Green Buildings in Green Cities: Integrating Energy Efficiency into the Real Estate Industry

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Abstract

The commercial real estate sector accounts for over a quarter of the energy consumption in the United States. This paper examines how characteristics of the commercial real estate industry and structural attributes of US cities affect the goals of improving energy efficiency and sustainability of buildings, and improving pollution and emission levels in US cities. We build a detailed picture of the factors involved in integrating energy efficiency into commercial real estate planning, design, finance and construction, and look at the interplay of the institutional and contractual structure of commercial real estate, the urban organization of space, and urban transportation patterns in producing "green" real estate. The research draws on a thorough review of academic and trade literature on the topic and describes the findings from detailed interviews of professionals in the real estate and real estate finance industries. We use data from COSTAR, Building Owners and Managers Association, Departments of Energy and Transportation, and the EPA to examine factors underlying energy efficiency improvements. We find that energy efficient and other green improvements are most likely to be found in large, newer, class A and B buildings in more productive metropolitan areas, but outside of downtown areas. Evidence of "learning" effects from a culture of green communities is mixed, with some factors significant in the expected direction (e.g. high transit use), a few in unexpected directions (e.g. some air pollutants and residential density), and many factors lacking significance. The paper draws from research funded by the US Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Program.

Key words: green building/ energy efficiency/ commercial real estate/ sustainable communities

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I. Introduction

Commercial buildings (office, retail and industrial) account for close to 20% of the total energy consumption in the United States. Their carbon footprint is significant. The potential benefits from reduced energy consumption are therefore considerable. There is growing awareness in the real estate sector and in policy making circles of the role that the commercial real estate sector could play in mitigating the harmful environmental fallout of energy consumption by office buildings in the US. A key debate is over the degree to which regulation, rather than voluntary compliance or market mechanisms would be necessary to bring about greener buildings. There is a body of thought that holds that “reliance on voluntary green building certification has very limited potential and stronger regulations are needed in the United States to minimize the environmental impacts of buildings” (Retzlaff, 2010). Others have pointed out the benefits that could be achieved from market based incentives to stimulate a greater supply of green and environmentally friendly buildings.

The growing academic literature in this field seems to suggest, with some caveats and qualifiers, that investors, landlords and even tenants could benefit financially from investment in green buildings, in addition to some non-pecuniary “image” benefits. Some of those perceived benefits have acted as incentives for owners to seek green certification and invest in the costs associated with it. Other avenues for seeking certification can include regulatory mandates, as well as voluntary certification for company goodwill development and reputation building.

This paper expands the discussion in two dimensions, by exploring in depth how the decisions on whether or not to make green or energy efficiency investments in buildings are made, and by examining the larger diffusion of green and energy efficient buildings throughout the urban landscape. Building from recent research on the value of LEED or Energy Star labeling[1] for commercial building rents or prices, we ask several research questions:

- What motivates green or energy efficiency investment in commercial buildings?
- What barriers exist to green or energy efficiency improvements?
- How do metropolitan-wide sustainability characteristics affect the likelihood of investing in green design or energy efficient technologies? Are there facilitating conditions at the metropolitan wide level that create a conducive atmosphere for developers and real estate investors to seek out green labeling? Such conditions might revolve around green life style, a particular urban structure, or the regulatory environment.

We begin with a review of research that focuses on the benefits of green design to commercial building owners, the costs of green and energy efficient buildings, barriers to introducing green features or energy efficiency into commercial buildings, and company, industry, and geographic characteristics that influence the adoption of green design and energy efficiency features. We next describe the results of forty-five in-depth interviews with representatives of the building industry, financial institutions, other investors, consultant firms, nonprofits, and government institutions. The third element of the paper examines empirical data and includes a preliminary statistical analysis, at both the individual building and aggregate metropolitan area level, of the factors influencing the diffusion of LEED and Energy Star buildings among geographic areas. In addition to market factors, we focus on underlying structural urban variables and the overall socio-cultural and regulatory environment that may

[1] LEED is an acronym for "Leadership in Energy and Environmental Design" and refers to a building certification system developed by the US Green Building Council (http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988). Energy Star is a voluntary rating system applied to appliances, computer equipment, and buildings, developed and administered by the US Environmental Protection Agency and the US Department of Energy

make green labeling or energy efficiency more desirable. We conclude with a discussion of policy and future research directions.

II. Literature Review

Previous research has addressed the incorporation of green features into commercial building from multiple points of view. Several authors examine demand side benefits, in terms of the effects of green design or energy efficiency on lease rates or sales price. Others have addressed cost factors, including the effects of variations in energy costs on the decision to adopt energy efficient design, as well as the overall cost of building green as compared to financial benefits. Both the academic and trade literature attempt to identify barriers to the adoption of green design or energy efficiency in commercial buildings. Additional research looks at the role of social and political factors in determining the attractiveness of a green building to tenants or the diffusion of green or energy-efficient buildings across a metropolitan market.

Demand for Green and Energy Efficient Buildings

The CoStar database[2], a detailed data base with observations of sales and leases at the building and the tenant level, underlies several analyses of the value to a commercial building of LEED or Energy Star rating. Studies relying on CoStar data have evolved from early efforts based primarily on descriptive statistics to more complex studies using multiple regression models across individual building and lease observations. Eichholtz, Kok and Quigley (2010) use the Co-Star dataset to compare "green" buildings (Energy Star and LEED rated) with others in the immediate neighborhood (a 0.25 miles radius from the labeled building). The analysis

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[2] CoStar Group is a commercial real estate information company that has established a data base of commercial properties in major metropolitan markets across the United States. Data is provided at the lease and building levels, as well as in aggregation and historically. http://www.costar.com/products/

provides evidence of the economic “value” of green buildings by showing that “buildings with a ‘green rating’ command rental rates that are roughly three percent higher per square foot than otherwise identical buildings,” (p. 2492) and that the sales price premium is about 16 percent. Based on their empirical results and regional energy prices, they conclude that, “on average, a dollar of energy savings yields 18.32 dollars in increased market value–implying a capitalization rate of about 5.5 percent,” (p. 2507) and that the price/rent premium is probably not due to the label alone but to actual energy savings. However, the authors cannot evaluate the costs for conversion to Green, which is critical in terms of evaluating net benefits and returns. Also, there are some simultaneity issues, such as the possible endogeneity of location and choice of Green buildings, as well as the lease-contract structure of the building.

Fuerst and McAllister (2011) evaluate the impact of environmental certification on rents and prices of commercial buildings. The authors use Costar data to identify 197 LEED and 834 Energy Star certified buildings, with over 15,000 benchmark buildings in US metropolitan markets. Through hedonic regression analysis, they find a rental premium of 4-5% in LEED/Energy Star certified buildings compared to non-certified peers. Using transaction prices for 559 Energy Star and 127 LEED certified buildings they find a price premium of 26% for Energy Star and 25% for LEED certified buildings. Unlike Eichholtz, Kok and Quigley, they do not show a direct effect of energy savings, through their capitalization on market values.

Cost Factors

Two general types of cost factors may affect the decision to invest in green or energy efficient features of a building. These include construction costs and operating costs. Most research considers cost factors alone or compares costs to expected price premiums, but one paper also considers these factors as elements influencing pricing.

Most studies discussing cost factors are separate from the demand analyses, and focus on the construction cost of the building. Fuerst and McAllister 2011 refer to several cost studies which indicate that additional costs for construction and certification of green or Energy Star buildings are within a few percentage points of building costs without these features. A report prepared for Industry Canada (2005) concedes that green buildings have higher costs, due to longer design and construction times, "nonstandard" materials and expensive equipment, but that "longterm benefits (money saved on energy, water, and so on) outweigh this first-cost premium."

Kats 2003, in a report prepared in partnership by the US Green Building Council and California's Sustainable Building Task Force, reviews both the costs and benefits of green buildings. The report points out that the "average premium for these green buildings is slightly less than 2%, or $3-5/sq.ft, substantially lower than is commonly perceived…" The energy savings of green buildings are up to 30%, and at an average electricity price of $0.08/kWh work out to about $ 0.30 per sq.ft. per year and a 20-year net present value of over $5/sq.ft. (using a discount rate of 5 % real), more than the average additional cost of building green. The paper argues that green pays for itself and that the benefits of a LEED certified building also include lower water costs and emissions costs.

Kapelina 2010 compares surveys of professionals with studies of costs and finds that while more than half of real estate professionals expect green design to cost at least 5% more than conventional buildings (over one fifth expect the cost premium to be 10% or more), cost studies have shown the premium to be closer to 1 percent. The article cites examples of cases with relatively low green construction costs or shorter payback periods for higher costs, including a 9.5 month cost recovery period for a well-publicized green retrofit of the headquarters of Adobe Systems.

Jaffee, Stanton and Wallace (2011) look at different aspects of energy cost structure, including operating expenses and energy risk exposure in their models of the determinants of building price. Their research takes the underlying cost basis into account in explaining price variation among buildings. Rather than relying on Costar records alone, they merge Costar data with the original Energy Star data (including building ratings), as well as data on operating expenses, the dominant lease structure, and geographic variation in energy cost and volatility. Their analysis indicates that net operating income and costs, rather than the Energy Star label, and the lease structure are significant factors in determining the sales price of a building, in addition to fixed market and year effects and regional energy price levels and variations.

Barriers to Adoption

If there are rent and price premiums for green buildings or lower energy costs, and either the label value or cost savings compensate for added construction costs, then what factors impede adoption despite a favorable benefit versus cost balance? The US EPA worked with two nonprofits, the Northeast-Midwest Institute and Delta, to draw together a panel of experts to identify barriers to green development and strategies for overcoming these barriers (US Environmental Protection Agency 2008). Barriers identified through workshops include information gaps (lack of "reliable performance, cost, and benefit information of green features"—page 10), communication shortfalls (where information is available, it is not conveyed to building users), ownership and lease structures (short term ownership outlook discourages long term investments, especially if tenant pays utility costs), funders that use criteria based on conventional developments, and risks of time lost from introducing new technologies to a conventional government building permit process. Other literature finds barriers to adoption include split incentives in the lease structure, the decision process in the finance industry, and the operating structure of real estate development and property management companies.

Lease structure: The issue of split incentives between landlords and tenants and the lease contractual structure is important in the context of pass-through energy costs: in triple-net leases tenants bear the costs of energy consumption, taxes, maintenance etc., whereas gross leases charge an all encompassing rent that includes all these operational expenses. Therefore, the contractual structure is of vital importance in terms of incentives for carrying out energy-efficiency investments and the willingness to pay for them. The determination of the choice of lease type depends on many things. The size/structure of the building and the number of tenants, e.g. with rare exceptions, downtown buildings are larger with many tenants, so transactions costs in terms of figuring out different tenant bills by category are higher, and sub-metering is problematic. Mooradian and Yang (2002) model the choice between gross and net lease type in a market where lessors can provide operating services at lower cost, but there is asymmetric information regarding lessee's expected intensity of utilization of space. The model shows that there is a critical cost of utilization point; not surprisingly, the higher expected utilization lessees with costs above this point select the gross lease and the lower expected utilization lessees select a net lease (all other aspects of the rent being equal).

Jaffee, Stanton and Wallace 2011 find that transaction prices are lower for buildings with full service or modified gross leases (as compared to triple net). Operating expenses are higher for full service and modified gross lease buildings because individual tenants have a less direct concern in energy conservation when costs are averaged over the entire building. This finding suggests that contractual structure and incentives to save on utility costs can positively impact building values and transaction prices. However, the authors do not find a significant relationship between lease structure and operating income. The analysis of factors influencing whether a building becomes Energy Star or not does not include the lease structure variables.

Two studies of the apartment sector address the effects of factors such as lease or ownership structure on energy usage. Levinson and Niemann (2004) take on the issue of divided incentives between tenants and landlords by looking at the apartment market. Using the Residential Energy Consumption Survey and the American Housing Survey the authors estimate energy consumption and rent premiums for utility-included apartments. They find that tenants in non-metered buildings use greater amounts of electricity. The difference between gross and net rents is smaller than the energy cost, suggesting that landlords find a benefit in avoiding metering. The reasons for this are a matter of speculation—savings on some kind of transactional costs, including costs of setting up metering, particularly for old buildings; "signaling" for landlords who have already invested in energy efficiency measures and expect low utility costs; or improving access to tenants who are risk-averse or face liquidity constrained tenants, or "simply dislike considering marginal costs." Davis (2010) addresses the potential distortion caused by conflicting incentives between landlords and apartment tenants by analyzing appliance usage by tenants. Comparing appliance ownership patterns between homeowners and renters Davis shows that renters are significantly less likely to have energy efficient refrigerators, clothes washers and dishwashers, after controlling for household income and other household characteristics.

Finance: The academic literature has not yet examined efforts of the banking industry to integrate traditional real estate lending and lending on sustainability projects. Journalism articles report ways that green factors are considered in lending. Hudgins 2008 provides an optimistic overview of green lending practices, highlighting programs at both Wells Fargo and some smaller lenders, but does not address the segmentation that occurs in some banks between the programs that target green projects and traditional real estate lending. The trade literature has begun to address issues of financing energy efficiency and other sustainability real estate investments. Muldavin 2010 consolidates material from the Green Building Finance Consortium and many other sources to offer an encyclopedia of issues and resources related to green finance. The book outlines a conceptual approach to financing sustainable buildings, recognizing that the cost of revamping the approach to building evaluation may be more challenging for owners of smaller buildings than for large building owners (or lenders to large building owners).

A McKinsey report (Granade et al 2009) examines the financing pipeline and identifies agency issues, payback mismatches, information shortfalls, and capital constraints. These may be on the part of the end user, who may be reluctant to increase debt, especially at the premium that may be charged by specialized energy companies, or the financial institution reluctant to take on unproven projects in the private real estate market.

An article by Goldman, Hopper and Osborn (2005) of the Lawrence Berkeley National Laboratory reviews the role of energy service companies (ESCOs) in delivering energy saving technologies to private sector institutional customers. These companies in some cases provide financing resources with payback tied to the performance of the energy saving investment. The ESCO model is found to apply primarily to complex projects for large commercial customers. Performance based financing was decreasing as a share of ESCO business, at the time of the survey reported in this article.

Business organization and operations: Including energy efficiency and sustainability in decisions regarding commercial buildings may require adjustments to firm operations and construction relationships. Bradshaw 2010 studies the integration of sustainability into the development process and building products. He finds that green development changes the relationship of the developer with investors because the investment and payoff periods are different with green technologies. The relationship between design and construction expertise must become more cooperative, with more frequent communication required between owner, design professionals, and building contractor. Different assembly processes may be needed to retain control over the performance of the sustainable design.

Operations and ongoing maintenance are also an issue at the building level. Several authors emphasize the mismatch between energy efficiency investments and energy efficiency results, pointing to building operations and "commissioning" as culprits. Mills 2009 reports on the results of a meta-analysis of case studies of commissioning for energy efficiency in over 400 projects (332 existing and 77 new), of which over 40 percent of square footage was in office buildings. Energy savings from commissioning were 16% in existing buildings, with an 0.4 to 2.4 year payback period, and 13% for new buildings, with a 1.5 to 10.8 year payback. Escrivá-Escrivá 2011 emphasizes the importance of a set of simple actions, including measurement, control systems, tracking daily usage, and internal communications, that can help even those projects with less technical staff improve energy efficiency operations in a building. Granderson *et al* describe the complexities of monitoring and adjusting energy use in large complexes, even with sophisticated measurement tools.

Social, Institutional and Political Factors, and a Culture of Sustainability

Other factors that may influence the adoption of green design and energy efficiency may include demand side elements such as tenant characteristics, as well as institutional characteristics, such as government requirements, and general geographic and demographic characteristics, such as urban form, climate, transportation systems, propensity to carpool, and so forth.

Eichholz, Kok and Quigley 2009 analyze the composition of tenants in commercial buildings to understand who rents in green space and why. The paper demonstrates that certain industries, such as banks, financial services, non-profit organizations, law firms and the government are the dominant tenants for green buildings. The authors develop four underlying determinants or factors that go into the making of corporate social responsibility in real estate decision making and then develop six hypotheses or propositions that suggest which firms in which industries were more likely to rent green. The motivations range from pecuniary to reputational. The results are strong when they study large tenants, but seem to disappear when they study all tenants.

Kok, McGraw and Quigley (2010) examine the "diffusion" of green labels (Energy Star and LEED) among (not within) different metropolitan areas. They find that diffusion has been proceeding rapidly. Metropolitan areas with higher incomes are more attractive locations for both Energy Star and LEED buildings. Higher energy prices have a greater influence in the adoption of energy efficiency technologies (Energy Star certification) than for broader sustainability labels (LEED). The availability of LEED professionals, and government regulations and incentives encouraging LEED status stimulate the adoption of LEED design, but have an ambiguous effect on Energy Star certification.

Muldavin 2010 touches on the variation among geographic locations in sensitivity to sustainability considerations (and thus the motivation to build green). Based on the experience of lenders associated with the Green Finance Consortium, the major factors distinguishing among geographic areas include government regulations and incentives; the degree of sensitivity to environmental factors of tenants, consumers, and employees; climate, energy sources and costs; and other local conditions such as water availability and traffic congestion.

There is extensive research on what makes a city green or sustainable, but little other work linking these factors specifically to the building industry. The Energy Information Administration 2005 provides data on residential building characteristics, such as size and orientation, and energy use. Glaeser and Kahn 2008 link carbon dioxide emissions to the urban development patterns. They find large differences in carbon dioxide emissions among metropolitan areas (generated by climate, commute patterns, and other factors), and smaller differences within metropolitan areas, with denser locations generally having lower emissions per household than more dispersed development patterns. Stone 2008 finds evidence that the degree of urban sprawl affects the amount of ozone formation. Holzclaw *et al* look at density effects, while Kenworthy and Laub 1999 examine the interaction between density and transportation efficiency. Other authors examine the challenges of addressing green house gas effects and meeting sustainability goals (Kennedy *et al* 2009, Newman and Kenworthy 1999), and the efforts to achieve improvements (Brown, Southworth and Sarzynski 2008, Williams 2000, Kahn 2006).

The following section draws on a set of interviews of builders, lenders, consultants, nonprofits, and government programs, to further illustrate the ways that sustainability and energy efficiency are integrated into the commercial building process, the barriers to incorporating sustainability and energy efficiency, and the role of geographic factors in encouraging or impeding these investments.

III. Interviews

Interviews were conducted as part of a research project funded by the Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program. The purpose of the interviews was to develop a comprehensive understanding of how sustainability features, and most specifically energy efficiency measures, become incorporated into commercial buildings. Interviews focused on who was involved (building owners of course, as well as designers, contractors, lenders, other investors, consultants, nonprofits, and government agencies), their level of interest in energy efficient or green building and the motivations behind this interest, barriers to energy efficiency and green building design, measures of green building/energy efficient operations, and barriers faced. For this paper, we draw on the interviews to develop an understanding of firm factors, market factors, operations and management structures, and outside institutional factors that influence or impede the adoption of green and energy efficient technologies.

The Interview Process

Between spring 2010 and winter 2011, we conducted interviews with representatives of 45 companies and organizations involved in some way in the introduction of energy efficiency technology into commercial office buildings, as summarized in Table 1. These included development firms (overseeing construction and frequently owning and managing space as well), banks, other financial providers (ranging from ESCOs to insurance companies), consultants, nonprofit corporations, and government programs. Depth of interviews ranged with the organization and individuals. Some were as brief as 15 minutes, but most were between one and two hours. For a few firms, we held several detailed interviews with a two or more departments. Because most interviews were done under assurances of confidentiality, the findings are described generically, rather than tied to company or individual names.

Table 1: Interviews by Institutional Type		
Type of Institution	Number of Institutions	Number of people
Bank	5	15
Broker/Property Management	4	4
Consultant (design, economic and real estate)	3	3
Consultant (energy)	6	7
Consultant (finance)	4	4
Developer/Owner/ Operator	6	6
Private Investor	3	3
Finance (other)	2	2
Energy Services	1	2
Legal	1	2
Nonprofit	3	6
Public official/ Utility/ Regulator	4	4
Trade Organization	3	3
Total	45	61

The Landscape of Players in the Production of Energy Efficient Buildings

The process of introducing energy efficiency or sustainability to a project can involve many players. Even within each type of player, there may be differing approaches to energy efficiency decisions and motivations.

Both ownership and the financial structure of commercial real estate can vary widely. At one extreme is an individual who invests in one or more buildings as income properties, and uses equity or bank loans to finance capital improvements. At the other extreme are publically held companies (often structured as REITS) that offer the individual investor more liquidity in the real estate investment. These companies may use short term bank loans for construction but find other sources of longer term investment to cover capital costs. Between these two, less liquid than REITS but more arms-length than the individual property owner, are private investment firms which again are less reliant on bank loans, with much of the long-term capital coming from investors (generally high wealth individuals, trusts or large institutions such as pension funds).

In addition to property owners and sources of funding, building operators and management companies play a critical role in determining how energy efficient a building is, while a variety of service providers, from brokers, to lawyers to consultants participate in the market for energy efficient space and the funding process. Building tenant type also influences both demand for efficient space and the operational characteristics of the space.

Nonprofits and the public sector are involved in both the development and operation of energy efficient buildings as well as in funding. Consultants and energy service providers (including ESCOs—energy service companies—which provide analysis, implementation, and performance guarantees, and other firms with narrower specializations) play a role in determining the investments and operational changes needed to make a building more energy efficient and in advising on ways to finance improvements, using both private and public sector resources. The public sector may be involved as a regulator or may develop programs that finance or provide incentives for improvements.

The interviews highlighted how business structure influences the perspectives of the individual or firm toward the value of an energy efficiency or green investment. Goals will vary with ownership structure of the property, lending alternatives, other available services, as well as perceptions toward broader public responsibility of the firm or organization.

Ownership Structure

In a simple world, a building would be owned by an individual or family who operate it as income property. The focus of this type of owner may be short or long term, in either case the main concern is the level of net income brought in by the property. Energy efficient investments would be evaluated in terms of costs versus savings. Private investment funds may pull unrelated individuals into the ownership of the building. The fund may focus on either income and/or adding value through improvements. In either case, this type of owner (a group of private investors) may have a greater concern with marketability of the building over the longer term, and would want to know the outlook for green or energy efficient firms over less efficient competitors.

Ownership may be achieved through shares sold on the public market. Investment goals will vary depending on the fund, with some (such as REITS) oriented to annual income distributed to the investors and others to longer term growth in product value. Green considerations may be hidden in the broader prospectus that is examined in the course of investment.

Corporations may own their space. Their goals reflect both investor and user concerns, ranging from operating costs to long term value or opportunity costs of renting alternative space, to corporate image. Public government and some institutional occupant/owners may have a perspective beyond that of an owner-occupant, considering larger public policy goals in determining building characteristics and managing operations.

Lending Structure

Financing for energy efficiency improvements may come from one or more sources, each with a different approach to lending. Commercial lending from traditional banks is not a single distinct activity. Short term construction loans fund the initial development process. When construction is completed, the loan may roll over to a commercial term loan at the bank, or be taken on by a different type of investor/lender. These loans would be commercial mortgages secured by the real estate (rather than the company's broader assets). Capital improvements related to energy efficiency, if not part of a larger real estate project (such as new construction or a major rehab) may be financed through the types of full recourse loans that would be used to fund operations, rather than as a mortgage tied only to the property as collateral. Construction loans, commercial term loans, and operations loans may all come through different departments of the bank or from separate banks. From the point of view of the borrower, adding the cost of energy efficiency improvements to operating costs may make it difficult or more expensive to obtain financing and requires the owner to shoulder a greater share of the risk than with a mortgage tied to building value alone.

A few smaller lending institutions have taken on energy efficiency or sustainable lending as a company-defining mission. These may offer the same range of products as the traditional lenders, but the factors considered in the due diligence process may be more specific to the energy efficiency or sustainability goals of the lender. Community development financial institutions (CDFIs) are beginning to fund green investments, primarily for affordable housing projects, but their charters would also allow them to provide funding to other community facilities.

Longer term loans on the property itself (either rolled over from construction loans or as capital for purchasing existing properties) may be held by other entities as well as the bank. Real estate investment firms, owner-operators, and other real estate ownership structures may choose to self-finance energy efficiency improvements. Institutional investors such as insurance companies or pension funds may take on the commercial mortgages when the funding turns over from the construction phase. Loans may be securitized, pooled with other commercial mortgages into investment vehicles. Energy efficiency or green measures may become opaque as loans are sold and packaged.

Lending may be integrated with other activities as well. Companies providing the energy improvements may provide financing through several mechanisms, including a) leasing equipment to the user, b) through a performance contract, allocating some or all of the savings from the energy efficiency improvement to paying, over time, for the energy service company services and equipment, or c) guaranteeing a specific level of savings, which can be allocated towards paying off the investment financed by a traditional lender. The energy company may also identify incentive savings offered by the public sector or utility companies that will lower the cost of the project. Nonprofits that provide broader sustainability or energy efficiency services generally do not provide direct funding to projects, but also may assist in creating a financing plan through identifying lenders and incentive programs that reduce costs.

Related Services

Many other types of companies are involved in designing sustainable buildings, financing buildings, or implementing sustainability programs. Consultants from design to finance assist with identifying energy efficiency improvement opportunities. Engineering consultants in addition have an established role in evaluating baseline fire and life safety and immediate repair issues during building due diligence, through the preparation of property condition assessments. Unless brought in specifically by the owner or service provider to evaluate energy and sustainability goals, the reports may ignore this aspect of building operation, focusing instead on identifying the expected life span of existing equipment and any immediate life safety hazards such as structural faults.

While some building owners also manage and operate their own buildings, many rely on building services companies to provide these services. It is the building operator or manager who generally has responsibility for ensuring that energy efficient equipment is used to specifications. These companies also may be instrumental in introducing new energy efficiency designs, equipment and management techniques. Coordinating energy-using operations to result in the most efficient use of resources is a specialization that may be beyond the scope of some building operations and management servicers. Independent firms provide these services to individual building owners or to manage energy use within a portfolio of buildings. Services may be packaged in a range of functions of which management of energy use is one element, or specialized, as with energy management software companies that focus only on the energy systems.

Brokerage firms and legal firms are both involved in the leasing process. They shape the agreement between owner and tenant that determines how costs and benefits of energy-efficiency investments are spread. A legal subspecialty has developed around the design of “green” leases, that lay out how building operations will affect tenants and how costs and savings will be distributed.

Players Influencing Demand, Incentives, and Regulations

The market and institutional and regulatory environment in which commercial buildings exist also influences how conscious building owners and lenders are of sustainability goals and requirements. Tenants are one significant but diverse element. How energy improvements are valued will vary with tenant type, with high-energy-use tenants more sensitive to energy costs (especially with triple-net leases). Large corporations in leased space can have significant influence on energy efficiency levels. If they value more energy efficient space, this can be a spur for building owners to make the investment, even if the direct benefits may go to the tenant.

The public sector has developed several roles in the adoption of energy efficient technologies within commercial buildings. Property assessed clean energy programs (PACE) provide a means of financing energy investments that have long term time frames for pay-offs by using public bonding powers to provide loan financing and the property tax system for paying off the loans on the property over an extended period, even beyond the individual's ownership of the home. The local government regulatory process may require energy upgrades on sale of property or higher energy efficiency standards in new property. State government building codes may also influence the level of energy efficiency in new buildings. Furthermore, as described under the lending structure, Federal, state and local incentives have become significant factors in the financing of energy efficiency investments.

Utility companies are another set of players, with an important role as partners with government in providing incentives for adopting new technologies or improving energy efficiency. They also may work with building owners to provide the means of better monitoring energy use at the portfolio, building, or tenant level. Furthermore, some utility programs develop demonstration projects to encourage energy efficiency, providing monitoring and evaluation as well as the initial design and operation.

Incorporating Energy Efficiency into Commercial Buildings—Motivations and Barriers

The interviews give a rich picture of how energy efficiency and other sustainability investments are considered by building owners, lenders, investors, and service providers. Responses also uncovered barriers to the adoption of energy efficient investments.

Motivations for Energy Efficient Buildings

Motivations for making energy efficient investments (or more general sustainability goals) ranged from global responsibility in the face of global warming to individual revenue and cost assessments. Factors such as marketability in the short and long term also played a role.

- *The right thing to do:* Some developers saw their product as playing a key role in addressing issues of global warming, and would make investment energy efficient even if the returns would not justify the investment on financial grounds alone. A description of the Empire State Building retrofit process identifies the "desire to prove or disprove the cost-effectiveness of energy efficiency retrofits" and "a desire to reduce greenhouse gas emissions and operating costs" as two major motivations (Jones Lang Lasalle et al 2010).
- *Marketability:* Most of the developers of new buildings whom we interviewed were well capitalized companies building in major markets. These builders often included energy efficiency and even LEED design in their building plans for reasons of marketability. This was important both in the short term and from a longer perspective. An immediate benefit was to be able to "attract the best talent" to a building (as put by a

nonprofit consultant to the Clinton Climate Initiative in Chicago), or capture a larger market share of tenants (as identified by an energy finance consultant). A green upgrade could make a rehab project competitive in a higher class of buildings. If holding investments, with possible sale in the future, perhaps five, ten, or twenty years down the line, several developers perceived building to state-of-the-art energy efficiency and sustainability as critical to maintaining future competitiveness of the product. Furthermore, LEED or Energy Star status had become part of the "brand" of several developers.

- *Cost Effectiveness:* This is an important consideration but not always straightforward. In addition, it interacts with other factors such as expected payback period. Lenders may be more responsive to features that will pay back their cost within the loan period (usually one to three years). Several respondents described a hierarchy of energy investments, from the "low hanging fruit" of lighting, which "almost always works," to the process of retrocommissioning (fine tuning energy operations in the building), to automating energy controls, to water conservation, to larger capital investments for new chillers or heating equipment, or for other heavy equipment or major building components. A full program design may include all of these approaches, but the owner may choose to do only the most cost effective and least intrusive first, ultimately abandoning the more costly or disruptive pieces of the plan.
- *Cash Flow:* Lenders have few tools for evaluating many of the positive aspects of green or energy efficient buildings (as described in the barriers section that follows), but if the improvement can be demonstrated to affect cash flow, then this can motivate lending to a green real estate project.

- *Government Regulations and Incentives:* Where government requires energy efficient new construction or efficiency upgrades on sale, building owners make the investment. Incentives also influence the quantity and type of investment. Even the requirement to disclose energy use on sale may influence owners to make investments in energy efficiency. A large property management company interviewed noted that earlier, owners acted because of government requirements, leading to a clustering of energy efficient or sustainable buildings in California, Seattle, Washington DC and New York City. One respondent noted the irony that far more solar energy equipment is installed in New Jersey, which has tough standards, than in Arizona, which has no specific renewable requirements and no incentives, but many more days of sunshine. A consultant referred to local governments as the "heroes," taking the most aggressive action in requiring energy efficient construction and operations.
- *Utility company pricing structure*: Pricing level and variations by use may affect investment in operations to improve energy efficiency as well as in capital improvements. One engineer from a financial institution noted that building owners in places where utilities used escalating fee schedules on energy usage were more likely to want to know and manage energy cost details.
- *Precipitating event*: An ESCO respondent noted that their clients are often brought to them by a precipitating event. A commercial building owner may come to the ESCO because of an initiating need, such as a burst pipe or tenant complaints. Fixing the issue may lead to a more comprehensive project than the customer initially envisioned. A financial consultant gave the example of a major retail project where the precipitating event was the need for a new roof. Even large institutions may have a precipitating

driver. For example, a college or private corporation may have signed an agreement to go carbon neutral, but more often these institutions consider a large retrofit because they are already involved in some building infrastructure project and decide to add energy efficiency to it.

- *A culture of sustainability*: Green investment may be self perpetuating. One investment firm in purchasing real estate first looks broadly for regions where land use patterns are "sustainable," and then invests in buildings, making sustainability improvements if needed, but with a preference for sustainability already in place. Sustainability of the location and metropolitan area further supports the marketability of the project and the company "brand."

Barriers

Barriers to adoption of energy efficient technologies and other sustainability measures include, for developers, complexity of the decisions, information gaps, regulatory barriers, problems with costs, paybacks, and allocation of benefits, financing options, and other agency problems. On the management side, ownership complexities add to agency problems. For lenders, silos, a traditional due diligence process that ignores energy efficiency and sustainability, measurement issues, and multiple loans on a property generate further issues.

- *Complexity:* For a large mixed-product real estate portfolio, balancing strategies and assessments of costs and benefits over several different product types, across multiple locations and jurisdictions can be daunting. One such firm has resorted to several layers of consultants, at one end addressing the companywide (worldwide) carbon footprint, at the other end addressing the specifics of energy management in individual buildings. Complexity of ownership structure is another factor. A major brokerage/management firm found that the building portfolio of a single real estate fund may have multiple owners (depending on when acquired and timing of investors) and multiple payback periods, complicating goals and how investments must be evaluated. Complexity may also bedevil older buildings. One nonprofit working on the Chicago Merchandise Mart upgrade pointed to building age, size, and a history of incremental upgrades that left the building with a hodge-podge of equipment, some needing replacement, some fully functional. The retrofit focused on quick fixes (lighting, systems automation) along with some operations changes, rather than on larger equipment investments and building rehabilitation.

- *Information and understanding:* Without expertise in the area, it is hard for the developer or owner to sift between effective and ineffective energy efficiency measures. "A lot of what is out there is junk," said one manager of energy efficient office and apartment properties, referring to energy efficiency products on the market. Poor training of operators can turn an efficient capital investment into an inefficient operation. Furthermore, one consultant emphasized that energy costs are hard to see and to predict and are not high on the list of what is looked at when a commercial building is evaluated. Information can be an issue from the point of view of providers of energy efficiency services. One engineering company providing web-based software mentioned the steep learning curve required when first working with commercial real estate clients. Information gaps resurface as capital is sought for the investment. A consultant commented that commercial real estate lending has no standard set of tools for due diligence, and that adding energy efficiency (or more broadly sustainability) "is just one more piece to try to fit into something already not standard."

- *Regulatory barriers:* Although local government may be the driver of new investments, it may also be an impediment. One builder pointed to issues related to site layout requirements that prevented optimal placement of buildings for solar use, as well as issues arising over the use of solar tiles on roofs.
- *Costs and payback periods:* Costs may at the same time be too low and too high. Energy costs for some types of buildings are a small part of the total expense to the tenant, and thus receive much less attention than other aspects of the rental space or the company operation. On the other hand, capital costs for some types of energy efficiency may be much higher than other alternatives. The investor in low end properties to be turned around within a few years reported that new (more energy efficient) equipment was five times the cost of repairing old equipment, and therefore not in the interest of the fund. Other builders reported that if the tenant or buyer was more interested in cosmetic features than energy efficiency, this is where the investment would focus. One consultant mentioned the certification cost of the LEED process could be a barrier even before financing was considered. The payback period for some new technologies, such as solar, can be long compared to the expected holding period of the property or typical commercial mortgage terms. Several respondents commented that solar cannot pay for itself without subsidies in the form of incentives. One pointed out that costs decline when solar was standard throughout the project rather than optional, but that this would raise costs for all tenants, although not by as much as the cost for solar just for a single tenant. One nonprofit mentioned more generally that commercial buildings, with expectations of a one to three year payback period, were much harder to work with than

the public sector, which was willing to evaluate costs and returns on a 15 year time horizon.

- *Who pays, who benefits—lease structure:* For commercial properties in particular, and tenant based properties more broadly, the building owner may be the investor in energy improvements, responsible for costs, but depending on the lease structure, it may be the tenant who reaps the benefits of the savings. Much of downtown office space is in full service leases, because of the higher costs of trying to allocate costs by tenant category, and because of the generally homogeneous character of tenants. Most retail properties, some suburban office space, and a portion of downtown space is in multi-tenant buildings with triple-net leases, meaning the tenant, not the landlord, pays utility costs. This may be either through direct metering of each unit or through pass through of costs based on square footage. The latter is perhaps the least effective from the point of view of encouraging energy efficient operations. The owner simply passes through the costs, and thus has less incentive for designing energy efficient space (although rents could be adjusted over time to reflect costs of improvements and the tradeoff with lower energy bills due to energy savings), while the tenant shares in the overall costs of usage, and thus has less incentive to conserve energy, as the savings are then diffused across all tenants.
- *Financing:* There is no clear path to financing energy improvements. Within the traditional lending community, functions are siloed, so that the group that might underwrite green technology is separate from the commercial lending group. The owner may have to look beyond the usual lending community to finance the energy saving investments. One company gave the example of using a combination of self-

financing, third party front end financing, and bonds sold to European investors to cover the financing needs of the energy retrofit. Another reported that among traditional lenders, the appraisers are not willing to give full weight to energy efficiency and green features. An appraiser from a lending institution was making early efforts to gather the information needed to move from case-by-case ad-hoc decisions to a more integrated consideration of green factors, including energy efficiency. Some found specialty lenders such as ESCOs an alternative way of financing, but others continued to seek but not find financing from traditional lenders, preferring to have more control over the savings from the investment. For any type of funding, the payback period was also at issue. Lenders, reluctant to lend at all in the 2010 financial climate, were seeking a one to three year lending term, while borrows for larger investments were hoping for longer term, of up to seven years. Financing constraints will influence not only whether the investment happens but how the job is done, according to an ESCO respondent. Work will be staged to meet the available capital, generally ordered towards the greatest payback first. Smaller owners have a harder time qualifying for all kinds of financing, and may have less access to contractors such as ESCOs. The ESCO business model involves up-front costs to the firm such as free assessments, many of which bring in no income—as a result, they may focus on large projects of 100,000 square feet or more, and are less likely to service small projects.

- *Multiple layers of lending:* Several respondents mentioned that there is a cost to trying to integrate multiple sources of funding. With a combination of rebates, PACE, working capital and other funds, one respondent asks “Where are the security, title, rights, responsibilities when there is a problem?" This is one of the elements making traditional lenders reluctant to take on loans for a building with PACE funding.

- *Who is in charge?* Consultants and nonprofits pointed out that energy is not a profit center, so there may be no leadership from the top. Because there is no one department in charge of energy usage levels, it is hard to identify who should make decisions regarding energy efficiency investments. Nonprofits found this to be particularly a problem for commercial buildings. In addition, this may dilute motivation—building owners may like the idea of a "green" campus, but may not have the time to follow through on the concept, as there is no individual for whom energy use is a first priority. Large property management firms saw other impediments related to the allocation of responsibility. A single portfolio may have multiple firms managing the properties. One service provider described a 155 building portfolio with 45 different management firms involved. This type of management works against developing a comprehensive energy management program across the portfolio.
- *Ownership Structure and Lending:* The type of owner will influence the lender's willingness to finance energy investments. An ESCO respondent noted that the LLC structure of real estate ownership can make it difficult for the owner to provide the value basis the bank will require to secure the loan. If each property in an investment firm's portfolio is held in an LLC structure, this can further weaken their basis for borrowing. With REITs, because properties are valued by comparables, energy savings will not be incorporated into the evaluation when a loan is being considered. Investment grade owners with strong credit ratings are more likely to get loans than other types of owners, regardless of the energy efficiency aspects of the project.

We distill from these interviews and the research reviewed earlier a set of factors expected to act as incentives for investment in energy efficient buildings. These are shown in Table 2. Landlords may be more likely to invest in energy efficiency improvements where the marginal costs of the certification are low compared to total costs of the building (tall or large floorplate buildings), and where tenants are more likely to be willing to pay for amenities (as indicated by a high rent building or by higher incomes in the region). An environmentally conscious community may also encourage this type of development, as indicated by mixed use development and transit use. Density can be conflated with many other factors, including the lease structure of downtown areas and the overall age of the community and infrastructure. A triple-net lease structure may be a negative incentive, as discussed above, while weaker economic indicators, such as high unemployment, could also discourage investment in building characteristics that do not have a quick payoff.

Table 2: Factors Expected to Influence Rate of Adoption of Energy Efficiency and Green Design

	Expected Results		
Factors	Positive (incentive)	Negative (barrier)	Indeterminant
Market conditions	High rents		Vacancy
Building characteristics	High rent Large floorplate or height Year built (reflecting age)	Triple-net leases	Vacancy
Metro area economy	Large city High income/output High energy costs	High unemployment/ employment volatility	
Metro area urban form	Mixed use	sprawl	Density
Metro area sustainability	Transit use		Pollutant levels

IV. Data and Empirical Work

It is convenient and appropriate to analyze the location and diffusion of green buildings, and indeed of other attributes of sustainable urban development at the level of cities and metropolitan areas. It is a suitable geographic unit of analysis, because a number of policies and factors that impact green buildings operate at the urban level: there exist citywide, and often metrowide, policies that regulate recycling, public space provision, public transportation initiatives, zoning, air quality monitoring and guidelines. Individual cities constituting a contiguous metropolitan area have huge spillover effects on each other and frequently coordinate policies, particularly those having to do with environmental protection. Metro areas also have very well defined and specific cultures and way of life; a certain atmosphere that promotes green living and is manifested in commuting patterns, lifestyle choices and occupational and industrial structure, leading to sympathetic correlates for green buildings.

Level of Analysis and Data Sources

Although the metropolitan area is an appropriate geographic scale for focusing the analysis, conducting an analysis at that level can be quite challenging, because of data issues. Measurement at the metropolitan level can become confusing by the use of different geographic catgeories for different indicators. For example, "San Francisco" can include only the city/county of San Francisco, the San-Francisco pmsa (made up of 3 counties), the San Francisco-Oakland msa (an older agglomeration, made up of 5 counties), or the San Francisco-Oakland-San Jose cmsa (at times defined by 10 or 11 counties). The market area for real estate may not conform to any of these definitions, as realtors prepare data based on the company's internal organizational structure. Further complexities arise from the level at which data is available, which may range from the individual lease or building level (either rental or sales data) to the zip code level, to cities, counties, or MSAs. An overview of selected data collected for this analysis is provided in Table 3.

We analyze the data at both the aggregate city level and at the building/property level. At this point in the research, the results are preliminary, as we are still grappling with finding the most consistent measures and definitions across geographic areas.

Table 3: Data Sources by Geographic Level

Data	Source	Geographic Level	comments[3]
Building data ▪ Square footage ▪ Stories ▪ Class ▪ Leed or Energy Star	Costar	Individual buildings	Data provided on zip code and city; string address data
Energy Star Buildings	EPA	Individual buildings	Data provided on address, zip code and city; address and city names not matched with Costar
LEED Certified Buildings	US Green Building Council	Individual building	Data provided on address, zip code and city; address and city names not matched with Costar or Energy Star
Office market data ▪ Total stock ▪ Rents ▪ Vacancies	Costar	Metropolitan area	Based on market and submarkets used by the brokerage industry
Air quality indicators	EPA Air Explorer	Metropolitan area	Uses 2000 definitions of metro areas
GDP by metro area	US Bureau of Economic Analysis	Metropolitan area	Uses 2000 definitions of metro areas

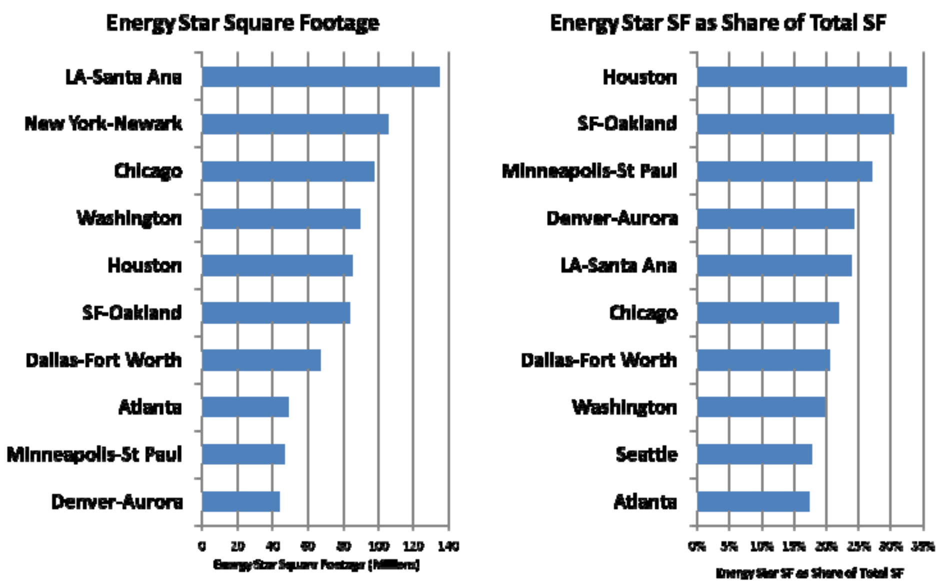
[3] In our metro area analysis, we use the LEED and Energy Star totals calculated from the sources listed in this table. With the individual building analysis, we use a function in Stata to extract from the comments section the LEED or Energy Star indicator and to create LEED and Energy Star dummy variables.

Table 3: Data Sources by Geographic Level			
Data	Source	Geographic Level	comments[3]
Population by metro area	US Census	Metropolitan area	Also available for smaller units; uses most current definition
Urban form measures of sprawl	Smart Growth America	PMSA level	
Transportation sustainability measures	Victoria Urban Transport Institute	MSA level	Uses sources based on 2000 definitions
Fuel prices	AAA	Metropolitan area	Specific metro area definition not given

Descriptive Statistics

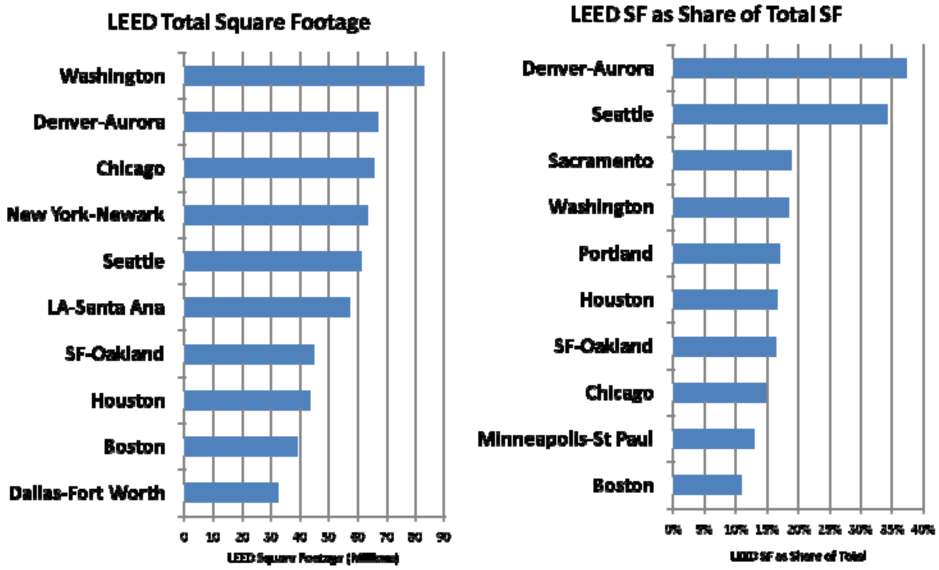
Figures 1 and 2 show the metropolitan areas with the largest square footage in Energy Star rated and LEED certified buildings, and the metropolitan areas with the largest shares of office building square footage rated Energy Star or certified LEED.

Figure 1: Metro Areas with Largest Amounts and Concentration of Energy Star Buildings



Source: Authors from US EPA and USGBC data.

Figure 2: Metro Areas with Largest Amounts and Concentration of LEED Buildings

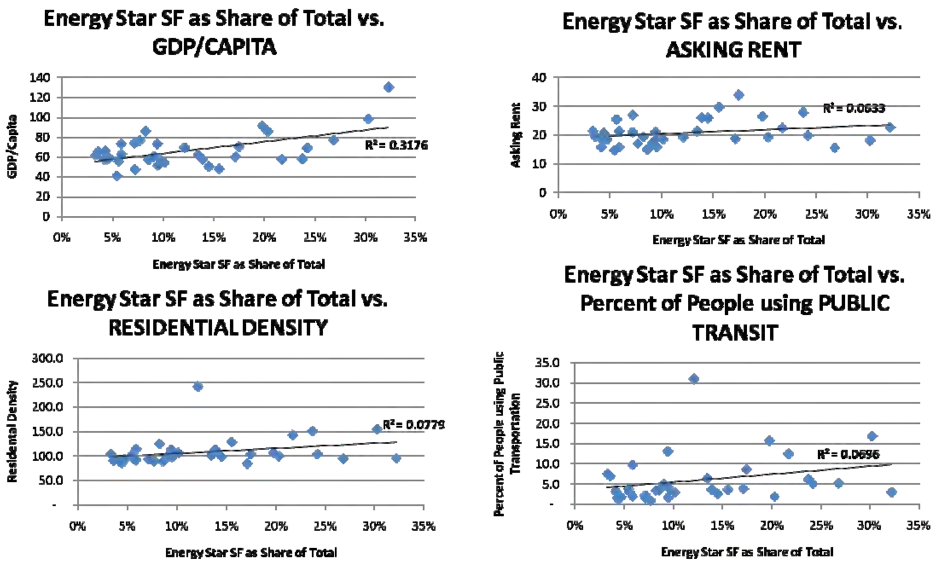


Source: Authors from US EPA and USGBC data.

Not surprisingly the largest cities are well represented in the ranking of places with the largest amounts of square footage, although the ranking is not strictly by size. Los Angeles tops the Energy Star total square footage ranking, while Washington has the largest amount of LEED square footage. In terms of share of square footage, the Energy Star ranks are dominated by west coast metro areas and by places with extreme climates, several of which are also in states with economies concentrated in resource extractive energy production. Cities with high concentrations of government buildings also have significant shares of LEED and Energy Star buildings.

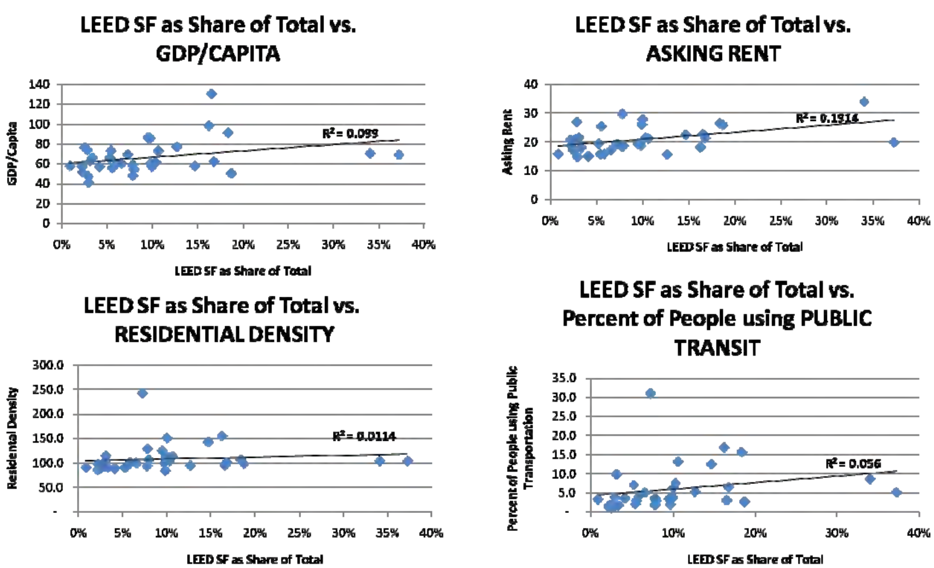
Figures 3 and 4 show scatter plots of relationships between Energy Star or LEED share of square footage and various metropolitan area indicators. For Energy Star, the highest correlation is with metropolitan area GDP per capita. Correlations with sympathetic factors associated with sustainability—residential density and use of public transit—are in the expected direction but weak.

Figure 3: Scatter Plots of Relationship Between Energy Star Concentration and Metro Area Factors



Source: Authors from data sources described in the text.

Figure 4: Scatter Plots of Relationship Between LEED Concentration and Metro Area Factors



Source: Authors from data sources described in the text.

For LEED buildings, the strongest correlation is with asking rents, a measure of the strength of the office market. The relationships with the two sustainability measures shown here are weaker than that seen with the Energy Star buildings.

Aggregate Analysis

To test the strength of the relationships identified in the correlations, we run some ordinary least squares models on the aggregate metropolitan-area data. Data is for 35 metro areas, with the transportation variables relating to the year 2009, and sprawl/density indices for year 2000. The results of one pair of models is shown in Table 4. For the share of Energy Star buildings in total building stock as dependent variable, only GDP per capita is significant, with higher shares of Energy Star buildings in higher output metro areas. None of the three sustainability measures for the metropolitan areas used in this model affect the share of Energy Star buildings in either a positive or negative way. The LEED share regression has a similar explanatory power, but is significant not only where GDP per capita is higher but also where transit use is higher.

Table 4: Ordinary Least Squares, Aggregate Metropolitan Data

Energy Star Share of Square Footage	Estimated Coefficient	Standard Error	T-statistic	P>|t|
Population (thousands) 2007	0.0000108	6.70E-06	1.61	0.117
GDP per capita	**0.0029956**	**0.0007014**	**4.27**	**0**
Residential density index	-0.0003235	0.0010203	-0.32	0.753
Mixed use index	0.0007532	0.0006483	1.16	0.255
Share using transit to work	-0.0024139	0.0035005	-0.69	0.496
Constant	-0.1370925	0.1020096	-1.34	0.189
R2			0.3411	0.0036
LEED Share of Square Footage				
Population (thousands) 2007	-5.84E-07	7.72E-07	-0.76	0.456
GDP per capita	**0.0002005**	**0.0000808**	**2.48**	**0.019**
Residential density index	-0.0000889	0.0001175	-0.76	0.456
Mixed use index	0.0000387	0.0000747	0.52	0.608

Share using transit to work	**0.0011149**	**0.0004032**	**2.77**	**0.010**
Constant	0.0006264	0.0117487	0.05	0.958
R2			0.3391	0.0038

Building Level Analysis

Table 5 gives the result of a series of logit models run on the likelihood that a building is Energy Star rated or LEED certified. The models are run on a set of approximately 200,000 buildings over 32 metropolitan areas. Results are shown for three different versions of the model for Energy Star, and the same three versions for LEED buildings. The first version of the model uses only building/property level characteristics as regressors. Based on this model, a building is more likely to be labeled Energy Star or certified LEED if it is relatively large, tall, new (in most cases), and of higher quality grading. These characteristics hold their direction and significance when other factors are added, with the exception of Year Built for Energy Star buildings.

Table 5: Statistical Results Using Building Level Data on Energy Star Ratings and LEED Certification

	Energy Star			LEED		
	I	II	III	I	II	III
rentable building area	**1.69E-06**	**2.07E-06**	**2.07E-06**	**1.49E-06**	**1.70E-06**	**1.65E-06**
number of stories	**0.04251**	**0.055907**	**0.059783**	**0.020912**	**0.025258**	**0.025423**
year built	**0.002752**	-0.00101	**-0.00179**	**0.017121**	**0.014804**	**0.014184**
classA	**4.995431**	**5.132789**	**5.181854**	**4.358811**	**4.370095**	**4.497798**
classB	**2.662109**	**2.710807**	**2.693726**	**2.326873**	**2.359826**	**2.457373**
GDP per capita		**0.017633**	**0.013601**		**0.00942**	**0.00457**
residential density		**-0.00352**	**-0.01234**		**-0.01223**	**-0.01599**
percent travel by transit		**-0.04668**	**0.020699**		**0.020026**	**0.063269**
gas price		**1.935245**	**1.240725**		**1.383194**	**0.553257**
average height/zip code		**-6.79E-02**	**-0.06042**		**-0.02384**	**-0.02526**
vacancy rate/zip code		**1.50E-07**	0.490036		4.96E-08	**-3.22189**
NO2 parts per million			**37.38861**			**23.71084**
SO2 parts per million			**-221.045**			**-188.578**
Constant	**-12.7767**	**-11.0736**	**-6.8578**	**-41.4688**	**-39.9821**	**-35.572**
Pseudo R2	**0.3467**	**0.3743**	**0.3872**	**0.2664**	**0.2766**	**0.2818**

Cells in boldface are significant at the 5% level or better.

In model II we add metropolitan area characteristics (GDP per population, residential density, the percent traveling to work by transit, and gasoline prices), as well as two market area characteristics by zip code —average building height (of non labeled/certified buildings; as a proxy for downtown) and vacancy rate (of non labeled/certified buildings, as a proxy for market strength). The GDP per capita measure and the residential density measures give results similar to the aggregate city models. The travel by transit measure varies inconsistently for the Energy Star buildings but is positively correlated with the presence of LEED buildings. Our indicators for downtown areas—residential density and the average building height in the zip code area—are negative, indicating lower likelihood of attracting LEED and Energy Star buildings, perhaps because of the purported higher prevalence of full service leases in downtown areas. Residential density could also be thought of as an environmental quality variable (lack of sprawl), but does not show the positive effect that might have been expected, possibly because it is doing “double duty” as an indicator for downtown as well. Adding air quality measures, as a correlate for urban green policy stance, in Model III further complicates the results. Overall, the evidence of “learning” and "spillover" effects from a culture of green communities is mixed. High proportions of green building corresponded with high use of transit and low levels of SO_2 emissions, but also with low residential density and high NO_2 emissions. Since the main source of SO_2 are from fossil fuel combustion at power plants (66%) and other industrial/manufacturing facilities (29%), the former is consistent with the location pattern of US industry. On the other hand, internal combustion engines are a key source of NO_2 emissions; therefore, the issue of suburban, low density proliferation of triple net leases and commuting patterns are probably conflating the results here.

Result Overview and Next Steps

The empirical analysis validates some of the points brought out in the interviews, but also raises many questions. Places with stronger economies, as measured by GDP consistently appear to have greater likelihood of encouraging energy efficient and LEED investments in commercial buildings. Energy efficient and LEED buildings were also more likely to be taller and of class A or B. The role of sustainability was left ambiguous by the results. Further research would involve adding more price data to the analyses, looking at alternative sustainability measures, updating LEED and Energy Star markers in the Costar data, , and using other Costar datasets to add lease and occupant data to the analysis. Other structural forms, including interacting variables and threshold levels may also prove to be more fruitful.

V. Concluding Remarks

The research described in this paper uncovers the complex process by which investments are made in energy efficient and sustainable commercial buildings. Interviews identified a wide range of motivations as well as barriers to energy efficient investments. While the cost benefit calculation may be positive, other investment considerations, such as payback periods and credit limitations may slow the pace of adoption of energy efficient and sustainable technologies and designs.

Market conditions are also of importance, as borne out by the statistical analysis. Investments in LEED and Energy Star buildings are more likely to occur where the local economy is strong—and thus able to pay the costs—and the price of no action is high—as with places with higher energy prices. While the interviews indicated that the culture of the metropolitan area (and local regulations and incentives) are also of importance, the initial measures of sustainability used in this analysis gave ambiguous results. This is not unexpected, given the relative newness of the green phenomenon, the developing nature of a core of sympathetic, cross-connected, spillover policies, and the sparseness and imprecise nature of the data. Additional work to define representative measures of sustainability would be needed to determine whether a metropolitan area's culture of sustainability will encourage greater investment in energy efficiency improvements.

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