ($/kWh)</td>
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<tr>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>State</td>
<td>Ratio of Emission Value to Electricity Value</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>VT</td>
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<tr>
<td>MA</td>
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<tr>
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<tr>
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<td>0.015</td>
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<tr>
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<tr>
<td>U.S. AVERAGE</td>
<td>0.032</td>
</tr>
</tbody>
</table>

U.S. RGGI market are unlikely to become a major factor affecting EEI investment decisions in most states.

If, however, market pricing as observed in the regulated markets in Europe (EU ETS) are assumed, the results change significantly. Exhibit 13 presents the ratio of carbon offset value to electricity price at an offset value of $35 per ton. At $35 per ton, not only do the carbon offset values become significant, but they can reorder the priority list of most financially attractive markets for EEI investment. This can be illustrated by examining state of Vermont. Vermont has the 11th highest electricity price among all U.S. states at a cost of $0.117 per kWh (Exhibit
Exhibit 13 | Ratio of $35/ton CO₂ Emissions Value to Electricity Value per kWh

<table>
<thead>
<tr>
<th>State</th>
<th>Ratio of Emission Value to Electricity Value</th>
<th>State</th>
<th>Ratio of Emission Value to Electricity Value</th>
</tr>
</thead>
<tbody>
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<tr>
<td>LA</td>
<td>0.300</td>
<td>NM</td>
<td>0.688</td>
</tr>
<tr>
<td>MD</td>
<td>0.311</td>
<td>IN</td>
<td>0.694</td>
</tr>
<tr>
<td>PA</td>
<td>0.315</td>
<td>KS</td>
<td>0.696</td>
</tr>
<tr>
<td>FL</td>
<td>0.323</td>
<td>MO</td>
<td>0.721</td>
</tr>
<tr>
<td>IL</td>
<td>0.325</td>
<td>KY</td>
<td>0.754</td>
</tr>
<tr>
<td>U.S. AVERAGE</td>
<td>0.351</td>
<td>UT</td>
<td>0.852</td>
</tr>
<tr>
<td>AZ</td>
<td>0.354</td>
<td>WV</td>
<td>0.893</td>
</tr>
<tr>
<td>NV</td>
<td>0.366</td>
<td>WY</td>
<td>0.903</td>
</tr>
<tr>
<td>AL</td>
<td>0.370</td>
<td>ND</td>
<td>0.968</td>
</tr>
<tr>
<td>MS</td>
<td>0.374</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10), making it a strong candidate for EEI investment today—when carbon has no value. When carbon offset value is considered at $35 per ton, Vermont falls to 50th on the list (Exhibit 13). Vermont is one of only two states that do not operate coal-fired power plants; almost three quarters of its energy comes from a nuclear power plant and much of the rest from hydroelectric sources that do not produce carbon emissions (U.S. Energy Information Administration, 2010).

Perhaps a more relevant comparison to illustrate the value of carbon offsets can be made through a comparison between states. For example, electricity prices are 5.3% higher in Arizona ($0.079 per kWh) than Colorado ($0.075 per kWh).
Referring back to Exhibit 13, note that the ratio of emission value to electricity price (at a $35 offset price) is higher in Colorado (0.613) than Arizona (0.354). In other words, the relative value of carbon emission reductions is greater in Colorado than in Arizona. For every $1 of electricity savings in Colorado, there is an additional $0.613 in carbon offset value, whereas in Arizona, the additional carbon savings are $0.354, a difference of 42%. Despite the higher electricity costs in Arizona, and hence greater savings from EEI investments, greater carbon offset values make an identical EEI project in Colorado more financially attractive than one in Arizona (Exhibit 14). This illustrates the potential value of carbon offsets in locations where emissions from the production of electricity are high. In most states, carbon offset values add between $0.10 and $0.70 in value for every $1.00 of electricity value saved.

As these examples illustrate, the decision of where to prioritize EEI investment becomes more than simply identifying the highest electricity prices—when carbon emission reductions have sufficient value. At higher carbon offset prices, there is likely to be significant interest in the monetization of commercial real estate carbon emission reductions associated with EEI investment.

**Additional Considerations**

Given the undefined nature of real estate participation in carbon markets in the U.S., a series of assumptions have been made to arrive at the conclusions. There are a number of additional considerations that are likely to have an effect on the eventual structure, value, and attractiveness of carbon offset generation by commercial real estate EEI investment. These are summarized below to highlight areas of uncertainty, as well as relevant efforts already underway.

*Unequal Offset Generation.* Carbon offset generation will likely be unevenly distributed throughout the commercial real estate industry. Although significant cost-effective energy conservation is possible for all asset types, some will likely see more retrofit activity than others. For example, EEI investment may occur in the office sector before the multifamily residential sector due to centralization of building systems and improved economies of scale. Additionally, large portfolios are in a better position to identify and implement the most attractive offset-producing projects at scale and with lower transaction costs across multiple

---

**Exhibit 14 | Comparison of EEI Investment in Arizona and Colorado**

<table>
<thead>
<tr>
<th>($) per kWh</th>
<th>Arizona</th>
<th>Colorado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Price</td>
<td>$0.079</td>
<td>$0.075</td>
</tr>
<tr>
<td>Carbon Offset Value ($35)</td>
<td>$0.028</td>
<td>$0.046</td>
</tr>
<tr>
<td>Total</td>
<td>$0.107</td>
<td>$0.121</td>
</tr>
<tr>
<td>Difference</td>
<td>+13%</td>
<td></td>
</tr>
</tbody>
</table>
markets. Triple-net lease structures will remain a split incentive barrier throughout the industry. While value from both carbon offsets and electricity savings may be recognized, the ability to assign or share these benefits between owner and tenant will continue to create challenges. Tenants with long-term leases may have more incentive to push for EEI efforts, while those with shorter leases may have more incentive to resist capital expenditures by the owner to achieve these benefits.

**Additionality Threshold.** Considerable debate will precede the adoption of an additionality standard. Regulators and industry participants will need to work collaboratively to set an appropriate threshold. Utility companies and others are also likely to have a voice in the discussion. Evolving technologies and market demand for exceptionally energy-efficient buildings will allow some developers and owners to surpass the additionality threshold, even as it rises over time. A methodology for effective real estate participation in carbon markets should account for this complexity with a robust mechanism that adjusts in a predictable, consistent way to changes over time, while meeting the goals of regulators and the realities of the real estate industry.

**Current Carbon Market Methodologies.** Several standards exist today for commercial real estate participation in carbon markets. These have yet to see widespread adoption, due in part to high transaction costs, low carbon offset value, proprietary information, and limited scalability. The Chicago Climate Exchange (CCX) has established a methodology available to CCX-member companies for quantifying and certifying energy efficiency-based emission reductions.

Methodologies also exist in the European Union Emissions Trading Scheme (EU ETS). But of more than 1,400 registered Clean Development Mechanism (CDM) projects, only 18 projects deal with energy demand reduction, and only four deal with real estate. The administrative burden under the CDM is a particular challenge. This is beginning to receive attention, but is unlikely to be fully restructured soon. CDM projects also must be implemented in non-Annex B countries (more commonly referred to as developing countries). U.S.-based emission reduction projects are therefore prohibited from entering the CDM pool.

**White Tags.** White tags, or energy efficiency certificates, allow businesses and utilities to meet conservation and renewable portfolio standard requirements by purchasing certificates generated by third parties. Connecticut is one of a few states that have implemented such a system. The market acceptance of white tags has been somewhat limited. Also, due to a lack of a nationally accepted standard or market for white tags, the additionality criteria are subject to scrutiny and in some cases skepticism.

**First Mover Advantage.** Those companies that choose to take advantage of carbon offset savings may enjoy a first mover advantage. While the costs to a first mover include a steeper learning curve and perhaps less efficiencies in the market, they will enjoy the marketing advantages that come with ‘greening’ their property portfolio. These can add value for those wishing to pursue an SRI (socially responsible investment) initiative or use such initiatives to send behavior signals to the marketplace.
Utility Incentives and Rights to Benefits. Utility incentives are available in many markets to subsidize the cost of energy efficiency improvements. By claiming the resulting kilowatt-hour reductions, utilities meet their regulated quotas (as discussed in White Tags above). When utilities are regulated in a carbon market, they will continue to count energy reductions and associated emission reductions for their own requirements. Building owners will not be allowed to claim the same emission reductions. In this scenario, EEI investors will need to decide at the outset if they are going to accept utility incentives and forego title to the carbon offsets, or if they will decline utility incentives and seek to monetize emission reductions themselves. This decision will depend largely on how cost-effective it is to monetize offsets, as well as the perceived risk of successfully monetizing them. For many, utility incentives may be the faster, simpler solution.

Securitization. Once a sufficient pipeline volume of carbon offsets from EEI investment is flowing, financial products that enable better risk management can be created. One example is the securitization of bundles of carbon offsets aggregated from portfolios of EEI projects. This may reduce uncertainty of offset delivery among those who invest in securitized carbon offset bundles. This “carbon offset-backed security” will likely carry with it the current stigma from the mortgage-backed security market failures over the recent past. If and when market confidence returns, securitization may be a viable tool for risk reduction, along with potentially more efficient pricing in the marketplace.

Conclusion

This paper describes a scenario where the U.S. commercial real estate industry, through participation in emerging carbon emission markets, can create up to $2.8 billion in revenue with a capitalized value of $40.0 billion. This can be accomplished by implementing energy conservation projects and developing highly energy-efficient buildings that reduce operating costs from electricity use while also reducing carbon emissions.

The value of emission reductions in real estate is dependent on a number of factors. These include achieving sufficient emission reductions to meet additionality requirements, scalability to reduce transaction costs, and the market price of carbon offsets. This research addresses this uncertainty by assuming that gross emission reductions for commercial real estate will reach 30% industry-wide, but that only 5% of gross emission reductions will be monetized in the carbon market after meeting additionality requirements and overcoming transaction cost barriers. This equates to 79.8 million metric tons of CO\textsubscript{2}e emission reductions per year.

At a low offset price scenario of $3 per metric ton CO\textsubscript{2}e, it is unlikely that investors in commercial real estate will seek to monetize emission reductions, due in large part to an inability to overcome transaction costs. In a high price carbon offset scenario of $35 per metric ton CO\textsubscript{2}e, there is likely to be significant interest in monetizing emission reductions. In fact, in some states the value of carbon offsets nearly equals the value of electricity savings at these prices. When the
value of carbon offsets is considered, they can re-prioritize which states are most attractive for EEI investment. This is most notable in states that have relatively low energy prices combined with high carbon emissions per kWh of electricity produced.

The value of carbon emissions reductions is dependent upon three major factors: electricity price, carbon emissions offset price, and carbon emissions rate per kWh. Electricity prices vary more than four times across all 50 states and carbon emissions per kWh vary in excess of 55 times. Both factors should be considered to monetize emission reductions effectively. Recognizing these factors will spur EEI investment in markets that have high carbon emissions rates but moderate-to-low electricity prices. This can lead to greater adoption of energy conservation measures that both reduce electricity costs and also maximize carbon emission reductions from the commercial real estate industry.

There is uncertainty in the exact value of emission reductions from EEI investment in commercial real estate. Despite the limitations discussed, there is potential for EEI investments to access a new source of revenue to incentivize greater energy conservation investment. This incentive can help maximize industry-wide carbon emission reductions. This will help meet the objective of the carbon markets: to spur meaningful and additional carbon emission reductions efficiently and at the lowest cost in order to lower the carbon footprint in an increasingly challenged environment.

An efficient carbon market will present significant opportunities to support greater investments in energy conservation that lower carbon emissions in the commercial real estate industry. This will not only help modernize buildings and reduce operating costs, but also reduce the impact of commercial buildings on the environment. This benefits owners, occupants, and society while reducing the impact of building operation on the natural environment.

**Endnotes**

1 EEI is construed to represent any capital expenditure undertaken in an effort to lower energy consumption in the ownership and operations of real estate. Examples could include upgrades in lighting, heating and cooling systems, control systems, and roofing upgrades.

2 Nitrogen oxides are often referenced as NO\textsubscript{x} and are measured alongside CO\textsubscript{2} when measuring greenhouse gas emissions.

3 Extreme weather events include increased frequency and severity of hurricanes, cyclones, tornadoes, and the like. Examples of climate change could include water shortages and desertification.

4 Examples could include the reluctance by some companies to move back into New Orleans in the aftermath of Hurricane Katrina.


6 The first compliance period, Phase I, was 2005–2007. Phase 2 runs from 2008–2012, with discussions currently underway to establish a successor phase.
As of July 2010, prices were generally in the $20–$23 U.S. dollar range. Pricing data are available from http://www.ecx.eu/ECX-EUA-Indices.

See http://www.rggi.org/home.

See http://www.rggi.org/co2-auctions/results.

See http://www.westernclimateinitiative.org/designing-the-program.

See http://www.midwesternaccord.org/.

The cost of emissions certificates were projected to be in the $13–$20 per ton range (Carey, 2009).

The term ‘additionality’ is widely recognized globally and pertains to carbon emission reduction projects. A technical definition for additionality, based on the United Nations Framework Convention on Climate Change (UNFCCC), enacted in 1994 and supported by 165 signatory countries, may be found at: http://www.cdmrulebook.org/84.

The impact of natural gas use and secondary carbon reductions could improve the results reported in this study by approximately 10%–15%.

First, for purposes of discussion, it is assumed that ‘investable’ real estate comprises approximately 60% of the overall commercial real estate market. This statistic was derived from the 2003 Energy Information Administration-Commercial Buildings Energy Consumption Survey, Table IA. From the total square footage of all buildings listed, we deducted those classified as education, museums, places of worship, and other categories not deemed to relevant for commercial ‘investment.’ Second, primary electricity is the electricity generated at the generation source before accounting for transmission and distribution losses.

A number of studies and reports suggest that 30% is a reasonable target to achieve. Deutsche Bank’s real estate group, RREEF, has committed to reducing energy consumption of its global portfolio by 30% by 2012 (Carpenter and Wyman, 2009). Research into the performance of LEED certified buildings found that on average the green buildings studied used 30% less energy than regular buildings (Kats, 2003). The McKinsey greenhouse gas abatement cost curve study assumed a carbon emissions abatement potential of 30% for real estate in the U.S. and 25% for China (Naucle´r and Enkvist, 2009).

For example, if total emissions were 100 units, and EEI measures reduced emissions by 30 units, only 5 units (1/6th of the 30 units reduced) are assumed to have additionality.

Assume an EEI project results in 2.5 kWh/SF energy savings that can be monetized via emission reductions: $2.5\text{kWh} \times 2.06 \text{ Lb/kWh} \times 2204.6 \text{ metric tons} \times 1,000,000 \text{ SF} \times \text{ carbon offset price (at $3 and $35)} = $7,008 and $81,761 respectively.

Using a 7% capitalization rate on offset value.

These figures are derived by taking the average level of carbon emissions by state times the carbon offset price and dividing this product by 2,204.6 (the number of pounds in a metric ton).

Vermont has a positive value for this statistic, but due to rounding, the result shows up as zero.

Billed electricity costs will vary due to time-of-use, demand charges, as well as additional fees and taxes.

Here and throughout this paper, the effect of utility and/or government involvement (incentives, rebates, regulations, etc.) in energy efficiency programs has been excluded due to inconsistencies from market to market and because they tend to distort price signals for EEI investment decisions.
See: http://cdm.unfccc.int/Projects/projsearch.html.

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The authors would like to thank Martha Peyton and Marc Louargand for helpful comments and suggestions. Support from the Real Estate Research Institute and the Royal Institute of Chartered Surveyors is gratefully acknowledged.

Aaron G. Binkley, AMB Property Corporation, San Francisco, CA 94108 or abinkley@alum.mit.edu.

Brian A. Ciochetti, Massachusetts Institute of Technology, Cambridge, MA, 02139 or tc@mit.edu.
Indoor Air Quality and Office Property Value

Authors
Kwame Addae-Dapaah, Tham Kok Wai, Mohd Jaafar Bin Dollah, and Yvonne Foo

Abstract
Urbanization and technological advancement have resulted in many urbanites working in window-sealed high-rise office buildings. Many researchers have found that indoor air quality (IAQ) affects tenant-landlord relationships, workers’ health and productivity, and building elements and systems. This may imply that IAQ could affect, positively or negatively, the value of buildings. This paper examines the impact of IAQ on the value of office buildings in Singapore. The results show that the return on investment in IAQ could be substantial (78.56%) while property values could increase by 1.28% to 3.85%. The findings could be of interest and usefulness to valuers and investors in office properties in Singapore and thus, help to promote sustainability in office property developments.

Environmental concern over the past decades, vis-à-vis the publication of “Our Common Future” by the World Conference on Environment and Development (WCED, 1987), has given sustainability worldwide currency. This is mainly due to the link that has been established between sustainability and economic, social, and environmental benefits. According to Cohen-Rosenthal and Smith (2003), sustainable buildings can be tagged as a “wave of the future,” and “value, value, and value” should be the developers’ and owners’ motto.

In Singapore, the quality of air and the work environment in office buildings has received much publicity since the introduction of the Guidelines for Good IAQ in Office Premise by the Ministry of Environment (ENV) in October 1996. The Green Mark Scheme (similar to the Green Building Rating by LEED in the United States), under which the Building Construction Authority of Singapore awards the Green Mark to buildings that satisfy certain criteria (including IAQ), has given further impetus to sustainability.

Studies have shown that indoor air quality (IAQ) has a direct impact on workers’ health and job performance (Djukanovic, Wargocki, and Fanger, 2002; Fisk, 2002; Wargocki, 2002; Olsen, 2005; Tanabe, Haned, and Nishipana, 2007). A good IAQ improves production qualities and helps to increase worker productivity by maintaining a healthy work environment (Martin, 1999). Poor IAQ and its concomitant sick building syndrome cause health problems, as well as uncomfortable workplace environments (Czubaj, 2002; Fisk, 2002).

This paper is motivated by the fact that in view of the several research findings showing the importance of IAQ on health and productivity, IAQ may affect
property values. However, no study has been done to relate IAQ *per se* to property value. Furthermore, although people laud the ideals of IAQ, green buildings, etc., little appears to be done simply because developers cannot see (in quantifiable monetary terms) how IAQ affect the value of their office buildings. In other words, developers/investors do not find the benefit-cost aspects of IAQ attractive enough to invest in it. Therefore, this paper is aimed at: (1) ascertaining (in monetary terms) the impact of IAQ on the rental value of office buildings in Singapore; (2) carrying out an IAQ audit to determine how the office IAQ complies with the stipulated guidelines; (3) determining office property owners’/tenants’ willingness to finance/pay premium rental for improvement in office IAQ; and (4) ascertaining the role of IAQ in tenant’s selection of an office space in Singapore.

The paper therefore proceeds as follows. The next section will deal with a review of the relevant literature. This is followed by data sourcing and management after which is presented the results, interpretation, and discussion of the data analysis. The last section is devoted to concluding remarks.

**Literature Review**

According to RICS (2005), green properties earn higher rents, attract tenants and buyers more quickly, and cost less to operate. Similarly, the Vancouver Valuation Accord (2007) highlights the need to recognize how inextricably intertwined are economic and environmental issues. The contributions of sustainable development (such as economic, health, ecological, etc. benefits) to the social well-being of occupants of such buildings are documented in the OCED, CaGBC, and USGBC reports (Lucuik, Trusty, Larsson, and Charette, 2005; Roper and Beard, 2006). A 15% reduction in absenteeism and a 90% decline in energy cost have been attributed to sustainable development (Morton, 2002). Cohen-Rosenthal and Smith (2003) state that higher real estate valuation can occur because of higher net income, higher productivity of money invested in real estate assets, higher productivity from the workforce, and positive company image as a result of lower operating costs for green buildings.

Gottfried (2003) observes that buildings with green rating may receive a superior capitalization rate than non-green buildings while Kats (2003) find that 72% of respondents to an extensive American office tenant survey would be willing to pay additional rent to have green features in their offices. According to Von Kempski (2003), investors and tenants demand a performance-based building, which goes well beyond traditional methods of addressing the well-being of building occupants to create building environments resulting in enhanced productivity, and reduced absenteeism and health risks. Physiological and neuro-physiological research shows that air quality and the perception of air encompassing both olfactory and thermal comfort play an important role in affecting human comfort. In mergers and acquisitions, corporate real estate values are tied more closely to the performance of the individual buildings. The differentiation between ‘normal’ and higher quality buildings is becoming more important (von Kempski, 2003).
Other studies have shown a positive relationship between sustainable buildings and productivity, and rent and occupancy premia, including Miller, Spivey, and Florance (2008), Fuerst and McAllister (2009), Miller, Pogue, Gough, and Davis (2009), and Eichholtz, Kok, Quigley (2010), Wiley, Benefield, and Johnson (2010). Similarly, Bako-Biro, Wargocki, Weschler, and Fanger (2004), Wyon (2004), and Seppanen, Fisk, and Lei (2006) have found a positive relationship between IAQ per se and productivity.

EPA (2000) suggests that given the relevant magnitude of operating cost, labor cost, and rental value in most buildings, it is possible that a modest investment towards improved IAQ would generate substantial returns. Gerard de Vries (2004) states that the provision of good office IAQ results in substantial savings in maintenance and replacement costs. Any such savings in operating expenses increases the net rental income and the related capital value of the building. According to Lam (2004), air conditioning and mechanical ventilation (ACMV) account for more than 30% of the operational cost of a building. Deterioration of the ACMV system would, [apart from resulting in poor IAQ which, among other things, causes sick Building Syndrome (Raw, 1993) with its attendant absenteeism, which affects office productivity], increase repair costs for the aging mechanical and electrical system. Judge (2003) finds that absenteeism costs the U.K. economy 12 billion pounds sterling per annum—a significant proportion of this figure is attributed to poor environmental conditions in buildings, which give rise to Sick Building Syndrome. All these factors are potential sources of a net rental loss to the building owner, which ultimately affects the economics of letting office space to tenants (Gan, Tan, and Premas, 2003). As observed by Dixon, Scura, Carpenter, and Sherman (1994), economic action, which includes environmental actions, generates two effects: benefits and costs. It is noted that there is a useful symmetry in benefits and costs: a benefit forgone is a cost while a cost avoided is a benefit.

The extant literature does not specifically relate IAQ to rental or property values. Given the effects of IAQ on buildings and the occupants thereof, which are lauded by most people, it appears paradoxical that both landlords/investors and tenants are somewhat reluctant to “commit” themselves to it. It is therefore hypothesized that IAQ does not affect office rental values in Singapore. This will be operationalized through statistical tests.

Data Sourcing and Management

The paper is based on rental data obtained from an international property consultancy firm in Singapore, data from an IAQ audit of an office, and three surveys that were conducted at different times from December 2004 to January 2008. Thus, both qualitative and quantitative analyses are employed for the study.

First Survey

The first survey, which was conducted in December 2004, focused on a sample population of 133 high-rise office buildings at Marina Centre, Raffles Place,
Shenton Way, Tanjong Pagar, and Beach Road (i.e., CBD of Singapore). Both the owners and tenants of these office buildings were interviewed during the survey. The entire building owners’ population constitutes the building owners’ sample size as the owners are few (133). In contrast 10% of the office tenants’ population (4,730) constitutes the sample size for the tenants (Tan, 2002). The sample population and size for both building owners and tenants are reported in Exhibit 1. Stratified random sampling was used for the office tenants to reduce sampling error (Mangione, 1995).

Two sets of questionnaires were used for this survey: one set each for building owners and tenants. Each set of questionnaires had three sections that solicited similar information from both groups. Section A investigated the degree of importance that the respondents attach to the management of IAQ of the office buildings. Section B explored the relationship between good IAQ and office rental value. In addition, the section solicited information on how much the respondents are willing to invest in (building owners), or pay for (i.e., payment of premium rental by tenants) improving the existing IAQ. The respondents were further asked to state their views on tenants’ office selection preferences/criteria using a 9-point ordinal rating scale with “1” signifying the most important and “9” the least important.

Self-addressed postage-paid return envelopes and questionnaires were hand-delivered to the 133 building owners and 615 office tenants. This was followed by emails. The whole exercise (collection of rentals for the office buildings and the survey) took two months (i.e., November and December 2004) to complete. A total of 475 tenants’ and 129 owners’ questionnaires were duly completed and found suitable for analysis. The data were coded as shown in Exhibit 2 to facilitate the use of SPSS for the analysis.

The variables in Exhibit 2 are used for the hedonic model (Equation 1), which is the basis for testing the hypothesis that IAQ has no impact on office rental. Thus, the hedonic model is specified as follows:

---

**Exhibit 1 | Population and Sample Size of the Building Owners and Office Tenants**

<table>
<thead>
<tr>
<th>Office Location</th>
<th>Population</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building Owners</td>
<td>Office Tenants</td>
</tr>
<tr>
<td>Marina Centre</td>
<td>9</td>
<td>900</td>
</tr>
<tr>
<td>Raffles Place</td>
<td>30</td>
<td>1250</td>
</tr>
<tr>
<td>Shenton Way</td>
<td>60</td>
<td>1380</td>
</tr>
<tr>
<td>Tanjong Pagar</td>
<td>23</td>
<td>680</td>
</tr>
<tr>
<td>Beach Road</td>
<td>11</td>
<td>520</td>
</tr>
<tr>
<td>Total</td>
<td>133</td>
<td>4730</td>
</tr>
</tbody>
</table>
Exhibit 2 | Variable Codes for Hedonic Model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Codes</th>
<th>Types</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rental Value</td>
<td>RENTAL</td>
<td>Numeric</td>
<td>Singapore Dollars</td>
</tr>
<tr>
<td>Age</td>
<td>AGE</td>
<td>Numeric</td>
<td>Years</td>
</tr>
<tr>
<td>Carpark Facilities</td>
<td>CARPARK</td>
<td>Dummy</td>
<td>1–with carpark facilities</td>
</tr>
<tr>
<td>Improvement of IAQ</td>
<td>IAQ</td>
<td>Dummy</td>
<td>1–with IAQ improvement</td>
</tr>
<tr>
<td>DISTANCE</td>
<td>DISTANCE</td>
<td>Dummy</td>
<td>1≤ 1 km from Mass Rapid Transit (MRT) station</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variable</td>
<td>0≥ 1 km from MRT station</td>
</tr>
</tbody>
</table>

Office Rental = \( \beta_0 + \beta_1 AGE + \beta_2 DISTANCE + \beta_3 IAQ + \beta_4 CARPARK + \varepsilon \).

The variables in the model are extremely few. This is intentional as the model is mainly aimed at exploring the effect of IAQ on office rental rather than the explanatory power of office building characteristics on rental. The model suffices for the purpose of this inquiry.

Furthermore, the analysis is based on rental instead of sale price as a block of offices in Singapore is rarely sold and bought. Thus, there is a dearth of sales data for office buildings. In contrast, data on office rentals abound in the market albeit difficult to obtain as the data are shrouded in confidentiality. This implies that an analysis based on rental value will reflect the market more than that based on market values (if they can be obtained), which are appraisal-based.

IAQ Audit and Second Survey

The objective of this exercise is to determine the impact of IAQ on the productivity of an office building in Singapore. The exercise took place in December 2006 and January 2007. It includes a walk-through inspection of the office areas, a survey of the 90 workers in the office (Exhibit 3), and an IAQ audit by an accredited IAQ consultant. The ENV Guidelines for Good IAQ in Office Premise were the criteria for the inspection and audit. The walk-through audit occurred on December 11, 2006 while the questionnaire for the IAQ survey was sent via email to the 90 office workers on December 15, 2006. This was followed by phone calls to ensure speedy return of the completed questionnaires. It took two weeks to complete the survey. The questionnaire covered environmental conditions, nature of occupation, health complaints, demographic factors, and importance of IAQ.

The questions relating to environmental condition are aimed at discovering the possible source of discomfort (if any) due to the workplace environment. The
nature of occupation deals with physical and psychological problems attributable to exposure to pollutants from work. Health complaints are due to the exposure to the discomfort, pollutants, etc., while the absenteeism rate will help to determine the cost of labor due to an IAQ problem. Questions on demographic factors were meant to solicit information on the salaries of the respondents so that monetary loss due to absenteeism and/or savings due to improvement in productivity as a result of IAQ could be calculated. Similarly, questions on IAQ were meant to gauge the office workers’ perception of IAQ. The distribution of respondents (85.6% of the office workers) among the office zones are presented in Exhibit 3.

The objective IAQ audit was done on January 8 and 9, 2007. The second survey preceded the IAQ audit to ensure that the respondents were not influenced by the results of the IAQ audit. This is meant to preempt any accusation of priming the survey results. It is possible that the results of the second survey might have been different if it had been done after the IAQ audit.

The office space was divided into four zones for the audit (details are available from the authors). Measurements were taken twice daily (morning and afternoon) from 28 sampling locations comprising 25 locations within the four zones and three outdoor locations. The IAQ audit was done after the IAQ survey to ensure that the survey results were not biased by the audit.

**Third Survey**

The third survey, which was conducted in December 2007 and January 2008, was aimed, among other things, at ascertaining the probable impact of sustainability (of which IAQ was found to be a major component according to the survey results) on rental and capital values of real estate. Both random sampling (for the general public) and snowball sampling (for real estate professionals) were used for the survey. A questionnaire was used for the survey that involved 150 interviewees from the general public and 71 respondents who are real estate professionals. A 5-point Likert scale, with “1” being least significant and “5” most significant was given to the respondents to indicate the impact of sustainability on rental and capital values of real property. SPSS was used to analyze the data.
Results

The results of the IAQ survey and audit are presented first to provide a systematic development of discussion.

Results of Walk-through Audit

The salient observations during the walk-through audit are as follows:

- The main doors to all the respective zones were left open. Some occupants complained of stuffiness in their workplace environment.
- Some of the occupants were wearing jackets, which was an indication of overcooling. This is symptomatic of thermal discomfort.
- The carpeted flooring was stained in some areas.
- There was an unpleasant odor in certain areas.
- There was an accumulation of dust at the supply and return air grilles, indicating that the air-conditioning ducts were dirty.
- Some ceiling boards were badly stained due to leaks.
- The offices were supplied by a constant air volume air-conditioning system. Except for Zone 1 that was using a chilled water system and having a fresh-air intake, the others were using an air-cooled system with no fresh air supply.

It is apparent from the above observations that there are some IAQ problems to be resolved if these observations could be supported by objective facts through a formal audit and a survey of the workforce. Similarly, the overcooling of the workplace is a potential source for energy and cost saving.

Results of the IAQ Audit

The relevant significant results are presented in Exhibits 4a, 4b, and 5 (detailed results are available from the authors). The results generally show that apart from carbon dioxide (18% above guidelines), bacterial count (16% above guidelines), and temperature (26% below guidelines), the rest of the parameters were within the ENV Guidelines. However, the level of carbon dioxide in two sampling locations in Zone 1 (Exhibit 4) was quite harmful. The trend shows that the carbon dioxide level was high for both morning and afternoon. Even though only 18% of the readings were above the limits, this is a cause for concern as 90% of the readings were above 800 ppm, which is close to the allowable limit of 1000 ppm. It must be noted that the audit was conducted with the office doors open to comply with the office workers practice of leaving the doors open. Thus, the carbon dioxide level could reach dangerous levels if the doors are closed as they are designed to. These findings are in consonance with Akbar (1999). Furthermore, Zone 1 is found to be problematic as far as temperature is concerned as its mean temperature (22°C and 21.9°C) is below the Guidelines minimum of 22.5°C. Moreover, every zone exhibits bacterial counts in excess of the 500 CFU/m³ maximum limit, although the frequency is relatively low (Exhibit 5).
Exhibit 4a | IAQ Audit: Trend of Carbon Dioxide in Air

Exhibit 4b | Mean Carbon Dioxide Content

<table>
<thead>
<tr>
<th>ENV Guidelines (1000 ppm)</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AM</td>
<td>PM</td>
<td>AM</td>
<td>PM</td>
</tr>
<tr>
<td>Mean</td>
<td>955</td>
<td>959</td>
<td>988</td>
<td>890</td>
</tr>
<tr>
<td>N (1)</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>N (2)</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes:
N (2): Number of sampling locations.
AM: Readings taken in the morning.
PM: Readings taken in the afternoon.

Results of IAQ Survey of Workforce

The results of the above survey are presented in Exhibit 6. Taking 80% (ASHRAE62-1989R) response of “just right” as the standard of acceptability, it may be concluded that “lighting” is not problematic. To some extent, “noise”
and “humidity” (both with 77.9% just right response) are not much of a problem. However, “air movement” and “temperature,” with an acceptance rate of 51.9% and 44.2% respectively, are problematic. The unsatisfactory air movement, vis-à-vis concentration of carbon dioxide above 800 ppm in 90% of the office environment, causes stuffiness and unpleasant odor; 88.3% and 63.6% of the respondents complained of stuffiness and bad smell respectively.

The response rate of 55.8% that the office areas were either cold or too cold is rather surprising since only Zone 1 had temperature readings below the limit and only about 16% of the respondents are from Zone 1. However, it is worth noting that 50% of the readings were 23.1°C and below. This could mean that the 22.5°C minimum under the ENV Guidelines could be too low. The overcooling of the work environment was attested by 89.7% of the respondents, who wear extra clothing to keep warm in the office. This may negate productivity to controvert Seppanen, Fisk, and Lei (2009), who conclude that the highest productivity is at a temperature of about 22°C.

The end result of all these is health complaints (Exhibit 7), with its attendant 140 days of absenteeism per year, with managerial/professional and secretarial/clerical staff accounting for 98 and 42 days respectively. According to the results of the survey, only 14.3% of the respondents did not have any health complaint. Of the 85.7% who had health complaints, 31.2% and 41.4% found relief when they left their workstations or building respectively while 13% did not find any relief at all. These results imply the existence of Sick Building Syndrome (ASHRAE62-1989R). Given that only 10.7% of the respondent workforce was on medication, it could be concluded that the health complaints are due to the workplace
### Exhibit 6 | Percentage of Acceptable Environmental Conditions

<table>
<thead>
<tr>
<th>Noise</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Just Right</td>
<td>Count</td>
<td>8</td>
<td>15</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Total respondents per zone</td>
<td>13</td>
<td>22</td>
<td>13</td>
<td>29</td>
<td>77</td>
</tr>
<tr>
<td>% Within Location</td>
<td>61.5%</td>
<td>68.2%</td>
<td>92.3%</td>
<td>86.2%</td>
<td>77.9%</td>
</tr>
</tbody>
</table>

| Lighting                  | Count  | 10     | 18     | 12     | 26    | 66    |
| Total respondents per zone | 13      | 22     | 13     | 29     | 77    |
| % Within Location         | 76.9%  | 90.9%  | 92.3%  | 89.7%  | 88.3% |

| Humidity                  | Count  | 9      | 18     | 10     | 23    | 60    |
| Total respondents per zone | 13      | 22     | 13     | 29     | 77    |
| % Within Location         | 69.2%  | 81.8%  | 76.9%  | 79.3%  | 77.9% |

| Air Movement              | Count  | 7      | 11     | 7      | 15    | 40    |
| Total respondents per zone | 13      | 22     | 13     | 29     | 77    |
| % Within Location         | 53.8%  | 50.0%  | 53.8%  | 51.7%  | 51.9% |

### Exhibit 7 | Health Complaints by Ranking

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Health Complaints</th>
<th>Percentage of Complaint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Headache</td>
<td>80.5%</td>
</tr>
<tr>
<td>2</td>
<td>Dry Throat</td>
<td>79.2%</td>
</tr>
<tr>
<td>3</td>
<td>Stuffy Nose</td>
<td>74.0%</td>
</tr>
<tr>
<td>4</td>
<td>Eye Irritation</td>
<td>72.7%</td>
</tr>
<tr>
<td>5</td>
<td>Lethargy</td>
<td>72.7%</td>
</tr>
<tr>
<td>6</td>
<td>Drowsiness</td>
<td>67.5%</td>
</tr>
<tr>
<td>7</td>
<td>Skin Rash</td>
<td>63.6%</td>
</tr>
<tr>
<td>8</td>
<td>Dizziness</td>
<td>57.1%</td>
</tr>
<tr>
<td>9</td>
<td>Short of Breath</td>
<td>48.1%</td>
</tr>
<tr>
<td>10</td>
<td>Nausea</td>
<td>46.8%</td>
</tr>
</tbody>
</table>
environment (office) rather than to the respondents’ medical conditions. It must be noted that the survey was conducted before the IAQ audit. Thus, the results could not be influenced by the IAQ audit. The cost and benefits of these results and their impact on property rental and capital values are discussed in the next sections.

Result of the Hedonic Model

The results are presented in Exhibit 8. The problem is that the increase in rental of S$0.161 per square foot attributable to improvement in IAQ is not statistically significant at any of the conventional levels. The same result is replicated by the general public survey (i.e., the third survey); the increase in rental value attributable to sustainable development has a p-value of 0.156. This is not good news for IAQ, although a positive correlation exists between IAQ and office rental. However, statistical insignificance does not necessarily mean that the impact on rental and capital value is not substantial. For, example, for an office space of 300,000 square feet (which is common in Singapore), the S$0.16 per square foot translates to a mean incremental rental value of S$48,000 per annum which, at a capitalization rate of 5%, adds S$960,000 to the capital value. This may not be statistically significant but it is nonetheless substantial. Furthermore, given a standard error of S$0.227 per square foot (Exhibit 8), a good IAQ can add a maximum\(^2\) of S$0.49 per square foot to the rental value. Thus, on the basis of 300,000 square feet of office space and a 5% capitalization rate, a good IAQ could increase rental and capital values (assuming the good IAQ can be perpetuated) by S$147,000 per annum and S$2,940,000 respectively. Moreover, improvements in IAQ lead to savings in energy consumption and other benefits to tenants, as evidenced by the cost-benefit analyses of an improvement in IAQ of the office space, which was the subject of the IAQ audit and survey (Exhibits 9a & 9b).

The analyses in Exhibit 9a show that an investment (S$41,800) in IAQ improvement for the office space (about 26,900 square feet), which was the subject of the IAQ audit and survey, provides an internal rate of return (IRR) of 78.56% and a net present value ((NPV) of S$159,770 based on a discount rate of 12%. Certainly, this is a very good investment by any standard. It must be noted that the analyses are based on the mean incremental rental of S$0.16 per square foot attributable to IAQ. The IRR and NPV increase to 100.51% and S$220,102 respectively if the analyses are based on the maximum incremental rental of S$0.49 per square foot attributable to IAQ improvement. These figures clearly reveal that accounting for all the benefits attributable to IAQ improvement provides a totally different (attractive) picture from that (dismal) provided by analyses solely based on rental value. However, it must be cautioned that the foregoing analyses assume an owner-occupier. Unfortunately, the position of an owner/investor who lets the property to tenants is not very attractive, as evidenced by figures in Exhibit 9b.

Such an owner/investor has to share the benefits from IAQ improvements with the tenants. Although it is the owner/investor who pays for the IAQ improvement, the major proportion of the benefits accrues to the tenant. The owner/investor
### Exhibit 8 | Results of Hedonic Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unstandardized Coefficients $\beta$</th>
<th>Std. Error</th>
<th>Standardized Coefficients Beta</th>
<th>$t$</th>
<th>p-value</th>
<th>Significant</th>
<th>95% Confidence Level for $\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L-bound</td>
</tr>
<tr>
<td>Constant</td>
<td>3.329</td>
<td>0.403</td>
<td>8.351</td>
<td>0.000</td>
<td>0.065</td>
<td>0.004</td>
<td>2.530</td>
</tr>
<tr>
<td>Age</td>
<td>-0.031</td>
<td>0.071</td>
<td>-0.131</td>
<td>-1.750</td>
<td>0.083</td>
<td>0.463</td>
<td>1.360</td>
</tr>
<tr>
<td>Distance</td>
<td>0.911</td>
<td>0.227</td>
<td>0.301</td>
<td>4.024</td>
<td>0.000</td>
<td>-0.289</td>
<td>0.607</td>
</tr>
<tr>
<td>IAQ</td>
<td>0.159</td>
<td>0.226</td>
<td>0.053</td>
<td>0.704</td>
<td>0.483</td>
<td>0.788</td>
<td>1.700</td>
</tr>
<tr>
<td>Carpark</td>
<td>1.244</td>
<td>0.230</td>
<td>0.406</td>
<td>5.404</td>
<td>0.000</td>
<td>0.788</td>
<td>1.700</td>
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</table>
## Exhibit 9a  | Cost-Benefit Analysis of IAQ Improvement\(^a\)

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Savings &amp; Incremental Rental Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absenteeism(^b)</td>
<td>0</td>
<td>19,600</td>
<td>19,894</td>
<td>20,192</td>
<td>20,495</td>
<td>20,802</td>
<td>21,114</td>
<td>21,431</td>
<td>21,753</td>
<td>22,079</td>
<td>22,410</td>
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<tr>
<td>Medical Fee(^c)</td>
<td>0</td>
<td>4,200</td>
<td>4,263</td>
<td>4,327</td>
<td>4,392</td>
<td>4,458</td>
<td>4,525</td>
<td>4,592</td>
<td>4,661</td>
<td>4,731</td>
<td>4,802</td>
</tr>
<tr>
<td>Electricity(^d)</td>
<td>0</td>
<td>6,690</td>
<td>7,294</td>
<td>7,954</td>
<td>8,673</td>
<td>9,457</td>
<td>10,312</td>
<td>11,244</td>
<td>12,261</td>
<td>13,369</td>
<td>14,578</td>
</tr>
<tr>
<td>Increase in Rent (S$0.16/ft(^2))</td>
<td>0</td>
<td>4,300</td>
<td>4,515</td>
<td>4,740</td>
<td>4,977</td>
<td>5,226</td>
<td>5,488</td>
<td>5,762</td>
<td>6,050</td>
<td>6,353</td>
<td>6,670</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>34,790</td>
<td>35,966</td>
<td>37,213</td>
<td>38,537</td>
<td>39,943</td>
<td>41,439</td>
<td>43,029</td>
<td>44,725</td>
<td>46,532</td>
<td>48,460</td>
</tr>
<tr>
<td>Expenditure(^e)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Improvement Works</td>
<td>41,800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Maintenance</td>
<td>0</td>
<td>3,000</td>
<td>3,045</td>
<td>3,090</td>
<td>3,137</td>
<td>3,184</td>
<td>3,231</td>
<td>3,280</td>
<td>3,329</td>
<td>3,379</td>
<td>3,430</td>
</tr>
<tr>
<td>5 yearly Cleaning of Ducting</td>
<td>0</td>
<td>8,491</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Expenditure</td>
<td>41,800</td>
<td>3,000</td>
<td>3,045</td>
<td>3,090</td>
<td>3,137</td>
<td>11,675</td>
<td>3,231</td>
<td>3,280</td>
<td>3,329</td>
<td>3,379</td>
<td>3,430</td>
</tr>
<tr>
<td>Net Income</td>
<td>−41,800</td>
<td>31,790</td>
<td>32,921</td>
<td>34,123</td>
<td>35,400</td>
<td>28,268</td>
<td>38,208</td>
<td>39,749</td>
<td>41,396</td>
<td>43,153</td>
<td>45,030</td>
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</table>
### Exhibit 9b | Cost-Benefit Analysis of IAQ Improvement | Owner's Viewpoint Only

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings in Electricity Consumption</td>
<td>0</td>
<td>6,690</td>
<td>7,294</td>
<td>7,954</td>
<td>8,673</td>
<td>9,457</td>
<td>10,312</td>
<td>11,244</td>
<td>12,261</td>
<td>13,369</td>
<td>14,578</td>
</tr>
<tr>
<td>Increase in Rent ($0.16/ft²)</td>
<td>0</td>
<td>4,300</td>
<td>4,515</td>
<td>4,740</td>
<td>4,977</td>
<td>5,226</td>
<td>5,488</td>
<td>5,762</td>
<td>6,050</td>
<td>6,353</td>
<td>6,670</td>
</tr>
<tr>
<td>Total Income</td>
<td>10,990</td>
<td>11,809</td>
<td>12,694</td>
<td>13,650</td>
<td>14,683</td>
<td>15,800</td>
<td>17,006</td>
<td>18,311</td>
<td>19,722</td>
<td>21,248</td>
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<tr>
<td>Expenditure</td>
<td>41,800</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement Works</td>
<td>41,800</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Maintenance</td>
<td>3,000</td>
<td>3,045</td>
<td>3,090</td>
<td>3,137</td>
<td>3,184</td>
<td>3,231</td>
<td>3,280</td>
<td>3,329</td>
<td>3,379</td>
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<tr>
<td>5 yearly Cleaning of Ducting</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Total Expenditure</td>
<td>41,800</td>
<td>3,000</td>
<td>3,045</td>
<td>3,090</td>
<td>3,137</td>
<td>11,675</td>
<td>3,231</td>
<td>3,280</td>
<td>3,329</td>
<td>3,379</td>
<td>3,430</td>
</tr>
<tr>
<td>Net Income</td>
<td>-41,800</td>
<td>7,990</td>
<td>8,764</td>
<td>9,604</td>
<td>10,513</td>
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<td>12,569</td>
<td>13,726</td>
<td>14,982</td>
<td>16,343</td>
<td>17,818</td>
</tr>
</tbody>
</table>

**Notes:**

Exhibit 9a: NPV (12%) = S$159,770 (based on mean incremental rental of S$0.16/ft²). IRR = 78.56%.

Exhibit 9b: NPV (12%) = S$17,803. IRR = 20.21%.

- Cash flow is over 10 years as ACMV is expected to last for 10 years according to IAQ Consultant.
- Based on 140 days absence per year and average salary of S$140 per day (based on 3 years’ salary statements). Salary is projected to increase at 1.5% inflation rate.
- Based on figures obtained from clinics. Projected to increase at 1.5% p.a. to account for inflation.
- Based on average consumption over 3 years and projected to increase at 9.04% p.a. computed from 3 years’ tariff.
- Figures were provided by the IAQ Consultant who did the audit. Figures are projected to increase at 1.5% p.a. to account for inflation (See Appendices 1 & 2 for detail).
only reaps benefits from savings in utility bills (if the owner/investor is responsible for the bills) and the incremental rental value, both of which provides an IRR of 20.21% compared to the overall IRR of 78.56% and NPV of S$17,803 compared to S$159,770 based on a discount rate of 12% (Exhibits 9a and 9b andAppendices 1 and 2). The IRR and NPV accruable to the owner/investor increase to 44.31% and S$78,141 (compared to 100.51% and S$220,102) respectively when analyses are based on the maximum incremental rental of S$0.49 per square foot. Although the analyses from the owner/investor’s viewpoint show that the investment in IAQ improvement is financially feasible, the figures imply that the owner/investor’s share of the NPV for all the benefits from improved IAQ is 11.14%.

In a situation where the tenant is responsible for the utility bill, the owner/investor’s return on the invested capital in IAQ improvement reduces to minus S$35,302 and plus S$25,036 (IRR of minus 13.53% and plus 24%) when analyses are based solely on the mean and maximum incremental rentals of S$0.16 and S$0.49 per square foot. This inequitable “natural” allocation of the benefits between the owner/investor and tenants could undermine IAQ improvement unless a satisfactory apportionment of the benefits and/or costs between the two groups could be found.

**Results of Owners’ and Tenants’ Survey**

The results of the owners’ and tenants’ survey reported below are in consonance with the statistical insignificance of the impact of IAQ on rental (see Results of Hedonic Model above). The results reported in Exhibit 10 show that the overwhelming majority of both owners (about 95%) and tenants (about 96%) agree that it is important/very important to maintain good IAQ in office space. Similarly, 100% and 96.21% of owners and tenants acknowledge the impact of IAQ on workers’ productivity. This is reinforced by 68.20% of owners and 80.60% of tenants agreeing that good office IAQ increases workers’ productivity (Exhibits 11a & 11b). These results are in consonance with the extant literature. It is noteworthy that only 19.40% of the tenant respondents do not think that good office IAQ increases workers’ productivity (Exhibit 11b). Furthermore, 71.40% of the tenant respondents agree that good office IAQ reduces absenteeism. These results are concurred by the general public survey in which 82.4% of the respondents agree to health, etc. benefits of sustainable developments.

These results imply that tenants do know the beneficial effects of good IAQ. In contrast, owners are not very sure that good IAQ will bring them commensurate monetary rewards through increased rental value. Only 49.60% (vs. 50.40%) of owners think that improvement in IAQ will lead to higher rental. Given the tenants’ awareness and acknowledgement of the benefits to them of good office IAQ, one would have expected IAQ to feature prominently on their office selection preferences. With a mean rank of 4.78 according to the Friedman test (Exhibit 12), IAQ is not considered to be a very significant factor in their selection preferences. Similarly, one would have expected tenants to be willing to pay higher rent for good office IAQ. Paradoxically, the majority of tenants (54.70%) do not
### Exhibit 10 | Importance of IAQ to Owners and Tenants (Tenants’ Response Bracketed)

<table>
<thead>
<tr>
<th>Upkeep of Office IAQ</th>
<th>Frequency</th>
<th>%</th>
<th>Effect of IAQ on Workers’ Performance</th>
<th>Frequency</th>
<th>%</th>
<th>Condition of Current IAQ</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>61 (229)</td>
<td>47.29</td>
<td>Yes</td>
<td>129 (457)</td>
<td>100</td>
<td>Excellent</td>
<td>0 (4)</td>
<td>0</td>
</tr>
<tr>
<td>Important</td>
<td>62 (226)</td>
<td>48.06</td>
<td>Good</td>
<td>79 (152)</td>
<td>61.24</td>
<td>Good</td>
<td>(32)</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>6 (19)</td>
<td>4.65</td>
<td>No</td>
<td>0 (18)</td>
<td>0</td>
<td>Neutral</td>
<td>27 (114)</td>
<td>20.93</td>
</tr>
<tr>
<td>Not Important</td>
<td>0 (1)</td>
<td>0</td>
<td>Satisfactory</td>
<td>17 (141)</td>
<td>13.18</td>
<td>Satisfactory</td>
<td>(29.68)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very Poor</td>
<td>6 (64)</td>
<td>4.65</td>
<td>Very Poor</td>
<td>(13.47)</td>
<td></td>
</tr>
</tbody>
</table>
Exhibit 11a | Owners’ Views on Factors Favoring IAQ Improvement

<table>
<thead>
<tr>
<th>Response</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased workers’ productivity</td>
<td>68.20</td>
<td>31.80</td>
</tr>
<tr>
<td>Recognition from building authority</td>
<td>59.70</td>
<td>40.30</td>
</tr>
<tr>
<td>Reduced maintenance cost</td>
<td>58.90</td>
<td>41.10</td>
</tr>
<tr>
<td>Higher efficiency in building system</td>
<td>57.40</td>
<td>42.60</td>
</tr>
<tr>
<td>Fewer tenant complaints</td>
<td>50.40</td>
<td>49.60</td>
</tr>
<tr>
<td>Higher office rental can be reaped from improved IAQ</td>
<td>49.60</td>
<td>50.40</td>
</tr>
<tr>
<td>Increased lifespan of building elements and system</td>
<td>38.80</td>
<td>61.20</td>
</tr>
</tbody>
</table>

want to pay higher rent for improvement in office IAQ; they want the owner to absorb the cost of IAQ improvement (Exhibit 13b). The weighted average percentage increase in rental value that the 45.30% of the “willing” tenant respondents want to pay for improvement in IAQ is 2.99%. Another paradox is that more owners (59.70%–Exhibit 13a) are willing to spend a relatively higher weighted percentage increase (5.47%) in funding for improvement in IAQ vis-à-vis their uncertainty about a commensurate return via increased rental value.

It is evident from the foregoing analyses that the tenants want to have their cake and eat it too. They want the owners/investors to pay for improvement in, and maintenance of, good office IAQ for them (the tenants) to reap the bulk of the monetary rewards. This may prove to be the greatest hindrance to improving IAQ in offices. The analyses presented in Exhibits 9a and 9b reveal that 88.86% of the monetary benefits (NPV) from improved IAQ accrues to the tenants. The owner/investor who pays for the improvement receives a paltry 11.14% of the resultant NPV.

The Way Forward

According to the results of the general public survey, the main obstacles to achieving sustainable developments in Singapore are: difficulty in quantifying benefits (4.30), higher construction cost (4.24), lack of awareness of benefits (4.20), and pay-back period being too long (4.0). The mean scores are out of 5 with “1” being very insignificant and “5” very significant. As far as IAQ is concerned, it has been shown that:

- The benefits can be quantified;
- The cost is not very high;
- The parties are aware of the benefits; and
- The pay-back period is relatively short: it is less than two years if all benefits are accounted for in the analysis (Exhibit 9a) and about seven
Exhibit 11b | Tenants’ Views on Benefits of IAQ Improvement

<table>
<thead>
<tr>
<th>Response</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased workers’ productivity</td>
<td>80.60</td>
<td>19.40</td>
</tr>
<tr>
<td>Reduction in absenteeism</td>
<td>71.40</td>
<td>28.60</td>
</tr>
<tr>
<td>Increase tenants’ annual profit</td>
<td>13.70</td>
<td>86.30</td>
</tr>
<tr>
<td>Enhance landlord-tenant relationship</td>
<td>28.20</td>
<td>71.80</td>
</tr>
<tr>
<td>Landlords owe a duty of care to tenants to provide good IAQ</td>
<td>52.80</td>
<td>47.20</td>
</tr>
<tr>
<td>Other: enhance tenants health</td>
<td>0.60</td>
<td>0</td>
</tr>
</tbody>
</table>

Exhibit 12 | Owners’ and Tenants Selection Preferences for Office Unit (Owners’ Ranking Bracketed)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean Rank</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of Building</td>
<td>2.10</td>
<td>1</td>
</tr>
<tr>
<td>Rental Rates</td>
<td>2.45</td>
<td>2</td>
</tr>
<tr>
<td>Accessibility</td>
<td>2.93</td>
<td>3</td>
</tr>
<tr>
<td>IAQ of the Building</td>
<td>4.78</td>
<td>4</td>
</tr>
<tr>
<td>Age of Building</td>
<td>5.90</td>
<td>5</td>
</tr>
<tr>
<td>Flexible office layout/column-free concept</td>
<td>6.04</td>
<td>6</td>
</tr>
<tr>
<td>Prestige of building &amp; availability of high-tech facilities</td>
<td>6.82</td>
<td>7</td>
</tr>
<tr>
<td>Availability of car parking facilities</td>
<td>6.92</td>
<td>8</td>
</tr>
<tr>
<td>Nearness to similar business types</td>
<td>6.96</td>
<td>9</td>
</tr>
</tbody>
</table>

years for the owner/investor who receives the incremental rental and savings in utility bills attributable to improved IAQ if he is responsible for utility bills (Exhibit 9b).

Thus, the main impediment to improvement in office IAQ could be the unwillingness of tenants to pay a premium rent for it when they enjoy most of the benefits accruable from IAQ improvement. It must be noted that notwithstanding the tenants’ acknowledgement that good office IAQ reduces absenteeism and increases productivity, they argue that it is the building owner’s
Exhibit 13a | Owners Willingness to Increase Funding for IAQ Improvement

<table>
<thead>
<tr>
<th>Response</th>
<th>%</th>
<th>% Increase in Annual Fund for IAQ Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>59.70%</td>
<td>20% more 3.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15% more 12.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% more 15.50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% more 27.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 5% 1.60%</td>
</tr>
<tr>
<td>No</td>
<td>40.30%</td>
<td>Reasons for Unwillingness to Increase Annual Fund for IAQ Improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IAQ is not an important factor 24.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Satisfied with the present IAQ 11.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current rent does not justify IAQ 4.70%</td>
</tr>
</tbody>
</table>

Exhibit 13b | Willingness to Pay Higher Rent for Improved IAQ

<table>
<thead>
<tr>
<th>Response</th>
<th>%</th>
<th>% Increase in Rental Tenants are Willing to Pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>45.30%</td>
<td>20% more 0.60%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15% more 1.10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% more 10.50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5% more 23.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 5% 9.70%</td>
</tr>
<tr>
<td>No</td>
<td>54.70%</td>
<td>Reasons for Unwillingness to Pay Higher Rent for IAQ Improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current rental is too high 7.20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landlord should absorb the cost of IAQ improvement 43.40%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not essential to have good IAQ in working environment 3.80%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others 0.40%</td>
</tr>
</tbody>
</table>

Responsibility to provide a healthy working environment. If the current condition of office IAQ is causing absenteeism and reduced productivity (both of which are costs to tenants) and the building owner concedes to it, the tenants could go to court to seek redress. Although the legal implications are beyond the tenets of this paper, such action could cause the owners to incur more costs. Thus, the tenants may argue that the benefits from improved IAQ directly (through increased rental value and reduction in maintenance cost) and indirectly (through preempting possible litigation) accrue to the owners of the building to make the cost of IAQ improvement the sole responsibility of the owners.

Notwithstanding the fact that the increased rental attendant to IAQ improvement does not justify the investment (as it results in negative NPV), the inclusion of savings in utility bills makes the investment in improved IAQ financially feasible—it provides a positive NPV. Recall that the analyses do not take into
account the savings in maintenance and repair costs that may result from improved office IAQ. Since maintenance and repair costs are operating expenses, any savings in these costs increase net income from the property (and therefore capital value) to increase the financial returns from IAQ investment. Thus, an increase in rental value (though important) should not be the sole justification for investment in improved office IAQ. Savings in operating expenses are equally important as they increase the net income to make the investment economically viable. After all, it is net income, not merely an increase in rental value, which determines the value of the property if the capitalization rate is held constant.

According to the results of the general public survey, the respondents gave a mean score of 3.16 and 3.71 respectively on the impact of sustainable development on the rental and market values of such buildings. The difference between the two means is statistically significant at the 0.05 level. This implies that while the general public expects sustainable development to have a muted impact on rentals, it expects the impact on capital values to be relatively substantial. This paradox is explained by the fact that savings in utility bills and maintenance costs (operating expenses) will increase net income and thus, capital value but not rental value. For example, if the benefits (total income of S$10,990 for Year 1) in Exhibit 9b can be perpetuated at 5% yield, they would add an average of S$219,800 (or S$695,800 if the analysis is based on all the benefits from IAQ—Exhibit 9a) to capital value. These figures translate into S$8.17/S$25.87 per square foot more in capital value, which amount to 1.22%/3.85% of the capital value (S$672 per square foot) at the time of the survey. Even if the analysis is solely based on Exhibit 9b (benefits likely to accrue to the owner/investor), the increase in capital value per square foot could be S$14.77 (2.20%) on the basis of the maximum incremental rental value of S$0.49 per square foot. In contrast, the incremental rental of S$0.16 (mean) and S$0.49 (maximum) per square foot amounts to a 0.48% and 1.46% increase in capital value. Moreover, Gottfried (2003) states that green buildings could have a superior capitalization rate to “normal” buildings. If account is taken of any reduction in capitalization rate vis-à-vis reduction in maintenance and repair costs attributable to IAQ improvement, the increase in capital value could be substantial.

Given that the cost per square foot for the IAQ improvement is S$1.55 (i.e., 0.23% of capital value), the increases in capital value per square foot presented above are quite attractive, especially to the owner-occupier, who enjoys all the benefits from IAQ improvement; the incremental capital value-IAQ improvement cost ratio is 16.69 (S$25.87/1.55). The ratio for owner-investor is 5.27 (i.e., S$8.17/1.55).

Furthermore, the results of the survey show that both parties share the same views on the importance and benefits of good office IAQ, especially in relation to increased productivity and reduced absenteeism. What is required is a common understanding between the two parties that improved office IAQ benefits both of them so that they can come to a win-win agreement for “equitable” sharing of the costs and/or benefits of IAQ to promote investment in improving office IAQ.
Conclusion

The paper set out to investigate the impact of IAQ on office property values. In view of this, three surveys were conducted. There was also an IAQ audit of an office space, as well as a hedonic analysis of the impact of IAQ on office rental. The results of the survey show that while both office building owners and tenants acknowledge the benefits of improved office IAQ, the majority of the tenants (54.70%) is not willing to pay additional rent for improved IAQ. This gives credence to the results of the hedonic model that the increased rental value attributable to improved IAQ is not statistically significant. Notwithstanding the statistical insignificance of the increase in rental value, the results show that the increase in capital value is relatively high. Even without accounting for a possible superior capitalization rate and savings from reduced maintenance and repair costs, the results show that improved IAQ could increase capital value by 1.28% (mean) and 2.29% (maximum) on the basis of net income from the property. Capital value could increase by 3.85% if all benefits from improved IAQ are taken into account. Moreover, it was found from an investment analysis of a test case that the return on investment in improved IAQ is substantial (78.56% if all benefits are included in the analysis). Even when analyses are based solely on incremental rental value and savings in operating expenses, the return on investment was found to be 20.21%. Given that the bulk (about 89%) of the monetary benefits from improved IAQ accrues to the tenants vis-à-vis the unwillingness of most tenants to pay a premium rent for improved IAQ, what is required is a common understanding between the two parties that improved office IAQ benefits both of them so that they can come to a win-win agreement for “equitable” sharing of cost and/or benefits of IAQ to promote investment in improving office IAQ. As the market becomes more familiar with the benefits of sustainable development, the impact of good IAQ on property value will be enhanced.

Appendix 1
Cost of IAQ Improvement

The cost of improving the IAQ for the office which is the focus of the IAQ audit is as shown below.

Scope of Work

- To seal off the 3 DX AHU rooms with 2” polyurethane panel and seal off all infiltration from the roof.
- Install fresh air inlet grilles with damper for all the 3 DX AHU rooms.
- Optimize the DX unit refrigeration system for all the 3 AHU/CDU units.
- Optimize the chilled water AHU units.
- Relocate one set of return air duct.
- Clean the ductwork.
- Install a fresh air treatment unit for the chilled water AHU unit. This comprises 2 chilled water coils with the ductwork connected to the suction end of the AHU unit.
- To re-commission all the AHU units.

**Estimated Cost Provided by the IAQ Consultant**

- PU ceiling work: S$20,000
- Fresh air coils: S$4,000
- Ductwork modification: S$3,800
- Installation: S$6,000
- Duct Cleaning: S$8,000
- Total: S$41,800

**Annual Expenditure**

1. Annual Cost of Replacement of Air-Filters and Maintenance of Filtration System is estimated at S$3,000.00. This is projected to increase at the average annual inflation rate of Singapore of 1.5% per annum.
2. The Air-conditioned Duct needs to be cleaned in Year 5 at a cost of S$8,000.00. Given an inflation rate of 1.5% per annum, this cost will increase to S$8,491.

**Appendix 2**

**Savings Resulting From IAQ Improvement**

**Savings**

1. Absenteeism: The number of days absenteeism per annum, according to the second survey relating to the IAQ audit, is 140 as follows:
   - 4 managerial staff were absent for a total of 19 days.
   - 20 professional staff were absent for a total of 79 days.
   - 2 secretarial staff were absent for a total of 10 days.
   - 4 clerical staff were absent for a total of 32 days.

   Staff cost (salaries) for the 145 workforce were:
   - Financial Year 2003/04 = $6,960,080
   - Financial Year 2004/05 = $7,400,784
   - Financial Year 2005/06 = $7,204,826

   Based on the 2005/06, the cost of absenteeism (which becomes a saving when there is no absenteeism is S$136.12 per day (i.e., [S$7204826/(145 staff × 365

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days)). This is based on a conservative and pessimistic assumption that employees, at least, earn their salaries and thus, contribute that amount to production. This implies that employees’ absence due to medical leave attendant to poor IAQ costs the company (to reduce profit) the employees’ salaries paid during medical leave. Thus an improved IAQ that reduces such absenteeism to zero improves profitability by the cost (which becomes a saving) of the absenteeism. The result of the DCF is therefore likely to be the minimum savings as employees normally produce more than they earn in salaries. Ideally, the analysis should be based on productivity for which accurate figures are not accessible to us.

Given that managerial and professional staff with a relatively higher salary account for 98 of the 140 days absenteeism, savings from absenteeism is based on a conservative estimate of S$140 per day to give an annual savings of S$196,000. This is projected to increase at an average annual inflation rate of 1.5%.

An average staff cost is used for the DCF analysis as the company’s accounts only provide total staff cost. There is no indication of salaries for different categories of employees.

2. Medical Fee: An annual medical fee of S$4,200.00 (140 days \( \times \) S$30) is used in the DCF calculations. The S$30 medical fee per visit was obtained via telephone interviews of clinics where employees on medical leave receive medical treatment. This is projected to increase by 1.5% per annum to account for inflation.

3. Electricity Bills = (S$10,000 \( \times \) 66.9%) = S$6,690.00. This is projected to increase by 9.04% annually based on Singapore Power’s electricity tariffs from January 2004 (S$0.1544) to January 2007 (S$0.2002).

- Based on Ng (1993) that 66.9% of the energy consumption in a typical high-rise office building is attributed to the ACMV system.

Endnotes

1 At the time of writing, US$1 = S$1.384.

2 Given a mean of S$0.16 and a standard error of 0.227, the minimum impact of IAQ is minus S$0.07 per square foot. A good IAQ certainly will not have adverse effect on rental value, as attested by the results of the survey. It is therefore meaningful to base the analyses on the mean and maximum impact.

References

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Kwame Addae-Dapaah, National University of Singapore, Singapore 117566 or rstka@nus.edu.sg.

Tham Kok Wai, National University of Singapore, Singapore 117566 or bdgtkw@nus.edu.sg.

Mohd Jaafar Bin Dollah, National University of Singapore, Singapore 117566 or mjaafar@science.edu.sg.

Yvonne Foo, Wing Tai, Singapore.
Location Efficiency and Mortgage Default

Authors
Stephanie Y. Rauterkus, Grant I. Thrall, and Eric Hangen

Abstract
Using a sample of over 40,000 mortgages in Chicago, Jacksonville, and San Francisco, we model the probability of mortgage default based on differences in location efficiency. We used two proxy variables for location efficiency: 1) vehicles per household scaled by income and 2) Walk Score. We find that default probability increases with the number of vehicles owned after controlling for income. Further, we find that default probability decreases with higher Walk Scores in high income areas but increases with higher Walk Scores in low income areas. These results suggest that some degree of greater mortgage underwriting flexibility could be provided to assist households with the purchase of location efficient homes, without increasing mortgage default. They also support the notion that government policies around land use, zoning, infrastructure, and transportation could have significant impacts on mortgage default rates.

The recent housing crisis has created a renewed interest in the drivers of mortgage default behavior. According to Haughwout, Peach, and Tracy (2008), “Historically, four key characteristics (“risk factors” or “underwriting criteria”) have been thought to determine the probability that a mortgagor will default. Those factors are the loan-to-value ratio (LTV), the debt service-to-income ratio (DTI), the mortgagor’s credit score, and the extent to which the mortgagor’s income and assets have been verified by third party sources such as employers, tax returns, and bank account statements.” A rich literature on mortgage default behavior exists that describes these predictors of default, and that explores the role of life events such as job loss, illness and divorce as well as market events, particularly home price declines (e.g., Foster and Van Order, 1984; Thibodeau, 1985; Quercia and Stegman, 1992; Kau, Keenan, and Kim, 1993; Vandell, Kau, Keenan, and Kim, 1994; Kau, Keenan, Muller, and Epperson, 1995; Vandell, 1995; and Elul, 2006). More recently, a literature has examined the terms and originators of the loans themselves, particularly subprime and broker-originated loans, as predictors of default risk (e.g., Alexander, Grimshaw, McQueen, and Slade, 2002; and Ding, Quercia, Ratcliffe, and Lei 2008).

One possible factor that may also impact mortgage default risk is location efficiency. Location-efficient homes are located in areas that enable lower automobile ownership. The most important determinants of location efficiency are the compactness of residential development (number of housing units per net acre of residential development) and transit access (number of buses per hour at bus stops within ¼ mile walk of the home) (Holtzeclaw, Clear, Dittmar, Goldstein, and
Haas, 2002). Such neighborhoods typically are close to schools, shopping, workplaces, and other amenities.

People living in these homes are able to drive less because they have other options for many trips: to walk, bike or use public transit. As a result, they may save significantly on the cost of driving, driving for fewer miles and potentially reducing the number of cars they would otherwise need to own. In turn, these expense reductions should create an economic buffer for location-efficient homeowners that may reduce their propensity to default compared to otherwise similar homeowners who must lay out a substantial portion of their household budget for automobile transportation. Furthermore, location-efficient homeowners may be buffered against increases in gasoline costs such as those observed in the summer and fall of 2008. Even before this spike in gas prices, transportation costs were the second-largest expenditure for the typical American household (Brookings Institution, 2006), averaging $8,500 per year. Therefore, one might well expect that households could afford to purchase a more expensive home if that home enabled them to reduce transportation expenses (e.g., by eliminating one car, or simply by driving less because they can now walk or use transit more). This realization has led to the development of a new housing affordability index that takes into account the expected transportation costs associated with the home’s location. Applying this index in place of more traditional measures of housing affordability shows that many car-dependent areas of metropolitan regions turn out to be much less affordable than initially thought, once transportation costs are factored in.

These research results raise the question: If housing affordability is impacted by location efficiency, shouldn’t mortgage underwriting take it into account? Environmental advocates have long promoted the idea of a “Location Efficient Mortgage” that would reward homebuyers of location-efficient homes with more flexible mortgage underwriting terms. For lenders to offer such flexible mortgage products, they must be convinced that location efficiency does indeed alter the risk profile of a mortgage. The specific hypothesis that must be tested is that after holding traditional underwriting factors constant, mortgages on location-efficient homes will have superior performance to those of non-location-efficient homes. If the hypothesis is shown to be true, then presumably underwriting guidelines should account for the location efficiency of a home. For example, underwriters could set a higher debt-to-income ratio for loans to location-efficient homes (reflecting the household budget savings on transportation in such homes) relative to the debt ratio allowed for location-inefficient homes.

If location efficiency is indeed predictive of lower mortgage default, it also provides additional justification for government policy interventions to promote a more location-efficient built environment. The harm of mortgage foreclosures is well documented (and now something that a great many communities nationwide are experiencing firsthand). Both families and lenders incur significant costs when a foreclosure happens. However, the costs do not end there. The resulting REO property reduces the community’s tax base, encourages arson and crime, and contributes to significant loss in property value of neighboring properties. Policies to promote a more location-efficient built environment generally fall under the
rubric of “Smart Growth”\textsuperscript{9} and include zoning tools and urban growth boundaries to promote denser development, targeting of infrastructure investments to built areas of the region, enhancements to transit and pedestrian infrastructure, open space preservation programs, and other policy tools.

**Review of the Literature**

Few studies to date have directly addressed the relation between mortgage default and location efficiency. Holtzclaw, Clear, Dittmar, Goldstein, and Haas (2002) aimed to find support for the development of the location efficient mortgage (LEM) by studying 2,820 transportation analysis zones (TAZs) in Chicago, Los Angeles, and San Francisco. The authors use auto ownership from 1990 U.S. Census data and vehicle miles traveled from odometer readings as their measures of location efficiency. They find that auto ownership and annual driving distance are a function of the density of the owner’s neighborhood. They also find a relationship, though weaker, between annual driving distance and the pedestrian and bicycle friendliness of the driver’s neighborhood.

In a preview of the 2002 study, Holtzclaw (2000) related the value of smart growth to location efficiency. In this study, Holtzclaw used preliminary location efficiency results to explain how the smart growth principle of creating walkable neighborhoods would in turn reduce automobile dependence and thereby reduce motor vehicle pollution.

Using a cohort of 8,000 FHA-insured loans made in the Chicago area from 1988 to 1992, Blackman and Krupnick (2000) conclude that location efficiency does not improve the risk characteristics of a mortgage. However, this study is somewhat limited in that it looks at only one metropolitan area and limited vintages of loans. A number of other studies have looked at whether certain neighborhood characteristics are predictive of future home value trends or of default risks, although most of these studies have focused on income and demographic characteristics as opposed to location efficiency per se (e.g., Goetzmann and Spiegel, 1997).

**Data**

We use data from a number of sources. First, we obtain loan-level mortgage data from LPS Applied Analytics. LPS, formerly McDash Analytics, owns the largest loan-level database of mortgage assets with loan-level data for more than 39 million active first and second mortgage loans, including portfolios serviced by nine of the top 10 mortgage servicers in the nation. This database represents approximately two-thirds of the mortgage market. The dataset has both static and dynamic variables that relate to characteristics of the loan and the borrower at origination (static) and at specific points in time subsequent to loan origination (dynamic). Since this data does not have property addresses, we obtain property transfer records for counties in each metropolitan area and match these records to the mortgage data in order to identify the location of each property.
We obtain a sample of loans outstanding as of December 2008 in each of three metropolitan areas: Chicago, IL; Jacksonville, FL; and San Francisco, CA. We choose these cities in order to examine potential regional differences in mortgage default. All of these regions are areas that have struggled with foreclosures. Additionally, each has a distinct development history and urban form; significant effects of location efficiency in these cities would suggest a greater likelihood that the findings are applicable to other communities nationally. To ensure that our analysis included both the central city and outlying areas, we obtain property transfer records for multiple counties in each metropolitan area. In Chicago, we selected properties located in Cook, Dupage, Kane, Kendal, Lake, McHenry, and Will counties. Exhibit 1 shows a map of our Chicago data. In Jacksonville, we selected properties in Clay, Duval, Nassau, and St. Johns counties. Exhibit 2 shows a map of our Jacksonville data. In San Francisco, we obtain property transfer data
for San Francisco County. Therefore, the observations in our final dataset are located within the city of San Francisco as shown in Exhibit 3.

Our primary construct of interest is location efficiency. We examine two alternative variables to measure this construct, income-normalized vehicles per household and Walk Score™. The assumption behind the selection of vehicles per household as a measure of location efficiency is that people will own fewer cars if they live in a more location efficient area, as demonstrated by Holtzclaw, Clear, Dittmar, Goldstein, and Haas (2002). To address the issue that people may choose to own more cars simply because they can afford them, and the incremental costs associated with them, we normalize this variable by income. We first obtain 2008 Census demographic estimates from the Environmental Systems Research Institute
(ESRI) for each block group identified in our data, which include an estimate of vehicles per household. Then, to normalize for differences in income, we divide this value by income. The result is our first key location efficiency variable—\( \text{vehper000inc} \). This variable measures the number of vehicles the typical resident in a given block group owns for every $1,000 of income. For example, across all three of our samples, this value ranges between 0.02 and 0.04. Using 0.03 as an average value, this means that a person who earns $20,000 per year would own 0.60 vehicles while a person who earns $200,000 per year would own 6.0 vehicles.

We use Walk Score as an alternative measure of location efficiency in our study. Walk Score rates the walkability of a specific address on a scale from 0 to 100, by compiling the number of nearby stores, restaurants, schools, parks, etc. within a one-mile radius from the subject location. Higher scores are indicative of more walkable locations and therefore should generally correlate with more walkable
neighborhoods whereas locations with scores below 50 are considered to be car dependent. After mapping the property addresses to obtain geographic coordinates for each location, we apply the Walk Score algorithm (defined below) to obtain the Walk Score for each location. The Walk Score algorithm awards points based on the distance to the closest amenity in each category and no points are awarded for amenities located more than one mile from the subject address. However, there are some key factors that affect walkability that are not accounted for in the Walk Score. If there is topography such as steep hills, freeways or bodies of water within the one-mile radius, they are ignored when calculating the Walk Score. Also, if the location is prone to extreme weather conditions, these are not reflected in the Walk Score. That is, the Walk Score is strictly based on the distance between a location and all amenities within a one-mile radius. Also, the distances used are “as the crow flies” distances as opposed to the actual distance walked along street grids. In effect, Walk Score assumes that residents can walk to each amenity using a straight path. In addition, Walk Score does not consider proximity to public transit. All three of the study cities appear on the Walk Score list of 40 most walkable cities. San Francisco tops the list with an overall score of 86; Chicago ranks fourth with a score of 76 and Jacksonville ranks 40th with a score of 36. Note that these Walk Scores refer to the city jurisdiction and not the metropolitan area.

Exhibit 4 describes the variables used in the study. DTI_orig is a static variable from the LPS Applied Analytics database. This measures the debt-to-income (“back end”) ratio of the borrower at origination of the mortgage as reported by the servicer. DTIs for mortgage borrowers typically range between 36% and 41%. Our sample observations tend to have DTIs at the lower end of this range. This statistic was not available for the Jacksonville sample. Also, a large number of loans in Chicago (37%) and San Francisco (39%) were missing this statistic. FICO_orig is also a static variable from LPS. This measure of credit worthiness created by the Fair Isaac Corporation is commonly used to measure an applicant’s credit risk. Scores range from 300 to 850 and scores above 680 are typically considered to be very good or “prime” borrowers. This data is more complete than the DTI variable, but still a number of the FICO scores are also missing in our sample. Across all three subsets of our data, mean credit scores are well above 680, indicating that the average borrower would likely qualify for prime borrowing terms. In San Francisco, however, credit scores are even higher. With a mean FICO score of 745, the average borrower in our San Francisco sample has excellent credit.

We obtain loan-to-value ratios (LTVs) from LPS. LTV expresses the amount of a first mortgage lien as a percentage of the total appraised value of real property. Conforming loans according to Fannie Mae and Freddie Mac standards are those with LTVs less than or equal to 80%. The mean LTV across all of our samples is less than 80% and as low as 71% in San Francisco. This indicates that the average mortgage in our study is a conforming loan and not subject to private mortgage insurance requirements.

We determine the age of each mortgage by calculating the number of days between the loan closing date and December 31, 2008. This age is reflected in our
#### Exhibit 4 | Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Panel A: Chicago, IL</th>
<th>Panel B: Jacksonville, FL</th>
<th>Panel C: San Francisco, CA</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTI_orig (%)</td>
<td>11,834</td>
<td>36.97</td>
<td>10.79</td>
</tr>
<tr>
<td>FICO_orig</td>
<td>16,542</td>
<td>695.74</td>
<td>65.74</td>
</tr>
<tr>
<td>LTV_orig (%)</td>
<td>18,607</td>
<td>79.36</td>
<td>11.58</td>
</tr>
<tr>
<td>Mort_age (days)</td>
<td>18,735</td>
<td>995.30</td>
<td>43.98</td>
</tr>
<tr>
<td>Orig_amt ($)</td>
<td>18,735</td>
<td>222,036.40</td>
<td>119,196.70</td>
</tr>
<tr>
<td>PCI ($)</td>
<td>18,735</td>
<td>33,731.98</td>
<td>21,626.74</td>
</tr>
<tr>
<td>Popgwh00CY (%)</td>
<td>18,735</td>
<td>0.45</td>
<td>4.72</td>
</tr>
<tr>
<td>PNonwhite (%)</td>
<td>18,735</td>
<td>43.43</td>
<td>30.19</td>
</tr>
<tr>
<td>VehperHH</td>
<td>18,735</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Vehper000HHinc</td>
<td>18,735</td>
<td>43.43</td>
<td>30.19</td>
</tr>
<tr>
<td>Walk_Score</td>
<td>18,735</td>
<td>64.53</td>
<td>19.53</td>
</tr>
</tbody>
</table>
mort\_age variable. In Chicago, our loans are 30 to 36 months old. In Jacksonville, we have a much wider age range with loans ranging from 3 months to 30 years old. The age of the San Francisco loans falls between one day and four years old.\textsuperscript{16}

We do not include the origination amount in our analysis, but we show it to here to emphasize the differences between these three geographic locations. Mean origination values in San Francisco are nearly three times the mean values in Chicago and five times the mean values in Jacksonville.

The demographic makeup of the three locations varies also. Similar to the disparity in origination values, per capita income varies greatly across the cities at the block group level. Per capita income in San Francisco is double the income measure in Jacksonville. Residents in the Chicago area earn slightly more but mean per capita income in Chicago is still only 60\% of the mean value in San Francisco. Population growth since 2000 (\textit{popgwth00CY}) at the block group level in Jacksonville is more than five times the rate of growth in Chicago. The minority share of the population at the block group level is also much greater in San Francisco (53\%) than in Jacksonville (39\%) and Chicago’s minority share falls between the two.

Walk Score, as described previously, measures walkability on a 100-point scale with more walkable areas earning higher scores. In Chicago, Jacksonville, and San Francisco, our samples have mean Walk Scores of 65, 33, and 84 respectively. These values are consistent with those reported on the Walk Score listing of “America’s Most Walkable Neighborhoods.” That listing reports values of 76, 36, and 86 for our sample cities of Chicago, Jacksonville, and San Francisco. According to the Walk Score website, Chicago would be classified as “Somewhat Walkable” according to our sample statistics. Jacksonville would be considered “Car Dependent,” and San Francisco would be considered “Very Walkable.” Recall that our samples include observations located in counties that surround these cities, whereas the Walk Scores cited in this paragraph are for the city jurisdiction. Also, these are mean values; parts of the city may differ greatly.

\textit{Vehperhh} is quite similar across cities with the mean value ranging from a low of 1.39 in San Francisco to a high of 1.67 in Jacksonville. We tested the correlation between Walk Score and vehicles per household and found that they are significantly negatively correlated. The correlation coefficient for the Chicago sample, $\rho_C$, is $-0.6102$; the Jacksonville correlation coefficient, $\rho_J$, is $-0.5726$; and the San Francisco correlation coefficient, $\rho_{SF}$, is $-0.6395$. These values indicate that the higher the Walk Score for the neighborhood where one lives, the fewer cars one tends to own.

\textbf{Methodology}

We test the null hypothesis that borrowers with homes located in location efficient areas are no more likely to default on their mortgages than borrowers with homes located in car-dependent areas. In other words,
H₀: The degree of location efficiency in a neighborhood has no impact on mortgage performance in that neighborhood.

H₁: Mortgage performance is related to location efficiency.

We use a probit regression analysis to model the probability that borrowers will default on their mortgages. We use the model \( \text{default} = a_0 + b_1 \text{LEFF} + b_2 \text{CONTROL} + \epsilon \), where default is a binary variable set to one if the mortgage is in default and zero otherwise, \( \text{LEFF} \) is a variable measuring location efficiency, and \( \text{CONTROL} \) is a vector of control variables that are widely seen as driving foreclosure risk. These control variables include three of the four most commonly used default predictors: back-end debt-to-income ratio (DTI), loan-to-value ratio (LTV), and FICO score. While the LPS database includes a variable for loan documentation type (no, low, full or unknown), few of the observations in our sample included data for this variable.

We find that income tends to be highly (positively) correlated with Walk Score. Therefore, we do not include per capita income in our vector of control variables. Instead, we stack our three location-based datasets into one combined dataset. Here, we create two sets of binary variables and one set of interaction variables. The first set of binary variables, \( \text{CHI}, \text{JAX}, \) and \( \text{SF} \), are set to one if the observation relates to a property located in Chicago, Jacksonville, or San Francisco respectively and are set to zero otherwise. The second set of binary variables, \( \text{qrt1}, \text{qrt2}, \text{qrt3}, \) and \( \text{qrt4} \), are set to one if the observation relates to a property located in a block group whose per capita income falls in the first, second, third, or fourth quartile with regard to the combined dataset. We then create a set of interaction variables, \( \text{citywalkqrt#} \) in all possible combinations. This gives us four variables (\( \text{chiwalkqrt1}, \text{chiwalkqrt2}, \) etc.) for each city and 12 total interaction variables. For example, \( \text{chiwalkqrt1} \) can be interpreted as the Walk Score conditional on the property being in Chicago and located in a block group with a low per capita income. If a particular property does not meet both of these conditions (city and per capita income quartile), this value will be zero. With these new location efficiency interaction variables now also controlling for income, we use the combined dataset to estimate our original equation \( \text{default} = a_0 + b_1 \text{LEFF} + b_2 \text{CONTROL} + \epsilon \) except now, \( \text{LEFF} \) is vector of location efficiency interaction variables and we use FICO score and binary variables indicating whether or not the block group is made up of primarily white or primarily minority residents as control variables.

Results

The results of our probit regressions are shown in Exhibit 5. In all cities, \( \text{lnvehper000inc} \) is positive and highly significant \( (p < 0.01) \) before controlling for other factors and the pseudo \( R^2 \) is approximately 3%. In Models 2 through 4 we add additional control variables to the model. In all models, \( \text{lnvehper000inc} \) remains positive and highly significant \( (p < 0.01 \) in all but one model) across all specifications.

In Model 2, we add key factors commonly found to be predictive of mortgage default—DTI, FICO, score and LTV. All three of these control factors are
### Exhibit 5 | Probability of Default and Vehicles per Household

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Chicago, IL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnvehper000inc</td>
<td>0.6761 (16.23)***</td>
<td>0.3069 (4.83)***</td>
<td>0.2969 (4.66)***</td>
<td>0.2574 (3.97)***</td>
</tr>
<tr>
<td>lnDTI_orig</td>
<td>0.4021 (7.16)***</td>
<td>0.4036 (7.19)***</td>
<td>0.3966 (7.06)**</td>
<td>0.3966 (7.06)***</td>
</tr>
<tr>
<td>lnLTV_orig</td>
<td>0.5138 (3.87)***</td>
<td>0.5160 (3.87)***</td>
<td>0.33753 (3.09)**</td>
<td>0.33753 (3.09)***</td>
</tr>
<tr>
<td>lnMort_age</td>
<td>0.5106 (1.29)</td>
<td>0.6575 (1.64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popgwth00CY</td>
<td>-0.0114 (1.02)</td>
<td>-0.0133 (1.22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minblkgrp</td>
<td></td>
<td></td>
<td></td>
<td>0.1213 (2.57)**</td>
</tr>
<tr>
<td>Ownocc</td>
<td></td>
<td></td>
<td></td>
<td>-0.0119 (0.16)</td>
</tr>
<tr>
<td>Refi</td>
<td></td>
<td></td>
<td></td>
<td>-0.2584 (6.71)***</td>
</tr>
<tr>
<td>Whiteblkgrp</td>
<td></td>
<td></td>
<td></td>
<td>-0.1364 (3.08)***</td>
</tr>
<tr>
<td>Constant</td>
<td>1.1946 (8.15)***</td>
<td>16.7104 (11.30)***</td>
<td>13.0952 (4.21)***</td>
<td>12.9345 (4.13)***</td>
</tr>
<tr>
<td>Pseudo R²</td>
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<td>0.0834</td>
<td>0.0839</td>
<td>0.0954</td>
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<tr>
<td>N</td>
<td>18,632</td>
<td>10,372</td>
<td>10,372</td>
<td>10,372</td>
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</tbody>
</table>
### Exhibit 5 (continued)
Probability of Default and Vehicles per Household

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lnvehper000inc</td>
<td>0.9654 (15.91)***</td>
<td>0.7121 (9.83)***</td>
<td>0.5563 (6.62)***</td>
<td>0.3845 (4.29)***</td>
</tr>
<tr>
<td>lnFICO_orig</td>
<td>-2.43 (-17.28)***</td>
<td>-2.3828 (-16.73)***</td>
<td>-2.5219 (-16.23)***</td>
<td></td>
</tr>
<tr>
<td>lnLTV_orig</td>
<td>0.6425 (9.01)***</td>
<td>0.6673 (9.22)***</td>
<td>0.6258 (7.46)***</td>
<td></td>
</tr>
<tr>
<td>lnMort_age</td>
<td>-0.1595 (-6.02)***</td>
<td>-0.1701 (-5.89)***</td>
<td></td>
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</tr>
<tr>
<td>Popgwth00CY</td>
<td>0.0015 (0.27)</td>
<td>-0.0044 (-0.79)</td>
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</tr>
<tr>
<td>lnUnemprty</td>
<td>0.1225 (4.39)***</td>
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<td>0.0105 (0.35)</td>
<td>-0.6711 (-19.21)***</td>
</tr>
<tr>
<td>Fixed</td>
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<td>-0.6711 (-19.21)***</td>
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<td></td>
</tr>
<tr>
<td>Minblkgrp</td>
<td>0.3340 (6.94)***</td>
<td></td>
<td>0.3340 (6.94)***</td>
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<tr>
<td>Ownocc</td>
<td>-0.2590 (-6.68)***</td>
<td></td>
<td>-0.2590 (-6.68)***</td>
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</tr>
<tr>
<td>Refi</td>
<td>-0.1806 (-4.53)***</td>
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<td>-0.1806 (-4.53)***</td>
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</tr>
<tr>
<td>whiteblkgrp</td>
<td>-0.1485 (-3.51)***</td>
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<td>-0.1485 (-3.51)***</td>
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</tr>
<tr>
<td>Constant</td>
<td>1.5611 (8.04)***</td>
<td>13.7274 (13.76)***</td>
<td>13.7016 (13.01)***</td>
<td>15.2165 (12.86)***</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0257</td>
<td>0.0853</td>
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<td>0.1593</td>
</tr>
<tr>
<td>N</td>
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<td>18,066</td>
<td>17,941</td>
<td>17,941</td>
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</tbody>
</table>
### Exhibit 5 (continued)

**Probability of Default and Vehicles per Household**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lnvehper000inc</td>
<td>0.7813 (10.34)**</td>
<td>0.5025 (4.39)**</td>
<td>0.4752 (3.80)**</td>
<td>0.3843 (2.41)**</td>
</tr>
<tr>
<td>lnDTI_orig</td>
<td>0.4156 (3.81)**</td>
<td>0.5348 (4.65)**</td>
<td>0.5581 (4.82)**</td>
<td></td>
</tr>
<tr>
<td>lnFICO_orig</td>
<td>-4.9592 (-10.38)**</td>
<td>-4.4795 (-9.10)**</td>
<td>-4.3745 (-8.43)**</td>
<td></td>
</tr>
<tr>
<td>lnLTV_orig</td>
<td>2.8739 (6.20)**</td>
<td>2.8841 (5.23)**</td>
<td>2.6579 (4.34)**</td>
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</tr>
<tr>
<td>lnMort_age</td>
<td></td>
<td>0.5777 (6.05)**</td>
<td>0.4486 (4.51)**</td>
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</tr>
<tr>
<td>lnUnemprt</td>
<td>0.0325 (0.72)</td>
<td>0.0231 (0.50)</td>
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</tr>
<tr>
<td>Fixed</td>
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<td>-0.5899 (-5.10)**</td>
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</tr>
<tr>
<td>Minblkgrp</td>
<td></td>
<td>0.1848 (1.75)*</td>
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</tr>
<tr>
<td>Ownocc</td>
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<td>-0.1187 (-0.80)</td>
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<td></td>
</tr>
<tr>
<td>Ref</td>
<td></td>
<td>-0.0838 (-1.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>whiteblkgrp</td>
<td></td>
<td>0.0170 (0.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.9680 (3.38)**</td>
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<td>10.8706 (2.55)**</td>
<td>11.8320 (2.53)**</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0353</td>
<td>0.1712</td>
<td>0.2023</td>
<td>0.2254</td>
</tr>
<tr>
<td>N</td>
<td>15,883</td>
<td>9,088</td>
<td>8,973</td>
<td>8,973</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of various probit model specifications. The dependent variable in all specifications is the binary variable `default` which is set to one if the mortgage is in default and zero otherwise. Location efficiency is measured by Vehicles per Household as adjusted by income. Z-scores are shown in parentheses.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.
significant as has been found in the prior literature. In addition, the explanatory power of the model grows to as much as 17% in San Francisco after adding these factors.

In Model 3, we add mortgage age, population growth, and unemployment rate. Neither mortgage age nor population growth explains the probability of default in Chicago. However, mortgage age is a significant factor in Jacksonville and San Francisco. In Jacksonville, default probability increases as the age of the mortgage decreases, but in San Francisco default probability increases as the age of the mortgage increases. In addition, the default probability rises with the unemployment rate in Jacksonville but is not a significant explanatory factor in San Francisco.

In Model 4, we add binary control variables. Here again, the results vary by city. In fact, none of these variables are significant in all cities. In San Francisco, neither mortgages initiated to refinance an existing mortgage nor properties located in block groups that are predominantly white are more likely to default; however, these are significant factors in Chicago and Jacksonville. Again, the explanatory power of our model is as high as 23% in San Francisco.

The coefficient for income-normalized vehicle ownership is positive and significant—even in models that include standard default risk factors such as DTI, FICO, and LTV and additional variables that explain regional differences in foreclosure likelihoods. We interpret these results to mean that income-normalized vehicle ownership increases the probability of mortgage default.

The following example explains our interpretation of these results. Assume that we wish to estimate the probability that an average borrower in San Francisco will default on their mortgage. According to our descriptive statistics, an average borrower in San Francisco lives in a neighborhood averaging 0.02 vehicles per thousand dollars of income, and has a DTI of 36.1%, a FICO score of 745, an LTV of 71.1%, a mortgage that is 779 days old, and lives in a block group where the unemployment rate is 6.86%. Assume also that this particular borrower originated the mortgage for a new home purchase, does not live in the home, and has an adjustable interest rate and lives in an integrated block group. For this particular borrower, our model indicates that the probability of default is:

\[
F[11.8320 + 0.3843 \times \ln(0.02) + 0.5581 \times \ln(36.1) - 4.3745 \\
\times \ln(745) + 2.6579 \times \ln(71.13) + 0.4486 \times \ln(779) \\
+ 0.0231 \times \ln(6.86)],
\]

where \(F\) is the cumulative distribution function of the standard normal. According to our model, the probability that this borrower will default is 1.2%.

We use Walk Score as an alternative measure of location efficiency. The results of our probit regressions for the individual cities using InWalk_Score as our key
location efficiency variable are shown in Exhibit 6. Panel A presents the results for Chicago, Panel B presents Jacksonville, and Panel C shows the results in San Francisco. The first model in all cities tests how well Walk Score alone predicts the likelihood of default. In all cities, \( \ln(\text{Walk Score}) \) is significantly different from zero when modeled without controlling for other factors. However, the explanatory power of the models as a whole is very low as indicated by pseudo R\(^2\) values close to zero. The signs of the coefficients are negative in both Chicago and San Francisco but positive in Jacksonville. This suggests that walkability decreases the probability of default in walkable cities but *increases* the probability of default in car-dependent cities.

Model 2 in all cities includes Walk Score plus key risk factors commonly related to mortgage default. These are DTI, FICO score, and LTV.\(^{22}\) In these models, the common risk factors are all significantly different from zero, indicating that they are predictive of default. However, in the Chicago sample, Walk Score loses significance when these factors are added to the model. In addition, the overall explanatory power of this model rises significantly across all cities to as much as 17\% in San Francisco as indicated by the pseudo R\(^2\).

In Model 3, we add additional discrete control variables. Specifically, we add the age of the mortgage, population growth, and unemployment rate. With the exception of Chicago, the sign and significance of our key variable, \( \ln(\text{Walk Score}) \), is consistent across all model specifications. With respect to the control variables, here again we find regional differences in the results. The age of the mortgage is insignificant in Chicago, negative and significant in Jacksonville, and positive and significant in San Francisco. These results indicate that the vintage of the mortgages in default as of December 2008 varies greatly across cities. In Jacksonville, newer mortgages are more likely to be in default, in San Francisco, older mortgages are more likely to be in default, and in Chicago there is no discernible trend with respect to mortgage age. There is less variability in the results regarding population growth and the unemployment rate. The probability of default increases with increases in the block group unemployment rate. Population growth in the block group decreases the probability of default but is a less significant factor.

In Model 4, we add binary control variables. These variables are ‘flags’ indicating whether or not the interest rate is fixed (\textit{Fixed}), the property is located in a primarily minority block group (\textit{Minblkgrp}), the property is owner-occupied (\textit{Ownocc}), the purpose of the loan is for refinancing an existing mortgage (\textit{Refi}), and whether or not the property is located in a block group where the population is primarily white (\textit{Whiteblkgrp}). While \( \ln(\text{Walk Score}) \) remains stable, the additional control variables exhibit regional differences. Specifically, whether or not the property is owner-occupied is only a significant factor in mortgage default in Jacksonville. In addition, despite a pseudo R\(^2\) of nearly 23\% in San Francisco, four of the 11 factors included in the model are insignificant. Two of these, \textit{Refi} and \textit{Whiteblkgrp}, are negative and highly significant in both Chicago and Jacksonville.

In order to estimate our model while controlling for income, we combine the observations from all three cities and create an interaction variable that flags the
**Exhibit 6** | Probability of Default and Walk Score

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lnWalk_Score</td>
<td>lnDITI_orig</td>
<td>lnFICO_orig</td>
<td>lnLTV_orig</td>
</tr>
<tr>
<td>Panel A: Chicago, IL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnWalk_Score</td>
<td>-0.2094 (-6.36)***</td>
<td>-0.0047 (-0.09)</td>
<td>0.0018 (0.03)</td>
<td>-0.0184 (-0.33)</td>
</tr>
<tr>
<td>lnDITI_orig</td>
<td>0.4132 (7.39)***</td>
<td>0.4141 (7.40)***</td>
<td>0.4065 (7.26)***</td>
<td></td>
</tr>
<tr>
<td>lnFICO_orig</td>
<td>-3.3874 (-17.64)***</td>
<td>-3.3659 (-17.49)***</td>
<td>-3.3196 (-16.24)***</td>
<td></td>
</tr>
<tr>
<td>lnLTV_orig</td>
<td>0.5513 (4.08)***</td>
<td>0.5532 (4.08)***</td>
<td>0.3954 (3.22)***</td>
<td></td>
</tr>
<tr>
<td>lnMort_age</td>
<td>0.6259 (1.58)</td>
<td></td>
<td>0.7610 (1.90)*</td>
<td></td>
</tr>
<tr>
<td>Popgwth00CY</td>
<td>-0.0173 (-1.79)*</td>
<td></td>
<td></td>
<td>-0.0193 (-2.05)**</td>
</tr>
<tr>
<td>Minblkgrp</td>
<td></td>
<td>0.1371 (2.90)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownocc</td>
<td></td>
<td>0.0082 (0.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refi</td>
<td></td>
<td>-0.2544 (-6.60)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whiteblkgrp</td>
<td></td>
<td>-0.1661 (-3.77)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.3365 (-2.49)***</td>
<td>16.8658 (11.37)***</td>
<td>12.3698 (3.98)***</td>
<td>12.0527 (3.85)***</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0029</td>
<td>0.0806</td>
<td>0.0820</td>
<td>0.0949</td>
</tr>
<tr>
<td>N</td>
<td>18,677</td>
<td>10,412</td>
<td>10,412</td>
<td>10,412</td>
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Note: ***p < 0.01, **p < 0.05, *p < 0.1.
### Exhibit 6 (continued)

**Probability of Default and Walk Score**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lnWalk_Score</td>
<td>lnFICO_orig</td>
<td>lnLTV_orig</td>
<td>lnMort_age</td>
</tr>
<tr>
<td></td>
<td>0.1552 (8.96)**</td>
<td>-2.6104 (-18.89)**</td>
<td>0.6779 (9.34)**</td>
<td>-0.1592 (-6.05)**</td>
</tr>
<tr>
<td></td>
<td>0.1299 (6.32)**</td>
<td>-2.4725 (-17.51)**</td>
<td>0.6918 (9.43)**</td>
<td>-0.1699 (-5.92)**</td>
</tr>
<tr>
<td>Panel B: Jacksonville, FL</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>lnFICO_orig</td>
<td>0.0911 (4.01)**</td>
<td>0.0609 (2.54)**</td>
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</tr>
<tr>
<td></td>
<td>lnLTV_orig</td>
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<td></td>
<td></td>
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<td></td>
<td>0.06408 (7.57)**</td>
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<tr>
<td></td>
<td>lnMort_age</td>
<td>-0.0005 (-0.09)</td>
<td>-0.0064 (-1.16)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Popgwth00CY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0005 (0.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>lnUnemprt</td>
<td>0.1740 (6.62)**</td>
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<tr>
<td></td>
<td>Fixed</td>
<td>0.6646 (-19.08)**</td>
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<tr>
<td></td>
<td>Minblkgrp</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0.3601 (7.60)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ownocc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.2628 (-6.80)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.1816 (-4.56)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>whiteblkgrp</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>-0.1841 (-4.39)**</td>
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</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-2.0574 (-34.62)**</td>
<td>12.0247 (12.05)**</td>
<td>11.9973 (11.62)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.9957 (12.06)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pseudo R²</td>
<td>0.0081</td>
<td>0.0784</td>
<td>0.0889</td>
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<tr>
<td></td>
<td>N</td>
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<td>18,184</td>
<td>18,059</td>
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### Panel C: San Francisco, CA

<table>
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<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnWalk_Score</td>
<td>$-0.8513 (-6.87)^{***}$</td>
<td>$-0.6898 (-3.47)^{***}$</td>
<td>$-0.6633 (3.20)^{***}$</td>
<td>$-0.5191 (-2.17)^{**}$</td>
</tr>
<tr>
<td>lnDTI_orig</td>
<td>$0.4323 (3.97)^{***}$</td>
<td>$0.5420 (4.73)^{***}$</td>
<td>$0.5573 (4.82)^{***}$</td>
<td></td>
</tr>
<tr>
<td>lnFICO_orig</td>
<td>$-5.0750 (-10.71)^{***}$</td>
<td>$-4.5492 (-9.30)^{***}$</td>
<td>$-4.4011 (-8.50)^{***}$</td>
<td></td>
</tr>
<tr>
<td>lnLTV_orig</td>
<td>$2.9607 (6.27)^{***}$</td>
<td>$2.9074 (5.29)^{***}$</td>
<td>$2.6494 (4.37)^{***}$</td>
<td></td>
</tr>
<tr>
<td>lnMort_age</td>
<td></td>
<td>$0.5720 (6.04)^{***}$</td>
<td>$0.4427 (4.48)^{***}$</td>
<td></td>
</tr>
<tr>
<td>lnUnemprt</td>
<td></td>
<td>$0.0883 (2.06)^{**}$</td>
<td>$0.0548 (1.20)$</td>
<td></td>
</tr>
<tr>
<td>Fixed</td>
<td></td>
<td></td>
<td>$-0.5921 (-5.13)^{***}$</td>
<td></td>
</tr>
<tr>
<td>Minblkgrp</td>
<td></td>
<td>$0.2450 (2.53)^{**}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownocc</td>
<td></td>
<td>$-0.1228 (-0.84)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refi</td>
<td></td>
<td>$-0.0812 (-0.98)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>whiteblkgrp</td>
<td></td>
<td>$-0.0613 (-0.40)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>$1.7178 (3.16)^{***}$</td>
<td>$20.2040 (5.24)^{***}$</td>
<td>$12.2428 (2.85)^{***}$</td>
<td>$12.8369 (2.71)^{***}$</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0134</td>
<td>0.1659</td>
<td>0.1995</td>
<td>0.2250</td>
</tr>
<tr>
<td>N</td>
<td>15,945</td>
<td>9,124</td>
<td>9,009</td>
<td>9,009</td>
</tr>
</tbody>
</table>

**Notes:** This table reports the results of various probit model specifications. The dependent variable in all specifications is the binary variable default which is set to one if the mortgage is in default and zero otherwise. Location efficiency is measured by Walk Score. Z-scores are shown in parentheses.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.
city where the property is located and the per capita income range of that block group along with the Walk Score for the property. The results of our probit regression for the combined dataset are shown in Exhibit 7. Here we find that 10 of the 12 Walk Score variables are significantly different from zero. Further, we find that the sign of the coefficient changes from positive to negative as income increases. That is, the signs of the coefficients for all three quartile one variables (Chiwalkqrt1, Jaxwalkqrt1, and SFwalkqrt1) are positive. Also, the coefficients decrease in size and significance (as indicated by lower Z-scores) as the income levels increase. In Jacksonville and San Francisco, this trend continues to the point that the signs of the coefficients for the quartile four variables (Jaxwalkqrt4 and SFwalkqrt4) are negative. In other words, higher Walk Scores appear to increase

### Exhibit 7 | Income and Walkability

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiwalkqrt1</td>
<td>0.1712 (10.35)***</td>
<td>0.1435 (8.49)***</td>
</tr>
<tr>
<td>Chiwalkqrt2</td>
<td>0.1305 (7.66)***</td>
<td>0.1230 (7.16)***</td>
</tr>
<tr>
<td>Chiwalkqrt3</td>
<td>0.0857 (4.89)***</td>
<td>0.0895 (5.07)***</td>
</tr>
<tr>
<td>Chiwalkqrt4</td>
<td>0.0382 (2.15)**</td>
<td>0.0479 (2.67)***</td>
</tr>
<tr>
<td>Jaxwalkqrt1</td>
<td>0.0838 (4.48)***</td>
<td>0.0583 (3.07)***</td>
</tr>
<tr>
<td>Jaxwalkqrt2</td>
<td>−0.0120 (−0.56)</td>
<td>−0.0119 (−0.56)</td>
</tr>
<tr>
<td>Jaxwalkqrt3</td>
<td>−0.0121 (−0.54)</td>
<td>0.0057 (0.25)</td>
</tr>
<tr>
<td>Jaxwalkqrt4</td>
<td>−0.0552 (−1.66)*</td>
<td>−0.0343 (−1.02)</td>
</tr>
<tr>
<td>SFwalkqrt1</td>
<td>0.0537 (2.74)***</td>
<td>0.0091 (0.45)</td>
</tr>
<tr>
<td>SFwalkqrt2</td>
<td>0.0428 (2.17)**</td>
<td>0.0052 (0.26)</td>
</tr>
<tr>
<td>SFwalkqrt3</td>
<td>−0.0316 (−1.70)*</td>
<td>−0.0422 (−2.24)**</td>
</tr>
<tr>
<td>SFwalkqrt4</td>
<td>−0.0873 (−4.88)***</td>
<td>−0.0878 (−4.87)***</td>
</tr>
<tr>
<td>lnFICO_orig</td>
<td>−3.3622 (−35.41)***</td>
<td>−3.2068 (−33.33)***</td>
</tr>
<tr>
<td>Minblkgrp</td>
<td>0.2317 (9.13)***</td>
<td></td>
</tr>
<tr>
<td>Whiteblkgrp</td>
<td>−0.1119 (−4.21)***</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>20.2153 (32.73)***</td>
<td>19.2171 (30.69)***</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.1378</td>
<td>0.1427</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of a probit model specification to estimate the probability of default. The dependent variable is the binary variable default which is set to one if the mortgage is in default and zero otherwise. Location efficiency is measured by Walk Score. Z-scores are shown in parentheses. We use the interaction term citywalkqrt#. Each citywalkqrt# variable identifies the city in which the property is located, the Walk Score for that unique property and the income quartile for the block group in which that property is located such that quartile one contains properties located in the lowest income areas and quartile four contains properties located in the highest income areas. We use lnFICO_orig to control for borrower credit worthiness. In Models 1 and 2, N = 49,597.

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.
the probability of default in low income areas but decreases the probability of default in high income areas.

Our results can best be interpreted with an example. Assume that we wish to estimate the probability that an average borrower in a low income Chicago neighborhood will default. Based on the descriptive statistics for our Chicago sample, this borrower would have a FICO score of 696, a Walk Score of 65, and the home will be located in a block group with a per capita income of less than $22,118.50. Based on the results of our model, the probability of default is:

$$F[20.2153 + 0.1712 \times \ln(65) - 3.3622 \times \ln(696)],$$

where $F$ is the cumulative distribution function of the standard normal. This results in a default probability of 14.08%. Alternatively, we can also estimate the default probability for an average borrower in a high income San Francisco neighborhood. According to the descriptive statistics for our San Francisco sample, this borrower would have a FICO score of 745, have a home in a block group, a per capita income of greater than $41,551, and a Walk Score of 84. According to our model, the probability of default is:

$$F[20.2153 + 0.1712 \times \ln(84) - 3.3622 \times \ln(745)].$$

This results in a default probability of 10.35%. Thus, our results indicate that significant differences in default probabilities across locations can be partially explained by income, Walk Score, and credit worthiness.

**Conclusion**

Our findings indicate that location efficiency matters. Taken together, our results have significant policy implications with respect to lending practices, land use, and transportation planning.

We test our hypotheses regarding vehicle ownership and mortgage default and find that the probability of default does increase with vehicle ownership. Moreover, the impact of location efficiency (as measured by income-normalized vehicle ownership) on default is nontrivial. Consider the following example, of a borrower in Chicago with a FICO score of 680, a debt-to-income (back end) ratio of 41%, and an LTV of 80%. If the borrower is purchasing a home of average location efficiency for the Chicago metro area (0.0299 vehper000 inc), our model return default probability is 9.9%. A second borrower could have exactly the same underwriting characteristics but purchase a location-efficient home (0.0172 vehper000 inc). The default probability for this borrower falls to 7.2%. A third borrower with the same credit score and LTV could have a remarkably higher
debt-to-income ratio, of 62.5%, and, if they purchased the location-efficient home, the model would return a default probability of 9.9%—the same probability as for our first borrower. Our results also suggest that increases in \textit{vehper000 inc} could compensate for substantial increases in LTV or decreases in FICO score. The results strongly suggest that researchers developing and refining automated mortgage underwriting models should seek to test the impact of location efficiency variables within their models.

It is interesting to note that there is an additional possible explanation for why mortgages for location-efficient homes perform better, beyond the household budgetary savings of lower vehicle ownership. This explanation is that location-efficient homes might hold their value better than other homes, and therefore better enable borrowers to avoid foreclosure through alternative measures (such as selling or refinancing the home) if they fall behind on payments or need to manage payment shock from an adjustable rate mortgage. Since the variable we use to measure default is whether the mortgage is in the foreclosure process or in REO status, we cannot be sure of the degree to which each of these two forces (household budget savings and home value performance) is contributing to the superior performance of location efficient mortgages. Future research on the linkages between vehicle ownership and default should explore these relationships more deeply.

We find highly nuanced results when we use Walk Score as an alternative measure of location efficiency. We find that it is closely related to income. Therefore, we find that its impact on mortgage performance differs across income categories. In low-income neighborhoods, Walk Score is positively related to mortgage default. We interpret this to mean that low-income, high default rate areas tend to be quite walkable (e.g., in urban areas within the central city). At the other extreme, we find that in high-income neighborhoods, Walk Score is negatively related to mortgage default. We interpret this as more of a location efficiency effect, with the causality flowing in the opposite direction as in low-income neighborhoods. That is, in high-income, walkable neighborhoods, borrowers have lower transportation costs and thus have more funds available to cover debt service thereby lessening the likelihood of default.

It is not clear from these results that it would be appropriate to utilize the Walk Score in mortgage underwriting, however. These results suggest that such a move could potentially reward borrowers in high income neighborhoods while punishing borrowers in low income neighborhoods if the interaction between income and walkability as measured by Walk Score were scored during the underwriting process. However, utilizing income-normalized vehicles per household as a proxy measure for location efficiency in underwriting criteria might avoid this issue, since it has a consistent effect in lowering default risk regardless of the income level of the neighborhood.

Moreover, our results provide support for policies supporting smart growth development and urban revitalization. That is, designing neighborhoods in such a way that reduces transportation needs is beneficial to borrowers as well as the environment.
Finally, we conclude that differences in location efficiency also help to explain the regional differences in mortgage performance often cited in academic literature. We examine three cities that vary greatly with respect to location efficiency, average borrower qualifications, and demographics. While significant empirical evidence exists to explain the various borrower qualifications and neighborhood characteristics that increase and decrease the probability of mortgage default, these results provide evidence that the degree of location efficiency present in a city or region may help to explain differences in mortgage performance.

**Endnotes**

1. These costs include the cost to lease or purchase the car, maintenance, gas, insurance, and parking.

2. Center for Neighborhood Technology, on the Internet at http://www.cnt.org/repository/heavy_load_10_06.pdf. Additionally, the U.S. Bureau of Labor Statistics 2006 Consumer Expenditure Survey estimates annual household transportation costs at about $8,500 per year, $8,000 of which are automobile related.


4. For detailed data and maps of the Housing-Transportation Affordability Index, visit the Center for Neighborhood Technology website at: http://www.cnt.org/tcd/ht.

5. See http://www.locationefficiency.com/ for information about a pilot project in four U.S. cities (Seattle, San Francisco, Los Angeles, and Chicago) that has had several participating lenders.


8. One study estimates that each foreclosure within 1/8 mile of a home reduces that home’s value by between 0.9% and 1.136% (Immergluck and Smith, 2005).

9. Smart Growth principles include creating a range of housing opportunities and choices; creating walkable neighborhoods; encouraging community and stakeholder collaboration; fostering distinctive, attractive communities with a strong sense of place; making development decisions predictable, fair, and cost effective; mixing land uses; preserving open space, farmland, natural beauty, and critical environmental areas; providing a variety of transportation choices; strengthening and directing development toward existing communities; and taking advantage of compact building design. See the Smart Growth Network at http://www.smartgrowth.org/about/principles/default.asp.
Census block groups are the smallest geographic level at which detailed Census data is available; they generally contain between 600 and 3,000 people, with an optimum size of 1,500. Block group boundaries are usually drawn with the input of local governments. See www.census.gov.

We used median household income as the income variable and divided this value by 1,000 in order to avoid generating a very small number as the resulting ratio.

For a detailed description of Walk Score, visit www.walkscore.com.

For specific information about the Walk Score Algorithm methodology, see www.walkscore.com/rankings/ranking-methodology.shtml.

Commonly, DTI is expressed as a pair of ratios X/Y with the first ratio representing housing-related debt and the second ratio representing all debt payments. LPS provides only the ratio of debt payments related to the subject loan to borrower income.

Twelve percent of the FICO scores in Chicago, 20% in Jacksonville, and 6% in San Francisco are missing in our sample.

The difference in the ages the three samples—especially Jacksonville as compared to Chicago and San Francisco—is largely due to the process that we used to match the mortgage data to the property transfer database. In Jacksonville, there were fewer total observations in the property transfer database and we were therefore able to match the entire property transfer database to our loan database; however, in Chicago and San Francisco, there were many more property transfers. We therefore chose to match our mortgage sample to property transfers between January 2004 and December 2008. We chose this timeframe because LPS Analytics’ coverage is limited prior to 2004.

We code a mortgage as in default if it is in foreclosure or REO in order to analyze extreme cases of default. We attempted an OLS regression with default rates by block group as the dependent variable. After eliminating all block groups with less than 30 observations (in order to maintain statistical significance) our sample was reduced by more than 80%, making this analysis infeasible.

The median per capita income for the combined dataset is $28,951. We assign each observation to quartiles accordingly such that quartile 1 observations are located in block groups with per capita income up to $22,118.50, quartile 2 is between $22,118.50 and $28,951, quartile 3 is between $28,952 and $41,550, and quartile 4 is block groups with per capita income greater than $41,551. There is approximately the same number of observations in each quartile.

The minblkgrp variable is created by coding minblkgrp to 1 if the percentage of the population in that block group that is non-white is 75% or more and 0 otherwise. The whiteblkgrp variable is created by coding whiteblkgrp to 1 if the percentage of the population in that block group that is non-white is less than 25% and 0 otherwise.

Recall that DTI was unavailable for the Jacksonville sample.

In our sample, the median household income is $64,579.85, so this borrower would own approximately 1.29 vehicles.

Recall that DTI was not available for the Jacksonville sample.

References


The authors acknowledge the support of the Natural Resources Defense Council. Rauterkus acknowledges the generous support of the Federal Reserve Bank of Atlanta.
for this project. The views expressed in this paper are those of the authors and do not necessarily represent those of the Natural Resources Defense Council, the Federal Reserve Bank of Atlanta or the Federal Reserve System. The authors are especially grateful to Norman Miller for helpful comments and suggestions.

Stephanie Y. Rauterkus, University of Alabama at Birmingham, Birmingham, AL 35294-4460 or srauter@uab.edu.

Grant I. Thrall, University of Florida, Gainesville, FL 32611 or grant@thrall.us.

Eric Hangen, I² Community Development Consulting, Inc., Cranston, RI 02905 or ehangen@i2community.org.
Capital Markets and Sustainable Real Estate: What Are the Perceived Risks and Barriers?

Authors
Louis A. Galuppo and Charles Tu

Abstract
This paper examines the perceptions of the real estate capital market players regarding green buildings. Through an online survey of lenders, equity investors, and developers, the study collects and analyzes their opinions on the incremental costs and benefits of energy-efficient projects, as well as the importance of various risks and barriers. While the majority of the respondents believe green buildings should have higher value, they are also concerned that this expectation might not materialize if space users (i.e., tenants) are unwilling to pay extra rent for the benefits associated with green space. Generally, the respondents believe that the lack of consumer awareness of these benefits, along with lack of incentives, is a major barrier to the growth of green development.

“Going green” has been a popular trend in the real estate industry in recent years. This is reflected in the dramatic increase in the number of green buildings worldwide. As of September 2009, there were over 3,800 Leadership in Energy and Environmental Design (LEED) certified commercial projects worldwide, increasing from about 400 in 2005. During the same period of time, the term “Going green” has been a popular trend in the real estate industry in recent years. This is reflected in the dramatic increase in the number of green buildings worldwide. As of September, the number of properties that had registered with the U.S. Green Building Council (USGBC) had increased from approximately 3,300 to more than 25,600. Additionally, many real estate professional groups and industry associations have featured this topic in their publications. Examples include the Counselors of Real Estate (CRE), the Commercial Real Estate Development Association (formerly known as the National Association of Industrial and Office Properties, or NAIOP), the Pension Real Estate Association (PREA), and the Urban Land Institute (ULI). As sustainable real estate gains popularity in the industry, it has also started to draw the attention of academic researchers.

The real estate business is highly capital intensive; therefore, a prerequisite of a successful project, either a development or acquisition, is its ability to obtain capital. One may argue that the primary purpose of building green is to reduce, or even eliminate, the negative environmental impacts; nevertheless, it is unlikely that lenders and equity investors would be willing to finance a green building if it is not expected to generate economic benefits. Does going green pay off?
Empirical research has revealed that LEED and ENERGY STAR buildings on average have higher value, rent, and occupancy than comparable conventional buildings (Miller, Spivey, and Florance, 2008; Dermisi, 2009; Fuerst and McAllister, 2009; Eichholtz, Kok, and Quigley, 2010; Wiley, Benefield, and Johnson, 2010). However, these studies do not compare the estimated benefits directly with incremental costs, if any. As empirical analyses do not provide a definitive conclusion on the profitability of building green, participants in the capital markets face uncertain outcomes when they lend or invest their money in a green project (Cochran, 2008; Vyas and Cannon, 2008; Jackson, 2009). Additionally, it is unclear whether current public policies provide necessary incentives to overcome the barriers (Simons, Choi, Simons, and Johnston, 2009). The purpose of this study is to understand how the real estate capital market participants (including lenders, equity investors, and developers) perceive the cost-benefit tradeoff of green development, and the risks and barriers associated with investing in energy-efficient buildings.

**Research Methodology and Data**

Because empirical data are unavailable, an online survey was constructed to collect opinions from various types of real estate capital market groups. The survey questionnaire had four sections. In addition to the general information, the survey asked a series of questions regarding the overall costs and benefits (in terms of property value) of energy-efficient buildings. Respondents were asked to provide their assessment regarding the cost: (1) Is it more expensive to build an energy-efficient building, and (2) If it is, how much higher is the cost? They were also asked to compare energy-efficient buildings to traditional buildings with otherwise similar attributes in terms of value: (1) Does an energy-efficient building have higher value, and (2) If it does, what are the reasons for the higher value? The final question asked whether they thought the higher value (if any) would be sufficient to offset the higher cost (if any).

The third section of the survey presented a list of risk factors that may affect the value of an energy-efficient building and/or the success of an energy-efficient development project. The respondents were asked to rate each risk factor based on how much they were concerned with the factor—from extremely concerned to not concerned at all. The final section focused on the barriers that might discourage the capital markets to provide financing for or invest in energy-efficient buildings/projects. The survey provided a list of perceived barriers and asked the respondents to assess the potential impact of each on their decision to get involved in an energy-efficient project. These barriers and risks were identified by participants in a series of stakeholder workshop held in the spring of 2008.

In June 2008, email invitations to participate in the survey were sent to 900 randomly-selected NAIOP and PREA members. In total, 132 responses were collected, but 12 of them had missing data and therefore were excluded from the analysis. Nearly half of the survey respondents were equity investors (49%), with lenders and developers representing 34% and 17% of the sample, respectively. In terms of geographical location, 32% of the respondents were located in California,
followed by Colorado, Illinois, Texas, New York, and Florida (ranging from 7% to 9% each). Over 65% of the respondents had been involved in projects with either LEED certification or ENERGY STAR designation. The high percentage of respondents with experience may indicate a potential sampling bias (i.e., those with experience were more interested in being part of this research project and thus more willing to complete the survey).

**Cost/Benefit Comparison**

In terms of the cost of an energy-efficient building, relative to that of a traditional building with otherwise comparable features, the vast majority of the respondents believed the cost is higher (94%). More specifically, about one-third of the sample (38%) estimated the incremental cost to be 1% to 5%, and another third (35%) 5% to 10%. Additionally, 21% of the respondents thought that the incremental cost would be over 10%. Exhibit 1 presents the breakdown of the estimated incremental cost.

With regard to value, an overwhelming majority (91.5%) of the sample believed that an energy-efficient building has higher value than a comparable traditional building. Nearly 80% of the respondents considered lower operating costs as the primary reason for the higher value. Other possible reasons include higher rent, a lower vacancy rate, and lower tenant turnover. Exhibit 2 shows the importance of factors contributing to the higher perceived value of energy-efficient buildings.

Given that an energy-efficient building was considered more valuable but also more costly to construct, it would be helpful to know whether the additional value can fully offset the higher cost. The respondents’ opinions on this issue were very diverse. Nearly 60% felt that the additional value would be sufficient to cover the incremental cost, with 16% responding “definitely yes” and 42% “probably yes.” On the other hand, 22% of the respondents disagreed, with 18% answering “probably no” and 4% “definitely no.” The remaining 20% of the participants said that they were not sure about the cost-value tradeoff (Exhibit 3).

---

**Exhibit 1** | Perceived Incremental Cost of Energy-Efficient Buildings

- **0%**
- **1-5%**
- **6-10%**
- **>10%**

- **21%**
- **35%**
- **38%**
- **6%**
The opinions across different groups of respondents were also compared based on their primary line of business, location, and experience in energy-efficient projects. The comparison between types of capital market participants (i.e., lenders, equity investors, and developers) is quite interesting (Exhibit 4). While the percentage of respondents who believed energy-efficient buildings cost more was similar across the three groups (ranging from 93% to 95%), the opinion on the size of the incremental cost was very different. The chart shows that the majority of the equity investors (51%) and developers (65%) estimated the incremental cost to be 5% or less; in contrast, nearly 80% of the lenders felt that the incremental cost would be higher than 5%. Because of the higher perceived cost, more lenders believed that the additional value would not be sufficient to offset the incremental cost.
California has arguably the highest standards and regulatory requirements related to environmental impacts and concerns in the nation. Therefore respondents in California were compared with the rest of the United States to determine if government policy would affect the opinions. The data shows that the incremental cost estimated by respondents in California was lower than others (Exhibit 5). Given that projects in California need to meet higher minimum regulatory
standards to begin with, the additional cost of achieving any kind of green label becomes smaller.

In terms of prior experience in energy-efficient projects, there exists a considerable difference between the two groups. Respondents who had not been involved with energy-efficient projects previously considered the incremental cost to be much higher, and consequently, fewer of them believed that the added value of an
Exhibit 6 | Comparison by Respondent’s Experience in Energy-Efficient Projects

**Perceived Incremental Cost**

<table>
<thead>
<tr>
<th>%</th>
<th>With experience</th>
<th>Without experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>20%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>40%</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>60%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>80%</td>
<td>70%</td>
<td>60%</td>
</tr>
<tr>
<td>100%</td>
<td>80%</td>
<td>70%</td>
</tr>
</tbody>
</table>

**Perception that Added Value is Sufficient to Offset Incremental Cost**

<table>
<thead>
<tr>
<th>%</th>
<th>With experience</th>
<th>Without experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely Yes</td>
<td>20%</td>
<td>10%</td>
</tr>
<tr>
<td>Probably Yes</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Not Sure</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>Probably No</td>
<td>80%</td>
<td>70%</td>
</tr>
<tr>
<td>Definitely No</td>
<td>100%</td>
<td>90%</td>
</tr>
</tbody>
</table>

An energy-efficient building would be sufficient to offset the perceived higher cost (Exhibit 6). The result is not surprising since this perception might well be the reason these respondents had not yet become involved in green projects.

It is possible that the three factors (i.e., type of capital market participant, location, and experience) are interrelated in the survey sample. Therefore further analyses were conducted to assess the impact of each factor with all three being considered simultaneously. Two logistic models were estimated. The first one had the
estimated incremental cost (based on the four survey categories) as the dependent variable and used survey participants’ line of business, location, and experience as explanatory variables. The value of the dependent variable is 1 if the estimated incremental cost is 0%; 2 if the cost is 1%–5%; 3 if the cost is 6%–10%; and 4 if the cost is greater than 10%. Two binary variables were used to represent a survey respondent’s line of business, with equity investors being the reference group. If the respondent was a lender, $LENDER$ was equal to 1, otherwise it was 0; if the respondent was a developer, $DEVELOPER$ was equal to 1, otherwise 0. $CALIFORNIA$ and $EXPERIENCE$ were also binary variables, which represented the survey respondent's location and prior experience in energy-efficient projects, respectively.

The parameter estimates presented in Exhibit 7 show that there was no significant difference between the perceptions of developers and equity investors; in contrast, the perceived cost by lenders was significantly higher than equity investors. Respondents who had been involved in energy-efficient projects estimated a significantly lower incremental cost than those without prior experience. Interestingly, after controlling for the type of respondent and experience, being in California no longer had a significant effect on the respondent’s opinion.

The second model used the same set of independent variables to explain the likelihood of the higher value being sufficient to offset the incremental cost. The signs of parameter estimates were consistent with the previous analyses (Exhibit 8). The results suggest that developers and equity investors had similar opinions, but lenders in general were more pessimistic than the other two groups about the net outcome of building green. Respondents with experience in energy-efficient projects had more confident that the higher cost would be offset by the added value. Again, the respondent’s location did not have a significant effect.

**Perceived Risks**

The survey respondents were asked to rate seven risk factors according to the level of concern they had as to how each risk could affect the success of an energy-efficient building. The risk factors were rated using the following scale: extremely concerned (4), moderately concerned (3), mildly concerned (2), not concerned (1), and not sure (NA). A concern factor was calculated as the weighted average of the ratings (excluding those who were not sure about the impact). Exhibit 9 ranks the risk factors based on the mean value of concern factor.

Overall, the survey sample was most concerned about not being able to benefit from the higher value of energy-efficient buildings, either because tenants would not be willing to pay a higher rent (a concern factor of 2.75) or because the added value would not be recognized by others, such as lenders or appraisers (2.62). The concern factor of these two risks was significantly higher than others, but there was no significant difference between them. On average, the survey participants were least concerned about the possibility that the entitlement process might take longer (1.63), and there is a significant gap between this risk factor and all others.
Exhibit 7 | Estimation Results of Incremental Cost Model

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Chi-Square</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept1</td>
<td>−1.54</td>
<td>5.91</td>
<td>0.015</td>
</tr>
<tr>
<td>Intercept2</td>
<td>1.19</td>
<td>4.51</td>
<td>0.033</td>
</tr>
<tr>
<td>Intercept3</td>
<td>3.10</td>
<td>24.20</td>
<td>0.000</td>
</tr>
<tr>
<td>LENDER</td>
<td>−1.26</td>
<td>9.49</td>
<td>0.002</td>
</tr>
<tr>
<td>DEVELOPER</td>
<td>0.27</td>
<td>0.27</td>
<td>0.599</td>
</tr>
<tr>
<td>CALIFORNIA</td>
<td>0.63</td>
<td>2.50</td>
<td>0.113</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>1.02</td>
<td>7.27</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Notes: The dependent variable is the estimated incremental cost. The value is 1 if the incremental cost is 0%; 2 if the cost is 1%–5%; 3 if the cost is 6%–10%; and 4 if the cost is greater than 10%.

Exhibit 8 | Estimation Results of Net Pay-off Model

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Chi-Square</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept1</td>
<td>−4.27</td>
<td>35.27</td>
<td>0.000</td>
</tr>
<tr>
<td>Intercept2</td>
<td>−2.37</td>
<td>16.62</td>
<td>0.000</td>
</tr>
<tr>
<td>Intercept3</td>
<td>−1.40</td>
<td>6.43</td>
<td>0.011</td>
</tr>
<tr>
<td>Intercept4</td>
<td>0.67</td>
<td>1.51</td>
<td>0.218</td>
</tr>
<tr>
<td>LENDER</td>
<td>0.60</td>
<td>2.44</td>
<td>0.097</td>
</tr>
<tr>
<td>DEVELOPER</td>
<td>0.30</td>
<td>0.37</td>
<td>0.540</td>
</tr>
<tr>
<td>CALIFORNIA</td>
<td>−0.59</td>
<td>2.37</td>
<td>0.123</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>−0.73</td>
<td>4.13</td>
<td>0.042</td>
</tr>
</tbody>
</table>

Notes: The dependent variable is the perception that added value is sufficient to offset incremental cost. The value is 1 if answer is “Definitely Yes,” 2 if “Probably Yes,” 3 if “Not Sure,” 4 if “Probably No,” and 5 if “Definitely No.”

Exhibit 10 compares the perception of risk factors by the different types of capital market participants, with the mean value of concern factor and the ranking (in parentheses). All three groups were most concerned about the possibility that tenants might not be willing to pay higher rent for “green” space. For lenders and equity investors, the next most important risk was the possibility that the benefits of an energy-efficient building might not be reflected in value, whereas developers ranked this risk factor third. Developers were more concerned about additional requirements and fees involved in energy-efficient projects; in contrast, this factor was ranked third by lenders and fifth by equity investors.
### Exhibit 9 | Perceived Risks of Energy-Efficient Projects

<table>
<thead>
<tr>
<th>Risk</th>
<th>Concern Factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenants might not be willing to pay higher rent for green space.</td>
<td>2.75</td>
</tr>
<tr>
<td>The benefits of an energy-efficient building might not be reflected in value (by lenders, appraisers, etc.).</td>
<td>2.62</td>
</tr>
<tr>
<td>The owner might be unable to benefit from the higher value when selling the building.</td>
<td>2.28&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>There might be additional requirements and/or fees involved.</td>
<td>2.26</td>
</tr>
<tr>
<td>As technology continues to change, the building might become functionally obsolete soon.</td>
<td>1.97</td>
</tr>
<tr>
<td>The design process might take longer due to the lack experienced teams.</td>
<td>1.93</td>
</tr>
<tr>
<td>The approval / entitlement process might take longer.</td>
<td>1.63&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes:

<sup>a</sup>Each respondent rated the risks using the following scale: extremely concerned (4), moderately concerned (3), mildly concerned (2), not concerned (1), and not sure (NA). The concern factor is the weighted average of the ratings, excluding those who were not sure about the impact.

<sup>b</sup>The concern factor is significantly different from the one above at the 5% level.

### Exhibit 10 | Comparison of Risks across Different Types of Capital Market Participants

<table>
<thead>
<tr>
<th>Risk</th>
<th>Lenders</th>
<th>Equity Investors</th>
<th>Developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenants might not be willing to pay higher rent for green space.</td>
<td>2.87 (1)</td>
<td>2.66 (1)</td>
<td>2.72 (1)</td>
</tr>
<tr>
<td>The benefits of an energy-efficient building might not be reflected in value.</td>
<td>2.72 (2)</td>
<td>2.63 (2)</td>
<td>2.33 (3)</td>
</tr>
<tr>
<td>The owner might be unable to benefit from the higher value when selling the building.</td>
<td>2.18 (4)</td>
<td>2.41 (3)</td>
<td>2.17 (4)</td>
</tr>
<tr>
<td>There might be additional requirements and/or fees involved.</td>
<td>2.29 (3)</td>
<td>2.15 (5)</td>
<td>2.53 (2)</td>
</tr>
<tr>
<td>As technology continues to change, the building might become functionally obsolete soon.</td>
<td>1.74 (6)</td>
<td>2.22 (4)</td>
<td>1.78 (6)</td>
</tr>
<tr>
<td>The design process might take longer due to the lack experienced teams.</td>
<td>1.95 (5)</td>
<td>1.91 (6)</td>
<td>1.94 (5)</td>
</tr>
<tr>
<td>The approval / entitlement process might take longer.</td>
<td>1.70 (7)</td>
<td>1.54 (7)</td>
<td>1.78 (6)</td>
</tr>
<tr>
<td>Average</td>
<td>2.21</td>
<td>2.22</td>
<td>2.18</td>
</tr>
</tbody>
</table>

Note: Value in parentheses is the ranking of the risk factor.
When the opinion of respondents with prior experience in dealing with energy-efficient projects was compared with those without experience, the rankings of risk factors were very similar (Exhibit 11). However, capital market participants who had not financed or invested in this type of project were much more concerned about the various risks. Overall, the concern factor is 2.59 for those without experience, compared with 2.01 for those with experience. Additionally, the difference is statistically significant across all seven risk factors.

**Perceived Barriers**

Survey respondents were also asked to assess the impact of five barriers that were believed to influence financing/investment decision-making regarding energy-efficient buildings. They rated each barrier using the following scale: great impact (4), moderate impact (3), little impact (2), no impact (1), and not sure (NA). An impact factor was then calculated as the weighted average of the ratings (Exhibit 12). The top barrier was that consumers and space users (such as homebuyers, apartment renters, and commercial tenants) were not aware of the benefits of green buildings, and thus would not be willing to pay more for it (with an impact factor 2.67). The next two were the lack of incentives, from both the public sector [i.e., state and local governments (2.65)] and the private sector [e.g., utilities and financial institutions (2.58)]. The results indicated less of a concern relative to building codes and the availability of experienced professionals. There were no statistically significant differences among the top three barriers in terms of their ratings by the survey respondents; on the other hand, the last two barriers were significantly less important.

### Exhibit 11 | Comparison of Risks Based on Respondent Experience

<table>
<thead>
<tr>
<th>Risk</th>
<th>With Experience</th>
<th>Without Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenants might not be willing to pay higher rent for green space.</td>
<td>2.53 (1)</td>
<td>3.13 (1)</td>
</tr>
<tr>
<td>The benefits of an energy-efficient building might not be reflected in value.</td>
<td>2.36 (2)</td>
<td>3.08 (2)</td>
</tr>
<tr>
<td>The owner might be unable to benefit from the higher value when selling the building.</td>
<td>2.12 (3)</td>
<td>2.63 (4)</td>
</tr>
<tr>
<td>There might be additional requirements and/or fees involved.</td>
<td>1.99 (4)</td>
<td>2.78 (3)</td>
</tr>
<tr>
<td>As technology continues to change, the building might become functionally obsolete soon.</td>
<td>1.88 (5)</td>
<td>2.18 (6)</td>
</tr>
<tr>
<td>The design process might take longer due to the lack of experienced teams.</td>
<td>1.77 (6)</td>
<td>2.24 (5)</td>
</tr>
<tr>
<td>The approval/entitlement process might take longer.</td>
<td>1.40 (7)</td>
<td>2.08 (7)</td>
</tr>
<tr>
<td>Average</td>
<td>2.01</td>
<td>2.59</td>
</tr>
</tbody>
</table>

*Note: Value in parentheses is the ranking of the risk factor.*
**Exhibit 12 | Perceived Barriers of Energy-Efficient Projects**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Impact Factor $^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers / space users are not aware of the benefits of green buildings.</td>
<td>2.67</td>
</tr>
<tr>
<td>State / local governments do not provide sufficient financial incentives.</td>
<td>2.65</td>
</tr>
<tr>
<td>The private sectors (such as lenders, utilities, among others) do not provide sufficient incentives.</td>
<td>2.58</td>
</tr>
<tr>
<td>Experienced design teams are difficult to find.</td>
<td>2.25$^b$</td>
</tr>
<tr>
<td>Local building codes are out-dated, so green building may violate many codes.</td>
<td>2.21</td>
</tr>
</tbody>
</table>

Notes:

$^a$ Each respondent rated the barriers using the following scale: great impact (4), moderate impact (3), little impact (2), no impact (1), and not sure (NA). The impact factor is the weighted average of the ratings, excluding those who were not sure about the impact.

$^b$ The impact factor is significantly different from the one above at the 5% level.

Exhibit 13 presents the average rating of each barrier, as well as its ranking among the barriers (in parentheses), across the entire sample and by different capital market participants. Equity investors considered the lack of consumer awareness of the benefits of green buildings as the biggest barrier; lenders and developers, in contrast, perceived the lack of government incentives as the top barrier. The top three barriers also included the lack of incentives from the private sector, such as utilities and financial institutions. All three groups agreed that neither the local building codes nor capable design teams were barriers with great impact.

**Exhibit 13 | Comparison of Barriers across Different Types of Capital Market Participants**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Lenders</th>
<th>Equity Investors</th>
<th>Developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers / space users are not aware of the benefits of green buildings.</td>
<td>2.68 (2)</td>
<td>2.70 (1)</td>
<td>2.53 (2)</td>
</tr>
<tr>
<td>State / local governments do not provide sufficient financial incentives.</td>
<td>2.71 (1)</td>
<td>2.53 (3)</td>
<td>2.88 (1)</td>
</tr>
<tr>
<td>The private sectors (such as lenders, utilities, among others) do not provide sufficient incentives.</td>
<td>2.58 (3)</td>
<td>2.63 (2)</td>
<td>2.38 (3)</td>
</tr>
<tr>
<td>Experienced design teams are difficult to find.</td>
<td>2.31 (4)</td>
<td>2.26 (4)</td>
<td>2.06 (5)</td>
</tr>
<tr>
<td>Local building codes are out-dated, so green building may violate many codes.</td>
<td>2.31 (4)</td>
<td>2.14 (5)</td>
<td>2.18 (4)</td>
</tr>
<tr>
<td>Average</td>
<td>2.52</td>
<td>2.45</td>
<td>2.40</td>
</tr>
</tbody>
</table>

**Note:** Value in parentheses is the ranking of the barrier.
Exhibit 14 | Comparison of Barriers Based on Respondent Experience

<table>
<thead>
<tr>
<th>Barrier</th>
<th>With Experience</th>
<th>Without Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumers/space users are not aware of the benefits of green buildings.</td>
<td>2.51 (2)</td>
<td>2.95 (1)</td>
</tr>
<tr>
<td>State/local governments do not provide sufficient financial incentives.</td>
<td>2.60 (1)</td>
<td>2.74 (3)</td>
</tr>
<tr>
<td>The private sectors (such as lenders, utilities, among others) do not provide sufficient incentives.</td>
<td>2.49 (3)</td>
<td>2.75 (2)</td>
</tr>
<tr>
<td>Experienced design teams are difficult to find.</td>
<td>2.14 (4)</td>
<td>2.43 (4)</td>
</tr>
<tr>
<td>Local building codes are out-dated, so green building may violate many codes.</td>
<td>2.10 (5)</td>
<td>2.42 (5)</td>
</tr>
<tr>
<td>Average</td>
<td>2.37</td>
<td>2.66</td>
</tr>
</tbody>
</table>

Note: Value in parentheses is the ranking of the risk factor.

Exhibit 14 compares the impact factor of barriers between respondents who had been involved in energy-efficient projects with those who had not. Respondents with experience considered the lack of government incentives as the biggest barrier to energy-efficient projects, followed by the lack of consumer awareness of the benefits of green space. In contrast, respondents who had not been involved in LEED or ENERGY STAR projects felt that the lack of consumer awareness had the greatest impact on their decision-making; the lack of incentives offered by the private sector and the public sector were ranked second and third, respectively. Regardless of their experience, the respondents agreed that local building codes and a capable design team would have much less impact than the other three barriers. Similar to the concern factor of risks, the impact factors of barriers for respondents without experience were significantly higher than those with experience across all barriers.

Conclusion

This study examines the perceptions of the real estate capital markets regarding energy-efficient buildings. An online survey was conducted to collect the views and opinions of market participants (including lenders, equity investors, and developers) in terms of costs and benefits, risks, and barriers. Analyses of the survey responses reveal diverse opinions across the entire sample. While more than half the respondents felt that the added value of energy-efficient buildings would be sufficient to offset the incremental costs, over 20% of the sample disagreed and another 20% were not sure. The results provide a better understanding of how capital market players perceive the cost-benefit tradeoff of green buildings. The mere fact that the survey respondents had remarkably different opinions leads to the conclusion that uncertainties exist. In terms of
specific risk factors, the respondents considered the possibility that: (1) tenants are not willing to pay higher rent; and (2) benefits are not reflected in value as the top two concerns. On the other hand, lack of consumer awareness of the benefits of green buildings and lack of incentives (provided by both the public and private sectors) were perceived as the main barriers.

The comparison between the different types of capital market participants revealed interesting differences. While the perceptions of equity investors and developers were more comparable, lenders were less positive about the financial payoff of green buildings. All three groups were most concerned about the possibility that space users might not be willing to pay extra for the benefits associated with green space. After that, their opinions differ substantially. For example, the additional requirements and fees factor was ranked second by developers, but fifth by equity investors. In terms of barriers, equity investors considered lack of consumer awareness the biggest barrier, whereas developers and lenders felt that the lack of government incentives would have more impact on their decisions.

This study fills a void in the existing literature in that few studies have examined the risks and barriers related to green buildings, particularly from the capital market perspective. Several studies have assessed the performance of existing buildings and, in some manner, found that green properties have higher value, rent, and occupancy. Despite these findings, green buildings still represent only a small portion of the real estate stock. Additionally, studies have reviewed public policies related to green building and sustainability, but it remains to be seen whether capital market players believe that the federal, state, and municipal governments have created the correct and necessary incentives, and have set up the appropriate policies to overcome the barriers and mitigate the risks. The findings of this study provide some insights regarding those issues.

This study is the first step toward a better understanding of the capital market perceptions regarding sustainable real estate and green buildings, and further research is needed in this area. Since the marketplace is changing rapidly due to market factors and newly enacted green building policies and laws, new research may continue to update the viewpoint of capital market players. Other research may investigate in more detail the type and impact of risk caused by building green. Additionally, the scope of the barriers may be identified, discussed, and quantified. Most importantly, further research may be conducted pertaining to the current incentives to determine whether they have been properly designed and successfully implemented from the perspective of the capital market players, and whether any additional incentives should be brought into the marketplace.

**Endnotes**


2. In 2008, CRE published a special issue of *Real Estate Issues*, focusing on “green” development and building. The main purpose was to illustrate the importance of introducing risk into the sustainability equation (Cochran, 2008; Vyas and Cannon,
“Green” was the feature story of the 2007 Spring issue of Development, the official publication of NAIOP (Rand, 2007). In the summer of 2007, PREA dedicated an entire edition of the PREA Quarterly to “green development” and “green building,” (Anderson, 2007). ULI launched a quarterly publication entitled Urban Land Green, with cover stories, featured articles, special sections, and columns all dedicated to “green development.”

For example, at the 2009 American Real Estate Society (ARES) annual meeting in Monterey, CA, two paper sessions and a panel discussion focused on green and sustainable real estate. Also, the Homer Hoyt Institute (an independent research and educational foundation) focused on green and sustainable real estate in its May 2009 meeting.

While there exist numerous green building rating systems, LEED and ENERGY STAR are most commonly referred to in the U.S. (Fowler and Rauch, 2006).

The online survey was created on http://www.surveymonkey.com.

The workshops were part of the Chula Vista Research Project (CVRP), a study that was sponsored by the U.S. Department of Energy and the California Energy Commission. Workshop participants included representatives of the: (1) real estate development transaction chain, including investors, lenders, developers and builders, design professionals, and brokers; (2) environmental organizations and community advocacy groups; and (3) local and state government agencies.

NAIOP, the Commercial Real Estate Development Association, is the leading organization for developers, owners, and related professionals in office, industrial, and mixed-use real estate. PREA is a non-profit trade organization for the global institutional real estate investment industry.

The response rate is relatively low, compared with several recent studies utilizing the survey approach. Their response rates range from 20% to 35% (Gibler, Sah, and Chen, 2008; Manning, Harrison, and Webb, 2009; Worzala and Tu, 2010). The response rates themselves, however, “do not necessarily differentiate reliably between accurate and inaccurate data” (American Association for Public Opinion Research, 2010).

For example, California Assembly Bill 32: Global Warming Solutions Act of 2006 requires that the state’s greenhouse emissions be reduced to the 1990 level by 2020 (Air Resources Board, 2010). In January 2010, California announced the first-in-the-nation statewide green building code that would take effect on January 1, 2011 (Office of the Governor, 2010).

The logistic procedure is used to fit linear regression models with binary or ordinal response data using the method of maximum likelihood. When the dependent variable \( Y \) has one of a number of ordinal values \( 1, ..., k, k + 1 \), the procedure fits a set of parallel lines based on the cumulative distribution probabilities (Pr):

\[
\Pr(Y \leq i | x) = \alpha_i + \beta'x, \quad 1 \leq i \leq k.
\]

Where \( \alpha_1, ..., \alpha_k \) are \( k \) intercept parameters, \( \beta \) is a vector of slope parameters, and \( x \) are the explanatory variables.

The negative parameter estimate indicates a lower cumulative probability of low-cost categories. In other words, lenders are more likely to select a higher incremental cost.

The value of the dependent variable is 1 if the answer is “Definitely Yes,” 2 if “Probably Yes,” 3 if “Not Sure,” 4 if “Probably No,” and 5 if “Definitely No.” That means the
higher the value, the less likely the respondent thought that the added value would be sufficient to offset the incremental cost.

13 Two risk factors are considered “significantly different” if the gap between their means is statistically different from 0 at the 5% significance level. The same analysis was also applied to the impact factor of barriers.

References


Louis A. Galuppo, University of San Diego, San Diego, CA 92110-2492 or lgaluppo@sandiego.edu.

Charles Tu, University of San Diego, San Diego, CA 92110-2492 or tuc@sandiego.edu.
Uncertainty, Real Option Valuation, and Policies toward a Sustainable Built Environment

Author: Emiel van der Maaten

Abstract: Real option value can severely hinder investments in energy conservation in real estate. This paper evaluates whether policy incentives to invest now, instead of tomorrow can be tailored to compensate for any option value to defer. A case study reviews a Dutch government subsidy program with the Cox, Ross, and Rubinstein (1979) binomial method. Based on market priced risk, the subsidy properly compensates investors for the real option value they forego by exercising the option and investing in a solar hot water system. A survey amongst homeowners reveals that private risks are an important part of the perceived uncertainty when investing in energy efficiency and should be included in the model. A practitioners’ method is proposed that uses a binomial real option model to design policy incentives and surveys to assess the relevant uncertainties to include in the model. The results displayed in strategy spaces makes intuitive decisions possible.

In recent years climate change and energy shortages have become mainstream problems. Their importance is now widely accepted. In the real estate sector this has led to initiatives like ENERGY STAR and LEED, and landmark buildings such as One Bryant Park in New York City. These are some clear signals that sustainability and energy efficiency are becoming a central focus in the real estate industry.

The built environment is a major energy consumer. Schools, offices, shops, and homes use many times the energy that the aviation industry uses. If in any sector sustainability can make an impact both environmentally and economically, it is in real estate. Although the environmental benefits are clear, the economical benefits are still largely unclear.

Recent literature such as Miller, Spivey, and Florance (2008), Eichholtz, Kok, and Quigley (2010), and Kok, Eichholtz, Bauer, and Peneda (2010) shows the first evidence of the financial benefits of green buildings. Green buildings command higher rents and higher transaction values (Eichholtz, Kok, and Quigley, 2010). Miller, Pogue, Gough, and Davis (2009) link greener buildings with higher productivity and give an indication of the added net present value this may create. However, benefits like higher productivity of the occupants and the marketing advantage related to corporate social responsibility remain rather difficult to measure and are therefore difficult to value. The one benefit that is relatively easy to measure is energy conservation.
To show how much energy a green building can save as opposed to a traditional building is rather straightforward, especially in hindsight. It is more difficult however to estimate before investing what the green investment is worth. The answer to this question depends a great deal on the expectation of the energy price development, because energy conservation is expressed in the price of conventional fuels. This is where uncertainty plays an important role. Prices of crude oil, electricity, and natural gas are known to be volatile. In 2008, there was a surge in the oil price to over $140 per barrel while today (March 2010) oil trades in the region of $70 to $90 per barrel. Since 1994, natural gas has traded at the Henry Hub in the United States at annual volatilities between 49% and 218% (Mastrangelo, 2007), which makes the price of natural gas highly uncertain.1

Due to the volatility of energy prices, it can be interesting to delay investments in energy conservation until prices have risen far enough to assure a handsome return. In fact the owner of real estate has the option to invest in his property’s energy efficiency but does not have an obligation to do so. An opportunity much like the one a financial call option offers. The tendency to defer investment causes investor inertia in the short-to-medium term. This could explain a lack of investment in greener real estate. To make the investment today rather than tomorrow, the investor will be looking for incentives or carrots. So the inertia toward investment can possibly be countered with policy intervention. When the option value is neglected however, the incentive is unlikely to properly compensate investors for the option value they have to forego by exercising the option they hold to invest in green(er) real estate.

Advances in technology for energy conservation or renewable energy generation may also be worth waiting for, as these may dramatically increase the payoff of the investment. Especially for photovoltaic panels, for which many different technologies have been developed (Curtright, Granger Morgan, and Keith, 2008). These may lead to panels with the same capacity as today but at a much lower price or with much more capacity at the same price. In both cases, the payoff of investment in a greener home will be affected. The first will lead to a lower exercise price, while the latter leads to a higher value of the underlying asset. The uncertainty regarding technological advance will likely increase volatility, which results in a higher option value. Technological development can therefore be worth waiting for.

The value of the option to defer is therefore central to design a carrot or stick that works well. The option value can help explain why investments in energy conservation in property are delayed. Policy incentives to invest now, instead of tomorrow, like subsidies or tax rebates can be tailored to compensate for any option value to defer.

The present paper discusses the role uncertainty and real option valuation can play in creating carrots that work. It uses a case study of a subsidized investment in a more energy-efficient home in the Netherlands to provide empirical evidence that a stimulus should be designed to compensate for any option value in waiting to invest. Does the subsidy make sense from a financial point of view? Or does real option valuation suggest otherwise? The case of a solar hot water system2 was chosen for evaluation, because it is an energy efficiency measure that can easily
be added on to most residences and is currently part of a Dutch government subsidy program.

The case study is also intended to show the practical suitability of real option valuation for policy intervention design. For the real option valuation method to be accepted, it should be user-friendly and easy for practitioners to incorporate into their everyday valuation tools.

This paper firstly introduces the concept of real option valuation and then describes the binomial option pricing model and its inputs. The sensitivity analysis of the model results is presented in strategy spaces and discussed. A survey then gives some insight into the perceived uncertainty by Dutch homeowners. Finally, the paper concludes on the suitability of real option valuation for designing incentives that work to achieve a green(er) built environment.

**Real Option Valuation**

Real option valuation (ROV) is an extension of or addition to discounted cash flow (DCF) analysis. DCF is considered quite a rigid valuation method because it uses a fixed discount rate, which is as Brennan and Schwartz (1985, p. 139) state: “...tantamount to assuming that the risk of the project is constant over its life.” In reality, risk is hardly ever constant over the life of the project. The DCF method also implicitly assumes immediate investment, while in real life investments can be timed for optimal entry. Therefore a growing amount of literature agrees that the classical DCF analysis does not capture the value of real life flexibility. For projects with substantial uncertainty, this can lead to underestimation of their value and cause a miss-allocation of scarce resources.

**Option Pricing Theory and Real Assets**

The underlying principle of ROV is option pricing theory (OPT), which was introduced by Black and Scholes (1973) and Merton (1973). OPT was intended to value options on financial assets. The value of real assets as opposed to financial assets also depends on private risks that are not priced in the financial markets (Amram and Kulatilaka, 1999, pp. 47–54). In the present case study, for example, a source of private risk can be that the government changes its subsidy program. The risk that this may happen can make it worthwhile for the homeowner to wait and see if this new subsidy program will offer a higher incentive to invest than the current one. In property development, an example of private risk can be for instance the failure to obtain planning permission. No traded securities are available that represent exactly these private risks. However, by using financial assets that have similar risk characteristics as the real asset, the risk associated to the real asset can be mimicked. Creating a proxy portfolio allows the ability to price the option on the real asset. Looking at the example of real estate, an appropriate proxy that can reasonably replicate the value of real estate as an underlying asset can be a portfolio of real estate investment trusts (REITs). Ott
and Yi (2001), for example, used REIT data as a proxy to find the volatility for their real options model.

**Real Options, Policies, and Sustainable Real Estate**

Real option valuation has numerous fields of application. Merton (1998) summarized in part of his Noble Prize address some 25 years worth of different real option applications. Without being complete, a number of them are mentioned: valuing insurance contracts, pricing credit derivatives, valuing fishery quotas, pricing licenses for the right to pollute, valuing offshore drilling rights, tax delinquency on real estate, and so on.

Patel, Paxson, and Sing (2005) provided a comprehensive overview of the literature on what they call “real property options” and reviewed a number of practical applications, such as: planning, investment timing, leasing, operation, funding, and industry strategy. They found that mortgage valuation is a particularly useful application for ROV. Azevedo-Pereira, Newton, and Paxson (2003) confirm this. Despite the wide scope of the Patel, Paxson, and Sing (2005) overview, sustainable real estate is not mentioned. Literature like Holland, Ott, and Riddiough (2000) and Grenadier (2002) confirms the presence of the option to delay uncertain investments in real estate. The sustainable built environment, however, appears to be a new avenue of research in the field of real property options.

The present case study focuses on improving the energy efficiency of existing homes. This topic has not yet been much explored within real options valuation. Recently, Hajek (2009) studied the impact of the deferral option on the energy efficiency of homes in Prague. He looked for empirical evidence to show that homeowners in Prague do not invest in the energy efficiency of their homes because of the valuable deferral option they hold. Although he showed the presence of investment deferral, it remained unclear whether this can be entirely attributed to the presence of option value. His study did not take into account much of the private risk sources, such as for instance the propensity of people to move. Also he found that a delay of over two years occurred between a “price signal” and the actual investment in energy efficiency measures. This also raises the question whether the option value to defer investment is entirely related to volatile energy prices.

Besides the deferral option found by Hayek (2009), Kumbaroglu, Madlener, and Demirel (2008) found that investments in renewable power generation technologies are severely hindered by the option to delay these irreversible investments.

So uncertainty can hold back investment in a green(er) built environment. Carrots, incentives or subsidies may be a way to counter the reluctance to invest. Dixit and Pindyck (1994, pp. 282–316) argue that when irreversible investments under uncertainty have to be made in situations or cases where the market does not function, policy intervention may be considered. In the case of investments in a
more sustainable home, the investor has the benefits of a lower utility bill and a hedge against future energy price increases. The benefits like a smaller carbon footprint and a lower dependency on fossil fuels are societal benefits, so-called positive externalities or external benefits. The investor does not count these benefits in his decision to invest and may therefore decide not to invest. A government, however, may judge the market for investment in a green(er) home incomplete. It may find the external benefits important enough to influence the investors’ decision by providing policy incentives, such as subsidies or tax rebates.

Some recent studies give empirical evidence that to design effective policies; a real options approach can be useful. Anda, Golub, and Strukova (2009), for instance, used real option analysis to formulate rules for the selection of an emission target for a climate policy. Fuss, Obersteiner, and Szolgayova (2008) found that even a moderate increase in the price uncertainty of CO₂ emission permits a dramatic increase in investment to reduce emissions. They also showed that a policy of deterministic permit pricing leads to less investment. In their study, real option valuation was used to show the value of volatility and how it can be used in environmental policy making. In this case, the volatility that the cap and trade system creates appears to be an effective stick, which makes CO₂ emitters want to reduce their emissions to have a more stable and predictable cost structure. The option to invest in CO₂ emission reduction is often “in the money” due to the high volatility of the price of CO₂ permits.

The present case study is a first empirical attempt to link an established real option value with consumers’ perception of uncertainty in investments in real estate.

**Methodology**

This research follows two tracks. Firstly, the call option to defer investment was modeled with the Cox, Ross, and Rubinstein (1979) binomial method and the results were presented in a strategy space. Secondly, a survey of homeowners was intended to disclose what they perceive as the most important uncertainties when faced with a decision to invest in a more energy-efficient home.

**Binomial Model**

Amram and Kulatilaka (1999, p. 108) distinguish three solutions for real option problems: (1) partial differential equations (PDEs) such as the Black-Scholes formula;³ (2) dynamic programming, which can be modeled with the binomial model; and (3) simulation, which can be done with, for example, the Monte Carlo method.

Both PDEs and simulation are rather complex methods, which require advanced calculus. This renders them rather unattractive for mainstream use by practitioners. The binomial lattice, however, is similar to a decision tree. The step from this well-known decision tool to the binomial tree is small, making it easy to understand. The binomial method offers a transparent way to value a real option, using only basic algebra instead of complex calculus (Copeland and Tufano, 2004).
Cox, Ross, and Rubinstein (1979), hereafter referred to as CRR, were the first to propose a binomial solution. Their method opened many new ways for the application of OPT. The binomial solution is a discrete-time model in which the price of the underlying asset can move either up or down at each time interval. The price movement of the underlying asset is represented by a binomial lattice or tree. Exhibits 4 and 5 are examples of such trees. Each node represents a possible value at that point in time. These values are the basis for the subsequent option value calculation. The previously mentioned tracking portfolio earns the risk-free rate of return. The CRR method uses that same principle. The option values are found by working from right to left through the lattice (Exhibits 4 and 5) and calculating the option value at each node with the risk-neutral probability. The result is a real option value for the present.

Survey: What Makes Homeowners Postpone Investment?

The binomial model described in the previous paragraph uses energy price development as the modeled uncertainty. The uncertainty related to technology advances, which may improve the payoff, was not modeled. The issues that worry investors, the homeowners, may therefore not be reflected correctly in the model. A survey was performed to find out what makes homeowners postpone investment. They were presented a number of uncertainties and were asked to indicate the two most important ones they worry about when making an irreversible investment in the energy efficiency of their home.

The survey sampled 330 people, which is part of the population of all 3.87 million households in the Netherlands, which according to Statistics Netherlands (2009a) own their home. The sample may be somewhat biased as most members live in big cities in the western part of the Netherlands and 19% of them may be more familiar with energy conservation in homes and real estate in general.

The survey was not intended to find out specifically about the investment in a solar hot water system, but about the investment in energy efficiency measures for homes in general. These may include insulation, double-glazed windows, heat pumps, photovoltaic panels, solar hot water systems, and others. This choice was made to be better able to generalize the results to investments in a more energy-efficient home instead of limiting them to the solar hot water system.

Model Inputs

The case study deals with an American call option on the subsidized investment in a solar hot water system by homeowners in the Netherlands. To determine the value of this American option, these five inputs were gathered: (1) the time to maturity; (2) the exercise price; (3) the risk-free rate; (4) the current value of the underlying asset; and the volatility of the underlying asset. These inputs are briefly described below; a more detailed account of how these inputs were gathered is available in Van der Maaten (2009). Exhibit 3 summarizes the model inputs for the medium growth scenario.
The Time to Maturity

The time to maturity was obtained from a factsheet (SenterNovem, 2009) about the government subsidy program for solar hot water systems. The option to postpone expires December 31, 2011. May 4, 2009 was chosen as the reference date. The time to maturity was therefore 2.7 years or 32 months.

The Exercise Price

The exercise price is made up of the cost of the solar hot water system and its installation. The reference system for this case study has a capacity of 3.0 GJ and costs €2,485 including VAT and installation costs.

The Current Value of the Underlying Asset

The current value of the underlying asset is the net present value of the investment in a solar hot water system today, at today’s expectation of the energy price development. The net present value is determined using the following inputs.

Annual Volume of Natural Gas Savings. The cash savings that a solar hot water system can generate depends on the volume of natural gas used by households. This volume is directly related to the household demand for hot tap water. The more hot tap water that is used, the more natural gas that is needed to heat it. For a solar hot water system to function optimally, a certain amount of hot water needs to be used. According to Milieu Centraal (2009), for households of three people and more, systems with a capacity of about 1 GJ per person are viable. A household size of three people was chosen as an input for the option pricing model in this study. This household can save between 150 m³ and 200 m³ of natural gas per year (Informatiecentrum Duurzame Energie, 2004; Bosselaar and Gerlach, 2006; SenterNovem, 2007; Milieu Centraal, 2009). It was assumed it would be able to save 175 m³ of natural gas on an annual basis with a solar hot water system with a capacity of 3.0 GJ for a working life of 30 years.\(^5\)

Price Development Scenarios for Natural Gas. The cash flows of natural gas savings depend on the expected price development of natural gas. The historical time series from 1980 to 2008 from Statistics Netherlands (2009b) as displayed in Exhibit 1 were used. The growth rates for a number of periods were extrapolated until 2020.

The three different average annual growth rates of 0.0%, 6.6%, and 9.7% were defined as respectively a zero, medium, and high growth rate scenario. From these price development scenarios, the cash flow projections could be made by multiplying the average annual gas savings for the reference household with the price of natural gas at each point in time for each scenario. Each scenario will generate a different cash flow during the economic working life of the system. All of these cash flows were then discounted at the appropriate discount rate.

From this point on, this paper only deals with the medium scenario result. For the zero and high growth scenario results, the reader is referred to Van der Maaten (2009).
**Exhibit 1** | Consumer Prices for Natural Gas in the Netherlands: 1980–2008 and Projections until 2020

![Graph showing consumer prices for natural gas in the Netherlands from 1980 to 2008 and projections until 2020 with different growth scenarios.]

*Note*: The source is historical data from Statistic Netherlands (2009b); projections authors’ own.

**Discount Rate: Capital Asset Pricing Model.** The capital asset pricing model (CAPM) was used to obtain a discount rate for calculating the current value of the investment in a solar boiler. The outcomes ranged from 6.9% to 11.73%. This range was also used in the sensitivity analysis for the ROV. The inputs gathered for the CAPM are summarized in Exhibit 2 and obtained as follows: A European energy industry beta derived from Damodaran (2009) was used as a proxy for the beta. The bond “NLRENT0%15JAN37” was the asset that matched the working life of the solar hot water system of 30 years the closest. Its rate of return is based on its quoted value on May 4, 2009 of €30.92 was 3.81% (IEX, 2009). This was used as the risk-free rate \( (r_f) \). Dimson, Marsh, and Staunton (2003) found that the arithmetic average market risk premium \( (r_m - r_f) \) measured against bonds for the Netherlands was 5.9%.

**The Current Value of the Underlying Asset.** With the inputs of Exhibit 2, the NPV of the underlying asset was calculated and varied between €860 and €4,805 depending on both the growth scenario and the applied discount rate. The mean NPV of the underlying asset was €2,833.

**Exhibit 2** | Gathered Inputs and Results for the Capital Asset Pricing Model

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta ([\beta])</td>
<td>0.64</td>
<td>1.13</td>
</tr>
<tr>
<td>Risk-free rate ([r_f])</td>
<td>3.81%</td>
<td>3.81%</td>
</tr>
<tr>
<td>Market risk premium ([r_m - r_f])</td>
<td>4.82%</td>
<td>6.98%</td>
</tr>
<tr>
<td>Discount rate ([r_a])</td>
<td>6.90%</td>
<td>11.73%</td>
</tr>
</tbody>
</table>
Volatility of the Underlying Asset

The seasonal volatility caused by the imbalance between hot water demand and solar heat supply is considered a short-term volatility that has no impact on the long-term volatility of the investment in a solar hot water system. This demand volatility, which constitutes a private risk, was therefore not included in the valuation.

From the historical annual natural gas price data of Exhibit 1, the volatility was calculated for different periods in the entire data period between 1980 and 2008. The volatility differs for each period. For example, the average annual volatility since 1980 until 2008 was 11%, but between 1980 and 1990 the volatility was as high as 16%. The lowest occurring volatility was 7% and the highest was 16%. As input for the model, the middle of this range was chosen, making the models’ annual volatility 12%. For the sensitivity analysis, the volatility was varied with increments of 20%, as can be seen on the horizontal axis of Exhibits 4 and 5. Exhibit 3 resumes the gathered model inputs.

Model Results

In this section the binomial method of CRR is briefly described and implemented. It is followed by a sensitivity analysis.6

Binomial Model

The binomial model described here was built in a simple spreadsheet as an addition to an existing DCF spreadsheet template. The method is quite user-friendly and easy for practitioners to add to their valuation tools. The binomial method itself is easy to understand and use. The choice of inputs, however, requires a deeper understanding of the concept of discount rates and volatility since good input is essential for good output. The following describes the basic working of the binomial method (Exhibit 2).

<table>
<thead>
<tr>
<th>Exhibit 3</th>
<th>Model Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to maturity</strong></td>
<td>[T]</td>
</tr>
<tr>
<td><strong>Exercise price</strong></td>
<td>[I]</td>
</tr>
<tr>
<td><strong>Risk free rate</strong></td>
<td>[r]</td>
</tr>
<tr>
<td><strong>Current value of the underlying asset</strong></td>
<td>[S]</td>
</tr>
<tr>
<td><strong>Volatility of the underlying asset</strong></td>
<td>[σ]</td>
</tr>
</tbody>
</table>

*Note: The mean value is for the natural gas prices medium growth scenario (6.6%)*
According to the CRR binomial method, the value of the underlying asset follows a random walk and can move either up or down with each time step. The factors for respectively an increase and a decrease in value are described as:

Increase or up-move: \( u = e^{\sigma \sqrt{\Delta t}} = 1.15 \). \hspace{1cm} (1)

Decrease or down-move: \( d = e^{-\sigma \sqrt{\Delta t}} = 0.87 \). \hspace{1cm} (2)

Where \( \sigma \) is the volatility; \( \Delta t = T/n \) is the time step; \( T \) is the time to maturity; and \( n \) is the number of time steps.

As illustrated in Exhibit 4, \( u \) and \( d \) determine the respective up and down movements in the binomial tree. The current value of the underlying asset \( (S) \) at \( t = 0 \) is \( \€2,833 \) (Exhibit 3). \( S_u \) and \( S_d \) are then obtained as follows:

\[
\text{Increase: } S_u = Su = \€2,833 \times 1.15 = \€3,257. \\
\text{Decrease: } S_d = Sd = \€2,833 \times 0.87 = \€2,464.
\]

(3) \hspace{1cm} (4)

Where: \( S_u \) is the value of the underlying asset after 1 move up; \( u \) is an increase or move-up factor; \( S_d \) is the value of the underlying asset after 1 move down; and \( d \) is a decrease or move-down factor.

The binomial tree for two time steps will then look like Exhibit 4. The option expires at \( t = 2 \) after 2.7 years or 32 months, which is December 31, 2011. Analogous \( t = 1 \) is 16 months after \( t = 0 \). The value of the underlying asset at \( t = 2 \) is \( S_2 \) minus the exercise price denoted as \( I \). As can be seen in Exhibit 5, the decision rule \( \max[0, S_2 - I] \) gives the call option value at \( t = 2 \) of \( C_{uu} = \€1,259, C_{ud} = 348 \) and \( C_{dd} = 0 \).
The call option value $C_{uu}$ corresponds to the value of the underlying asset $S_{uu}$. The lattice was then folded back to obtain the value of the option at $t = 1$ and $t = 0$. Risk neutrality was assumed. This means that the outcomes for an up and down movement multiplied by their respective probabilities and summed are equal to the risk-free rate ($r_f = 2.19\%$). The probability of an upward move of the value of the investment in a solar hot water system is given by Equation 5. The call option values at $t = 1$, denoted by $C$, are then obtained as in Equations 6 and 7.

\[ p = \frac{(e^{r_f \Delta t} \cdot d) - (u \cdot d)}{(u - d) - (1.15 - 0.87)} = 0.573 \]  

\[ C_u = e^{-r_f \Delta t} (C_{uu} \cdot p + (1 - p)C_{ud}) \]
\[ = 0.97(€1,259 \times 0.573 + (1 - 0.573)€348) = €844 \]  
\[ C_d = e^{-r_f \Delta t} (C_{ud} \times p + (1 - p)C_{dd}) \]
\[ = 0.97(€348 \times 0.573 + (1 - 0.573)€0) = €193 \]

Where $C_u$ is the call option value corresponding to the value of the underlying asset after 1 move up ($S_u$); and $C_d$ is the call option value corresponding to the value of the underlying asset after 1 move up ($S_d$). The option value at $t = 0$ can be obtained in the same way from the two option values of the previous time step $t = 1$. Now that the option value $C$ is known,
the homeowner can apply the decision rules of Exhibit 6. Payoffs between €0 and €300 were assumed to be amounts that would leave the investor in doubt as to whether to wait a bit longer or exercise immediately. This assumption is the authors’ subjective idea about the decision rules. These should always be agreed upon by those deciding on the investment.

The investment payoff (Equation 8) follows from the call option value $C$ at $t = 0$, the exercise price $I$, the subsidy, and the current value of the boiler system $S$:

$$ S - I - C + \text{subsidy} = \varepsilon2,833 - \varepsilon2,485 - \varepsilon549 $$
$$ + \varepsilon600 = \varepsilon399 \quad (8) $$

The calculated investment payoff is €399. According to the investment decision rules, the call option is “deep in the money.” It pays to exercise the option immediately. In this medium growth scenario, it can be concluded that for the homeowner the option value he holds for postponing the investment is reasonably compensated by the subsidy amount. In the following section, the effect of different assumptions about the estimated inputs on the option value and the decision to invest in the solar hot water system are studied with sensitivity analysis. The binomial model shows that for the inputs of Exhibit 3, the subsidy is a reasonably sized carrot that should financially convince homeowners to invest.

**Sensitivity Analysis: Strategy Space**

The estimated inputs in this model are to some extent subjective. The assumptions and choices made to arrive at the estimates also reflect the subjective view of the person making them. The sensitivity analysis results are therefore displayed in a graphical form called a strategy or option space. Both Luehrman (1998) and Amram and Kulatilaka (1999) propose this sort of visualization to make intuitive decisions by management possible. This strategy allows the decision maker to see

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**Exhibit 6 | Investment Decision Rules**

<table>
<thead>
<tr>
<th>Investment Payoff</th>
<th>Option</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S - I - C + \text{subsidy} &lt; 0$</td>
<td>Out of the money</td>
<td>Wait</td>
</tr>
<tr>
<td>$0 \leq S - I - C + \text{subsidy} &lt; 300$</td>
<td>In the money</td>
<td>Maybe invest</td>
</tr>
<tr>
<td>$S - I - C + \text{subsidy} \geq 300$</td>
<td>Deep in the money</td>
<td>Invest</td>
</tr>
</tbody>
</table>

Note: The source is authors’ own.

$S = \varepsilon2833$ = The current NPV of the solar boiler system.

$I = \varepsilon2485$ = The exercise price of to acquire the solar boiler system.

$C = \varepsilon549$ = The value of the American call option on the solar boiler system.

Subsidy $= \varepsilon600$ = The subsidy amount offered to acquire the solar boiler system.
how different estimates and assumptions affect the option values. This should make the method suitable for designing stimulus measures for a green(er) built environment.

The discount rate was varied between 6.9% and 11.73%. The annual volatility was varied between 2% and 21% around its estimate of 12%. Exhibit 7 displays the option values for the range of discount rates and the variation of the volatility for this scenario. The call option value increases with increasing volatility and decreases with an increasing discount rate. The highest option value was found at the highest volatility of 21% and the lowest discount rate of 6.90%, while at the lowest volatility of 2% and the highest discount rate of 11.73% the call option value was zero. The option value of €549 obtained in Exhibit 5 was found for a discount rate of 7.32%. In Exhibit 7, this lies between the discount rates of 6.90% and 7.44% for the mean volatility of 12%. The value of €549 fits nicely between the option values of €494 and €687. Once the call option value is known, the investment payoff can be calculated (Equation 8).

According to the sensitivity analysis, an investment payoff with subsidy for the medium growth scenario (Exhibit 8) is highest for low volatility and low discount
rates. The highest payoffs occur in the lower left corner. A volatility of 5% and a discount rate of 7.44% give a payoff of €457.

The results of Exhibit 9 can now be translated to an option or strategy space by applying the decision rules in Exhibit 6. The strategy space in Exhibit 9 shows that when the payoff is negative, the option is “out of the money,” the homeowner should wait until, for instance, energy prices go up or higher subsidies or better technology appear.

A payoff between €0 and €300 for an investment is worth considering, as the option is now “in the money.” When the payoff is over €300, the option is considered to be “deep in the money” and should be exercised. If the decision makers agree on the decision rules, they can now see in the strategy space (Exhibit 9) whether their different views on volatility and discount rate still lead to the same decision.

When it is assumed that the mean values for all estimates are the most likely, then the payoff (Equation 8) for this medium growth scenario (6.6%) is such that the option is in the money or deep in the money for the majority of combinations. Based on Exhibit 9, the subsidized investment in a solar boiler is financially justified when the embedded real option is included in the valuation. The effect of the embedded real option is not clear at this point. In Exhibit 10, the strategy space for the same valuation without the embedded option but with classical DCF analysis is shown.

Both DCF and ROV agree that for higher discount rates, the investment has a negative payoff and should not be undertaken. For higher discount rates, the homeowner should wait until the investment becomes more viable. However, the strategy space in Exhibit 10 shows that when valued with DCF analysis, the homeowner can invest in more cases than when valued with the embedded option. The investment in a solar hot water system would sooner be financially justified. The value of waiting was not captured by the DCF method. Based on the ROV results, the subsidy will likely have less effect than estimated by the DCF method. The latter will likely overstate the effect of the subsidy.
Survey Results: Homeowners’ Perceived Uncertainty

The binomial tree modeled the option value embedded in the investment in a solar hot water system based on market priced risk. The questionnaire amongst Dutch homeowners was aimed at establishing whether homeowners who are postponing investment do so because of a perceived option value based on market priced risk or for other reasons, which are also known as sources of private risk. Although the model indicates that the Dutch government subsidy program for solar hot water systems makes financial sense based on market priced risk, it is not very popular. Two years after the start of the program, only half of the funds have been applied for, whereas a different fund for photovoltaic cells was depleted within days. This may indicate that the private risks play an important role in the investment decision, as will be confirmed by the following survey results.

The total number of completed responses from homeowners was 100. The response rate was 30%. For the 95% confidence interval, the sampling error was 10%. The sample size was large enough to state that the responses were good estimates of the answers that the population would give.

At the onset of this questionnaire, the author expected that energy price uncertainty would be the main cause for homeowners to postpone investment. However, Exhibit 11 shows that amongst the motives homeowners had for postponing investment in a more energy-efficient home, the market priced risk was not the most important. They gave two main reasons for waiting to invest: (1) “I am waiting for technology to improve” and (2) “I expect to move within the next five years.” Overall, 38% of respondents preferred to wait until energy-saving technology improves. Homeowners apparently find technology development an important uncertainty; 27% of respondents believed they will move within the next five years and are therefore afraid they will not recuperate the entire investment before moving. This question was posed under the assumption that some or all of the cost of the system is sunk and cannot be recovered in the sale of the home.

As can be seen in Exhibit 11, only 11% of the respondents agreed that energy prices are an important uncertainty. The survey by Intomart Gfk (2009) showed
that 10% of the respondents thought of rising energy prices when considering whether to invest in energy conservation measures and confirms the result of the present questionnaire. Energy prices may no longer be of serious concern to most of the public. Their drop in the wake of the current world-wide recession may have turned attention away from the energy price rises earlier in 2008. Advances in technology that may lead to a higher payoff, however, are clearly on the mind of homeowners contemplating investment in the energy efficiency of their home.

**Do the ROV and Survey Data Support Each Other?**

The ROV showed that under moderate estimates of the inputs into the model (Exhibit 3), the subsidized investment in the solar hot water systems was justified when the real option value was taken into account. The subsidy appears to compensate for the option value the homeowner has to give up for the investment. This conclusion is based on the market priced risk that was used in the binomial model. The survey results show that for homeowners the most important uncertainties that tend to make them wait are sources of private risk, as the market priced risk was not seen as the main source of uncertainty. The option value may be much higher when the private risks are incorporated into the model. This would explain to some extent the relative unpopularity of the current Dutch government.
subsidy program for solar hot water systems. So to establish an effective subsidy, the effects of these private risks should be evaluated.

**Conclusion**

This study has made a first empirical attempt to link an established real option value and the consumers' perception of uncertainty in investments in real estate. The study followed two lines of research. The first was to model the American call option on a solar hot water system with the binomial model of Cox, Ross, and Rubinstein (1979). The second line was to find out with a survey which uncertainties make homeowners postpone their investment.

The idea behind the methodology choices was to make the results transparent and suitable for intuitive interpretation. This was mainly inspired by Amram and Kulatilaka (1999) and Copeland and Tufano (2004). The binomial lattice is similar to a decision tree. The step from this well-known decision tool to the binomial tree is small, making it easy to understand. The tree was built with algebraic equations and could be added to existing DCF spreadsheets. It was shown that the classical DCF approach can overstate the effect of a subsidy. Including the real option value gives a more realistic idea of the effects a subsidy will have. The study effectively showed that ROV does take the value of waiting into account, where DCF does not. The present application of the binomial model has demonstrated its user friendliness and transparency. Strategy spaces have proven to provide an excellent visual presentation of the sensitivity analysis results and make intuitive decisions possible. The combination of chosen methods proved efficient, transparent, and accessible for practitioners.

The survey results showed that homeowners did not see the market risk of the energy price as the most important source of uncertainty. This was also confirmed by the results of the recent survey by Intomart Gfk (2009). In fact, homeowners found sources of private risk such as the uncertainty about technological development and the chance that they will move homes before recuperating their investment of more importance. These private risks and perhaps others that the survey did not cover should be included in the model to be able to say whether the subsidized investment in solar hot water systems makes financial sense to homeowners. Including them may cause volatility to rise considerably, which will lead to higher option values. This would explain to some extent the lack of popularity of the current Dutch government subsidy program.

The results show that real option valuation is indeed a powerful tool to value investment under uncertainty and to design policy interventions. The use of a binomial model and strategy spaces combined with surveys appears suitable for practitioners that design or evaluate incentive policies. This new method for designing a carrot or stimulus measure with help of real option valuation should be further explored. It follows these steps:

1. Establish the type of real option the investment opportunity holds.
2. Determine the exercise price, the time to maturity, and the risk-free rate.
3. Establish the current value of the underlying asset. That is the value of the investment in, for example, a solar panel when it is made today.
4. Assess with a survey which uncertainties potential investors worry about.
5. Determine an appropriate volatility, preferably with market priced proxies.
6. Build and run a binomial model and display the results in a strategy space.
7. Decide on an appropriate stimulus.
8. Verify with a second survey whether the stimulus is likely to have the desired effect.

The current fiscal deficits of governments around the world, as well as the need and desire for a greener built environment make it important that stimulus money is allocated as optimal as possible. Testing the stimulus viability with the method described in this paper could lead to better and more effective stimulus design and ultimately perhaps to a greener built environment.

Endnotes

1 Dutch households are not exposed to the market volatility of natural gas but face biannual price adjustments by the energy providers. The annual volatility experienced by Dutch households is therefore much lower than the volatilities at the Henry Hub in the United States.

2 A solar hot water system is an installation that consists of a solar collector with tubing connecting it to a heat exchanger in a boiler barrel. The collector is located outside on the rooftop or in the yard where it has maximum exposure to the sun. The boiler can be attached to the collector or located inside the building. The solar heat is transferred from the collector through the heat exchanger to the boiler barrel. The reservoir of hot water is attached to the tap water system of the building.

3 The Black-Scholes formula is a partial differential equation that provides an analytical solution to European options. This type of option can only be exercised on the expiry date, contrary to the so-called American option. An American call option can be exercised at any time until it expires, contrary to a European call option, which can only be exercised on the expiration date.

4 Per household the ownership of the home may be shared, therefore the actual number of homeowners is likely to be larger, but this was not taken into account in this study.

5 Little information was found about the actual working life of the system but estimates range between 20 and 30 years. Deege, Warmerdam, and Zegers (2006) found that the capacity of solar boiler systems hardly declines after 10 years of service. Their data were based on actual field measurements of working systems and indicate that economic working lives of 30 years are quite realistic. For the present study, it was therefore assumed that the 175 m$^3$ will remain constant throughout 30 years of working life.

6 The option values displayed in Exhibit 5 are values for a binomial tree with only two time steps. The tree can also be expanded to many more time steps. The more time steps, the higher the accuracy of the call option value at $t = 0$ becomes. In this sensitivity analysis, a binomial lattice with 32 time steps was used (Van der Maaten, 2009).

References


The author expresses gratitude to Maurice J. Beard of the College of Estate Management at the University of Reading, United Kingdom, for the discussions we had that gave shape and direction to this research.

Emiel van der Maaten, In de Stad, Rotterdam, The Netherlands or evdmaaten@yahoo.co.uk.
Owner-Tenant Engagement in Sustainable Property Investing

Author: Gary Pivo

Abstract: When it comes to sustainability, improving existing buildings is arguably more important than developing better new facilities. But that can be more difficult because it requires cooperation between owners and tenants. Fortunately, owners are finding ways to cooperate through green leasing, incentives, and educational programs. This paper presents eight examples from the United States, Europe, and Australia. They demonstrate that property firms can work with new and existing tenants toward greater cooperation around sustainable real estate concerns. Transformation to sustainable property investing will be a “sociotechnical” process. It will require technical skill to improve eco-efficiency, but also new social capabilities that facilitate cooperation among owners and their tenants. Fortunately, the cases presented illustrate ways this can be done.

This article presents leading examples of property owner-tenant engagement activities aimed at furthering Responsible Property Investing (RPI). RPI includes property investment, development, and management strategies that go beyond compliance with minimum legal requirements in order to address environmental, social, and governance issues in the course of profitable investing. This article supplements other material already published by the United Nations Environment Program Finance Initiative (UNEP FI) Property Working Group (PWG) on what leaders are doing in energy conservation, green building, fair labor practices, and many other aspects of RPI. It also supplements prior efforts to document what signatories to the Principles for Responsible Investment are doing to apply those principles to property assets.

Making improvements to existing building performance is arguably more important than efforts to acquire or develop new high performance or certified green properties. That is because existing buildings comprise the bulk of the market. “Unfortunately, retrofitting existing buildings is significantly more difficult than creating a new green building from scratch. For example, in existing multi-tenant commercial buildings, any sustainability retrofit or technology upgrades require the cooperation and participation of a wide range of stakeholders (i.e., owners, managers, occupants and contractors).” (Miller and Buys, 2008).

One reason investors must cooperate with tenants is that they do not fully control the properties they own. They share control with the tenants. In direct property investments, when owners do not occupy the property, they “sell the right” to
occupancy to a tenant through some type of leasing arrangement.\textsuperscript{3} Through the lease, owners give up most of the control during the lease period over how the property is used and managed.

Cooperation is also required because of what is variously known as the misplaced incentive, split-incentive, or principal-agent problem (International Energy Agency, 2007). This is where the economic benefits of energy conservation or other such conservation measures do not accrue to the person or organization trying to conserve. “For example, in an apartment building, where the tenant pays the utility bill, the landlord has little incentive to make energy conserving improvements; if the landlord pays the bill, the tenant has little incentive to be frugal in his use of energy,” (Blumstein, Krieg, Schipper, and York, 1980), or to make capital efficiency improvements that revert back to the landlord when they vacate the property. However, “if all parties are committed to improving the green credentials of the building, many of the problems around equipment upgrades and so on can be sorted out by negotiation. This is even true during the life of a lease; with consent the parties can always agree to depart from the strict wording of a lease,” (Hinnells et al., 2008).\textsuperscript{4}

Cooperation is important for other reasons as well. It may be required if physical improvements are to be made while a property is occupied. It may be important for gathering baseline information on carbon footprints, transit use or other performance indicators. And perhaps most importantly, success with sustainability strategies often depends on the behavior of those occupying a property. This is crucial because the choices made by people living, shopping or working in properties regarding the appliances they install, the resources they consume, and the way they use building technologies can do more to explain property performance than the design and engineering of the buildings themselves.

Thus, improving sustainability in existing stock vitally depends on owner-tenant collaboration. In other words, “an active partnership...must be forged, a shift in social relations from adversaries to partners (which recognizes) the mutual cultural and economic benefits of concern with the efficient use of resources in the built environment.” (Guy, 1998).

Fortunately, leading property investors from around the world are developing techniques for achieving better cooperation. The remainder of this paper describes the work being done by several of them, in hopes of illustrating the possibilities that others might wish to adapt to their own situation. The cases are primarily drawn from among the membership of the UNEP FI PWG, which works collaboratively to find innovative approaches to issues around finance and sustainability in the property sector.\textsuperscript{5} Each case is based on material submitted by the firms and edited by the author. As with all case studies, readers must decide whether the strategies and results could work in their firms and circumstances. Nevertheless, these cases do illustrate that it is possible to achieve a good deal of owner-tenant collaboration around corporate responsibility and sustainability issues in property investing and development.
Land Securities

Land Securities is a FTSE 100 company and the largest real estate investment trust in the United Kingdom with a commercial property portfolio worth just under US$16.4 billion. The company recently obtained voluntary agreement on a “Sustainable Leasing Memorandum of Understanding” from tenants in one of its office buildings and is in the process of adding other buildings as well. Future plans include rolling this approach out across the company’s entire managed London office portfolio of 40 locations. A similar approach is being taken in retail.

As an incentive for tenants to participate, Land Securities is offering free energy audits, training, awareness materials, and other services through its in-house environmental team. The key elements of the MOU are as follows:

1. The Parties agree to work together collaboratively to improve the environmental performance of the Building and the Premises.
2. The Parties agree to share with each other all data and relevant information they have in relation to the Building and the Premises concerning electricity consumption, gas consumption, other fuel consumption, water consumption, waste generation, management and recycling, and maintenance of plant and equipment used in connection with these resources.
3. The Parties will set up a Building Management Committee which will meet regularly, comprised of representatives of the Landlord, the Tenant, any managing agents, and other persons involved from time to time in the operation or management of the Building and the Premises. The Committee will review the environmental performance of the Building, agree to an environmental management plan for the Building and annual targets for reduction of energy, water, carbon and waste increase use of renewables and recyclables, and produce an annual statement on progress toward targets.
4. The Tenant will share information with the Landlord on hours of occupancy and lighting, heating, and cooling needs. The Landlord will share information with the Tenant on the building environmental management system and minimize the unnecessary provision of lighting, heating, and cooling.
5. The Landlord will not require reinstatement of alterations made by the Tenant that improve environmental performance of the building.
6. The Parties will work together to implement other specifically listed measures pertaining to waste, water, energy, auditing, alterations, cleaning, transportation, and educational programs.
7. The Parties will have their managing agents implement this agreement.
8. The Parties will encourage new owners or sublet tenants to implement this agreement.
The charge from the CEO that drives this work is simple, “to be universally acknowledged as sector-leader in terms of sustainability.” So, quite simply, the firm is seeking to accomplish sustainability measures that are most important and/or cost-effective.

In one sense the MOU program has no cost, as it does not use consultants and the team to achieve it is already in place. However, Land Securities does not have internal processes for cross-charging the costs of the time of the environment team, or the energy team or the estates managers who liaise with tenants to get the MOUs signed and implemented.

The wider justification is that as landlords/property managers, Land Securities understands that it cannot make significant reductions in building energy consumption, or reduce waste or improve recycling, without a high level of cooperation from the tenants. Its own case studies show that on its own, Land Securities can reduce energy usage in a building by maybe up to 10% over three years through improved management. But with tenant buy-in, they can achieve 15%–20% reductions in one year.

Of course, in the U.K. owners and tenants face the Carbon Reduction Commitment (CRC) beginning in 2010 (mandatory emissions trading) and this will affect larger property companies like Land Securities. They need to be able to reduce energy/carbon in order to meet targets in the CRC and avoid large costs for the carbon allowances. This is further justification for the MOU work, which is expected to help with the CRC obligations.

So far the MOUs have been voluntary and focused on existing tenants. The question of whether new tenants will actually agree to similar clauses in new leases, making them legally binding on both parties, is so far unanswered.
**Online Feedback:** GPT’s open invitation to all stakeholders to submit views or concerns. GPT has a practice of responding within 10 days.

Tenants are engaged in sustainability across the office, retail, and industrial/business park portfolios. Engagement methods vary; however, the objectives remain the same, namely, to support tenants with similar corporate sustainability goals to achieve their objectives and to increase awareness of other tenants.

Since 2004, GPT has been investing in the development of property-specific “ecological footprint calculators” with the Environmental Protection Authority of Victoria and the Global Footprint Network (GFN). These calculators are given to tenants and have been a key component of the GPT engagement program. All new and renewing retail tenants are required to sign a green lease, requiring them to go through the footprint assessment and to meet certain minimum eco-efficiency measures. Since adopting this policy in 2007, a total of 625 such leases have been entered into, which represents 16% of all retail leases in GPT owned and managed retail assets. GPT has a target to see this increase to 27% by the end of 2010.

Use of the ecological footprint calculators has resulted in an average energy reduction of 29% for eco-certified tenancies, according to GPT. In requiring tenants to engage in calculating the ecological footprint of their stores and achieving a variety of minimum water and energy efficiency standards, GPT hopes it will support the transformation of the retail sector to a more sustainable level. GPT, in partnership with EPA Victoria and the Global Footprint Network, has committed to expanding footprint calculators to cover all assets classes and aspires to achieve the same level of engagement in the Office and Industrial portfolios by 2012.

GPT has seen its investment in the development of footprint calculators translated to economic outcomes and benefits for all stakeholders through reduced tenant occupancy costs. To date, national retail chains, including Woolworths (supermarkets), Westpac Bank Corporation, and Telstra Corporation have used this approach to adopt new “national fitout” standards informed by the eco-efficiency design reviews sponsored by the GPT group.

**Hermes Real Estate**

Hermes Real Estate offers property investment through segregated and pooled vehicles. It is one of the largest real estate managers in the U.K. As a first step toward greater cooperation, Hermes has amended its standard form lease, adding green clauses that reflect obligations on both parties to cooperate and ensure the property is managed in the most efficient and sustainable manner possible. The green lease clauses are intended to encourage closer engagement between owner and occupier rather than being overly prescriptive or target based. The new standard form green lease came into effect in April 2008. To date more than 50 tenants have agreed to the new clauses, many embracing the initiative very positively. There has been significant resistance from some tenants, however, resulting in extensive dialogue and negotiation to find an acceptable, positive way forward.
In order to fully understand its tenants’ needs and ambitions, Hermes commissioned a comprehensive occupier survey. The survey covered a sample of offices, business parks, industrial assets, and shopping centers. The results are being used to review and set clear objectives to govern their Occupier Engagement Program. Office tenants requested prioritization of recycling, promotion of green fuels and energy efficiency, and more communication on sustainability issues. Industrial tenants were particularly concerned with rising energy costs and want more owner engagement to prioritize recycling. Over 70% of shopping center interviewees said that sustainability is either “important” or “very important” to their organization and 50% were “very interested” in talking to Hermes about energy saving and carbon reduction initiatives.

Through its active participation in initiatives such as the London Better Buildings Partnership and Green500, Hermes is engaging with key tenants, both at the board level and at individual properties, which it believes will ensure a consistent approach to sustainable building performance. These partnerships provide a forum to meet with like-minded tenants and discuss opportunities that will be of mutual benefit.

Hermes has a significant amount of environmental and community data and information relating to its portfolio, some of which relates directly to occupied space. It offers to share this information with its tenants, which could help them address their corporate sustainability objectives. In return, Hermes is looking to its tenants to share data and information they may have relating to its assets, so it can accurately measure and monitor the environmental impact of its buildings. With new government regulation, such as the U.K. Carbon Reduction Commitment (CRC), it will be necessary for tenants to have far more detailed knowledge relating to their occupied space. As an example, those tenants who qualify for inclusion in the CRC will need to declare their energy consumption on an annual basis. Hermes currently holds this information for many of its tenants and is working to comprehensively record all metering and billing arrangements across its portfolio, so that when its tenants request this information, Hermes will be able to provide them with the necessary data.

Many of Hermes’ tenants want to reduce the environmental impact of their operations. The challenge is how to do it. Across its London office portfolio, with the support of their property manager, Jones Lang LaSalle, Hermes is working to develop joint carbon programs with a number of tenants. These programs establish joint action plans to deliver respective sustainability targets and objectives. One example of this is the program adopted for Prospect House, a London office property. Working in partnership with tenant NBC Universal, in 2008 Hermes reduced carbon emissions by almost 15%, water use by 18%, and ensured that nothing is sent directly to a landfill. This has saved over US$80,000 in energy costs and over US$3,000 in direct landfill tax costs. Another case involved the Freeport Braintree Outlet Shopping Village, an 80-store shopping center in Braintree, Essex. In this case, the introduction by manager REALM of a tenants’ energy league table, showing the performance of each shop against the center’s energy targets, helped deliver a yearly decrease in landlord energy usage of 13%.
British Columbia Investment Management Corporation

British Columbia Investment Management Corporation (bcIMC) provides funds management services for Canadian public bodies and publicly administered trusts. bcIMC’s real estate investment program has incorporated corporate responsibility guidelines within its real estate investment policies, including, for example, policies on accessible real estate and consideration of community interests.

In 2005, bcIMC formalized the underlying philosophy, which helped to integrate responsibility into its operational framework. This included expanding into sustainable building design and retrofitting projects. bcIMC assesses sustainability concerns prior to the purchase or development of new properties. Once within the portfolio, bcIMC ensures that individual property business plans consider corporate responsibility initiatives for implementation. In addition, analysis is conducted on the sustainability aspects of all major capital budgets.

One development project bcIMC has been strategically working on is Westmount Corporate Campus, located in Calgary, Alberta. Together with bcIMC’s external manager, Great West Life Realty Advisors (GWLRA), a sustainable business park development strategy was designed and implemented. In 2007, bcIMC and GWLRA entered into discussions with Carma Developers, a potential tenant, about the idea of developing a new head office in Calgary, Alberta. It was seeking a new office location and was interested in the Westmount Corporate Campus setting. In conjunction with Carma, bcIMC focused on incorporating several environmentally sustainable elements into the building during its design and development process. The result of Carma and bcIMC joining together was an unusual partnership between landlord and tenant, where each contributed equally to an extra menu of sustainable building elements. Examples of the elements include:

- **Waste Management Plan:** The project will divert materials from the landfill and recycle as much construction material as possible. To date, approximately one-third of the materials that would usually be sent to the landfill have been diverted and recycled.

- **Alternative Transportation:** In an effort to promote alternative modes of transportation, additional bicycle racks and storage facilities were incorporated into the building design.

- **Efficient Lighting:** More efficient outdoor lighting fixtures were installed to contain the spread of light rays. These more efficient lights also help to reduce the amount of heat generated from lighting and as such, lessen the ‘heat island effect.’

- **Water Reduction:** All toilets within the building are either low flow or dual flush, which reduces the amount of waste water consumed. In addition, all urinals are waterless, which completely eliminates water consumption.
- **Recycling Facilities**: A conveniently located recycling facility encourages employees to divert waste from the landfill and increase recycling efforts.

- **Indoor Air Quality**: Better quality indoor air can create a healthier work environment and improve employee productivity and performance. To that end, monitoring devices have been installed to accurately assess indoor air quality performance and provide accurate baseline level data, which will be continuously assessed.

In addition to Carma being engaged throughout the development period, all other providers to the project were integrated into the design process. For example, Carma’s design firm worked closely with both the landlord and tenant to ensure the most sustainable features and initiatives were incorporated into the project. This integrated design concept also flowed down to the individual employees at Carma. Most recently, Carma’s corporate head office at Westmount Corporate Campus was selected as one of *Avenue Magazine’s* 2009 Best Places to Work. In planning its new Calgary headquarters, employees were invited to contribute design ideas and were able to select from a list of design options and materials for their own workspaces.

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**Investa**

Investa Property Group is a fully integrated real estate company and one of the largest, unlisted owners of commercial real estate in Australia. Investa has developed a number of innovative environmental initiatives to facilitate owner-tenant cooperation. For example, Investa’s standard EcoSpace offering for newly refurbished office space includes a number of sustainability options, which aim to create a healthier workplace, smarter business, and a better environment. The EcoSpace offering is designed to help tenants:

- Reduce their energy bills. For example, improving a tenant’s NABERS Energy rating (Australia’s energy rating system) from 0 to 5 stars could reduce energy bills from over AU$30/square meter (approx. US$20.0/square meter) to around AU$12/square meter (approx. US$11.2/square meter) per annum.
- Improve employee health and well-being and therefore productivity.
- Enhance their brand and company reputation with staff and clients.

All Investa EcoSpace tenancies include energy-efficient lighting and controls, low emission paints, low emission carpet tiles, waterless urinals, and other environmental commitments agreed to in the leasing process.

Their [*Green Lease Guide*](#) accompanies the Investa precedent lease. It provides an opportunity to identify, discuss, and commit to objectives that will save tenants money over time, provide an excellent working environment for employees, and enhance tenant organizations’ reputations. The *Guide* provides tenants with a useful framework to design an environmentally-friendly and energy-efficient tenancy.
Investa also recognizes that many of its existing office tenants want to minimize their greenhouse emissions through better energy management. The Investa Greenhouse Guarantee helps make the transition to energy-efficient offices as painless, cost-effective, and risk-free for tenants as possible. By introducing the latest energy-saving technologies and challenging management practices, the Guarantee provides strong rates of return on investment, reduces energy costs, and helps demonstrate corporate social responsibility—all within a risk-free framework. Tenants can enter into the Guarantee at any point during their tenancy. For new tenants, the Guarantee is introduced as an integral part of design and fitout.

To implement this program, Investa has teamed up with Energy Conservation Systems (ECS), one of Australia’s energy solutions companies and a specialist in office lighting systems, to provide tenants access to products and expertise at competitive rates. After conducting a review of an interested tenancy (either at design, or in operation), ECS provides a firm quote with a guaranteed cap on office energy bills and greenhouse gas emissions. Once the upgrade work is done, if energy consumption exceeds the guaranteed cap, the cost of any excess energy consumed is refunded and green power credits are purchased from a green power provider to deliver the reduction in greenhouse emissions. If a tenancy performs better than the Guarantee, the tenant keeps the savings. The energy-saving technologies delivered as part of the Guarantee can be financed in a number of ways. For example, in Melbourne tenants can access funding from the City of Melbourne’s Sustainable Melbourne Fund and use savings to progressively acquire the equipment, and in NSW the state government has made a grant available to subsidize projects delivered under the Guarantee. In many instances tenants elect to self-fund due to the appealing returns on investment.

Tenants representing more than 50,000 square meters of office space have taken up the Guarantee service since it was launched in late 2004. One of them was Investa’s new 2,880 square meter head office at Deutsche Bank Place in Sydney. The new office incorporates highly efficient light fittings and the latest lighting control technology, which all together cost an additional AU$60,000 (approx. US$56,000) up-front but was guaranteed to deliver a AU$24,000 (approx. US$22,500) per annum saving in energy bills compared to the initial design. After two years of operation, the tenancy is performing more efficiently than projected and is saving in excess of AU$30,000 (approx. US$28,000) per annum. According to the New South Wales Department of Environment and Climate Change, in 2007/08 it was the most efficient NABERS Energy rated tenancy in NSW.

Any existing or prospective tenant in an Investa building that accepts the Investa Greenhouse Guarantee can expect to receive:

- A NABERS Energy Commitment Rating certificate.
- A guaranteed cap on energy bills.
- A guaranteed cap on greenhouse emissions.
- Guaranteed NABERS Energy Performance Ratings.
- The highest quality energy-saving systems and equipment.
Regular performance reports to assist in marketing to staff, clients and other key stakeholders.

Lower operating costs post guarantee.

Every lease entered into by Investa could be described as a green lease because they all include a schedule of environmental objectives and clauses that require collaboration. One recent advance is the inclusion of clauses that overcome the split incentives problem in net leases by allowing the landlord to recoup capital investment in buildings from tenants where the tenant is the financial beneficiary, so long as the cost does not exceed the benefit. Investa does not require tenants to adopt green measures and does not discriminate between tenants on the basis of their sustainability commitment, or line of business. Rather their focus is on education. They rely on enlightened self-interest to motivate their staff and tenants.

Tenant request data analyzed recently through the Investa Sustainability Institute supports this proposition. It appears that in some buildings the root cause of almost 50% of complaints recorded via Investa’s independently operated tenant “helpdesk” can be traced to factors outside the landlord’s (i.e., Investa’s) direct control, in particular, tenant fitout, tenant supplementary air-conditioning, and tenant equipment.

Investa meets with every tenant in every building every month. During these meetings Investa representatives discuss the performance of the building (and provide statistics), inform the tenants about new initiatives, and get their feedback. There is also an Investa-employed property supervisor on site at all of its buildings full-time. Investa does not think the value of having a direct relationship with tenants at multiple levels can be overstated.

PRUPIM

PRUPIM is a top 20 global real estate investment manager. It forms part of the M&G Group of Companies, which is the asset management arm of Prudential plc in the U.K. and Europe. Through its membership of the Better Building Partnership, PRUPIM worked with the Office of Government Commerce (OGC), a major occupier in the U.K., to agree on a standard memorandum of understanding useful for guiding owner/occupier relations in reducing carbon emissions through better management of resources. PRUPIM is now engaged in encouraging other tenants in the buildings occupied by OGC to sign up to the MoU, extending use of the MoU to other, major managed office buildings in PRUPIM’s management, and investigating whether the MoU can be extended into a Green Lease.

According to PRUPIM the major benefits of collaboration include:

- Better owner and occupier relations.
- More efficient management of resources (e.g., energy, water, and recycling).
Efficiencies that could potentially lead to lower service charges for tenants.
- Improved building ratings (e.g., energy ratings and environmental certification).
- Strengthening PRUPIM’s credentials as “Landlord of Choice.”
- Maintaining and improving investment returns.

The potential benefits of owner/tenant collaboration have been demonstrated in four specific buildings:

An Environmental Performance Review was conducted for an occupier of Minster Court, a London office property. A carbon footprint was identified from an analysis of building operations (including electricity, gas, and water consumption), waste disposal covering various waste streams (and identification of recycling percentages), business travel, use of couriers, and materials use (covering office consumables such as paper). Opportunities were identified for improvement to reduce environmental impacts in each of these areas. The analysis also enabled the occupier to establish a baseline of current performance and the capacity to measure improvements over time.

Work to raise tenant awareness and increase recycling rates across the PRUPIM portfolio has resulted in a notable success story at Atlantic Quay, a mixed-use complex offering over 28,000 square meters of high class office accommodation. The Facilities Management (FM) team, the cleaning contractors, and the tenants all agreed to adopt a single central recycling facility in favor of individual contracts previously held by tenants. The FM team coordinated the installation of facilities and maintained communication with tenants throughout the transition and beyond. The result of this collaborative approach saw recycling rates increase from an impressive 40% to an outstanding 70% in one year and reduced costs for all those involved.

Another project is the Ultra Challenge at Green Park, a major business park on the outskirts of Reading. The FM team requested tenants to switch off all non-essential equipment over the weekend, such as screens, printers, and photocopiers. Electricity consumption was measured over a “control” weekend and the initiative weekend. In the initiative weekend, one-third of tenants inspected switched-off all equipment, one-third switched off the majority of their equipment, and one-third did nothing. Using meter readings, the initiative successfully reduced electricity of 39% compared to the control weekend.

Finally, with three lease renewals approaching at Hollywood House, Woking, PRUPIM took a different approach to the usual financial incentives to induce the tenants to renew. In this instance they agreed with two of the tenants to replace the obsolete building air conditioning system with a modern, more efficient alternative. This would potentially cut the tenant’s energy costs by a quarter. On the basis that longer income streams were thus secured, the landlord saw a yield improvement by 0.5% (after costs deducted).
CB Richard Ellis is the world’s largest commercial real estate services firm (in terms of 2008 revenue). In 2007, it announced a commitment to achieve carbon neutrality by 2010 in its own business activities. Perhaps the most significant aspect of their commitment is in helping their clients achieve a greater degree of environmental sustainability. Given their size, their ability to introduce, implement, and promote building management practices that have lasting environmental benefits is quite substantial. Perhaps even more far reaching could be their ability to affect occupant behavior beyond the work environment. Based on the idea that people who behave differently in one place will carry that behavior into other areas of their lives, CBRE has realized it has an opportunity to influence the broader communities that their tenants inhabit. From this idea, Planet Building—a concept that demonstrates the interconnectedness of home and work environments—was born.

Planet Building provides the vision and framework that guides CBRE in implementing greener building management practices and policies. Concepts were first introduced through 101 Tips Toward a Greener Tomorrow, a comprehensive guide designed to assist managers and engineers in establishing sustainable practices and policies in their office buildings. Subsequently, 101 Tips for the Office, an occupant version directed at their tenant population, was created and made available to every tenant in each building they manage. They then developed the next in the series, 101 Tips for the Home, as part of their participation in the World Wildlife Fund’s (WWF) Earth Hour campaign in March of 2009. 101 Tips for the Home was made available on both CBRE’s and WWF’s websites for public download. The popularity of these guides prompted the latest version, 101 Tips for Travel, which was distributed during the summer of 2009.

CBRE also believes that specific campaigns are also critical to engaging the building population because they allow managers to keep the conversation fresh and relevant while reinforcing desired outcomes. Both Earth Day and the U.S. Environmental Protection Agency’s “Change the World, Start with ENERGY STAR” program provide these kinds of opportunities. The Change the World Campaign offered the opportunity for occupants to measure their impact. Through the generosity of CBRE clients, each occupant was given one compact fluorescent light (CFL) to replace at home. Over the past 18 months, CBRE has distributed nearly 30,000 CFLs to tenants and has garnered over 200,000 pledges to replace additional bulbs.

Effective communications are crucial in establishing and maintaining occupant engagement. CBRE has pursued various communication channels and approaches, including monthly building newsletters detailing the progress of sustainability programs and providing carbon reductions, kWh or water savings, and recycling statistics. Presenting the outcomes in a fashion that allows occupants to see and understand their personal contributions helps encourage continued participation. Targeted communication programs are also launched for each initiative of the building management team, ranging from reducing weekend building hours to
daylight janitorial to recycling or water conservation. All communications programs are thematic, unified, and aimed at familiarizing occupants with the program, helping them understand the concept and promoting individual participation. Every program, whether it appeals to the masses or takes a more sophisticated business approach, delivers the message in a manner aligned with intended outcomes.

CBRE is searching for new and innovative ways to take Planet Building outside the confines of the building structure. For the second year in a row, they partnered with a national landscaping company in 10 U.S. cities for Park(ing) Day, a global event that brings green spaces into the urban environment by transforming sections of street parking into public parks for the day. Originally initiated in San Francisco by REBAR, Park(ing) Day promotes the need for more parks and open spaces. They have also taken their messaging into a local school district in the form of sustainability “superhero” characters developed as part of their communications program. Working with at-risk middle school children, they created a contest to help them “Design the Next Superhero.”

Kennedy Associates

Kennedy Associates Real Estate Counsel LP (Kennedy) is an investment advisor for public, corporate, and Taft-Hartley (labor union) retirement systems. Across the Kennedy portfolio, Kennedy’s asset managers and third-party property management and leasing teams promote tenant engagement through continuous and active dialogue, ongoing lease negotiations, and communications for property operations, as well as through specific programs and initiatives aimed at increasing the sustainability of the Kennedy portfolio on behalf of its clients.

One successful example of active tenant outreach is the ongoing waste management program at Pacific Place in Seattle, Washington. Pacific Place is a five-story, 300,000 square meter upscale shopping center in Seattle’s central business district. The “Erasing Waste at Pacific Place” project has three components: shopper awareness, tenant employee training, and the installation of recycling containers. To make recycling easier for shoppers and tenants, recyclable material is collected in public areas and stores, and organic material is collected at restaurants and coffee service areas. The program has consistently diverted significant amounts of solid and food waste (almost 1,400 tons in 2008), while reducing the Pacific Place carbon footprint by an estimated 2,300 tons.

Since the start of 2009, Kennedy has been using a “green lease,” which promotes sustainable property operations, by providing specific landlord and tenant recommendations and requirements for Class A office space. The lease, used as the starting point for all office lease negotiations, incorporates guidelines intended to promote energy and water efficiency, environmental reporting and disclosure, sound indoor environmental quality, and waste management and recycling, while protecting the asset’s environmental rating if applicable. Kennedy has also created specific lease language for its industrial portfolio to assist with its energy
management activities and the acquisition of utility information from tenants with triple-net leases.

In concert with the use of its green lease, Kennedy has partnered with Better Bricks, the commercial initiative of the Northwest Energy Efficiency Alliance, to create a Sustainable Tenant Improvement Guide for Class A office space. The guide provides various audiences (including tenants) with the technical framework needed to build-out sustainable space in areas such as energy and water, while also creating an environment that meets current tenant demands related to air quality through the use of recycled and low-emitting materials, day-lighting, and occupant temperature controls among others. The Guide will assist the growing number of tenants interested in pursuing LEED Commercial Interior certification, and ensure the tenant’s occupancy supports the asset’s ongoing sustainable property operations.

In March 31 2009, Kennedy Associates was named ENERGY STAR Partner of the Year for its exemplary energy performance, monthly benchmarking, and portfolio-wide reductions in greenhouse gas emissions. One very important component of the Partner of the Year Award was the external promotion of ENERGY STAR energy management best practices and programs, such as the “Change a Light Campaign” to tenants, clients, and the general marketplace. Every year, Kennedy’s property teams use various outreach strategies, such as education materials, sustainable tenant events, and monthly outreach emails and newsletters to improve tenant energy conservation awareness. A concrete by-product of this outreach has been multiple landlord-tenant lighting retrofit projects resulting in substantial reductions in energy use and corresponding operating expenses.

As the first institutional investment advisor in the U.S. to achieve LEED Existing Building Operations & Maintenance (EB O&M) program volume pre-certification, Kennedy is utilizing its LEED EB O&M program to strengthen tenant engagement, which will assist them in achieving building certification for over 5.5 million square meters of office space. Through its LEED EB O&M program, Kennedy has standardized sustainable practices and implemented corresponding training and education that aid in tenant engagement, while reducing operating expenses and promoting a healthy indoor environment for building occupants.

Finally, Kennedy employs the ongoing use of a proprietary tenant survey to assess tenants’ satisfaction related to its RPI efforts and sustainable property operations. From the survey results, Kennedy is able to discern what areas tenants are most concerned about. Selected RPI highlights from the most recent tenant survey include:

- **54%** of multi-family tenants indicated their community’s “green” features were important factors influencing their housing selection.
- **87%** of office tenants and **75%** of industrial tenants indicated that implementing an indoor air quality program at their building was important to them.
- **85%** of office tenants and **67%** of industrial tenants stated that implementing a recycling program at their property was important.
84% of office tenants and 79% of industrial tenants responded it was important for their building to utilize energy efficiency practices.

Summary and Conclusion

This paper has highlighted eight examples of owner-tenant collaboration by some of the world’s leading property investors. All these firms are finding special ways to work with tenants to improve the sustainability of existing (and new) building stocks, as follows:

- **Land Securities** uses a Sustainable Leasing MoU with existing tenants. They offer free energy audits and other services to tenants willing to join the agreement, which provides for collaborative efforts to improve the environmental performance of the building and premises.

- **GPT** uses a variety of techniques to engage with its tenants. Most notably, it requires retail tenants to sign a “green lease” and use an “ecological footprint calculator,” which help them move toward reducing their environmental impacts.

- **Hermes** has also added green lease clauses to its standard lease, stating the obligations of both parties toward sustainability. It has conducted a comprehensive occupier survey, offered to share energy consumption and other data with tenants, and is working with several tenants on “joint carbon programs” to deliver carbon reduction targets.

- **bcIMC** worked directly with a tenant planning to occupy a new office project on ways to incorporate better environmental features into the building. The effort produced an agreement to contribute equally to a menu of sustainable building elements.

- **Investa** offers a number of innovative initiatives to promote owner-tenant cooperation including EcoSpace, a greener offering for newly refurbished office space, a Green Lease Guide that helps new tenants select green options for their tenancy, and the Greenhouse Guarantee that gives tenants a risk-free and cost-effective way to lower their energy consumption.

- **PRUPIM** also uses a MoU between itself and major tenants to guide carbon reduction efforts.

- **CB Richard Ellis**, through their Planet Building program, offers tips on sustainability practices that can be implemented by their tenants, free light bulbs, and special communications devices targeted to property occupants.

- **Kennedy Real Estate Council** reaches out to its shopping center tenants to promote recycling, uses green leases in its office and industrial portfolios, offers a sustainable tenant improvement guide, promotes energy conservation through outreach activities, involves tenants in achieving LEED certification for existing building operations and maintenance, and uses ongoing surveys to assess tenant satisfaction with its RPI programs and activities.
All of these examples demonstrate how real estate firms can work with both new and existing tenants to move toward greater cooperation in responsible property investing. Clearly, these efforts take considerable commitment and effort on both sides, but just as clearly, they can produce significant business and sustainability benefits, which make them worth pursuing. More fundamental, however, is that it seems impossible for a fully successful program of sustainable and responsible property investing to succeed without initiatives like these in owner-tenant cooperation.

It would appear from these cases that the “green lease” is becoming a key vehicle for facilitating the owner-tenant relationships around sustainability. Today green lease toolkits and model green leases are increasingly available. However, the MOU’s, service contracts, and educational programs reported here are also worthwhile devices that should not be overlooked and could be at least as effective. The time has come for researchers to begin quantifying and comparing the cost-effectiveness of these different approaches.

One green leasing provision that seems particularly promising was reported in the Investa case, where the landlord is allowed to recoup capital investment in buildings from tenants where the tenant is the financial beneficiary, so long as the cost does not exceed the benefit. This could go a long way toward overcoming the split incentive problem and it deserves further attention.

What all these programs often have in common, however, is their piecemeal nature. They are implemented one tenant at a time. While this is attractive for some reasons, it is also worth recognizing the potential for corporate-to-corporate cooperation at a higher level. Property companies that own many shopping centers, for example, could enter into strategic alliances with retail firms with many tenancies to promote fitout and operational programs that promote corporate social responsibility and sustainability. Such alliances could help both organizations achieve their social and environmental goals. They could also increase the attention paid to corporate real estate in corporate social responsibility and sustainability reporting, which unfortunately is often underplayed. The GPT case, where national retail chains have adopted “national fitout” standards informed by eco-efficiency design reviews sponsored by GPT, is suggestive of this approach. Indeed, without strategic direction from corporate leaders, it may be difficult for property-level managers to gain full cooperation from store managers. Thus, a programmatic green-leasing program agreed to between corporate owners and tenants for all of their common concerns may be an effective strategy for greatly increasing the level of owner-tenant cooperation in the future.

As Simon Guy has suggested, transformation toward sustainable real estate will be embedded in a “sociotechnical” process in which technical choices are shaped by social institutions and behaviors (Guy, 2006). Thus, to a considerable degree, progress on sustainability in real estate will depend upon transforming both our physical and our social capital stocks. The physical stocks must be redesigned and refurbished to improve their eco-efficiency, but that will require new social capacity to facilitate better cooperation between owners and their tenants. Fortunately, the cases presented here suggest that both capabilities are emerging.
Endnotes

1 The publications are available at http://www.unepfi.org/publications/property/index.html.
4 For an excellent review of green leasing, see Sayce, Smith, Sundberg and Cowling (2009).
5 More information about the group can be found at www.unepfi.org.

References


This paper was adapted from a recent report compiled by the author from contributions made by the companies and published by the UN Environment Programme Finance Initiative under the auspices of its Property Working Group. It contains both material written by the author and edited by him from documents submitted by the firms represented in the cases. The report, entitled Owner-Tenant Engagement in Responsible Property Investing is available at www.unepfi.org. The author is grateful to the companies for their contributions and to the leaders in the firms who have created and reported on these programs. As always, however, any failures in this paper remain solely his responsibility.

Gary Pivo, University of Arizona, Tucson, Arizona 85721 or gpivo@u.arizona.edu.
The Challenges of Identifying and Examining Links between Sustainability and Value: Evidence from Australia and New Zealand

Authors: Georgia Warren-Myers and Richard Reed

Abstract: A commonly-accepted observation by industry stakeholders is that the financial benefits of sustainable real estate investment are inherently difficult to quantify (RICS, 2009). The lack of transparent financial correlations between sustainability and economic return in real estate has created major issues for real estate appraisers and valuers seeking to accurately reflect the impact of sustainability. This paper argues the lack of transparency with financial drivers restricts substantial investment in sustainability because stakeholders have limited ability to measure the sustainability of the building or understand the impact on value.

Although advances in sustainable buildings has gained momentum in the design and construction disciplines, commensurate levels of development and investment in the same buildings by the private sector have remained limited for some time (Reed and Wilkinson, 2005). With sustainable buildings it is commonly accepted that there is limited availability of market information and an absence of transparent mechanisms that identify the financial viability for investment in sustainable commercial property. This is partly due to the relatively recent emergence of sustainable buildings into the mainstream property market. Unfortunately, the absence of a defined connection between sustainability and economic returns directly affects stakeholders who invest in the built environment—predominantly large financial, banking, and superannuation organizations who are the key drivers in the real estate market. Arguably this ongoing absence of reliable and accurate evidence for valuation and appraisal purposes is problematic in trying to identify whether there is any correlation between value and sustainability. Consequently, this leaves the investment industry uncertain about the financial benefits of sustainability (Madew, 2006) and the risks involved in sustainability investment (Warren-Myers, 2009). Therefore, if the progress and uptake of sustainable buildings is to develop further within the real estate market, it is essential that the links in the relationship between market value and sustainability are identified. In turn this will enable sustainable buildings to be promoted to the investment industry with a higher level of confidence about risk and return.

Increasingly stakeholders in the global real estate markets, where possible, seek to incorporate sustainability into commercial building stock through new
developments and upgrading existing buildings. This statement is directly applicable to markets in Australia and New Zealand. Although there is considerable advancement by investors to incorporate sustainability initiatives in their building portfolios, there remains uncertainty about the direct relationship with real estate market values. The type and level of sustainability initiatives being implemented are primarily focused on efficiencies and cost minimization, with a concentration on payback ability of the initiatives. However, the lack of clear financial drivers is preventing substantial investment in sustainability because stakeholders have a limited ability to measure the sustainability of the building or understand the relationship with value. This affects investors’ decisions due to a higher level of risk being associated with unknown information, particularly surrounding sustainability. Valuers and appraisers are challenged in finding enough detailed market evidence, sales data, and lease transactions relating to sustainable buildings, let alone examining the different sustainability parameters in the properties for the comprehensive comparison required for market value assessments. This is further compounded by uncertainty in the industry surrounding the accurate measurement of sustainability in reference to commercial real estate.

Valuers and appraisers often operate across global real estate markets and they need to be fluent with the increased diversity in rating tools (Reed, Bilos, Wilkinson, and Schulte, 2009a) and also be able to monitor changes in values in the real estate market (Lorenz et al., 2008). However, for valuers and appraisers to accurately reflect the real estate market, they must to be able to compare and analyze the market based on current, comparable, and reliable data. For example, in Australia the sustainability of a particular building is rated using different rating tools. In this scenario, new buildings and construction are commonly assessed through the ‘Green Star’ system, which has limited applicability to existing buildings or alternatively NABERS, which focuses on the measurable operational aspects of a building. The rating tools have encouraged the design and development of new buildings and also the measurement of existing buildings. However, differences between rating tools raises the question: How do appraisers assess the sustainability of a new or an existing building in relation to the surrounding building stock? If valuers and appraisers are experiencing difficulties in accurately reflecting the changing perception towards sustainability in the real estate market, therefore: If they cannot accurately assess the level of sustainability in a building, then how can they identify whether there is a difference in the value? This paper addresses these questions and examines previous research that identifies misconceptions between (a) stakeholders who drive the market (i.e., investors) and (b) valuers/appraisers, who analyze real estate data to accurately reflect the market and use this information to identify the market value of commercial real estate. Key findings are examined from previous studies undertaken in Australia and New Zealand into the relationship between sustainability and the market value of commercial real estate. However, during this process certain key barriers were identified that prevent the market, and more particularly the valuation profession, from quantifying the linkages between value and sustainability in commercial real estate. The findings discuss key issues in the real estate marketplace to be resolved and whether investment and development of sustainability in commercial real estate can be maintained and increased.
Sustainability and Rating Tools

For some time there has been considerable confusion over the definition of sustainability as more than 500 different definitions exist (Phillips, 2003). The concept and definition of sustainability over the past two decades has been and still is being constantly redefined (JLL, 2007). However, the majority of definitions have developed or evolved from earlier explanations, such as Brundtland (1987), Pearce, Markandya, and Barbier (1989), and WBCSD (2006), which are now widely accepted as a basis for definition.

An awareness of the need for sustainability has developed and changed in recent years due to the increasing global focus on the world’s finite resources, excessive carbon dioxide levels, and the threatening consequences of global warming and climate change. This has highlighted the urgent need for solutions. The common acceptance of climate change globally has been through major reports such as the Stern Review (2006) in the United Kingdom and the Garnaut Report (2008) in Australia. These reports concluded there is overwhelming scientific evidence climate change is occurring; as such it presents serious and seemingly unavoidable global risks. These documents, among others, suggest the cost of maintaining a ‘business-as-usual approach’ could result in severe impacts on society, the environment, and the economy, where these impacts are likely to escalate if greenhouse gas emissions are not reduced substantially. However, the worst-case scenario can possibly be avoided if strong global action is undertaken immediately (Stern et al., 2006). As a consequence, a global focus on reducing greenhouse gas emissions has developed a greater urgency than previously and governments are endeavoring to coordinate a reduction in emissions.

The contribution of the built environment to resource consumption, waste, and greenhouse gas emissions production is gradually gaining momentum (Brown, Dillard, and Marshall, 2006). As a result, specific taskforces have been developed to focus on sustainable development for the built environment, such as the RICS (2009), Department of Environment Transport and the Region (DETR, 1999, 2000), and Egan (2004). In addition, in Australia and New Zealand there have been other groups including government, non-profit organizations, and industry bodies; for example, the Department of Energy, Utilities and Sustainability (DEUS, NSW government), the New Zealand Ministry for Environment, and the World and National Green Building Councils. These groups have aimed to develop policy and legislation, create assessment tools, and educate and promote the implementation of sustainability in the property industry. There has been considerable research into the importance of sustainability in the built environment and the triple bottom line model and its relationship with the built environment (e.g., Pivo and McNamara, 2005; WWF and Insight, 2005; Eurosif, 2006, 2007; and Strong and Hemphill, 2006).

Classifying sustainability has been attempted by various researchers, industry and non-profit groups, organizations, and government (e.g., Hemphill, McGreal, and Berry, 2002; Boyd, 2006; Ellison and Sayce, 2006; Green Building Council of Australia, 2007; Lutzkendorf and Lorenz, 2005; New Zealand Green Building...
An earlier study concluded that more than 600 tools were available to measure or evaluate the environmental, social, and economic dimensions of sustainability in the built environment (Building Research Establishment, 2004). The vital role of Green Building Councils have played in promoting sustainability in the built environment has been driven primarily by the development of rating tools to provide benchmarks, objectives, and rewarding of best practice (Todd, Crawley, Geissler, and Lindsey, 2001). Rating tools (Exhibit 2) that have gained considerable traction in the commercial property industry, which have often been developed in specific national contexts, are Leadership in Energy and Environment Design (LEED) (United States and Canada), ENERGY STAR (United States), Building Research Establishment Environmental Assessment Method (BREEAM) (United Kingdom), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) (Japan), Green Star (Australia), and National Australian Built Environment Ration System (NABERS) (Australia). These tools predominately focus on using the design elements within a property to identify the sustainability design potential of the property (Warren, 2009). The industry

**Exhibit 1** | Comparison of Green Star and NABERS

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Green Star</th>
<th>NABERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Star Ratings</td>
<td>Design, broad holistic criteria</td>
<td>Operation, measurable building data</td>
</tr>
<tr>
<td></td>
<td>4–6 Stars (No 1/2 Star Increments)</td>
<td>0–5 Stars (1/2 Star Increments)</td>
</tr>
<tr>
<td>Rating Categories</td>
<td>8 environmental categories (energy, water, management, indoor environment quality, land use and ecology, materials, transport) plus an innovation category</td>
<td>Energy and Water, Waste and IEQ (Pilot)</td>
</tr>
<tr>
<td>Administrator</td>
<td>Green Building Council Australia and New Zealand Green Building Council</td>
<td>DECC (NSW Government)</td>
</tr>
<tr>
<td>Rating Frequency</td>
<td>Once off</td>
<td>Annual</td>
</tr>
<tr>
<td>History</td>
<td>6 years (based on LEED &amp; BREEAM)</td>
<td>10 years (previously known as ABGR)</td>
</tr>
</tbody>
</table>

Note: The source is Warren-Myers (2009).
The Challenges of Identifying and Examining Links

Preference for these tools is evidenced by the utilization of these formats in other countries. Although there are similarities between the tools, the mechanisms of assessment and operation of the tools make cross-country comparison difficult (Reed, Bilos, Wilkinson, and Schulte, 2009b).

Although building rating tools have helped to develop the concept and the development of more sustainable properties, the downside is the varying degrees of assessment characteristics, parameters, and approaches available (Reed, Bilos, Wilkinson, and Schulte, 2009a). In turn this complicates assessment and investment parameters for stakeholders, particularly global property investors, because the development and use of these complex tools makes understanding the level of sustainability in the property and the surrounding response by the market increasingly more difficult (Dixon et al., 2008).

Many of the rating tools share similar intellectual property and intent with the majority of these tools rating a building through the design and construction phases of a property. Note only ENERGY STAR, EBOM (LEED), NABERS and Australian Building Greenhouse Rating (ABGR)\(^1\) examine a property in operation based on actual usage of resources. This research examines buildings in Australasia (i.e., Australia and New Zealand), therefore the tools requiring further explanation are those primary assessment tools used in the commercial property market in Australia and New Zealand. While this paper focuses specifically on the Australasian region, it is acknowledged that there is continuing development worldwide on the topic and issue of rating tools; however, this study only addresses the tools used in commercial property within the region. The assessment tools utilized to rate the sustainability aspects in commercial property in the Australasian region are Green Star, Green Star NZ, and NABERS (which now includes ABGR). The key differences between the tools are shown in Exhibit 1,

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**Exhibit 2 | Global Rating and Assessment Tools**

The source is Reed, Bilos, Wilkinson, and Schulte (2009b).
where there are alternative environmental categories assessed, stages of certification and associated requirements, assessment methodologies, as well as the actual rating attributed to each system.

Green Star and NABERS are the two primary rating tools used for commercial property in Australia; New Zealand also uses an adapted version of Green Star, but yet NABERS. NABERS is an operational tool requiring at least 12 months of building data in order to achieve certification; at present, NABERS rates only in two main categories: energy and water. The assessment tools for waste and indoor environment quality are in the pilot stage. Whereas Green Star uses a standard base of eight environmental assessment categories and the tool rates properties under (a) Design and (b) As-Built. The Design tool is the most readily used and assesses the property on its potential to achieve certain performance levels, while the As-Built rates the property on completion and ensures the elements certified in the Design stage are implemented as stipulated in the Design tool. There is concern with these tools around certification creep (the escalation of requirements) and the state-based discrepancies.

To-date relatively little research has been undertaken to compare the performance potential of a property rated under the Green Star system in comparison to actual performance. Therefore, the rating tool is highly theoretical and unproven in performance (e.g., the energy and water calculators, which assess the design of the property and estimate the potential consumption levels in operation). However, Green Star is arguably holistic in a sense since it incorporates some measures that are inherently difficult to assess in an operationally-based performance assessment (e.g., assessing levels of effect on the land use and ecology of the site or the transport benefits of a property).

As the focus has been primarily on new design and construction, due to the considerable promotion of the Green Star rating system, the lack of a tool that evaluates existing properties has been a considerable hindrance for the property market through not being able to compare the new and existing property stock. Although the NABERS system does examine the existing building stock, this is not an ‘apples to apples’ comparison as required for valuation and appraisal. The Green Star certification structure means owners’ are not under any obligation to share how they achieved the certification. This creates a potential issue for valuers and appraisers as they are unable to gain an understanding of how the property achieved a particular certification, which consequently limits the comparative analysis required in valuation. This further limits an appraiser’s’ ability to develop more strategic knowledge around sustainability characteristics and attributes and the influence of ratings. For example, in a particular scenario two different properties may achieve a 5-Star Green Star rating in design; however property A achieved a key proportion of its points through the energy category while property B achieved the score predominately through water, land use and ecology, and materials. In this example, both properties have the same rating but are inherently different in their sustainability attributes. Thus comparison of certified properties is inherently difficult unless the owner and other owners have been forthcoming with how they achieved their ratings.
While in the same system there is difficulty undertaking a direct comparison, it should be noted that examining new and existing properties with the two industry rating tools (i.e., Green Star and NABERS) is even more complicated. However, there have been suggestions of combining the two rating tools. An article in *The Financial Review* (11/09/08), for example, suggested that Green Star and NABERS were joining forces to make an optimal tool. However, to-date there has been little to no indication of any progress towards a unified rating tool utilizing both Green Star and NABERS. The actual integration of the tools was not discussed in the article, although this does present a way forward by unifying the segmented rating tool system in Australia. It is envisaged that a unified tool would also reduce the amount of confusion about rating tools by stakeholders in the industry. Both these rating tools are used on a voluntary basis; however, to achieve real change in the industry a degree of government input is needed. This has developed in Australia where disclosure of property consumption of energy will be required to be disclosed at point of transaction (Council of Australian Governments, 2009). A study into the Kyoto Protocol targets found that those countries achieving a reduction compared to 1990 levels were those that had a relatively more stringent regulatory regime (Kruse, 2008). The Building Code of Australia (BCA) is not making significant advances in the level of sustainability through the Building Code, although the 2010 revisions may be different; note that Green Star is arguably not the correct mechanism to legislate the use of because the parameters are continually changing and are focused on leading edge properties and rewarding best practice rather than policing the industry (NZGBC, 2008), in addition to the focus (to date) on new or major refurbished properties and ignoring existing property. However, the Property Council of Australia (PCA) has incorporated NABERS (previously known as the ABGR) ratings into the upper levels of its property quality grading matrix (PCA, 2006). In this scenario, the number of properties actually certified under these systems compared to the total stock indicates the limited market acceptance and take-up rate.

In analyzing markets’ change in terms of sustainability, the number of properties that have actually adopted more sustainable practices through certification schemes and non-certified initiatives in Australia and New Zealand needs to be investigated further. Of the 208 properties with NABERS ratings in 2009, 202 had achieved a NABERS (energy) star rating, as shown in Exhibit 3. While NABERS properties are rated through the assessment of annual operational data, there is an option to improve ratings by the purchase of green power. Green Star is certified only once and Exhibit 4 demonstrates the increasing number of Green Star certified properties in the industry. However, with over 22 million square meters of commercial office space in capital cities around Australia (PCA, 2009), the comparison of sustainable properties versus conventional indicates very limited take-up of certification. The number of Green Star properties in New Zealand has been increasing since 2007; by 2009 there were 10 properties certified with 21 registered projects (Cowley, 2009). Although increasing in number, this still represents a very small proportion of sustainable property in the commercial property market. The limited number of sustainable properties in comparison to the broader market limits transactional evidence (i.e., rents and sales) in the
market. The low frequency of transactions restricts the amount of evidence that appraisers and valuers can use to analyze and form opinions. This is further exacerbated by the number of properties purpose-built for government, owner/occupiers, and outside of major central business districts in suburban or regional areas. Although exponential growth in sustainable properties, in comparison to
the larger commercial property markets, this represents only a very small percentage of properties. Consequently, this limits valuers’ and appraisers’ ability to examine and compare market evidence in practice to analyze whether sustainability is the factor influencing a rent or sale price. However, the lack of data is only one issue. Valuers and appraisers do not traditionally have high levels of sustainability knowledge as a core element in their valuation or appraisal practice; consequently, changing market dynamics towards or against sustainability may not be fully recognized by valuers or appraisers. Therefore, if valuers and appraisers are uncertain or lack knowledge of sustainability, their ability to accurately assess whether sustainability has any influence or relationship with market value is questioned.

Methodology

The objective of the research was to provide an account of the perception of the market and provide subsequent evidence to identify and examine the relationship between sustainability and market value. The qualitative approach involved two surveys: (1) a survey of real estate market investors and (2) a survey of commercial valuers/appraisers. Investors were identified because they are the main demand drivers in the market while the role of valuers/appraisers it to reflect the activity in the market through valuation/appraisal. For sustainability to receive serious investment, real estate occupiers and investors who want to respond to issues raised by the sustainability agenda, there is a need to understand the affects of building occupation and ownership regarding sustainability through perception and its relation to worth (Ellison and Sayce, 2006). Therefore, to successfully determine the relationship between sustainability and market value in commercial real estate, it is important to focus on both stakeholder groups. The dual approach has been used in recent attitudinal studies, which compare real estate professionals’ attitudes and opinions (e.g., real estate valuers/appraisers) and stakeholders (e.g., real estate investors). The aim is to determine the likely market uptake of sustainability from buyers and investors and determine the degree to which valuers/appraisers perceive that this uptake would impact on the market value of commercial office buildings. Sims and Dent (2005) found that obtaining the opinions of valuers/appraisers and agents appeared to produce a reliable and accurate assessment of market value.

The investor surveys were undertaken in Australia and New Zealand during 2007 and 2008. The investor survey involved an interview of nine unstructured questions relating to sustainability, commercial real estate, and value. The respondents were decision-makers including predominately chief executive officers (CEOs), fund managers, general managers, and portfolio managers of major commercial real estate funds, listed and unlisted trusts, and companies. These investors totaled 59 potential participants identified in Australia and New Zealand. The respondents included 14 investors in New Zealand and 16 investors in Australia, equating to a response rate of 51%.

The valuer/appraiser survey was distributed and accessed online and included 16 questions including information about each participant’s location, experience,
perception of rating tools, drivers of market value and sustainability, and its effect on elements in the valuation equation. The Australian Property Institute (API), Property Institute of New Zealand (PINZ), and the Royal Institution of Chartered Surveyors (RICS) assisted with the survey distribution (e.g., via their member newsletters). A total of 255 responses were received through the online survey. The response rate was not as significant as the investor survey, although when the percentage of practicing commercial valuers/appraisers is taken into account the survey response rate improves. Using this type of survey approach enabled most valuers/appraisers to potentially access the survey; in turn this would produce some interesting insights into the valuation profession and their knowledge and understanding of sustainability in commercial real estate.

Measurement of Sustainability: Investor and Valuer/Appraiser Perceptions

Investors are the drivers of the commercial real estate market, while valuers/appraisers tend to reflect the market dynamics through valuation in the form of a hypothetical sale. Therefore, the perception, action, and rationale of the investment sector is extremely important. The perception of investors is discussed in other publications; however, their perceptions on rating tools are relevant to this paper. Investors were asked whether they would have a preference for a design-rated building or a building that demonstrated performance. Overall, the overwhelming response from Australian and New Zealand investors was for operation. However, many respondents argued there was a place for both design rating and performance because of the ability to impact on a building’s operational potential through design.

Exhibit 5 highlights that Australian investment companies have greater knowledge about the impact of design rating tools, where this may support reasons why they overwhelmingly prefer performance over the design rating tool. In contrast, New Zealand respondents have a preference for a design (or attribute rating) tool, as well as a performance tool. On an individual basis, they are not as supportive and prefer having either design or performance, but have a strong preference for a tool that rates the attributes of a building, as well as measuring the performance of the building. Overall, the preferred option is for measuring the building performance.

The impact of these results represents an observed preference for the performance assessment of buildings. If investors are actively making choices in preference to operational over design-rated buildings, this will have a flow-on effect on the apparent perceived value of ‘Green Star’ in the market. However, being able to identify and quantify the level of sustainability in a building is inherently important, although to place additional emphasis on having a ‘certification’ may misinform the industry of the true market value of building sustainability. The focus of investors as reported is reflected to some extent by the increasing use of NABERS certifications (Warren, 2009); however, findings relating to valuers/appraisers perception seem to differ somewhat.
The valuer/appraiser survey provided important insights into their perspective of sustainability and rating tools. Although the survey was developed with an objective to find whether valuers/appraisers had identified value in sustainability, the results have accurately identified how large the knowledge gap is for the valuation industry. Certainly a number of responses were identified as having considerable knowledge about sustainability in buildings and the industry rating tools; however, the vast majority of respondents lacked knowledge and understanding. Results for the initial analysis identified that only 35% of respondents had actually valued a building promoted as having sustainable attributes while the vast majority (65%) had not. Given that there were not a considerable number of buildings with sustainable attributes, this proportion probably reflects local market conditions.

Valuers/appraisers were asked whether in the case of valuing a building with sustainable attributes, how they would determine the level of sustainability. Exhibit 6 highlights the distribution of responses to this question. The vast majority of valuers/appraisers (82%) indicated that an industry rating tool would be how they would identify the sustainability in a building, while the next parameter was operational expenditure (35%). This contrasting view to the investors in the market is cause for concern. It can be hypothesized that the views of the valuers/appraisers is based on their lack of knowledge and understanding of the concept of sustainability, or alternatively on their lack of knowledge and understanding of how the rating tools work. It is clear that for the valuation profession to accurately assess the market value of sustainability in commercial real estate, there is a need for up-skilling and understanding of sustainability and industry rating tools.

The next question probed further into the understanding of the rating tools present in the industry. The question asked whether valuers/appraisers were familiar with
the distinction between the rating tools. Exhibit 7 highlights that a higher proportion of valuers/appraisers (64%) in Australia were aware of the distinction between the rating tools compared to New Zealand (36%). This result was not unsurprising given that Australia has had industry environmental rating tools since early 2003, while New Zealand was introduced to the concept in 2007. This
response outlines the valuation profession’s general knowledge of rating tools in their industry.

Arguably valuers/appraisers prefer to use an industry rating tool to identify the level of sustainability in commercial buildings. However, if the knowledge of industry ratings tools and the distinctions between them is not fully understood by the valuation community, then how can valuers/appraisers accurately identify the impact of these ratings tools on market value?

Market Value and Industry Rating Tools

There has been discussion in the industry whether a certification has an impact on the rents, yields, and sale prices of commercial real estate. Three key studies to date have been undertaken using the CoStar database to identify whether buildings with sustainability certifications had increased rents and sale prices (Fuerst and McAllister, 2008, 2009; Miller, Spivey, and Florance 2007, 2008a, 2008b; Eichholtz, Kok, and Quigley, 2008, 2009). Primarily using hedonic pricing models and rental/price data, it was determined in all three studies that those buildings that had a certification commanded higher rents and prices. This was important research into the relationship between sustainability and value. The use of hedonic methodology studies are indicative and provide a generalized market analysis of the effect sustainability may have. However, the comparative nature of valuation requires a different type of analysis than hedonic modeling, in that when practicing professionally valuers/appraisers have to compare like with like, to examine the various attributes of the properties, the basis of transaction and other particulars in order to ascertain assumptions and adjustments to assess a market value. This process in the hedonic studies is not able to undertake this process in the same manner as a valuer/appraiser would in practice. As a consequence, there is evidence that can be used in hedonic modeling; however, in practice valuers/appraisers need to have access to more data and have a thorough understanding of a vast variety of characteristics and particularly sustainability in order to draw accurate assessments of any relationship between sustainability and market value. This level of analysis is not undertaken in hedonic studies and although there may be enough data to conduct hedonic modeling relating to sustainability in commercial property, from a valuation and appraisal perspective there is a consensus that although evidence is emerging, there is not yet enough information to draw conclusive views on the relationship between sustainability and market value.

Exhibit 8 illustrates that the valuation profession cannot confirm if there is a relationship between industry rating tools and the market value of commercial real estate. However, where rating tools have been more established, there was a stronger view that it would have some positive impact on the market value, although the Australian valuers/appraisers also indicated industry rating tools had no impact on market value. The overwhelming response to this question was that the valuation professions in Australia and New Zealand do not know to what effect the rating tools have on the market value of commercial buildings. Overall, this response may relate to their lack of knowledge and understanding of the
ratings tools and their inability to accurately make a comparative judgment of the buildings.

The survey also asked if the surveyed valuers/appraisers had found evidence of any sort that may be able to identify a connection between sustainability and market value and the overwhelming response was no (i.e., not at this stage). This finding is in contrast to other studies that try to justify that an industry certification through the use of industry rating tools did improve market value. Although it was commented that a building with a certification may help to market the building to tenants or prospective buyers, there was not conclusive evidence to suggest that the certification improved the market value of an office building.

The question of whether industry tools had an impact on the market value of an office building was elaborated on, therefore presenting valuers/appraisers with an opportunity to comment on the range of rating tools and whether there was a perception that the individual rating tools had an effect on market value. Exhibit 9 portrays the perceptions of whether a particular rating tool has an impact on the market value of commercial real estate. Clearly, the 'don’t know' response was overwhelming in all categories and ranged from 55% to 69%. However, ABGR (which has since been renamed NABERS Energy although at the time of survey distribution it was still ABGR) was clearly identified with 30% of the market as having an impact on value, followed closely by performance data at 27% having a positive impact on the market value, while Green Star received a close response being evenly split between having a positive impact (21%) or a nil/negative impact (24%) on market value. This corroborates with some of the studies undertaken in the U.S. using the CoStar study. Fuerst and McAllister (2008) and Eichholtz, Kok, and Quigley (2009) both found that the ENERGY STAR certified buildings
Exhibit 9 | Valuer/Appraiser Perception of Rating Tools

Total Respondents

<table>
<thead>
<tr>
<th>Rating Tool</th>
<th>Nil</th>
<th>Positive</th>
<th>Negative</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Data</td>
<td>7%</td>
<td>27%</td>
<td>0%</td>
<td>66%</td>
</tr>
<tr>
<td>NABERS</td>
<td>16%</td>
<td>16%</td>
<td>0%</td>
<td>69%</td>
</tr>
<tr>
<td>Green Star NZ</td>
<td>20%</td>
<td>21%</td>
<td>3%</td>
<td>56%</td>
</tr>
<tr>
<td>Green Star Aus</td>
<td>21%</td>
<td>21%</td>
<td>3%</td>
<td>55%</td>
</tr>
<tr>
<td>ABGR</td>
<td>7%</td>
<td>30%</td>
<td>0%</td>
<td>63%</td>
</tr>
</tbody>
</table>

(similar to NABERS Energy) had a slightly increased premium for rent, whereas LEED rated buildings (similar to Green Star, primarily used for new buildings in design) achieved a much reduced premium or none (Fuerst and McAllister, 2008; Eichholtz, Kok, and Quigley, 2009). In contrast, the study by Miller, Spivey, and Florence (2008) found that LEED achieved a considerably rental premium compared to ENERGY STAR's rental. Evidently methodologies play a large role in the identification of these premiums; however, from a practice perspective these results are not indicative and valuers/appraisers would need to assess their own markets for evidence and comparability before identifying whether a premium exists. The information in Exhibit 9 asked valuers/appraisers in Australia and New Zealand whether any of the rating tools had any impact on the market value, and the overwhelming result was that valuers/appraisers had no idea.

A range of further comments were added by survey participants when asked if valuers/appraisers could put a percentage value on the rating tools’ impact on market value. Respondents’ comments as follows:

- “Design ratings like Green Star do not identify the performance of the building only the potential...thus if the building is not proven in performance how can a value be attributed.”
- “If a premium exists it would be identified through the rent, however there is no evidence of this in the market yet.”
- “It would be difficult to put a percentage value because every building would be different.”
- “The impact on value would be directly correlated with the overall net income and capital expenditure costs.”
“Comparison of office buildings through the rating systems is confusing and difficult let alone identifying the difference in market value.”

“It’s difficult to assess unless the building demonstrates where it has managed to achieve points within the rating systems.”

The findings from this research have identified a high level of confusion and misunderstanding in the valuation community surrounding sustainability identification and quantification and how the different rating tools relate to identifying the level of sustainability in a building. This may have a direct relationship with the limited knowledge valuers have of sustainability and their limited ability to gain further education on this topic from a valuation perspective. Valuers/appraisers in response to the questionnaire indicate they require a simple solution in terms of being able to identify the level of sustainability by using an industry rating tool. However, at present these results confirm that valuers/appraisers do not have a thorough understanding of the issues that surround the use of rating tools to identify the level of sustainability in a building. In comparison, investors in the real estate market have the opposite opinion as their preference is for buildings to demonstrate performance rather than have a rating. Although acknowledging the positive impacts of a building that has a certification, the majority of investors commented that it would not be a necessary requirement when acquiring real estate. If valuers/appraisers are meant to reflect the markets that the investors drive then the two key actors in this market are not aligned with their perceptions and assessment of sustainability in commercial real estate. This, in turn, makes it inherently difficult for any conclusions to be drawn as to whether sustainability has an impact on the market value of commercial real estate.

**Conclusion**

These research findings identified and examined key barriers restricting the valuation/appraisal profession from being able to accurately reflect the market value of sustainability through valuation. This research confirmed a need for further education of the valuation/appraisal profession in the industry rating tools and potentially for the development of a simple matrix which valuers/appraisers could use to accurately assess the sustainability of a building; possibly a global matrix or set of metrics could be used to help the valuation and appraisal professions examine property sustainability. However, in order for this to be implemented successfully, the valuation profession would require considerable upskilling in understanding the elements that make a building more sustainable. Other research from other markets, namely the U.K. and Germany (Lutzkendorf and Lorenz, 2005; Ellison and Sayce, 2006) have made attempts to create a matrix; however, the practical implementation of these tools into markets where valuers/appraisers have limited understanding of sustainability would cause considerable issues for the industry.

The research found valuers/appraisers are using industry rating tools as the primary metric to assess the level of sustainability in commercial real estate, yet have little knowledge of the rating tools. This contradicts the metrics used by the
investors within the market, who focus on real estate performance levels. Valuers/ appraisers should be reflecting and interpreting the methods used by industry as measurement tools. However, it is not only the contradictory nature of assessment, but the assessment tools themselves that cause issues in valuation practice regarding comparative analysis, which may lead to incorrect assessment and reporting of market values. The research also established that half of the valuers/ appraisers were unfamiliar with the workings of the rating tools available in their market. Yet, valuers/appraisers identified rating tools as having a positive effect on market values, but could not clearly differentiate which industry rating tools had an effect. This clearly demonstrates the confusion and limited knowledge in the general valuation profession of sustainability assessment and the relationship with market value, which is enhanced by limited transactions for analysis within specific markets.

The research found investors in assessing sustainability in commercial real estate used performance measures to identify the level of sustainability. As investors concentrated on cost minimization primarily through energy consumption, consequently, their assessment of sustainability was based on the level of energy consumed by the real estate. Investors focus on cost minimization as a result of risk mitigation drivers and the relationship to their perception and identification of value in sustainability. This contradicts valuers’ primary response to sustainability assessment, which indicates valuers/appraisers are misinformed regarding investors’ investment strategies. The valuation assessment, being a hypothetical simulation investment analysis conducted by valuers/appraisers, may ignore one of the investors’ key considerations in addressing sustainability in a transaction, which may lead to incorrect assessments of market value, as the concept and definition in assessing market value may not be reflected adequately in valuation practice.

This research concluded the reliance of valuers/appraisers on a rating system is potentially flawed and could prevent the identification of a relationship between sustainability and market value. The research found valuers/appraisers in Australia and New Zealand were not fully competent and experienced in the nuances of the various certification methodologies. The effect of certification creep, varying state-based discrepancies, and lack of market uptake, complicates and hinders the ability of valuers/appraisers to accurately compare sustainability levels of commercial real estate across different jurisdictions.

Endnotes

1 NABERS and ABGR are now known collectively as NABERS.
2 Recent legislation in Australia, the Commercial Building Disclosure program (CBD program), requires the disclosure of NABERS ratings to be made available to prospective purchasers and lessors of commercial office space greater than 2,000 square meters or more from November 1, 2010.
3 NABERS rating has an option to purchase green power, which affects certification by half a star, affecting actual performance of the property and inflates the rating. This is
an issue relating to misdirection and misinformation to the market about the actual performance of the property.

Reference made to other findings within the study but not directly reported here are found in Warren-Myers (2009).

References


The Challenges of Identifying and Examining Links


Georgia Warren-Myers, RMIT University, Melbourne, Australia or georgia.warren-myers@rmit.edu.au.

Richard Reed, Deakin University, Melbourne, Australia or richard.reed@deakin.edu.au.
Integrating Sustainability and Green Building into the Appraisal Process

Authors
Timothy P. Runde and Stacey Thoyre

Abstract
Sustainability’s key concepts and impacts on real estate valuation have been largely sidestepped to date. Sustainability and green building require the appraiser to recognize the influence of a new market force (sustainability) and understand a new set of property characteristics (green features). These elements are market-specific and change rapidly. This article discusses sustainability and its relevance in real estate valuation. In addition, green building criteria are offered so that green features can be analyzed. The concept of sustainability and the relative “greenness” of a property are then brought together into a three-step Sustainability Valuation Model that can be used to guide the appraiser in valuing real property—green and brown—now and as market conditions with respect to sustainability change.

The green building trend in real estate has been well documented in the media and academic literature. What has received less attention is the potential impact of the underlying principle of sustainability on properties both green and not green (brown). Sustainability, an emerging megatrend according to the Harvard Business Review (Lubin and Esty, 2010) is an oft-used but ill-defined principle that is rapidly being adopted worldwide, from the individual consumer opting increasingly for organic foods and hybrid cars to large corporations such as Walmart, which has incorporated sustainability into its business model and is developing a sustainability product rating system.

As society’s values shift to include sustainability, so, too, will the way real estate decisions are made. The 2009 CoreNet Global and Jones Lang LaSalle annual sustainability survey reported that 70% of commercial real estate executives cite sustainability as a critical business issue and 89% consider it in their real estate decisions (CoreNet, JLL, 2009). Increasingly, Socially Responsible Investing (SRI), Corporate Social Responsibility (CSR), and climate change related risk are factors investors must consider. In real estate, Responsible Property Investing (RPI) is gaining ground as well, emphasizing transit-oriented development, energy efficiency, and urban regeneration, among other values.

On the tenant/occupant side, quality of life, productivity, and interior environmental quality are emerging with a new role in office leasing decisions. Green credentials evidenced by LEED certification and proximity to public transit are becoming important considerations for office employers seeking to attract a bright, young workforce.

The questions relevant to appraisers and those concerned with valuation are: In what ways does sustainability impact market value? And how does one identify
it, measure it, and price the impact? It may be years before paired-sales analysis or definitive comparable data are available in many markets, to empirically prove or disprove the value impact. In the meantime, with change underway, appraisers need to know how to address sustainability impacts within the confines of the most probable price market value definition.

This article begins by reviewing the current valuation dilemma faced by practicing appraisers. The principle of sustainability is then explained in terms relevant to real estate and valuation professions. A discussion of what constitutes a green building and the potential value impact of commonly accepted green building features follows. Finally, the authors present a Sustainability Valuation Model that incorporates the concepts of sustainability and green building into appraisal and can be used to address sustainability impacts on any property—green or brown—no matter the level of the market’s sustainability orientation, and no matter how the market’s or the property’s sustainability orientation change over time.

Current Dilemma Facing Appraisers

Lack of Standardized, Conceptual Approach to Valuing Green Buildings

The rise of green building and sustainability has ushered in a new and formidable set of challenges to practicing appraisers. How do you incorporate a vague concept like sustainability into the concrete world of appraisal? And how do you translate the non-economic impacts that sustainability identifies into the most probable price definition of market value, which requires that all impacts, including social and environmental impacts, be measured in economic terms? The solution to this dilemma requires the valuation professional to overcome two significant hurdles that are stalling the evolution of current appraisal practice: (1) lack of systematic, conceptual approach to valuing green buildings and (2) lack of well-defined terminology. Without a systematic, conceptual approach to the problem, appraisers are at a loss for which valuation tool to use to solve the problem. And without standardized terminology, the appraisal problem itself cannot be defined.

Green Premium Data of Limited Use to Appraisers. To date, the academic literature addressing the value effects of green building and sustainability has been dominated by statistical analyses of large data sets. Some of the topics addressed include the effect of green building characteristics on assessed values and assessor-estimated market values by Dermisi (2009), office occupancy (Fuerst and McAllister, 2009), occupant productivity (Miller, Pogue, Gough, and Davis, 2009), and economic impacts of certification (Eichholtz, Kok, and Quigley, 2010), among others. The impact of green building features on valuation has been addressed in the appraisal literature (Guidry, 2004; Price-Robinson, 2009), and more recently in case studies by Wright-Chappell and Smith (2009), and statistical analyses of institutionally owned office properties (Pivo and Fisher, 2009). The energy efficiency premium in residential properties has also been addressed (Nevin, 1998, 1999).

Most of the literature to date seeks to identify the “green premium” or “business case” for properties that possess green features. While these studies are useful in
developing policy and for portfolio-level decisions about whether or where to invest, they lack the specificity and market sensitivity necessary to be useful in supporting adjustments to the comparables or the yield rates in a typical appraisal assignment. Statistical studies based on large-scale data sets like national CoStar data fail to capture the nuances of local markets, nuances that are at the core of professional valuation. Green features that add value in one market might not be recognized in another, due to geographical differences like water scarcity, or variation in market uptake of sustainability. Studies that drill down to the granular level typical of appraisal assignments often cannot be generalized to areas outside the study area. For example, the incremental value of solar panels on single-family homes depends in some degree on the price of electricity, so the study that purports a 10% premium for homes with solar panels in Sacramento has limited applicability for homes in neighboring San Francisco. Despite the geographical proximity, the utility jurisdictions differ, and so the price of electricity is much different.

In addition, sample size limitations and other problems have often resulted in large unexplained variation (low coefficient of determination) within the models, which weakens the reliability and limits their applicability.

**Brown Discount Unaddressed.** The question of how green building and sustainability affect the vast majority of the existing building stock that is not in any way sustainable, green, or high performance has been largely unaddressed. Currently, brown properties are far more prevalent than green properties. For owners of existing brown real estate, the concern centers as much on how their portfolio is at risk of losing its competitive position, as it is on what kind of rent premium LEED might confer. In many markets, the brown discount may quickly become a more significant issue than any green premium—both now and as market conditions change over time. Andrew Nelson of RREEF notes: “...many major markets will reach the critical mass where green buildings account for enough of the building stock that tenants have a choice. At this point, the performance premiums for green buildings will flip to a discount for older, less efficient, conventional buildings. We are already at or near this point in the mature economies of Europe and developed Asia, and getting closer in the major money centers of the United States,” (Nelson, 2009).

For appraisers, the distinction between a green premium and a brown discount can prove meaningful. While they both describe the delta in rent between a subject property’s rent/value and market rent/value, each of them require different circumstances in order to exist. Exhibit 1 illustrates this point, showing a hypothetical market where the supply of and demand for green space grows over time.

As seen in Exhibit 1, potentials for variance from market value based on relative greenness or brownness comes down to the degree to which the subject is in sync with the market. A green premium requires that demand for green space is greater than or equal to the supply of green space. Brown discounts exist at a different point in a market’s evolution and rely on demand for green space being greater than demand for brown space (i.e., tenants prefer green space) and that there exists
Exhibit 1 | Green Premium vs. Brown Discount

**Market Rent**

**Green Premium** = green rent > market rent; contingent upon:
Demand for green ≥ supply of green

**Brown Discount** = brown rent < market rent; contingent upon:
Demand for green > demand for brown, and sufficient supply of green.

**Time**

Graph assumes that both the supply of, and the demand for, green building space are increasing over time.

sufficient green space that tenants have a choice between green and brown. As Nelson (2007) explained, “At present, there is not enough green product available to force discounts for brown buildings, but that dynamic will flip once there is a critical mass of green buildings.”

The timing of the inflection point will vary by market, but because valuation occurs at a specific point in time, it’s critical for valuation professionals to understand where the specific market lies on the continuum. Is the market defined by green space and green demand or brown space and brown demand? Even if a subject is currently showing a green rent premium, the graph shows how the premium is likely to evaporate once green becomes the new market standard. If DCF modeling or direct capitalization is used, this point is especially relevant as the current (premium) rent will last only as long as the subject outperforms the general market.

Limitations of a DCF-Based Valuation Approach. Others, such as Muldavin (2010) have suggested that the discounted cash flow (DCF) is the ideal tool for green building valuation, primarily because there are numerous inputs that can be adjusted for green building features. The DCF is a powerful tool that can be useful for valuing both green and brown buildings. However, as with any financial model, the quality of the output is contingent upon the quality of the inputs and the skill
and experience of the valuer. Used without market-based support for the inputs or without proper benchmarking with direct capitalization or comparables, the result can be misleading.

Additionally, using a DCF approach to value green buildings lacks reliability in cases where the typical buyer and seller would not ordinarily use the technique, such as small commercial, industrial, or residential properties. In these cases, market support for the DCF inputs becomes particularly difficult to obtain (or may not exist).

Finally, suggesting that the DCF is the best method of valuing green building bypasses the critical question of whether sustainability matters to the market, and thus, to what degree green features should (or should not) be valued. As yet, not every market believes green features increase market value. No matter which valuation technique is used, it’s critical that the appraiser first understand whether the market values the green feature for which the appraiser is adjusting.

While in some cases, it may be relatively easy to see what adjustments need to be made, in cases where the subject’s greenness is not aligned with its market or its peers, knowing whether or not to make adjustments to either the subject or the comparables can become difficult. The Sustainability Valuation Model, presented below, provides the appraiser with a systematic methodology for approaching the valuation process, which considers the market’s sustainability orientation relative to the subject, using whichever techniques are appropriate for that market and property type.

Lack of Well-Defined Terms Relevant to Valuation Professionals

In addition to the lack of a standardized conceptual framework, the valuation profession lacks a set of key definitions. What, exactly, is a green building? Is it a process or a product? Or just hype? What does sustainability have to do with green building and real estate? What is the green premium, exactly? Is it good or bad?

Even among green building professionals there is confusion. Most appraisers think of a premium as a good thing—a premium to the base market value. But in the Spring 2010 Commercial Real Estate Update from the United States Green Building Council (USGBC), the lead article entitled Addressing the Green Building Premium (USGBC, 2010) stated: ‘‘...there has been enough research and observation to dispel the notion of a ‘green premium.’’” The article was speaking of the cost premium for building green, which elucidates the communication gap between those who create and rate green buildings, and those who deal with what gets built—the owners, managers, and appraisers. Even a cost premium is not always a negative in the world of appraisal. In the cost approach, higher costs can add to value, to the degree the market recognizes the costs as added value.

Need for Systematic Methodology

Sustainability uptake varies from market to market and is evolving quickly. As yet, there is no systematic, conceptual framework that links a property’s specific
characteristics to its specific market’s sustainability uptake. Such an approach must be flexible enough to apply to all property—green and brown—and allow for changes over time as the market influence matures and market conditions change.

The Sustainability Valuation Model, presented below, provides the valuation professional with just such an approach by allowing a property to be analyzed based on its specific green features (or lack thereof) relative to its market’s sustainability orientation at any given point in time.

The Principle of Sustainability

What is Sustainability?

A fair question to ask is: Why do appraisers need to understand sustainability if all they are concerned with is market value of real estate? Would it not make more sense to focus on quantifying the green premium, or the brown discount, so that green building valuation could be reduced to a mechanical adjustment anyone could understand?

The flaw in this line of thinking is that green building is not a monolithic feature or single set of characteristics and neither is sustainability. Sustainability connects current actions to all of their impacts, both current and future, and is therefore a fundamental departure from the “in the long run we are all dead” mentality that has been pervasive for the last 50 years or more. Sustainability uptake varies from market to market and is evolving over time. The most effective way to deal with an evolving market influence, especially one that is changing rapidly, is to understand the concepts that drive it. Valuation that takes into account sustainability and green features does not require the appraiser to develop a new set of tools, but it does require the appraiser to have a methodology for knowing which tools to use, and when and how to use them.

There’s More to Sustainability Than Green Building

Green building and sustainability are often used interchangeably, but the terms are far from synonymous. Sustainability, a very broad and far-reaching concept, is the underlying principle of green building. Sustainability encompasses much more than green building, however; the slow/organic food movement, conservation, and corporate social responsibility (CSR) are other examples of sustainability’s influence.

Sustainability’s broad and complex nature makes precise definitions difficult to obtain. Further, it is often spoken of in theoretical terms, complicating the picture even more for those interested in business applications like real property valuation. Definitions with relevance to business or to real estate valuation are therefore limited.

One of the earliest definitions cited for sustainability is the one offered in 1987 by the Brundtland Commission (WCED, 1987): “Humanity has the ability to
make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.” While it captures the intentions of the concept, its lack of specificity limits applicability in business and practical use.

On the other hand, Elkington’s (1998) Triple Bottom Line (TBL) concept is widely used in business: “Sustainability is the principle of ensuring that our actions today do not limit the range of economic, social and environmental options open to future generations.”

This idea that one must balance economic, social and environmental concerns is at the heart of many definitions of sustainability. The RICS Global Property Sustainability Survey (2009) strongly echoes this TBL concept by “…equat[ing] sustainability with the goal of balancing economic, environmental and social objectives at global, national and local levels in order to meet the needs of today without compromising the ability of future generations to meet their needs.”

The TBL approach gives clarity to the range of impacts, but raises its own set of problems when attempting to quantify these impacts. How does one account across three bottom lines?

Meyer (2008) proposes a definition of sustainability based on economic externalities—those impacts, positive or negative, not anticipated or paid for at the time of the event—that can be useful when indentifying off-site impacts of real estate activities, and the risks posed to property value. He explains, “If you bought a car battery and paid nothing to sequester its toxic materials upon disposal, the cost to society of dealing with it—whether counted as health care for people getting heavy metal poisoning or their harder-to-measure suffering—were deemed externalities because neither the customer nor the battery maker paid this cost.” Meyer goes on to define activities as sustainable “…when all costs are internalized, because if the costs are too high, the activities stop.”

Defining Sustainability for Applied Real Estate Valuation

Drawing upon the TBL and externality definitions results in the following definition of sustainability for applied real estate valuation: Sustainability is the principal of seeking to avoid, minimize, and/or mitigate adverse current and future social, environmental and economic impacts (externalities).

In theory, a sustainable land use would avoid any current and future adverse social, environmental, and economic impacts (externalities), including those that extend beyond the property line. In practice, a land use moving toward sustainability status would first seek to avoid adverse externalities, then minimize, and finally mitigate what could not be avoided or minimized. Land uses that do not are at greater risk that sooner or later the cost will be internalized, and that they will obsolesce faster.

From a real estate valuation perspective, understanding and defining a sustainable activity or land use may be more difficult, and less useful, than understanding what it means for a building or land use to be unsustainable. A site with a leaking
underground diesel storage tank and an office building with unremediated/unencapsulated asbestos are examples of unsustainable land uses. These cases are fairly obvious and familiar to most real estate professionals.

Less clear are land uses like a suburban office building in an isolated location without access to public transit that relies solely on automobile commuting. Tract housing in an isolated rural area (leap-frog development) with poor access to services, employment centers, or public transit falls into the same category. As environmental legislation increases, so will the likelihood that these properties’ negative externalities—greenhouse gas emissions, traffic burden on infrastructure—will be internalized in the form of direct or indirect carbon taxes, special assessments, or impact fees.

Sustainability as a Risk to Market Value

Sustainability’s influence on real estate, particularly to the existing brown building stock, can be viewed as a risk to market value. From the perspective of a typical market participant, a new and evolving market influence like sustainability likely presents more risks than opportunities. How many brown properties do you want in your portfolio if your market demands green? Is it financially feasible to green up? Will the costs associated with going green truly pay off and over what time horizon? What is the cost of staying brown?

In the United Kingdom, researchers Ellison, Sayce, and Smith (2007) have proposed a risk-based approach to calculate sustainable value based on the calculation of worth definition (RICS, 1997). While their use of the investment value premise renders it of limited utility for an appraiser interested in calculating market value as defined as most probable price (value in exchange), the concept of seeing sustainability as a risk to property value is enlightening.

A risk-based approach works to appraisers’ strengths, since they are accustomed to identifying existing and future property risks, and then accounting for their impact in the adjustment of the comparables, the overall capitalization or yield rate selection.

To guide the appraiser in assessing sustainability risk, a review of the various definitions of sustainability results in the following shared underlying themes:

- Inter-generational equity (concern for future generations)
- Intra-generational equity (social/political/economic, across current generations)
- Balance social/environmental costs with economic cost/benefit
- Stakeholder activism
- Disclosure and transparency
- Supply chain focus vs. end user
- Life-cycle focus vs. up-front cost
- Elimination of waste
To assess sustainability’s impact on the market value of real estate, the authors have further distilled these eight underlying themes into the following four risk categories dubbed ROTE:

- **Resource Use: Operational and Construction/Renovation**
- **Obsolescence**
- **Transparency & Stakeholder Influence**
- **Externalities**

Exhibit 2 shows some examples of sustainability-related risks in each of the ROTE categories and the potential value impacts on real estate.

ROTE risk assessment will help the appraiser identify sustainability risks that pertain to the subject and subject’s market. The intent is to capture sustainability-related risks that impact market value but may otherwise be missed in the appraisal process. Application of ROTE risks will be discussed further below with the Sustainability Valuation Model.

### Exhibit 2 | ROTE Sustainability Risk Assessment

<table>
<thead>
<tr>
<th>RISK CATEGORY</th>
<th>EXAMPLES OF SUSTAINABILITY RISKS</th>
<th>POTENTIAL PROPERTY VALUE IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td><strong>RESOURCE USE</strong></td>
<td>• ↑ global demand for materials vs. fixed supply</td>
<td>• ↑ replacement cost; ↑ TI &amp; future renovation costs</td>
</tr>
<tr>
<td></td>
<td>• ↑ energy cost, volatility; ↑ water cost, rationing</td>
<td>• ↑ operating expenses; ↓ NOI; Energy efficiency becomes paramount</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ↑ replacement cost may ↑ market barriers to entry; Renovate preferred over new construction; Life cycle costing</td>
</tr>
<tr>
<td><strong>OBsolescence</strong></td>
<td>• Consumption rate ↓, or patterns shift</td>
<td>• ↓ demand for retail; change in type/location</td>
</tr>
<tr>
<td></td>
<td>• ↑ need for properties to adapt to future uses and users (not yet identified)</td>
<td>• ↑ rate of depreciation; ↑ TI, cap ex cost for less adaptable properties</td>
</tr>
<tr>
<td></td>
<td>• Increased rate of change expected in future</td>
<td>• ↓ economic growth due to ripple effect of consumer (70% GDP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ↑ risk for special-purpose improvements</td>
</tr>
<tr>
<td><strong>TRANSPARENCY &amp; STAKEHOLDER INFLUENCE</strong></td>
<td>• ↑ disclosure of energy efficiency</td>
<td>• GRI reporting that triggers green-up of REIT portfolio; carbon reporting</td>
</tr>
<tr>
<td></td>
<td>• Non-financial stakeholders influence investor decisions</td>
<td>• Stigma for poor performers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Supply chain reporting requirements</td>
</tr>
<tr>
<td><strong>EXTERNALITIES</strong></td>
<td>• Greenhouse gas (GHG) and climate change legislation</td>
<td>• Carbon taxes, cap &amp; trade; Project GHG emissions used as reason not to allow development</td>
</tr>
<tr>
<td></td>
<td>• Community charges back project externalities</td>
<td>• Impact fees, assessments</td>
</tr>
<tr>
<td></td>
<td>• Poor indoor air quality</td>
<td>• Health risk liability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stigma: ↓ marketability</td>
</tr>
</tbody>
</table>
What is a Green Building?

Understanding sustainability allows one to readily see how the green building trend aligns with sustainability’s intentions. But, like sustainability, definitions for green building abound and as yet, a commonly accepted definition that is relevant for real estate valuation is lacking. If valuation professionals are to address green building in any meaningful way, there needs to be an agreed-upon criteria that define a green building—even if the actual product based on those criteria differs from market to market and over time.

Green Building Criteria

For the purposes of valuation, the authors propose that a green building must meet three criteria: (1) commonly accepted set of features based on the principle of sustainability; (2) features must independently verifiable; and (3) modeled performance must be verifiable by actual results.

Commonly Accepted Features based on the Principle of Sustainability. No matter how green building is defined, it must be based on features that are commonly accepted by the relevant market participants so that valuation professionals are able to assess the possible impact on market value. The rating system most prevalent in the local market may be the best guide for whether a building is considered green. In the United States, the Leadership in Energy and Environmental Design (LEED) rating system provides the most widespread example of a set of commonly accepted green building features for commercial buildings. In the United Kingdom, the Building Research Establishment Environmental Assessment Method (BREEAM) is more prevalent, while Japan uses the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE). In the U.S. residential sector, there is as yet no single, dominant rating system. A review of the major rating systems currently in use throughout the world (Reed, Bilos, Wilkinson, and Schulte, 2009) shows that the most commonly occurring categories of green building features are the following:

- **Energy Efficiency:** Reduce use of energy, especially non-renewable;
- **Resource Use Efficiency:** Water, materials, and waste stream reduction;
- **Site Efficiency:** Location specific characteristics such as proximity to transit and infill development; and
- **Quality of the Interior Environment:** Such as daylighting, low VOC-emitting materials, and green cleaning.

Independently Verifiable. Part of due diligence in appraisal is third-party verification. Among other things, appraisers confirm comparables, review historical operating statements and tax returns, compare line item expenses to similar expenses in similar buildings, read leases, and CC&Rs. Auditors sign off on corporate accounting to insure fair representation of a company’s financial condition. Green building features must submit to the same rigor in order to be considered in valuation.
Modeled Performance Must Be Verifiable. Most commercial appraisers are aware of the limitations of valuation models like a DCF. Actual results almost never match forecast, and the results of the model are highly vulnerable to fairly minor tweaks in the assumptions. As the late and venerable James Graaskamp was fond of quipping, “You’re not just buying real estate, you’re buying a set of assumptions: if you don’t buy the assumptions, don’t buy the real estate.” In appraisal practice, modeled performance is verified by supplementing a DCF with direct capitalization and the sales comparison approach. Modeled performance of green building features like daylighting, building energy management systems, and low-flow fixtures needs to be verifiable—through year-over-year utility bill comparisons, for example, if they are going to matter to appraisal.

Rating Systems

Rating systems can be a reasonable guide for the appraiser in determining whether the subject (or comparable) is green, especially if the subject’s green features can be verified and performance audited as discussed above. There are a few caveats concerning rating systems that bear mention:

- **A green label is not enough.** The LEED system, while considered the standard for green properties in the U.S. commercial market, has faced some criticism revolving around whether a LEED-certified building will continue to perform as promised by its initial certification. Some of these long-term performance issues are addressed via building commissioning and via performance auditing measures, such as those inherent in the Energy Star Portfolio Manager system.

- **Closely analyze green features...even in brown buildings.** The appraiser needs to familiarize him/herself with the specifics of the prevalent local system and be prepared to closely analyze green features. The categories in which a subject received credit can make a substantive difference as to whether a green feature has an impact on value, as illustrated in Exhibit 3. Some of the green features may have a larger potential impact than the appraiser may expect, such as the cost savings associated with triple waste stream programs or water efficiency upgrades. For example, repairs and upgrades to plumbing fixtures in a 1920s 15-unit San Francisco apartment building reduced the annual water/sewer bill almost 40%, which resulted in a 4% increase in the market value as indicated by the income approach. What’s particularly notable in this case is that the building owner was not intending to “green up” the property yet the upgrades resulted in considerable savings. Appraisers should make a practice of breaking down historical utility costs into energy, water/sewer, and waste for all buildings (green and brown) so that any cost savings can be noted and acknowledged. In the apartment building example, this savings would have been missed without disaggregating the utility costs.

- **Not all rating systems are equal.** Rating systems limited only to energy efficiency, such as ENERGY STAR and Home Energy Rating System (HERS) are not sufficient to deem a building green as they do not take
into account any other features beyond energy efficiency. Rating systems based on TBL (i.e., sustainability) concepts, such as LEED, will meet the standard of criterion 1.

**Greenwashing**

This above set of criteria can be used to readily distinguish green buildings from non-green (brown) buildings. But what about buildings that claim to be green but where it is not readily evident if the claims are being made solely for marketing purposes? In other words, how can you tell green building from greenwashing?

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### Exhibit 3 | Potential Value Impacts of Green Building Features

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>EXAMPLES OF GREEN BUILDING FEATURES</th>
<th>POTENTIAL VALUE IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENERGY EFFICIENCY</strong></td>
<td>• Motion sensor lighting controls; Building Mgmt System; High-efficiency HVAC/lighting</td>
<td>• ↓ energy costs = ↑ NOI; Insurance ↓ for green buildings</td>
</tr>
<tr>
<td></td>
<td>• On-site cogeneration</td>
<td>• No transmission loss, so ↓ effective cost</td>
</tr>
<tr>
<td></td>
<td>• On-site renewable energy</td>
<td>• ↑ energy efficiency; Government incentives</td>
</tr>
<tr>
<td></td>
<td>• Building commissioning (initial and ongoing)</td>
<td>• ↑ efficiency ↓ energy costs &amp; ↑ systems lives; Ongoing comm. ↑ operating expenses</td>
</tr>
<tr>
<td></td>
<td><strong>RESOURCE USE</strong></td>
<td><strong>Direct</strong></td>
</tr>
<tr>
<td></td>
<td>• Under floor HVAC/mechanical</td>
<td>• ↓ future Ti cost; ↓ energy use due to more efficient HVAC</td>
</tr>
<tr>
<td></td>
<td>• Renovate instead of build new: Recycle, use fast renewables</td>
<td>• Cost may ↑ or ↓</td>
</tr>
<tr>
<td></td>
<td>• Triple Waste Stream (recycle/compost/landfill)</td>
<td>• ↓ trash expense; ↑ cost of staff/tenant education/cooperation</td>
</tr>
<tr>
<td></td>
<td>• Low-flow plumbing fixtures</td>
<td>• ↓ water/sewer cost</td>
</tr>
<tr>
<td></td>
<td><strong>SITE</strong></td>
<td><strong>Indirect</strong></td>
</tr>
<tr>
<td></td>
<td>• Mass transit access; Alternatives to auto commuting; Re-use of infill/brownfield sites</td>
<td>• ↑ tenant comfort due to diffuser control; ↑ satisfaction → retention</td>
</tr>
<tr>
<td></td>
<td><strong>INTERIOR ENVIRONMENT QUALITY</strong></td>
<td>• Renovate may result in functional inefficiencies vs. new build</td>
</tr>
<tr>
<td></td>
<td>• Daylighting/views to entire floor</td>
<td>**Core, CBD and transit-oriented assets tend to reflect ↓ risk, thus ↓ OAR &amp; IRR, &amp; ↑ values; ↓ impact land uses = ↓ risk over holding period</td>
</tr>
<tr>
<td></td>
<td>• Low VOC paint, carpet, furniture; ↑ ventilation (↓ CO2); High-particulate air filtering</td>
<td>• ↑ light/views may ↑ rent but ↓ perimeter offices</td>
</tr>
<tr>
<td></td>
<td>• Green cleaning</td>
<td>• ↑ cost of materials; May ↑ cost of HVAC operation, maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ↑ cost of green products and training</td>
</tr>
</tbody>
</table>
Greenwashing is any green or environmental claim that is unsubstantiated, unverifiable, or inconsistent with the principle of sustainability.

A property or feature that claims to be green or sustainable, but fails any one of these three tests, is not truly green or sustainable. For example, if the LEED rating system is manipulated to earn a high LEED rating by garnering credits in categories unrelated to energy efficiency, energy efficiency performance may be below modeled levels or worse yet, below conventional non-green efficiency levels. In this situation, the manipulation of the LEED system would fail the sustainability test and thus would be considered greenwashing. An example of this very phenomenon was reported in a *New York Times* article in August 2009, citing the Federal Building in Youngstown, OH (Navarro, 2009). A leasing broker advertising a property as “registered for LEED certification,” but where certification is not being actively pursued, is another clear example of greenwashing.

**The Sustainability Valuation Model**

At this point, the relevance and role of sustainability in real estate have been established, and definitions for both sustainability and green building in a real estate valuation context have been established. The next step is to integrate sustainability into the process of real estate valuation—for both green and non-green buildings.

The Sustainability Valuation Model, developed by the authors, is a systematic, three-step approach to valuation, designed specifically for appraisers and other valuation professionals, which can be applied to any property type, in any market, and is not temporally sensitive. That is, the model allows for variations over time in a particular subject property, as well as variations within the specific market both in terms of building features (green or brown) and the context (to what degree the market values sustainability).

**Step 1: Assess Market Uptake of Sustainability**

Whether sustainability influences market value depends on the degree to which the specific market values sustainability. Is this a cutting-edge market that can’t wait for the next clean technology, or a wait-and-see market that views green as a fad that will pass? Getting this part right is essential to avoid introducing an unintended green or brown bias into the valuation process. The appraiser who views green as good in a market that isn’t yet convinced is introducing bias to the valuation process. But the risk of brown bias by appraisers and other valuation professionals who are unaware of sustainability influences is at least as great and potentially more pervasive.

But precisely how does one assess a market’s uptake of sustainability? How do practicing appraisers determine where a market falls on the sustainability continuum? Appraisers can utilize the same tools used to assess any other market influence—examine the behaviors of relevant stakeholders and use collected market survey data and studies where available.
The relevant stakeholders fall into three categories: policy makers (government and non-government organizations, or NGOs), property owners (landlords), and end users (tenants and owner-users). Key points to consider when evaluating the actions and behavior of each stakeholder group follow.

**Policy makers**

- **Check for regulations and incentives at local, state, and federal levels.** Local green building codes, state-mandated renewal energy standards (such as renewable portfolio standards, RPS), and the various federal mandates requiring federal agencies to be in green space are examples of policy decisions that affect real estate at each of these levels. Generally, the more localized the sustainability and green building policy, the more sustainability oriented a market is likely to be. For example, San Francisco is at the leading edge of sustainability orientation in the state, and adopted a green building component to its building code well ahead of the recent CALGreen statewide green building code that goes into effect in January 2011.

- **New construction or all existing?** A market with a green building code that mandates all new construction be LEED-certified may at first seem quite sustainability oriented. But the effect of such a policy on the overall market is really more symbolic, since in any given year, new construction compromises, on average, only 2%–3% of the building stock in the U.S. (Brown, Southworth, and Stovall, 2005). Requiring both new construction and all renovations over a certain size to meet LEED requirements, as is the case in San Francisco, is likely to have a far greater effect on the market, and indicates a more significant commitment to sustainability, at least by policy makers. In addition, attention should be paid to whether landlords are pursuing certification under LEED Existing Buildings Operations and Maintenance (EBOM) since that is a voluntary action not mandated by policy and therefore indicates that the market has moved beyond compliance to internalizing sustainability.

- **Consider influence from Non-governmental Organizations (NGOs).** NGOs from national organizations down to neighborhood Not In My Backyard (NIMBY) groups are included here, because they typically act through the creation and enforcement of policy. Powerful NGOs such as Ceres, a nonprofit organization that aims to incorporate sustainability into capital markets, can directly influence real estate. For example, the Global Reporting Initiative (GRI), an organization originated through Ceres, recently announced the addition of real estate-specific guidelines for their GRI Sustainability Reporting Framework, designed to address “…specific sustainability issues that are unique to the Construction and Real Estate industry such as product and service labeling including building and materials certification, building energy intensity, water intensity and CO₂ emissions related to buildings in use, management and remediation of contaminated land, labor health and safety issues when operating in insecure environments, and contractor/subcontractor labor supply chain issues,” (GRI, 2010).
While policy and regulations can be a leading indicator of sustainability orientation, alone they are not reliable indicators of market uptake because policies are almost always created outside of the market by non-market participants.

**Property Owners.** On the other hand, the voluntary sustainability-related actions of property owners, particularly landlords who operate primarily for financial gain, are the strongest indicator of a market uptake of sustainability.

- **Consider type of ownership.** Institutional ownership may be pursuing LEED certification to respond to activist shareholder demands, or investment policy such as Responsible Property Investing (RPI), carbon reporting, or compliance with GRI. In these cases, considering national or international sustainability trends may be more useful than a strict focus on the local market.

- **Check the USGBC database.** The USGBC website has a searchable database of both LEED-certified and LEED-registered buildings by type and city. The registered list can be a leading indicator, particularly using the most recent registrations. However, since registration requires little more than payment of a modest fee, the older registrations are of little utility in gauging market uptake, since the owners may have simply registered as a placeholder in an early version. LEED-certified (as opposed to registered) buildings in a market serve as a far better indicator of uptake, and tend to correlate positively with increased sustainability uptake. In addition, the number of LEED APs (Accredited Professionals) in the area may also be an indicator of a market’s sustainability orientation.

- **Check with the local USGBC chapter.** The local USGBC chapter may also have additional information on LEED certifications and LEED-registered buildings in the area. The presence (or lack) of a local USGBC chapter, and its activity level, can also be an indicator of the market’s sustainability orientation.

- **Green leases or clauses.** The use of green leases, or green clauses in leases, is another indicator of owner uptake of sustainability.

**End Users.** End users include tenants, owner-occupants, and their customers and clients.

- **Interview local brokers to gauge tenant and owner-occupant demand for green space.** Exhibit 4 provides a sample list of questions. Tenant desires for green space can be a reliable indicator of market uptake, but measuring that desire can be elusive. Asking a tenant if they will pay more for green space (or anything) is likely to result in a negative response, no matter what the core values or beliefs of the tenant might be. Asking leasing brokers what percentage of tenants requested LEED-certified space in the past year, with follow-up as to the size and nature of those tenants, would be more enlightening. However, if the tenants are often Fortune 500 and government tenants—credit tenants who tend to lease larger spaces than the typical local professional services firm that
Exhibit 4 | Broker Interview Questions

Note: This list of sample questions is not meant to apply to all assignments nor is it intended to be exhaustive. While LEED is used here, the appraiser should use the most common green rating system used in his/her market for the subject.

When confirming lease comparables:
- Are tenants requesting LEED-certified space in this market?
- In the past year, what percentage of tenants would you say request LEED space?
- Is that more or less than the prior year?
- What type of tenants are they? Fortune 500? “Green” companies? Government? Non-profits? Other?
- Do they tend to be large or small tenants?
- Have you leased any space recently involving LEED space or where LEED was a tenant requirement?
- How did that impact the leasing process?
- Is there any measurable difference in rent for green or LEED space in your market? If yes, can you give me an example?
- Do you have any evidence that LEED buildings lease faster?
- Is there an example you can think of where LEED certification caused the tenant to choose the LEED building over another, non-LEED building?
- Do tenants differentiate between the different levels of LEED, such as Certified versus Silver versus Gold? Will tenants pay more for a higher LEED rating?
- Is LEED a deal maker or a deal breaker?
- How would you say LEED affects marketability of space in this market, or is there no effect?
- Are landlords using green leases? Are tenants asking for them?

When confirming sales comparables:
- In your experience, do investors consider green ratings like LEED in the purchase decision? What about ENERGY STAR? What about owner-users? If so, how is it considered?
- Or do buyers simply view it as a “value added” feature (upside)?
- Does it depend on the type of buyer? If so, how?
- What is the appeal of LEED to investors: the label effect (“green” the portfolio), enhanced marketability leading to rent premium or faster absorption, cost savings due to energy efficiency, or “future proofing” (delayed obsolescence)?

comprise the bulk of the leasing market as measured by tenant count—then the impact is probably understated.

Corporate headquarters and government buildings. Owner-users may perceive a halo effect of a LEED Platinum headquarters, which speaks more to their corporate image or guiding principles than it does about the local market. Likewise, government buildings with sustainability features may be more tied to policy goals than the sustainability orientation of the market.

Consider the behaviors and actions of the community. Even if the observed behaviors are not those of the person signing the lease, they can
be relevant indicators of a market’s uptake of sustainability. A community that embraces sustainability principles is more likely to support, or advocate for, local regulations and incentives for green building, and to reward (or penalize) companies that adopt (or fail to adopt) sustainability practices. Consider the presence of Whole Foods Markets or local farmers’ markets; how much floor space the organic produce section takes up at the conventional grocery store; the proportion of hybrid vehicles in parking lots; bike lanes painted on the side of the street; car-share operations (like Zipcar) or priority parking for van pooling; solar panels on the roofs of the houses; compost, recycle, and trash bins in the offices, or out on the residential streets on trash day indicating a triple waste stream system, etc.

Third-Party Market Surveys

As sustainability moves more mainstream, it is being increasingly studied and tracked in the same way that other market trends such as vacancy, rents, net absorption, and anticipated investor yields. Here are some examples of market surveys that could prove useful to the appraiser.

- **Surveys of corporate real estate executives related to sustainability:** Jones Lang LaSalle (JLL) and RICS’ Global Property Sustainability Survey provide information about sustainability uptake for those properties and markets that involve institutional investors, as the landlord’s sustainability views are likely to be national or global.

- **National surveys that contain local market data.** Cushman and Wakefield recently released the Green Building Opportunity Index, which ranks the top 25 U.S. office markets on a variety of criteria relating to green building, such as Green Adoption and Implementation, Mandates and Incentives, State Energy Initiatives, and Green Culture.

- **Local surveys.** These types of surveys are more likely to be found in sustainability-oriented markets. In the San Francisco Bay Area, for example, Cassidy Turley BT Commercial publishes a RealGreen Index that tracks inventory and vacancy levels for LEED-certified space.

Considering the behaviors and actions of the relevant stakeholders and any pertinent market survey data is the first step of the Sustainability Valuation Model. The goal in Step 1 of the model is to determine if the local market is Sustainability Oriented (SO) or Not Sustainability Oriented (NSO). Exhibit 5 lists some typical characteristics of NSO and SO markets. Some markets may be clearly SO or NSO, but in many cases, a market will fall at some point along the continuum. The idea is not to place the subject precisely on the continuum, but rather, to gauge in a more general sense whether sustainability has little to no effect or a strong effect on the local market.

**Step 2: Categorize the Subject**

The Sustainability Valuation Matrix, presented in Exhibit 6, categorizes the subject in a way that allows the appraiser to take into account the sustainability orientation
of the subject property’s market relative to the subject’s specific green-brown characteristics. Step 1 of the model allows for determining where the subject’s market falls on the sustainability axis (y-axis). The prior discussion of what constitutes a green building allows for orienting the subject along the brown-green axis (x-axis). In this way, one can place the subject where it best belongs in one
of the four quadrants. Since both axes (brown-green and NSO-SO) are continuums rather than absolutes, a property may not fit perfectly into any one quadrant, and the position could change over time. The idea is to find the best fit, not the perfect fit. Once placed, the appraiser can analyze the subject based on its location in the matrix.

Relating the subject’s level of greenness to its market’s sustainability orientation is important so that the appraiser knows whether to adjust the subject and the comparables for green (or brown) features. Let’s say, for example, that the subject property is green, and the comparables include one green comparable while the rest are brown. How is the appraiser to know whether an adjustment is necessary for the green features in either the subject or the green comparable, or the lack of green features in the brown comparables, without first analyzing whether the market values green features? If the market is sustainability oriented (SO) (i.e., the market values green and the subject is green), then the brown comparables likely need to be adjusted upward. The green comparables may need to be adjusted based on the specific green features relative to the subject. If the market is not sustainability-oriented (NSO), further analysis of the green features of the green comparable (and the subject) would be needed to determine whether green features add value in a brown market. Exhibit 7, the Sustainability Valuation Impact Grid,
illustrates how the actions of the appraiser vary depending on the quadrant in which the subject has been categorized. Additional discussion of these points will follow as each of the four quadrants of the Sustainability Valuation Matrix is examined more closely.

A note of caution is appropriate when categorizing the subject on the brown-green continuum. Green buildings are surprisingly easy to miss, even for someone well versed in green building. Most green buildings look just like their conventional, brown counterparts. In one recent appraisal assignment, neither the client nor the property contact informed the author that the subject was LEED certified. The giveaway was a sign touting the benefits of a waterless bathroom fixture—the LEED plaque was tucked away in a corner of the lobby. This problem is particularly pervasive in the early stages of market uptake, when the appraiser may not expect to find a green building.

*Brown in an NSO Market.* This category applies to a property that does not meet the three green building criteria presented earlier, and for which the appraiser determines the market is not sustainability oriented (NSO). This is a brown building in a brown (NSO) market. A 1980s suburban office building in Tulsa, Oklahoma, where there are currently no LEED-certified buildings and no local green building codes, would likely fall into this category. The appraisal response is:

- Analyze green features = N/A for subject.
- Review comparables to be sure they are not green and adjust as necessary.
- Consider ROTE risks.

While the subject in this case lacks green features, green comparables can be found even in NSO markets. Even though the overall market may not appear to be sustainability oriented, green features like energy or water efficiency improvements that result in lower-than-market utility costs will affect the NOI and thus, value. For example, if the comparable’s utility costs are substantially lower than the subject due to energy efficiency improvements or on-site power generation (solar panels), then an adjustment may need to be made to the comparable. Care must also be taken not to double count green features where adjustments are already being made. For example, proximity to transit (site efficiency), might already be inherent in the appraiser’s generic “location” adjustment. The appraiser may need to refine the location adjustment to reflect the components that “location” reflects for a suburban office building, such as linkages to mass transit, freeway access, proximity to workforce housing, business park setting, and others. The appraiser may also need to consider that a comparable’s low parking ratio, which is below both the market standard and the subject’s ratio, may not require an upward adjustment if the comparable has superior mass transit accessibility. The specific adjustments will of course vary by market, and identifying and properly adjusting for these factors is where appraisers use their local experience and expertise.

Lastly, the appraiser should consider the impact of any specific ROTE sustainability-related risks on the subject (Resource Use, Obsolescence,
Transparency, Externalities) and whether these risks have been adequately addressed in the previous adjustments. ROTE risks like escalating energy costs and materials costs respond to global market forces and will adversely affect all properties, irrespective of the local market’s sustainability orientation. Obsolescence risk can arise from outside the local market as well, due to state and federal legislation (like California’s new statewide green building code) and could affect the market by setting a new minimum standard for new construction, thus creating implied obsolescence to the existing building stock.

**Green in an NSO Market.** This category applies to a property that meets the three green building criteria presented earlier, but where the appraiser determines the market is not sustainability oriented. This is a green building in a brown (NSO) market such as a net-zero energy warehouse building with a green roof in Omaha, Nebraska. It may or may not be LEED certified. The appraisal response is:

- Analyze green features = adjust subject as necessary.
- Review comparables to be sure they are or are not green and adjust as necessary.
- Consider ROTE risks.

The Sustainability Valuation Impact Grid (Exhibit 7) shows how the appraiser should consider sustainability impacts in the appraisal process. If the green building is LEED rated, line-by-line analysis of the credits earned in each category is necessary to determine if the features add value, incur additional cost, and/or enhance marketability. Do the features add discreet value (like a super-efficient HVAC system, with solar panels and a ground source heat pump that makes the building net-zero, i.e., no net energy demand from the grid)? Are there maintenance or other costs that offset the benefits? How fast is the market moving toward sustainability? Is the subject ‘future-proofed’ to some degree, and if so, will the value accrue in the ownership horizon of the typical buyer? If it is, this characteristic should be considered in the overall or yield rate selection. How long will the benefits accrue, and what will be required in terms of maintenance or replacement over and above a conventional building? For example, solar panels typically require ongoing monitoring that may cost extra, and the inverter typically needs to be replaced after 10 years or so. And how far into the 25–30 year economic life are the panels?

Since the subject and the market differ in sustainability orientation, special attention to the comparables is warranted. As shown in Exhibit 7, brown comparables may need to be adjusted for green features that add value, even in a brown (NSO) market. For example, in the warehouse example above, the typical lease is triple net, and the subject provides net-zero electrical power due to on-site generation. The comparables that lack this feature need to be adjusted upward to account for the fact that the occupant/tenant of the subject does not incur the typical energy expense. In addition, any green comparables will need to be carefully compared to the subject for differences in green features that impact value.

ROTE risks need to be considered for the subject, particularly in selecting the overall rate. If the subject is ahead of the curve, then its risk profile may be lower,
and this factor should be considered by lowering the overall capitalization or yield rate. For the Omaha warehouse example above, the subject’s green features might make it more marketable to logistics companies that supply Walmart, which requires its suppliers to report on sustainability initiatives, or the federal government GSA, which plans to ask its 600,000 registered suppliers who provide it with $600 billion in products and services annually to begin reporting greenhouse gas emissions. If there is evidence that these types of users are active in the market, the subject may be ahead of the comparables in meeting the future market demand. The appraiser would want to consider this in the risk analysis of the comparable overall rates, for example.

**Brown in an SO Market.** This category applies to a property that does not meet the three green building criteria presented earlier, but where the appraiser determines the market is sustainability oriented (SO). This is a brown building in a green (SO) market. An example of this would be an aging corporate headquarters campus in Oakland, California, which claimed the No. 2 spot in the Cushman & Wakefield Green Building Opportunity Index cited earlier. Here, the appraisal response is:

- Analyze green features = what is the subject missing?
- Review comparables to be sure they are or are not green and adjust as necessary.
- Consider ROTE risks.

For a brown building in a green market the risk is obsolescence, previously discussed as the brown discount. If the market is dominated by green/LEED-certified buildings, or there is clear evidence it is moving in that direction, what features does the subject need, in order to meet the market standard? Is it physically possible and financially feasible to “green-up”? The highest and best use analysis may need to include the financial feasibility of “greening up.” If the cost to cure renders the upgrade infeasible, then the highest and best use as improved may have to be reconsidered. Are the improvements a candidate for adaptive re-use, or is demolition and redevelopment the highest and best use?

As in the previous section, since the subject and the market differ in sustainability orientation, special attention to the comparables is warranted. If the rent comparables are located in LEED buildings and the subject is not, additional research is necessary to determine if there is a rent differential for LEED space. If so, an adjustment to the comparables is warranted.

The Sustainability Valuation Impact Grid (Exhibit 7) lists the various components of the income approach, where sustainability impact should be considered. Is there evidence of lower rents for non-green space? Should the vacancy rate be adjusted in the income statement? If a DCF is used, should down-time between leases be extended, or renewal probability reduced? If the building is vacant, should the absorption period be extended? Will the landlord have to “green-up” by getting the building LEED certified in order to land an attractive tenant, as was the case for the recent relocation of USGBC headquarters in Washington D.C.? If so, will the tenant improvement allowance be affected? Are utility costs likely to be higher
than market? Is a higher capital expense reserves allowance indicated? These factors will have a direct impact on the income stream and therefore, the value indication by the income approach.

ROTE risks rise to the fore for a brown building in a green market. While operational resource use has already been considered in the utility cost adjustment mentioned earlier, resource use risk could affect an aging building, which will require above-standard tenant improvement costs. Obsolescence risk is greatest for buildings that cannot be cost effectively greened up. All of the potential ROTE risks are best considered in the selection of the overall capitalization rate and/or discount rate. How brown is the subject relative to the comparables? If all the overall rate indicators are brown, despite the SO nature of the market, adjustment to the overall rate may not be warranted. Conversely, if the comparables are all LEED-certified, the subject would likely warrant a higher overall capitalization rate in an SO market. Paired-sale data to prove the appropriate load may not be available, and so the appraiser will have to rely on professional judgment after careful analysis of the market and the relative risks posed by the subject, at least until sufficient market data surfaces.

Finally, if a cost approach is used, the costing source will likely reflect green replacement cost for an SO market, and therefore the depreciation allowance should also consider the relative brownness of the subject.

Green in an SO Market. This category applies to a property that meets the three green building criteria presented earlier, and where the appraiser determines the market is also sustainability oriented (SO). This is a green building in a green (SO) market such as a Midtown Manhattan office building that is LEED-certified at the Platinum level. The appraisal response is:

- Analyze green features = adjust subject as necessary.
- Review comparables to be sure they are or are not green and adjust as necessary.
- Consider ROTE risks.

Here, line-by-line analysis of the LEED credits or green features is necessary to determine if the features add value, incur additional cost, and/or enhance marketability. Is there a net benefit or cost associated with the features?

Although the subject and the market are aligned in terms of sustainability orientation, the comparables still may need adjustment. Sustainability-oriented markets will still have a fair number of brown or non-LEED comparables for the foreseeable future. And even among LEED-certified buildings, it cannot be assumed that one LEED-certified building is “equal” to another even in the same market or at the same award level. The multiple versions and flexibility inherent in the LEED system means each property’s credit profile is distinctive, and has to be considered individually.

In the case of the Platinum-rated building example, the green features need to be analyzed for impacts on initial cost, operating cost, and ongoing capital costs like tenant improvements. Impacts on tenant satisfaction may affect employee
productivity, marketability of the space, and thus, tenant turnover and lease-up. For example, a raised-floor system that distributes HVAC beneath the floor typically reduces energy costs because the conditioned air is focused on the occupied portion of the space. Raised floors are also more readily reconfigured and therefore reduce future tenant improvement materials use and costs. Occupant satisfaction may be improved because the floor diffusers are individually adjustable. Happier tenants may impact renewal probability and achievable rents.

A greywater system that harvests rainwater and sink water for re-use in flushing toilets adds to construction costs initially but lowers potable water use and thus the ongoing water expense used in the income approach will be lower. Since water is currently relatively inexpensive, the cost savings may or may not justify the original cost, so in the cost approach, superadequacy may need to be addressed.

ROTE risks still need to be considered, especially in selection of the overall capitalization rates and/or discount for the subject. Since green buildings tend to have lower ROTE risk exposure, the brown comparables may need adjustment downward when developing the appropriate OAR and yield rate for the subject.

Step 3: Monitor over Time

Sustainability orientation of the market, and the “greenness” of the subject’s peers, will change over time and require monitoring, along with traditional market fundamentals like supply and demand, occupancy, net absorption, and rent levels. The important difference with sustainability is that the rate of change is rapid, and can be sudden and unexpected.

This step differs from Step 1 in that the information monitoring here is geared to the larger picture versus the primary local market and specific subject property. It is much easier to understand local changes when they can be viewed within a larger context. Examples of larger issues that should be considered are the previously mentioned new real estate sector-specific GRI reporting requirements, the pending HR 2336 that includes a provision, supported by the Appraisal Institute, requiring a higher level of competency for appraisers valuing green residential buildings, and the EPA’s recent designation of CO₂ as a pollutant that must be regulated.

Sources of sustainability and green building information are also different, and evolving. Much of the discussion occurs on blogs and through email from businesses and other organizations advocating green building. This is typical of market trends in the early stages of adoption, but care must be taken to look past the advocacy to see the information in a balanced, unbiased way. Many organizations, such as ULI, Appraisal Institute, CoStar, USGBC, and others, offer educational opportunities such as lectures and webinars, which can broaden the appraiser’s knowledge in this area.

Exhibit 8 provides some selected resources of currently available Internet-based sources of information that may prove useful to the appraiser for Steps 1 and 3 of the model.
Exhibit 8 | Monitoring Sustainability and Green Building Resources

These selected resources may be useful for monitoring trends in sustainability and green building and for assessing sustainability uptake as discussed in Steps 1 and 3 of the Sustainability Valuation Model.

REGULATIONS & INCENTIVES

- **USGBC searchable database for public policies and incentives**: http://www.usgbc.org/PublicPolicy/SearchPublicPolicies.aspx?PageID=1776

BLOGS AND SITES FOR NEWS AND TRENDS

- **Building Energy Performance News (BEPN) newsletter (free but sign up is required)**: http://www.bepinfo.com/default1.aspx
- **Greener Buildings website and blogs**: http://www.greenbiz.com/buildings:

USGBC (LEED) SPECIFIC INFO

- **USGBC searchable database for LEED-registered and LEED-certified properties**: http://www.usgbc.org/LEED/Project/CertifiedProjectList.aspx
- **To find a local USGBC chapter**: http://www.usgbc.org/FindaChapter/ChapList.aspx

THIRD-PARTY MARKET SURVEYS ON SUSTAINABILITY UPTAKE

- **Jones Lang LaSalle (JLL) annual survey**: http://www.joneslanglasalle.com/pages/SustainabilityResearch.aspx

Conclusion

Sustainability, the key principle underlying green building, is a global megatrend that influences consumer behaviors and business decisions across a wide range of industries. Thus, the impact of sustainability on real estate in the future will extend far beyond green building. To understand this influence on real property values—green or brown—requires a conceptual understanding of sustainability as it applies not just to real estate, but also within its broader context in society.

The current focus on the green premium, or even green building value, misses the larger picture: that sustainability is affecting everything around us, including all of the real estate that is not in any way sustainable, green, or high performance.
To miss this important connection is to come up short as valuation professionals. The challenge for appraisers, and anyone concerned with property valuation, will be to understand sustainability, and then incorporate a sustainability-oriented approach to real estate and valuation that is appropriate for the market, the property type, and the subject property under appraisal.

This article provides appraisers a methodology to meet that challenge. The definitions of sustainability, green building, and greenwashing presented above provide a foundation for understanding sustainability and the risks it poses to all real estate, green and brown. The ROTE risk categories, Exhibit 2, provide a method to identify and categorize the sustainability risks to both green and brown properties, so that the risks can be appropriately considered in adjustment of the comparables, and selection of the capitalization and/or yield rate. Finally, the Sustainability Valuation Model provides a systematic methodology that allows the sustainability orientation of the subject property to be considered in conjunction with the sustainability orientation of the market, and remains applicable as either, or both, change over time.

Sustainability may appear an entirely new and foreign valuation influence. In many ways, it is. But the solution is not that different from how appraisers approach any new market influence or appraisal problem: research, analysis, judgment. In real estate, and appraisal in particular, value is most often estimated by looking in the rear view mirror at comparables and last quarter’s market statistics to read the market and predict the market’s behavior. Sustainability brings an entirely new forward-looking, long-view approach that, while now unfamiliar, will influence valuation practice in the future.

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Timothy P. Runde, Carnegie-Blum & Partners, Inc., San Francisco, CA 94105 or trunde@comcast.net.
Stacey Thoyre, San Francisco, CA 94121 or sthoyre@prodigy.net.
Implementing ESG in Private Real Estate Portfolios: The Case of U.S. and Pan-Europe Core Fund Managers

Author  Tamara Larsen

Abstract  This paper provides an overview of current environmental, social, and governance (ESG) practice with some of the leading U.S. and pan-Europe institutional real estate open-end fund managers. There were 18 firms that participated in the interviews, which were conducted with 36 persons, of which 72% were at the decision maker level. The participant firms represented over $300 billion in assets under management at year-end 2009. The paper discusses how fund managers balance fiduciary responsibilities and sustainability goals, the impact of green regulatory pressures, holistic approaches to ESG implementation, green push/pull on tenants, perceived and realized economic returns to sustainability, and the need for internal and external “buy in” for sustainability implementation.

Environmental, social, and governance (ESG) factors represent a component of a full spectrum of sector attributes and manager skills for investors to consider in evaluating investment opportunities. Among the advantages of the real estate sector is that it offers the potential for a relatively practical, transparent way to connect progress on sustainability initiatives to the impact on an investment’s bottom line. Those managers who are farthest along in gaining momentum on initiatives that translate into positive investment returns are expected to be at a competitive advantage relative to their peers, particularly as regulatory and market forces increasingly reward strong ESG practices over time.

The focus is on managers of “core” strategy funds in the United States and Europe, which comprise a subset of Russell’s real estate private equity manager research coverage. Not all of the managers within the coverage universe participated in the discussions, and it does not reflect a scientific study or a statistically significant sample of the entire U.S. and European private real estate open-ended fund universe. However, the interview participants are leading institutional investment managers in private real estate (see the Appendix). The participants’ firms represented over $300 billion in assets under management at year-end 2009. There were 18 firms represented, with interviews conducted with 36 persons, of which 72% were at the decision maker level. These decision makers included global and regional heads of real estate teams, members of the portfolio and asset management teams, sustainability officers, acquisitions officers, research
team members, and members of the development, environmental, and engineering teams. It is not unreasonable to presume that those fund managers who agreed to participate in the interviews are those who have conviction on their sustainability goals, and have experienced traction in implementation of sustainability initiatives within their respective portfolios. Thus, the sample is likely to be biased. Additionally, while the themes presented in this paper reflect current practice, they may also represent “best” practice in certain regards.

Increasing numbers of fund management organizations are becoming signatories to the United Nations-backed Principles for Responsible Investment (PRI) initiative, which carries responsibilities with regard to implementing ESG into business practices as well as reporting to the UN. What follows is an overview of current ESG practice—highlights from a series of discussions with some of the leading U.S. and pan-European institutional real estate open-end fund managers.

**Major Themes in Current ESG Practice**

**Balancing Value with Values**

Much of the emphasis among the fund managers interviewed was on the “E” (“environmental”) element in ESG, rather than on the social and corporate governance elements. In part, this is due to the increasingly quantifiable aspects of no- and low-cost sustainability initiatives, as well as return on cost and near-term payback periods on sustainable building systems replacement and capital programs. Fund managers are seeking to balance their fiduciary responsibilities, economic return targets, and sustainability goals. Thus, a financial analysis is typically a part of the consideration of a particular sustainability initiative. Fund managers generally spoke of payback periods within four years or, as core investors, over the anticipated hold period of the investment. They also evaluated the return on cost or investment and the internal rate of return (IRR) associated with the initiatives. In certain cases, fund managers indicated that the IRR was in the double digits, far higher than what is typical for a core real estate investment.

**Green Regulatory Pressures**

Regulatory pressures are expected to play an increasing role in the pace of sustainability programs within the commercial real estate markets in the U.S. and Europe. In the U.K., the Energy Performance Certificate requirement has been implemented for residential, commercial, and public buildings. The certificates are required for the rental, sale or development of buildings, and must be displayed for public buildings and larger commercial buildings. Though the program is a step in the right direction with regard to consistency and transparency, one of the challenges mentioned during the interviews was the “theoretical” nature of the certificates. Multiple fund managers noted that the certificates are based on the energy efficiency potential given the profile of the building, rather than the in-place performance of the building. According to Neil Harris, of Invesco, at present there is no single recognized pan-Europe survey or product that can provide,
across property types, an indication of in-place sustainability performance by use of investment criteria designed to provide a context for payback and timing considerations.

The advent of energy performance certificates is indicative of the growing regulatory push toward a greater emphasis on sustainability in the commercial real estate market and on developing market-accepted ways to measure sustainability performance. For both U.S. and European portfolios, fund managers spoke of engaging third-party “sustainability auditors” to conduct performance reviews and provide recommendations for improvements. Such recommendations were deemed useful not only for managers for internal considerations, but also for tenants, particularly in instances where tenants are directly engaged with the utility providers.

The connection between the regulatory framework and sustainability in commercial real estate investment is expected to grow stronger over time. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the U.S. Green Building Council (USGBC), and the Illuminating Engineering Society have published a new U.S. standard that “defines the minimum requirements for a high-performance green building” that will be code-intended (ASHRAE, 2010). That work product, Standard 189.1, has five key focus areas: site sustainability, water use efficiency, energy efficiency, indoor environmental quality, and the building’s impact on the atmosphere, materials, and resources. The intent is for Standard 189.1 to be adopted into local building codes; if implemented, it would be part of a broader regulatory framework that increasingly rewards sustainable buildings.

**Holistic Approaches to ESG Issues**

The fund managers spoke of the goal of integrating sustainability into the investment framework for a more holistic approach. Among those interviewed, sustainability initiatives were increasingly included as part of the annual business plan and capital budgeting process within asset management, as well as asset strategy reviews with the fund management team.

The sheer size of these portfolios can enhance fund managers’ ability to implement holistic approaches. For instance, Michael Spies, of Tishman Speyer, spoke of the firm’s decision to buy “green energy” in bulk in Germany. The sponsor signed a three-year contract that locked in the cost structure during what was a volatile pricing period, purchased “green energy” and thereby helped to create the market. The contract pricing represented a savings to the portfolio, and now the German portfolio has green energy.

Giving another example of a holistic approach, Nicholas Stolatis, of TIAA-CREF, spoke of considering a capital program for replacing chillers and other building systems that are approaching their useful life expectancy, where earlier replacement with more efficient systems may have an accretive, positive impact on returns. The building systems emphasis had particular traction in the industrial sector, where tenants’ direct payment of utility bills and tenant uses within the spaces can pose challenges to landlord engagement.
“Buy-in” for Sustainability Implementation

To support successful implementation, stakeholders—the fund management team, property management firms, and joint-venture partners—need to be “on board” with sustainability initiatives. The ability to accelerate implementation of sustainability initiatives that positively impact the bottom line can, across a portfolio of assets, significantly impact the value of a fund. Successful implementation of accretive sustainability initiatives can help to protect and enhance property values through real estate market cycles (all other things held constant).

Setting Policy. The degree of internal, joint-venture partner, and property management buy-in and information sharing on sustainability initiatives can enhance traction in implementation, accelerating the impact to the bottom line. Fund managers spoke of members of the asset management team, engineering team, and property management team approaching the annual business plan and capital planning process with a holistic approach to evaluating ways to increase sustainability. They also noted the benefits of sharing sustainability “best practices,” based on actual experiences within the operating portfolios, with the acquisitions team. Additionally, the information sharing appears to span across regions. For instance, Tom Enger, of UBS Global Asset Management, spoke of ongoing “best practice calls” with counterparts in Europe to discuss certification efforts and property management practices.

Most of the firms have instituted a sustainability policy at the corporate level, which was readily available upon request. The corporate policy establishes a framework from which the investment teams can approach sustainability. The real estate groups that were a part of a broader organization had, in certain cases, developed their own sustainability policy or set of guidelines. As Preston Sargent, of Multi-Employer Property Trust (MEPT), put it, the mission statement “plants a flag” and establishes a context so that managers can “begin the process of creating coherent terms.” Even as the economic crisis affected the global private real estate market, implementation of sustainability into day-to-day fund management practices appears to have gained momentum in the last two years among the fund managers interviewed. While certain managers were actively evaluating efficiency initiatives for some years, others reported increased awareness and traction in just the last few years.

Implementing Policy. The implementation process requires buy-in not only from internal teams, but also from third-party partners involved in investment management. In most cases, third-party firms are engaged to provide property management and leasing services at the property level. Additionally, given the magnitude of the assets, joint-venture partners may have monetary interest in the investments, with some acting as general partners where there may be property management and leasing services provided as well (in “vertical integration”).

Certain fund managers have developed sustainability guidelines that are provided to joint-venture partners as well as property managers. These guidelines cover sustainable asset management, energy conservation, green cleaning, indoor air
quality, sustainable purchasing, solid waste management, and water conservation. Adrian Benedict and Aymeric De Seresin, of Fidelity’s Europe team, indicated that there is variation by region in terms of property management engagement with responsible property investing (RPI)-type policies. They indicated that, in comparison to the U.K., RPI-type policies are relatively new for property managers in France and Germany, though potential changes in public policy would have an impact. They spoke of Fidelity’s efforts to “go beyond the regulations of countries” in order to have a consistent set of sustainability goals and benchmarking tools across Fidelity’s portfolios.

However, there is also increasing awareness that sustainability guidelines for property management must be nimble enough to account for variation by region or country. For instance, Brett Levy and Bill Anderson, of Prudential, talked of how the lighting guidelines for the U.S. are not globally applicable. Levy and Anderson spoke of “molding” guidelines for use in various regions.

**Green Push/Pull on Tenants**

Tenants play a critical role in sustainability efforts, in terms of investment performance from the demand side point of view and also in terms of the practical application of a landlord’s sustainability initiatives. Depending on lease structure, a landlord may have limited ability to oblige tenant participation. Fund managers spoke of educational efforts to bring tenants up the learning curve with regard to occupancy cost savings associated with sustainability practices within their space.

A relatively recent innovation has been the concept of “green leases.” In such leases, fund managers have revised their standard tenant leases to include certain provisions, which might include tenant reporting on energy performance within the tenant unit, compliance with landlord sustainability guidelines, and terms that support a landlord-tenant “partnership approach” to sustainability within the building. For the fund managers with U.S. portfolios, the U.K. Energy Performance Certificate program and innovation in leasing for green elements is especially timely, given movements in Washington, D.C. and California (and possibly other states, in the future) to require the provision of energy data in commercial transactions.

It is clear that multiple forces are at work in putting sustainability initiatives on the agenda for fund managers. Though the current period represents the early stages of ESG development in the U.S. and European commercial real estate markets, the discussion above suggests that regulatory (i.e., federal, state, and municipal policy) and market (i.e., investor, tenant, and future buyer demand) pressures will increasingly reward high-performance buildings (or discount low-performance buildings). Thus, those fund managers who are able to construct property portfolios weighted toward high-performance buildings will be better positioned to maintain or enhance the value of their portfolios over time.

**“Getting Paid to be Green”**

A “green premium” is not yet believed to be manifest in the transaction market. However, certain fund managers indicated enhanced traction in tenant retention
and tenant appeal associated with ESG initiatives. For U.S. commercial buildings in the CoStar database, Fuerst and McAllister (2008) identified lower vacancy rates and higher rents in Leadership in Energy and Environmental Design (LEED)-rated buildings. However, they noted “significant differences between the sample and the wider population” that were not controlled for, such that certified buildings tended “to be newer, owner-occupied or single tenanted, concentrated geographically and sectorally (in the office sector).” Generally, the fund managers did not believe that the current market offered a green premium on the sale of high-performance buildings.

It is widely believed, however, that high-performance buildings are able to enhance tenant appeal and retention through lower total occupancy costs (rent plus the tenant’s share of other expenses associated with tenant space and with use of common areas of the building). In today’s market, wherein many businesses are retrenching and competition for tenants is fierce, the ability to attract and retain tenants and hold occupancy is no small feat.

The “future proofing” idea, to be discussed in more detail below, suggests that the rewards to high-performance buildings will increase over time. Over time, the market is expected to increasingly differentiate between high- and low-performance buildings. If high-performance buildings become the new standard for high quality “Class A” institutional buildings, then the buyer base for such properties may become deeper relative to low-performance buildings. A deeper institutional buyer base offers the potential to translate into upward pressure on pricing in the event of a sale of the property.

Increased Fortune 500 Interest in Sustainability. A recurring theme in manager discussions is that Fortune 500 tenants are particularly interested in sustainability labeling or “green certification” as they seek to meet their own sustainability goals. Such labeling might include ENERGY STAR and Leadership in Environment and Energy Design (LEED), in the U.S.; Building Research Establishment Environmental Assessment Method (BREEAM), in the U.K.; Haute Qualité Environnementale (HQE), in France; Protocollo ITACA, in Italy; and the German Sustainable Building Council (DGNB), in Germany (see the Glossary). For the U.S., recent federal policy is such that building owners seeking to attract federal agencies as tenants must have the ENERGY STAR label.

Saving Money May Boost Valuations. Fund managers indicated that independent surveyors or appraisers are recognizing in-place operating expense savings associated with ESG initiatives when estimating the market value of properties. Institutional real estate private equity open-end funds are distinguished from their unlisted closed-end counterparts in part by the scheduled external appraisal and “mark to market” processes, which may be applied on a monthly, quarterly or annual basis. In-place vacancy and leasing assumptions have a significant impact on the discounted cash flow analysis performed to value properties. Thus, the tenancy of investment properties and the appraisers’ or surveyors’ view of the prospects for leasing up vacancy and near-term lease expirations over the forecast horizon have a meaningful, ongoing impact to the valuation of the funds.

According to the fund managers, the surveyors are incorporating in-place operating expense savings into their valuation analyses. However, prospective
Implementing ESG in Private Real Estate Portfolios

savings associated with sustainability initiatives that have not been completed are not included in the discounted cash flow. Additionally, the fund managers’ general view was that U.S. and European surveyors were not impacting the discount rate or exit cap rate associated with the sustainability performance or certification of a given building. To the extent that operating expense savings have been achieved by a specific asset relative to its peer set, it is reasonable to conclude that sustainability initiatives leading to incremental expense savings and higher net operating income will translate to a higher property value (all other things held constant) or a higher purchase price for a future buyer.

Development of Frameworks/“Scorecards”

Certain managers appear to be developing their own performance measurement frameworks, or “scorecards,” to compare the sustainability performance of assets within their portfolios across property types and countries. Michael Loose, of UBS, described how the UBS construction and development team in Europe was taking elements of existing certification programs, such as LEED and BREEAM, and incorporating them into an overall framework that could be applied consistently across their portfolios. Nicholas Stolatis spoke of developing a proprietary benchmarking system for the retail portfolio, with an emphasis on tools to measure energy efficiency, even though there is limited labeling opportunity. More than one sponsor spoke of the ability to do the initial training of property managers and internal engineering teams with third-party consultants, particularly at the acquisition phase, and then to conduct the ongoing sustainability evaluation without the third-party consultants. This approach offers the potential to significantly lower the year-to-year costs associated with monitoring progress on sustainability performance at the asset level. Michael Loose indicated that his comparison test of performance data from property management staff and third-party consultants showed little variation, which supported his view that there was sufficient integrity in the data gathered by the property managers.

The variations in approaches to sustainability and the challenges inherent in developing benchmarks applicable across both property types and countries signal that the evolution of ESG is still in the early stages. However, they also represent an opportunity for fund managers to develop and implement sustainability initiatives that will have a positive impact on their portfolios’ bottom lines—ahead of their peers, and in line with anticipated changes in regulatory environments. Implementing sustainability initiatives is not only a strategy to potentially enhance investment performance; it can also be viewed as part of a broader risk management approach.

“Future Proofing”

Fund managers expect that the market will increasingly differentiate between high- and low-performance buildings. Fund managers spoke of the “future proofing” impact of implementing sustainability initiatives. Richard Schaupp, of ING, indicated that from an efficiency and sustainability standpoint, high-performance buildings are becoming “the standard for being Class A” buildings in “top-tier
markets.” Jim Kennedy, of J.P. Morgan, said that “at some point, inefficiency will translate into a competitive disadvantage.” That disadvantage may result in a reduced pool of potential buyers, particularly institutional investors, in the event of a sale of the property.

Regulatory changes that have been implemented or that are perceived to be on the horizon are also having an impact on sustainability initiatives. Andrew Smith, of Aberdeen Asset Management, spoke of proactively going “beyond the minimum in each country” to ensure that the appropriate energy performance ratings were in place, in an effort to preempt anticipated regulatory changes. Tom Enger indicated that UBS’s U.S. team uses regulatory and technology changes in Europe as a proxy for what is to come in the U.S.

There is also the view that high-performance buildings will gain momentum with regard to tenant demand and market rents, particularly during the growth phases of a real estate cycle. Michael Kirby, of Invesco’s U.S. team, believes that “in five years, and especially in ten years, buildings that have the right sustainability designation or policy will garner higher rents.” Dave Morrison, of Morgan Stanley, believes that the “tremendous payback in cost savings” translates to limited downside risk associated with implementing certain sustainability initiatives, but that the “unknowns are risks to upside.” (PRUPIM took the “future proofing” idea a step further by incorporating a sustainability questionnaire into its asset appraisal process, the output of which is a “statement on future proofing” by building. An associated impact is the ability to “evangelize” the issue among surveyors.)

Approaches to Sustainability

The fund managers are engaged in an investment process that they expect will yield compelling economic returns associated with specific strategies. The implementation of each strategy is typically executed over the “life cycle” of an investment, which includes acquiring the asset, implementing a business plan during the investment period, and disposing of the asset, with ongoing reporting of asset performance. This section looks at how fund managers are approaching sustainability over the life cycles of investments within the fund portfolios. As will be discussed herein, there is significant variation in the scope and traction of sustainability initiatives by property type and region. Among the fund managers interviewed, sustainability programs within the investment framework typically included combinations of the following:

Acquisitions/Development

- Sustainable real estate development
- Pollution prevention
- Benchmarking and certifications under regional programs that identify environmental “best practice”
Portfolio/Asset Management
- Energy conservation and carbon reduction
- Water conservation
- Solid waste management, including construction waste management
- Indoor air quality
- Green cleaning
- Green leasing
- Sustainable procurement/purchasing
- Benchmarking and certification under regional programs that identify environmental “best practice”

External & Internal Engagement
- Sustainability awareness and training
- Reporting
- Public engagement/consultation

Acquisitions/Development
A key part of the investment proposition is the ability to “buy right.” Incorporating ESG into the acquisition and development stages can enhance the competitive positioning of an asset within its submarket, as well as its investment performance. Some fund managers have begun specifically to include ESG components in their investment opportunities review process (by including sustainability in a separate section of the investment committee book), while others are focused more on operational review of a particular acquisition (by including sustainability in the acquisitions checklist and asset management review).

The fund managers did not indicate that they were currently including the economic benefits of implementing sustainability initiatives in their acquisition pro forma underwriting. However, they did speak of their increasing expertise in quantifying the economic benefit and timing for specific sustainability initiatives as contributing to upside potential.

For new development, there was an emphasis on certification. The fund managers spoke of the limited incremental costs associated with developing new projects to meet sustainability certification standards, due to local regulatory requirements and to expected gains in tenant attraction, particularly large corporate (i.e., Fortune 500) tenants seeking to meet their own sustainability goals.

Due to the core strategy orientation of the sponsor funds, many of the fund managers take a relatively conservative approach to environmental pollution, particularly with regard to liability risk. Typically, core funds take minimal environmental risk in the acquisition of assets. These funds tend to require completion of cleanup efforts to regulatory standards at a minimum, and a notice of regulatory compliance (such as, in the U.S., a “No Further Action” letter) prior
to acquisition, with the asset management and engineering team engaged to address any pollution matters that arise post-acquisition.

**Portfolio and Asset Management**

The asset management stage represents the fund manager’s opportunity to execute a business plan that will enable the fund manager to monetize the value creation upon sale of the property. Most of the world’s building inventory is in existing stock, and as Paul McNamara, of PRUPIM, put it, existing stock “is the major battleground” for implementing sustainability in commercial real estate.

Typically, upon acquisition of an investment property, the asset management team undertakes day-to-day operations management. The team works with the portfolio manager and is closely engaged with the third-party property management team. To the extent that implementation of ESG initiatives at the asset management stage translates to enhanced revenue or reduced operating expenses for a property, the fund manager should be able to realize a higher value for the investment (all other things held constant).

**External and Internal Engagement**

As discussed above, the actual implementation of sustainability initiatives involves the successful engagement of internal and external stakeholders over the life cycle of an investment. These stakeholders may include members of the fund management team, as well as third-party property management team members, joint venture partners, and even tenants. Certain fund managers have implemented sustainability policies that have direct application to the internal real estate investment “practice,” as well as policies and procedures that have been incorporated into the governing documents for property operations and management. The policies help to build awareness and, to the extent that they incorporate reporting guidelines on sustainability initiatives, support the development of a benchmarking framework across an investment or property management portfolio. The reporting element may feed into internal and external reports, such as a firm’s overall annual sustainability report or a fund’s quarterly investor report. Generally, the sustainability benchmarking and reporting frameworks are still in the early stages, with varying degrees of traction across certain property types, markets, or countries. However, the development of a reporting process supports an ongoing feedback loop between the stakeholders engaged at the investment level (i.e., fund management team, joint venture partner, property management team, tenants) and the broader investor base for a given fund.

**Low- to No-cost Approaches**

Fund managers appear to be pursuing low- and no-cost sustainable operational initiatives across property types (office, retail, industrial, and multifamily). As Paul McNamara, of PRUPIM, put it, “the low-hanging fruit of portfolio management” is in the “myriad of small actions that can lessen the environmental footprint.”
Fund managers often spoke of the “practical aspects” of sustainability initiatives, such as installing energy-efficient light fixtures or transitioning to green cleaning. (A frequently cited no-cost strategy is simply turning off the lights in vacant spaces.) This orientation is supported by industry research in energy efficiency projects reported by real estate decision makers. In the 2009 Johnson Controls Study, companies that allocated capital to energy efficiency projects targeted “energy efficient lighting (77% response), adjusting HVAC controls (64% response), and educating facilities operators on efficient building management practices (62% response)” (Peterson and Gammill, 2009).

Michael Spies, of Tishman Speyer, gave an interesting example of a practical no-cost approach to reducing energy consumption in an office building. One of Tishman Speyer’s assets under management is occupied as the European headquarters of a multinational company. With the prior agreement of the company’s senior management, Tishman Speyer adjusted the building controls to raise the temperature by one degree every few days and waited until the calls came in—at which point, Tishman Speyer knew that the adjustment had gone too far. The simple strategy translated to a change of about 2 degrees Celsius or 3 degrees Fahrenheit, yet had a material impact on that building’s energy consumption during the hot summer months.

Industrial Properties Lag Behind. Generally, the fund managers interviewed reported much less traction in the industrial segment of their portfolios, due to lease structures and variation in tenant uses of space. According to the U.S. fund managers, the industrial sector lacks an energy benchmarking system that provides meaningful data. The application of ENERGY STAR to industrial buildings has not translated well thus far; and a USGBC working group is engaged in creating a LEED standard for warehouse and distribution centers. For Aaron Binkley, AMB’s sustainability officer, the emphasis was on retrofits and upgrades for water and energy conservation from a building systems approach. According to Binkley, the building systems approach serves as a proxy for a sustainability benchmarking system.

Fund managers have also been proactive in reaching out to regulatory authorities for assistance in developing useful tools for benchmarking industrial properties. For instance, Prudential found that industrial tenants engaged in laboratory work tend to be “voracious users of energy.” Brett Levy and Bill Anderson spoke of approaching the U.S. Environmental Protection Agency to develop an ENERGY STAR subset for laboratory users, to encourage best practices for that tenant set.

The Residential Sector Also Lags. The fund managers interviewed typically do not invest in the residential sector for the European portfolios. In U.S. multifamily, the fact that tenants typically deal directly with the utility companies has been cited as limiting landlord sustainability initiatives. From an alignment of interest point of view, however, the perception is that there is limited financial incentive to lower operating expenses in this sector, given the muted impact to the landlord’s bottom line.

Dave Morrison, of Morgan Stanley, spoke of “baseline measurements” performed by a third-party consultant on a subset of apartment properties within the core
fund portfolio. For that fund, the property management firm’s (AMLI’s) engineering team accompanied the consultant to train the team to conduct energy audits on multifamily properties. The plan is to transition the ongoing sustainability audits to the property management team, rather than continue to use third-party consultants.

AMLI then began to incorporate sustainability elements into its operating performance “dashboard,” which uploads data from all assets under management for comparative statistics on tenant retention, leasing velocity, cost controls, etc. (The statistics are shared across the entire company and serve as a motivation tool for performance. The dashboard is referenced on national meeting calls and serves as the basis for rewarding outperformers.) A “green dashboard” will have data for electrical consumption in the common areas and vacant units; water usage; “green spend” (i.e., appliance purchases); nontoxic material for recaulking and painting; cleaning/gardening materials; education for tenants on green practices; and overall recycling volumes. Through its energy performance audits and active property management engagement, this sponsor demonstrated the potential for considerable traction in the multifamily sector.

Measuring Success and Creating Standards

As discussed above, the desire to reliably identify opportunities to enhance the value of a property or portfolio through sustainability initiatives leads directly to the issue of benchmarking. Fund managers have not been able to identify a sustainability benchmarking system that is applicable across countries. For instance, Michael Loose said that he “could not compare a BREEAM ‘excellent’ to a LEED ‘gold.’” A number of managers cited the sheer volume of sustainability labeling products and benchmarking certifications in the global market as a challenge to increased engagement, since it does take time and resources to sift through the various programs.

Generally, managers of U.S. portfolios seem to have had the most traction with sustainability initiatives within their office portfolios. This is due in part to the dearth of benchmarking systems in the U.S. that translate well for retail and industrial property types. Additionally, the structure of tenant leases and allocation of operating expenses may pose challenges. Some U.S. fund managers had moved subsets of their office portfolios, and others, such as Invesco, had transitioned their entire office portfolios into ENERGY STAR as a baseline. Jay Butterfield and Paul Vacheron, of American Realty Advisors, both spoke of using ENERGY STAR within the asset management process, such that low-end scores trigger more analysis of ways to increase efficiency. According to Preston Sargent, if an asset is seen to fall below a target threshold for portfolio operating efficiency, it may be put on an accelerated track for consideration for sale. Over the long term, active culling conducted from an operating performance perspective may enhance the quality of the portfolio and the competitive positioning of the holdings in their respective markets.
An interesting development with regard to U.S. LEED for Existing Buildings (LEED-EB) is a pilot program for certification of portfolios of office buildings, instead of the typical individual asset certification process. Certain fund managers spoke of the costs associated with involving consultants in the LEED certification process, which impacted the economics of seeking LEED labeling even for high-performance buildings. The pilot will enable portfolios of office buildings (including suburban and urban, single- and multi-tenant, and multiple markets profiles) to proceed through the certification process at once. MEPT is participating in the pilot with a high-performance subset of its portfolio. In theory, the process will establish a consistent set of policies and procedures that would be structured as a one-time cost to the fund; then the process could be replicated on a lower-cost basis across the fund. The economies of scale associated with such a process for owners of large portfolios may fit well within the open-end fund investment framework.

According to Jack Beuttell, of Hines, the company is participating in the ASHRAE pilot program, Building Energy Quotient. For that program, the visual and labeling scheme is based on the European Energy Performance Certificate program. Building Energy Quotient will have two key labels, “As Designed” and “In Operation.” The labels can be compared side by side to determine any gaps between design and operations, why those gaps occurred, and how to correct them. Beuttell indicated that the ASHRAE pilot offers the potential to be a comprehensive energy tool, due to its dual labeling process.

**Interpreting the “S” and “G” in ESG**

Much of the emphasis among the fund managers was on the “E” (“environmental”) element in ESG, rather than on social and corporate governance. In part, this is due to the increasingly quantifiable aspects of no- and low-cost sustainability initiatives, as well as return on cost and near-term payback periods on sustainable building systems programs. However, overall there was a sense that responsible property investing was “the right thing to do” and that it fit well within a fiduciary framework emphasizing sustainability initiatives that enhance economic value for investors.

**Developing a Common Language on ESG**

Even though many of these open-ended core funds have a significant proportion of their portfolios in urban infill communities and transit-oriented locations in major markets, there was not necessarily a strong identification with such portfolio characteristics as part of the social component of ESG. Similarly, it is standard practice among these funds to seek to comply with the regulatory framework in the communities in which they invest. Yet that approach is not necessarily viewed as a “governance” component for ESG. This may be due in part to investment managers being in the early stages of developing a common language around ESG, which will continue to evolve as more sponsor firms sign on to the UN’s PRI initiative and the definition of “sustainability” is more broadly considered.
Investor Base Impact

The composition and orientation of the underlying investor base also plays a role in the interpretation, as does the investment strategy. For instance, a U.S. fund with a high proportion of building trade unions and pension plans may be likely to have a responsible contractor policy that emphasizes fair labor practices (i.e., living wage, health care, pension benefits), such as MEPT’s and American Realty’s. That orientation may be supported by a belief that the responsible labor policy will result in projects that are more likely to be completed on time, on budget, and at a high level of craftsmanship. The series of interviews for this research paper targeted “core” real estate private equity open-ended funds, where there is typically less emphasis on development/new construction and redevelopment strategies.

Corporate Governance Orientation

From a corporate governance standpoint, the fund managers tended to talk of efforts to share information with the shareholders and investor base through annual reports (and in certain cases quarterly fund reports). Fund managers did indicate increasing investor interest in sustainability initiatives, but that interest had been answered largely through use of one-off questionnaires or review of investor requests for proposals. Certain fund managers will be issuing annual company sustainability reports, which will include progress on sustainability initiatives for underlying funds. Fund managers have also become signatories with organizations that support transparency in sustainability reporting. For instance, in addition to participating in the UN’s PRI, TIAA-CREF joined the Carbon Disclosure Project, which is a mechanism for organizations to “measure and disclose their greenhouse gas emissions and climate change strategies” (Carbon Disclosure Project, 2009). Fund managers spoke of compliance with ISO 14001, which is part of the International Organization for Standardization of good management practice recommendations. If compliance builds momentum within the international fund manager community, it may provide a helpful framework for supporting transparency on sustainability.

It is worth noting that the pool of funds that were the focus for this paper are institutional core private real estate funds that, typically, include advisory councils or committees as part of the standard fund governance structure. The advisory councils often comprise a range of investor types, including larger investors and consultants. The advisory councils provide policy guidance, review matters relating to conflicts of interest and act as “sounding boards” for the fund manager. Representatives are typically nominated for a specific advisory council term. Additionally, the U.S. funds may also include a fund board of directors, with independent director participation. Generally, the advisory councils further support the feedback loop between the investor base and the fund management team and, in certain cases, the fund board of directors. It is reasonable to consider the advisory council governance mechanism as standard practice among these types of institutional open-ended private real estate funds.
Conclusion

The recent financial crisis and economic slowdown impacted real estate portfolios worldwide, and the fund managers interviewed have not been immune. However, the interviews suggest that they are finding ways to leverage their sustainability initiatives to attract and retain tenants, reduce operating expenses, and more thoughtfully craft their building systems and capital investment programs—all of which can have a positive impact on the bottom line and potentially “future proof” their assets for enhanced competitive positioning and valuation over the longer term. The emphasis on performance measurement offers a way to quantify the impact of sustainability initiatives and tie it back to financial performance in a consistent, measurable way.

Though there is still significant progress to be made with regard to benchmarking tools across property types and consistency in certification standards across regions, some fund managers are moving forward with innovative approaches to track sustainability performance for their portfolios. These “early movers” appear poised to reap near-term economic benefits associated with low- to no-cost initiatives, enhanced tenant appeal, reduced operating expenses, and lower volatility in asset cash flow. Over the long term (all other things held constant), traction on accretive sustainability initiatives can position properties for higher overall performance—due to a broadened tenant pool, increased tenant retention, a deeper buyer base (particularly among institutional buyers), and higher asset valuation.

Glossary

BREEAM BRE Environmental Assessment Method (U.K.); the system considers a broad range of environmental impacts under the following issue categories: management, health and well-being, energy, transport, water, materials and waste, land use and ecology, and pollution. Versions are updated regularly in line with U.K. building regulations. Current versions include Court, EcoHomes, Education, Healthcare, Industrial, Multi-Residential, Office, Prisons and Retail. Versions under development include Developments and In-Use. Versions of BREEAM have been adapted for use in other countries (Lowe and Ponce, 2009).

Protocollo ITACA Istituto per l’Innovazione e Trasparenza degli Appalti e la compatibilità ambientale (Italy); Federal Association of the Italian Regions. The full version of the system includes the following categories: site quality, energy and resource consumption, environmental loadings, and indoor environmental quality. Versions of Protocollo ITACA currently exist for residential buildings, with systems under development for office, retail, school and tall buildings.
Protocolla ITACA is an adaptation of SBTool, which has been adapted for use in several countries (Lowe and Ponce, 2009).

**HQE**

Haute Qualité Environnementale (France); National certification system for residential and non-residential buildings. The system identifies 14 environmental issues and covers two aspects: environmental quality of the building and environmental management of the entire project. Current versions of HQE include: commercial centers, hotels, schools, houses, residential, offices and in-use. Versions that are under development include healthcare, sports buildings and operational buildings. Versions of HQE have been adapted for use in other countries (Lowe and Ponce, 2009).

**High-Performance Building**

The United States National Renewable Energy Laboratory definition is a building that “integrates and optimizes on a life cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations,” (Peterson and Gammill, 2009).

**LEED**

Leadership in Energy and Environmental Design (U.S.); Each version of LEED covers a range of environmental impacts under the following issue categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation. The following LEED versions currently exist: New Construction, Existing Buildings, Commercial Interiors, Core and Shell, Schools, and Homes. The following versions are under development: Retail, Healthcare, Neighborhoods. Versions of LEED have been adapted for use in other countries (Lowe and Ponce, 2009).

**Appendix**

**Interview Participants**

I would like to extend special thanks to all those persons who generously gave their time for interviews.

Andrew Smith, Global Head of Property/Aberdeen Asset Management, €24.6 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Aaron Binkley, Director-Sustainability Programs/AMB Property Corporation, gross private real estate AUM of $12.5 billion at December 31, 2009.

Jay Butterfield, Managing Director–Fund/Separate Account Operations, and Paul Vacheron, Managing Director–Asset Management/American Realty Advisors, $3.3 billion gross private real estate AUM at March 31, 2010.
Brian Murdy, Portfolio Manager/Cornerstone Real Estate Advisers, $31.0 billion gross private real estate AUM at December 31, 2009.

Adrian Benedict, Investment Director–European Real Estate, and Aymeric De Seresin, Portfolio Manager/Fidelity International Limited, AUM not available.

Jack Beuttell, Global Sustainability Manager, Daniel Chang, Asset Manager, Andrew Joyner, Fund Analyst, and Andy Smith, Associate/Hines, $22.2 billion gross private real estate AUM at December 31, 2009.

Richard Schaupp, Senior Vice President and Chairman of ING Clarion Partners’ Sustainability Task Force/ING Investment Management, $21.4 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Neil Harris, European Head of Asset Management, and Michael Kirby, Managing Director–Director of U.S. Operations and Asset Management/Invesco Real Estate, $26.5 billion gross real estate AUM at March 31, 2010.

Ann Cole, Client Portfolio Manager, and Jim Kennedy, Managing Director–Head of Development and Engineering/J.P. Morgan Asset Management–Global Real Assets, $38.4 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Tuba Malinowski, Director–Marketing and ClientServices, and Meighan Phillips, Assistant Portfolio Manager/Principal Real Estate, real estate AUM of $33.0 billion at December 31, 2009.

Bill Anderson, Principal–PRISA Asset Management, and Brett Levy, Director of Sustainability/Prudential Real Estate Counsel, $22.1 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Paul McNamara BSc (Hons) PhD ASIP FRSA OBE, Director-Head of Research, and Robert Tidy, Director–Fund Management/PRUPIM, $23.4 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Vadim Goland, Assistant Portfolio Manager, Nicholas Stolatis, Director-Strategic Initiatives Asset Management, and Cherie Santos-Wuest, Director-Global Social and Community Investments/TIAA-CREF, $39.2 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Michael Spies, Senior Managing Director-Head of Europe, and Sarah Warmisham, Director-Equity Capital Markets/Tishman Speyer, $31.7 billion gross private real estate AUM at December 31, 2009.

Tom Enger, West Region Head for Asset Management, Michael Loose Executive Director-Head Construction and Development Europe, Deborah Ulian, Director, and Roberto Varandas, Head of Business Development-Continental Europe/UBS Global Real Estate, $54.1 billion gross private real estate AUM at December 31, 2009, Signatory to UN PRI.

Endnotes

ISO 14001 “gives the requirements for environmental management systems, confirms its global relevance for organizations wishing to operate in an environmentally sustainable manner” (ISO, 2009). The standard provides “a framework for a holistic, strategic approach to the organization’s environmental policy, plans and actions...by establishing a common reference for communicating about environmental management issues between organizations and their customers, regulators, the public and other stakeholders.” (ISO, 2009).

AMB AUM represents the company’s estimate of assets owned or managed through co-investments.

Firm private real estate AUM of $3.3 billion represents gross market value of all assets and accounts managed by American as of March 31, 2010, excluding partners’ share of equity and partner’s share of debt on partnership investments.

Firm private real estate AUM of $31.0 billion as of December 31, 2009, and includes subsequently combined entities.

Real estate AUM represents gross fair market value of the real estate assets managed by Morgan Stanley on behalf of the firm and its clients, presented at direct ownership interest. Real estate AUM for certain minority interests represents Morgan Stanley’s equity investment in the entity, rather than the gross fair market value of the underlying real estate assets.

Real estate AUM represents real property direct investments (gross), fund investments, and commercial mortgages.

AUM stated on gross asset value basis, reflecting property values as at December 31, 2009, where available. Includes assets managed by the joint venture with Mitsubishi Corporation, Japan.

References


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Tamara Larsen, Russell Investments, San Diego, CA 92122 or tlarsen@russell.com.

Author  
Scott Anders

Abstract  
This paper evaluates a range of policies within local government authority to reduce greenhouse gas (GHG) emissions from electric and natural gas use associated with buildings. San Diego County is used as a case study because significant work already has been completed to characterize regional emissions. Within San Diego County, GHG emissions associated with buildings constitute about 30% of total emissions. It appears that statewide building and appliance standards and utility-administered efficiency incentive programs combined with local government policies could reduce emissions enough to meet California’s 2020 greenhouse gas targets as applied to the San Diego region; however, to reach long-term targets that seek to cut emissions significantly below 1990 levels by 2050, more aggressive policies would be needed.

Even though climate change is a global phenomenon, policy action at the international, state, and local levels will be required to achieve long-term greenhouse gas (GHG) reduction targets. While some overlap in responsibility among levels of government exists, each has some unique jurisdiction to adopt policies that affect GHG emissions. This paper focuses on the role of local governments, including cities and counties, to adopt policies that can reduce emissions and contribute to statewide or national reduction targets. The San Diego region is used as a case study because significant analysis has already been done to characterize emissions and potential mitigation strategies. In September 2008, an inventory of GHG emissions was developed. It estimated the San Diego region’s GHG emissions and identified strategies to reduce regional emissions to 1990 levels by 2020, as required by California law. While a necessary step in the GHG mitigation process, it did not provide any specific analysis to determine which specific policy actions could achieve reductions necessary to meet California’s GHG reduction targets, nor did it provide any way to prioritize activities and policies. This paper conducts more detailed analysis on strategies and policies related to energy use in buildings and assesses policy options based on their potential to reduce GHGs, implementation cost, and experience by other jurisdictions to help evaluate and prioritize mitigation actions.
The results presented here are not intended to be a detailed cost effectiveness or GHG reduction analysis; rather, the results should be viewed as preliminary information to understand relative cost and the GHG reduction potential of the policies assessed. Exhibit 1 provides a list of the policies assessed, indicates whether the policy is applied to existing or new buildings, and lists examples of jurisdictions that have adopted the policy.

The research presented here focuses on policies that local governments can adopt because their jurisdiction allows them to directly regulate an area or to influence implementation of state and federal policies and programs (typically making them stricter) and that could reduce GHG emissions across the entire population of a city or county. It is important to assess community-wide emissions (i.e., all emissions from within a jurisdiction’s boundaries) because even though cities have direct control over their own operations, emissions resulting from city operations only account for a small percentage of total emissions within a given jurisdiction. For example, GHG emissions from the City of San Diego municipal operations constitute approximately 1% of the all the GHGs emitted within the City boundaries. So even if the City of San Diego eliminated its emissions completely, it would only account for a very small portion of overall citywide emissions.

### Exhibit 1 | Summary of Policies Assessed

<table>
<thead>
<tr>
<th>Policy or Measure</th>
<th>Building Type</th>
<th>Jurisdictions That Have Adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Rating and Disclosure</td>
<td>Existing</td>
<td>New York City (NY), Austin (TX), Montgomery County (MD), European Union</td>
</tr>
<tr>
<td>Efficiency Retrofits</td>
<td>Existing</td>
<td>Berkeley (CA), San Francisco (CA), Austin (TX), Wisconsin</td>
</tr>
<tr>
<td>Retro-Commissioning for Commercial Buildings</td>
<td>Existing</td>
<td>New York City</td>
</tr>
<tr>
<td>Solar Water Heating</td>
<td>Existing and New Construction</td>
<td>Spain</td>
</tr>
<tr>
<td>Enhanced Building Energy Standards</td>
<td>New Construction</td>
<td>San Francisco (CA), City of Santa Barbara (CA), Palm Desert (CA), Marin County (CA), and many other CA Cities</td>
</tr>
<tr>
<td>Energy Efficiency Appliances</td>
<td>New Construction</td>
<td>Santa Barbara (CA)</td>
</tr>
<tr>
<td>Pre-Plumb for Solar Water Heating</td>
<td>New Construction</td>
<td>Chula Vista (CA), Carlsbad (CA)</td>
</tr>
<tr>
<td>Photovoltaics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-wire for Photovoltaics</td>
<td>New Construction</td>
<td>Chula Vista (CA), Palm Desert (CA)</td>
</tr>
<tr>
<td>Photovoltaics on New Buildings–Commercial</td>
<td>New Construction</td>
<td>Culver City (CA)</td>
</tr>
<tr>
<td>Photovoltaics on New Buildings–Residential</td>
<td>New Construction</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## Background

### San Diego County Greenhouse Gas Inventory

To understand the context of this paper, it is helpful to realize its relationship to the San Diego County Greenhouse Gas Inventory (Inventory), which developed a detailed accounting of GHG emissions in San Diego in San Diego County and identified strategies to reduce emissions to 1990 levels by 2020—the statewide statutory target under AB 32. The Inventory showed that electricity accounted for 25% of regional emissions and 9% of natural gas.

The Inventory also identified 19 emissions reduction strategies that in combination could reduce regional GHG emissions to 1990 levels by 2020, thus meeting statewide targets applied to San Diego County. Exhibit 2 presents the strategies related to electricity and natural gas. This study focuses on three broad strategies (presented in bold in the exhibit) related to building energy use—reducing electric consumption, reducing natural gas consumption, and increasing distributed photovoltaics—that taken together equal about 10% of the total GHG emissions reductions needed to lower regional emissions to 1990 levels by 2020. The total emissions reduction target from energy efficiency activities—both electric and natural gas—is 0.9 million metric tons of carbon dioxide equivalent (MMT CO₂E). Increasing distributed photovoltaics to 400 megawatts (MW) region-wide could reduce emissions by 0.2 MMT CO₂E.

### Energy Efficiency Potential in the San Diego Region

California has used three primary policy approaches to reduce electric and natural gas usage in the state: energy efficiency programs regulated by the California

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**Exhibit 2 | Emission Reduction Strategies: Electric and Natural Gas**

<table>
<thead>
<tr>
<th>Emissions Category / Strategy</th>
<th>Reduction Amount (MMT CO₂E)</th>
<th>Percentage of Total Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>3.8</td>
<td>28%</td>
</tr>
<tr>
<td>Renewable Portfolio Standard 20%</td>
<td>1.2</td>
<td>8%</td>
</tr>
<tr>
<td>Reduce Electricity Consumption 10%</td>
<td>0.7</td>
<td>5%</td>
</tr>
<tr>
<td>Renewable Portfolio Standard 33% (Incremental)</td>
<td>0.7</td>
<td>5%</td>
</tr>
<tr>
<td>Cleaner Electricity Purchases (≤ 1,100 lbs/MWh)</td>
<td>0.6</td>
<td>4%</td>
</tr>
<tr>
<td>Replace Boardman Contract (Coal)</td>
<td>0.3</td>
<td>2%</td>
</tr>
<tr>
<td>Increase Distributed Photovoltaics to 400 MW</td>
<td>0.2</td>
<td>1%</td>
</tr>
<tr>
<td>Increase combined heat and power by 200 MW</td>
<td>0.2</td>
<td>1%</td>
</tr>
<tr>
<td>Natural Gas End-Use</td>
<td>0.3</td>
<td>2%</td>
</tr>
<tr>
<td>Reduce Natural Gas Consumption 8%</td>
<td>0.3</td>
<td>2%</td>
</tr>
</tbody>
</table>
Public Utilities Commission (CPUC) and administered by utilities and building and appliance standards promulgated by the California Energy Commission (CEC). The combination of these statewide policies has significantly reduced statewide energy consumption since the 1970s. The CEC estimates that between 1975 and 2003, the cumulative energy savings from efficiency programs and standards is equivalent to about 15% of total electricity consumption in 2003.8

Estimates vary on what level of future energy reductions will be attributed to efficiency programs, building and standards, and state legislation to increase the efficiency of lighting over the next decade, depending on the assumptions used. Exhibit 3 presents the GHG emissions reduction implications from the CPUC estimates of future energy savings for the San Diego region.9 This combination of savings falls short of the GHG reductions needed from energy efficiency (presented above) by about 30%, which highlights the role for local government policy in reducing GHG emissions.

If energy efficiency is an important component of any GHG mitigation strategy, it is important to understand which sectors have the highest potential for reducing energy use. To determine the remaining potential for energy efficiency programs in California, Itron Inc. conducted a detailed, bottom-up study that estimates efficiency potentials through 2016, with a long-term projection for 2026.10 The study identifies energy savings potential for programs in the residential, commercial, and industrial sectors both for new construction and existing buildings. Even though the Itron study only assesses the potential of energy efficiency programs, such as rebate programs to reduce electricity and natural gas use, for the purposes of this study, its results provide a reasonable proxy of remaining potential that local government policies could affect.

The Itron study results show that the residential sector has the highest remaining potential for energy program reductions, representing 49% of the total potential,
followed by the commercial (34%) and industrial (17%) sectors. Existing buildings represent 89% of the energy reduction estimate, while new construction represents 11%. The residential existing building sector represents about 48% of the entire efficiency potential identified in the analysis. Existing commercial buildings have the second highest potential for energy reductions at 24% of total and existing industrial buildings account for about 17% of the total. Exhibit 4 presents the breakdown of GHG emissions associated with energy reductions in each of the sectors covered for both electricity and natural gas.¹¹

The total GHG emissions reductions associated with the energy savings from programs is 44% of the GHG reduction target for the electric and natural gas categories (0.9 MMT CO₂E). It is possible that building and appliance standards could account for the remaining 56% of emission reductions, nonetheless these data suggest a role for local government policy actions to supplement state policies and programs.

**The Role of Local Government in Energy Efficiency**

In general, matters of energy efficiency are regulated by state and federal agencies. In California, state agencies have significant control over energy efficiency. The California Public Utilities Commission (CPUC), which regulates the investor-owned electric and natural gas utilities (IOU), administers the portion of the public good monies¹² used to fund energy efficiency programs. The CPUC establishes energy efficiency targets for IOUs and approves all energy efficiency funding expenditures. The California Energy Commission (CEC) promulgates new

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**Exhibit 4 | Projected GHG Reductions from Efficiency Program Potential (San Diego County, 2020)**

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[Graph showing projected GHG reductions by sector for San Diego County, 2020.]

- Residential Existing
- Commercial Existing
- Industrial Existing
- Commercial New Construction
- Residential New Construction

Electric
Natural Gas
building energy standards, known as Title 24, and appliance standards. Despite state regulation of electric and natural gas efficiency in California, local governments can play an important role in promoting efficiency either through direct local regulation or by adopting local policies that support or strengthen state policies.

An example in which local governments exert direct control is an ordinance to require certain energy efficiency upgrades at the time a building is sold. There is no existing state authority within the agencies that regulate energy efficiency in California, although such a requirement could be adopted by statute. An example of where local governments can use their authority to influence a state policy is to require all new homes to have ENERGY STAR appliances. Local governments do not promulgate appliance standards but by requiring ENERGY STAR appliances, such a policy would support California’s appliance standards, which are typically more aggressive than federal standards.

The CPUC’s Long-Term Energy Efficiency Strategic Plan specifically addresses the role of local governments in promoting energy efficiency and includes the following specific recommendations for implementing energy savings targets:

- At least 5% of California’s local governments (representing at least 5% of CA total population) each year adopt “reach” (enhanced energy efficiency) codes for new buildings.
- By 2020, the majority of local governments have adopted incentives or mandates to achieve above-code levels of energy efficiency in their communities, or have led statewide adoption of these higher codes.
- The current rate of non-compliance with building codes and standards is halved by 2012, halved again by 2016, and full compliance is achieved by 2020.
- By 2015, 50% of local governments have adopted energy efficiency/sustainability/climate change action plans for their communities and 100% by 2020, with implementation and tracking of achievements.

The Plan also identifies the following areas where local government authority can reduce energy use in new and existing buildings:

- Ensuring compliance and enforcement of the Title 24 energy code for residential and commercial buildings.
- Adopting building codes beyond Title 24’s energy requirements (and potentially other “green” requirements).
- Supporting highly efficient projects that voluntarily exceed minimum energy codes through favorable fee structures, fast-tracked permitting, and other innovative and locally appropriate approaches.
- Enacting ordinances with point-of-sale or other approaches that spur efficiency actions in existing, privately-owned buildings.
- Applying efficiency-related “carrots” and “sticks” using local zoning and development authority.
These and other policy options for local governments to encourage energy efficiency are discussed in detail below.

**Data on San Diego Building Stock**

While cars and trucks are the primary emitters of GHGs in the San Diego region, buildings are the next largest category of emitters. Approximately 80% of GHG emissions in the electricity category and 90% of emissions in the natural gas category are associated with buildings. Overall, electric and natural gas use associated with buildings accounts for about 28% of all GHG emissions in the region. Understanding from a broad perspective some information about the San Diego region’s building stock can be very helpful on determining how to reduce its energy consumption.

**Residential Buildings**

According to the San Diego Association of Government housing stock data, in 2008 there were 1,147,900 housing units in the region, including single-family, multi-family, and mobile homes. Just over 60% of all housing units (over 700,000) were built prior to 1980, about when building energy efficiency standards came into force in California (Exhibit 5).

On average between 1990 and 2008, just over 1% of the entire residential building stock was built new each year and about 3.5% was sold annually (Exhibit 6). These proportions correspond roughly to statewide numbers, which estimate that roughly three times as many homes are sold in California each year than built new. Though not enough data are publicly available to assess trends, limited data suggests that alterations and additions that receive permits account for about 1% of all existing buildings annually. The CPUC estimates that the balance of renters to homeowners in California is about 42% to 58%, respectively.
Commercial Buildings

According to data from the CEC, the San Diego region had a total of 537 million square feet of commercial real estate space in 2008. Unlike residential buildings in the region, significant commercial development occurred between 1980 and the present. In 1980, only about 40% of today’s commercial building space was already constructed. Exhibit 7 presents the trends of commercial building space, including building space as a percentage of the total that existed in 1980.

The type of lease arrangement and term of the lease can be an important factor to determine how the building occupant will invest in energy efficiency

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Square Footage (MM SF)</th>
<th>Percentage of 2008 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>208</td>
<td>39%</td>
</tr>
<tr>
<td>1985</td>
<td>263</td>
<td>50%</td>
</tr>
<tr>
<td>1990</td>
<td>337</td>
<td>64%</td>
</tr>
<tr>
<td>1995</td>
<td>388</td>
<td>74%</td>
</tr>
<tr>
<td>2000</td>
<td>436</td>
<td>83%</td>
</tr>
<tr>
<td>2005</td>
<td>500</td>
<td>95%</td>
</tr>
<tr>
<td>2008</td>
<td>528</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note: The source is the California Energy Commission.
improvements. In a report on options to reduce energy use in existing buildings, the CEC estimates that in California 23% of commercial floor space is leased. Of that percentage, about 50% are net leases, in which the tenant pays many of the property expenses, including electric and natural gas utility costs. These data on leasing in California indicate that the split incentive problem, where energy efficiency retrofits are not conducted because the building owner does not pay utility expenses and the building occupant does not own the building, remains a significant challenge.

Existing Building Policies

Given the current building stock and future trends, it is very likely that a significant proportion of building that will be in place in 2050 already exists today; therefore, any strategy to reduce regional GHG emissions from electricity and natural gas use must include measures to improve the energy performance of existing buildings. This paper estimates the potential GHG reductions associated with a range of policies that target existing buildings. Below is a summary of the cost and GHG reduction estimates for a range of policies to reduce energy use in buildings. Also included is a brief summary of the policy and examples of adopted policies.

Improving the energy efficiency of existing residential and commercial buildings has the greatest potential of all the policies assessed in this study to reduce energy and GHG emissions in the region. This is due primarily to the number of existing buildings compared to the number of buildings constructed each year. Also, 60% of the residential and 40% of the commercial buildings in the region were built before new building energy standards were fully implemented in California. To differentiate between buildings built before and after adoptions of statewide building efficiency standards, results were calculated for the emission reduction potential of policies assuming a percentage of the pre-1980 building stock (prior to adoption of comprehensive building codes) and of the entire building stock. The results of these two approaches are included in the results below. Exhibit 8 shows the GHG reduction potential of policies that would target existing buildings.

Based on preliminary cost estimates, a local policy to encourage or require commercial efficiency retrofits has both high potential to reduce GHG emissions and low cost of reductions. On the other hand, a policy to encourage residential energy retrofits, which has the highest potential for reductions, was just below average in terms of cost. One policy that has a relatively high cost is residential energy rating and disclosure policies. This is because if no efficiency retrofit is required, it is assumed that only a fraction of the homes audited will actually conduct upgrades. Nonetheless, energy rating and disclosure policies may be an effective way to raise awareness about building energy performance, provide a benchmark and rating system for future efficiency retrofit policies, and to help jumpstart the energy rating and building performance industry. Exhibit 9 presents a summary of results for existing building policies. Exhibit 10 shows the jurisdictions that have adopted the existing building policies assessed here.
### Exhibit 8 | GHG Reductions: Existing Building Policies (2020)

<table>
<thead>
<tr>
<th>GHG Reduction Policy Option</th>
<th>GHG Reduction Potential$^1$ (MMT CO₂E)</th>
<th>Cost per Unit of GHG Reduction$^a$ ($/MT CO₂E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Efficiency Retrofits (ALL)$^b$</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits (ALL)</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit (ALL)</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Residential Efficiency Retrofits (Pre-1980)$^c$</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Retro-Commissioning (ALL)</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit (Pre-1980)</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits (Pre-1980)</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Residential Audit / Rating (ALL)</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Commercial Retro-Commissioning (Pre-1980)</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Residential Audit / Rating (Pre-1980)</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Residential Pre-Plumb (New)</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

**Notes:**

- $^a$L = Low, M = Medium, H = High
- $^b$“All” means policy applies to a percentage of all buildings.
- $^c$“Pre-1980” means policy applies to a percentage of buildings built before 1980.
Exhibit 10 | Jurisdictions with Existing Building Policies

<table>
<thead>
<tr>
<th>GHG Reduction Policy</th>
<th>Jurisdiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Efficiency Retrofits</td>
<td>San Francisco (CA), Berkeley (CA), Burlington (VT), Wisconsin, Austin (TX)</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits</td>
<td>Berkeley (CA), New York City (pending)</td>
</tr>
<tr>
<td>Commercial Retro-Commissioning</td>
<td>New York City (pending)</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit</td>
<td>Barcelona (Spain)</td>
</tr>
<tr>
<td>Residential Audit/Rating</td>
<td>Austin (TX), Montgomery County (MD), European Union</td>
</tr>
</tbody>
</table>

**Examples of Efficiency Retrofit Policies**

This section presents examples of policies adopted by local governments in the United States and Europe to reduce energy consumption in existing buildings.

**Residential Energy Rating and Disclosure**

In 2007, California enacted legislation to require commercial buildings starting January 1, 2010 to benchmark energy use through the United States Environmental Protection Agency’s ENERGY STAR Portfolio Manager and to disclose this information to prospective buyer, lessee, or lender.

Several cities and the European Union have adopted residential rating and disclosure policies. In 2009, New York City adopted a policy to require certain buildings to conduct energy audits. Under Local Law 87, buildings that are 50,000 gross square feet or larger and multiple buildings on the same lot that exceed 100,000 gross square feet, would be required to receive an efficiency audit to identify all reasonable retro-commissioning and retrofit measures.

In November 2008, the City of Austin Texas adopted the Conservation and Disclosure Ordinance. The policy, which took effect June 1, 2009, requires all commercial, residential or multi-family facilities to receive an energy audit if they are 10 years or older, receive services from the Austin Electric Utility, and are for sale, lease, or rent. Building owners must disclose the audit results to current and prospective tenant and buyers. For most consumers, efficiency retrofits remain voluntary; however, multi-family facilities that have an average per-square-foot energy usage exceeding 150% of the average for similar facilities within the Austin Electric Utility service territory are required to undergo mandatory energy efficiency upgrades.

In April 2008, the Montgomery County, Maryland enacted a law to require sellers in single-family homes to disclose certain information about energy use. Under the law, before signing a contract for the sale of a single-family home, the seller must provide the buyer with information about home energy efficiency
improvements, including the benefit of conducting a home energy audit; and two copies of the electric, gas, and home heating oil bills or cost and usage history for the single-family home for the immediate prior 12 months.

In December 2002, the European Union adopted the Directive on the Energy Performance of Buildings. It required, among other things, that member states “ensure that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant....” Certificates are valid for ten years and must include benchmarks to allow consumers to compare and assess the energy performance.

**Residential and Commercial Efficiency Retrofits**

Efficiency retrofit polices, sometimes called “energy conservation ordinances,” require building owners to conduct energy efficiency retrofits at defined trigger points. Examples of these policies include Residential Energy Conservation Ordinances (RECO) and Commercial Energy Conservation Ordinances (CECO). These policies are analogous to policies adopted to increase water efficiency. For example, the City of San Diego Municipal Code (SDMC) 147.04 requires all buildings to install water-conserving plumbing fixtures prior to a change in property ownership. City of San Francisco Housing Code Chapter 21A also contains a similar requirement. An overview of existing efficiency upgrade policies is presented below, followed by a more detailed discussion of the elements of such policies.

The City of San Francisco adopted a Residential Energy Conservation Ordinance in 1982. It requires certain residential property owners constructed before 1978 to make prescribed energy and water efficiency upgrades prior to sale of the property. Owners of single- and two-family dwellings, apartment buildings, and residential hotels must comply at the time of sale. Conversion of a unit from the master meter to an individual meter, major renovation, and condominium conversions also must comply as part of the city approval process. To comply with the RECO, residential property owners who plan to sell their property, must obtain a valid energy inspection, install certain energy and water conservation measures and then obtain a certificate of compliance. Completion of this procedure must occur prior to transfer of title and the seller must provide a copy of the compliance certificate to the buyer prior to title transfer.

The City of Berkeley enacted its RECO in 1987 and a similar Commercial Energy Conservation Ordinance in 1994. Like San Francisco’s policy, Berkeley’s RECO requires residential property owners that seek to sell, exchange, or substantially renovate their facility to install the required energy efficiency measures (up to cost caps), receive an inspection, and provide a copy of the compliance certification to prospective buyers or in the case of a renovation project, submit a copy to the City’s Building Department.

Under Berkeley’s CECO, whenever a building is sold, transferred, or undergoes a major renovation, the building owner or responsible party must obtain an energy
audit for the building for the purpose of ascertaining the costs and energy savings of each required energy conservation measures, submit the audit findings with proper city department, install all required energy efficiency, obtain a final energy inspection, and file the results with the city to demonstrate compliance.\(^{26}\)

As noted above, the City of Austin has adopted a rating and disclosure policy. Most buildings are not required to install energy efficiency measures; however, in certain cases, owners of all multi-family facilities that are ten years old or older must have an energy audit performed and install efficiency measures. The owner must post and provide to current and prospective tenants the results of the audit in a manner prescribed by rule, and must provide a copy to the director of the Austin Electric Utility within 30 days of its completion. Regardless of the age of the building, the director can designate certain facilities as “High Energy Use” if it has an average per-square-foot energy usage exceeding 150% of the service area average. Owners of these facilities must implement enough efficiency measures to bring it within 110% of service area average within 18 months.\(^{27}\)

In 1997, the City of Burlington, Vermont enacted its Minimum Rental Housing Energy Efficiency Standards Ordinance, which seeks to improve the efficiency of rental housing. It requires that “[u]pon transfer of rental property where there is a deed recorded, an inspection report, signed by a Vermont-licensed mechanical engineer or an inspector certified by the program administrator, must be filed with the city clerk when the deed is recorded in the land records. The inspection report shall either include a certificate of energy efficiency compliance, if the standards of this article are met, or list the standards not met and inform the property owner that the recruited energy improvements must be made within one year of the date of transfer.”\(^{28}\)

The State of Wisconsin adopted its Rental Weatherization Program in 1985, which requires efficiency upgrades in rental properties. Under the policy, a property owner must obtain an inspection by a certified inspector or the Department of Commerce to determine whether the rental unit meets the energy efficiency requirements of the rule. If the property meets the requirements, the inspector issues the owner a certificate of compliance and files a copy with the Department within 15 days. If the property fails, the inspector must notify the owner within 10 days of the reason, defects, and measures required to comply. The owner must then bring the property into compliance (within one year if a purchaser “stipulation” applies) and obtain a final re-inspection inspection. Once the owner is given a certificate of compliance (or waiver, stipulation, etc), he must then present it as a precondition of recordation at the time the deed transfer is recorded with the register.\(^{29}\)

**Commercial Retro-commissioning**

The New York City Council adopted a policy in 2009 that, among other things, requires retro-commissioning in large buildings.\(^{30}\) Under Local Law 87, buildings that are 50,000 gross square feet or larger and multiple buildings on the same lot that exceed 100,000 gross square feet, would be required to receive an efficiency audit to identify all reasonable retro-commissioning and retrofit measures. A
building owner is required to perform retro-commissioning measures. Certain exemptions apply, including for buildings that have demonstrated an acceptable level of efficiency or are LEED certified.

New Construction Policies

In general, policies that focus on new construction have a relatively low potential to reduce GHG emissions compared to policies that focus on existing buildings. Emission reductions from the new construction policies totaled 15%–30% of all the potential emissions reductions the policies assessed, depending on the population of buildings captured and whether the emission reductions associated with photovoltaics are included. This difference exists because on average only a small percentage of the total building stock is built new each year. Also, policies seeking to increase efficiency in new homes and commercial buildings by strengthening requirements of California’s building energy standard yield relatively low GHG reductions because in some cases—particularly residential—Title 24 regulates a relatively small proportion of overall energy usage.

Of all the new construction policies assessed, requiring photovoltaics on all new homes has the greatest GHG reduction potential and a medium cost of implementation. It is not clear whether local government policies to encourage photovoltaics would lead to net GHG reductions in the short run as investment in this technology is heavily dependent upon subsidies and the market could grow only as fast and large as incentives will allow; however, after current subsidies expire (2016), local policies to encourage photovoltaics could become more important. Two policies to make all new homes “solar ready” to accommodate later installation of solar photovoltaics or solar water heating have relatively low potential to reduce GHG emissions, mainly because it is not clear that buyers of solar-ready homes would install solar technologies. Exhibit 11 presents the GHG emission reduction potential of the new construction policies assessed in the study.

Among those that focus on energy efficiency, two policies have a low cost of implementation. Requiring new commercial builders to meet building energy standards that exceed California Title 24 has moderate potential to reduce GHG emissions and a relatively low cost of implementation. A policy to require that all new homes have ENERGY STAR appliances has a relatively low cost of implementation, although it is among the lowest in terms of GHG reductions. Exhibit 12 presents a summary of the GHG reduction potential, costs, and jurisdictions that have adopted the new construction policies analyzed in this study.

Examples of New Construction Policies

This section presents examples of policies adopted by local governments in the U.S. and Europe to reduce energy consumption in new homes and non-residential buildings.

Enhanced Building Codes. Enhanced new construction energy standards vary in scope, strictness, and design. Some focus on energy specifically while others are part of broader green building policies. Some are mandatory, while others are
Because the new construction sector has relatively low potential for GHG reductions, a sample of the mandatory policies in California is presented here. The policies summarized here represent a range of policy approaches and city sizes.

In 2002, the County of Marin adopted mandatory energy efficiency standards for single-family homes. Under the ordinance, all new single-family homes, additions, and substantial remodels must exceed the 2005 Title 24 Standards by 15% or greater. Projects that are 4,500 square feet or greater are required to reduce energy use to a greater degree. Residential buildings between 9,500 and 10,499 square feet are required to exceed Title 24 requirements by 51.5%. Energy targets for these buildings increases as the square footage of the building increases and varies by climate zone.

In 2008, the City and County of San Francisco enacted a mandatory Green Building Standard that requires new commercial buildings over 5,000 square feet, all new residential buildings, and renovations to areas over 25,000 square feet to meet certain levels of green building requirements. In most cases building classes are required to meet increasing Green Building standards over time, based either on the LEED or GreenPoint rating systems. The energy component of the policy requires buildings to achieve a level of efficiency 14% better than Title 24. All projects that meet or exceed a LEED Gold rating receive priority permit processing.

The City of Santa Barbara’s Local Energy Efficiency Standards requires the following building projects meet energy efficiency standards: all new buildings, renovations above 100 square feet of conditioned area, indoor lighting alterations in conditioned space greater than 100 square feet in non-residential buildings, all new mechanical heating or cooling systems, and all projects that involve new
### Exhibit 12 | Summary of New Construction Policies

<table>
<thead>
<tr>
<th>GHG Reduction Policy Option</th>
<th>GHG Reduction Potential (MMT CO$_2$E)$^a$</th>
<th>Cost per Unit of GHG Reduction ($/MT CO$_2$E)$^b$</th>
<th>Examples of Jurisdictions that Have Adopted Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Photovoltaics</td>
<td>H</td>
<td>M</td>
<td>N/A</td>
</tr>
<tr>
<td>Enhanced Commercial Building Codes</td>
<td>M</td>
<td>L</td>
<td>San Francisco (CA), City of Santa Barbara (CA), Palm Desert (CA), others</td>
</tr>
<tr>
<td>Commercial Photovoltaics</td>
<td>L</td>
<td>M</td>
<td>Culver City (CA)</td>
</tr>
<tr>
<td>Residential Pre-Wire</td>
<td>L</td>
<td>M</td>
<td>Chula Vista (CA), Palm Desert (CA)</td>
</tr>
<tr>
<td>Residential Appliance Standards</td>
<td>L</td>
<td>L</td>
<td>Santa Barbara (CA)</td>
</tr>
<tr>
<td>Enhanced Residential Building Codes</td>
<td>L</td>
<td>H</td>
<td>San Francisco (CA), City of Santa Barbara (CA), Palm Desert (CA), Marin County (CA), others</td>
</tr>
<tr>
<td>Residential Pre-Plumb</td>
<td>L</td>
<td>H</td>
<td>Chula Vista (CA), Carlsbad (CA)</td>
</tr>
</tbody>
</table>

**Notes:**

$^a$L = Low, M = Medium, H = High
heaters or circulation pumps for swimming pools, spas, and water features. Santa Barbara requires certain mandatory efficiency requirements including that all appliances for residential construction must be ENERGY STAR rated, all swimming pool and spa heaters and pumps must meet performance specifications, and mechanical heating and cooling systems must also meet certain National Electrical Manufacturers Association (NEMA) standards. In addition, the policy requires all low-rise residential new construction or remodel projects to be 20% more efficient than Title 24; all new high-rise residential building to be 10%–15% more efficient, depending on compliance approach; and additions to high-rise residential buildings to be 15% more efficient. Commercial buildings also are covered by the policy. All non-residential and hotel/motel occupancies must be 10% more efficient than required by Title 24.

The City of Palm Desert adopted energy efficiency standards that combine prescriptive requirements and performance targets. All new homes and remodels are required to install certain lighting, mechanical, and swimming pool equipment. In addition, new projects are required to meet energy standards that are between 5% and 15% better than Title 24, depending on building type and size.

**Solar Pre-plumb.** Two jurisdictions in the San Diego region currently require that all new homes be pre-plumbed to accommodate future installation of solar water heating. The City of Carlsbad, which adopted such a requirement in 1981, requires all new residential units to include “plumbing specifically designed to allow the later installation of a system which utilizes solar energy as the primary means of heating domestic potable water.” A builder can be exempt from this requirement if he can demonstrate that including the pre-plumbing is not practical due to shading, building orientation, construction constraints, or configuration of the parcel. The City of Chula Vista recently adopted a similar ordinance.

**Solar Water Heating Retrofits.** In July 1999, Barcelona, Spain adopted a policy requiring that solar hot water systems supply a portion of the overall hot water supply of certain buildings. Barcelona’s Solar Thermal Ordinance applies to new construction, major rehabilitations, buildings seeking a change of use that have an annual average forecasted hot water need greater than 276,000 net British Thermal Units (BTU) or 2.8 therms. This regulation applies to the following types of buildings: residential, health-care, sports, commercial and industrial use and, generally, any activity involving the existence of dining rooms, kitchens, laundries or other circumstances that lead to high hot water consumption.

**Solar Photovoltaics Pre-wire.** Several cities in California have adopted ordinances that require certain new buildings to include the wiring necessary to install photovoltaics at a later date. The City of Chula Vista has enacted a photovoltaics pre-wiring ordinance that requires that “all new residential units shall include electrical conduit specifically designed to allow the later installation of a photovoltaic (PV) system which utilizes solar energy as a means to provide electricity.” The City of Chula Vista’s requirement can be waived if the building owner can demonstrate that compliance would be impractical due to shading,
building orientation, construction constraints or configuration of the parcel. The City of Palm Desert has adopted a similar requirement that provides detailed requirements for the location and specifications of the equipment needed to comply.\textsuperscript{46}

**Solar Photovoltaics on New Buildings.** The City of Culver City requires new buildings that are 10,000 square feet or greater, additions, and major renovations of 10,000 square feet or greater of gross floor area to install 1 kW of photovoltaics for each 10,000 square feet of gross floor area.\textsuperscript{47} In the case of major renovations, to be required to comply with the photovoltaics requirement, the renovation must be equal to 50\% of the valuation of the existing building. The requirement does not apply to one- and two-family residences, parking structures, and garages. Also, the policy provides for two alternative compliance mechanisms, including fee-in-lieu options whereby the building owner can pay a fee equal to the cost of installing the system. Revenue generated from the fee would be used to design and install photovoltaics systems on city facilities. To comply with the solar requirement, building owners also can install comparable photovoltaics on another building owned by the applicant and located in the city.

\textbf{Exhibit 13 | GHG Reduction Potential (2020)}

![Graph showing GHG reduction potential](image-url)
**Overall Findings**

When all local policy measures assessed in this study are combined, it is possible to compare the relative GHG reduction potential and implementation cost and to assess their combined impact. Of the policies included in this paper, residential and commercial efficiency retrofits targeting a percentage of all buildings have by far the highest GHG reduction potential, followed by a requirement to install solar photovoltaics on new homes (Exhibit 13) and policy to install solar water heating systems on existing homes. Also, the vast majority of potential GHG reductions from the policies evaluated—between 55% and 73%, depending on the building population addressed, result from policies that target existing buildings.

There are five policies that have high potential to reduce GHG emissions in the region. None of these have high implementation costs and only one policy—

### Exhibit 14 | Summary Table of GHG Reduction Potential and Cost (2020)

<table>
<thead>
<tr>
<th>GHG Reduction Policy Option</th>
<th>GHG Reduction Potential(^a) (MMT CO(_2)E)</th>
<th>Cost per Unit of GHG Reduction(^a) ($/MT CO(_2)E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Efficiency Retrofits (ALL)(^b)</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits (ALL)</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Residential Photovoltaics (New)(^c)</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit (ALL)</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Residential Efficiency Retrofits (Pre-1980)</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Retro-Commissioning (ALL)</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit (Pre-1980)</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits (Pre-1980)</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Enhanced Commercial Building Codes (New)</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Residential Audit / Rating (ALL)</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Commercial Retro-Commissioning (Pre-1980)</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Commercial Photovoltaics (New)</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Residential Pre-Wire (New)</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Residential Audit / Rating (Pre-1980)</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Residential Appliance Standards (New)</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Enhanced Residential Building Codes (New)</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Residential Pre-Plumb (New)</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

**Notes:**

\(^a\) L = Low, M = Medium, H = High

\(^b\) “All” means policy targets a percentage of all buildings.

\(^c\) “Pre-1980” means policy targets a percentage of buildings built before 1980.
requiring commercial energy retrofits in a percentage of all buildings—also has a relatively low cost of implementation. Three policies—requiring commercial retro-commissioning in a percentage of all buildings, commercial efficiency retrofits in buildings built prior to the adoption of energy codes, and a local policy to require new commercial buildings to be more energy efficient than mandated by state law—also have a low cost of implementation but they all have a medium potential to reduce emissions. Exhibit 14 provides a summary of the GHG reduction potential and the associated cost for the policies evaluated in this study.

**Conclusion**

Many policy options exist within the authority of local governments that can reduce community-wide GHG emissions. Of the policies analyzed in this study, all can be developed and implemented in the short term (1–2 years), most of the policies have been adopted by one or more local governments in California or the U.S., and several policies have a relatively low cost per metric ton of GHG reduction.

Based on preliminary quantitative analysis, one policy—commercial efficiency retrofits targeted at a percentage of all buildings—has a high potential to reduce emissions and a relatively low cost per unit of GHG reduction. Several policies have a moderate potential to reduce emissions and have a low implementation cost. These include: commercial retro-commissioning in a percentage of all buildings, commercial efficiency retrofits in buildings built prior to 1980, and enhanced new construction energy standards in commercial buildings. Another policy—requiring ENERGY STAR appliances in all new homes—also has a low cost per unit of GHG reductions, although it has a relatively low potential to reduce emissions. With the exception of one policy with high potential for GHG reductions, all would target existing buildings. Further, of the energy efficiency policies assessed, those targeting existing buildings have a higher potential to reduce GHG emissions than those targeting new construction or solar photovoltaics.

It appears that local policies combined with those expected from statewide policies, including building and appliance standards and efficiency programs, could reduce emissions to levels necessary to meet hypothetical regional targets by 2020; however, attaining longer term, deep GHG cuts will require more aggressive action at the local level.

**Appendix**

**Implementation Cost Methodology and Results**

Implementation costs for the policies evaluated here were estimated using per-unit costs derived from actual data or published reports and studies, average useful life
data from the California Database for Energy Efficient Resources (DEER),\textsuperscript{48} energy price data from the CEC, and penetration rates used to estimate GHG reductions. Details on the values used for these calculations are presented in the exhibits. To capture the differences among the useful life of the measures evaluated in this study and to enable comparison across policies, the net present value (NPV) was calculated for each policy over its useful life with a 5\% discount rate. For example, NPV calculations for energy efficiency covered a 12-year life, for solar water heating 20 years, and for solar photovoltaics 20 years. Because this study evaluates policies that are implemented annually from 2010 to 2020 and that savings from measures implemented in 2019 will produce GHG reductions for another 10–20 years beyond the 2020 time horizon, for AB 32 compliance, average annual implementation costs and customers savings were used to derive a NPV value. This also allows cost estimates to reflect any potentially declining implementation costs and the GHG-intensity of electricity.

The results of the NPV calculation were used to develop a ratio of cost per metric ton of \( \text{CO}_2 \text{E} \), which normalizes cost and allows for comparisons of policy costs. The study estimates cost per metric ton of \( \text{CO}_2 \text{E} \) using the NPV for cost.

The costs considered in this paper represent the total implementation cost and do not include any financial subsidy such as tax credits or rebates. Subtracting such incentives from the total implementation cost likely will reduce the actual cost paid by homeowners and businesses, thus potentially affecting the economics of specific projects; however, such subsidies do not reduce the overall cost of implementation. Results of the cost calculations are presented in Exhibit 15.

\section*{Cost Categories}

The results from Exhibit 16 were into three cost categories: low, medium, and high. The range of costs that constitute the medium category was determined by adding and subtracting one-half of one standard deviation from the mean value. Those policies with costs below one-half a standard deviation from the mean were considered the “low” category, those with a cost above one-half a standard deviation from the mean were considered the “high” category. Exhibit 16 presents the low, medium, and high categorization of the policies evaluated.

\section*{Greenhouse Gas Calculation Methodology—Existing Buildings}

The following general assumptions were used in estimating the GHG reduction potential and implementation cost for existing building policies.

- GHG intensity of electricity declines through 2020 as reduction measures are implemented.
- Transmission and distribution losses included in electricity savings amounts.
- GHG content of natural gas is 0.005 MMT \( \text{CO}_2 \text{E} \)/MM therms.
### Exhibit 15 | Cost Evaluation Results

<table>
<thead>
<tr>
<th>Local Government Policy Measure</th>
<th>Average Annual Implementation Cost</th>
<th>Average Annual Customer Savings</th>
<th>NPV @ 5%</th>
<th>Useful Life</th>
<th>Total GHG Reduction (MT CO₂E)(^a)</th>
<th>NPV / MT CO₂E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Retro-Commissioning</td>
<td>($6,355,410)</td>
<td>$2,317,710</td>
<td>$12,282,330</td>
<td>10</td>
<td>75,161</td>
<td>$163</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits</td>
<td>($17,896,488)</td>
<td>$4,443,638</td>
<td>$20,465,332</td>
<td>12</td>
<td>141,683</td>
<td>$144</td>
</tr>
<tr>
<td>Residential Appliance Standards (New)</td>
<td>($2,402,250)</td>
<td>$376,977</td>
<td>$894,283</td>
<td>12</td>
<td>15,541</td>
<td>$58</td>
</tr>
<tr>
<td>Enhanced Commercial Building Codes (New)</td>
<td>($11,640,437)</td>
<td>$1,105,504</td>
<td>($1,754,358)</td>
<td>12</td>
<td>37,303</td>
<td>($47)</td>
</tr>
<tr>
<td>Residential Efficiency Retrofits</td>
<td>($72,067,488)</td>
<td>$4,515,209</td>
<td>($30,521,954)</td>
<td>12</td>
<td>155,522</td>
<td>($196)</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit</td>
<td>($66,151,035)</td>
<td>$2,308,075</td>
<td>($35,606,966)</td>
<td>20</td>
<td>147,183</td>
<td>($242)</td>
</tr>
<tr>
<td>Commercial Photovoltaics (New)</td>
<td>($28,194,990)</td>
<td>$1,125,291</td>
<td>($13,496,547)</td>
<td>20</td>
<td>43,423</td>
<td>($311)</td>
</tr>
<tr>
<td>Residential Photovoltaics (New)</td>
<td>($124,385,024)</td>
<td>$5,083,742</td>
<td>($58,124,149)</td>
<td>20</td>
<td>170,066</td>
<td>($342)</td>
</tr>
<tr>
<td>Residential Pre-Wire (New)</td>
<td>($28,603,253)</td>
<td>$1,016,748</td>
<td>($15,173,638)</td>
<td>20</td>
<td>34,013</td>
<td>($446)</td>
</tr>
<tr>
<td>Residential Pre-Plumb (New)</td>
<td>($17,402,811)</td>
<td>$76,786</td>
<td>($15,662,748)</td>
<td>15</td>
<td>21,095</td>
<td>($743)</td>
</tr>
<tr>
<td>Enhanced Residential Building Codes (New)</td>
<td>($13,333,250)</td>
<td>$166,108</td>
<td>($11,296,186)</td>
<td>12</td>
<td>14,438</td>
<td>($782)</td>
</tr>
</tbody>
</table>

Note:

\(^a\) GHG values here represent total emissions reductions over the useful life of the measure.
Exhibit 16 | Cost Categories for Policies Evaluated

<table>
<thead>
<tr>
<th>Policy or Measure</th>
<th>Cost of GHG Reduction (NPV$/MT CO₂E)</th>
<th>Cost Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Retro-Commissioning</td>
<td>163</td>
<td>Low</td>
</tr>
<tr>
<td>Commercial Efficiency Retrofits</td>
<td>144</td>
<td>Low</td>
</tr>
<tr>
<td>Residential Appliance Standards (New)</td>
<td>58</td>
<td>Low</td>
</tr>
<tr>
<td>Enhanced Commercial Building Codes (New)</td>
<td>-47</td>
<td>Low</td>
</tr>
<tr>
<td>Residential Efficiency Retrofits</td>
<td>-196</td>
<td>Medium</td>
</tr>
<tr>
<td>Residential Solar Water Heating Retrofit</td>
<td>-242</td>
<td>Medium</td>
</tr>
<tr>
<td>Commercial Photovoltaics (New)</td>
<td>-311</td>
<td>Medium</td>
</tr>
<tr>
<td>Residential Photovoltaics (New)</td>
<td>-342</td>
<td>Medium</td>
</tr>
<tr>
<td>Residential Pre-Wire (New)</td>
<td>-446</td>
<td>High</td>
</tr>
<tr>
<td>Residential Rating/Disclosure</td>
<td>-637</td>
<td>High</td>
</tr>
<tr>
<td>Residential Pre-Plumb (New)</td>
<td>-743</td>
<td>High</td>
</tr>
<tr>
<td>Enhanced Residential Building Codes (New)</td>
<td>-782</td>
<td>High</td>
</tr>
</tbody>
</table>

- All energy consumption, housing, and building area data are scaled to SD County.

Exhibit 17 presents the assumptions used to calculate both reasonable GHG reduction potential and implementation costs. It should be noted that many of the assumptions are based on averages and therefore obscure differences among subsectors. For example, the cost of energy efficiency retrofits likely differs by housing type (single-family and multi-family), building age, and climate zone. Further analysis should be conducted to differentiate the GHG reduction potential and implementation costs among different building types, vintages, and locations to help craft policy and prioritize actions.

**Greenhouse Gas Calculation Methodology–New Construction**

Exhibit 18 presents the assumptions used to estimate the GHG reduction potential and cost for new construction policies.

**Greenhouse Gas Calculation Method–Common Data Used**

Exhibit 19 provides the building and energy data used to estimate the GHG reduction and cost for the policies included in this paper.

**Energy Price Data**

Exhibit 20 presents the energy prices used for the implementation cost estimates for the policies evaluated in this paper.
### Exhibit 17 | Assumptions Used to Estimate GHG Emissions and Cost for Existing Building Policies

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Annual Penetration Rate</th>
<th>Penetration of the Total Building Stock by 2020*</th>
<th>Total Number / Area of Buildings by 2020</th>
<th>Total Annual Energy Reduction (unless units specified)</th>
<th>Cost of GHG Reductions</th>
<th>Average Useful Life (years)</th>
<th>Assumptions / Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Energy Audit and Rating</td>
<td>3.5% receive audit</td>
<td>37% (audits)</td>
<td>460,359 (audits)</td>
<td>3% Low</td>
<td>$500 / audit</td>
<td>12</td>
<td>1. Adoption rate is constant through 2020 and is equal to the average number of home sales annually in SD County.</td>
</tr>
<tr>
<td></td>
<td>25% of audits conduct retrofits</td>
<td>22% (audits)</td>
<td>278,737 (audits)</td>
<td>7.5% Medium</td>
<td>$1,000 / retrofit</td>
<td></td>
<td>2. Savings rate applied to annual average consumption level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9% (retrofits)</td>
<td>115,090 (retrofits)</td>
<td>11% High</td>
<td></td>
<td></td>
<td>3. Savings rate and audit cost data adapted from CEC 2005 study on existing building efficiency.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6% (retrofits)</td>
<td>69,684 (retrofits)</td>
<td></td>
<td></td>
<td></td>
<td>4. Based on CEC RASS report, 54% of total energy consumption is natural gas, 46% is electricity.</td>
</tr>
<tr>
<td>Residential Efficiency Upgrades</td>
<td>2%</td>
<td>21%</td>
<td>263,062</td>
<td>10% Low (retrofits)</td>
<td>$2,500 / retrofit</td>
<td>12</td>
<td>1. Savings rate adapted from CEC 2005 study on existing building efficiency and Berkeley RECO information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13%</td>
<td>159,278</td>
<td>15% Medium (retrofits)</td>
<td>$500 / audit</td>
<td></td>
<td>2. Cost estimate based on Berkeley and San Francisco RECO cost caps, Consol estimate of Berkeley RECO costs, and Sustainable Spaces estimate for GHG reductions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20% High (retrofits)</td>
<td></td>
<td></td>
<td>3. Based on CEC RASS report, 54% of total energy consumption is natural gas, 46% is electricity.</td>
</tr>
</tbody>
</table>
### Exhibit 17 (continued)
Assumptions Used to Estimate GHG Emissions and Cost for Existing Building Policies

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Annual Penetration Rate</th>
<th>Penetration of the Total Building Stock by 2020 *</th>
<th>Total Number / Area of Buildings by 2020</th>
<th>Total Annual Energy Reduction (unless units specified)</th>
<th>Cost of GHG Reductions</th>
<th>Average Useful Life (years)</th>
<th>Assumptions / Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All Buildings</td>
<td>Pre 1980</td>
<td>All Buildings</td>
<td>Pre 1980</td>
<td>Low therms</td>
<td>Medium therms</td>
</tr>
</tbody>
</table>
| Residential Solar Water Heating Retrofit | 0.80%                  | 9%           | 5%       | 109,609      | 66,366    | 88 therms | 117 therms | 146 therms | $6,500 / SWH | 20                     | 1. Assumes all solar water heaters offset natural gas.  
2. Energy savings and cost values based on ITRON Evaluation of the SWH Pilot Project; CPUC Energy Division report on SWH PP (AB 1470). |
| Commercial Retro-Commissioning        | 2%                      | 20%          | 1.4%      | 131 MM SF    | 45 MM SF  | 0.625 kWh / SF  | 1.25 kWh / SF | 1.875 kWh / SF | $0.55 / SF | 10                     | 1. Penetration, energy savings, and cost rates based on LBNL and CEC reports. |
| Commercial Efficiency Upgrades       | 2.0%                    | 22%          | 8%        | 252 MM SF    | 86 MM SF  | 0.013 therms / SF | 0.025 therms / SF | 0.038 therms / SF | $1.50 / SF | 12                     | 1. Savings rate adapted from CEC 2005 study on existing building efficiency and Berkeley CECO savings information.  
2. Cost based on SDG&E SPC program data for HVAC, lighting, and other categories.  
3. Based on CEC Commercial End Use Survey, 35% of total energy consumption is natural gas, 65% is electricity. |

**Note:**
* Totals do not equal penetration rate times 11 years, because the number and area of buildings varies each year. Values for pre-1980 buildings show percentage of the total building stock in 2020.
### Exhibit 18 | Assumptions used to Estimate GHG Emissions and Cost for New Construction Policies

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Annual Penetration Rate</th>
<th>Penetration of the Total Building Stock by 2020</th>
<th>Total Number/Area (MM SF) of Buildings by 2020</th>
<th>Annual Energy Reduction / Production</th>
<th>Cost of GHG Reductions (medium scenario)</th>
<th>Useful Life</th>
<th>Assumptions / Notes</th>
</tr>
</thead>
</table>
| Residential Enhanced Energy Buildings Standards | 1% | 6.0% | 131,531 | Low 5% of total annual consumption | $1,250 / home | 12 | 1. 10% of average home’s electric consumption is covered by Title 24.  
2. 80% of average home’s natural gas consumption is covered by Title 24.  
3. Percentage consumption covered by T24 based on CEC RASS Study.  
4. Percentage better than T24 is phased out and replaced with NZEH standard. No incremental savings from 2016–2020. |
| Residential Appliance Standard (Energy Star) | 1% | 11.0% | 131,531 | Refrigerator 111 kWh  
Dish Washer 25 kWh, 1 therm  
Wash. Machine 24 kWh, 10 therms | $200 / home | 12 | 1. Cost and energy savings estimates based on Energy Star Cost Calculator assumptions. Calculated value is $159. To be conservative, an incremental cost of $200 per home is used. |
| Residential Solar PV Pre-wire | 1% get prewire  
% install PV varies | varies | varies | Energy saved based on 10% of pre-wired homes install PV  
Energy saved based on 15% of pre-wired homes install PV  
Energy saved based on 20% of pre-wired homes install PV | $300 / home  
$7,796 / kW (average 2010 to 2020) | 20 | 1. 17% capacity factor.  
2. Cost estimate is average based on $0.25/yr/W reduction until 2015 and a $0.15/yr reduction until 2020. This is reduced from $9.41 statewide cost of CSI in 2008. |
### Exhibit 18  | [continued]
Assumptions used to Estimate GHG Emissions and Cost for New Construction Policies

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Annual Penetration Rate</th>
<th>Penetration of Total Building Stock by 2020</th>
<th>Total Number/Area (MM SF) of Buildings by 2020</th>
<th>Annual Energy Reduction/Production</th>
<th>Cost of GHG Reductions (medium scenario)</th>
<th>Useful Life</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Solar PV Mandate</td>
<td>1% homes is target</td>
<td>varies</td>
<td>varies</td>
<td>Energy savings based on 65% of new homes install PV</td>
<td>$7,796/kW (average 2010 to 2020)</td>
<td>20</td>
<td>1. 17% capacity factor.</td>
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<tr>
<td></td>
<td>15% install PV</td>
<td></td>
<td></td>
<td>Energy savings based on 75% of new homes install PV</td>
<td></td>
<td></td>
<td>2. GHG savings accrue to CSI program.</td>
</tr>
<tr>
<td></td>
<td>varies based on exemptions</td>
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<td></td>
<td>Energy savings based on 85% of new homes install PV</td>
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<td></td>
<td>3. Policy allows exemptions.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>4. Cost estimate is average based on $0.25/yr/W reduction until 2020. This is reduced from $9.41 statewide cost of CSI in 2008.</td>
</tr>
<tr>
<td>Residential Solar Water Heater Pre-plumb</td>
<td>1% get pre-plumb</td>
<td>11%</td>
<td>131,531 pre-plumb 19,730 install SWH</td>
<td>88 therms</td>
<td>$450 for pre-plumb $6,500/SWH 20</td>
<td>20</td>
<td>1. Assumes solar water will offset natural gas water heating.</td>
</tr>
<tr>
<td></td>
<td>15% install SWH</td>
<td></td>
<td></td>
<td>117 therms</td>
<td></td>
<td></td>
<td>2. Savings rates based on ITRON report on CCSE SWH Pilot Program.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>146 therms</td>
<td></td>
<td></td>
<td>3. Cost estimate is 80% of retrofit cost and assumes economies of scale.</td>
</tr>
</tbody>
</table>
Assumptions used to Estimate GHG Emissions and Cost for New Construction Policies

<table>
<thead>
<tr>
<th>Policy Measure</th>
<th>Annual Penetration Rate</th>
<th>Penetration of the Total Building Stock by 2020</th>
<th>Total Number/Area (MM SF) of Buildings by 2020</th>
<th>Annual Energy Reduction/Production</th>
<th>Cost of GHG Reductions (medium scenario)</th>
<th>Useful Life</th>
<th>Assumptions/Notes</th>
</tr>
</thead>
</table>
| Commercial Enhanced Energy Buildings Standards       | 2%                      | 20%                                           | 133 MM SF                                     | 5%                                | 15%                                     | 12         | 1. Based on CEC Commercial End Use Survey, 65% of average commercial energy use is natural gas, 35% is electric.  
2. Based on CEC End Use Survey, 70% of both natural gas and electric consumption are regulated by Title 24.  
3. Required percent better than T24 phased out as T24 standard becomes stricter. No incremental savings after 2018.  
4. Cost estimates based on local government proposals to enhance T24 standards. |
| Commercial Solar PV Mandate                          | 2% targeted 75% install solar PV | 15%                                           | 133 MM SF targeted 100 MM SF install PV       | 2.5 kW/10,000 SF 5 kW/10,000 SF 10 kW/10,000 SF | $6,526/kW 20 kW/10,000 SF 10 kW/10,000 SF | 20         | 1. 17% capacity factor.  
2. PV capacity adapted from existing City of Culver City policy (1 kW/10,000SF).  
3. Cost estimate is average based on $0.25/yr/W reduction until 2015 and a $0.15/yr reduction until 2020. This is reduced from $8.41 statewide cost of CSI in 2008. |

Note:

a Totals do not equal penetration rate times 11 years, because the number and area of buildings varies each year.
## Exhibit 19 | Building and Energy Data Used for GHG Reduction and Cost Estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial Building Floorspace SD County ONLY (0.91 of total SDG&amp;E Service Territory) MM SF</th>
<th>Residential Dwelling Units</th>
<th>Average Residential Electricity Consumption SD County (CEC consumption + losses) kWh/Residential Unit</th>
<th>Average Natural Gas Consumption SD County MM Therms/Residential Unit</th>
<th>Average Commercial Electricity Consumption SD County Only (CEC Consumption + Losses) kWh/SF</th>
<th>Average Commercial Natural Gas Consumption SD County Only Therms/SF</th>
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<tbody>
<tr>
<td>1990</td>
<td>337</td>
<td>946,240</td>
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<td>1991</td>
<td>355</td>
<td>958,859</td>
<td>5,911</td>
<td>348</td>
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<td>0.35</td>
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<tr>
<td>2005</td>
<td>500</td>
<td>1,108,500</td>
<td>6,544</td>
<td>276</td>
<td>17.3</td>
<td>0.29</td>
</tr>
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</table>
### Exhibit 19 | (continued)

#### Building and Energy Data Used for GHG Reduction and Cost Estimates

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial Building Floorspace SD County ONLY (0.91 of total SDG&amp;E Service Territory) MM SF</th>
<th>Residential Dwelling Units</th>
<th>Average Residential Electricity Consumption SD County (CEC consumption + losses) kWh/Residential Unit</th>
<th>Average Natural Gas Consumption SD County MM Therms/Residential Unit</th>
<th>Average Commercial Electricity Consumption SD County Only (CEC Consumption + Losses) kWh/SF</th>
<th>Average Commercial Natural Gas Consumption SD County Only Therms/SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>507</td>
<td>1,121,527</td>
<td>6,845</td>
<td>294</td>
<td>17.7</td>
<td>0.29</td>
</tr>
<tr>
<td>2007</td>
<td>517</td>
<td>1,134,854</td>
<td>6,792</td>
<td>279</td>
<td>17.5</td>
<td>0.27</td>
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<tr>
<td>2008</td>
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<td>1,147,900</td>
<td>6,890</td>
<td>271</td>
<td>17.6</td>
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<tr>
<td>2009</td>
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<td>1,151,296</td>
<td>6,792</td>
<td>261</td>
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<td>0.25</td>
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<tr>
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<td>0.25</td>
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<tr>
<td>2011</td>
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<td>2013</td>
<td>570</td>
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<td>262</td>
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</table>
### Exhibit 20 | Energy Price Data Use for Costs Estimate Calculations

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential Electricity ($/kWh)</th>
<th>Residential Natural Gas ($/therm)</th>
<th>Commercial Electricity ($/kWh)</th>
<th>Commercial Natural Gas ($/therm)</th>
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<tbody>
<tr>
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<tr>
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</table>
### Exhibit 20 (continued)

Energy Price Data Use for Costs Estimate Calculations

<table>
<thead>
<tr>
<th>Year</th>
<th>Residential Electricity ($/kWh)</th>
<th>Residential Natural Gas ($/therm)</th>
<th>Commercial Electricity ($/kWh)</th>
<th>Commercial Natural Gas ($/therm)</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
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<td>$0.20</td>
<td>$0.43</td>
<td>$0.17</td>
<td></td>
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<tr>
<td>2028</td>
<td>$0.20</td>
<td>$0.43</td>
<td>$0.18</td>
<td></td>
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<tr>
<td>2029</td>
<td>$0.21</td>
<td>$0.44</td>
<td>$0.18</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>$0.21</td>
<td>$0.44</td>
<td>$0.18</td>
<td></td>
</tr>
</tbody>
</table>


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### Endnotes

2. California’s Global Warming Solutions Act of 2006 was signed into law in September 2006. It requires the state to reduce GHG emissions to 1990 levels by 2020.
3. Electronic copies of the executive summary and eight supplements sector reports are available on the EPIC website at: http://www.sandiego.edu/epic/ghginventory/.
4. San Diego County is the third most populous county in California with approximately 3 million inhabitants. It has 18 cities within its borders, and covers an area of 4,526 square miles, about the size of the state of Connecticut.
5. To do this, we adapted the well-known approach used by Pacala and Socolow (2004).
6. GHG reduction values for several building-related strategies have been modified from those in the Inventory due to a refined methodology and updated energy forecast. For instance, the amount of GHG emissions expected from energy efficiency has been revised down to 0.68 MMT CO$_2$E from 1.1 MMT CO$_2$E. The total amount of GHG reductions from the electricity sector still meets the 1990 target by 2020. Also, the natural gas value has been revised down to 0.26 MMT CO$_2$E from 0.3 MMT CO$_2$E.
7. 1 million metric tons of CO$_2$E is roughly equivalent to the annual emissions of 83,000 typical San Diego residents. Carbon dioxide equivalent includes the sum of all GHGs converted to the global warming potential (GWP) of carbon dioxide. For example the GWP for methane is 21. This means that 1 million metric tons of methane is equivalent to emissions of 21 million metric tons of carbon dioxide.
10. Itron, Inc., California Energy Efficiency Potential Study—CALMAC Study ID: PGE0264.01, September 2008. For a discussion of Itron’s methodology, see Section 3

11 The values presented in Exhibit 4 represent the results of the mid-restrict scenario, which represents the level of efficiency expected if financial incentive levels are halfway between those available in 2006 and the full incremental cost.

12 The public goods (or system benefits) charge is assessed to all electric and natural gas ratepayers and used to fund programs that in theory benefit all ratepayers, such as research and development and energy efficiency programs. For more on California's public goods charge, see Anders and Kuduk (2006).


14 Ibid at 89.

15 Residential housing stock data provided by San Diego Association of Governments, residential permit data provided by the Construction Industry Research Board.


17 Roth (Oct. 2004).


20 Cost used here means total cost to implement and does not take into account any financial incentives that might reduce the final cost to the customer.


22 Montgomery County Code Chapter 40, real Property Section [[40-13A]] 40-13B.


27 Austin Municipal Code Chapter 6–7 §6-7-21 et seq.


29 Wisconsin Administrative Code, Department of Commerce. Chapter Comm 67 Subchapter III, §Comm 67.05 et seq.

30 The California Energy Commission defines retro-commissioning as the process of “systematically investigating the operation of a building’s energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems.” Retro-commissioning is typically only done in commercial buildings.

31 For a more complete listing of energy-related and green building policies in California, see the California Office of the Attorney General website. Available at: http://www.ag.ca.gov/globalwarming/greenbuilding.php.

33 City of San Francisco Building Code Chapter 13C.
34 City and County of San Francisco, Department of Building Inspection, Administrative Bulletin No AB-093 (Sept. 24, 2008).
35 San Francisco Planning Department. Director’s Bulletin 2006-02 (Sept. 28, 2006).
36 Santa Barbara Municipal Code Title 22, Chapter 22.82, Section 22.82.030.
37 Ibid at Section 22.82.050.
38 Code of the City of Palm Desert Chapter 24.30, Section 24.30.030.
39 Ibid at Section 24.030.040.
41 City of Chula Vista Municipal Code—Section 15.28.015 Ord. 3122 § 1, 2009.
44 Ibid at Article 3 Section 1.
46 City of Palm Desert Ordinance No. 1124, Section 24.30.030.
47 Ord. No. 2008-004 § 1 (part) § 15.02.1005.
48 The Database for Energy Efficient Resources (DEER) is a California Energy Commission and California Public Utilities Commission (CPUC) sponsored database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL). The DEER is available at: http://www.energy.ca.gov/deer/.
49 Housing Data from the San Diego Association of Governments.

References

Roth, R. Using Additions and Alterations Permits to Estimate Remodeling Activity in Metropolitan Areas. Harvard University Joint Center for Housing Studies, October, 2004.

Scott Anders, University of San Diego, San Diego, CA 92110 or scottanders@sandiego.edu.
Energy Efficiency Improvements: Do they Pay?

Authors
Brian A. Ciochetti and Mark D. McGowan

Abstract
This study attempts to quantify the economic gains associated with investment in energy efficiency improvements (EEI) for commercial real estate. We discuss reasons and challenges associated with taking on this endeavor. Benchmarking the performance of these improvements is discussed through an explanation of the Leadership in Energy and Environmental Design (LEED) program. A series of projects for which investment in EEI has been conducted are reviewed. While data limitations preclude the ability to generalize our results, we believe they demonstrate an area of real estate investment that should not be overlooked. The findings should appeal to owners and operators of commercial real estate, as well as tenants who occupy space in these buildings.

There is a growing interest in the effect of global warming and climate change on our environment and they are at the forefront of scientific, business, and political discourse. While the two terms have slightly different definitions, there is good reason to pay attention to them, as any change to our global environment is important to us all. As Thomas Friedman recently stated in his book, Hot, Flat, and Crowded: Why We Need a Green Revolution—and How It Can Renew America, “It only takes a small increase in global average temperatures to have a big effect on weather, because what drives the winds and their circulation patterns on the surface of the earth are differences in temperature. So when you start to change the average surface temperature of the earth, you change the wind patterns—and then before you know it you change the monsoons. When the earth gets warmer you also change the rates of evaporation—which is a key reason we will get more intense rainstorms in some places and hotter dry spells and longer droughts in others,” (Friedman, 2008). As the population of the world continues to grow, and urbanization patterns accelerate, our actions in daily life necessitate a better understanding of resource allocation and the impact of that allocation on our environment.

Greenhouse Gas Emissions
While other countries have taken a more proactive stance on this topic, the United States has remained somewhat idle by comparison. Measures such as the Kyoto Protocol, adopted in 2005, which requires members to reduce global greenhouse gas emissions to 1990 levels, have helped accelerate a global awareness of the issue (United Nations, 1999). The European Union Emission Trading Scheme
(EU-ETS) governs the 27 EU members who have adopted a Kyoto-based compliance market on greenhouse gas emissions. The U.S. was neither a party to the Kyoto Protocol, nor has it taken a firm stance on regulating carbon emissions. This is despite the fact that, on a per capita basis, the U.S. emits more carbon dioxide from the consumption of fossil fuels than any other country in the world (EIA, 2006).

The issue of carbon emissions is receiving much more attention in the U.S. today, and the federal government continues to investigate the merits of a regulated cap and trade system for large carbon emitters. Many states and some regions have now implemented their own greenhouse gas systems, but largely on a voluntary basis. Some public and private industries are beginning to acknowledge and address their own greenhouse gas footprints, and are increasingly looking for ways to offset their ‘carbon footprint,’ (CBRE, 2007). Other companies in the U.S. have taken a proactive stance in dealing with their role in the environment. For example, Google committed in 2007 to become carbon neutral and continues to take steps to achieve this goal (Google, 2010). TD Bank Financial Group announced at the beginning of 2010 that its entire global operations are carbon neutral (Cram, 2010).

The Carbon Disclosure Project, a U.K. based group that seeks to “collect and distribute information to motivate investors, corporations and governments to take action to prevent dangerous climate change,” found a 48% increase in the number of the world’s largest companies that initiated greenhouse gas emission reductions from 2006 to 2007 (Carbon Disclosure Project, 2010). Many of these companies look to real estate as an initial entry point to create a better corporate image and do their part to help reduce their carbon footprint. Between cities, regional markets, and the numerous bills, resolutions, and amendments focusing on greenhouse gas emissions and climate change regulation in Congress today, most agree that a regulated carbon market in the U.S. is not a matter of if, but when, and how (Mufson, 2007).

Buildings are directly responsible for 43% of all annual carbon emissions related to energy consumption in the U.S. This figure dominates transportation at 32% and industry at 25% (Brown, 2005). As the EU and other Kyoto Protocol-compliant countries look beyond the 2008–2012 round of trading, they will most surely focus on the role of real estate in carbon emission reductions (Lend Lease, 2007). The U.S. continues to search for a compromise on the future of regulating carbon emissions and it is highly likely that the real estate industry will come under scrutiny as well.

Most in the commercial real estate sector would agree that the industry needs to be more proactive on the sustainability front. This view has led to a significant increase in our awareness and interest in green building and building technology. The predominant green building program in the U.S. is the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) program, founded in 1998 (Doan, 2006). This program has a number of standards for achieving environmentally balanced, resource-efficient, and healthy buildings. Green buildings are laudable for their positive impact on working and
living environments, but because of their whole building focus, only part of their criteria focus on energy and carbon emissions.\(^5\) Moreover, new construction on an annual basis represents less than 1.5% of the entire stock of commercial buildings in the U.S. (EIA, 2003). Of the nearly 4.6 million commercial buildings in the U.S., 75% (3.4 million) were built prior to 1990 (EIA, 2006). Not surprisingly, most of these buildings have much larger carbon footprints and energy consumption needs due to design inefficiencies, outdated systems, and a general lack of understanding of the benefits that may accrue to investment in energy efficiency improvements (EED).\(^6\) The quickest and most immediate steps can be taken by looking at the efficiency of our current real estate operations and consumption patterns, and exploring opportunities to improve them.

Academic research on the topic of energy efficiency improvements as they relate to the commercial real estate market is limited. Prior research in the area has focused primarily on facilities management applications, or the more technical aspects of system design and operational management efficiency.\(^7\) While a large market exists for the products of Energy Service Companies (ESCOs), much of their work is focused on government entities, non-profits, and single purpose users.\(^8\) Due to the competitive nature of this work, ESCOs have little incentive to share proprietary data for purposes of academic work.

The market for energy efficiency upgrades is sizeable. Anecdotal evidence from the commercial real estate market suggest that upgrades can realize returns of 15%–25% on capital invested, and that the overall market in terms of energy savings range from $40 to $200 billion annually (Binkley, 2007). When combined with potential carbon emission offsets, the annual savings for commercial real estate could range from $45 to $275 billion annually. By way of comparison, the market capitalization of the entire U.S. public REIT industry currently stands at approximately $271 billion (NAREIT, 2009).

The main objective of this study is to provide a background and better understanding of the issues associated with investment in energy efficiency improvements in commercial real estate. While EEI and carbon emission offsets are inter-twined and both relate to the world of commercial real estate, our focus in this paper will be on investment in EEI.\(^9\) To do so, we will discuss energy prices, operational savings, and potential U.S. regulatory actions around carbon emissions. We also explore various options for benchmarking the performance of buildings with special emphasis on motivations, costs, and financing of LEED for existing buildings. We then review a series of examples to illustrate costs and savings associated actual energy efficiency improvements and conclude by discussing the implications of our findings.

**Real Estate and Energy Efficiency Improvements**

Energy efficiency can be defined as the reduction in energy, which is sought in order to affect some level of service or activity. Broad reasons to adopt such measures include improved energy security (less dependence on fossil fuels or sources of energy), employment creation (jobs resulting from such activities), new business opportunities, and cost savings (Klessmann, et al., 2007). Energy
efficiency measures can be undertaken at a broad economic level, or within certain sectors of the economy. Examples include a desire to reduce the U.S. consumption of oil and gas, the creation of more efficient distribution lines for electricity transmission, or the creation and development of more efficient lighting for use in businesses and homes. As with many terms associated with ‘sustainability,’ energy efficiency has different meanings to different people. Common to most is the notion that energy efficiency is about ‘doing more with less,’ not ‘doing without.’ Of the many reasons for undertaking energy efficiency measures, perhaps one of the most compelling is the speed and cost at which many energy efficiency improvements may be implemented. Examples in the area of real estate include changes in lighting, installing insulation and thermostats, use of more efficient blinds and shades, re-commissioning of systems, and the like.

Buildings constitute the largest users of energy in the U.S., with 41% of the market (Exhibit 1). This dominates energy use by both the transportation and industrial sectors, which comprise 29% and 30% of the total consumption in the U.S., respectively. As one might expect, consumption of energy is highly correlated with CO₂ emissions as well.

While residential buildings consume the majority of energy in the building sector, this is due to the sheer number of homes in the U.S. The approximate size of the residential market is 225 billion square feet, nearly nine times that of the office market, which comprises approximately 12.2 billion square feet. Yet, when energy consumption is compared on a relative per square foot basis, residential buildings lag all other uses, with the exception of religious institutions and warehouse and storage buildings (Exhibit 2). Of particular note is the fact that annual residential energy consumption is almost half that of commercial office buildings, at 43,700 BTU/sq. ft. as compared to 92,889 BTU/sq. ft. for office. In this study, we focus our attention on office buildings since they: (1) constitute the

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**Exhibit 1 | Consumption of U.S. Energy in 2009**

- **Residential**: 22%
- **Commercial**: 19%
- **Industrial**: 30%
- **Transportation**: 29%

Exhibit 2 | Energy Consumption of Buildings

<table>
<thead>
<tr>
<th>Principal Building Activity</th>
<th>Annual Consumption per Sq Ft (BTU)</th>
<th>Number of Buildings (000)</th>
<th>Total Sq. Ft. (mn)</th>
<th>Total Energy Consumption (Btu) (bn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>43,700</td>
<td>111,100</td>
<td>225,800</td>
<td>10,550,000</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>83,046</td>
<td>386</td>
<td>9,874</td>
<td>820,000</td>
</tr>
<tr>
<td>Food Sales</td>
<td>200,000</td>
<td>226</td>
<td>1,255</td>
<td>251,000</td>
</tr>
<tr>
<td>Food Service</td>
<td>258,162</td>
<td>297</td>
<td>1,654</td>
<td>427,000</td>
</tr>
<tr>
<td>Health Care</td>
<td>187,796</td>
<td>129</td>
<td>3,163</td>
<td>594,000</td>
</tr>
<tr>
<td>Inpatient</td>
<td>249,343</td>
<td>8</td>
<td>1,905</td>
<td>475,000</td>
</tr>
<tr>
<td>Outpatient</td>
<td>94,594</td>
<td>121</td>
<td>1,258</td>
<td>119,000</td>
</tr>
<tr>
<td>Lodging</td>
<td>100,078</td>
<td>142</td>
<td>5,096</td>
<td>510,000</td>
</tr>
<tr>
<td>Retail (Non-Mall)</td>
<td>73,893</td>
<td>443</td>
<td>4,317</td>
<td>319,000</td>
</tr>
<tr>
<td>Office</td>
<td>92,889</td>
<td>824</td>
<td>12,208</td>
<td>1,134,000</td>
</tr>
<tr>
<td>Public Assembly</td>
<td>93,932</td>
<td>277</td>
<td>3,939</td>
<td>370,000</td>
</tr>
<tr>
<td>Public Order &amp; Safety</td>
<td>115,596</td>
<td>71</td>
<td>1,090</td>
<td>126,000</td>
</tr>
<tr>
<td>Religious Worship</td>
<td>43,420</td>
<td>370</td>
<td>3,754</td>
<td>163,000</td>
</tr>
<tr>
<td>Service</td>
<td>77,037</td>
<td>622</td>
<td>4,050</td>
<td>312,000</td>
</tr>
<tr>
<td>Warehouse &amp; Storage</td>
<td>45,247</td>
<td>597</td>
<td>10,078</td>
<td>456,000</td>
</tr>
<tr>
<td>Other</td>
<td>164,556</td>
<td>79</td>
<td>1,738</td>
<td>286,000</td>
</tr>
</tbody>
</table>

Note: The source is the U.S. Energy Information Administration (2005).46

largest investable commercial real estate sector in the U.S., and (2) since office buildings have a high level of energy consumption, there may be more opportunity for energy efficiency improvement investments in this product type.14

The impact of energy improvements on buildings can be measured, monitored, and improved upon, and since buildings are major consumers of energy, opportunities for efficiency improvements are ongoing. The type of energy consumed in the operations of office buildings is shown in Exhibit 3 and consists of four major categories: electricity, natural gas, fuel oil, and district heat.15

As shown, electricity represents by far the most dominant form of energy consumed in office buildings in the U.S. today. This type of power is typically purchased from utility companies and is produced by the burning of coal, oil, natural gas, or through sources such as hydropower, wind, solar, or nuclear. Approximately 66% of electricity comes from the burning of fossil fuels.16 Most of these sources create some form of emission, typically in the form of CO₂, and consumption of electricity comprises nearly 80% of the total amount of CO₂ emissions within the commercial building sector.17

When News Corporation announced in 2007 that it had set a goal to reach carbon neutrality by the end of 2010, they conducted a study on their existing use of energy for all operations within the company and their effect on greenhouse gas
Exhibit 3 | Office Energy Consumption by Fuel Type (U.S.)

- Electricity: 63%
- Natural Gas: 24%
- Fuel Oil: 2%
- District Heat: 11%


Exhibit 4 | News Corps’ Greenhouse Gas Emissions by Source

- Electricity: 72%
- Transport: 23%
- Other: 5%


emissions. As shown in Exhibit 4, electricity was by far the most significant contributor to greenhouse gases, comprising 72% of total emissions.

In the role of real estate decision-making, one often encounters a conflict between a ‘top-down’ or ‘bottom-up’ approach as to whether and how decisions are made. Typically, strategic and tactical decisions about investing in real estate come from mixed-asset portfolio managers and/or those with overall responsibility for real estate operations. Individual investments are often made by acquisition teams with support from others in the organization, and management of the assets is generally handled by asset and property managers. In the case of real estate investment motivated primarily by sustainability concerns, it is often the operations managers or onsite facilities managers that see the opportunity for value enhancement at the
individual building level. Only over the past few years has awareness increased to a level that those with overall control of portfolios understand the economic and marketing benefits associated with a ‘greening’ of their portfolios.

**Why Energy Efficiency Improvements?**

While there are many ways to measure the ‘greening’ of a building and associated benefits, investment in EEI stand out because of three important reasons: (1) the upward trend of energy prices, (2) the potential for operational savings that increase net operation income, and (3) potential U.S. regulatory actions around carbon emissions.

**Energy Prices**

One of the most compelling motivations for investment in EEI is to lessen the reliance on energy and hence its’ cost in building operations. While crude oil prices have ranged from $38 to $144 per barrel over the past three years, most consumer energy prices in the U.S. have experienced a continued upward climb over the past fifteen years. Exhibits 5 and 6 provide an historical view of commercial electricity and natural gas prices as experienced by commercial users since 1994. Note that while prices were stable for both products in the mid 1990s, electricity pricing declined slightly in the late 1990s and has increased continuously since that time. Overall, commercial electricity prices have increased approximately 25% since 2000 and most economists believe that the days of low cost energy are a thing of the past (Lave, 2008).

Natural gas prices increased slowly from the mid to late 1990s before also increasing at a more rapid rate since 1999. In fact, natural gas pricing at the

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**Exhibit 5** | Average Retail Price of Electricity to Commercial Sector

![Graph showing the average retail price of electricity to commercial sector over the years.](graph.png)

commercial level has increased from $6.59 per cubic foot in 2000 to $11.91 per cubic foot in 2008, an increase of 77% (EIA, 2008). This is not lost on those in areas of the U.S. where electricity is produced through the combustion of natural gas. For both of these ubiquitous sources of energy, prices are expected to increase in the future and thus impact the operational performance of commercial real estate.

Clearly one benefit to building owners is that by paying attention to the efficiency of building systems and consumption of energy, they will be better positioned to benefit from the potential volatility in energy prices, allowing for better operational budgeting.

Savings in Operating Expenses

In a typical urban office building, energy costs range from 15% to 25% of operating expenses. This variance depends on a number of factors such as building age, systems employed, location of property, and predominate form of energy used in the building. Depending on the lease structure, the landlord and/or tenant could be responsible for part, or all of those costs. Any efforts to decrease controllable expenses, like energy use, fall directly to the bottom line and can increase net income by 2%–3%. As energy prices increase over time, savings and net income will grow as well, positively impacting building value.

Regulating Carbon

The U.S. has yet to enact a national climate bill. In early 2009, President Obama called on Congress to send him “legislation that places a market-based cap on carbon pollution and drives the production of more renewable energy in America.”
Congress responded on March 31, 2009 with the House Democrats introducing the American Clean Energy and Security Act of 2009, which includes a cap and trade program (Johnson, 2009). This draft bill includes language on updating state building energy efficiency codes, but to date the bill has not specified how it will treat commercial real estate. However, Democratic leaders in the Senate conceded in July of 2010 that they did not have the votes to move the bill forward (Power, 2010). Until such time as we create incentives for those to save energy in a more thoughtful way, it is likely we will not see adoption on a large scale.

**Benchmarking Performance**

The real estate industry’s effort to combat climate change and reduce greenhouse gases requires measurement and a more definitive understanding of environmental impact. For better or worse there is a growing tendency by building owners (or their representatives) to declare their property “green” or as having certain sustainable features with little more than their word and experience to document their assertions. This presents a challenge to an observer looking to understand a particular building’s green design or operational features or compare one building to another. The presence of an objective third-party monitoring system can provide an opportunity to assess and certify a building’s performance. Across the globe, there are many third-party rating systems by which a building can benchmark its design, construction, and operations. In the U.S., the most prominent systems are ENERGY STAR and Leadership in Energy and Environmental Design (LEED).

**ENERGY STAR**

In the U.S., the Environmental Protection Agency released the ENERGY STAR program for Office Buildings in 1999. This program allows a building owner to measure the energy efficiency of a building and compare it to other buildings across the U.S. Under the program, the energy performance of a building is scored on a 1–100 scale and buildings that achieve a score of 75 or above are eligible for the ENERGY STAR designation (ENERGY STAR, 2010). For example, a building that has a score of 80 means the building is in the top 20% of facilities in the country for energy performance. The score is calculated by estimating how much energy the building would use if it were the best- or worst-performing building of its type (along with levels in between) in terms of its size, location, and number of occupants. The rating system then compares the actual energy data input to the internal database to determine where the building ranks relative to other similar buildings. For existing buildings, applicants can use the Portfolio Manager tool on the ENERGY STAR website to organize, evaluate, and track energy (and, more recently, water) consumption. While the move to include water consumption has broadened the scope of ENERGY STAR, it still does not address or rate many of the sustainable or green aspects surrounding a given building, and is not generally considered a comprehensive green building rating system.
Leadership in Energy and Environmental Design

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is a third-party certification program, overseen by a non-profit organization, the U.S. Green Building Council (USGBC). LEED promotes a whole-building approach to sustainability by recognizing performance in five categories of human and environmental health: sustainable site development, water efficiency, energy efficiency, materials selection, and indoor environmental quality (USGBC, 2009). New and creative strategies and solutions that exceed credit requirements receive points in the ‘innovation’ section of LEED and regionally-specific environmental issues that are addressed can also receive points.

In each of the five categories, there are requirements and performance criteria. The USGBC calls these requirements prerequisites and these stipulate the minimum conditions that need to be met for the project to be considered under the rating system. The performance criteria are called credits, and there are a certain number of credits within each category that have points assigned to them; the better you perform (and document), the more points you can achieve. In order to achieve a point, the applicant has to demonstrate compliance with the credit to the USGBC. LEED has a number of separate rating categories, and for each, applicants can achieve four levels of certification: certified, silver, gold or platinum.

This third-party rating system gives owners, managers and tenants, along with their professional team of engineers, architects, and contractors, the ability to benchmark building design and performance. The purpose of assessing and benchmarking the performance of a design or operations of a building is largely to make measurement possible. Whether to comply with a government mandate or to differentiate a product, the more a developer or owner is able to measure green building performance, the better the management team can do its job. This adoption of standards, along with compelling financial savings, brings clarity and organization to the greening of construction and building operation within the commercial real estate arena.

LEED-EB

One of the categories of LEED rating is the LEED for Existing Buildings (LEED-EB) Rating System. This was created to assist owners and operators to maximize their building’s operating efficiency, as well as minimize its environmental impact. Although the LEED-EB Rating System has been in existence since 2004, there are currently 604 LEED-EB certified buildings in the U.S. Compared with the success of the LEED for New Construction program (LEED-NC), LEED-EB has had a slow start. However, there appears to be a substantial shift in the market towards embracing LEED-EB, particularly in the investor-owner Class A urban office building sector. Currently there are 2,491 total buildings (representing approximately 0.24% of the existing office building stock in the U.S.) that are registered for LEED-EB designation. The majority of these are owned by for-profit companies and governmental agencies, and a breakdown of the occupancy...
for both certified and registered LEED-EB office projects during 2008 are provided in Exhibit 7.\textsuperscript{29}

Major office owners in the U.S., such as Beacon Capital Partners, Boston Properties, Brookfield Properties, Hines Interests, Liberty Property Trust, Tishman Speyer, and Vornado Realty Trust, are currently registering and certifying their investor-owned office buildings under the LEED-EB program. Typically these properties are Class A buildings located in core urban markets, such as Boston, New York, Washington D.C., Chicago, and San Francisco. Brookfield Properties Corporation, which has one of the world’s largest office portfolios, plans to retrofit at least one building in each U.S. market every year to LEED-EB certification.\textsuperscript{30} Many of the other companies contacted during this study have indicated plans to upgrade selected properties within their portfolios in the coming months, but few had specific timeframes. Nearly all mentioned that they currently had no LEED-EB certified properties in their portfolio.

Those in the property management business are also taking a more proactive stance in registering and certifying properties that they manage on behalf of third parties. Some in the management business have commented that knowledge of the LEED-EB process provides a differentiating factor in the current environment of a very competitive market place. For example, CB Richard Ellis and Transwestern have registered 100 and 51 U.S. office buildings, respectively, in the USGBC LEED-EB Pilot Portfolio Program (Burr, 2008).\textsuperscript{31}

\textit{Motivations}

The LEED-EB rating system is second only to LEED-NC in terms of registered projects. Many of the new applicants for LEED-EB are investor-owners, while the majority of prior applicants for LEED-EB were owner-occupiers. Owner-occupiers were the early adopters of LEED-NC and LEED-EB, since they tend to have a longer term outlook on their real estate holdings, including a general awareness

\begin{center}
\textbf{Exhibit 7} | Occupancy for LEED-EB Certified and Registered Office Projects, 2008
\end{center}

\begin{center}
\begin{tabular}{lcccr}
\hline
Occupyant Type & Certified & Percentage & Registered & Percentage \\
\hline
Fed Gov't & 4 & 2.4\% & 134 & 6.5\% \\
State Gov't & 15 & 8.9\% & 183 & 8.9\% \\
Local Gov't & 8 & 4.8\% & 78 & 3.8\% \\
Non-profit & 9 & 5.4\% & 181 & 8.8\% \\
For-Profit & 106 & 63.1\% & 636 & 30.8\% \\
Mixed Occupancy & 24 & 14.3\% & 775 & 37.6\% \\
Individual & 2 & 1.2\% & 76 & 3.7\% \\
Total & 168 & & 2,063 & 100\% \\
\hline
\end{tabular}
\end{center}

\textit{Note:} The source is USGBC (2008).
of the benefits inherent in EEI upgrades, including: higher employee productivity, retention and recruitment, lower absenteeism, and lower operating costs. Thus, one could argue that perhaps owner-occupiers have more of a vested interest in improving their space to provide more comfort and a better environment for their employees.

Investor-owners may have less of an incentive to invest in EEI for their properties. They incur the initial costs for energy upgrades, while only being able to recoup savings if their leases allow them to pass through the upgrade costs or recoup energy savings from the tenants. Moreover, they have until recently received little or no additional monetary reward for the improvements incurred from the marketplace. What, then, are the reasons for the recent shift towards securing LEED-EB approval for investor-owned buildings? Many reasons could be put forth for this shift, but five of the most compelling are as follows:

1. **The Threat of New Green Construction.** In the past decade, a growing majority of newly constructed buildings have been designed and built to green standards, such as LEED-NC. With regulatory forces in many cities across the U.S. requiring buildings over a specified size to be “certifiable,” and markets such as San Francisco, where nearly 100% of new commercial buildings (either under construction, approved, or in the planning stages) are seeking LEED certification, there seems to be shift in the ‘standard’ for new commercial space (Nelson, 2008). Many building owners, and especially those with large portfolios of Class A space, have indicated a strong preference in having their existing buildings comply with LEED (or other) levels of certification in order to compete with newly created stock.

2. **Green is a New Amenity.** Owners often feel that LEED certification is another amenity or seal of approval that sets their buildings apart from the rest. In a competitive marketplace, having an amenity like LEED-EB certification can make the difference between capturing tenant interest and not. Thus far, buildings with EEI improvements are treated in a similar way to those with fitness clubs, cafeterias, proximity to transportation or additional parking; LEED-EB is another amenity. Others contacted for this research echoed this sentiment, indicating that LEED would be a powerful marketing tool in attracting tenants, many of whom are becoming increasingly aware of their environmental footprint.

3. **Tenant Demand.** Tenants are beginning to ask for more energy efficient space, particularly that which carries LEED certification. These tenants tend to be corporations with socially responsible investment (SRI) goals, government agencies, and technology companies that have stated sustainability initiatives. Companies that place a very high value on the recruitment and retention of their employees also see the importance of being able to point to a healthy and sustainable work environment. Many companies, especially those in the technology and biotech areas compete aggressively for human resources and often use their physical space as a recruiting tool. Clearly if employees are being asked to spend significant amounts of time at work, having a building with good air quality and
other environmental enhancements is essential. The old adage that ‘people are a firm’s most expensive and valuable asset’ rings true, especially in today’s economy.

Many tenants, however, adhere to more traditional selection criteria when searching for office space. Since the search for space happens at infrequent intervals (typical office leases range from 3–7 years), tenant awareness of space needs may take some time to change.33 Yet, even though many tenants do not occupy or insist upon LEED (or equivalent) space, many employees carry out sustainable practices within existing space. Examples include replacing disposable coffee cups with personal mugs, use of paper products with recycled content, or separating trash products into disposables and recyclables.

4. **Investor Demand.** Investors are beginning to ask about and for sustainability.34 Results from a conversation with an international developer who polled both foreign and American investors indicated that over half said they would pay a premium for a green building; and that the premium would range from 2% to 5%. Foreign investors, especially Europeans, seem to be leading the pack in terms of sustainably-oriented investments, as they have more knowledge and background on the issues and benefits. Moreover, many foreign investors have experienced the impact of regulatory activity in the area of sustainability. Conversations with one of the respondents to our request for data indicated that one of their clients, a Canadian investor, was highly receptive to LEED, since it was comparable to the ISO certification in Europe.35

Many investors are focused on the bottom line; a return on their investment. Increasingly, evidence is mounting that energy efficient and ‘green’ buildings can offer competitive, or even superior, returns. According to a recent study by CoStar, “demand in the marketplace for sustainability creates higher occupancy rates, stronger rents and sale prices in ‘green’ buildings.”36 Specifically, the CoStar study stated that LEED buildings command rent premiums of $11.33 per square foot over their non-LEED peers while also enjoying a 4.1% higher occupancy rate. Additionally, rental rates in buildings with ENERGY STAR ratings are shown to capture a $2.40 per square foot premium and have a 3.6% higher occupancy than their non-ENERGY STAR counterparts.37

5. **Responding to Climate Change.** Many professionals indicated that improving the state of the built environment was ‘the right thing to do,’ and that one area in which participants can take an active role is in the area of real estate. Others are conscious of the impact that real estate has on the environment, in terms of energy use and carbon emissions, and would like to lessen the environmental impact of their professional activities.

**Obstacles**

Given the opportunities associated with investment in EEI, one would surmise that all participants would be active in trying to improve their entire inventory of
property holdings. This is not the case, as a number of outstanding issues need to be addressed before the market for EEI investments will grow. A few of these include:

1. **Minimum Level of Energy Efficiency Performance.** One of the largest obstacles for owners to deal with when considering an improvement of their existing properties is the LEED-EB’s minimum energy efficiency performance prerequisite. In order to qualify for EB certification, a building needs to achieve a pre-determined number of LEED points. One of the criteria for certification is that the building needs to achieve an ENERGY STAR rating of 69. If not, the road to certification through LEED is much more difficult, timely, and costly. While buildings often have a number of components to their energy efficiency strategy, and many have payback periods of less than three or four years, a building with poor prior energy efficiency performance usually needs more comprehensive and costly upgrades to achieve LEED-EB certification. Many of those comprehensive upgrades have longer payback periods and lower returns, which can make them less attractive economically and thus less likely to be carried out. Therefore, a building’s prior energy efficiency performance, or ENERGY STAR rating, is generally seen as the first indicator of whether or not the building owner should attempt to secure LEED-EB certification.

2. **Water Efficiency.** Efficient use of potable water is another obstacle associated with LEED-EB approval. When a building has a large number of well-functioning toilets and urinals that consume too much potable water, a challenge arises as to whether it makes financial or ecological sense to dispose of them all, and purchase new ones. Nor does it seem to make ecological sense to replace the well-functioning equipment, when the new ones consume substantial raw material and energy to manufacture, transport, and install. In some drought-stricken locations and nations, such as Australia, the decision to change well-functioning toilets for new water-efficient ones may be wise; however, in most locations there are more financially and ecologically sound solutions for saving potable water on or off site, such as xeriscaping or a condenser water loop.

3. **Education.** LEED-EB may require the introduction of new procedures and policies that tenants and building staff are not used to. An example of this challenge would be how to motivate and break the habits of building staff who are accustomed to turning on a heating or cooling system to high first thing in the morning, as opposed to slowly ramping up the systems with the help of technology. Additionally, the culture or modus operandi of the building’s vendors and contractors must be changed. While more and more people are hearing about sustainability, the challenge is getting them to incorporate it into the service or products that they provide, such as green cleaning or landscaping. This trend is growing as peoples’ perception of effective recycling is on the increase in modern industrial societies.

4. **Verification.** Another obstacle to increased LEED-EB activity is the ability to isolate and verify changes that are undertaken. For example, one could
change paper products and the water flow of the toilets in restrooms at the same time, which may cause problems with the plumbing. It would therefore be difficult to determine whether it was the switch to recycled content paper (which uses more glue to bind the paper), or the low-flow toilets that caused the plumbing to back up.

5. The LEED-EB Paperwork and Documentation. One of the most frequently cited hurdles in undertaking the LEED-EB process is the amount of documentation required when submitting an application to the USGBC. The need to document ‘before and after’ operations is thought to be particularly onerous. In April 2009, the USGBC introduced a new streamlined and user-friendly LEED-EB Rating System, called LEED-EB Operations and Maintenance. 40 LEED-EB Operations and Maintenance (O&M) not only has fewer prerequisites (9 as opposed to 13), but also has realigned the focus of the program more closely with the industry’s concerns, such as energy and water efficiency. While this new streamlined version has helped significantly, several owners have voiced a desire for more human interaction with the USGBC. While the amount of paperwork for LEED-EB O&M is now approximately 2,000 pages (a decrease of 2,000 pages from version 2.0 of LEED-EB), documentation is still a considerable task. Despite the fact that much of LEED-EB’s documentation is warranted, owners claim that additional communication and/or interaction would increase the transparency and effectiveness of the program.

6. Time. Securing a LEED-EB certification typically takes from 12 to 18 months, and is dependent upon a number of building and engineering-related factors. 41 Unlike LEED-NC, LEED-EB requires re-certification on a five-year basis. This allows for a periodic monitoring of building performance to ensure that operational standards are maintained over the life of certification. 42

Implementation

A major cost of pursuing LEED-EB relates to energy and water efficiency projects. Some owners justify the costs by projecting higher tenant satisfaction and retention, while others expect value creation. The observed practice by owners is to compute the IRR of their energy and water efficiency upgrades and, if the efficiency projects have a higher IRR than their cost of capital, they will undertake the efficiency upgrade, especially since efficiency projects are seen as very low-risk investments.

Most building owners fund improvement projects internally and usually attempt to pass through the capital cost of the upgrades to their tenants in some type of amortized fashion. This of course becomes a function of the type of lease arrangement between landlord and tenant, current market conditions, or other agreements made subsequent to the implementation of EEI investments. The ability to pass through energy or water efficiency improvement costs—amortized over time to be equal to the tenants’ direct operational savings—can be of economic benefit to both landlords and tenants.
Costs

Many variables influence the cost of upgrading a building to LEED-EB’s standards, but the most significant factors are twofold: the building’s prior energy or water efficiency performance level and the building owner/management team’s knowledge and time constraints. Some motivated management teams take it upon themselves to become experts in understanding the framework, process, and particulars of the LEED-EB rating system. This information allows them to navigate the process and achieve credits towards the rating with greater ease, less assistance, or capital investment. Overall, the building’s prior energy and water efficiency, along with the owner/management team’s knowledge and experience with LEED are often used as a good determining factor as to the feasibility and cost of pursuing LEED-EB.

How much does the process of obtaining LEED-EB cost? In one study, overall costs of implementation and certification were found to range from $0.02 to $5.01 per square foot of gross floor space, with an average of $1.61 per square foot. While the range might appear to be large, it is a function of existing performance and upgrades associated with buildings used in the study.

Does It Pay?

As the cost and procedures to green an existing building to LEED standards can vary greatly, real world examples can shed light on the economics associated with EEI investment. In this section we will illustrate a number of examples, each of which has varying level of detail. One of the challenges with this study was the shortage of data that were available for analysis. While many buildings are registered for certification, the number available for analysis is very small. Over the course of this research, we were able to access information on 38 of these properties. Of those, eleven owners 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 five others.

Case Study

The property used in this example is owned by a real estate investment firm that develops, owns, and manages properties throughout the U.S. and Europe. 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 owner has a stated goal of benchmarking and certifying 60% of their portfolio to a LEED Silver rating level and achieving LEED Certified rating for the remaining 40%. The firm’s motivations include: (1) an internal push at the firm to make LEED a part of their platform and provide market leadership in the area of EEI; (2) an awareness of the high returns in energy and water efficiency investments; and (3) to hedge operating risk against rising energy prices. The building is located in a U.S. metropolis on the East Coast and has recently received a LEED Silver certification.
Team
The owner championed the LEED-EB efforts and worked closely with the building’s management staff to seek certification. The owners also incentivized the building’s engineers to achieve higher energy efficiency by offering bonuses based on increased energy performance. The owner elected to use a LEED-EB consultant for assistance in both the management of the process and the documentation collection and completion.

Property. 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.

Costs. The total cost of the project was $938,613. The cost associated with a LEED-EB consultant was approximately $60,000. The registration and certification costs were $450 and $12,500, respectively; however, it is important to note that there were no estimates of staff time used or the cost of the staff time to obtain certification. Other costs obtained were related to energy conservation measures. Exhibit 8 displays operational changes that had no initial outflow, but that but produced operational savings.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost $</th>
<th>Savings $/Yr</th>
<th>Electrical Savings kWh/Yr</th>
<th>Steam Savings Mlb/Yr</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommission General Exhaust Fans</td>
<td>$0</td>
<td>$2,241</td>
<td>13,183</td>
<td>—</td>
<td>General exhaust fans turned off.</td>
</tr>
<tr>
<td>Decommission Cooling Towers for Winter Season</td>
<td>$0</td>
<td>$18,226</td>
<td>—</td>
<td>701</td>
<td>Draining cooling towers for winter season reduces steam consumption for freeze protection.</td>
</tr>
<tr>
<td>Temperature Control in Garage</td>
<td>$0</td>
<td>$19,500</td>
<td>—</td>
<td>750</td>
<td>Project involves installing temp control on garage heaters.</td>
</tr>
</tbody>
</table>

Return on Investment (ROI) = infinite (no upfront costs).
Payback Period = 0, savings were immediate.

The savings column for all of the figures in this case study was calculated by multiplying the kilowatt hour (kWh) per year savings by cost per kilowatt hour at the time of investment, which for this building was $0.17/kWh. The same methodology was used to calculate steam savings by multiplying the thousand pound (Mlb) per year savings by the cost of steam per thousand pounds, or $26.00 per Mlb. In the event that a measure produced both electricity and steam savings, they were added together.
Exhibit 9 provides a breakdown of the costs and savings associated with reprogramming the Energy Management System (EMS) to heat and cool water more efficiently.

**Exhibit 9 | Costs and Savings Associated with Reprogramming the EMS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Savings</th>
<th>Electrical Savings</th>
<th>Steam Savings</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset Chilled Water Supply Temp. Setpoint on Outdoor Air Temp.</td>
<td>$6,500</td>
<td>$44,590</td>
<td>—</td>
<td>1,715</td>
<td>By reprogramming the EMS system they can raise the set point of the chilled water temp during optimal conditions depending on dewpoint.</td>
</tr>
<tr>
<td>Reset Secondary Hot Water Supply Temp. for Night Setback</td>
<td>$7,286</td>
<td>$51,454</td>
<td>—</td>
<td>1,979</td>
<td>By reprogramming the EMS system they can lower the set point of the hot water in the secondary loop.</td>
</tr>
</tbody>
</table>

**ROI = 697%**
**Payback ≤ 2 months**

The energy conservation measures in Exhibit 10 were completed concurrently during a period of six months and the cost includes engineering fees and utility rebates. The owner stated that these energy efficiency projects would have been done regardless of LEED-EB because of their quick paybacks.

**Exhibit 10 | Concurrent Energy Conservation Measure Projects**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Savings</th>
<th>Electrical Savings</th>
<th>Steam Savings</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convert Perimeter Fan Systems to Return Air</td>
<td>$225,212</td>
<td>—</td>
<td>8,662</td>
<td></td>
<td>This will allow us to eliminate the heating &amp; cooling of outside air for an extended period of time.</td>
</tr>
<tr>
<td>Reset Variable Air Volume (VAV) Supply Fan Static Pressure Setpoint on Outside Air Temp</td>
<td>$16,965</td>
<td>99,796</td>
<td>—</td>
<td></td>
<td>By reprogramming the EMS system we can slow down the supply fan motors to achieve power savings.</td>
</tr>
</tbody>
</table>
Exhibit 10 | (continued)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Savings</th>
<th>Electrical Savings</th>
<th>Steam Savings</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Garage Temperature and Ventilation Control</td>
<td>$78,958</td>
<td>138,847</td>
<td>2,129</td>
<td></td>
<td>Install thermostats and VFDs to reduce power and steam.</td>
</tr>
<tr>
<td>Variable Frequency Drives (VFDs) for Secondary Water</td>
<td>$359,827</td>
<td>33,976</td>
<td>199,856</td>
<td>—</td>
<td>Installing VFDs will provide power savings by reducing the speed of the pumps.</td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Sensors for Demand Ventilation Control</td>
<td>$51,116</td>
<td>—</td>
<td>1,966</td>
<td></td>
<td>Adding CO₂ sensors to all return systems will allow for reduced outside air intake in the summer months</td>
</tr>
<tr>
<td>Install Variable Frequency Drives on Perimeter Supply Fans</td>
<td>$79,671</td>
<td>468,651</td>
<td>—</td>
<td></td>
<td>Installing VFDs will provide power savings by reducing the speed of the 4 supply fans.</td>
</tr>
<tr>
<td>VFDs for Reheat/Radiation pumps on Service Level</td>
<td>$11,255</td>
<td>66,208</td>
<td>—</td>
<td></td>
<td>Installing VFDs will provide power savings by reducing the speed of the pumps.</td>
</tr>
</tbody>
</table>

ROI = 138%
Payback = 9 months

Exhibit 11 | ECM Measures with Less Than a 3-Year Payback

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Savings</th>
<th>Electrical Savings</th>
<th>Steam Savings</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Area Lighting Retrofit</td>
<td>$142,874</td>
<td>70,152</td>
<td>—</td>
<td>—</td>
<td>Project involves replacing ballasts and fixtures with Super T-8 ballasts and lamps. (tenant space excluded).</td>
</tr>
<tr>
<td>Variable Frequency Drives (VFDs) for Condenser</td>
<td>$69,460</td>
<td>33,559</td>
<td>—</td>
<td>—</td>
<td>Installing VFDs will provide power savings by reducing the speed of the pump.</td>
</tr>
<tr>
<td>Water Pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Exhibit 11 (continued)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Savings</th>
<th>Electrical Savings kWh/Yr</th>
<th>Steam Savings Mlb/Yr</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>VFDs for Chilled Water Pumps with Freeze Protection Modification</td>
<td>$74,945</td>
<td>$35,046</td>
<td>—</td>
<td>—</td>
<td>Installing VFDs will provide power savings by reducing the speed of the pump.</td>
</tr>
<tr>
<td>VFDs for Cooling Tower Fans &amp; CWS Temp. Setpoint Reset on OAT</td>
<td>$52,720</td>
<td>$22,005</td>
<td>—</td>
<td>—</td>
<td>Installing VFDs will provide power savings by reducing the speed of the cooling tower fans.</td>
</tr>
<tr>
<td>District Utility Steam Condensate Heat Recovery</td>
<td>$225,000</td>
<td>$74,982</td>
<td>—</td>
<td>—</td>
<td>Very rough estimate. Project includes recovering 180 degree condensate water and using it in parking garage and other applications.</td>
</tr>
</tbody>
</table>

**Return on Investment (ROI) = 42%**  
**Payback = 2 years, 5 months**

The energy conservation measures (ECMs) in Exhibit 11 have higher costs related to their associated savings and have paybacks of three years or less.

As described in Exhibits 8–11, total costs for the LEED-EB certification project were $1,011,562 (including the cost on the consultant, registration, and certification) and the total savings were $868,908.45 This results in an overall economic performance of:

**Total Return on Investment (ROI) = 86%**  
**Total Payback = 14 months**

Clearly in this example, the investment in EEI has paid off handsomely. But what about the long-term impact on energy consumption? Exhibit 12 provides the monthly energy cost and consumption data for the building for 2006, 2007, and up to May 2008.
Note that the electricity consumption for the first five months of 2008 is showing signs of being less volatile compared to the two years prior. The kilowatt-hour consumption for 2008 nearly looks as if it can serve as a trend line for the electricity consumption for 2007. A major benefit that can be inferred from Exhibit 12 is that less volatile electricity consumption reduces the management and operational risks for building and can help managers and owners budget and manage cash flows in a more predictable fashion.

**Additional Projects**

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.

1. **Project: Mixed-Use**
   - **Location:** Midwest
   - **Size:** 4.2 million square feet
   - **Year built:** 1930

In this project, the building owner instigated efforts to improve the efficiency of the building’s cooling system. The project included replacing a pair of one-speed electric motors and installing variable-speed upgrades. The overall cost of these improvements was $350,000. Resulting energy savings were approximately
$50,000 a year, for a payback period of seven years, and a 14% ROI. In another project the owner had meters installed on different equipment and fixtures in the common areas. A $16,000 sensor was installed to monitor leaks in the cooling system that was causing air compressors to work overtime. Once building staff identified and patched leaks, the compressor was running more efficiently and consumed $4,000 less energy per year. While a simple improvement, the ROI was 25%, with a payback of four years.

2. Project: Office
   Location: California
   Size: 990,000 square feet (3 buildings)

A corporate group with a headquarters complex in California spent $1.2 million on energy and water efficiency projects over the course of five years (Exhibit 13). The projects ranged from replacement and upgrades of equipment to installing monitors and controls. The project also directed a significant amount of capital to load management, undertaking efforts to effectively spread out the peaks and valleys in energy demand. The project received $389,000 in rebates and reduced operating costs by $1.03 million per year. This is an average payback period of approximately 10 months and an overall ROI of 121%.

3. Project: Office
   Location: California
   Size: 950,000 square feet
   Year built: 2000

Energy efficiency improvements are not the only upgrade that commands a return. This owner of this building in California planted native, drought-resistant grasses, plants, and trees to minimize storm water runoff and reduce heat build up on the roof. Municipalities across the country dedicate resources and personnel to maintaining adequate storm water management systems, so there is a cost that the taxpayer covers for the unmitigated impacts of development. Another upgrade project installed low-flow toilets, water-free urinals, and water-efficient fixtures.

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**Exhibit 13** | Upgrade and Performance Statistics

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Rebate</th>
<th>Savings</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Management</td>
<td>$445,248</td>
<td>$205,437</td>
<td>$729,185</td>
<td>304%</td>
</tr>
<tr>
<td>Lighting</td>
<td>$300,701</td>
<td>$44,918</td>
<td>$155,616</td>
<td>61%</td>
</tr>
<tr>
<td>Equipment</td>
<td>$298,439</td>
<td>$122,575</td>
<td>$107,976</td>
<td>61%</td>
</tr>
<tr>
<td>Monitor &amp; Controls</td>
<td>$39,472</td>
<td>$11,000</td>
<td>$12,001</td>
<td>42%</td>
</tr>
<tr>
<td>Water Management</td>
<td>$145,732</td>
<td>$5,396</td>
<td>$31,287</td>
<td>22%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,229,592</strong></td>
<td><strong>$389,326</strong></td>
<td><strong>$1,036,065</strong></td>
<td><strong>123%</strong></td>
</tr>
</tbody>
</table>
These measures have decreased exterior water use by 50% and interior water use by 20%. Water is a resource that has different values depending on the region of the country. Regardless of the location there is a price to consuming water, and owners that manage this consumption will be in a better position as water costs increase. One innovative and cost-cutting effort used by the property management team was to initiate a vermicomposting program, which ended up diverting over 10 tons of waste from landfills and saves approximately $10,000 annually. Other non-traditional improvements include eliminating garbage can liners and using reusable cloth bags in centrally located recycling bins, which together save nearly $80,000 per year. While these projects are not classified as investments in energy efficiency improvements, they do illustrate examples of how resources can be utilized in a more efficient manner and thereby save operating costs.

4. Project: Office
   Location: Washington, DC
   Size: 840,000 square feet
   Year Built: 4 interconnected buildings ranging from 20 to 100 years old

The energy efficiency improvements for this project included upgrading the heating, cooling, and interior lighting systems. The result was a reduction in energy consumption of 20%. One specific improvement included an overhaul of an existing HVAC system. The owners utilized an energy savings performance contract to implement the project, and rather than doing it themselves, they brought in a third-party vendor, an Energy Service Company (ESCO). This approach allowed the $5.5 million HVAC system improvements to be financed and carried by the ESCO, and included a guaranteed level of energy savings.

5. Project: Convention Center
   Location: Midwest
   Size: 250,000 square feet
   Year Built: 1997

In this project the local municipality decided to obtain LEED certification on an existing, but relatively new convention center. The cost to obtain LEED certification was approximately $111,000. As a result of being LEED Certified, the convention center was able to book eight additional events from groups seeking venues with a focus on sustainability. This translated into additional net revenue of approximately $292,000, an ROI of nearly 270%. This is in addition to the operational savings being enjoyed by the municipality.

Conclusion

As the environmental impact of buildings seep into the consciousness of the real estate industry, the efficiency and environmental performance of the existing building stock is receiving a much closer look. There are many factors responsible for this rising level of awareness—from an expanding knowledge of greenhouse gases and their impact on climate change, to the rising prices of electricity and natural gas. Municipalities and state governments are playing a more active role
in regulating the “green” standard to which new development projects will be built. Add to this a national overlay of a proposed cap and trade program, and it is easy to see that the real estate industry will experience significant changes going forward. This will impact how building owners perceive and value the consumption of energy.

Energy efficiency improvements are a direct and relatively simple way to reduce the carbon footprint of real estate. Steps taken to measure and monitor energy consumption can lead to efficiency improvements that translate into real economic savings, not only through a decrease in operating expenses, but also the increase in value associated with an increase in property level revenue. Determining whether energy efficiency improvements pay is very much related to how and where an owner or investor places value. While some owners/managers seeking LEED-EB certification may be doing so as a risk management tool, and others because of tenant demand, the characteristic that is consistent through all these early adopters is the desired result: a building of superior quality. The LEED for Existing Building program appears to be working as designed, helping building owners and managers to deliver efficient, healthy, and environmentally-friendly space.

While data representing the impact of investing in energy efficiency improvements continues to pose a challenge, our initial research into this area suggests that investment in these projects produce sufficient return on investment, increase the predictability of energy consumption, and add value by decreasing operating costs. Sophisticated building owners have been and will continue to improve the operational efficiency of their assets by managing and benchmarking and ultimately improving their energy performance.

Endnotes

1 While these two terms are often used interchangeably, the National Academy of Sciences prefers the phrase ‘climate change’ to ‘global warming’ because it helps convey that other changes are occurring, in addition to rising temperatures (National Academy of Sciences, 2009). These include change in measures of climate (such as temperature, precipitation, or wind), which can result from natural factors (the Earth’s orbit, intensity of solar gain), natural processes (changes in ocean circulation), and human activity (burning of fossil fuels, deforestation, and urbanization). Global warming is an increase in the average temperature of the atmosphere near the Earth’s surface, which can contribute to changes in global climate patterns. This can occur from a variety of causes, both through natural and human activity. However, global warming is most commonly thought of as warming that occurs as a result of increased emissions of greenhouse gases from human activities.

2 Estimates from the United Nations estimate a global population of approximately 6.9 billion inhabitants. This number is expected to grow to 9 billion within 30 years (United Nations, 2009).

3 Adding more greenhouse gases to the atmosphere increases the chances for more heat to be trapped and creates the potential for further increases in average global temperatures. Carbon dioxide is the most abundant greenhouse gas in the atmosphere after water vapor (NOAA, 2009). There has been a natural processing system in place
for the past 10,000 years in which carbon dioxide is taken out of the atmosphere by plants and is almost perfectly balanced with the amount put back into the atmosphere by respiration and decay. Humans have been changing that since the pre-industrial period (1750) from our burning of fossil fuels, and deforestation practices. In the U.S., greenhouse gas emissions come primarily from the combustion of fossil fuels to create energy (EIA, 2008).

4 The U.S. was an active participant in the Copenhagen Summit in December 2009 and made a pledge to cut greenhouse gas emissions by 17% below 2005 levels by 2020. The outcome of the Summit, resulting in the Copenhagen Accord, was a non-binding agreement.

5 For example, to obtain a LEED certification of ‘Silver’ in new construction, one needs to capture 50 points. Of these, 35 must relate directly to energy issues.

6 A carbon footprint is defined as “the representation of the effect that human activities have on the planet’s climate in terms of the total amount of greenhouse gases produced, as measured in units of carbon dioxide (CO2),” (Royal Geographical Society, 2008).

7 For examples of work conducted in the area, see Ashford, et al. (1999), Binkley (2007), Nelson (2007), DiBona (2008), or Carpenter (2009).

8 An Energy Service Company (ESCO) is a business that develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs for facilities over a seven- to twenty-year time period. ESCOs generally act as project developers for a wide range of tasks and assume the technical and performance risk associated with the project (National Association of Energy Service Companies, 2009).

9 For more information on carbon emission offsets, see Binkley and Ciochetti (2010).

10 See DiBona (2008) for additional information on the definition and applications of energy efficiency concepts.


12 Buildings produce 43% of all carbon dioxide emissions from fossil fuel consumption, as compared to 32% from transportation and 25% from industry. Within the building sector, industrial buildings produce 11.6%, commercial 39.5%, and residential 48.9% (Pew Center on Global Change, 2005).


14 By market capitalization, office product constitutes approximately 40% of institutional investment holdings in real estate (National Council of Investment Fiduciaries, 2008).

15 District heat refers to a source emanating from outside the building in a central plant and then being piped into a building for distribution and use.

16 U.S. Energy Information Association (2009). Other sources of U.S. electricity include 19% from nuclear sources, 6.5% from hydro, and 3.5% from renewable sources. By way of comparison, France generates 10% from the burning of fossil fuels, 77% from nuclear sources, and 12% from renewable resources; Germany produces 62% of its electricity from the burning of fossil fuels, 22% from nuclear sources, and 14% from renewable resources.


18 News Corporation (2010).

19 Each building will have its own ‘energy’ signature based on type of energy consumed. Notwithstanding this however, the role of potential energy savings in the construction and operations of real estate products are significant.

20 Increasingly, the path to sustainability is being motivated by those in facilities and operations management (Real Estate Weekly, 2008).
For example, in the New England region of the country, nearly 42% of electricity production comes from the combustion of natural gas (ISO New England, 2008).

A survey was conducted in 2008 of a sample of building owners responsible for the acquisition and development of over 140 million square feet of space globally. From this, we determined that office buildings of the 1990s vintage had energy costs averaging between 15% and 17% of total operating expenses (excluding real estate taxes), while those from the 1970s averaged 22% to 26%. Large buildings in major urban centers averaged between 26% and 28%.

The EPA is considering regulating greenhouse gases, following a Supreme Court decision that ruled the agency has authority to do so under the federal Clean Air Act. However, 11 states are party to a case in front of the Supreme Court to stop such efforts.

These include the National Australian Building Environment Rating System (NABERS, 2008), the Building Research Establishment’s Environmental Assessment Method (BREEAM, 2008). See Fowler and Rauch (2006) for a discussion of other rating systems in use.

For more information on Portfolio Manager and ENERGY STAR, see https://www.energystar.gov.

LEED-EB was updated and streamlined in 2009 and is referred to as LEED-EB: O&M. Hereafter, our use of the term LEED-EB will be synonymous with LEED-EB O&M.

There are three terms commonly used when discussing LEED approval. Registered buildings are those under consideration for approval by LEED. Certified buildings are those that have received LEED approval for the proposed designation, and certifiable means that the owner has constructed/upgraded the building in accordance with LEED designation, but has not sought approval. This is often done to signal to the market/tenants that the building complies with LEED standards, but that the certification process has not been completed.

See USGBC (2008).

The pilot Portfolio Program has been set up by the USGBC as a way to help companies register multiple properties at a single time, thereby eliminating much of the repetitive paper work involved with registration.

See Dermisi (2009) and Jones Lang LaSalle (2008).

Most brokers and leasing agents interviewed during our research reported that while more and more tenants are asking about the potential for LEED certified space, supply continues to be restricted, so finding properties that meet their requirements could be difficult.

See, for example, Addae-Dapaah, Liow, and Shi (2009) or Rohde and Lutzkendorf (2009).

For example, the ISO (International Organization for Standardization) certification standard in Europe identifies and establishes general principles for sustainability in building construction. It is based on the concept of sustainable development as it applies to the life cycle of buildings and other construction works, from their inception to the end of life. This standard shares many of the general characteristics of LEED.

This study does not differentiate new from existing buildings, so the ability to make definitive comments about LEED-EB is not possible.
38 It rarely makes financial sense to replace well-functioning toilets with new water-efficient ones, as the monetary savings from reduced water consumption is minor compared to the cost of the new equipment.

39 Xeriscaping refers to landscaping that does not require supplemental irrigation. It uses plants whose natural requirements are appropriate to the local climate thus eliminating or reducing water needs, and takes care to avoid losing water to evaporation and run-off. A condenser water loop moves water between the chiller’s condenser and the cooling tower and has the ability to use recycled water to cool space rather than potable water.

40 LEED-EB was first released in pilot version in January 2002, and then formally as LEED-EB v2.0 in October 2004. In November 2009, the USGBC introduced an updated version entitled LEED for Existing Building: Operations & Maintenance (LEED-EB O&M).

41 As would be expected, minor upgrades to recent buildings are typically completed in a shorter time frame than major upgrades on older buildings, or ‘deep energy’ upgrades that may involve systems with much more complexity.

42 This re-certification process could prove challenging if standards change over time.

43 Third-party consultants are often used to monitor baseline conditions and other technical aspects of the process.

44 Leonardo Academy (2008).

45 While we were not able to identify the costs of management and staff time, the owners indicated it was done as an investment in a knowledge base to be applied to future upgrade projects.

46 The Energy Information Administration conducts energy consumption surveys for residential and commercial buildings every four years, and it can take two to four years for the EIA to process and release the data.

References


Energy Efficiency Improvements: Do they Pay?


The authors would like to thank Martha Peyton, Marc Louargand, and two anonymous referees for helpful comments and suggestions. We would also like to acknowledge the support of the Real Estate Research Institute and the Royal Institute of Chartered Surveyors.

Brian A. Ciochetti, Massachusetts Institute of Technology, Cambridge, MA 02139 or tc@mit.edu.

Mark D. McGowan, Skanska USA Commercial Development Inc., Boston, MA, 02210.
Teaching Sustainability: Applying Studio Pedagogy to Develop an Alternative Post-Hurricane Housing Solution Using Surplus Shipping Containers

Authors: Pernille Christensen and Elaine Worzala

Abstract: This paper illustrates the use of studio teaching as a technique for promoting an interdisciplinary approach to teaching students about sustainability. It emphasizes an iterative decision-making process to help students think ‘outside the box’ when exploring sustainable solutions. The paper focuses on a particular case adopted by a combined studio of architecture and landscape architecture students to help provide sustainable housing solutions for post-hurricane victims. The studio format provides a student-centered learning environment where students, faculty, and industry professionals work together to propose alternative post-disaster housing and community restoration strategies. The students gained a heightened understanding of the need to address global challenges in an interdisciplinary manner, which is key for solving sustainability problems.

The focus of the paper is to explore the advantages and disadvantages of using the studio format that is most often associated with the design disciplines as an alternative educational pedagogy for teaching sustainability in real estate programs. Specifically, this paper will illustrate the application of an interdisciplinary approach for teaching sustainability concepts in programs focused on the built environment. A case study of the Sustainable, Environmental and Economical Development (SEED) Alternative Post-Disaster Housing project, which was developed for a studio course taught in the fall of 2009, will serve as an example of how the studio approach can be used to tackle real estate problems and teach the basic principles of sustainability. A multi-disciplinary group of students representing architecture, landscape architecture, city planning, and welding disciplines worked together in a studio setting throughout the research and development of the housing prototype and its implementation strategy. Issues were addressed through open discussion, desk critiques by the faculty, and studio ‘pin-ups’ with guest critics and industry professionals helping to make sure the students understood the various facets of the problem and that they came up with viable solutions. Industry partners were also actively engaged with the students throughout the process, offering a business perspective to influence their decision-making process, mentorship, and industry contacts for future employment.
In addition, it is important to note that the studio setting, focused on applied problem solving, can be a way to build a network with industry partners and raise external funding and recognition for the university. For this case, an industry partner, Container-It, Inc., brought the idea to the studio, donated the container to the studio for students to be able to build a prototype and test their design solutions, and provided additional funding to cover expenses associated with the studio. Other industry partners were instrumental in providing information during the research phase and/or services and materials during the construction phase. Additional funding was provided by an Environmental Protection Agency (EPA) P3: People, Prosperity and the Planet Student Design Competition for Sustainability Award. The competition was designed to engage students in focusing on the P3 concepts of sustainability, to create solutions benefiting people, promoting prosperity and protecting the planet through innovative designs to address challenges to sustainability in both the developed and developing world (www.epa.gov/P3).²

Specifically, students in the course designed post-disaster housing solutions for hurricane victims where ‘People’ would benefit from affordable housing, increased hurricane safety, community involvement with the reuse of displaced surplus containers, and a healthy and productive landscape. ‘Planet’ challenges were addressed by studying the effect of hurricanes on the islands of the Caribbean in general, looking at sustainable agricultural strategies for the Commonwealth of Dominica, reducing resource consumption and creating alternative water and energy sources. ‘Prosperity’ is envisioned to be promoted through an increased life-cycle and affordability of housing, the development of jobs associated with building and implementing SEED homes, and the implementation of sustainable agricultural practices for the islanders.

Literature Review

Teaching Sustainability in the Classroom

Since the Declaration of the United Nations Conference on the Human Environment, more commonly known as The Stockholm Declaration (UNEP, 1972), there has been an increased national and international interest in incorporating sustainability literacy, skills, attitudes, and concepts into higher education courses in a wide range of disciplines (Wright, 2002). This is certainly true of education in the built environment disciplines where incorporating sustainability concepts is often a course goal. However, for educators that task can be daunting when confronted with a surfeit of literature on sustainability. To confound matters further, there is a large variation in the way experts conceive of and explain the general concepts of sustainability (Filho, 2000; Robert et al., 2002; Carew and Mitchell, 2008).

Sustainability is commonly defined using the Brundtland Statement, “Humanity has the ability to make development sustainable—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs,” (WCED, 1987). This definition was further evolved in Agenda 21,
which was adopted at the 1992 United Nations Conference on Environment and Development (UNCED, 1993), and in the UN 2005 World Summit Outcome document, which referred to the “interdependent and mutually reinforcing pillars” of sustainable development as economic development, social development, and environmental protection. The latter report further stated that “poverty eradication, changing unsustainable patterns of production and consumption and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development,” (UN, 2005). The vast literature on sustainability further expands and evolves this definition by describing the inter-relationships of the three sub-concepts and representing them either as pillars, embedded circles (also known as the ‘bulls-eye’ diagram) or in some variation of the popular Venn diagram of three overlapping circles. McDonough and Braungart (2002) take the concept one step further by introducing the concept of cradle-to-cradle, thus extending the use, and sustainability considerations, of objects into a second lifecycle. Crofton (2000) suggests that this conceptual debate opens the door for a broader range of starting and ending points, which sustainable decision-making processes may work from and towards allowing us greater flexibility to adapt to distinctive contexts and to embody an array of stakeholder perspectives.

Sustainability issues are difficult both to teach and to study. Conventional lecture and seminar formats alone cannot adequately teach the necessary skills to understand the complex social and ecological risks associated with sustainability. They need to be supplemented with active, experiential learning methods (Truscheit and Otte, 2004/5). The studio format, most often associated with the design fields, is ideal for this type of active, experiential learning because it inherently incorporates the four basic steps of the experiential learning model cycle as outlined by Svoboda and Whalen (2004/5): act, reflect, reframe, and apply. For application in the studio setting, and as used in the SEED case study, these steps were modified slightly and applied as: concept development; act; reflect and assess; reframe; and apply and rework. These steps are then re-iterated several times through the design and development phase of the studio. The use of studio pedagogy is an appropriate avenue for exploring and developing solutions to sustainability challenges because, in contrast to the more linear form of thinking that is encouraged in lecture formats and multiple choice exams, the studio environment encourages an iterative decision-making process and incorporates interdisciplinary work as part of the process of developing creative solutions. In addition, studio courses expand the knowledge and skills sets of students by giving them the opportunity to engage in real-world projects that challenge them to think about their work and their solutions in new ways (Heathcott, 2007).

**Container Housing**

There has been a limited amount of academic research on the reuse of shipping containers for housing; most of the research has been exploratory in nature and undertaken by private firms looking to create a niche market. The largest of these efforts was undertaken by TempoHousing and resulted in the construction of Keetwonen, a student housing project in Amsterdam. Originally intended as a five-
year temporary solution to create 1,000 units that would house students attending universities in Amsterdam, Keetwonen has been so popular with the residents that the relocation has been postponed until 2016. Other projects by TempoHousing include: the luxurious Hotel Yenagoa in Nigeria, Diemen Student Housing in Amsterdam, Skaeve Huse in Denmark for mentally challenged residents, and the Labour Hotel, which has been fully booked since its opening in 2008 through 2013. Most recently, TempoHousing has developed a solution to service the post-earthquake victims in Haiti (www.tempohousing.com/projects).

Future Shack, designed by Sean Godsell, is among the first attempts to address the use of container modification for emergency housing. Future Shack can be fully assembled in 24 hours, makes minimum cuts in the container, and addresses all the basic human needs. However, the cost of this proposal is in excess of $30,000 (Helsel, 2001; www.seangodsell.com/future-shack) and is therefore not a solution that would be suitable for a post-disaster situation in a developing country.

Global Portable Buildings offers a more finished alternative for container housing and specifically addresses both disaster recovery and temporary housing solutions on their website. These units can be customized or they offer several standard ‘series.’ But like Future Shack, the starting costs of these units were in excess of what low-income families in the Caribbean could afford (www.globalportablebuildings.com).

Arieff and Burkhart (2002) were among the first to bring attention to the history and range of efforts related to prefabricated housing. Among the efforts highlighted were several examples of container housing alternatives. However, none of these projects addressed disaster relief or post-disaster community rebuilding. More recently, Levison (2006) provided a thorough history of the shipping container and its impact, but he also does not discuss the growing interest in its potential for alternative uses such as housing or disaster relief.

After disasters people want to go home to their communities and start rebuilding their lives (Honychurch, 2009). Standard protocol in the United States is for governmental and non-governmental agencies to provide disaster housing relief to people displaced due to property damage or destruction. This relief often comes in the form of mobile home trailers, as occurred post-Katrina in 2005. Unfortunately, FEMA only allows use of a trailer or mobile home for 18 months for those needing disaster-related housing needs (FEMA, 2006). This policy does very little to rebuild the communities that are devastated by the disaster. The more resources that are poured into temporary arrangements, the less are available for permanent reconstruction efforts (Rybczynski, 2005). Container homes provide a more feasible solution than just offering temporary housing. Instead people would be offered temporary housing that could evolve into a permanent housing solution and aid in the rebuilding of their community.

The SEED project is the first study we are aware of that encourages a system of creating not only emergency post-disaster housing but also aims to create a sustainable, long-term strategy to provide a more permanent housing solution to
help restore the disaster-struck communities in developing economies. In addition, it promotes principles of sustainability by reusing surplus shipping containers that have been abandoned in ports where there are trade imbalances and it is too costly to remove the empty shipping containers.

Why Use a Studio Format for Teaching Sustainability?

Very little has been written about the best methodology for teaching sustainability in a real estate curriculum. Historically, traditional real estate classes are designed with a lecture/seminar format that is confined more to the “chalk and talk” or PowerPoint slide pedagogy rather than the active, experiential teaching and learning format that is typically found in the studio. Graaskamp (1976) argued that “[r]eal estate education should be eclectic, but traditional real estate departments do not subscribe to integrated education.” Some real estate educators attempt to expand real estate education by including case studies in the classroom (Rose and Delaney, 2007). More recent studies have shown that teaching critical thinking and the ability to deal with complicated situations (Tu, Weinstein, Worzala, and Lukens, 2009), incorporating an interdisciplinary focus and combining theory and practice (Weinstein and Worzala, 2008) are important concepts that are found in successful real estate education programs. Therefore, case studies alone cannot meet the needs of today’s real estate students who are struggling with the complex and multidisciplinary issues associated with sustainability.

While conceptually the case study approach is similar to the studio in some ways, it differs markedly in its execution. In a studio, students apply theory learned in their other coursework to a live project that brings ‘real world’ challenges into the classroom. Many studio-format courses are taught as multidisciplinary studios with multiple professors bringing expertise from their various disciplines. This is an ideal format when teaching students to wrestle with the inter-connected sustainability concepts that must be understood. Rather than the linear analysis taught in the traditional case study approach, the studio encourages a cyclical process. The studio format involves a dynamic, iterative approach where the students create solutions and then get feedback on those solutions during ‘pin-up’ presentations from expert guest critics, project clients, classmates, and faculty. In addition, students get regular one-on-one desk critiques with their professor.

Each project begins with preliminary background research of the live project, the suitability of the site and program are then analyzed, an iterative design and development process is then engaged, implementation strategies are explored, and finally solutions are presented. Throughout the project development, after each feedback session, students reassess their solution, reframe their next steps, and evolve their solution to incorporate information from the feedback loop. This cycle is repeated throughout the project so that students are forced to return to the initial project challenge and ensure that their solution directly addresses the identified issues as they advance with the development of their project solution. The iterative process of the studio challenges students to think critically and develop innovative solutions to complex problems. When integrating this format for teaching
sustainability in the real estate curriculum, the studio would ideally be interdisciplinary and encourage cross-collaboration, engaging students from all of the various disciplines involved in the real estate process, including the traditional finance and/or real estate development students, as well as other business, planning, architecture, and construction science students.

Real estate problems are inherently multidisciplinary (Dasso and Woodward, 1980). For this reason, the studio format may benefit the real estate curriculum in many ways; however, it is particularly suited for addressing the issues of sustainability, which is, by its very nature, an interdisciplinary challenge. Its complexity invites the participation and contribution of multiple disciplines to solve the plethora of issues facing the real estate industry. The collaborative atmosphere of the studio allows synergistic results to emerge that better address the challenges of sustainability. However, even single discipline studios have advantages over traditional lecture format courses because they encourage student interaction and iterative ‘outside the box’ thinking. Boulanger and Brechet (2005) describe the five most important criteria that should be considered for modeling sustainability issues from a policy perspective, specifically: (1) use of an interdisciplinary approach; (2) managing uncertainty; (3) having a long-range or intergenerational point of view; (4) applying a global-local perspective; and (5) stakeholder participation.

A holistic consideration of these criteria creates a methodology that can be applied and easily implemented when teaching sustainability in a studio environment. This educational approach of service-based or active, experiential learning using real world problems can easily be applied to the more traditional real estate classroom, and provide real estate students with hands-on experiences solving complex sustainability issues. Multi-disciplinary teams encourage interdisciplinary work where often a synergistic solution is the result of incorporating the viewpoints and goals of multiple disciplines, as well as using the diverse input to manage uncertainty in the development of the solution. The studio approach also considers the long-term impact by exploring both the global and local impacts of the solution. Ideally, there are also opportunities for stakeholder participation meetings that inform the development of the solution. Depending on the project location, stakeholder participation is not always possible.

The studio format offers additional educational benefits for students tackling the challenging and complex issues associated with sustainability by offering opportunities for: (1) active, engaged learning; (2) work on ‘live’ projects/problems; (3) understanding and resolving conflicting viewpoints and goals in the design/development process; and (4) understanding how other coursework concepts are integrated and applied in real “live” projects.

One of the potential shortcomings of the interdisciplinary studio approach as applied to real estate education is that many students in real estate, particularly those in programs that are housed in the finance departments of business schools, are often taught to problem solve to one-answer solutions for most of their academic careers. The iterative nature of the studio process encourages students to reevaluate their solutions to ensure that they align with the studio objectives,
reframe their objectives, then move into further development of the solution, re-evaluate, and potentially start the process over again. Many typical real estate students are linear thinkers and want to step through a logical progression of answers and are not accustomed to playing “what if” games or considering “have you thought about this” comments. Therefore, they are uncomfortable with the breadth of solutions expected to come out of a studio investigation and unaccustomed to making changes and reanalyzing their work as additional ideas are cultivated. Hopefully this discomfort will only be an initial reaction, but educators should be mindful of addressing this potential area of concern upfront when explaining and establishing the studio format and process in an effort to overcome any hesitations.

Interdisciplinary Student Participation: The Case Study Process

The nature of the SEED project brought together a number of inter-related but contrasting viewpoints from multiple disciplines. The challenge for the students working on the SEED project was to gain an understanding of the multi-faceted requirements of the project, bring their individual disciplinary skill sets and knowledge to the group discussions (multidisciplinary work), and then collaborate in an interdisciplinary manner to create a synergistic solution to address the sustainability concerns explored in the studio setting. A typical studio is designed with students first identifying the project challenge and scope. Then there are typically three phases including preliminary research, design and development of a solution, and implementation strategies. The preliminary research phase further refines the project and establishes the questions that the design development phase will aim to solve. The implementation phase tests the viability of the solution. The three phases are cyclical in that the students continually return to assess alignment with the project challenge and scope (please see https://sites.google.com/a/g.clemson.edu/permille-christensen-teaching/ if you are interested in more details about the studio class, its syllabus, and how the course was set up).

Within the SEED studio project, the first step of the process was for the students to identify the sustainability challenge and project parameters that would guide them in the preliminary research phase. To do this, they examined the various facets of the project scope and identified the elements of sustainability that needed to be addressed both for the client and for the EPA P3 competition. For the SEED project, the sustainability challenge was to examine the use of a global surplus item, the ISO shipping container, as an alternative housing solution for post-disaster hurricane victims. Therefore, the students began by investigating the global/local dichotomy of hurricane devastation, shipping container usage and its potential for localization, containers being a global waste product that are given a second life in the project by examining their potential for localized adaptation for housing in hurricane-affected areas.

Upon identifying the sustainability challenge, the first phase involved preliminary research, where the students explored a broad spectrum of issues to gain an
understanding of the larger global issues and the contextual implications within the locality of study. The students analyzed the social, economic, and environmental impacts for each research topic. Specifically, students began this phase by understanding the hurricane phenomenon at the macro scale of the Caribbean and then narrowed their focus to understand the impact of hurricanes on Dominica. After gaining a perspective of the devastation caused by hurricanes and the challenges of post-disaster rebuilding, the students studied the container and its structural qualities to determine whether it would be able to fulfill the goal of creating hurricane-resistant housing. Having determined that the shipping container met the criteria, the students studied the local cultural dynamics to gain an understanding of local lifestyles and daily living activities, existing housing stock conditions and styles, and cultural norms. Would the container even be acceptable as housing to the local population?²

The second phase of the studio involved the design conceptualization, development, and construction of a prototype. This phase involves the iterative process previously discussed in a manner that encourages students to work together to create a test solution, reflect on the solution to evaluate whether it meets the sustainability challenge criteria, reframe the direction for further development, and improve their solutions based on feedback obtained through a series of ‘pin-ups’ (where guest speakers and experts give critical feedback on the proposed solution), internal reviews (where students present to each other for feedback and collaborate with each other to create a synergistic final design), and desk critiques with the studio professors.

The third phase looks at the macro scale and the implementation of the solution, if applicable, at the larger community scale. Throughout this process, the success of the studio is predicated upon the multiple disciplines interacting and students sharing their varied knowledge and skills to produce solutions that one discipline alone could not achieve. In the end, the input from multiple disciplines creates a better, more thoughtful and thorough response to the challenge being studied. In particular, sustainability challenges benefit from this interdisciplinary process because there are so many factors involved. In the case of the SEED project, the sustainability challenge encompassed the myriad factors involved with developing a sustainable solution for reusing surplus shipping containers as a housing solution for hurricane victims in the Caribbean.

Due to time constraints for the studio course, students were unable to finalize any cost estimations for the container modifications, provision of components, and transport to the site, which would itself vary depending on terrain and location. Had the studio been able to continue working on this project for another semester, the next stage would have been to complete the costing and feasibility analysis.

The goal of the project was to design and develop a strategy of modification that could produce a housing unit for less than $5,000. Preliminary research related to cost estimation and feedback from industry partners indicated that the goal was attainable based on calculations that included purchasing the surplus containers at a break-even cost, ranging from $1,500 to $2,000 (the remainder of the value could be used as a charitable tax write-off for the ‘donating’ corporations), and
building the various utility components in bulk, ranging from $200 to $500 each, depending on the component.³

**Identifying the SEED Studio Sustainability Challenge**

The SEED project that was developed in a studio environment in Fall 2009 will be used to illustrate the studio pedagogy applied to find sustainable solutions. In a nutshell, the students proposed to reuse retired International Standards Organization (ISO) shipping containers as a safe and secure housing alternative for people in the hurricane-prone region of the Caribbean. This project was rooted in the double-edged sword of globalization and the increasing awareness by the world’s population of our interconnectedness. The shipping container is perhaps the ultimate representation of our global interconnectedness because of the role it plays in consumption and the ability to ship goods around the world cheaply and securely. Currently, when a shipping container is retired, it is classified as “waste.” In the spirit of *Cradle to Cradle* by McDonough and Braungart (2002), who call for the transformation for human industry through ecologically intelligent design and of closing the life-cycle loop on current business practices, the SEED project was developed.

ISO containers were invented by a forward-thinking trucker named Malcolm McLean in 1956 in an effort to increase efficiency and reduce the costs associated with loading and unloading of cargo. His standardized dimensions for shipping containers made it faster and more organized to load-unload freight—reducing the costs by more than 90%—ultimately leading to a significant reduction in the prices of consumer products. “In 1956, loose cargo cost $5.86 per ton to load. Using an ISO shipping container, the cost was reduced to only .16 cents per ton. The shipping container invention of Malcolm McLean has certainly changed the world and thus, it has changed the lives of every human on the planet,” (www.isbu-info.org). The aim of the SEED project was to capture the spirit of McLean and use surplus containers to further change “the lives of humans on the planet” by developing a safe, hurricane-proof, low-energy, low-cost, sustainable housing alternative for areas affected by natural disasters. The challenge was to discover a strategy to locally inflect these mass standardized objects to provide safe, secure, culturally appropriate housing. Intermodal containers are global, ubiquitous, standardized, structurally strong, adaptable, and affordable.

While the ISO container was originally developed to streamline the shipping industry to make it more sustainable and efficient, it has now, ironically, become a waste item sitting idle in ports. This is because it is more expensive to transport an empty container than it is to build a new one. Large numbers of ISO intermodal containers arrive daily to the Caribbean, but few leave with export goods. This pattern causes a surplus of shipping containers to accumulate in regional ports (Levinson, 2006). Currently, these excess shipping containers are either shipped empty to another port, recycled (down-cycled) into steel, or simply remain warehoused in Caribbean ports (Boile, Theofanis, and Mittal, 2004; Stangel, 2009). None of these strategies are economically effective or sustainable nor do they take advantage of the potential of the ISO container as a building module.
Simultaneously, there is a tremendous need in the Caribbean region for affordable, hurricane-resistant housing. The studio approach to the challenge was unique in that it identified the sustainability problem both at the micro and macro scales as an “ecology,” and proposed an adjustment to the ecological system to return it to balance.

The catalyst of the SEED project idea was a conversation with John Stangel, the CEO of our industry partner, Container-It, Inc., who expressed a desire to help these Caribbean communities create better housing options while also reducing the company’s costs of removing the empty containers from the region (Stangel, 2009). While much research has been done on the strength and reuse possibilities of the ISO container in recent years (www.isbu-info.org), these benefits have yet to be fully explored in the hurricane-affected islands of the Caribbean where homes and businesses are regularly devastated by the high-force winds associated with hurricane seasons. While it is unavoidable that the Caribbean islands will be struck by natural disasters with some regularity, even the slightest bit of stability during the aftermath is welcomed by the victims. The island communities of the Caribbean often lack the financial means to construct adequate housing, and the result is regular rebuilding of a mediocre product after a hurricane hits (Honychurch, 2001, 2009). According Davis (1978), “survivors priorities in order of importance are: to remain as close to their damaged or ruined homes and means of livelihood, to move temporarily into homes of families or friends, to improvise temporary shelters as close as possible to the site of their ruined homes (these shelters frequently evolve into rebuilt houses), and to occupy emergency shelters provided by external agencies.” The function of emergency shelter is manifold beyond protecting individuals from the elements but also provides emotional security and fills the need for privacy (UNDRO, 1982).

The goal for the studio was to develop a container modification strategy that re-utilizes the ISO containers and resolves the challenge of creating housing that meets immediate post-disaster emergency housing needs but that is also flexible enough to evolve over time into a permanent hurricane-resistant housing solution for families in the Caribbean. The studio project had a number of phases, each of which cycle back to constantly reference the studio sustainability challenge. During the semester-long studio, students developed the SEED project, which proposed a sustainable housing solution by:

1. Applying the Cradle to Cradle philosophy and giving shipping containers a second life by transforming them into homes in the wake of hurricanes.
2. Tackling the long-term challenge of providing permanent hurricane-resistant homes for under-served families in the Caribbean region, resulting in a reduction of catastrophic property loss in the face of future hurricanes.
3. Proposing a sustainable strategy of site design and implementation that would help get displaced people back into their neighborhoods quickly, working together to rebuild their communities and their food supplies.
4. Creating self-sufficient housing to function ‘off-the-grid’ until post-disaster devastation of infrastructure is restored to neighborhoods—and possibly long-term.
Phase I: Preliminary Research

The studio research phase began by exploring the devastation caused by hurricanes throughout the Caribbean to gain an understanding of the macro phenomenon, and then the students narrowed their focus more specifically to examine the impact of hurricanes on the Commonwealth of Dominica. The Commonwealth of Dominica was chosen as the case study location for several reasons. First, it falls in the mid-range for number of hurricane landfalls, monetary damage, and death counts caused by hurricanes, as well as being in the mid-range for density, socio-economic conditions, and population diversity. Secondly, the combination of Dominica’s level of poverty (IMF and IDA, 2006), geography, vulnerability to natural disasters (UNDRO, 1982), and need for a more sustainable living environment led the students to choose this island as the test site. In addition, the topography of Dominica offers a unique opportunity to explore three very different site conditions for the adapted container, the feasibility of locating shipping containers in different terrain conditions, and to investigate innovative methods for securing the ISBU to the ground in various conditions to resist being overturned by high-force winds. This research is important because, in addition to addressing the immediate needs of the population in Dominica, it also provides a test bed for transferring the use of containers as an alternative post-disaster housing solution to other disaster areas.

Having gained a grasp of the hurricane phenomenon and the devastation of housing and farming it annually causes in the Caribbean region, the studio next analyzed whether the ISO container would be able to maintain its structural integrity and withstand the wind forces of a Level 5 hurricane. This research also spurred investigations into local construction constraints, how to package all the necessary modification materials into one of the ISO containers, and the possibility that a threshold quantity of units sent simultaneously to the island may be more cost-effective for both the industry and the community in which they are being built. The possibility that communities may be constructed entirely using this prototype also allows for the creation of “Business in a Box” opportunities within the community to support the construction of SEED homes and the people living in them (www.cubicinspirations.com).

Recognizing that the ISO container is a mass standardized object, the students began to wonder about the cultural appropriateness of using the container as housing in the Caribbean. For this part of the project, the students explored strategies to customize the containers. By creating opportunities for individualization of each SEED home, residents are able to create more culturally sensitive and appropriate housing by infusing local character into the final design. To gain an understanding of the local cultural attitudes and living conditions, students grouped themselves into multi-disciplinary teams and compiled an immense amount of data about the Caribbean, including: disaster protocols, relief programs, container routes in the Caribbean, local ports, container surplus locations and quantity, government structures, demographic information, economic and industry information, labor forces, temperatures, rain fall patterns, solar availability, local materials, vernacular construction, growth and production rates.
of local foods, nutritional values of local foods, farming strategies, available and alternative technologies, cultural patterns, family and living structures, daily routines, and lifestyles of the local population to better understand the diverse settings found on the island to which the students’ proposed solutions would need to adapt in order to be effective.

The advantages of the multi-disciplinary teams during this phase are that the students who come from different disciplines tend to interpret information differently; therefore, the compiled data are richer and more diverse. The thought process and evolution of the preliminary research phase (Phase I), as well as the catalyst questions that emerged from the research to guide Phase II, are outlined in Exhibit 1.

The Hurricane Phenomenon: Addressing Sustainability. Dominica has a long history of being devastated by hurricanes; its “geographic location and topography make it vulnerable to natural disasters,” (www.reliefweb.int). Most recently, Dominica was hit by Hurricane Dean in 2007 and Hurricane Omar in October 2008. In both cases, there was significant damage to infrastructure, roads, and bridges as a result of landslides and fallen trees, and housing communities were hard hit by the devastation. The banana crops were ‘wiped out’ by Hurricane Dean (http://www.iht.com/articles/ap/2007/08/21/business/CB-FIN-Hurricane-Dean-Bananas.php) and although Dominica was indirectly hit by Hurricane Dean, the “hurricane force winds, torrential rains and high sea swells resulting from its passage affected several sectors of the Dominican economy. Swollen rivers, flash floods and landslides caused extensive damage to agriculture, housing and infrastructure. The United Nations’ Food and Agriculture Organization (FAO) reported a loss of over 70 percent of total agricultural production,”

Exhibit 1 | Thought Process and Evolution of Phase I: Preliminary Research

Note: Topics and questions explored in Phase I are in blue; Phase II catalyst questions generated from the research are in red.
In addition, the Office of Disaster Management in Dominica reported that 771 houses were damaged, while 43 houses were completely destroyed after Hurricane Dean.

The students’ preliminary research identified a dire need for a sustainable housing alternative for populations throughout the Caribbean that are affected by hurricanes on an annual basis. This need is further compounded by the economic and political instability within many Caribbean countries, cities, and communities, which result in poor housing standards. The students’ design of the SEED prototype directly addresses this need for sustainable hurricane-resistant housing. In addition, the students proposed the integration of hurricane-resistant planting as part of the edible landscaping design, which provided a strategy to reduce the environmental degradation often created by hurricane winds. Their solution also provides for a renewable food source for residents, many of whom live below the poverty line. The economic benefits of the SEED housing alternative includes improved, low-cost, hurricane-proof housing for local residents, job opportunities related to the construction of the container housing and the potential for low-cost, hurricane-proof “business in a box” opportunities.

**ISO Intermodal Containers: Addressing Sustainability.** The ISO intermodal container is the backbone of international trade as we know it today. The students focused on the most common type of container, the GP-40, because it is widely available in every nation throughout the Caribbean. The GP-40 is a 40’ long × 8’ wide × 8.5’ high steel moment frame (a structurally rigid box) comprised of 12 steel sticks welded at 8 corner connections to form a steel box weighing slightly more than 8,000 pounds and entirely constructed of rust-proof weathering steel. It is the strongest modular structure—mobile or stationary—in the world (www.isbu-info.org). While the corrugated steel used for the walls and roof is of a relatively thin gauge, it is welded continuously and uniformly, making it waterproof and incredibly strong. Unaltered, it can withstand 140 mph winds. A large portion of the corrugated steel can be cut and removed without compromising its structural integrity (www.isbu-info.org). Together these qualities provide an ideal building module for affordable housing because they are resistant to water, fire, mold, wind, and vandalism.

A unique element incorporated in the SEED project development is the consideration of locality while using a global waste product. In the development of the prototype, opportunities for infusion of local character were noted, so that the final product would ultimately blend with the vernacular case house and chattel house architecture of the islands. The integration of the SEED prototype into its new locality becomes an interdisciplinary challenge in which students must address a spectrum of sustainability requirements including large-scale community rebuilding, individual unit siting, container individualization and localization, plant selection, and landscape design strategies.

In keeping with the *Cradle to Cradle* philosophy, the re-use of the ISBU effectively and efficiently extends the life-cycle of the product, giving it a second life by providing a new use. The reuse gives the container a second life-cycle, beginning from a new ‘cradle’, and eliminates the need for the removal and
shipping of empty containers to another location, thereby reducing overall fossil fuel consumption and greenhouse gas emissions (Levinson, 2006). Globally, this reduces the negative environmental impacts of high energy costs and the mitigation of disposal associated with traditional recycling. Locally, the use of ISBU housing reduces resource consumption over the long-term as the structures are hurricane-resistant, eliminating the need for residents to continually rebuild after hurricanes.

In addition, the students worked to address the pressing post-disaster needs of energy availability, reliable clean water supplies, and basic sanitation at the scale of the individual SEED home. The studio designed a series of ‘pod’ components that applied a limited use of advanced technologies, as well as taking advantage of the abundant water, solar, and wind resources that exist in the Caribbean. The ‘energy pod’ enables the container to capture solar power and run ‘off-the-grid’ with the expectation that power may be unavailable to remote residents following a hurricane. A water filtration system uses an adaptation of Manz’s BioSand Water Filter (Manz, 2006, 2007) in the re-use of another surplus item in the Caribbean islands, the 55-gallon metal drum. The system allows captured rain water to be filtered through the BioSand Water Filters constructed in three 55-gallon drums on the roof into separate holding drums for potable drinking water and use in the ‘water pod.’ Previous experiments utilizing the Manz BioSand Filter have indicated a 65%–90% removal rate of bacteria and contaminants, with some systems filtering 100% over time once the biolayer is fully formed (Manz, 2006, 2007). The water pod gravity feeds water from the holding drums on the roof to a shower and sink, as well as providing a composting toilet. By considering such a broad spectrum of needs for the end-user, the students’ holistic, interdisciplinary approach hopes to improve each resident’s quality of life while ultimately reducing the overall environmental impact of the project.

Cultural Dynamics: Addressing Sustainability. The cultures, traditions, economics, and politics of the countries that comprise the Caribbean are diverse and heterogeneous. It is common for a family of six to share a house of one or two rooms equaling no more than three to four hundred square feet. The majority of the cooking and socializing happens either directly outside or within an interstitial space like a covered or screened porch. Semi-enclosed/private spaces are defined by walls of wood or corrugated steel and are primarily for sleeping and family living. Due to a lack of available and affordable glazing, openings are permeable or perforated via material connections. The highly permeable surfaces that are used to define space in the Caribbean vernacular allow for a high degree of ventilation and some natural lighting. This strategy of passive cooling was one the students aimed to integrate into their solution as well (Honychurch, 2009; www.lennoxhonychurch.com).

Understanding the basic daily lifestyles and living conditions of the local population raised questions of appropriateness. How could the container be modified to not only fulfill basic living needs, but also be accepted by the local population as a permanent housing solution? Throughout the design and development phase, the students constantly returned to this question and their preliminary research in an effort to create physical modifications to the container
that were in keeping with indigenous architectural style and incorporated possibilities for individual unit customization.

**Farming: Addressing Sustainability.** Farming is one of the main economic engines in Dominica and was hard-hit by Hurricane Dean. Students researched local farming practices, as well as sustainable farming solutions to gain a better understanding of the advantages and disadvantages of promoting and diversifying local farming. Increasing and diversifying local agriculture will contribute to a reduction in worldwide gas emissions associated with the production and distribution of food products. According to the Earth Policy Institute, an ecological economy think tank, the process of worldwide food production and distribution is the single largest producer of greenhouse gas emissions (www.earth-policy.org). This should be no surprise when one considers the enormous fossil fuel budget integral to the conventional industrial food chain in the form of fertilizers, pesticides, operation of machinery, refrigeration, transportation, and processing. Based on their preliminary research, students proposed sustainable agricultural strategies for both city planning and residential site design.

In addition, local cooking habits were researched to determine common food needs. “A wide diversity of annual and perennial food species will help to ensure a more prolonged harvest, will provide a wider spectrum of taste and nutrients, and will be more resistant to pests, weather conditions and other stresses,” (www.cityfarmer.org/Berezan.html). The nutritional value, growth rate, and productivity cycle of a variety of commonly planted vegetables and fruits, edible trees and shrub species, and herbs were analyzed and are detailed in Exhibit 2. This research was completed to ensure that the students learned how to assess the appropriateness of chosen plant species for a given environment, in this case—Dominica.

This analysis led to a recommendation for a post-disaster replanting and food network strategy that would enable local families to become self-sufficient more quickly while also regaining access to undamaged nutrient-rich foods from unaffected areas of the islands. Because the topsoil pH balance is damaged from hurricane flooding, it was necessary to identify agricultural areas that were unlikely to be flooded by the sea and rains. In addition, the students proposed the development of an emergency garden for each SEED home to facilitate the replanting of edible vegetation while topsoil rebalancing efforts were executed post-disaster.

**Phase II: Design and Development of the Sustainability Challenge Solutions**

The SEED project proposes a design to cut across regional variations while at the same time providing an open framework for the home to “grow” over time and localize (to become culturally appropriate for its specific locality). While an ISO container makes an intelligent building module because of its structural integrity and resistance to water, mold and pests, it is not a home. The students’ primary objective was to transform the shipping container from an incredibly robust, global ‘packaging’ commodity/waste product into a home. At the larger scale, the objective was to develop an implementation strategy that allowed the modified container homes to become the ‘seeds’ that rebuild the community.
Note: Analysis performed on 15 planted vegetables, 15 planted fruits, 15 food-producing trees, 15 food-producing shrubs, and 15 herb/spice plants found locally in the region.
The process applied in Phase II for design and development of solutions to these objectives follow the five steps of the modified experiential Svoboda and Whalen (2004/5) model as illustrated in Exhibit 3. The students developed two distinct design strategies that would be combined to accomplish the first objective. The first design strategy is the physical modification of the container. This strategy includes the work directly on the container through cutting and welding operations. The second design strategy was to develop a series of “plug and play” components that would provide necessary human comfort and meet basic needs of nutrition, drinking water access, and hygiene.

**Container Modification.** The container modification strategy was guided by a design ethos of producing the maximum benefit with the minimum means. The cuts into the container are the first step in transforming the container into a home. The welding students were instrumental in helping the design students decide how to make the various openings and also maintain the structural integrity of the container. First, the welding students conducted a welding seminar for all the design and planning students working on the project so that they could gain some first-hand knowledge of the process and understand the options for how the different types of cuts could be made. A big part of the studio culture is that students learn from each other’s strengths. The interaction of the students at this stage is an example of how the studio format can enrich the learning experience by allowing students to disseminate knowledge to each other in an active, engaged, hands-on manner rather than have the instructors be the only ones teaching. Finally, the cuts were made on the prototype container by the welding students.
using hand-held plasma cutters from a reusable, prefabricated jig that was fitted to the container. The cuts open the container to provide adequate access to light and air for the occupants. There are two types of openings: major openings, which expand the living space, and secondary openings, which allow the container to ‘breathe.’ The students designed the placement of these openings to allow for cross-ventilation/passive cooling to occur, which eliminated the need for environmentally insensitive artificial cooling devices.

Components. The second design strategy for transforming the containers consisted of a series of prefabricated ‘plug and play’ components designed. The five components are:

- Energy pod
- Water pod
- Water filtration system
- Emergency garden
- Canopy
- Root system-scissor foundation

The students considered how each of these components could be most efficiently and sustainably manufactured and brought to the disaster-struck port for use in the modified containers. All components are based on principles of flat packing and modular sizing based on pallet sizes for transport efficiency. The pods are designed as pallet-sized or half-pallet sized modules that can be mass prefabricated and shipped to the disaster-affected areas. The pallet-sized pods can be shipped 20 pods to a single container while the half-pallet-sized pods can be shipped 40 pods to a container. The idea is to store these components at disaster relief staging areas throughout the Caribbean so that they are ready to transport immediately after a natural disaster, enabling all useable ISO containers that are on-hand in local ports to be transformed rapidly into housing. The students identified the components to meet user needs and to further transform the container from an industrial surplus item into a home once the openings have been made. The water filtration system and emergency garden utilize 55-gallon drums that can double stack into the container and can be shipped 160 to a container. In addition, residents can use surplus drums available in the disaster-struck port and/or community. The canopy and root systems are designed in such a manner that they are flat-packed (like an IKEA item) and easily assembled upon arrival at the final site destination.

The energy pod and water pod were designed as half-pallet-sized and pallet-sized crate modules, respectively. By using pallets, which are also globally standardized, prefabricated industrial elements, as the base for the ‘pod’ components, the modules can be efficiently mobilized to disaster areas. The students have begun making contacts in the crating industry to discuss the further development of the ‘pod’ prototypes as semi-finished structural crates. These two components provide essential human biological needs of access to energy and water. For more details on the sustainability and real estate solutions developed and the iterative process used during Phase II of the studio, see Exhibit 4a and Exhibit 4b. In addition, we
### Exhibit 4a | Design and Development Process for ‘Pod’ Component Solutions and Associated Sustainability Components

<table>
<thead>
<tr>
<th>Design and Development Process for ‘Pod’ Component Solutions</th>
<th>Sustainability Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Pod</strong>: Developed primarily as a group effort among the architecture students with input from students in other disciplines.</td>
<td><strong>Off-the-grid energy</strong></td>
</tr>
<tr>
<td>- <strong>Concept Development</strong>: Efficient packaging and transport; provide off-the-grid power source; meet basic cooking needs.</td>
<td>- Reuse of surplus ‘waste’ material</td>
</tr>
<tr>
<td>- <strong>Act</strong>: Utilize standardized pallet; inclusion of 60 watt thin film solar panel; powers minimum lighting, cooling, and at-home business.</td>
<td></td>
</tr>
<tr>
<td>- <strong>Reflect and Assess</strong>: Appears cold; mass-produced object like shipping container.</td>
<td></td>
</tr>
<tr>
<td>- <strong>Reframe</strong>: Provide opportunity for individualization of unit.</td>
<td></td>
</tr>
<tr>
<td>- <strong>Apply / Rework</strong>: Semi-finished packaging as waterproof ‘crate’ allows end-user localization; flexibility for roof or roof canopy mounting.</td>
<td></td>
</tr>
</tbody>
</table>

| **Water Pod**: Developed collaboratively between architecture and landscape architecture students. | |
| - **Concept Development**: Efficient packaging and transport; uses captured rainwater to provide off-the-grid hygiene and sanitation solution. | **Reuse of captured and filtered rain water** |
| - **Act**: Utilize standardized pallet; includes shower and composting toilet; gravity feed water from water storage drums on roof. | - Reuse of surplus ‘waste’ material |
| - **Reflect and Reassess**: Bulky, appears cold; mass-produced object like shipping container. | |
| - **Reframe**: Expandable unit; provides opportunity for individualization of unit. | |
| - **Apply / Rework**: Pallet-sized unit expands to width of container upon insertion; semi-finished packaging as waterproof ‘crate’ allows end-user localization; connects to water filtration system for potable water in sink. | |

**Note**: This is not a linear thought process as implied by the table format. Refer to Exhibit 3 for an illustration of the cyclical process of the design and development phase of a typical working studio.

have noted which disciplines were primarily responsible for each solution although for most solutions the problems were solved with input from the other disciplines, highlighting the importance of interdisciplinary studios to come up with more creative and well thought out solutions.

The water filtration system and emergency garden are a linked system designed to get families back to a level of self-sufficiency in terms of drinking water and food supply. They are designed to utilize surplus 55-gallon drums, which have been cleaned and sealed to prevent leakage of any rust or toxins from the drum into the soil and water contained in the drums. The water filtration system and emergency garden components enable families to regain their self-sufficiency for both clean water and food production, creating a reduction of reliance on post-
Exhibit 4b | Design and Development Process for ‘Drum’ Component Solutions and Associated Sustainability Components

<table>
<thead>
<tr>
<th>Design and Development Process for ‘Drum’ Component Solutions</th>
<th>Sustainability Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water Filtration Strategy:</strong> Developed primarily as a group effort among the landscape architecture students with input from students in other disciplines.</td>
<td></td>
</tr>
<tr>
<td><strong>Concept Development:</strong> Reuse of 55 surplus gallon drums; simple modification; provide potable water for drinking and cooking as well as clean water for basic hygiene needs.</td>
<td><strong>Purification of water for potable and non-potable use</strong></td>
</tr>
<tr>
<td><strong>Act:</strong> Utilize standardized 55-gallon drum; adaptation of Dr. Manz’ BioSand filtration system.</td>
<td><strong>Capture and reuse of rain water</strong></td>
</tr>
<tr>
<td><strong>Reflect and Assess:</strong> Increase water supply; safety of water stored in previously used drums; secondary filtration at ground level for cleaner potable water and better accessibility; also capture &amp; reuse of grey water for garden.</td>
<td><strong>Capture and reuse of grey water</strong></td>
</tr>
<tr>
<td><strong>Reframe:</strong> Need water storage units for excess water; how to clean drums; accessibility to potable water.</td>
<td><strong>Reuse of surplus ‘waste’ material—55-gallon drum</strong></td>
</tr>
<tr>
<td><strong>Apply / Rework:</strong> Link with canopy to capture and filter rainwater; development of different drum designs to either store water or filter water; include percolation filter to protect bio-layer and slow water entry speed; cleansing and sealing of drums in port prior to use; two-tier water filtration to improve accessibility.</td>
<td></td>
</tr>
<tr>
<td><strong>Emergency Garden:</strong> Developed primarily as a group effort among the landscape architecture students with input from students in other disciplines.</td>
<td></td>
</tr>
<tr>
<td><strong>Concept Development:</strong> Efficient packaging and transport in surplus 55-gallon drums; provides a ‘starter garden’ to aid families in regaining self-sufficiency; protects food production from flooding by placing on roof of container.</td>
<td><strong>Restoration of local food production network</strong></td>
</tr>
<tr>
<td><strong>Act:</strong> Consider possibility of bio-remediation strategy for filtering soil; analyze local produce and herbs for nutritional value, growth, and production rates; possibility for permanent ‘starter’ garden in place.</td>
<td><strong>Reuse of surplus ‘waste’ material—55-gallon drum</strong></td>
</tr>
<tr>
<td><strong>Reflect and Assess:</strong> Excess weight/distribution issue with all drums being filled with soil for water filtration; determine which produce and herbs should be included in garden; how to protect produce for next hurricane.</td>
<td><strong>Capture and reuse of grey water</strong></td>
</tr>
<tr>
<td><strong>Reframe:</strong> Separate from water filtration system; consider timeline for food production; how to move drums off roof into container.</td>
<td><strong>Reduction of GHG emissions with reduction of food aid shipments</strong></td>
</tr>
<tr>
<td><strong>Apply / Rework:</strong> Preassemble and ship garden in sealed 55-gallon drums for easy assembly on site; design optimum soil depth and design ‘soil shelf’ to lighten weight; consider pre-planting and packaging of emergency garden; pulley system in canopy to move drums into container in the event of approaching hurricane.</td>
<td></td>
</tr>
</tbody>
</table>

Note: This is not a linear thought process as implied by the table format. Refer to Exhibit 3 for an illustration of the cyclical process of the design and development phase of a typical working studio.
disaster food aid and thereby reducing the green house gas emissions associated with the long-term shipment of food to the island. Larger-scale sustainable agricultural strategies were also proposed to help return the ecology of food production to a ‘balanced’ state quickly in a post-disaster situation and to create a food network that would bring in ripe produce from unaffected areas.

The canopy, developed collaboratively by the architecture students and another industry partner, Sargent Metals, serves the multiple purposes of shading the container, to reduce heat gain inside the unit, and guiding captured rain water to the water filtration system. A repetitive pattern of slots are digitally pre-cut into large Cor-Ten steel sheets to maximize the configuration flexibility for the homeowners and allow a variety of materials to be attached for customization. Assembly on-site consists of pulling the pieces apart, using the slots to create the desired configuration, and attaching to the container roof. All components are shipped flat-packed.

The ‘roots’ of the container were designed as a collaboration between the architecture students, the landscape architecture students, and the welding students. The Scissor Foundation is made of laser-cut, corrosion-resistant Cor-Ten steel for ease of welding to the ISO container in the port. It is designed to unfold from below as the container is being placed on site to allow the foundation to adjust to varying topographies. In addition, the foot pads use low-impact foundation technology to ensure that the system will work in most soils. Pipes driven through the foot pads create a structural wedge with the soil while resisting uplift in the case of high winds.

**Phase III: Implementation: An Emergency Scenario—Logistics and Site Planning**

Phase III is the development of implementation strategies for the solutions derived in Phase II. This phase tests the viability of the solution and may raise questions about some of the decisions made during Phase II; when this occurs, the students must return to Phase II for further design and development. The SEED concept from implementation is unique in that it combines an approach of reutilizing dormant, surplus shipping containers in ports throughout the Caribbean with ‘emergency packets’ containing prefabricated infrastructural elements (energy pod, water pod, water filtration system, emergency garden, canopy, and scissor foundation), which lay dormant and ready to ship in shipping containers at staging areas throughout the Caribbean until a disaster strikes. In Phase III, the students created a synergistic implementation strategy that considered a range of obstacles that might emerge and proposed solutions to them. By working in a collaborative manner, students from outside one of the disciplines were encouraged to ask questions that brought to light questions that those inside the disciplines may not have considered or had, out of habit, for which they had assumed definitive solutions. The final implementation solution proposes a timeline for implementation of various container modifications, site clean-up, and community rebuilding steps that are detailed below.

The first stage involves having the component elements lying “dormant” in staging areas as first-aid ‘kits’ to transform containers in the port of any hurricane-
affected country. Staging areas are located such that all potentially serviceable islands are within 3–4 day travel by container vessel. The students chose these staging areas based on the assumption that in the days following a hurricane, container vessels would be made available to relief agencies to get much needed supplies to victims in need and that the pods would be among those supplies.

The students identified ports as the best place to set up temporary modification facilities following a hurricane. Ports are the place where the greatest resources (power, welding equipment, forklifts) are concentrated, where the shipping containers are warehoused, and where the equipment for moving them is located. Their solution proposes that temporary modification facilities be set up in the local ports. Additionally, the ‘emergency packets’ described above will be shipped directly to the ports and the containers’ transformation can be completed without excess movement of these components. While these emergency housing ‘packets’ are in transit to the port, the openings are cut into the containers.

Simultaneously with the modification occurring in the port, debris removal is occurring in neighborhoods, at home sites, and along major roadways to facilitate transportation of the SEED housing. In the port, the pod components of the emergency kit are fitted into the modified containers. Each container receives an energy pod, water pod, water filtration system, emergency garden, canopy, and scissor foundation. The SEED home is then either airlifted by helicopter or loaded onto a truck and transported to the homeowner’s cleared site and placed onto its deployable scissor foundation. The canopy, water filtration system, and emergency garden are installed by the homeowner in their preferred configuration and the family moves in. A unique aspect of the SEED implementation strategy as designed by the students is that families are returned quickly to their communities and are able to work together to rebuild their neighborhoods. This solution is a direct reaction against the conditions the students uncovered while researching the post-Katrina rebuilding efforts. While the SEED container design is initially considered as a post-disaster emergency shelter, the uniqueness of the students’ final design is its ability to transform into a permanent residence over time due to the adaptable nature of the design elements, as well as its ability to help restore the social and physical health of the community.

Conclusion

This paper summarizes the efforts of an interdisciplinary group of students that envisioned a sustainable solution to a world problem: the need for hurricane-resistant housing. Dubbed the SEED project, we have demonstrated that students from multiple disciplines are able to work together to create synergistic solutions to sustainability issues raised within an interdisciplinary studio environment. The SEED project addresses the relationship between industrial waste, global trade, housing, and basic human living needs by proposing a process to convert surplus shipping containers into hurricane-resistant housing in the Caribbean. The students’ solution connects an international surplus of shipping containers with a tremendous need for safe, affordable housing for the poor.
Much has been made of using shipping containers as housing; however, most approaches overlook the complex economic, social, and logistical challenges of utilizing shipping containers as dwellings, and even fewer focus on the further complexities associated with emergency relief housing. The studio approach brought together a multidisciplinary team from both academia and industry to gain a full understanding of not just the object (shipping container) but also the processes surrounding it (when it becomes a waste product in a developing economy prone to natural disasters). The SEED project provides a hurricane-resistant “framework” for people affected by disaster to rebuild on their own home sites in their own communities ... to the places they call “home.” It orchestrates the complex logistics of securing unused containers, their modification and eventual deployment as housing. The “SEED packs” provide a safe secure home, along with inexpensive “off-the-grid” infrastructure for electricity and water.

It is recognized that the proposed solutions have yet to be cost-estimated or tested in the field but, ideally, this would be the next stage. The benefits of the classroom and single-container prototype construction in a ‘no crisis’ condition is that it shows how students from different disciplines can bring varying and complementary skills and knowledge to a project to create the first stage of a sustainable solution.

The SEED analog is an example of the creativity that often develops from the interactions within the interdisciplinary studio environment. The SEED logo (as shown earlier in Exhibit 1) addresses the idea that the housing initiative is a beginning for people rebuilding after the devastating loss experienced during and after a hurricane, a seed of hope. It grows roots (foundations) and canopy over time as it localizes with the customization of each individual homeowner. Ultimately, it is designed to become permanent housing that helps avert loss during future natural disasters.

This project increased the exposure of students to the concepts of sustainability through the interdisciplinary nature of the design studios, collaboration with private corporations’ intent on implementing ‘green’ strategies in the real world, and through exposure to the community in Dominica, which is directly affected, through the increase of hurricane devastation, by global warming. The emphasis of the educational experience was to make clear to the students the important role that design plays in bridging between disciplines, as well as between industry and academia; this bridge is necessary to meet the increasingly complex challenges when addressing client design goals while also attempting to maintain an awareness of the economic, social, and environmental impact of decisions.

It has been illustrated through the SEED case study that the interdisciplinary studio environment works when exploring some of the sustainability challenges facing the built environment disciplines, such as material reuse and recycling, water capture and filtration, sustainable agriculture, etc. This paper suggests that the studio environment can be adapted for use within the real estate education process for the same purpose. Real clients, acting as guest critics and mentors during the process, provide a live project that can be used to explore these challenges associated with teaching sustainability. The process is further enhanced by
integrating student participation from other disciplines, as well as guest speakers from outside disciplines. A few examples of how this approach might be integrated into a real estate curriculum include the valuation, cost-estimating, and capstone project courses. Ultimately, students will benefit by being challenged, through the iterative process inherent to the studio process, to think ‘outside the box’ for solutions to a multitude of critical issues that face the real estate industry today.

**Endnotes**

1 In this particular project the EPA P3 grant provided $10,000 for studio support. Students were invited to Washington, DC to compete for a second phase of funding that would result in an additional grant of $75,000 to further develop the prototype and bring the solutions to market. This provided an excellent experience for the students to compete on a national level.

2 Additional information on resources used in Phase I are available upon request.

3 Recent developments of the application of SEED in Haiti are highlighted in an article by Banerjee. A modified prototype was built in Canada in 10 days for $8,000–$10,000. It is expected that this cost will be significantly lower in Haiti when using local labor.

**References**


Crofton, F. Educating for Sustainability: Opportunities in Undergraduate Engineering. *Journal of Cleaner Production*, 2000, 8, 397–405.


The authors would like to thank the 2009 LARCH 252 and ARCH 894 Spring Studio students, whose hard work is presented in this paper, as well as the faculty members who participated in the SEED project: Doris Gstach, Paul Phelps, Douglas Hecker, and Martha Skinner, for their efforts to promote collaborative work among the landscape architecture, welding, and architecture design studios; Cynthia Nolt-Helms and her team for their assistance in guiding us through the P3: People, Prosperity and the Planet Student Design Competition for Sustainability; John Stangel at Container-It, Inc. and Sargent Metals for their generous support of the project; and Nick French for his editorial help.

Pernille Christensen, Clemson University, Clemson, SC 29634 or pchrist@clemson.edu.

Elaine Worzala, Clemson University, Clemson, SC 29634 or eworzal@clemson.edu.
“Hey, Your Tree Is Shading My Solar Panels”: California’s Solar Shade Control Act

Authors Scott Anders, Taylor Day, and Carolyn Adi Kuduk

Abstract This paper explores laws adopted in the United States at the state level to ensure that a property owner has access to direct sunlight. In particular, it focuses on laws designed to prohibit vegetation on adjacent properties from shading solar energy equipment, such as photovoltaics or solar water heating collectors. The paper compares the laws adopted by states and focuses on California’s Solar Shade Control Act as a model for other states. It provides a detailed analysis of the provisions of the Act and a review of cases brought under it.

In the late 1970s and early 1980s as a result of the oil crisis, there was increased interest in promoting alternative energy sources to reduce dependence on foreign oil. As a result, many states adopted laws to encourage or promote renewable energy technologies, including solar energy. Among these laws were financial incentives, such as tax credits and rebates, and, in the case of solar energy, provisions to protect a landowner’s right to sunlight and provisions to prohibit deed restrictions such as covenants and conditions from unduly discriminating against solar energy devices. In recent years, there has been renewed interest in solar energy. More than 30 states have adopted financial incentive programs, innovative financing programs, or other regulatory mechanisms that encourage the use of solar energy. As a result, solar energy installation rates have increased significantly in recent years. For example, installed capacity of photovoltaics in the United States increased steadily from 4 megawatts (MW) in 2000 to 435 MW in 2009—a more than 100-fold increase.

Over 65% of the installed photovoltaics capacity in the U.S. is located in California. The state has been a leader in promoting solar energy since 1976, when it began to provide financial incentives for investment in solar energy technologies. One legacy of California’s early interest in solar energy is a series of laws designed to protect a consumer’s right to install and operate solar energy technology on a home or business, including access to sunlight, or solar access. Although California’s solar energy laws have been around for nearly thirty years, we now examine this groundbreaking legislation for three reasons. First, consumers and businesses often misunderstand the provisions and application of these laws. Thus, this paper is intended in part to provide solar energy users and neighboring tree and shrub owners more information about the content and application of California’s solar laws. Second, given the significant financial incentives available for solar technologies and the possibility of property-assessed
clean energy ("PACE") financing programs around the country, it is likely that the number of operating solar energy systems will increase dramatically. Thus, it is reasonable to expect that the number of solar access questions will also increase. Third, given the relative paucity of solar shading laws in the U.S., it is likely that other states will consider adding similar provisions to their statutes as the number of solar energy systems increase around the country. California’s Solar Shade Control Act of 1978 can serve as a model for states that are developing similar laws.

This paper provides a brief comparison of solar access laws adopted by states in the U.S. to demonstrate how few solar shading laws exist. There is a detailed discussion of the Act, including key provisions, along with detail on how and to whom the Act applies. It also lists statutory criteria included in the Act, and there is a review of California case law under the Act. The paper also includes an Appendix that provides other informative resources related to the Act, along with the full text of the Act.

Solar Access Laws

In concept, solar access laws spring from deep historical roots. The Romans, whose architecture was designed to take advantage of the sun’s light and heat, likely were the first to codify protections of a homeowners’ access to sunlight. Similarly, the doctrine of ancient lights protected landowners’ access to sunlight as far back as seventeenth century Great Britain. Modern day solar access laws vary by state and have many unique features, but can be grouped into four general categories:

- **Prohibition of Conditions, Covenants, and Restrictions**: These laws protect against prohibitive covenants, conditions, and restrictions, generally limiting a common interest homeowner’s association or local government from undue restrictions on installation of solar energy. Many states have adopted some version of a solar rights law.

- **Solar Easements**: These laws typically allow a landowner to enter into an agreement with adjacent landowner to ensure that sunlight reaches the property. Like solar rights laws, many states have adopted solar easement laws. Because obtaining an easement is a bilateral negotiation, it is not clear how effectively these provisions promote solar energy.

- **Local Zoning Authority to Adopt Solar Access Regulations**: Several states permit local zoning authorities to adopt rules and regulations in the permitting and zoning process that preserve solar access, including consideration for shading from other structures or vegetation.

- **Solar Shading**: These laws ensure that the performance of a solar energy device will not be compromised by shade from vegetation on adjoining properties.
Solar Access Laws in the States

More than 30 states have adopted legislation that provides one or more of the above solar protections. Exhibit 1 shows the states that have some form of statutory solar protection, which type of law they have adopted, and the building sector that is covered by the law. A significant majority of states have either a law limiting the use of covenants, conditions, and restrictions that restrict use of solar energy or solar easement law—or both. Seven states—Massachusetts, Minnesota, New Mexico, New York, Oregon, Rhode Island, and Tennessee—also have statutory provisions that allow the local zoning authority to adopt regulations to protect access to sunlight, including consideration for shading from vegetation and structures. Two states—California and Wisconsin—have statutes that provide specific if limited relief for shading from vegetation on neighboring properties.

This paper is mainly concerned with laws that specifically address shading from neighboring vegetation. Other than California’s Solar Shade Control Act, which will be discussed in detail below, Wisconsin is the only other state that has a law that provides specific, if limited, protections for solar energy system owners to protect against shading from adjacent properties. It states that “[a]ny structure that is constructed or vegetative growth that occurs on adjoining or nearby property after a solar energy system...or a wind energy system...is installed on any property, that interferes with the functioning of the solar or wind energy system, is considered to be a private nuisance.”

There is an important distinction between the solar shade laws and those that provide for local authorities to adopt solar access rules and regulations. These provisions are not as specific or strong as the specific solar shading laws of California and Wisconsin. They may or may not include restrictions on shading from vegetation and do not necessarily result in local rules—they simply provide for the option to develop such rules. For example, Minnesota law permits municipalities to “by ordinance regulate on the earth’s surface, in the air space above the surface...”, including “access to direct sunlight for solar energy systems” as defined in the law. Oregon law also provides that “[c]ounty governing bodies may adopt and implement solar access ordinances. The ordinances shall provide and protect to the extent feasible solar access to the south face of buildings during solar heating hours, taking into account latitude, topography, microclimate, existing development, existing vegetation and planned uses and densities”[emphasis added]. It is not clear how many local municipalities have adopted rules and regulations that would address shading from structures or vegetation. Such a survey is beyond the purview of this paper and is an interesting area for further investigation.

The absence of solar shading is particularly evident among the states with the most installed photovoltaics capacity. Among the top 10 states, only California has adopted a solar shading law, although Oregon’s local zoning authority provision specifically mentions existing vegetation (Exhibit 2).
### Exhibit 1 | States with Solar Access Laws

<table>
<thead>
<tr>
<th>State</th>
<th>Prohibition of CC&amp;Rs*</th>
<th>Solar Easement</th>
<th>Local Zoning Authority</th>
<th>Solar Shade Control</th>
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</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>X</td>
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<tr>
<td>Arizona</td>
<td>X</td>
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<tr>
<td>California</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<td>Colorado</td>
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<td>Delaware</td>
<td>X</td>
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<tr>
<td>Florida</td>
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<td>X</td>
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<tr>
<td>Georgia</td>
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<td>Hawaii</td>
<td>X</td>
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<td>Idaho</td>
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<td>Indiana</td>
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<td>Iowa</td>
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<td>Kansas</td>
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<td>Nebraska</td>
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<td>Nevada</td>
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<td>New Hampshire</td>
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<td>Utah</td>
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<td>Vermont</td>
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<tr>
<td>Virginia</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
### Exhibit 1 | States with Solar Access Laws

<table>
<thead>
<tr>
<th>State</th>
<th>Prohibition of CC&amp;Rs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Solar Easement</th>
<th>Local Zoning Authority</th>
<th>Solar Shade Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Note:
<sup>a</sup>Conditions, Covenants, and Restrictions.

### Exhibit 2 | States with the Most Installed Photovoltaics

<table>
<thead>
<tr>
<th>State</th>
<th>Percentage of Total Installed PV Capacity</th>
<th>Prohibition of CC&amp;Rs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Solar Easement</th>
<th>Local Zoning Authority</th>
<th>Solar Shade Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>67%</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>New Jersey</td>
<td>9%</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Colorado</td>
<td>5%</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Nevada</td>
<td>4%</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Arizona</td>
<td>3%</td>
<td>X</td>
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<tr>
<td>New York</td>
<td>3%</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hawaii</td>
<td>2%</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Connecticut</td>
<td>1%</td>
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<td></td>
<td></td>
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<tr>
<td>Oregon</td>
<td>1%</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>1%</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>All Other States</td>
<td>5%</td>
<td></td>
<td></td>
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</tbody>
</table>

Note:
<sup>a</sup>Conditions, Covenants, and Restrictions.

### California’s Solar Shade Control Act

California’s interest in solar access laws began in 1973, when the U.S. faced an energy crisis on multiple fronts, including an inadequate electricity supply, climbing fuel prices, and an oil embargo. This crisis, in conjunction with a second that occurred in 1979–1980, increased consumer and government interest in resource conservation and alternative energy technologies. Consequently, in 1978 California passed legislation, among other energy-related measures, that provided financial incentives for consumers and businesses to invest in solar energy technologies, as well as Assembly Bill 2321, the Solar Shade Control Act. The
Act was later amended in 2008 after the story of two Santa Clara County residents being criminally prosecuted and convicted under the Act for letting their redwood trees cast shade on a neighbor’s solar panels received national attention.\textsuperscript{11}

This section of the paper examines Sections 25980–25986 of the California Public Resources Code, known as the Solar Shade Control Act (hereinafter “the Act”), and reviews lawsuits brought under the Act. Through the Act, which was enacted in 1978 and later amended in 2008, the legislature sought to balance the desired effects of planting trees and shrubs for shade and visual appeal with the desire for increased use of solar energy devices, whose performance can be hindered by shade from nearby vegetation. The Act provides limited protection to solar energy system owners from shading caused by trees and shrubs on adjacent properties. Generally speaking, the Act prohibits a property owner from allowing trees or shrubs to shade an existing solar energy system installed on a neighboring property, provided the shading trees or shrubs were planted after the solar collecting device was installed. The Act includes the following key provisions, which also could serve as key provisions for other states and levels of government seeking to develop similar laws.

\textit{California’s Policy Intent}

Section 25980 provides a policy rationale for the Act: “It is the policy of the state to promote all feasible means of energy conservation and all feasible uses of alternative energy supply sources.” This section also encourages the planting of trees and shrubs to create shade and moderate ambient air temperature. But with passage of the Act, the legislature recognized that circumstances may exist “in which the need for widespread use of alternative energy devices, such as solar collectors, requires specific and limited controls on trees and shrubs” when plant shading interferes with the use of solar systems on adjacent properties.

\textit{Definition of “Solar Collector”}

Section 25981(a) of the Act provides the statutory definition of a solar collector as “a fixed device, structure, or part of a device or structure ... that is used primarily to transform solar energy into thermal, chemical, or electrical energy.” In 2008, the Act was amended to exclude from its protection any solar device or structure that is “designed and intended to offset more than the building’s electricity demand.”\textsuperscript{12} Under the Act, a solar collector is to be used as part of a system that makes use of solar energy for water heating, space heating or cooling, or power generation.\textsuperscript{13} Based on this statutory definition, the following common solar energy systems would be considered “solar collectors”: photovoltaics, solar water heating for use in buildings, solar water heating for space heating, and solar pool heating.

The Act does not specify whether a residential structure designed to take advantage of the sun’s light and warmth, sometimes referred to as a passive solar home, would be defined as a solar collector by the Act. However, this question was answered in \textit{Sher v. Leiderman}, in which the California Court of Appeal held that a passive solar home would not meet the definition of a “solar collector,” as
defined in Section 25981. The court reasoned that statutory language defining a solar collector was not intended to accord protection to passive systems. Consequently, the Sher court held that exclusively passive solar homes are not protected from shading by the Solar Shade Control Act.

Confusion over what systems are “active” or “passive” under the Act is compounded by system-specific terminology. For example, there are two main types of solar water heating systems: active and passive. Active systems use pumps and sensors to control the flow of water into and out of the collector. Passive systems have no moving parts and rely on existing water pressure from the home’s plumbing and convection to move water through the collector. But, because both active and passive solar water heating systems are used primarily to convert solar energy into hot water, they are “solar collectors” under the Act, and entitled to protections from shading thereunder.

**Installation Requirements**

A solar collector is defined under Section 25981(a) as including only those devices or structures fixed on the roof of a building. However, if “a solar collector cannot be installed on the roof of [a] building receiving the energy due to inappropriate roofing material, slope of the roof, structural shading, or orientation of the building,” the Act promulgates that a solar collector can instead be installed on the ground.

Whether affixed to the roof or the ground, Section 25981(d) provides that the Act’s protections only apply to solar collectors, as defined above, which have been installed and comply with all local building and setback regulations. In the relevant part, the Act specifies that solar collectors must “be set back not less than five feet from the property line, and not less than 10 feet above the ground. A collector may be less than 10 feet in height, only if, in addition to the five-foot set back, the solar collector is set back three times the amount lowered.” Thus, it is possible that a solar energy system that meets Section 25981’s definition of a solar collector may be installed in a manner that violates the Section 25981(d) setback requirements. In such a case, the solar energy system would not be protected by the provisions of the Act.

**Optional Notice Prior to Installation**

The Act’s amendment authorizes property owners contemplating solar collector installations to provide notice to affected neighbors of a proposed solar collector installation. While this is not required, Section 25982.1(a) states that the owner of a property where a solar collector is proposed to be installed may provide, no more than sixty days prior to its installation, a written notice by certified mail to the owners of the affected property using a specified form. The notice would state, in part, the property owner’s contact information, the specific location of where the solar collector will be installed on the property, and the proposed installation date of the solar collector. A copy of the specified form to be used is provided in Section 25982.1(a) and included here in the Appendix.
Threshold for Violation

Specifically, Section 25982 of the Act prohibits certain tree owners from planting or allowing a newly planted tree or shrub to cast a shadow over more than 10% of a solar collector on a neighboring property at any one time during the hours of 10:00 AM and 2:00 PM. However, the Act’s amendment exempts all trees and shrubs planted prior to the time of the installation of a solar collector. In other words, the Act allows trees and shrubs to grow and shade solar panels without penalty as long as they predate the neighboring solar collector.

Who is Liable Under the Act?

Section 25983 provides that “the person who maintains or permits the tree or shrub to be maintained” can be liable if they violate the Act. Specifically, the Act states that those people who fail to “remove or alter the tree or shrub after receiving a written notice from the owner or agent of the affected solar collector requesting compliance with the requirements” of the Act can be held responsible for violations of the Act.

Penalties for Violation

Prior to its amendment in 2008, violators of the Act could be criminally prosecuted and convicted of maintaining a public nuisance for allowing their trees to shade neighboring solar collectors. California legislators acted to change this punishment after the story of two Santa Clara County residents being criminally convicted and ordered to prune their redwood trees sparked national debate. After the Act’s amendment, violations are no longer considered criminal. Instead, Section 25983 provides that violations of Section 25982 now constitute a private nuisance, as defined in Section 3481 of the California Civil Code. It should be noted, however, that the 2008 amendment is not retroactive. In other words, any criminal convictions issued under the prior Act still stand.

Procedures for Seeking Protection Under the Act

Before the Act’s amendment became effective on January 1, 2009, solar collector owners seeking to enforce the Act had to have their claims prosecuted by a district attorney or other prosecutor. This entailed demonstrating to the prosecutor that a violation occurred, having the prosecutor deliver a thirty-day abatement notice to the offending tree or shrub owner to cure the violation, and finally prosecuting this person if the violation was not abated within thirty days.

Now that violations of the Act are no longer criminally prosecuted, the solar collector owner is solely responsible for enforcing the protections afforded by the Act. This is essentially a two-step process. First, the affected solar collector owner must provide the tree or shrub owner written notice requesting compliance with the requirements of Section 25982. Second, if the tree or shrub owner fails to comply with the written notice requesting compliance with the Act, the affected solar collector owner may bring a private nuisance suit under the Act against the negligent person to remedy the solar shading.
**Exemptions for Certain Property Owners**

The Act both explicitly and implicitly exempts certain property owners and certain trees and shrubs from the Act. Indeed, the solar collector owner’s right to sunlight is not absolute.

**Exemption for Existing Trees or Shrubs**

Section 25984(a) states that the Act does not apply to trees or shrubs planted prior to the installation of a solar collector. Therefore, trees or shrubs planted before a solar collector is installed and later grow to cast a shadow over more than 10% of the solar collector are completely exempt from the Act.

**Exemption for Timberland and Agricultural Land**

Section 25984(b) of the Act specifically exempts all trees planted, grown, or harvested on timberland or on land devoted to the production of commercial agricultural crops.16

**Exemption for Replacement Trees**17

Section 25984(c) provides an exemption for trees or shrubs planted to replace trees or shrubs that had been growing prior to the installation of a solar collector. Consequently, if a tree planted prior to the installation of the solar collector dies, or is removed for the protection of public health, safety, or the environment, and is subsequently replaced, the replacement tree is exempt from the Act, even if it shades the solar collector in a way that would otherwise violate the Act.

**Exemption for Trees Subject to a Local Ordinance**

Section 25984(d) exempts from the provisions of the Act any “tree or shrub that is subject to a city or country ordinance.”

**Exemption for Municipalities**

Section 25985(a) of the Act allows any city or unincorporated areas of a county to adopt an ordinance exempting itself from the Act.18 This exemption applies only to trees planted and maintained by the municipality itself, and not to trees owned by private citizens. Zipperer v. County of Santa Clara, 133 Cal. App. 4th 1013 (2005), discussed below, further discusses this exemption.

**Exemption for Passive Systems**

Section 25986 permits owners of passive solar systems that would cast a shadow over a solar collector on an adjacent property to seek an exemption from the Act. To grant an exemption, the court must find that the net energy savings from the passive solar system would exceed those of the shaded solar collector.

As discussed above, the statute does not clearly define what solar energy systems or structures constitute a “passive or natural solar heating system or cooling
system’ and are exempt from the Act’s protections. A passive or natural solar heating or cooling system could be interpreted to mean a structure or building that is designed to use orientation, thermal mass, and shading for passive heating or cooling. Alternatively, a passive or natural solar heating or cooling system could be interpreted to mean deciduous trees that would block summer sunlight but permit winter sunlight to enter a building. Trees or shrubs used as passive or natural solar heating or cooling systems that shade an adjacent active solar system may be exempt from the provisions of the Act, provided the court finds that the passive system provides greater net energy savings than the adjacent solar collector.19

How the Provisions Affect Each Party

We have grouped the key provisions of the Act to demonstrate the threshold for the solar collector owner to demonstrate a violation under the Act, and the tree or shrub owner to determine if the alleged violation is actionable.

Solar Collector Owner

The following provides a listing of the statutory conditions necessary to demonstrate that a tree or shrub on an adjacent property is shading a solar collector in a way that violates the Act. The solar collector owner must be able to answer the following questions in the affirmative to be protected by the Act:

- Was the tree or shrub in question planted after the solar collector’s installation?
- Was the solar collector installed pursuant to Section 25981(d)’s setback requirements?
- Does the solar collector meet the statutory definition of a “solar collector” provided in Section 25981?
- Does the neighboring tree or shrub shade more than 10% of the solar collector between 10:00 AM and 2:00 PM local standard time?

Tree or Shrub Owner

The following provides a list of the statutory conditions necessary to determine if a property or tree owner is violating the Act. There may be no violation of the Act if the tree or shrub owner can answer in the negative to any of the following questions:

- Does the tree or shrub shade more than 10% of the solar collector between 10:00 AM and 2:00 PM local standard time?
- Was the tree or shrub in question planted after the solar collector was installed?
- Did the solar collector owner, or their agent, provide written notice requesting compliance with the requirements of Section 25982?
Further, there may be no violation of the Act if the tree or shrub owner also can answer any of the following questions in the affirmative:

- Was the solar collector designed and intended to offset more than the building’s electricity demand?
- Is the tree or shrub in question owned by a municipality that has passed an ordinance exempting itself from the Act?
- Is the tree or shrub subject to a city or county ordinance?
- Is the tree or shrub in question growing on land designated as timberland or agricultural land?
- Are the trees or shrubs in question part of a passive cooling and heating strategy in which net energy savings from the passive solar system are demonstrably greater than those of the shaded solar collector?

Cases Relating to the Act

Though relatively few cases have examined the Solar Shade Control Act since its enactment in 1978, the following cases provide insight into the Act’s interpretation and legal argumentation:


*California v. Bissett*

The first and only prosecution under the Act occurred in *California v. Bissett.* The story begins in 1996, when defendant Bissett and her husband Treanor planted three redwood trees in their backyard. The next five years, they planted five more redwoods. In 2001, plaintiff neighbor Vargas installed solar panels on his roof and shortly thereafter asked the defendants to remove or prune the shading redwood trees. After the defendants refused to comply, the District Attorney’s Office commenced its prosecution against the defendants under the Act.

Upon concluding that some of the redwood trees were in violation of the Act, Judge Kumli of the Santa Clara County Superior Court convicted Bissett and Treanor under the state’s nuisance law. As part of the conviction, Judge Kumli ordered Bissett and Treanor to alter or remove any offending tree so that less than 10% of Vargas’ solar panels would be shaded. After the conviction, and in order to comply with the court’s order, the defendants eventually pruned one of the redwood tree’s upper branches.

As a result of this case, and the widespread attention it received nationwide following the conviction, California State Senator Joe Simitian introduced Senate
Bill 1399 (2008), an amendment to the Solar Shade Control Act. The bill exempting all trees and shrubs planted prior to the installation of a solar panel was signed into law by Governor Arnold Schwarzenegger in July 2008 and became effective January 1, 2009.22

_Sher v. Leiderman_

_Sher v. Leiderman_ provides guidance as to whether a passive solar home meets the Act’s definition of a “solar collector.”23 The Shers designed and constructed a house that takes advantage of winter heat and light. The Shers installed south-facing windows, skylights, and a large south-facing concrete patio as passive design features to light and heat the home’s interior. The home, which did not include any solar collectors as defined by the Act, was characterized by the trial court as a “passive solar” home, even though it had no thermal mass features to store and emit radiation of heat.

In the decades after the Shers built their house, trees on the adjoining property, owned by the Leidermans, matured and prevented winter sunlight from reaching the Sher’s home. Between December and February, the trees cast a shadow on much of the Sher’s home from 10:00 AM to 2:00 PM. To restore sunlight to the Sher’s home, some trimming, topping, and removal of the Leiderman’s trees would have been necessary. As required by then-existing Section 25983, the Shers contacted the Santa Clara County District Attorney, who determined that the Solar Shade Control Act did not apply to the Sher’s situation and did not offer a notice to abate to the Leidermans.

The Shers then sued their neighbors on three causes of action: (1) private nuisance; (2) public nuisance under the California Solar Shade Control Act; and (3) negligent infliction of emotional distress. We focus primarily on the application and interpretation of the Solar Shade Control Act in this case. The court noted in its ruling that at the time no case law had developed regarding the Act, so the question of whether a passive solar home is eligible for the protections afforded solar collectors under the Act was one of first impression.24

The California Court of Appeal ruled against the Shers, holding that a passive solar home designed to collect solar heat does not meet the statutory definition of “solar collectors” contained in Section 25981. The court also held that blockage of sunlight in and of itself does not constitute a private nuisance.

In its ruling, the court referred to then existing Section 25981, which defined “solar collector” as “a fixed device, structure, or part of a device or structure, which is used primarily to transform solar energy into thermal, chemical, or electrical energy.” The Act further provided that a “solar collector shall be used as part of a system that makes use of solar energy for any or all of the following purposes: (1) water heating, (2) space heating or cooling, and (3) power generation.”

The Shers argued that their passive solar home is a “structure, or part of a...structure... used as part of a system which makes use of solar energy,” thereby
meeting the definition of “solar collector” as promulgated under the Act. The court disagreed, stating that the key word in the definition of a solar collector under the Act is “primarily,” rather than “structure.” Although the Sher’s south-facing windows were part of a strategy to passively heat and cool their home, the court did not agree that the primary function of their windows were to heat their home, since the windows also allowed light into the home.

The court further held that permitting the Sher’s home to be considered a solar collector would create a definitional problem whereby every home that has a south-facing window would be considered a solar collector, regardless of any intention to passively heat or cool their home, and therefore be eligible to receive the protections of the Act. The court additionally referred to the Act’s setback restrictions to support its conclusion that the Sher’s home was not a solar collector. The court reasoned that the setback restrictions pertain to a solar collector that would be installed on a home or building and not to the home itself. Lastly, the court noted that if the legislature had intended to apply the rights and remedies of the Act to buildings, it would have indicated its intent through explicit statutory language.

**Zipperer v. County of Santa Clara**

*Zipperer v. County of Santa Clara* examines the municipal exemption contained in Section 25985 of the Act. The central question in this case was whether a municipality could exempt itself from the Solar Shade Control Act after the alleged violation of the Act.

The Zipperers built a home with solar heating and cooling systems in the mid-1980s. The County of Santa Clara purchased an adjacent property in 1991, which contained a small grove of trees, and designated this land as a park reserve. After the County acquired the land, the trees on this parcel grew significantly and began to shade the Zipperer’s home, hindering the performance of their solar system. In 1997, the Zipperers requested that the County trim or remove the offending trees. The County did not respond to this request, but in 2002 passed an ordinance exempting itself from the Act. In 2004, the Zipperers brought suit against the County seeking relief under the Act. The Zipperers alleged that the County violated the Act well before it exempted itself, and that allowing the exemption to retroactively apply would allow the County to escape liability for preexisting violations.

The court found in the County’s favor, holding that Santa Clara County may, without limitation, exempt itself from the Act. Because the legislature expressly empowered cities and counties to exempt themselves from the Act, the *Zipperer* court held that the County’s validly enacted ordinance extinguished any statutory Solar Shade Control Act claim.

**Kucera v. Lizza**

*Kucera v. Lizza* concerns the validity of a town ordinance protecting property views and sunlight against unreasonable obstruction by tree growth. One of the
issues addressed by the California Court of Appeal was whether the Solar Shade Control Act preempts separate local ordinances regarding blockage of sunlight not related to solar collectors.

A Town of Tiburon ordinance, entitled “View and Sunlight Obstruction from Trees,” prohibited trees from blocking neighboring homeowners’ preexisting views and access to sunlight. When neighboring trees began to obstruct the Kucera’s views of San Francisco Bay, the Kuceras brought suit against Lizza, the neighboring tree owner, for violating the town’s ordinance. Lizza argued, in part, that the Act preempted the local ordinance due to the perceived conflict between the state law and the Town of Tiburon ordinance.

The Kucera court disagreed with Lizza, holding that the Act does not preempt local ordinances restricting the growth of trees from unreasonably blocking views and sunlight. The court reasoned that the town’s ordinance was not preempted by the Act partly because Lizza identified “no provisions of Tiburon’s ordinance as inconsistent with the state legislation.” Therefore, the court’s ruling in Kucera holds that local ordinances principally concerned with preserving views and sunlight will not be preempted by the Act.

Prah v. Maretti

Prah v. Maretti is a Wisconsin Supreme Court case in which a homeowner sued a neighbor whose construction plans would block sunlight needed for the homeowner’s solar collector. At the time, Wisconsin had no state law protecting access to sunlight, so the homeowners claimed that blocking sunlight from reaching their solar collector constituted a private nuisance.

In this case, the circuit court ruled in favor of the neighbor on a summary judgment motion. The circuit court held that private nuisance law does not apply to blockage of sunlight, and therefore there is no claim upon which the homeowners can seek relief.

The Wisconsin Supreme Court reversed the circuit court’s ruling and determined that the case should proceed to trial on the merits. The Wisconsin Supreme Court posited that private nuisance law might apply to obstruction of sunlight for solar energy purposes, and therefore the homeowners stated a claim for which relief could be granted. The case was remanded back to the circuit court.

In reversing the circuit court ruling, the Wisconsin Supreme Court detailed arguments for why blockage of sunlight could constitute a private nuisance. The court noted that this question “requires the court to make ‘a comparative evaluation of conflicting interests and to weigh the gravity of the harm to the plaintiff against the utility of the defendant’s conduct.’” The Prah court also examined three policy reasons explaining why other jurisdictions have traditionally been unwilling to apply the broad power of private nuisance to cases involving solar access. The first of these is the longstanding right of landowners to use property as they wish as long as they did not cause physical damage to a neighbor. Secondly, sunlight has historically only been valued for aesthetic enjoyment or
**Exhibit 3 | Summary of Cases Related to the Solar Shade Control Act**

<table>
<thead>
<tr>
<th>Case</th>
<th>State</th>
<th>Description</th>
<th>Central Question</th>
<th>Court Ruling</th>
<th>Case Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prah v. Maretti</td>
<td>WI</td>
<td>Maretti’s newly constructed building would shade Prah’s solar collector.</td>
<td>Would shading from building constitute nuisance.</td>
<td>Circuit court denied Prah’s injunction in summary judgment, WI Supreme Court reversed ruling and remanded back to circuit court.</td>
<td>108 Wis. 2d 223 (1982).</td>
</tr>
</tbody>
</table>
for illumination, not as a means of power generation. Third, society has a strong interest in not restricting or impeding land development. The Wisconsin Supreme Court argued that all three of these policy concerns are no longer fully accepted or relevant, especially considering the increase in regulation and development of the use of sun for energy purposes. Exhibit 3 provides a summary of the cases discussed here.

**Conclusion**

Increased interest in clean energy options has led to an increase in policies designed to encourage installation of solar energy devices. Many states have policies in place to protect solar access. The majority of these laws focus on the ability of covenants, conditions, and restrictions (CC&Rs) to limit solar energy installations or provide for solar easements. There is a relative paucity of statutory provisions that provide protections against shading from neighboring vegetation. As the number of solar installations increases nationwide, it is inevitable that issues related to shading from vegetation will arise. As states consider solar shading laws, California law may provide some guidance. California’s Solar Shade Control Act provides limited protections for solar collector owners whose devices are shaded by neighboring trees and shrubs. These protections are limited because the Act contains specific requirements that determine which solar collectors are eligible for protections under the Act, including the function of the collector, the manner in which it was installed on the building, and the date the offending tree or shrub was planted.

**Appendix A**

**Legal Journals and Law Review Articles**

For information about the possible conflicts of California’s Solar Shade Control Act with the U.S. Constitution, and other interpretations of the Act, the following law review articles and books are a useful resource:

- Sara C. Bronin, *Solar Rights*, 89 B.U.L. Rev. 1217 (2009). This article outlines the various means of protecting the right to solar access and devotes some discussion to the Act.
- *Energy; Solar Shade Control*, 10 Pac. L.J. 484 (1979). This article provides an overview of the Act including unresolved interpretational questions.


**Appendix B**

**Full Text of Solar Shade Control Act**

The Solar Shade Control Act is contained in the California Public Resources Code Sections 25980–25986. The full text of the statutes is provided below. 29

25980. This chapter shall be known and may be cited as the Solar Shade Control Act. It is the policy of the state to promote all feasible means of energy conservation and all feasible uses of alternative energy supply sources. In particular, the state encourages the planting and maintenance of trees and shrubs to create shading, moderate outdoor temperatures, and provide various economic and aesthetic benefits. However, there are certain situations in which the need for widespread use of alternative energy devices, such as solar collectors, requires specific and limited controls on trees and shrubs.

25981. (a) As used in this chapter, “solar collector” means a fixed device, structure, or part of a device or structure, on the roof of a building, that is used primarily to transform solar energy into thermal, chemical, or electrical energy. The solar collector shall be used as part of a system that makes use of solar energy for any or all of the following purposes:

1. Water heating.
2. Space heating or cooling.

(b) Notwithstanding subdivision (a), for the purpose of this chapter, “solar collector” includes a fixed device, structure, or part of a device or structure that is used primarily to transform solar energy into thermal, chemical, or electrical energy and that is installed on the ground because a solar collector cannot be installed on the roof of the building receiving the energy due to inappropriate roofing material, slope of the roof, structural shading, or orientation of the building.
(c) For the purposes of this chapter, “solar collector” does not include a solar collector that is designed and intended to offset more than the building’s electricity demand.

(d) For purposes of this chapter, the location of a solar collector is required to comply with the local building and setback regulations, and to be set back not less than five feet from the property line, and not less than 10 feet above the ground. A solar collector may be less than 10 feet in height only if, in addition to the five-foot setback, the solar collector is set back three times the amount lowered.

25982. After the installation of a solar collector, a person owning or in control of another property shall not allow a tree or shrub to be placed or, if placed, to grow on that property so as to cast a shadow greater than 10% of the collector absorption area upon that solar collector surface at any one time between the hours of 10 AM and 2 PM, local standard time.

25982.1. (a) An owner of a building where a solar collector is proposed to be installed may provide written notice by certified mail to a person owning property that may be affected by the requirements of this chapter prior to the installation of the solar collector. If a notice is mailed, the notice shall be mailed no more than 60 days prior to installation of the solar collector and shall read as follows:

Solar Shade Control Notice

Under the Solar Shade Control Act (California Public Resources Code Sec. 25980 et seq.) a tree or shrub cannot cast a shadow greater than 10% of a solar collector absorption area upon that solar collector surface at any one time between the hours of 10 AM and 2 PM local standard time if the tree or shrub is placed after installation of a solar collector. The owner of the building where a solar collector is proposed to be installed is providing this written notice to persons owning property that may be affected by the requirements of the act no more than 60 days prior to the installation of a solar collector. The building owner is providing the following information:

Name and address of building owner:
Telephone number of building owner:
Address of building and specific location where a solar collector will be installed (including street number and name, city/county, ZIP Code, and assessor’s book, page, and parcel number):
Installation date of solar collector:

______________________________
Building Owner, Date

(b) If the owner of the building where a solar collector is proposed to be installed provided the notice pursuant to subdivision (a), and the installation date
is later than the date specified in that notice, the later date shall be specified in a subsequent notice to persons receiving the initial notice.

(c) (1) A transferor of the building where the solar collector is installed may provide a record of persons receiving the notice pursuant to subdivision (a) to a transferee of the building.

(2) A transferor receiving a notice pursuant to subdivision (a) may provide the notice to a transferee of the property.

25983. A tree or shrub that is maintained in violation of § 25982 is a private nuisance, as defined in Section 3481 of the Civil Code, if the person who maintains or permits the tree or shrub to be maintained fails to remove or alter the tree or shrub after receiving a written notice from the owner or agent of the affected solar collector requesting compliance with the requirements of § 25982.

25984. This chapter does not apply to any of the following:

(a) A tree or shrub planted prior to the installation of a solar collector.

(b) A tree planted, grown, or harvested on timberland as defined in Section 4526 or on land devoted to the production of commercial agricultural crops.

(c) The replacement of a tree or shrub that had been growing prior to the installation of a solar collector and that, subsequent to the installation of the solar collector, dies, or is removed for the protection of public health, safety, or the environment.

(d) A tree or shrub that is subject to a city or county ordinance.

25985. (a) A city, or for unincorporated areas, a county, may adopt, by majority vote of the governing body, an ordinance exempting their jurisdiction from the provisions of this chapter. The adoption of the ordinance shall not be subject to the California Environmental Quality Act (commencing with Section 21000).

(b) Notwithstanding the requirements of this chapter, a city or a county ordinance specifying requirements for tree preservation or solar shade control shall govern within the jurisdiction of the city or county that adopted the ordinance.

25986. Any person who plans a passive or natural solar heating system or cooling system or heating and cooling system which would impact on an adjacent active solar system may seek equitable relief in a court of competent jurisdiction to exempt such system from the provisions of this chapter. The court may grant such an exemption based on a finding that the passive or natural system would provide a demonstrably greater net energy savings than the active system which would be impacted.

Endnotes

1 Database of State Incentives for Renewables and Efficiency (DSIRE), 2010. See http://www.dsireusa.org/.
2 Sherwood (2009).
3 PACE programs allow local government entities to offer sustainable energy project loans to eligible property owners. Through the creation of financing districts, property owners can finance renewable onsite generation installations and energy efficiency improvements through a voluntary assessment on their property tax bills.
4 The Solar Shade Control Act refers to both shrub owners and tree owners.
5 Eisenstadt (1982).
6 Anders et al. (2010).
7 Wis. Stat. § 844.22.
8 Minn. Stat. § 462.357.
9 ORS § 215.044 et seq.
10 Sherwood (2009).
11 Barringer (2008).
12 § 25981(c).
13 § 25981(a).
16 § 4526 defines “Timberland” as: [L]and, other than land owned by the federal government and land designated by the board as experimental forest land, which is available for, and capable of, growing a crop of trees of any commercial species used to produce lumber and other forest products, including Christmas trees. Commercial species shall be determined by the board on a district basis after consultation with the district committees and others.
17 § 25984 does not specifically define what constitutes a replacement tree.
18 § 25985(a) further states that “adoption of the ordinance shall not be subject to the California Environmental Quality Act.” The following California jurisdictions have exempted themselves from the Act: Butte County, City of Santee, City of Shasta Lake, Sacramento County, and Santa Clara County. Note that this is not an exhaustive list. Review local municipal codes or contact local officials to determine if a municipality has an exemption.
19 See generally John W. Gergacz, Legal Aspects of Solar Energy: Statutory Approaches for Access to Sunlight, 10 B.C. Envtl. Aff. L. Rev. 1, 20 (1982) (“tree and shrub placement may work passively with the design of a building to naturally heat or cool it, at least in part”).
24 A case of first impression is the first time such a specific legal question on that specific topic has been considered by the court.
26 108 Wis. 2d 223, 224–25 (1982). Note that because Prah is not a California case, California courts are not required to abide by its holding.
27 Shortly after Prah was decided, Wisconsin passed legislation similar to California’s Solar Shade Control Act, and which provided two remedies for solar shading claims. See

28 This is not intended to be an exhaustive list of resources available on the Solar Shade Control Act.

29 All current California laws can be found at http://www.leginfo.ca.gov.

References


The materials included in this paper are intended to be for informational purposes only, and should not be considered a substitute for legal advice in any particular case.
Wind Farm Announcements and Rural Home Prices: Maxwell Ranch and Rural Northern Colorado

Authors
Steven P. Laposa and Andrew Mueller

Abstract
This study examines the announcement affect of a proposed wind farm development on an 11,000-acre ranch in Northern Colorado on surrounding rural housing prices. This study analyzes 2,910 single-family home transactions in two rural census tracts adjacent to the proposed wind farm prior to, and after the wind farm announcement. The results account for the timing of the announcement in March 2007, which coincided with the beginning of national and regional housing price declines, and still shows insignificant and minimal impacts to surrounding home values and sales, adjusted for the economic recession, after the announcement.

In March 2007, Colorado State University (CSU) announced a proposed wind farm development on an 11,000-acre ranch known as Maxwell Ranch in Northern Colorado. Although the proposal eventually collapsed with the original wind farm developer, at the time of the announcement local homeowners publicly expressed concerned about the impact of the wind farm on rural home prices located adjacent to Maxwell Ranch.

CSU acquired the Maxwell Ranch property, located in Larimer County in Northern Colorado, in the 1970s and subsequently used the property for agricultural research. CSU’s strategy to cultivate a ‘green university’ encouraged the Colorado State University Research Foundation (CSURF) to investigate its diverse portfolio of land and ranch holdings as possible alternative energy locations, suitable for education and research. Maxwell Ranch is located in a rural, semi-mountainous corridor estimated to have ‘excellent’ wind farm capacity based on numerous studies including the U.S. Department of Energy’s National Renewal Energy Laboratory. The original wind farm developer of the CSU Green Power Project at Maxwell Ranch received regulation approvals to move forward with the project on October 20, 2008 by the Larimer County Commissioners. By November 2009, the project was in an undetermined state due to lease defaults by the wind farm developer. In June 2010, CSU reached an agreement with a new wind farm developer and the project is currently proceeding through the development process.

General studies on wind farms and home prices build on the literature based on home valuation impacts due to externalities like high voltage transmission lines and underground storage tanks, which illustrates a broader view of sustainability and real estate by addressing the externality effects of the growing alternative
energy sector. Although there is a growing body of research on green building in the residential sector (Laquatra, Pillai, Singh, and Syral, 2008; Williams, 2008; Gottfried and Malik, 2009; Dator, 2010; Soratana and Marriott, 2010), this article builds specifically on the literature addressing wind farms and home values, with a focus on the announcement impact on a semi-mountainous rural location.

The emergence of government policies attempting to influence the innovation and economic development in areas such as the clean energy sector in an economy has direct and indirect relationships with the real estate sector. Clean energy clusters, wind farm developments, geothermal installations, new transmission lines, and extensive solar installations directly and indirectly alter the spatial economy by changing economic and business agglomerations with new firms, suppliers, and land use demand. Furthermore, there is the possibility of positive and negative spillover effects due to changes in the externalities of locations surrounding such developments. The development, construction, and operation of such alternative energy projects challenges existing land use codes, homeowner association regulations, zoning restrictions, and consumer acceptance of sustainable developments.

As various alternative energy development projects are announced, local and regional stakeholders react with a range of emotions and opinions from strong support to typical not-in-my-backyard (NIMBYism) sentiments and opposition. Prior to the recent approval of an offshore wind farm near Cape Cod, Massachusetts, local residents and national anti-wind farm coalitions frequently protested their resistance to the offshore development based on a variety of environmental impacts and property valuation concerns.

Installation of industrial projects is typically accompanied by some negative externalities to the surrounding community. In the case of Maxwell Ranch and wind farms in general, these externalities include visual impacts on scenery, increased noise resulting from the operation of wind turbines, and disturbance of previously natural environments during construction and installation of wind turbines and transmission lines.

This study specifically develops a hedonic price model using sales of existing single-family homes located in close proximity to Maxwell Ranch and compares these sales to other sales occurring over the same time period in Larimer County within the same census tract, and the census track adjacent to the west. The hedonic pricing model tests if the mere announcement of the proposed wind farm installation on Maxwell Ranch had a significant effect on home prices near Maxwell Ranch subsequent to March 2007.

Literature Review

Growing acceptance and public sentiment toward renewable energy indicate that development of wind farms in the United States is likely to continue. Annual wind capacity in the U.S. grew by 46% in 2007, adding 5,329 MW of generation capacity and $9 billion of investment (Wiser and Bolinger, 2008). Two distinct
approaches to determining the market and social consequences of new wind projects have developed: post-development hedonic pricing models of real estate values and consumer sentiment surveys.

Sterzinger, Beck, and Kostiuk (2003) conduct an analysis of wind farms in nine site locations across the country and find that in all but two of the locations, the property values of residential real estate increased at a faster rate for properties located within the view shed of wind farm projects. Their approach incorporates sales in each view-shed area (defined as a five-mile radius) of existing wind farm projects and comparing the median house price against a township or city with comparable geographic and demographic characteristics. Due to apparent deficiency, the data is limited to sales price and sale date for each property. Their model suffers from missing variable bias, as it does not control for typical housing characteristics that affect price, but does provide evidence that view sheds disturbed by wind farms may not impact home prices.

Other literature uses survey methods to determine public perception of wind farm developments in existing communities. Warren and McFadyen (2009) survey residents with and without experience living near wind farm projects and find that people with experience of wind farms are more likely to favor their expansion. Ouderkirk and Pedden (2004) perform a survey of local impacts of wind farm development in Sherman County, Oregon and find that substantial tax revenues, additional income to landowners on which turbines are located, and stimulated local employment generated through development, construction, and operations had a positive effect on regional businesses. Groothuis, Groothuis, and Whitehead (2008) perform a logit model test of a sample population in Wautaga County, North Carolina and determine that a payment to households can induce a willingness to accept wind farm development in a mountainous region where wind farm visibility is high for residential and recreational users. A summary of several studies finds that on an abstract level, about 80% of the population supports wind power in the surveys studied (Damborg and Krohn, 1998).

Many of the conclusions drawn from the various survey studies imply that collaboration between developers and local governments with the local communities in the development stage of wind energy facilities can generate valuable community benefits and energy commodities with minimal impact on the region (Woods, 2003; BBC, 2005; Toke, 2005; Devine-Wright, 2005; Warren and McFadyen, 2009). The survey literature suggests that good planning and collaboration with all stakeholders involved in the development of wind energy in local communities plays a large role in the public acceptance of wind farm projects. By involving regional stakeholders in the design and placement of wind turbines and addressing public concerns from the beginning, much of the negative impacts associated with wind farm projects can be mitigated and offset by positive economic benefits, an increased sense of involvement of community members, and actual community ownership of the wind farm projects.

Hoen, Wiser, Cappers, Thayer, and Sethi (2009) recently analyzed 7,459 home sales within 10 miles of 24 wind energy facilities. They do not find a widespread and statistically significant negative impact on home values across the wind energy
locations, although they recognize the probability of individual homes negatively impacted. The authors’ offer an extensive literature review on wind farms and residential impacts and include several models that address announcement and post-construction impacts to home values. The study, however, does not directly address rural locations as the average lot sizes by distance ranges are generally less than five acres.²

Hoen (2006) used a hedonic pricing model on homes surrounding a wind farm project in Madison County, New York and found no statistically significant difference in sale prices for houses that were sold within the view shed of an existing wind farm. Several hedonic pricing models are compared, and the conclusion from each model is similar, including testing for properties located within a view shed defined as a one or five-mile radius around the existing wind farm. Hoen’s model included actual on-site inspections of each home’s view of the existing wind farm project and a score associated with the amount and level of visible turbines from each residential property. The model also controlled for generated income from the projects payments in lieu of taxes and found that this variable was also not significantly different from other counties that did not receive payments from the wind project.

Dent and Sims (2008) study of visual impacts of wind farms in the United Kingdom found that distance from the nearest turbine is not a significant factor in house price, while a view of the countryside significantly increases price. The authors caution that although no causal link between proximity to wind turbines and housing price was found, the vista enjoyed by the property occupier had some intrinsic value and therefore further research in developing a methodology that captures the value of scenic vistas for property owners needed to be developed. The authors performed a hedonic pricing model of housing prices near a wind farm in the U.K., and found that screened and side views had a positive impact on housing prices, while a rear-facing view of the wind farm had a significantly negative impact on housing sale price.

The general conclusions of the studies referenced above are contrary to common perceptions of the visual impacts of wind turbines on residential property values. While negative impacts of other large-scale utility projects such as high voltage transmission lines have found negative impacts on property values (Colwell, 1990; Delaney and Timmons, 1992), these effects may be due to characteristics that are different from those of wind turbines. The findings of previous studies suggest that wind farms may escape the negative impact on housing prices that are found with high voltage transmission lines based on current research. Part of the answer may lie in a different public perception of wind turbines, and their association with renewable and “environmental” goals, which possibly induce higher public acceptance.

**Methods and Data**

Residential sales transaction data was collected from Colorado State University’sEveritt Real Estate Center’s database of previous home sales and currently listed
properties in northern Colorado. The dataset is based on the regional provider for the National Association of Realtors’ Multiple Listing Service (MLS) and includes attached and detached residential sales dating from 1997 that has been scrubbed, geocoded for location verification, and cross-checked with county assessor data.

Residential house sales transactions were grouped into: (1) properties located in the local homeowners’ associations adjacent to Maxwell Ranch, (2) properties located in the census tract that includes Maxwell Ranch but not in the adjacent local homeowners’ associations, and (3) properties located in the census tract west of Maxwell Ranch’s census tract. Exhibit 1 shows the two census tract boundaries that include all three group (census tract 08069002500 includes Maxwell Ranch and 08069002400 includes the Red Feather Lakes area).

The rural nature of the residential developments surrounding Maxwell Ranch and topography of the surrounding developments, based on several site visitations,
indicate that the majority of properties in developments not sharing or abutting Maxwell Ranch will have little or no view of the proposed wind turbines, while some of the homes in adjacent developments are also shielded from view of the projected wind turbine operation areas. Exhibit 2 confirms the rural nature of Maxwell Ranch and Red Feathers Lake census tracts by highlighting the low population densities per square mile in both census tracts. Population growth in the area exploded from 1990 to 2000, growing at a compound annual growth rate (CAGR) close to 6%, fueling rising housing demand. Over the last decade, population growth has moderated and is forecast to slow even further through 2014. Maxwell Ranch and Red Feather Lakes also include a sizeable amount of second home and retirement home households.

Home prices in the Maxwell Ranch and Red Feather Lakes census tracts followed the Larimer County index from 1997 to 2001, as seen in Exhibit 3. As home prices moderated in Larimer County in the years following the 2001 recession, home prices in the Maxwell Ranch census track continued to increase through 2006 before declining through 2009. Conversely, home prices in the Red Feather Lakes census tract abruptly fell, coinciding with national and regional house price

### Exhibit 2 | Census Tract Demographics

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Red Feather Lakes</th>
<th>Maxwell Ranch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>08069002400</td>
<td>08069002500</td>
</tr>
<tr>
<td>Population 1990</td>
<td>2,189</td>
<td>6,013</td>
</tr>
<tr>
<td>Population 2000</td>
<td>3,860</td>
<td>10,754</td>
</tr>
<tr>
<td>Population 2009</td>
<td>4,775</td>
<td>15,736</td>
</tr>
<tr>
<td>Population 2014</td>
<td>5,252</td>
<td>18,181</td>
</tr>
<tr>
<td>CAGR 1990 to 2000</td>
<td>5.84%</td>
<td>5.99%</td>
</tr>
<tr>
<td>CAGR 2000 to 2009</td>
<td>2.39%</td>
<td>4.32%</td>
</tr>
<tr>
<td>CAGR 2009 to 2014</td>
<td>2.93%</td>
<td></td>
</tr>
<tr>
<td>Area in square miles</td>
<td>1,344.84</td>
<td>410.74</td>
</tr>
<tr>
<td>Population density 2009 per square mile</td>
<td>3.55</td>
<td>38.31</td>
</tr>
<tr>
<td>Households 1990</td>
<td>927</td>
<td>2,203</td>
</tr>
<tr>
<td>Households 2000</td>
<td>1,686</td>
<td>3,917</td>
</tr>
<tr>
<td>Households 2009</td>
<td>2,156</td>
<td>5,800</td>
</tr>
<tr>
<td>Households 2014</td>
<td>2,395</td>
<td>6,721</td>
</tr>
<tr>
<td>CAGR 1990 to 2000</td>
<td>6.16%</td>
<td>5.92%</td>
</tr>
<tr>
<td>CAGR 2000 to 2009</td>
<td>2.77%</td>
<td>4.46%</td>
</tr>
<tr>
<td>CAGR 2009 to 2014</td>
<td>2.13%</td>
<td>2.99%</td>
</tr>
<tr>
<td>Population per household 2009</td>
<td>2.21</td>
<td>2.71</td>
</tr>
<tr>
<td>Median household income 2009</td>
<td>$61,130</td>
<td>$70,713</td>
</tr>
<tr>
<td>Median value home 2009</td>
<td>$248,839</td>
<td>$257,448</td>
</tr>
</tbody>
</table>

Note: The sources are ESRI, Business Analyst, and authors.
declines. The final database of all individual home sales transaction used in the hedonic models are represented in the two distinct census tract home price indices in Exhibit 3.

The relevant issue regarding the Maxwell Ranch wind farm announcement is separating the effects of the announcement with the contagion consequences of national and regional home price devaluations. Exhibit 3 includes the national OFHEO\(^3\) home price index, which illustrates the proximity of the wind farm announcement to the beginning of the national decline in home prices. Did home prices near Maxwell Ranch decline solely due to national and regional housing declines, or are they due to the wind farm announcement? The solution to isolating the national contagion from the wind farm announcement is addressed in the Results section.

The initial data set included 5,621 property sales in the two census tracts between January 1, 2000 and December 31, 2008. Of these sales, 144 were dropped because the subject property was an attached residential building rather than single-family dwelling. Another 2,110 sales were dropped for critical missing variables in the data, and an additional 97 observations were dropped for sales where the property did not have at least one bedroom, one bathroom, or were at least 600 square feet to eliminate properties that were either land only or land with a non-residential property built on it. The truncated and final sample contained 2,910 observations. Summary statistics are listed in Exhibit 4.

The majority (83\%) of residential sales from January 2000 to December 2008 were prior to the announcement of the Maxwell Ranch wind farm, consistent with


Exhibit 4 | General Descriptives

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of sold price</td>
<td>2,910</td>
<td>10.60</td>
<td>14.88</td>
<td>12.45</td>
<td>0.52</td>
</tr>
<tr>
<td>Log of sq ft</td>
<td>2,910</td>
<td>6.40</td>
<td>8.94</td>
<td>7.41</td>
<td>0.41</td>
</tr>
<tr>
<td># bedrooms</td>
<td>2,910</td>
<td>1.00</td>
<td>7.00</td>
<td>3.11</td>
<td>0.94</td>
</tr>
<tr>
<td># of baths</td>
<td>2,910</td>
<td>1.00</td>
<td>7.00</td>
<td>2.44</td>
<td>1.05</td>
</tr>
<tr>
<td># of garage spaces</td>
<td>2,910</td>
<td>0.00</td>
<td>10.00</td>
<td>1.86</td>
<td>1.25</td>
</tr>
<tr>
<td># of acres</td>
<td>2,910</td>
<td>0.05</td>
<td>160.00</td>
<td>7.06</td>
<td>13.81</td>
</tr>
<tr>
<td>Days on market</td>
<td>2,910</td>
<td>1.00</td>
<td>1,160</td>
<td>149.00</td>
<td>135.68</td>
</tr>
<tr>
<td>Sold price ($)</td>
<td>2,910</td>
<td>40,000</td>
<td>2,900,000</td>
<td>294,499.53</td>
<td>189,434.07</td>
</tr>
<tr>
<td>List price ($)</td>
<td>2,910</td>
<td>42,900</td>
<td>3,300,000</td>
<td>303,305.02</td>
<td>199,996.70</td>
</tr>
<tr>
<td>Year built</td>
<td>2,910</td>
<td>1875</td>
<td>2008</td>
<td>1988.81</td>
<td>19.48</td>
</tr>
<tr>
<td>Age</td>
<td>2,910</td>
<td>1.00</td>
<td>134.00</td>
<td>20.19</td>
<td>19.48</td>
</tr>
<tr>
<td>Square footage</td>
<td>2,910</td>
<td>600</td>
<td>7,607</td>
<td>1,797.22</td>
<td>779.82</td>
</tr>
<tr>
<td># full baths</td>
<td>2,910</td>
<td>0</td>
<td>8</td>
<td>1.67</td>
<td>0.798</td>
</tr>
<tr>
<td># half baths</td>
<td>2,910</td>
<td>0</td>
<td>8</td>
<td>0.35</td>
<td>0.543</td>
</tr>
<tr>
<td># 3/4 baths</td>
<td>2,910</td>
<td>0</td>
<td>4</td>
<td>0.41</td>
<td>0.597</td>
</tr>
<tr>
<td>Price per square foot</td>
<td>2,910</td>
<td>25.27</td>
<td>855.82</td>
<td>163.37</td>
<td>59.88</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>2,910</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The sources are Everitt Real Estate Center (CSU) and authors.

the amount of time prior to the wind farm announcement. Over half (62%) of all sales involved homes in the Maxwell Ranch census tract, with 17% of all sales transactions occurring in the Maxwell Ranch census tract after the announcement. Only 36 sale transactions occurred in the adjacent Maxwell Ranch homeowners’ associations’ boundaries—29 sales prior to the announcement and seven sales after the announcement (Exhibit 5). Acreage for all 36 sale transactions ranged from 35 to 40 acres, confirming the rural nature of the location, with selling prices of $213,000 to $675,000, and house sizes from 1,040 square feet to 4,926 square feet.

The sales transactions were concentrated in the larger cities of Northern Colorado, but did include several in small rural towns such as Livermore and Red Feather Lakes, which provide a sufficient non-Maxwell Ranch sample for comparative purposes. The Red Feather Lakes census tract effectively acts as an out-of-sample subset to test for national housing crisis effects after the wind farm announcement.

Exhibit 6 compares correlations between the natural log of sold price by time periods (prior to and after announcement) and by census tracks (Maxwell Ranch and Red Feather Lake) to the natural log of square footage, # of acres, and days on market. The objective of the correlation matrix is to examine initial differences


### Exhibit 5 | Descriptive by Locations

<table>
<thead>
<tr>
<th>Announcement</th>
<th>Maxwell Ranch Census Track</th>
<th>Maxwell Ranch HOAs Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 = No</td>
<td>1 = Yes</td>
</tr>
<tr>
<td>Before</td>
<td>1,106</td>
<td>1,288</td>
</tr>
<tr>
<td>After</td>
<td>—</td>
<td>516</td>
</tr>
<tr>
<td>Totals</td>
<td>1,106</td>
<td>1,804</td>
</tr>
</tbody>
</table>

Note: The sources are the Everitt Real Estate Center (CSU) and authors.

### Exhibit 6 | Correlation Matrix by Announcement Periods by Census Tracts

<table>
<thead>
<tr>
<th>Census Tracks</th>
<th>Log sold price vs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log of sq. ft.</td>
</tr>
<tr>
<td>Sold Prior to Announcement</td>
<td></td>
</tr>
<tr>
<td>Red Feather Lake (n = 880)</td>
<td>.695</td>
</tr>
<tr>
<td>Maxwell Ranch (n = 1,288)</td>
<td>.794</td>
</tr>
<tr>
<td>Sold after Announcement</td>
<td></td>
</tr>
<tr>
<td>Red Feather Lake (n = 226)</td>
<td>.616</td>
</tr>
<tr>
<td>Maxwell Ranch (n = 516)</td>
<td>.803</td>
</tr>
</tbody>
</table>

between the dependent variable (natural log of sold price) to several primary independent variables for the two census tracts and the pre- and post-announcement time periods. Correlations are significant at the 1% level for Maxwell Ranch for both time periods, whereas the correlations between natural log of sold price and days on market for the Red Feather Lake census track are insignificant in both time periods.

Our proposed hedonic price models follow common methodologies found in Sirmans, Macpherson, and Zietz (2005) and Hoen, Wiser, Cappers, Thayer, and Sethi (2009) in order to account for the announcement and spatial characteristics of the three location groups. Unlike prior wind farm studies, however, this study investigates the impact of an announcement of future wind farm development plans rather than the effect of existing wind farm externalities. Previous studies have found little to no evidence of an impact from existing wind farms on residential property values. This study attempts to determine whether just the threat of wind farm development within close proximity to residential properties
in a rural area may have an effect on residential property values. Unlike other wind farm studies, we did not use distance as an independent variable due to: (1) the exact location of the wind turbines is not finalized, and (2) the rolling hills and mountainous qualities of the surrounding land area bordering Maxwell Ranch that impact potential visibility of wind turbines regardless of distance.

Five models are proposed, beginning with a general model without the announcement dummy variable (Equation 1), and progressing to additional models that cumulatively add the announcement dummy (Equation 2), the Maxwell Ranch census tract dummy (Equation 3), the Maxwell Ranch dummy that includes all home sales located in one of the six adjacent homeowner associations (Equation 4), and finally a basic model with an interactive variable accounting for the wind farm announcement and properties located within the six Maxwell Ranch HOAs (Equation 5).

**General model without announcement:**

\[
\ln(\text{soldprice}) = \alpha + \beta_0(\ln\text{sqft}) + \beta_1(\text{bdrm}) + \beta_2(\text{garspaces}) \\
+ \beta_3(\text{acres}) + \beta_4(\text{dom}) + \beta_5(\text{fullbath}) \\
+ \beta_6(\text{halfbath}) + \beta_7(\text{threeqtrbath}) \\
+ \beta_8(\text{age}) + \epsilon. \tag{1}
\]

**General model with announcement:**

\[
\ln(\text{soldprice}) = \alpha + \beta_0(\ln\text{sqft}) + \beta_1(\text{bdrm}) + \beta_2(\text{garspaces}) \\
+ \beta_3(\text{acres}) + \beta_4(\text{dom}) + \beta_5(\text{fullbath}) \\
+ \beta_6(\text{halfbath}) + \beta_7(\text{threeqtrbath}) + \beta_8(\text{age}) \\
+ \beta_9(\text{announce}) + \epsilon. \tag{2}
\]

**General model, announcement and census tract:**

\[
\ln(\text{soldprice}) = \alpha + \beta_0(\ln\text{sqft}) + \beta_1(\text{bdrm}) + \beta_2(\text{garspaces}) \\
+ \beta_3(\text{acres}) + \beta_4(\text{dom}) + \beta_5(\text{fullbath}) \\
+ \beta_6(\text{halfbath}) + \beta_7(\text{threeqtrbath}) + \beta_8(\text{age}) \\
+ \beta_9(\text{announce}) + \beta_{10}(\text{census}) + \epsilon. \tag{3}
\]
General model, announcement, census tract, and Maxwell Ranch HOAs:

\[
\ln(\text{soldprice}) = \alpha + \beta_0(\ln\text{sqft}) + \beta_1(\text{bdrm}) + \beta_2(\text{garspaces}) \\
+ \beta_3(\text{acres}) + \beta_4(\text{dom}) + \beta_5(\text{fullbath}) \\
+ \beta_6(\text{halfbath}) + \beta_7(\text{threeqtrbath}) + \beta_8(\text{age}) \\
+ \beta_9(\text{announce}) + \beta_{10}(\text{census}) \\
+ \beta_{11}(\text{mwrhoa}) + \varepsilon. \tag{4}
\]

Basic model, announcement \times Maxwell Ranch HOAs:

\[
\ln(\text{soldprice}) = \alpha + \beta_0(\ln\text{sqft}) + \beta_1(\text{acres}) + \beta_2(\text{dom}) \\
+ \beta_3(\text{age}) + \beta_4(\text{mwrann}) + \varepsilon. \tag{5}
\]

Where:

- \(\ln\text{sqft}\) = Log square foot of single-family home;
- \(\text{bdrm}\) = # of bedrooms;
- \(\text{garspaces}\) = # of garage spaces;
- \(\text{acres}\) = # of acres;
- \(\text{dom}\) = Days on market;
- \(\text{fullbath}\) = # of full baths;
- \(\text{halfbath}\) = # of half baths;
- \(\text{threeqtrbath}\) = # of three-quarter baths;
- \(\text{age}\) = Age of property structure in years;
- \(\text{announce}\) = Sold after March 2007 = 1, else 0;
- \(\text{census}\) = Property in census track 08069002500 = 1, else 0;
- \(\text{mwrhoa}\) = Property in Maxwell Ranch HOAs = 1, else 0; and
- \(\text{mwrann}\) = Announcement x Maxwell Ranch HOAs interactive variable.

There are three hypotheses based on the five equations. The first hypothesis states that the announcement of the Maxwell Ranch wind farm did not have a significant price impact on homes located in the two census tracks (Equation 2). The second hypothesis states that the announcement of the Maxwell Ranch wind farm did not have a significant price impact on homes in the Maxwell Ranch census tract (Equation 3), and the third hypothesis states that the announcement of the Maxwell Ranch wind farm did not have a significant price impact on properties located in the adjacent Maxwell Ranch six homeowner associations (Equations 4 and 5).

Exhibit 7 illustrates the sale price per square foot history for the 2,910 sample, with the vertical line indicating the date of the announcement of the wind farm.
Results

Results of the five proposed models are listed in Exhibit 9. The general model without the announcement dummy variable (Equation 1) shows a relatively high explanatory power of 0.689, with all coefficients significant at the 5% level with the exception of # bedrooms and age of the property. Adding the announcement dummy variable to the general model (Equation 2), shows similar results as the
previous model and a coefficient of −0.022 for the announcement variable, although insignificant at the 5% level but showing partial support for the spurious impact of the national and regional housing price declines.

The coefficient for the announcement variable effectively remains the same in the additional models (Equations 3, 4, and 5), with significance levels slightly increasing from 0.086 to 0.095. The Maxwell Ranch census tract dummy variable is insignificant (Equation 3), as well as the Maxwell Ranch HOA variable (Equation 4). The new interactive variable consisting of the wind farm announcement dummy multiplied by Maxwell Ranch HOA location dummy results in “1” for only properties sold after the announcement and located in the adjacent Maxwell Ranch HOAs. The coefficient of the interactive variable is −0.070 with a significance level of 0.448, indicating insignificant impact of the wind farm announcement.

Based on the results in Exhibit 9, we conclude that:

1. **Hypothesis One:** The Maxwell Ranch wind farm announcement did not have a significant impact on property values in the Maxwell Ranch and Red Feather Lakes census tracts.
### Exhibit 9 | Summary Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Equation 1</th>
<th>Equation 2</th>
<th>Equation 3</th>
<th>Equation 4</th>
<th>Equation 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.408</td>
<td>7.423</td>
<td>7.426</td>
<td>7.426</td>
<td>5.520</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Log of sq. ft.</td>
<td>0.618</td>
<td>0.617</td>
<td>0.616</td>
<td>0.616</td>
<td>0.931</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td># bedrooms</td>
<td>−0.010</td>
<td>−0.010</td>
<td>−0.008</td>
<td>−0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.210)</td>
<td>(0.219)</td>
<td>(0.316)</td>
<td>(0.301)</td>
<td></td>
</tr>
<tr>
<td># of garage spaces</td>
<td>0.070</td>
<td>0.071</td>
<td>0.072</td>
<td>0.072</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td># of acres</td>
<td>0.008</td>
<td>0.008</td>
<td>0.008</td>
<td>0.008</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Days on market</td>
<td>7.886E⁻⁵</td>
<td>7.813E⁻⁵</td>
<td>7.349E⁻⁵</td>
<td>7.405E⁻⁵</td>
<td>5.285E⁻⁵</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.051)</td>
<td>(0.071)</td>
<td>(0.068)</td>
<td>(0.225)</td>
</tr>
<tr>
<td># full baths</td>
<td>0.115</td>
<td>0.116</td>
<td>0.116</td>
<td>0.116</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td># half baths</td>
<td>0.100</td>
<td>0.101</td>
<td>0.101</td>
<td>0.101</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td># 3/4 baths</td>
<td>0.157</td>
<td>0.157</td>
<td>0.156</td>
<td>0.156</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>5.158E⁻⁵</td>
<td>−3.581E⁻⁶</td>
<td>5.883E⁻⁶</td>
<td>−5.065E⁻⁶</td>
<td>−0.001</td>
</tr>
<tr>
<td></td>
<td>(0.868)</td>
<td>(0.991)</td>
<td>(0.985)</td>
<td>(0.987)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Announcement dummy</td>
<td>−0.022</td>
<td>−0.021</td>
<td>−0.021</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.092)</td>
<td>(0.095)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxwell Ranch census tract dummy</td>
<td>−0.009</td>
<td>−0.009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.490)</td>
<td>(0.509)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxwell Ranch HOA dummy</td>
<td>−0.034</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.503)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxwell Ranch HOA announcement dummy</td>
<td>−0.070</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.448)</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.689</td>
<td>0.689</td>
<td>0.689</td>
<td>0.689</td>
<td>0.630</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>F</td>
<td>716.29</td>
<td>645.39</td>
<td>586.65</td>
<td>537.70</td>
<td>990.596</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
</tbody>
</table>

Note: Significance levels are in parentheses.

2. **Hypothesis Two**: The Maxwell Ranch wind farm announcement did not have a significant impact on property values specifically in the Maxwell Ranch census tract.

3. **Hypothesis Three**: The Maxwell Ranch wind farm announcement did not have a significant impact on the property values located in the local homeowner associations adjacent to the proposed wind farm development.
Exhibit 10 | ANOVA Results of Log of Sold Price by Announcement

<table>
<thead>
<tr>
<th>Maxwell Ranch Census Tract Dummy</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Feather Lakes census track</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>.206</td>
<td>1</td>
<td>.206</td>
<td>.922</td>
<td>.337</td>
</tr>
<tr>
<td>Within Groups</td>
<td>246.904</td>
<td>1104</td>
<td>.224</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>247.110</td>
<td>1105</td>
<td>.224</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxwell Ranch census track</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>.074</td>
<td>1</td>
<td>.074</td>
<td>.277</td>
<td>.599</td>
</tr>
<tr>
<td>Within Groups</td>
<td>478.497</td>
<td>1802</td>
<td>.266</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>478.571</td>
<td>1803</td>
<td>.266</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The table gives the results of an ANOVA test for the natural log of the sold price by census tract by announcement period.

In addition to testing for the wind farm announcement affect on home prices in the adjacent Maxwell Ranch homeowners’ associations or the Maxwell Ranch census track, it is necessary to test for spurious impacts of a national housing crisis on home sale transactions in the area. If the presence of a national housing crisis is present, then it is reasonable to expect significant differences in home values (e.g., decline in home values after the wind farm announcement in March 2007 that coincides with the beginning of the national housing crisis). Thus, the hypothesis is that there is a significant difference of means for a variable such as the natural log of sold price pre- and post-announcement for either the Maxwell Ranch or Red Feather Lakes census tracts. Exhibit 10 shows the results of an ANOVA test for the natural log of the sold price by census tract by announcement period. The results show that there is insufficient evidence to state that the means are different from each other for either the Maxwell Ranch or Red Feather Lakes census tracts pre- and post-announcement. Therefore, the presence of the national housing crisis contagion is insignificant during the time period.

Conclusion

This study is one of the first to investigate wind farm announcements on rural residential properties, developing five alternative models to test for significant impacts at a regional (two census tracts), local (Maxwell Ranch census tract), and adjacent properties (Maxwell Ranch HOAs) levels. The rolling terrain near the proposed wind farm at Maxwell Ranch challenges typical spatial-based models that use latitude and longitude coordinates of individual properties and calculate distances to wind turbine locations to estimate visual impacts.4

The Maxwell Ranch wind farm announcement is significant at the 10% level for the entire sample. Yet, this level of significance is attributable more to the beginning of the national housing crisis rather than the wind farm announcement. The entire sample of 2,910 sales transactions includes properties located in the Red Feather Lakes census tract that contains home sales located 10 to over 50 miles from the Maxwell Ranch. There are, however, no significant property value
impacts for homes located in the Maxwell Ranch census tract or the adjacent Maxwell Ranch homeowner association properties. As previously stated, the announcement variable is a time event variable that splits the sample into home sales before and after March 1, 2007. The wind farm announcement coincides with the rupture of the national, regional, and local housing bubbles and therefore any significance is most likely spurious with the general decline in housing values.

Our conclusion is that prices in Larimer County and the sample census tracts, as measured by the home price indices in Exhibit 3, started to decline sometime around the start of 2007, and the cause of the decline may be linked to the announcement of the wind farm, but may also be linked to the general decline in housing prices nationally. The fact that the Maxwell Ranch announcement variable is insignificant indicates that the properties most likely to actually see or be affected by the wind farm, did not experience an impact from the announcement significantly different from other properties in the region that are least likely to experience any impact from the announcement. Thus, we can reasonably conclude that the announcement variable is acting as a proxy for the start of the downturn in overall market conditions rather than a negative impact caused by perceived externalities arising from the Maxwell Ranch wind farm project announcement.

There are several limitations to this study. First, the contagion effect of the national and regional housing crisis clouds the results, although the models included several spatial dummy variables to isolate impacts of the wind farm announcement. The use of home sales in the Red Feather Lakes census tract essentially acts as a control subset of the overall 2,910 home sale transactions. Second, the rural nature and diminished residential inventory turnover in the adjacent Maxwell Ranch HOAs resulted in a small sample of sold properties out of the 2,910 total population of sold properties. Third, our focus on the announcement effect rationally does not include an actual construction or operation period of the wind farm and thus any positive or negative wind farm impacts are beyond the scope of this study.

As part of this study, we interviewed several residential real estate brokers that had active listings close to Maxwell Ranch to gain a subjective assessment of the impact that the announcement of the proposed wind farm has had on local residential values, and the general conditions of the market surrounding Maxwell Ranch. We identified 13 residential real estate brokers with active listings as of June 2009 and contacted them for interviews (Exhibit 12). Of the thirteen contacted, we were able to reach ten. The brokers were asked questions about the state of the rural real estate market in Northern Colorado and if they had heard of the proposed wind farm project, and if the project had had any impact on their listed properties.

During our interviews with the brokers, several indicated that they had not heard of the proposed project. Several others had heard of the project but admitted they had very little knowledge of any details and a few other brokers indicated that they had knowledge of the proposal. Of those who had knowledge of the proposed wind farm, only one indicated it had impacted a listing, with a buyer backing out of a signed contract after the announcement of the wind farm project. Another
broker indicated that his sellers viewed the project favorably, and that any increase in jobs in the area would only help real estate prices.

Most of the brokers thought that the wind farm would have a negative impact on residential real estate values, but said it was hard to tell if the current lack of showings in the area was caused by the general downturn in the real estate market or by the announcement of the wind farm. A small sample of the brokers also stated that they thought only a few properties would have their view affected because the primary orientation of views for properties in the area is westward. Overall, the general impression is that some of the brokers thought that the real estate might be impacted negatively in the area, but could not be sure that this was the case.
There are numerous areas for further research as alternative energy projects are announced, constructed, and operated in the future. Returning to the housing market in the Maxwell Ranch census tract once the wind farm is operating and the housing crisis dissipates may result in different findings as demand for housing could increase due to changes in job-related growth associated with the wind farm. Additional time series of home sale transactions in geographies adjacent to wind farms will likely support or challenge existing research such as Hoen, Wiser, Cappers, Thayer, and Sethi (2009). The development of alternative energy projects such as wind farms, whether urban, semi-rural, or rural-based, impacts land uses, spatial agglomerations, and local externalities. Developments supporting clean and alternative energy sectors will change the urban and rural landscape and thus offer new research opportunities to explain positive and negative valuation impacts, as well as intended and unintended consequences.

Endnotes

Homes adjacent to Maxwell Ranch are generally 35 acres.

See http://www.fhfa.gov under the Home Price Index pull-down menu for complete series.

The authors completed two field trips in 2009 to Maxwell Ranch visually inspecting adjacent home sites. The project’s engineering firm provided a preliminary plan of wind turbine locations and nearby existing residential properties (see http://www.green.colostate.edu/pdfs-gpp/visual-resources.pdf for further information [May 15, 2010]).

The Everitt Real Estate Center at Colorado State University produces quarterly repeat sales indices for Northern Colorado at the county, city, and census tract levels.

References


This research was partially underwritten by Colorado State University Research Foundation. The views expressed are the authors and do not necessarily reflect the views of Colorado State University or Colorado State University Research Foundation.

Steven P. Laposa, Colorado State University, Fort Collins, CO 80523-1272 or steve.laposa@colostate.edu.

Andrew Mueller, Colorado State University, Fort Collins, CO 80523-1272 or Andrew.Mueller@lamar.colostate.edu.
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