Real Estate Opportunities in Energy Efficiency and Carbon Markets

by

Aaron G. Binkley

Bachelor of Architecture, 2000

Carnegie Mellon University

Submitted to the Department of Architecture in partial fulfillment of the requirements for the degree of Master of Science in Real Estate Development

at the

Massachusetts Institute of Technology

September 2007

Signature of Author: ____

Department of Architecture
July 27, 2007

Certified by: ____

Brian A. Ciochetti, PhD
Professor of the Practice of Real Estate
Thesis Supervisor

Accepted by: ____

David Geltner
Chairman, Interdepartmental Degree Program in
Real Estate Development

Real Estate Opportunities in Energy Efficiency and Carbon Markets

by
Aaron G. Binkley

Submitted to the Department of Architecture on July 27, 2007 in partial fulfillment of the requirements for the degree of Master of Science in Real Estate Development

Abstract

Global interest in the effects of climate change has grown rapidly in recent years. The US federal government mulls a cap and trade system for large carbon emitters while states implement their own greenhouse gas schemes. Private industries are beginning to see the need to address their greenhouse gas footprints and are increasingly offsetting their carbon emissions. The real estate industry has been under little scrutiny in spite of being responsible for over 40% of all US greenhouse gas emissions.

The real estate industry is in the unique position of being able to reduce greenhouse gas emissions through energy efficiency improvements that are low cost and that create value within the underlying asset. The objective of this research is two-fold: First, to examine the potential value and feasibility of energy efficiency improvements, and second to determine if there is sufficient value creation from abatement of greenhouse gas emissions, called offsets, to subsidize further energy efficiency measures. Through a case study example I examine energy efficiency improvements at two levels and determine the resulting greenhouse gas offsets on a state-by-state basis. Then I evaluate energy savings and greenhouse gas offsets across a low and high price range. Once the case study analysis is complete, I examine the magnitude of economic value resulting from energy efficiency improvements and the sale of greenhouse gas emissions offsets for the entire real estate industry.

My analysis indicates that there is potential for significant value creation. Opportunities are focused in states where energy prices are higher and where greenhouse gas emissions from power generation are greatest. In the case study, capital investment in energy efficiency has an IRR range from 26.4% to over 125%. Greenhouse gas offset value increases IRR further; providing an additional 26% increase in the original available energy retrofit funding. Net asset value increases from 1.1% in a low carbon price scenario to 5.5% in a high carbon price scenario. At the market level, efficiency improvements are worth between $40.3 and $201 billion annually. Greenhouse gas emissions are worth an additional $1.46 to $48.8 billion. The sum of energy efficiency and greenhouse gas emissions offsets have the potential to add between 1.0% and 6.1% to the value of the $4.03 trillion US commercial real estate market. I conclude that there is significant potential for value creation resulting from rigorous energy efficiency improvements and the sale of offsets in emerging greenhouse gas markets.

Thesis Supervisor: Brian A. Ciochetti, PhD
Title: Professor of the Practice of Real Estate

Table of Contents

List of Figures

Part I

Chapter One

1.0 Overview

Within the US there is considerable policy interest in setting limits on greenhouse gas emissions at the federal level. While effective mechanisms are being debated in Congress, several regional regulatory frameworks in the Northeast and in California have been established to address carbon emissions. Many cities have also adopted greenhouse gas reduction targets similar to those of the Kyoto Protocol, but on a voluntary basis. Between cities, regional markets, and the more than 70 bills, resolutions, and amendments focusing on greenhouse gas emissions and climate change in Congress today, many agree that a regulated market in the US is a matter of when, not if.[1] "It is becoming clear that the carbon-constrained economy has arrived and carbon regulation or climate-change regulation in the United States is clearly in the works," says Eron Bloomgarden, U.S. director for EcoSecurities. "That presents both opportunities and risks for companies. So companies that recognize those opportunities can capitalize on them, and those that don't will suffer."[2] This sentiment will increase as the world becomes more aware of the impacts of global warming.

Corporations have begun to lobby the government to act by setting consistent environmental and greenhouse gas emissions policies at the federal level. The real estate industry is beginning to seek ways to improve energy efficiency and reduce their environmental footprint. But there have been few comprehensive efforts to involve the real estate industry in discussions on climate change and proposed greenhouse gas emissions markets.

1.1 The Real Estate Industry's Relationship to Global Greenhouse Gas Emissions

Nearly 75% of the commercial buildings currently standing in the US are twenty or more years old, and will still be in use fifty years from now.[3] Owners of these ageing buildings increasingly

---

[1] Mufson, Steven. "Companies Gear up for Greenhouse Gas Limits." Washington Post. 29 May 2007. Accessed 28 June 2007. < http://www.washingtonpost.com/wp-dyn/content/article/2007/05/28/AR2007052801050.html>

[2] Mufson, Steven. "Companies Gear up for Greenhouse Gas Limits." Washington Post. 29 May 2007. Accessed 28 June 2007. < http://www.washingtonpost.com/wp-dyn/content/article/2007/05/28/AR2007052801050.html>

[3] "2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables; Table B4". Energy Information Administration. Washington DC. December 2006.

need to find cost-effective ways to make energy efficiency and greenhouse gas emission reductions a reality to maintain industry competitiveness and protect against operational risks such as energy price volatility. Real estate is the largest sector emitter of greenhouse gases in the US, responsible for 43% of all annual emissions when accounting for energy consumption. Transportation is responsible for 32% and industry produces the remaining 25%.[4] While it has not yet happened in the US, the real estate industry is in a vulnerable position of being targeted as government policy is formed to address issues surrounding climate change. As the EU and other Kyoto Protocol compliant countries look beyond the 2008-2012 round of emissions trading they will almost certainly focus on the role of real estate in carbon emissions reduction.[5] The US is expected to eventually follow suit.

The real estate industry has recently begun to examine the carbon markets for several reasons. The first has tended to be reactive; to avoid being at the mercy of legislation that may negatively impact the industry. Second, there are numerous indirect benefits such as better shareholder perception, improved client relations, and better employee retention and recruiting that may impact corporate decision making. Third, owners are challenged to find ways to justify the upfront costs of improved energy efficiency when holding periods are short and incentives to save energy are split between owners and tenants, as is the case with triple-net leases. Some have also found difficulty obtaining financing to invest in capital improvements that will lower operating costs. The last points can be addressed by exploring opportunities to capture financial value from energy efficiency investments above and beyond direct energy cost savings. This is an economic opportunity for those involved in real estate to be on the forefront of an emerging market, add value within their asset portfolio, contribute to greenhouse gas emission reductions, and demonstrate industry leadership and corporate social responsibility.

1.2 Global Greenhouse Gas Systems

Emerging greenhouse gas, or carbon, commodities markets consist of regional and global voluntary and regulated systems where greenhouse gas emissions are quantified, registered with a clearinghouse, and traded on spot and futures markets. This market is unique in that it does not

---

[4] Brown, Marilyn A., et al. *Towards a Climate Friendly Built Environment*. Pew Center on Global Climate Change. June 2005.

[5] "Buildings Must Be Part of Carbon Emissions Trading Scheme". Lend Lease press release. 4 June 2007. Accessed 24 June 2007. <http://www.lendlease.com.au/llweb/llc/main.nsf/all/news_20070406_llc_2>

trade physical commodities like steel or coal. The carbon market trades *avoided* greenhouse gas emissions, or said another way, emissions that are not produced. This slightly unusual structure makes this market hard for some to understand. The framework for many global markets was established by the Kyoto Protocol.[6] Currently 27 European Union member states operate under the EU ETS (Emissions Trading Scheme), a Kyoto-based compliance market. There are other international markets in New Zealand, Canada, Australia, and Japan that currently have markets that will be expanding in the coming years. In the United States there are several regional trading schemes in development including the New England Regional Greenhouse Gas Initiative (RGGI) and the Western Regional Climate Action Initiative initiated by California. There is also a voluntary market traded on the Chicago Climate Exchange. This paper will focus on the United States but provides parallels to the EU regulated market in anticipation of an eventual US national greenhouse gas compliance market, and eventually an integrated global greenhouse gas marketplace.

1.3 Standard Measurements and Definitions

The standard unit of measurement of greenhouse gas emissions is the *metric ton of carbon dioxide equivalent* (tCO_2e),[7] the global warming impact of one metric ton of atmospheric carbon dioxide. This measure allows gases that exacerbate global warming to be converted to a common unit. *Figure 1* lists several GHGs and their relative Global Warming Potential (GWP) compared to CO_2:

Figure 1: Global Warming Potential of Various Gases.[8]

Gas	GWP
Carbon Dioxide (CO_2)	1
Methane (CH_4)	23
Nitrous Oxide (N_2O)	296
HFC-152a	120
HFC-134a	1,300
HFC-143a	4,300
Perfluoromethane (CF_4)	5,700
HFC-23	12,000
Sulfur Hexafluoride (SF_6)	22,200

[6] Kyoto *Protocol to the United Nations Framework Convention on Climate Change*. Signed in 1999 and entered into effect in 2005, and requires members' emissions reductions to 1990 levels. <http://unfccc.int/resource/docs/convkp/kpeng.html>
[7] In the EU-ETS this is termed a European Union allowance (EUA) when allocated to regulated industries.
[8] "Carbon Trading Fact Sheet." Clifford Chance Client Briefing. Clifford Chance. March 2006.

To the extent that emission reductions of more potent gases can be achieved, the global warming impact is reduced more effectively. For example, avoiding the release of one ton of N_2O (a by-product of fossil fuel combustion) is equal to avoiding emissions of 296 tons of CO_2.[9]

In the US the Carbon Financial Instrument (CFI) is the tradable greenhouse gas unit. One CFI equals 100 tCO2e of emissions reductions. Prices for one tCO_2e in the voluntary and compliance markets currently exhibit significant differences. The US voluntary market prices on the Chicago Climate Exchange (CCX) hover around $3.30, and the EU ETS market price on the European Climate Exchange (ECX) is $30.27, with future vintages trading at similar prices.[10] There is roughly a ten-fold price difference between markets. Prices for Phase II ETS trading are expected to be more stable. With pending US carbon market regulation, the pricing of carbon offsets in the US is likely to rise toward EU levels. To set a range of prices to evaluate in this research paper, the voluntary (CCX) price and the regulated (ECX) price will be used.

1.4 Kyoto Protocol

The regulated, or compliance, market was brought about by the Kyoto Protocol (KP). The KP sets limits (caps) on greenhouse gas emissions on a country-by-country basis, and each country then allocates their allowances to *large emitters* across the range of regulated industries. There are over 10,000 such facilities throughout the European Union. These industries include:

- Electricity generation
- Pulp and paper and wood products
- Smelting and refining
- Iron and steel
- Cement and lime production
- Chemicals production

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, political pressure, and a healthy dose of industry lobbying. These companies are required to reduce their emissions to meet their

[9] The combination of N_2O and NO are typically referred to as NOx and are measured alongside CO_2 when calculating greenhouse gas emissions.
[10] The price of 2007 vintage CFI on CCX as of 29 June 2007 = $3.30. The price of 2007 vintage CFI on ECX as of 29 June 2007 = €22.36; Dollar to Euro exchange rate as of 29 June 2007 = 1.3537

allocated cap within the compliance period. The first compliance period, called Phase 1, was 2005-2007. The second allocation, Phase 2, runs from 2008 through 2012. There is currently no successor phase after 2012 but discussions are underway. This system is organized in the European Union through the Emissions Trading Scheme, a market-based scheme to reduce carbon emissions. The intent is to financially reward companies with lower emissions and incentivize others to reduce emissions or face fines. The market allows regulated industries to seek the lowest cost abatement mechanisms that meet the required emissions reductions. Fines for the 2008 to 2012 phase have been set at €100 per metric ton, roughly five times the current market price for carbon emissions offsets, and the emissions reductions are still required even if the fine is levied. This system 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 under it's NAP 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 the turbines produce very little pollution. The Spanish company has excess offsets and can sell them via the EU ETS greenhouse gas market to the German company to meet their NAP reduction targets.

The Kyoto Protocol has approved Clean Development Mechanisms (CDMs) and Joint Implementation (JI) schemes that allow regulated entities to contract carbon emission reduction projects with third parties globally in developing countries. The CDM has provisions for demand side (including real estate) efficiency to be included as a compliance mechanism, though there have been negligible attempts to include this type of CDM project in carbon offset schemes. Typically an abatement project is established with the intent to be approved as a Certified Emissions Reduction (CER). If an abatement project was generated in a country with no compliance market, it must be certified and quantified as Verified Emissions Reductions (VERs), not a CER. If a VER is able to be certified by the CDM executive board, it can be converted into a CER and can then enter the compliance market. VERs exist because the protocols used to establish them in voluntary markets vary, and there is currently no method of ensuring strict CER protocol compliance in these markets. As a result the exact nature and composition of VERs can vary from protocol to protocol in the voluntary market.

The United States has not ratified the Kyoto Protocol and is not involved in national allotment of emissions allowances. Regulated markets have, however, been proposed in the United States on the regional and federal level. The Regional Greenhouse Gas Initiative (RGGI), a coalition of ten New England and Mid-Atlantic states, is establishing a region-based cap and trade system with similarities to the EU ETS. California and other northwestern states are also exploring a similar system with very stringent emissions reductions goals. The federal government is actively debating cap and trade systems for greenhouse gas regulation, although no agreements have been reached.

1.5 Voluntary Markets

Voluntary carbon emissions market offset buyers consist of organizations and individuals that electively seek to reduce their carbon emissions by purchasing carbon offsets. The objective is typically referred to as 'carbon neutrality' – offsetting the emissions of one's activities by purchasing offsets from a third party. Registries certify the validity of the offsets, and track the issuance and retirement of the offset in the market. Buyers in this market typically seek to reduce their carbon emissions due to Corporate Social Responsibility (CSR) directives, Socially Responsible Investment (SRI) goals, public relations benefits, and a desire to proactively gain familiarity with carbon market systems. Many major corporations have committed in recent years to reducing their carbon emissions. Examples include ProLogis, CB Richard Ellis, Simon Property Group, Google, Xerox, and JP Morgan Chase atop a rapidly growing list.

Relative to the compliance market, the voluntary market is small and prices are considerably lower. This is due to the lack of a regulated cap on emissions that places a decreasing emissions ceiling on industries, and forces industries to participate in the market. Some have carbon liabilities and others have surpluses to fuel the market. The voluntary market lacks clear definition and certification of offset characteristics, leading to concern among purchasers that the offset may not actually benefit the environment or their corporate goals. Uncertainty about the quality of what is being bought heavily discounts the commodity price. In spite of these concerns there is currently rapid growth of the voluntary market in the US (thirteen-fold growth from 2005 to 2006) as these issues are addressed. This is in part due to increasing interest, lower bureaucracy relative to Kyoto-compliance, and lower overhead investment in abatement projects which improves feasibility of smaller, more diverse projects. As recognition of the risks of climate change grows and regulation of greenhouse gases become increasingly likely this market is poised for continued growth. Clifford Chance, a UK based consulting and law firm, predicts that in 2007 the market will grow in value 16-fold to more than $400M, and could reach $3 billion by 2010.[11] I believe this value is aggressive, but it indicates that the industry expects the voluntary market to see rapid expansion.

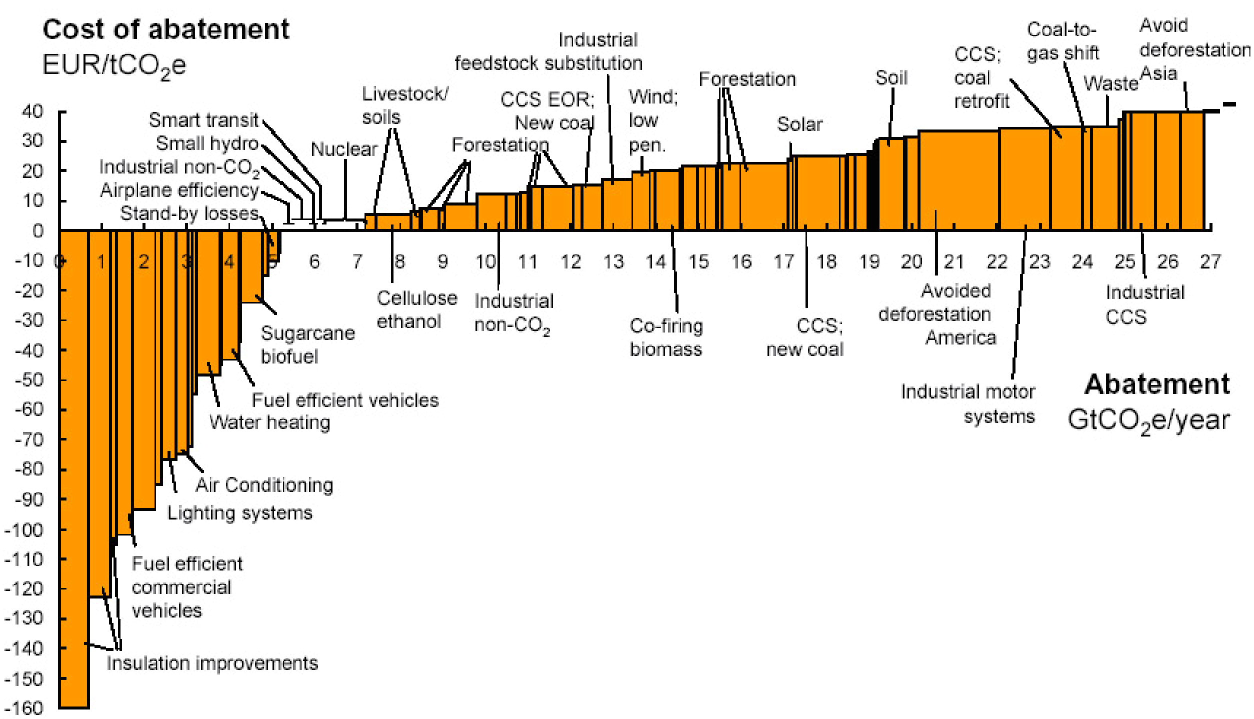
[11] "The Voluntary Offset Market; a Primer". Clifford Chance. Client Briefing. May 2007.

Chapter Two

2.0 Why real estate? The Global Cost of Abatement

A Vattenfall AB report referencing a 2007 McKinsey Quarterly publication illustrates a range of carbon emissions reduction measures, and compares them with their implementation cost and the potential associated carbon abatement. *Figure 2* shows a range of carbon abatement measures and technologies and their associated cost to implement on a Euro per ton basis. The items toward the left of the chart are lowest cost and those to the right are the highest cost for equivalent abatement. For example, building insulation is highly cost negative because it actually saves considerably more money in lifetime energy expenditures than it costs to implement. In contrast, solar energy production is only feasible when carbon offset costs approach €18 per ton because of the high cost of the systems. Without carbon or other subsidies, photovoltaic systems rarely have an economic payback period less than 30-40 years and as such would not be financially feasible for most organizations.

Figure 2: Cost of Carbon Abatement.[12]

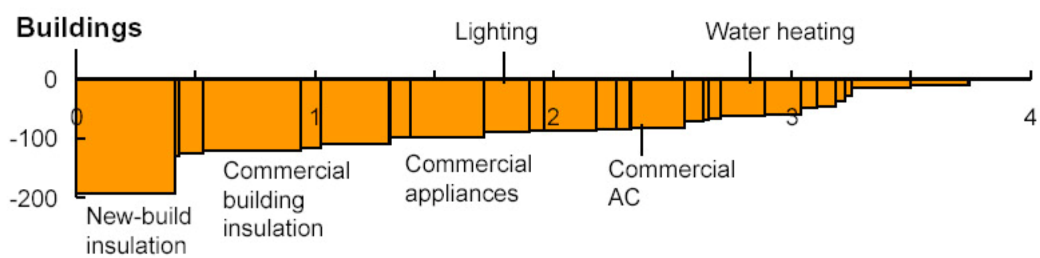


---

[12] "Global Mapping of Greenhouse Gas Abatement Opportunities". Vattenfall AB. January 2007.

Across the spectrum of carbon reduction opportunities, the Vattenfall report notes that more than half of the seven gigatons of cost-negative or cost-neutral abatement methods are building related; that their implementation cost is lower than their lifecycle benefit. Major items are illustrated in *Figure 3*. For instance, the cost of lighting improvements has roughly a negative €90 cost because the lifetime savings of reduced energy consumption pays for the improvements many times over.

Figure 3: Abatement Opportunities for Buildings.[13]



Cost negativity or cost neutrality in greenhouse gas abatement terms does not necessarily equate to economic feasibility at the real estate asset level; it does however indicate that these measures provide the offsets at lower implementation costs than other methods in the industrial, energy, and agriculture/forestation sectors that are currently the focus of attention for greenhouse gas abatement activity. In total, the McKinsey study indicates that energy efficiency measures across all sectors have the potential to nearly halve the expected growth in global energy demand, from 2.5% to 1.3%.[14]

2.1 Challenges to Real Estate Participation

Despite higher abatement costs there are legitimate reasons for emissions reductions activity in non-real estate sectors. Identifying and capping sector emissions is more manageable than attempting to do the same for real estate because these sectors consist of relatively few emitters who release large volumes of greenhouse gases. In contrast the real estate industry consists of millions of buildings of virtually every size imaginable. In the US alone, there were over 4.6

[13] "Global Mapping of Greenhouse Gas Abatement Opportunities". Vattenfall AB. January 2007.
[14] Enkvist, Per-Anders, Tomas Naucler, and Jerker Rosander. "A Cost Curve for Greenhouse Gas Reduction". The McKinsey Quarterly. McKinsey & Co. 2007. Accessed online 25 June 2007.

million commercial buildings in 2004.[15] All are unique in some way and fall under many distinct municipal and regulatory jurisdictions. Administrative needs to oversee programs effectively would be extensive.[16] But there are potential benefits for those interested in real estate carbon market participation. The market is expanding rapidly, financial value of the market remains largely untapped, the need to mitigate climate and market risks is growing, and corporate needs to meet market demand are unchanged. The carbon markets provide a vehicle to address these needs and are worth further examination.

2.2 Indirect Benefits

Indirect benefits that emerge from carbon emissions reductions and overall corporate sustainability are increasingly being recognized by the real estate industry. CB Richard Ellis announced in May 2007 a goal to become carbon neutral by 2010. The reasons cited by Brett White, President and CEO included demand for green facilities from clients and employees, an evolving marketplace, energy saving demands from clients, improved operational performance, and better climate protection.[17] According to research and studies, ancillary benefits from reduced carbon emissions from environmentally preferable buildings generally reflect White's comments and include:[18]

- Improved indoor and outdoor air quality
- Enhanced energy security
- Increased building valuation
- Longer building lifespan
- Reduced insurance premiums[19,20]
- Improved worker productivity[21]

---

[15] Brown, Marilyn A., et al. "Towards a Climate Friendly Built Environment." Pew Center on Global Climate Change. June 2005. Page 9.
[16] "Buildings and Climate Change; Status, Challenges, and Opportunities". United Nations Environment Programme. 2007.
[17] "CB Richard Ellis Group, Inc. Announces Carbon Neutral Goal and Plans for Assisting Clients with 1.7 Billion S.F. of Properties Worldwide on Carbon Reduction Programs". CB Richard Ellis press release. 31 May 2007. Accessed online 27 June 2007.
[18] Barker, Terry et al. "Climate Change 2007: Mitigation of Climate Change; Summary for Policymakers". Intergovernmental Panel on Climate Change. United Nations Environment Programme. 23 May 2007.
[19] Fireman's Fund offers 5% reductions on insurance premiums for green buildings. "Fireman's Fund Introduces Green Building Coverage". Insurance Journal. 16 October 2006. Accessed online 25 June 2007
[20] "Green Businesses Get Insurance discounts". Progressive Investor. 21 June 2007. Accessed online 26 June 2007. <http://www.sustainablebusiness.com/features/feature_template.cfm?ID=1463>

- Higher employee and tenant retention
- Marketing opportunities
- Perception of environmental industry leadership

Regardless of the potential financial value from greenhouse gas markets, a small but increasing number of building owners are recognizing the potential value these indirect benefits have to tenants and are modifying business practices to align with tenant demands. The real estate industry will increasingly have to meet these needs, and energy efficiency and carbon markets provide a solution to doing so at low cost.

2.3 Carbon Market Value

The global carbon market is currently worth €22.5 billion ($30.5 billion) and the largest market, the EU ETS, is valued at €18.1 billion ($24.5 billion).[22] The voluntary market in the US is currently small, valued in 2006 at $37.9 million, but this market has grown rapidly from only $3.21 million in 2005. This represents more than thirteen-fold growth in one year, and this market is expected to grow in value to $400 million in 2007.[23] The total non-EU ETS global market is currently valued at €300 million ($406 million), and is expected to grow to €500 million ($677 million) in 2007.[24] The majority of this growth is expected in the United States. US voluntary market offset prices are expected to rise from around $3 today to $15 by 2010.[25]

---

[21] Loftness, Vivian et al. "Building Investment Decision Support". Carnegie Mellon University Center for Building Performance and Diagnostics. Pittsburgh, PA. 2005. Accessed online 25 June 2007.
[22] Dollar to Euro exchange rate as of 29 June 2007 = 1.3537
[23] "The Voluntary Offset Market; A Primer". Client Briefing. Clifford Chance LLP. May 2007.
[24] Roine, Kjetil ed. Carbon 2007: A New Climate for Carbon Trading. Point Carbon. 13 March 2007.
[25] "The Voluntary Offset Market; A Primer". Client Briefing. Clifford Chance LLP. May 2007.

Chapter Three

3.0 Methodology

The objective of this research is two-fold: First is to examine the potential value and feasibility of energy efficiency improvements, and second to determine if there is sufficient value creation from resulting avoided greenhouse gas emissions to subsidize further energy efficiency measures.

This objective will be explored by first identifying and describing the state of the existing greenhouse gas markets by researching the history of the current and proposed carbon markets through publicly available information sources. This research will identify the magnitude of the real estate sector in the carbon markets and the opportunities for real estate to participate in the carbon market.

To determine asset level value, a case study is presented in Boston, Massachusetts. This case study was selected because it offered a building approximately twenty years old, the age where equipment replacement is considered. This building was also well maintained and typical of its vintage mechanical and electrical systems. It also falls at roughly the average of energy performance among its peers, and in this regard is useful as an example that is relevant to other average buildings in the office sector as well as other sectors. Building energy consumption data was also available for the past twelve months to use as a baseline consumption. The building also had documented energy performance retrofit measures with detailed energy savings, implementation costs, and utility incentive amounts. This facilitates detailed examination of the costs and benefits of the retrofits.

To analyze this data, I compiled the average yearly energy consumption. I then applied the retrofit measures to the building to create a revised energy consumption value. The difference between the two values is the energy savings. I multiplied this by the documented building energy cost to obtain the real dollar savings resulting from the retrofits.

3.1 Calculating Carbon Offsets

To calculate carbon offsets, I multiplied the kWh energy savings by the GHG emission level of NStar, the Boston electric utility company. The data was gathered from the federal eGrid website, which lists CO_2 emissions and NOx emissions levels in units of lbs. per kWh. I multiplied NOx emissions by the GWP of NOx (296) to get effective CO_2 emissions. CO_2 and effective NOx-generated CO_2 emissions were added together to arrive at the total CO_2 emissions.

Next I multiplied the total annual CO_2 emissions level by the voluntary carbon market price to determine the value of carbon savings. I performed the same procedure to determine the value in the compliance market price scenario.

I used this information to establish the maximum allowable performance contract debt service. I set the performance contract value equal to the retrofit cost information provided with the case study data, and amortized the cost over a ten year period at 6% interest to determine the annual debt service level required by energy savings to fully fund the retrofit measures. This term and interest rate is based on information provided by an energy service company specializing in this type of work in New England. I compared this debt service amount in several IRR scenarios with four year and ten year financing terms. I also calculated IRRs based on obtaining utility incentives or carbon offsets at low and high prices. This calculation provided the relative IRR for capital energy retrofit investment options. These were used to determine which investment had the highest return over a ten year period.

3.2 State-to-State Comparison

I examined the energy improvements and the greenhouse gas offsets on a state-by-state basis. I collected federal Energy Information Administration data for commercial retail electricity prices in each state. I multiplied this data by the energy savings to determine the relative difference in energy cost savings from state to state. I then collected federal eGrid utility greenhouse gas emissions data for each state and converted all real emissions to effective emissions as previously described to calculate carbon offsets. I then multiplied carbon emissions data by the carbon offset amount and by carbon offset price to determine the value of carbon offsets in each state. The sum of the energy cost savings and the carbon offset value determined the total value for each state. I used this data to rank states relative to their potential to fund energy efficiency via energy cost savings and carbon offsets.

3.3 Energy Price Volatility

I analyzed energy price data and office rent data from Torto Wheaton Research for Boston to compare price change volatility. I used real electricity, natural gas, and rent prices from 1990 to 2006 from the Bureau of Labor and Statistics to determine the percent change from year to year. I graphed the percent change for each item to compare volatility and long term trends. I also ran correlations between the data sets. This conclusion was used to assess the volatility reducing benefits of carbon offset income compared to rental income.

3.4 Real Estate Industry Energy Efficiency Value

My objective was to provide a range of values within which many projects would fall. To determine the energy savings value for the US I used the data from the case study showing that 6.75% energy savings equated to approximately 1% growth in net asset value to set a lower boundary for energy efficiency improvements. I then reviewed Energy Star literature and other warehouse case study information to set 30% energy efficiency improvement, or approximately 5% growth in net asset value, as the upper boundary for energy efficiency improvements. I used percentage and value information for the US commercial real estate industry from LaSalle Investment Management data for Q2 2006 to multiply the 1% and 5% asset value to determine the range of total potential value.

3.5 Real Estate Industry Carbon Offset Value

I approached this calculation in several ways to provide checks between one calculation and another. First I averaged the case study carbon offsets across all states for the low price and high price carbon offset scenarios to determine low and high total carbon offset average value. I then divided by the energy savings resulting from the 6% lower efficiency boundary or 30% upper efficiency boundary for each state. This value is a percentage of the energy efficiency gain in each state and ranges from 3.63% to 24.3%. This yielded a range of carbon offset value based on offset price and efficiency level.

Second, I compared these values to McKinsey data on global carbon abatement opportunities. I discounted the building-related abatement potential by 51% to account for the US portion of global commercial real estate (from Lasalle I.M. information). I then multiplied this by (44%) to determine the portion of GHG emissions produced by commercial real estate based on World Resources Institute data on carbon emissions. I multiplied this value by the low and high price scenarios to determine a range of carbon offset value. I then compared this to the carbon offset value estimated earlier from the case study data.

Chapter Four

4.0 Relevant Issues and Mechanisms

Ownership of the environmental attributes of real estate, in this case carbon emissions, becomes increasingly important as a carbon constrained world economy develops. Businesses with above average emissions increasingly face regulatory risk and market risk, evidenced by a Citigroup analyst's recent across-the-board downgrade of coal stocks.[26] As a result, clear definition of who owns emissions and who owns emissions *reductions* will become increasingly important. Ownership, however, is not as simple as looking to see what chimney the smoke is coming from.

4.1 Regional Utilities

Regional power utility companies have traditionally been a source of rebate incentive programs that subsidize the cost of energy efficiency improvements at the commercial, as well as residential scale. These programs are legislated requirements to promote energy efficiency, as well as utility needs to reduce peak electricity demand loads to prevent overburdening physical infrastructure. Commercial lighting system retrofits are a common example. But because the utility provides the materials and installation at highly subsidized rates or at no cost to the building owner, the utility retains the ownership of the environmental attributes associated with the retrofit. Utility programs are also usually focused in a few areas, such as lighting or replacement windows and do not offer a comprehensive energy efficiency strategy; nor are they looking to maximize overall energy or carbon emissions reductions as much as they are looking to reduce peak electricity demand. Incentives also vary considerably from one utility jurisdiction to another and are not always simple to qualify for. Many incentives focus on specific real estate sectors, such as single family residences or office buildings, further affecting the potential value to owners of other types of assets.

Utilities with carbon emission liabilities in a compliance market could find it advantageous to increase funding of building efficiency retrofits as a low cost component (relative to internal abatement) of a comprehensive carbon emissions reduction scheme. Utilities could offer increased subsidies for comprehensive energy efficient building improvements as well as energy auditing services to assist building owners in managing energy consumption and cost. In this

[26] Gardner, Timothy. "Greens Rejoice as Analyst Sours on US Coal." Reuters. 20 July 2007.

scenario real estate would receive the energy savings benefits of measures funded through the utility, but no carbon offsets accrue to the property.

4.2 Energy Service Companies

Energy service companies (ESCO) are service providers that have expertise in the optimization of energy performance of building systems. Their suite of services is commonly referred to as a *performance contract*. A performance contract typically includes a comprehensive building survey that examines the exterior envelope, mechanical and electrical systems, and building control systems. It documents the existing physical conditions of the facility, profiles existing energy consumption, identifies retrofit measures with their associated cost and payback period and models a new energy profile that the ESCO is able to guarantee. This level of operating costs is commonly guaranteed for eight to ten years, backed by an ESCO commitment that allows building owners to obtain financing for the term of the contract. The ESCO will undertake all capital improvements, energy savings measures, and operate the building systems for the contract term to ensure savings targets are met. Savings are directed toward payment of the financing obligation for the contract term. The owner receives modest operational cost reductions during the contract period after debt service has been paid, and receives all the operational cost savings after the contract is retired. Financing the ESCO services allows the owner to avoid capital outlay, utilizing instead the savings from the operating expenses to fund the retrofit costs. Major ESCO providers include Honeywell, Johnson Controls, Inc, Siemens and Trane as well as many regional providers.

Performance contracts focus on the ‘low hanging fruit’ – measures that yield the greatest savings most quickly, but can be very exhaustive depending on the opportunities and desires of the owner. These measures may include:

- Lighting upgrades and daylight harvesting
- Occupancy sensors
- Pumps and motor replacement with variable frequency drives (VFDs)
- Replacement of outdated central plant equipment
- Energy recovery systems
- Fuel switching when new equipment is installed

- Demand reduction to reduce peak energy demand charges
- Building Automation systems
- Operational and management education
- Window replacement / Low-E coatings
- Roof replacement or recoating
- Cogeneration

Typical ESCO clients are governments, non-profit institutions including schools and hospitals, and industrial facilities. These owners tend to be more operationally cost-sensitive, have centralized management, own multiple buildings, and tend to be long-term owner/operators. In contrast, commercial real estate is more fragmented and transactional, a deterrent to investing in efficiency measures with a payback of more than two to three years. Building valuation also currently does not fully take into account energy cost sensitivity of tenants and owners as utility prices fluctuate. But the real estate industry is beginning to address this disconnect. CoStar Group announced in February that they would add Energy Star ratings to buildings listed on their property database.[27] This will allow buyers to see how one asset compares to another relative to energy performance within their respective real estate sectors. This still does not address split incentives between owners and tenants, as is the case with the triple-net lease where energy costs are paid by tenants. There is little incentive for the owner to operate the building above a standard level because the money they invest primarily reduces the tenants' utility bills. In spite of these limitations, there are opportunities for commercial real estate owners to utilize ESCO services to guarantee a level of energy cost savings. Sophisticated owners may also choose to develop this expertise in-house; some already have energy efficiency programs for their asset portfolio.

Because the owner is financing the energy efficiency improvements, environmental attributes of the retrofit measures remain with the asset, not the ESCO. The carbon emission reductions associated with a contracted level of energy savings can also be readily identified and guaranteed

[27] "CoStar Group Promotes Energy Efficient, Sustainable Green Buildings by Adding EPA's ENERGY STAR® Rating to Commercial Properties in its Database". CoStar Group press release. 12 February 2007. Accessed online 29 June 2007. <http://www.costar.com/Corporate/Press/Release.aspx?c=2620&ekmensel=8_submenu_76_link_2>

alongside the ESCO contract provisions for energy savings. As carbon offsets become more valuable, ownership of these attributes will become a more prominent issue.

4.3 Clinton Climate Initiative

Major recent activity in the global performance contracting marketplace will impact energy efficiency and the quantification and delivery of carbon offsets from real estate. The Clinton Climate Initiative program, announced in May 2007, 'brings together four of the world's largest energy service companies, five of the world's largest banks, and fifteen of the world's largest cities in a landmark program designed to reduce energy consumption in existing buildings.'[28] These are listed in *Figure 4*.

Figure 4: Table of Clinton Climate Initiative Participants.

Cities	Banks	Energy Service Companies
Bangkok	ABN AMRO	Honeywell
Berlin	Citibank	Siemens
Chicago	Deutsche Bank	Johnson Controls
Houston	JP Morgan Chase	Trane
Johannesburg	UBS	
Karachi		
London		
Melbourne		
Mexico City		
Mumbai		
New York		
Rome		
Sao Paulo		
Seoul		
Tokyo		
Toronto		

This effort has attracted $5 billion in capital to jumpstart significant growth in global performance contracting activity. Note that this initiative is focused on the public sector, targeting leading global cities and their municipal real estate assets, so there is no direct link to commercial real estate. The attention paid to the efforts, the resultant doubling of the global performance contracting business, as well as the monetary commitments from financial

[28] "President Clinton Announces Landmark Program to Reduce Energy Use in Buildings Worldwide". Clinton Climate Initiative press release. Clinton Foundation. 16 May 2007. Accessed online 26 June 2007. <http://www.clintonfoundation.org/051607-nr-cf-pr-cci-president-clinton-announces-landmark-program-to-reduce-energy-use-in-buildings-worldwide.htm>

institutions is likely to spur increased spillover investment in the private sector and lower financing costs for performance contracting services. In the long term this may lead to municipalities raising the energy performance standards for commercial developers and owners.

Chapter Five

5.0 Real Estate Participation in Carbon Markets

There are several issues that are relevant to real estate participation in the carbon markets. These issues include how to handle renewable energy and sustainable buildings, determining carbon emissions accurately, and voluntary market buyer concerns over credit creation. Carbon markets currently have limited mechanisms to allow the real estate industry to engage in carbon trading, but opportunities exist and interest in them is growing. ProLogis, the world's largest logistics REIT developed a protocol with the CCX to capture carbon offsets from energy efficiency improvements within their property portfolio. In the EU ETS, energy efficiency improvements and fuel switching can be quantified through the Clean Development Mechanism (CDM). To date, projects have been limited both in the voluntary market and in the EU ETS, due in part due to the start-up effort required to begin accruing offsets, which is disproportionate when compared with a large emitter's economies of scale, and unfamiliarity with the markets.

To participate in the EU ETS, building-related demand side management or fuel switching must be employed. This can be registered through a Clean Development Mechanism. There are a number of steps involved in doing so, including:[29]

- Determine energy efficiency benchmarks for large regions and market sectors
- Formulate a methodology to compare traditional buildings to improved buildings
- Establish an annual building monitoring system
- Create a legal framework defining the ownership of environmental attributes
- Establish compliance period
- Aggregate sufficient credits to bring to market
- Maintain ongoing contract compliance

CDMs are focused on developing countries such as India and China, not mature markets like the US. But the adoption of widely applicable energy efficiency benchmarks and carbon offset

[29] "Buildings and Climate Change; Status, Challenges, and Opportunities". United Nations Environment Programme. 2007.

identification methodologies required by the EU ETS for offset projects will begin to spur the development of real estate-specific CDMs around the globe.

The European Commission (EC) issued Directive 2002/91/EC requiring improvements to energy efficiency in buildings and consistent reporting for energy performance, effective in 2006. This Directive is meant to create the framework for implementing EU-wide Kyoto-compliant energy reduction standards. The EC estimates that energy efficiency standards could reduce energy consumption by 20% by 2010. For buildings over 1,000m^2, inspections and certification are required.[30]

A consistent benchmarking system being implemented in the EU with mandatory certifications will make it easier for highly efficient buildings to determine their marginal efficiency and their carbon offsets. It then becomes a matter of being able to supply those offsets to the carbon market. If this proves attractive, the US market may follow suit. CoStar's Energy Star labeling within its property database is a step in this direction. As this becomes standard listing practice , the cost will be built in to all assets and will thus not be seen as a marginal cost simply to support certification for the carbon markets. This represents an opportunity for owners of highly efficient real to capture benefits as market prices climb and as transaction costs decrease.

5.1 Renewable Energy Protocols

The US voluntary market recently added protocols permitting real estate-related offsets to be created and sold as carbon offsets. The CCX has the following protocols:

- Agricultural Methane
- Landfill Methane
- Agricultural Soil Carbon
- Forestry
- Renewable Energy
- Coal Mine Methane
- Rangeland Soil Carbon Management
- *Clean Development Mechanism-Eligible Projects*

[30] *Better Buildings* leaflet. European Commission. 2003. Accessed online 24 June 2007. <http://ec.europa.eu/energy/demand/legislation/doc/leaflet_better_buildings_en.pdf>

- *Building efficiency and fuel switching*

The last two were added to the approved list in mid-2007. Until recently, the only real estate-specific opportunity was in *renewable energy*, commonly building-integrated photovoltaics. The focus of this protocol, however, is utility-scale renewable energy. The small size of typical building-integrated renewable energy and its associated carbon offset creation is small enough that the transaction costs undermine efforts to capture value from the market. This is illustrated by a portfolio of eleven BJ's Wholesale Club buildings located in the northeastern US and producing electricity for twelve consecutive months in 2006. In *Figure 5* I compiled a list of facilities and the annual energy production in kilowatt-hours of their photovoltaic systems.

Figure 5: Selected portfolio of photovoltaic systems output.[31]

	BJs Location	Output 2006
1	Depford	32,471
2	Farmingdale	8,435
3	Islandia	8,591
4	Middletown	52,553
5	North Dartmouth 1	655
6	North Dartmouth 3	13,499
7	Plymouth Meeting	25,193
8	Riverhead	7,951
9	Stoneham	12,428
10	Westbury	7,346
11	Saratoga Springs	91,718
	Total kWh	260,840

Photovoltaic arrays at these facilities produced a total of 260,840 kWh of renewable, emission-free electricity in 2006, avoiding the consumption of an equal quantity of electricity from the utility grid. I calculated the quantity of carbon emissions offset through this renewable energy generation by determining the quantity of emissions in pounds per kilowatt-hour of electricity generated by the utility and multiplying it by the output of the systems. The US Department of Energy publishes aggregate carbon dioxide emissions across ten regions and for each state.[32] For this example, regional emissions data will be used since the installations are in several northeastern states. The table in *Figure 6* identifies the power generating region and the

[31] Soltrex system explorer website. Soltrex. Accessed 2 July 2007. < http://www.soltrex.com/systems.cfm>
[32] Within each region there are numerous power generators and the CO_2 emissions for each generator will vary somewhat from the overall region. Data on emissions by zip code and utility company can be found at the EPA Energy Profiler website. <http://www.epa.gov/powerprofiler/powerprofiler.htm>.

associated output of carbon dioxide and nitrogen oxides. I converted nitrogen oxides with their GWP factor (296) to effective carbon dioxide emissions. The total effective carbon emissions are the total of CO_2 and CO_2-equivalent NOx emissions.

Figure 6: Table of Utility Carbon Emissions by US Region.[33]

Energy Region	CO_2 lbs. per kWh	NOx lbs. per mWh	NOx effective lbs. CO_2 per kWh	TOTAL Lbs/ CO_2/kWh
Alaska Systems Coordinating Council	1.11	3.68	1.09	2.19
Electric Reliability Council of Texas	1.42	0.98	0.29	1.71
Florida Reliability Coordinating Council	1.33	2.27	0.67	2.00
Hawaiian Islands Coordinating Council	1.66	3.76	1.11	2.77
Midwest Reliability Organization	1.82	3.73	1.11	2.93
Northeast Power Coordinating Council	**0.91**	**1.02**	**0.30**	**1.21**
Reliability First Corporation	1.43	2.48	0.73	2.17
SERC Reliability Corporation	1.39	2.11	0.63	2.01
Southwest Power Pool	1.83	3.02	0.89	2.72
Western Electricity Coordinating Council	1.11	1.62	0.48	1.59

Converted with Northeast utility CO_2 emission rate of 1.21 lbs.CO_2/kWh this yields 143.2 metric tons CO_2:

260,840kWh x 1.21 lbs.CO_2/kWh ÷ 2204.6 lbs. per metric ton = 143.2 metric tons CO_2

At current voluntary market prices this is worth:

$3.30 x 143.2 = $472 per year

Even with a system ten times larger or a carbon value ten times higher, this suggests the value of renewable energy at the building scale is too low to justify the transaction costs of creating carbon credits for the voluntary market.

5.2 Carbon Emissions by State

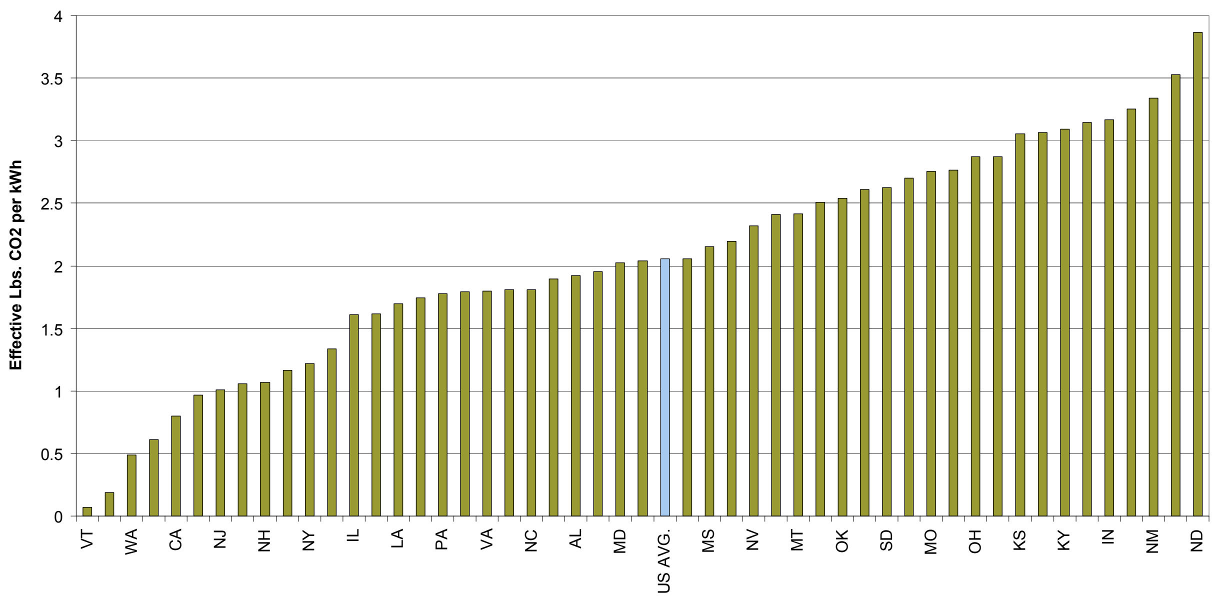
Carbon emissions data is also available on a state-by-state basis. This permits a comparison between states to determine where energy savings would generate the greatest carbon offset potential. This data will be used in *Chapter 6* for the case study. The quantity compared across all states is illustrated by the graph in *Figure 7.*[34] Emissions vary from a low in Vermont of

[33] "eGrid2006 Version 2.1 (April 2007) Year 2004 Summary Tables. NERC Region Emissions" Environmental Protection Agency. Washington DC. April 2007. <http://www.epa.gov/cleanenergy/egrid/index.htm>

[34] See *Appendix A* for a full state-by-state list.

0.070 lbs. CO_2 per kWh to a high of 3.865 lbs. CO_2 per kWh in North Dakota. Power generation in Vermont is much lower polluting (typically hydro-electric, nuclear, or wind power) and much higher polluting (from low grade coal burned in old power plants with fewer pollution controls) in North Dakota. The graph indicates that for the same energy savings in one state, the potential greenhouse gas offsets can be over 5.5 times higher or lower in another state

Figure 7: Comparison of CO2 Emissions by State.[35]



5.3 Carbon Offset Additionality

The procedure for setting an appropriate baseline above which carbon offsets can be accrued is a topic of active debate and is particularly relevant for real estate. Carbon market participants have concerns with a *lack of additionality*, the notion that carbon offsets can be gained through business as usual; i.e. they could be created without needing any additional market incentives to make them economically feasible. This can be illustrated by a generic example. A cement plant is replacing an old, obsolete kiln with a more efficient one that is currently industry standard technology. They cannot capture carbon offsets because they are undertaking the upgrade because the system needs replacement anyway, and they are upgrading to an industry-standard system. If they were to capture offsets there would be an additionality problem because they came from a business-as-usual practice. In contrast, if the same factory upgraded to the most

[35] "eGrid2006 Version 2.1 (April 2007) Year 2004 Summary Tables. NERC Region Emissions" Environmental Protection Agency. Washington DC. April 2007. <http://www.epa.gov/cleanenergy/egrid/index.htm>

efficient kiln available today, and also invested in other heat recovery and energy recapture systems that exceed industry best practices, they could accrue carbon offsets on the portion of the project that exceeded typical good practice. What constitutes standard practice and best practices can be a grey area, so the additionality issue does require vigilance among carbon market participants.

Additionality can short circuit the goal of the marketplace and is one of the critical issues the carbon markets must adequately address. It implies that there are 'free' credits being supplied to the market, preventing accurate price discovery. Some feel that real estate energy efficiency improvements do not meet the additionality test because energy efficiency improvements benefit the owner economically as well as by avoiding carbon emissions. With this logic, any negative cost abatement item listed in *Figure 2* is vulnerable to additionality concerns. But there should be recognition of those buildings that exceed the performance of their peers, as illustrated in the cement plant example. At present, rigorous energy efficiency improvements are not routinely pursued, signaling that there is not sufficient financial incentive for building owners to undertake the measures when faced with other uses of their limited capital.

If additionality concerns are addressed, another requirement is a robust system that prevents the environmental attributes from being sold more than once. This is an issue that the whole the voluntary market shares. This is particularly the case if buildings have systems that generate renewable energy certificates that are converted to carbon offsets, as the environmental attributes of these systems can be claimed by various entities, including the building owner, the utility, and the system installer. Failure to address this concern could significantly devalue building-related carbon offsets.

5.4 Recent Voluntary Market Protocols

At the end of 2006 the Chicago Climate Exchange completed a protocol for energy efficiency in warehouses in conjunction with the industrial and logistics property REIT, ProLogis. This protocol is designed to allow ProLogis to benchmark their buildings against an Energy Star 75 rating, and quantify offsets beyond that level attained through lighting and thermal building envelope improvements.[36] The protocol is applicable to renovations as well as new construction.

In the example of the ProLogis protocol, it is assumed that a building owner may invest in retrofits to achieve an Energy Star 75 rating and expect reasonable economic payback. Measures up to this threshold are considered industry standard best practice and cannot be counted toward carbon offsets; there is no additionality and carbon offsets can not be accrued. Measures that bring building performance above the 75 threshold can begin to accrue carbon offsets. Credits are determined based on building energy modeling and verification with actual energy consumption data over a four year compliance period. These criteria are likely to be used as a baseline for establishing similar protocols for other real estate companies that join the CCX in the future.[37]

5.5 The Relevance of High Performance Buildings

In addition to Energy Star compliance, some may look to high performance, or green, buildings to set baseline performance or provide a system for clarifying carbon ownership. The predominant voluntary green building program in the US is the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program. This program has a number of standards for achieving environmentally balanced, resource efficient, and healthy buildings. This standard and others are rapidly gaining acceptance in the real estate industry due largely to tenant demand and construction industry supply chain shifts. One component of these protocols typically requires energy performance above a specified minimum level, currently ASHRAE 90.1-2004 standards. Green design standards 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. They are generally unsuited to the rigorous sector-by-sector benchmarking requirements to address additionality concerns. They also do not provide a chain of custody for ownership of environmental attributes. Perhaps future versions of the protocols will include more stringent energy performance measures and

---

[36] Energy Star is a voluntary government energy rating system that benchmarks building energy performance relative to their sector peers based on energy consumption per G.S.F. A rating of 50 is defined as the "average" building. A number above the average is deemed better performing than the average, so 75 is better than 50.

[37] "Energy Efficiency Protocol for Warehouses." The Chicago Climate Exchange. Chicago, IL. 2006.

carbon emissions reductions that will be an acceptable substitute for other benchmarks (such as Energy Star), but they are currently not appropriate for this task.

5.6 Voluntary Market Concerns

The ProLogis-CCX protocol's Energy Star baseline, energy modeling and consumption verification, and four year compliance period are ways of addressing additionality concerns that affect the acceptance of real estate-generated carbon offsets. But there are other mechanisms that can also be implemented. A performance contract that ensures energy performance targets will be met is one effective way to address this concern.

Another way to do this is to aggregate the carbon offsets across a pool of assets that provide offsets that are not dependent solely on one underlying asset. If a single asset cannot deliver the carbon offsets that are contractually required it is akin to a mortgage defaulting – the contracted obligation of offsets cannot be met. If assets are pooled the owner could swap assets into and out of the asset portfolio as building performance changes to maintain offset contract compliance.

At the financial market level banks could engage in a similar process; distribute their risk by purchasing large diverse pools of carbon offsets. Offsets could be securitized in much the same way that commercial mortgages are to provide traunched levels of risk for buyers of the resulting carbon securities. This also provides the bank some flexibility to move offset contracts into and out of a pool to maintain overall performance. Risk-averse buyers can purchase highly rated traunches, while those with greater appetite for risk can seek higher returns on riskier traunches of carbon securities. These institutions need rigorous underwriting criteria to minimize carbon credit default during the life of the carbon contract for these securities to be successful.

Part II

Chapter Six

6.0 Case Study Analysis

My research has identified the issues and opportunities of real estate participation in the carbon markets, but there has been no discussion of how value can be captured at the individual asset level. Furthermore, the magnitude of asset-level value has not been determined, which is arguably the most relevant issue for the real estate industry. This case study follows two parallel paths. First it uses a real building example to determine the potential value of energy efficiency improvements. Second, it goes a step further to quantify the carbon emissions reductions and place a value on them. To do this I have assessed the energy profile and indirect emissions of a stabilized commercial office building. I also calculated its existing carbon emissions. With this base case established, I will identify a series of energy saving and emissions-reducing measures. Then I will determine the current and projected value of the carbon offsets and assess their impact on the overall financial feasibility retrofit measures to determine if there is sufficient value from carbon offsets to fund further energy efficiency improvements. I will also use this to make a state-by-state comparison of the range of financial value based on where the building is located across the country.

6.1 Case Study Building Profile

The Boston Case Study building is located in the Boston CBD. It was completed in 1987 and contains 46 floors of class-A commercial office space, and is roughly 95% occupied. The building is steel frame construction, with stone and glass curtain wall facades enclosing 1,028,344 square feet.[38]

Existing Systems: Building systems are electric, including all boilers and chillers, original to the date of construction.

Existing Energy Consumption: In 2006, the building consumed an average of 2,820,983 kWh of electricity per month. The energy intensity of the building was 32.9 kWh/SF/year (112

[38] Building data was provided under the condition of anonymity.

kBtu/SF/year). Energy intensity measures energy consumption on a per square foot basis. This consumption figure places the building at the average among office building efficiency in the Boston area with an Energy Star 50 rating.

6.2 Retrofit Measures and Energy Savings

Specific retrofit measures to reduce electricity consumption were recommended as part of an energy audit study completed within the past two years. These measures are listed in *Figure 8*.

Figure 8: Table of Proposed Energy Conservation Measures (Owner's data)

Energy Conservation Measure	kWh/Year Savings	Utility Cost Savings $	Implementation Costs $
Retrofit VFD Chiller with VFD CHW & CW VFD pumps	631,280	91,536	262,081
Water Side Economizer	391,630	56,786	175,788
Garage lighting upgrade to T5 HO Fluorescent fixtures	293,460	42,552	150,425
Lobby lighting to metal halide	179,211	25,840	106,025
Elevator Lobby Lighting Changes	348,662	50,556	236,459
Atrium Lighting to Metal Halide	203,314	29,480	154,090
Stairway Lighting Changes	63,401	9,193	80,872
Restrooms Lighting Changes	229,076	33,216	307,046
Total	2,340,034	339,160	1,472,785

The estimated implementation cost and anticipated savings were calculated as part of the energy audit study performed by a local engineering company. These potential savings represent 6.75% of the annual electricity consumption in 2006. These measures, without utility incentives, have a simple payback of 4.3 years.[39] Based on the energy conservation measures listed in *Figure 8*, the resulting energy and operational savings are produced. These are listed in *Figure 9*.

Figure 9: Table Comparing Energy Savings and Cost Savings

Units	Original Energy Consumption	Revised Energy Consumption	Change
kWh	2,820,983	2,630,672	(190,311)
	Original Energy Cost	**Revised Energy Cost**	**Change**
$ per Month	$527,728	$492,126	$ (35,602)

Implementing these measures would save an estimated $35,602 in monthly electricity costs. This would raise the Energy Star rating to 56.

[39] One additional measure with a payback period of 23 years was excluded from this evaluation. This measure, "Replace VFDs on chiller and condenser water pumps" has an implementation cost of $150,604. Refer to *Figure 14* for additional information.

To achieve an Energy star 75 rating energy efficiency would need to be increased 30%, to achieve consumption of 23.6 kWh/SF/year (80.5 kBtu/SF/year) based on the online Energy Star Portfolio Manager performance target calculator. 30% energy improvement is also a target referenced in Energy Star literature as achievable for many commercial buildings. For the purposes of this case study I have assumed that additional measures could be implemented to reduce energy consumption by 30%. This assumption provides a low and high range (~6% to 30%) for comparison purposes into which many buildings will likely fall. This information will be used in *Section 6.8 Reversion Value of Energy Savings and Carbon Offsets at 30%.*

6.3 Assumptions

The retrofit measures payback analysis does not consider the potential cost differential of electricity saved during peak and off-peak time periods due to uncertainty of time-of-day impact to demand changes based on the measures implemented. Instead for clarity and simplicity, I have proportionally attributed energy savings to peak and off-peak time periods; although the reduction during peak demand periods would likely be of greater quantity and value due to the utilization of upgraded equipment primarily during those times, such as chillers, pumps, and area lighting.

I assumed the retrofit measures have been implemented and are providing the savings anticipated. Based upon this 6.75% savings in electricity consumption I calculated the quantity of avoided carbon emissions based on Massachusetts utility generation data available from the Energy Information Administration. 1.616 lbs. of CO_2 were generated per kWh in Massachusetts in 2004.[40] See *Appendix A* for a state-by-state breakdown.

For the purposes of the case study I assumed that the existing building currently meets the baseline efficiency standards (i.e. assume Energy Star 50 is the baseline). Emissions reductions beyond this level will be counted toward carbon offset creation. As a result the following offsets are generated, shown in the calculation below.

$$190{,}311 \text{ kWh} \times 1.616 \text{ lbs/kWh} \div 2204.6 \text{ lbs./metric ton} = 1{,}674 \text{ MtCO}_2\text{e offsets}$$

[40] "eGrid2006 Version 2.1 (April 2007) Year 2004 Summary Tables." Environmental Protection Agency. Washington DC. April 2007. <http://www.epa.gov/cleanenergy/egrid/index.htm>

6.4 The Value of Energy Savings and Carbon Offsets

Carbon offset value is highly variable based on location given the same energy efficiency improvements due to varying carbon emissions in each state. *Figure 10* below indicates the range of possible values based on the current US voluntary market price and the current compliance market price in Europe respectively. The range is consistent with research that suggests that long term prices will rise to the $20-$30 range.[41]

Figure 10: Table of Carbon Offset Value (US)

Value	Market type
$5,524	CCX ($3.30)[42]
$50,670	ECX (30.27)[43]

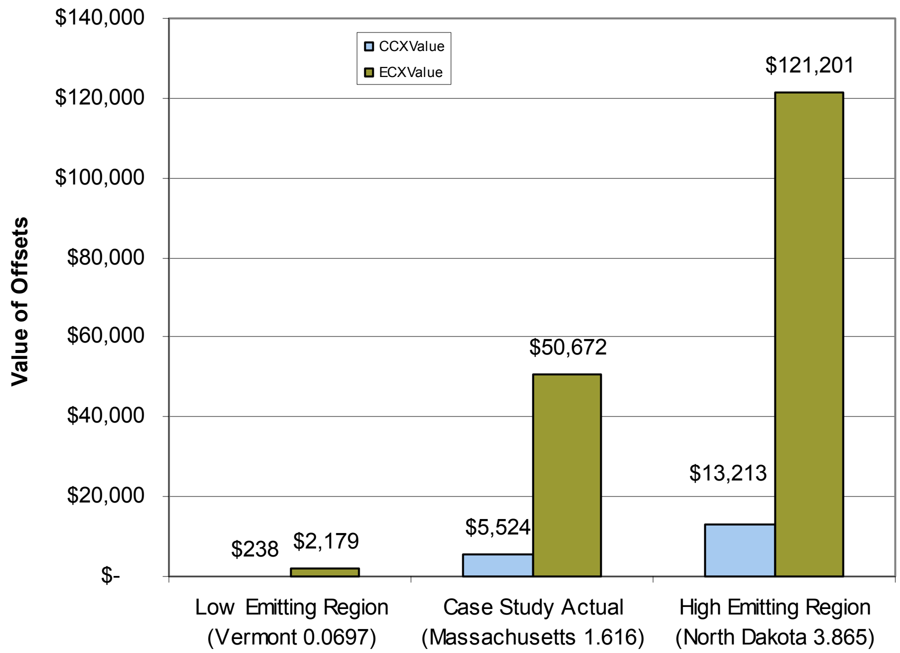
The value ranges between $238 and $2,179 in the low price voluntary scenario in the cleanest state utility (Vermont) and $13,213 and $121,201 in the high price compliance scenario in the dirtiest state utility (North Dakota). *Figure 11* compares the value of the Boston case study building across low to high utility carbon emissions and low value and high value carbon prices. This illustrates what the carbon offsets would be worth in various states where utility pollution levels are lowest or highest. This also shows the value that can be captured if carbon offset prices rise from the current voluntary market price of $3.30 to a compliance market price of $30.27.

[41] Roine, Kjetil ed. *Carbon 2007: A New Climate for Carbon Trading*. Point Carbon. 13 March 2007. This report predicts prices in 2010 of €17.5/tCO_2e and in 2020 €23.1/tCO_2e, equivalent to $23.69 to $31.27 respectively. Dollar to Euro exchange rate as of 29 June 2007 = 1.3537

[42] CCX 2007 CFI price as of 29 June 2007.

[43] Price of 2008 CFI on ECX as of 29 June 2007 = €22.36; Dollar to Euro exchange rate as of 29 June 2007 = 1.3537

Figure 11: Range of Carbon Offset Value for Low and High Emitting Regions.



This presents an opportunity for building owners in certain states who can extract over *55 times more* carbon value from comparable energy efficiency improvements due to the quantity of carbon emissions of regional power generators. Owners of geographically diverse asset portfolios may use these criteria as one way to prioritize energy efficiency retrofits.

Energy savings is another criterion for real estate owners to prioritize retrofits. In this case energy cost savings provide more than sufficient economic value to fund retrofit measures. Energy savings exceed financing costs for the retrofits over 1) an aggressive four year term 2) over a more typical ten year term. *Figure 12* illustrates the cost savings available to fund debt service over a four year period. This example I assumed the retrofit measures have been debt funded by a financial institution to avoid the initial cash outlay of $1.42M. This is consistent with the implementation of a performance contract, where retrofits are paid for over time through energy savings that are guaranteed by an ESCO.

Figure 12: Table of Energy Savings and Carbon Feasibility Analysis, 4 yr.

Savings Value 6% interest, 4-year period	Implementation Cost	Monthly Debt Service	Monthly Savings	Difference
Energy Savings Only	$1,420,888	$33,370	$35,602	+$2,232
Energy Savings + $3.30 Carbon offsets			$36,062	+$2,692
Energy Savings + $30.27 Carbon offsets			$39,825	+$6,455

Over a ten year term, the debt service is reduced considerably as shown in *Figure 13*.

Figure 13: Table of Energy Savings and Carbon Feasibility Analysis, 10 yr.

Savings Value 6% interest, 10-year period	Implementation Cost	Monthly Debt Service	Monthly Savings	Difference
Energy Savings Only	$1,420,888	$15,775	$35,602	+$19,827
Energy Savings + $3.30 Carbon offsets			$36,062	+$20,287
Energy Savings + $30.27 Carbon offsets			$39,825	+$24,050

Carbon offset value in all cases functions as an additional financial incentive to motivate energy efficiency retrofit activity, providing an additional $460 (CCX) to $4,222 (ECX) for monthly debt service which could fund up to an additional $380,000 in efficiency measures when capitalized and financed over ten years.[44] In the initial case study description, an energy savings measure with a 23 year payback was excluded from the analysis. This measure is described in *Figure 14*.

Figure 14: Table of Excluded Energy Conservation Measures (Owner's data)

Energy Conservation Measure	kWh/Year Savings	Utility Cost Savings $	Implementation Costs $
Replace VFDs on chiller and condenser water pumps	40,155	$5,822	$150,604

With the additional capitalized value from carbon offsets, the energy conservation measure that was excluded from the initial round of energy efficiency improvements becomes feasible. $380,000 in financing capacity has been created and implementation costs are only $150,604.

At present there is little financial incentive in the voluntary market to aggregate and sell offsets due to low prices and comparatively high transaction costs. If exchange prices rise to the level currently observed in the EU compliance market, the benefit of the carbon offsets would add 12% to the energy cost savings amount quantified in this case study, a capitalized value of

[44] Assumes a 6% interest rate for the performance contract, ten year loan term.

$380,000. In this case study, the initially excluded retrofit measure would indeed become economically feasible by capturing carbon offsets.

This example does not account for other financial factors because of their building-specific nature, including utility incentives which present a risk if collected that they may cause carbon offsets to accrue to the utility and not the building owner, depreciation and other tax treatment, and other reimbursements or triple-net lease structures with tenants. These would tend to improve the financial picture of the decision to invest in retrofit measures.

6.5 Barriers to capturing carbon offsets

For building owners with single assets or small asset portfolios the required verification and in-house or contracted expertise would be a major deterrent to quantifying and selling carbon offsets. Carbon offset aggregators, third party brokers who purchase small quantities of offsets, bundle them, and resell them on the carbon market provide a method for reducing transaction costs and increasing liquidity of small carbon offset volumes. The uniqueness of real estate-generated offsets may also cause buyers to discount the price they are willing to pay. This may be due to concerns about additionality or ability to meet compliance requirements over the contract period. But if carbon offset prices rise as predicted, capturing carbon offset value will become increasingly attractive.

6.6 IRR Analysis of Energy Savings and Carbon Offsets

What is the feasibility of the energy efficiency investment ignoring carbon credits? These measures have a simple payback of 4.3 years, and an implementation cost of $1.42 million which can be financed. *Figure 15* provides an IRR matrix of various energy efficiency investments.[45] Detailed spreadsheets are included in *Appendix B*.

[45] Assumes capital investment in Year 1 and energy savings beginning in Year 2, ten year IRR calculation. A 10% deduction is taken from annual carbon value to account for transaction costs necessary to sell offsets.

Figure 15: Energy Efficiency Funding Scenarios IRR Comparison.

Method of Financing	Energy Efficiency Financing Term (Yrs.)	Utility or Carbon Incentive Payout Term (Yrs.)	Annual D.S. Payment	IRR (%)
Capital Expenditure	none	-	0	**26.4**
Energy Savings	4	-	400,435	**38.6**
Energy Savings	10	-	189,297	**125.6**
Energy Savings + Carbon Offset Incentive (CCX)	10	9	189,297	**128.2**
Energy Savings + Carbon Offset Incentive (ECX)	10	9	189,297	**149.7**
Energy Savings + Utility Incentives	10	2	189,297	**176.0**

This demonstrates that financing the retrofit costs over longer terms improves IRR considerably, and carbon credits are less valuable than the up-front utility incentive for maximizing IRR. Another way to look at it is to compare the 125.6% IRR to the 149.7% IRR. The difference between no carbon offsets and ECX price offsets for this asset equates to the $380,000 capitalized value previously identified. This illustrates compelling returns on energy efficiency investments that appear to justify investment in energy efficiency at the capital budget level over a ten year term, with or without accruing carbon offsets.

6.7 Reversion Value of Energy Savings and Carbon Offsets at 6.75%

When examining *Figure 15*, the question of 'why would I bother with carbon at all when the highest IRR (176%) comes from only energy efficiency and utility incentives?' What is not taken into account in these scenarios is the potential value creation at the sale of the asset. The revenue stream from the carbon offsets raises NOI over the long term unlike utility incentives. Carbon offsets are contracted for multi-year terms, guaranteeing stable annual cash flow from the offsets.[46] To determine the change in asset value in *Figure 16* I assumed a *Base Case* purchase price and a sale price that does not include any efficiency improvements, utility incentives, or carbon offset sales.[47] Subsequent sale prices incorporate utility incentives, low carbon value offsets, and finally high carbon value offsets.

---

[46] Recall the ProLogis/CCX protocol. The protocol has provisions for a four year compliance period with recertification eligibility.

[47] Detailed calculations can be found in *Appendix C.* Assumes retrofit measures cost $1.42 million, 4.5% going in cap rate, 4.5% going out cap rate, 15% tax at 1.5% annual growth, 1.5% annual rent growth. Sale of the asset occurs at the end of Year 10.

Figure 16: Reversion Price Comparison 6.75% Efficiency Gain.

(x$1000)	Purchase Price	Sale Price	Difference	%	IRR
Base Case	$ 719,430	$897,649			6.16%
Efficiency + Utility Incentives		$907,565	$9,916	1.10%	6.27%
Efficiency + CCX Carbon Credits		$907,694	$10,044	1.12%	6.27%
Efficiency + ECX Carbon Credits		$908,742	$11,093	1.24%	6.28%

In this example capturing energy savings plus utility incentives increases the value of the property 1.10% at the time of sale, or just over $9.9 million.[48] In both carbon offset scenarios, the value at the time of sale is greater than the utility case. The carbon offset scenarios result in a reversion value premium of between $10.0 million and $11.1 million. IRR is improved by 11 to 12 basis points.

6.8 Reversion Value of Energy Savings and Carbon Offsets at 30%

It is worth remembering that this scenario as assumed energy efficiency improvements of only 6.75%. In this example I assumed 30% efficiency gains, and increased the cost of retrofit measures to $6.5 million, the corresponding increase in value would be as shown in *Figure 17*.[49]

Figure 17: Reversion Price Comparison 30% Efficiency Gain.

(x$1000)	Purchase Price	Sale Price	Difference	%	IRR
Base Case	$ 719,430	$897,649			6.16%
Efficiency + Utility Incentives		$941,766	$44,117	4.91%	6.63%
Efficiency + CCX Carbon Credits		$942,337	$44,687	4.98%	6.63%
Efficiency + ECX Carbon Credits		$946,999	$49,349	5.50%	6.69%

In this example capturing energy savings plus utility incentives increases the value of the property 4.91% at the time of sale, or over $44.1 million.[50] The carbon offset scenarios result in a value between $44.7 million and $49.3 million. This increases net asset value between 4.98% and 5.5%. IRR is improved by up to 53 basis points. To illustrate the potential value of carbon offsets, assume the building were located in the state with highest utility carbon emissions, North

[48] Assumes utility incentive is paid to owner in year 2 and year 3.
[49] Detailed calculations can be found in *Appendix D*. Assumes retrofit measures cost $6.5 million, 4.5% going in cap rate, 4.5% going out cap rate, 15% tax at 1.5% annual growth, 1.5% annual rent growth. Sale of the asset occurs at the end of Year 10.
[50] Assumes utility incentive is paid to owner in year 2 and year 3.

Dakota. The marginal carbon value benefit would reach $56.6 million; an IRR 62 basis points above the base case.

6.9 Warehouse Portfolio Example

Figure 17 assumed that efficiency could be improved by 30% for a Class-A office building. While this improvement may seem aggressive, the asset currently operates at approximately an Energy Star 50 rating, or average compared to its peers. 30% improvement equates to an Energy Star 75 rating, a level achievable by many buildings. *Figure 18* provides another illustration of warehouse buildings of a similar age in Miami, Florida where energy savings reach 30% and even higher by implementing only one retrofit measure.

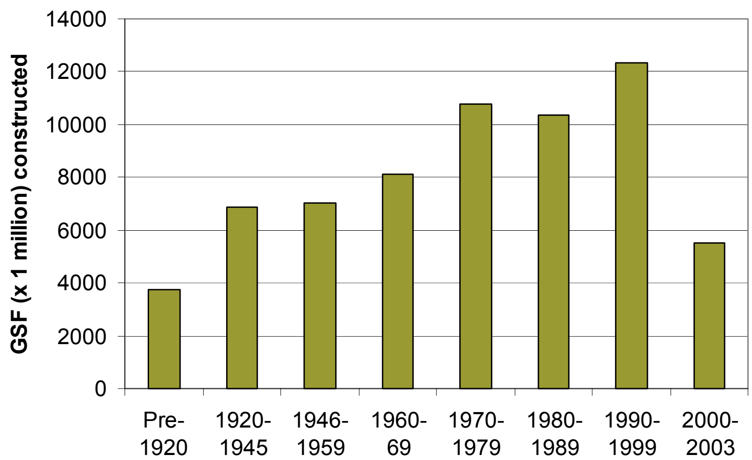
Figure 18: Table of Warehouse Energy Savings.

Facility	Year Built	GSF Roof	Existing Electricity Cost	New Electricity Cost	Annual Savings	Percent Savings
Building 1	1992	122,700	$241,842	$217,670	$24,172	9.99%
Building 2	1993	73,600	$146,685	$ 95,386	$51,299	35.0%
Building 3	1989	97,830	$193,703	$126,788	$66,916	34.5%
Building 4	1990	35,220	$71,884	$ 64,875	$ 7,009	9.75%
Average	1991	82,338	$163,528	$126,180	$37,349	22.8%

Note that these buildings have an average age of sixteen years; slightly younger than the office building, an age that is not generally considered obsolete. The range of energy efficiency improvements is between roughly 10% and 35%, and averages almost 23%. This example involved only the replacement of existing black membrane roofs with a new high reflectance white TPO (thermo polyolefin) roof membrane to achieve these savings. Roof insulation values were not altered in this case. The energy savings difference was due to the existing roof composition; the high savings value occurred in buildings with insulated roofs, and the low savings value occurred in buildings with un-insulated roofs. This example indicates that the 30% energy efficiency range is reasonable.

The building in the case study as well as those in the warehouse example were built in the late 1980s and early 1990s. If building this age or older are better candidates for energy efficiency improvements, what is the magnitude of the opportunity in the US? *Figure 19* indicates that over 72% of all commercial building square footage in the US was built prior to 1990.[51]

Figure 19: Commercial Gross Square Footage by Decade.



If these buildings can benefit from cost-effective energy retrofits, the industry-wide potential value creation is significant.

The Boston case study demonstrates that investment in energy efficiency improvements provide a compelling return range up to an IRR of 176%, largely because the ability to finance the costs externally minimizes the cash outlay and risks borne by the owner. The market level valuation varies from +1.1% to over +5.5%, or between $10M and $49M. This is achieved while putting little capital risk. Additionally, the majority of the value is created from energy efficiency improvements that can be contractually guaranteed by utilizing performance contracting. To the extent owners utilize this they can diversify the risk of asset ownership by implementing measures that simultaneously increase NOI.

In spite of this potential benefit, current low prices for offsets and challenges for real estate to accrue carbon offsets create little financial incentive today to focus on the carbon market. In light of this, in the short term real estate owners should focus on the economics of energy cost savings as the driving factor in making energy retrofit decisions. In the coming years if carbon

[51] "2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables; Table B9". Energy Information Administration. Washington DC. December 2006.

prices rise, the threshold where accruing carbon offsets becomes economically beneficial will move closer.

6.10 Carbon Offsets and Real Estate Market Volatility

The value of carbon offsets is determined directly by the carbon markets and indirectly by GHG regulations and demand from non-real estate sources, not the real estate markets. Offsets can therefore be seen as a way to diversify against real estate market volatility. The correlation between the carbon markets and the real estate markets could be the subject for another research paper, but a low correlation would intuitively be anticipated because the factors driving price in each market differ. Rent price is driven by supply and demand for space in a region and submarket. Carbon markets are driven by government-allocated state-wide or nation-wide allocations and abatement project costs in a compliance market. In a voluntary market the price is affected by purchaser demand based on corporate environmental goals, abatement costs, as well as additionality and other credit legitimacy concerns that tend to discount prices. Carbon credit income is also dependent on building operation, not on tenants. Even if vacancies reduce rental income, carbon offset value is largely unaffected. A possible exception is if a building had sufficient vacancy that energy consumption dropped below the level where offsets could be provided to meet the carbon contract requirements.

Carbon pricing is not available in a sufficiently long data series for direct comparison with office rents over a typical cycle. But in a regulated carbon market where electricity generators have to comply with carbon limits such as in the EU ETS the price of carbon is passed through more or less fully to the consumer in the price of electricity. As carbon prices rise, utilities with carbon liabilities who are buying credits are able to pass the cost along to consumers. In the EU market, this positively correlates prices of carbon and electricity. Referring back to the case study, below is a comparison of Boston rental price change to commercial retail electricity price change and commercial retail natural gas price change since 1991. *Figure 20* shows the real percent change between electricity price, office rent, and natural gas prices in Boston. *Figure 21* identifies the correlation between these values.

Figure 20: Table: Percent Change Comparison of Rent, Natural Gas, Electricity.

Year	% Change Electricity	% Change Office Rents[52]	% Change Natural Gas
1991	-4.93%	-23.80%	-6.8%
1992	-3.48%	-1.71%	-7.8%
1993	-4.08%	11.80%	0.1%
1994	-4.77%	1.05%	10.0%
1995	-5.12%	-1.37%	-6.0%
1996	-5.29%	3.82%	-0.6%
1997	-4.57%	11.20%	6.4%
1998	-4.93%	3.69%	-1.9%
1999	-5.91%	28.29%	1.5%
2000	-3.15%	24.34%	9.1%
2001	2.45%	-17.83%	30.5%
2002	-4.35%	-18.37%	-24.6%
2003	-2.10%	-12.95%	22.1%
2004	-4.18%	-5.90%	10.3%
2005	-0.46%	-0.31%	10.7%
2006	2.34%	7.94%	5.6%
Spread	11.2	52.1	55.1
StDev	0.026	0.145	0.127
StDev Rent/StDev Electricity			5.6
StDev Rent/StDev Natural Gas			1.1

Rent price percent change has a low negative correlation with electricity price percent change over the past sixteen years. If a building owner is able sell carbon offsets in a market that has a low negative correlation with rents (in this example use electricity price change as a very rough proxy for carbon price changes), they can provide asset level cash flow diversification. Changes in rents would not have an effect on carbon offset pricing or resultant income.

Figure 21: Table: Correlation of Rent, Natural Gas, Electricity.

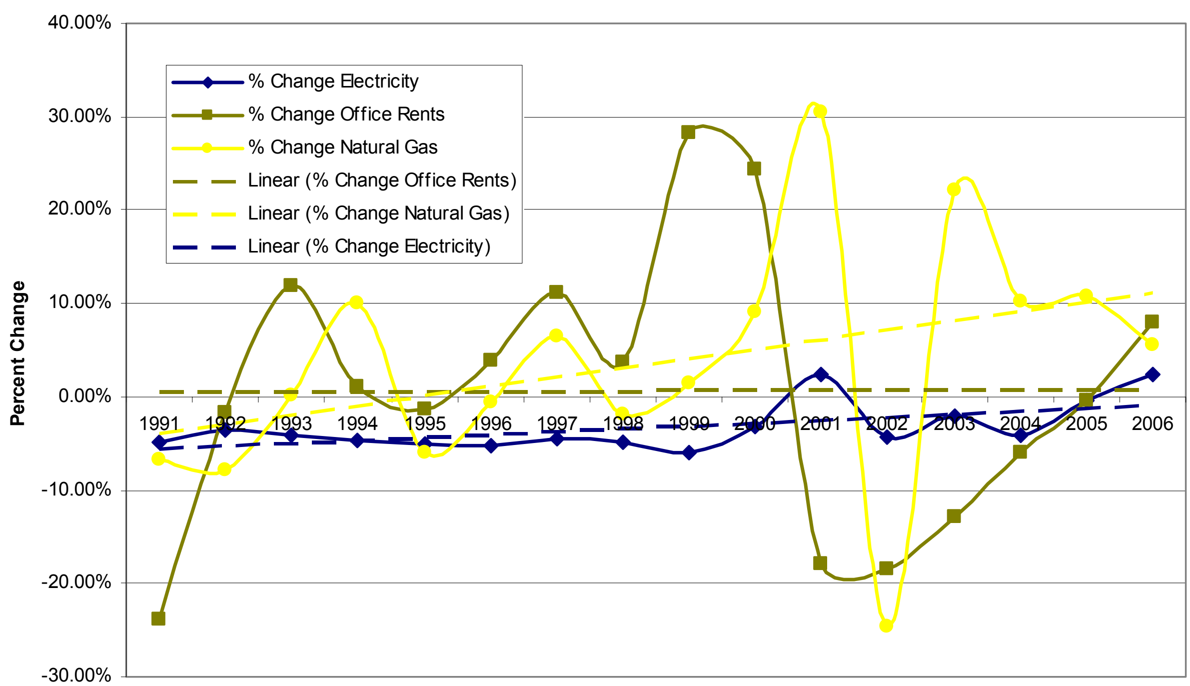
	% Change Electricity	% Change Office Rents	% Change Natural Gas
% Change Electricity	1		
% Change Office Rents	-0.207	1	
% Change Natural Gas	0.570	0.032	1

Figure 22 graphs percent changes from 1991 to 2006. A dashed linear trend line is also included to illustrate the long term trend of price change. An upward sloping line indicates that overall

[52] Data provided by Torto Wheaton Research.

percent change has been positive, i.e. prices are rising above inflation. Rent change is flat while electricity is slightly upward sloping and natural gas prices are sharply upward sloping. Over time energy costs are rising but rent is not keeping pace. As energy costs rise the impact on building operations and on asset value will grow. Triple-net lease tenants are also likely to become more energy cost sensitive as the cost and variability of their energy bills increases. This opens the door for assets that can demonstrate lower and more stable energy costs to be recognized as superior to those with greater tenant energy cost exposure. This trend is already emerging to some degree with new sustainable buildings. As more tenants request sustainable space, buildings that are not able to meet this demand face accelerated movement out of Class-A status. Energy efficiency is a key component of building sustainability and will play an increasing role in the determining the attractiveness of space to tenants.

Figure 22: Graph of Percent Change: Rent, Natural Gas, Electricity.

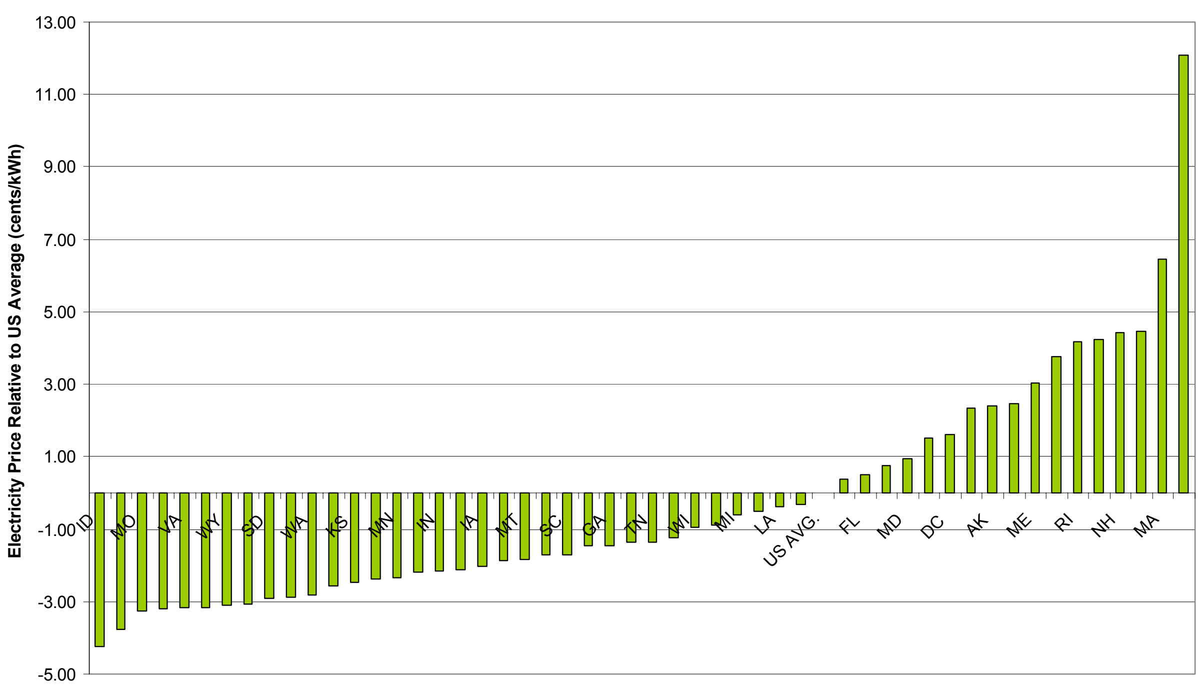


If and when a compliance market emerges in the US, the price of electricity in regions with higher carbon emissions will face upward pressure in the face of the cost to purchase emissions offsets to reduce utility GHG liability. Understanding the timing and likely range of utility price increases as a result of greenhouse gas regulation will allow building owners to further prioritize their decision to invest in energy efficiency improvements. These investments can help shield owners from rising energy prices where they have exposure in high carbon emitting utilities.

6.11 Energy Savings and Electricity Price

The next step in understanding opportunities to maximize value creation comes from the energy prices. For this examination I focused on electricity consumption because the case study building is an all-electric facility. Natural gas prices are also relevant for further study as a secondary source of building energy. Buildings consumed 39.05% of all energy in the US in 2006 and commercial buildings accounted for 18.0% of total US energy consumption.[53] Average 2006 commercial electricity prices per kilowatt hour range from a low of $0.0513 in Idaho to a high of $0.2141 in Hawaii, with a US average of $0.0920. Massachusetts average price was $0.158, the second highest in the US. This Boston case study has electricity prices 208% higher than the least expensive state, and 72% higher than the US average. There is significantly higher potential value for energy efficiency in regions with high electricity costs than in regions with much lower costs. *Figure 23* illustrates the states with energy costs above the national average.

Figure 23: Electricity Price by State Compared to the US Average



---

[53] "Annual Energy Review 2006; diagram 1: Energy Flow." Energy Information Administration. Washington DC. 2006.

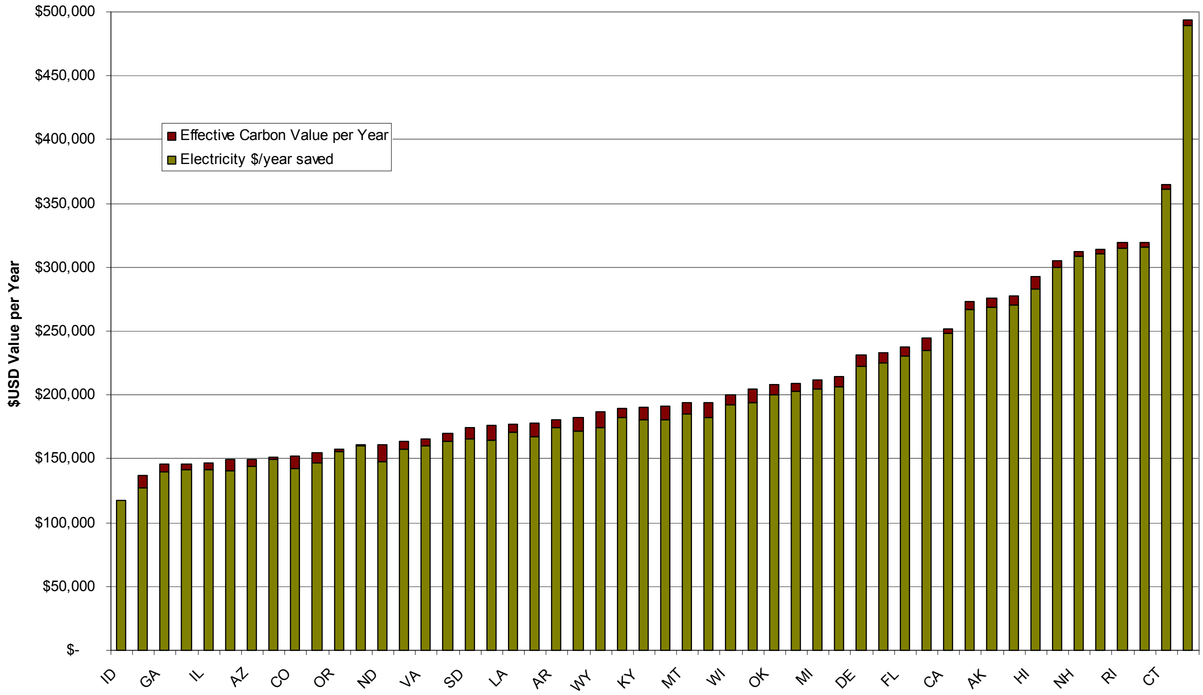
Given the variability of carbon emissions and electricity price by state (see *Appendix A*), there more advantageous locations than others for a building owner interested in maximizing their value between energy efficiency improvements and carbon offsets. By factoring the electricity price with the carbon emissions value of utility generated power, a relative ranking of states attractiveness to combined energy efficiency and carbon offsets can be created. Note the **bold** cells in *Figure 24* and *Figure 26*. These cells indicate a discontinuity between the electricity price and the total value creation when carbon offsets are factored in. This means that the marginal value of the carbon offsets is sufficient to make one state more attractive than another in spite of higher electricity costs. For example, Illinois (IL) electricity costs savings result in savings of $141,236, higher than Minnesota (MN) at $140,398. Looking only at energy costs, Illinois would be a preferable location to invest in efficiency improvement. But when carbon offset value is added in, the total value of Illinois increases to $146,742 while the value in Minnesota increases more to $149,318. In total, Minnesota becomes more attractive financially than Illinois. By *Total Value/Year*, states are ranked in order from least to most attractive in *Figure 24* and are illustrated in *Figure 25*.

Figure 24: Table of Utility Rates + Carbon Offset Value Attractiveness by State, Low Value

Effective Carbon Value		**$3.30**				
Case Study kWh saved		2,283,732				
State	**Effective CO@ Emissions (Lbs/kWh)**	**Effective (mTon CO2/Year)**	**Electricity cost cents/kWh**	**Electricity $/year saved($)**	**Effective Carbon Value per Year ($)**	**Total Effective Value per Year ($)**
ID	0.19	194	5.12	116,994	642	117,636
MO	2.76	2,855	6.11	127,477	9,421	136,899
GA	1.89	1,961	7.90	139,463	6,471	145,934
SC	1.33	1,383	7.65	141,538	4,563	146,101
IL	1.61	1,669	7.99	**141,236**	5,507	146,742
MN	2.61	2,703	7.03	**140,398**	8,920	149,318
AZ	1.74	1,805	7.89	143,773	5,958	149,731
WA	0.49	509	6.55	**149,674**	1,679	151,353
CO	2.87	2,978	7.48	**142,710**	9,827	152,537
NE	2.41	2,497	6.20	**146,992**	8,241	155,233
OR	0.61	634	6.99	155,371	2,092	157,463
VT	0.07	72	11.70	**160,545**	238	160,784
ND	3.87	4,004	6.30	**147,900**	13,214	161,113
PA	1.78	1,839	8.86	**157,372**	6,070	163,442
VA	1.80	1,864	6.18	**159,732**	6,150	165,881
NC	1.81	1,876	7.17	163,843	6,191	170,034
SD	2.63	2,723	6.44	**165,461**	8,984	174,445
NM	3.34	3,458	7.65	**164,864**	11,411	176,275

State	Effective CO@ Emissions (Lbs/kWh)	Effective (mTon CO2/Year)	Electricity cost cents/kWh	Electricity $/year saved($)	Effective Carbon Value per Year ($)	Total Effective Value per Year ($)
LA	1.69	1,755	8.97	**170,931**	5,791	176,722
IA	3.07	3,177	7.32	**167,155**	10,484	177,639
AR	1.79	1,855	6.80	**174,764**	6,123	180,887
WV	3.15	3,261	5.58	**171,566**	10,762	182,328
WY	3.53	3,654	6.25	**174,733**	12,058	186,791
AL	1.92	1,989	8.12	**182,541**	6,562	189,104
KY	3.09	3,202	6.48	**180,189**	10,567	190,756
KS	3.05	3,162	6.89	**180,486**	10,436	190,922
MT	2.42	2,502	7.51	**185,497**	8,257	193,754
UT	3.25	3,370	6.15	**182,729**	11,120	193,849
WI	2.51	2,600	8.41	192,010	8,580	200,590
IN	3.17	3,281	7.22	193,726	10,829	204,555
OK	2.54	2,628	7.25	199,921	8,674	208,595
TN	1.95	2,023	8.00	202,431	6,676	209,108
MI	2.06	2,131	8.75	204,808	7,031	211,839
MS	2.16	2,233	9.05	206,790	7,368	214,158
DE	2.70	2,795	10.89	222,188	9,224	231,411
NV	2.32	2,400	10.11	225,200	7,920	233,120
FL	2.04	2,111	9.86	230,782	6,968	237,750
OH	2.87	2,974	8.48	235,010	9,814	244,824
CA	0.80	830	13.13	248,656	2,740	51,397
TX	1.81	1,874	9.73	267,173	6,184	273,357
AK	2.20	2,274	11.75	268,245	7,505	275,750
MD	2.03	2,098	10.29	270,315	6,925	277,240
HI	2.77	2,866	21.43	283,029	9,458	292,487
MA	1.62	1,674	15.82	299,782	5,523	305,306
NH	1.07	1,108	13.79	308,816	3,658	312,474
NJ	1.01	1,045	11.84	310,296	3,447	313,744
RI	1.17	1,208	13.52	314,987	3,987	318,974
ME	1.06	1,095	12.39	315,712	3,612	319,324
CT	0.97	1,003	13.82	361,279	3,310	364,589
NY	1.22	1,264	13.59	489,462	4,173	493,634

Figure 25: Case Study energy Savings by State, Low Value



At low carbon value there are few instances where carbon offsets significantly change the investment attractiveness away from strictly energy cost savings, but they do exist. *Figure 26* and *Figure 27* illustrate the marginal value of carbon offsets in a high price scenario. Note the increasing number of states where the marginal carbon value impacts the overall attractiveness of that state, and the much higher carbon value as a percentage of total potential value creation illustrated in the graph by the darker portion of the vertical bars.

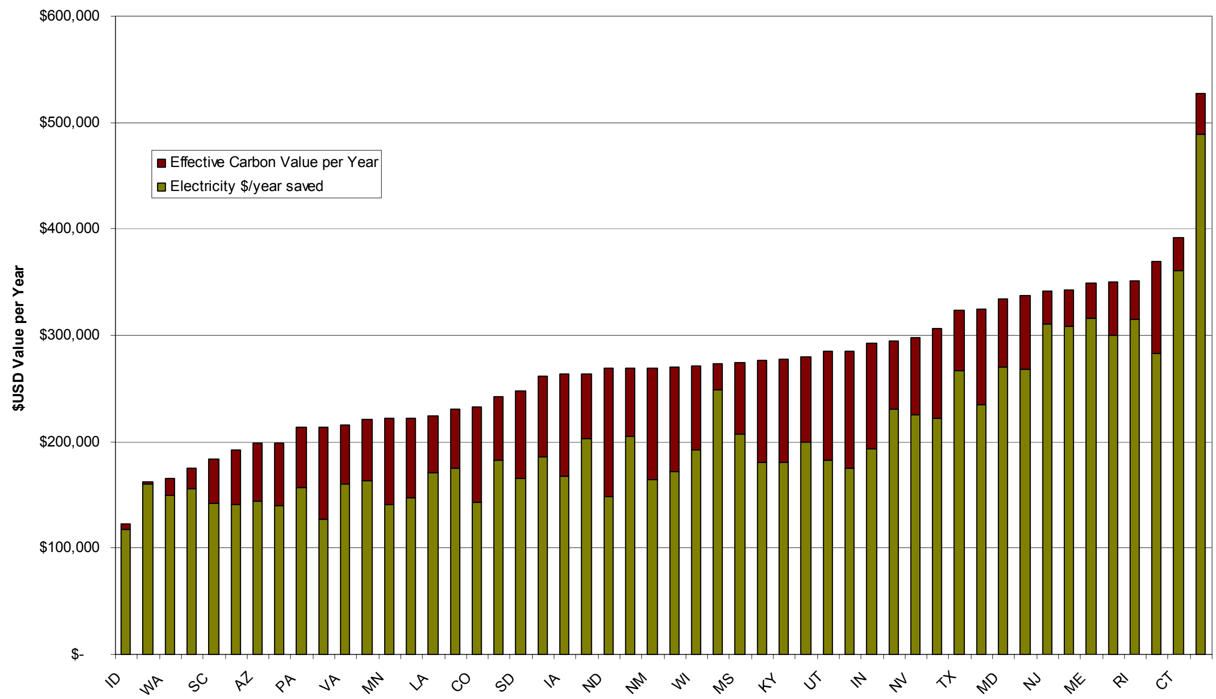
Figure 26: Table of Utility Rates + Carbon Offset Value Attractiveness by State, High Value

Carbon Value		**$30.27**				
Case Study kWh saved		2,283,732				
State	**Mton CO2/year**	**Effective CO2 by Region**	**Electricity cost cents/kWh**	**Electricity $/year saved**	**Effective Carbon Value/Yr.@$30.27**	**Effective Total $ Value/Year**
ID	0.19	194	5.12	**157,372**	5,887	163,259
CA	0.80	830	13.13	**141,236**	25,136	166,372
CT	0.97	1,003	13.82	**142,710**	30,359	173,069
AK	2.20	2,274	11.75	**116,994**	68,842	185,837
AL	1.92	1,989	8.12	**127,477**	60,194	187,671
AZ	1.74	1,805	7.89	**140,398**	54,648	195,046
AR	1.79	1,855	6.80	**139,463**	56,164	195,627
ME	1.06	1,095	12.39	**171,566**	33,131	204,697

State	Effective CO@ Emissions (Lbs/kWh)	Effective (mTon CO2/Year)	Electricity cost cents/kWh	Electricity $/year saved($)	Effective Carbon Value per Year ($)	Total Effective Value per Year ($)
GA	1.89	1,961	7.90	**147,900**	59,358	207,258
IL	1.61	1,669	7.99	**159,732**	50,512	210,244
FL	2.04	2,111	9.86	**146,992**	63,914	210,906
MA	1.62	1,674	15.82	**167,155**	50,662	217,817
LA	1.69	1,755	8.97	**165,461**	53,119	218,580
NH	1.07	1,108	13.79	**193,726**	33,550	227,275
DE	2.70	2,795	10.89	**143,773**	84,608	228,381
NJ	1.01	1,045	11.84	**199,921**	31,623	231,544
CO	2.87	2,978	7.48	**141,538**	90,140	231,678
MD	2.03	2,098	10.29	**170,931**	63,517	234,448
HI	2.77	2,866	21.43	**149,674**	86,757	236,431
MI	2.06	2,131	8.75	174,733	64,493	239,227
NC	1.81	1,876	7.17	182,729	56,787	239,516
NY	1.22	1,264	13.59	**206,790**	38,274	245,064
MS	2.16	2,233	9.05	**180,486**	67,589	248,075
OR	0.61	634	6.99	**230,782**	19,193	249,975
IA	3.07	3,177	7.32	**155,371**	96,167	251,538
MN	2.61	2,703	7.03	**174,764**	81,819	256,583
MT	2.42	2,502	7.51	**182,541**	75,737	258,278
KS	3.05	3,162	6.89	**163,843**	95,725	259,569
IN	3.17	3,281	7.22	**160,545**	99,330	259,876
KY	3.09	3,202	6.48	**164,864**	96,929	261,793
MO	2.76	2,855	6.11	**180,189**	86,421	266,610
NE	2.41	2,497	6.20	**192,010**	75,589	267,598
NV	2.32	2,400	10.11	**204,808**	72,649	277,457
RI	1.17	1,208	13.52	**248,656**	36,571	285,228
PA	1.78	1,839	8.86	**235,010**	55,678	290,688
OK	2.54	2,628	7.25	**225,200**	79,563	304,764
ND	3.87	4,004	6.30	**185,497**	121,206	306,703
NM	3.34	3,458	7.65	202,431	104,674	307,105
SC	1.33	1,383	7.65	**267,173**	41,856	309,029
OH	2.87	2,974	8.48	**222,188**	90,022	312,209
VT	0.07	72	11.70	310,296	2,185	312,482
WA	0.49	509	6.55	**314,987**	15,398	330,385
TN	1.95	2,023	8.00	**270,315**	61,240	331,555
TX	1.81	1,874	9.73	**283,029**	56,726	339,755
SD	2.63	2,723	6.44	**268,245**	82,410	350,655
VA	1.80	1,864	6.18	308,816	56,410	365,226
WI	2.51	2,600	8.41	**315,712**	78,706	394,418
UT	3.25	3,370	6.15	**299,782**	102,003	401,786
WV	3.15	3,261	5.58	361,279	98,721	460,000
WY	3.53	3,654	6.25	489,462	110,601	600,063

Figure 27 shows that in certain states carbon value is a significant portion of total value creation potential, from a little as 0.7% in Vermont to as much as 38.5% in North Dakota. In many instances carbon offsets have enough impact to make a more expensive utility area less attractive than one that with lower energy costs and higher emissions. Wisconsin and Utah are good examples. Electricity costs make Wisconsin more attractive, but when carbon offsets are factored in Utah becomes more attractive.

Figure 27: Case Study energy Savings by State, High Value



In both scenarios above across all states, energy prices and carbon emissions per kWh exhibit low negative correlation. This implies that there may be a slight association between lower CO_2 emissions and higher electricity cost as shown in *Figure 28*.

Figure 28: Table of Correlation between CO2 Emissions and Electricity Cost.

	CO2 Emissions by State	Electricity cost cents/kWh
CO2 Emissions by State	1	
Electricity cost cents/kWh	-0.323	1

6.12 Indirect Impact of Energy Efficiency Improvements

This chapter has so far addressed the direct financial impact of energy efficiency improvements and carbon offsets for buildings. There are other indirect benefits and risks that may be derived from building performance improvement. Potential benefits include:

- Higher tenant retention
- Fewer occupant complaints (temperature, lighting)
- Reduced building maintenance
- Reduced capital expenditures
- Lower energy price volatility
- Improved perception in the industry
- Better investor perception
- Higher occupant health and productivity (tenants)
- Better ability to attract and retain employees (tenant + owner)

Potential risks:

- Expenditure does not meet energy savings targets
- Predicted quantity of carbon offsets not able to be verified
- Tenant disruption and loss of productivity
- Building operations staff retraining
- Up-front investment in due diligence
- Discovery and disposal of hazardous material discovered during retrofit
- Transaction costs to quantify and sell carbon offsets
- Price fluctuations in carbon offset market
- Carbon market excludes real estate-derived offsets

Financial value creation is only one part of the decision to invest in energy efficiency improvements and carbon offset sales. Non-monetary factors may be seen as more important and more or less risky to an owner and influence their investment decision. Direct financial value and indirect operational improvements create opportunities to capture additional benefits from existing assets at low cost. This value can be created from both small efficiency gains and from much larger gains, as the office building case study and warehouse examples indicate.

Part III

Chapter Seven

7.0 Real Estate Industry Value

The case study exploration has followed two paths, energy efficiency improvements and carbon offset creation. Energy efficiency improvements generate carbon offsets; carbon offsets can provide sufficient funding to spur additional energy efficiency improvements. Both have been shown to have the potential to create value at the asset level. In this chapter I determine the industry-wide value that can be created through energy efficiency and carbon offsets. To provide a range of possible values, I assumed two scenarios: a 'low value' 6.75% energy cost savings and 'high value' 30% energy cost savings which equates to approximately 1% and 5% additional asset value respectively. This is based on the case study where 6.75% efficiency gains led to 1.1% greater asset value at the time of sale and 30% efficiency improvements increased asset value roughly 4.9% at the time of sale.[54] Using these values, energy savings alone are worth between $40.3 billion and $201 billion per year of the $4.03 trillion US commercial real estate market.[55]

1% x $4.03 trillion = $40.3 billion

5% x $4.03 trillion = $201 billion

Next I estimate the carbon offset value resulting from commercial real estate energy efficiency. This requires setting a benchmark of current sector-by-sector energy performance and then estimating the potential to economically exceed that benchmark. The value is dependent on a number of factors, including:

- Benchmark efficiency level
- Costs to exceed benchmark
- Carbon market demand for building-generated offsets
- Carbon offset prices
- Implementation of cap and trade system
- Capability of real estate to engage carbon market

---

[54] See *Figure* 16 and Figure *17*.
[55] "Investment Strategy Annual 2007." LaSalle Investment Management. 2006.

In aggregate across all states for the 6.75% efficiency improvement case study, the average value of carbon offsets as a percentage of the total energy cost savings was 3.63% in the low value (CCX) scenario to 24.3% in the high value (ECX) scenario.[56] Based on the aggregate energy savings calculation at the beginning of this chapter ($40.3 billion to $201 billion), the total carbon value range is between $1.46 billion and $48.8 billion per year. These calculations are illustrated in *Figure 29* for the 1% growth in asset value scenario and *Figure 30* for the 5% growth in asset value scenario. The 1% and 5% scenarios are compared in *Figure 31*.

Figure 29: Table of Energy Savings Value at 1% Growth in Asset Value.

	Carbon Value as % of Total Energy Cost Savings	Value ($billion)
Energy Efficiency (EE) Value		$40.3
Low Carbon value	3.63%	$1.46
High Carbon value	24.3%	$9.79
Total EE + Low Carbon Value		$41.8
Total EE + High Carbon Value		$50.1

Figure 30: Table of Energy Savings Value at 5% Growth in Asset Value.

	Carbon Value as % of Total Energy Cost Savings	Value ($billion)
Energy Efficiency (EE) Value		$201
Low Carbon value	3.63%	$7.30
High Carbon value	24.3%	$48.8
Total EE + Low Carbon Value		$208
Total EE + High Carbon Value		$250

Figure 31: Table: Summary of Market Value.

	Energy Savings Range ($ x billion)	Carbon Value 2.2%	Carbon Value 20%	Energy Efficiency + 2.2% Carbon	Energy Efficiency + 20% Carbon
1% Asset Value Growth	$41.8	$1.46	$9.79	$41.8	$50.1
5% Asset Value Growth	$208	$7.30	$48.8	$208	$250

56 Refer to *Figure 24* and to *Figure 26*. Divide "Effective Carbon Value per Year" by "Total effective Value per Year" to obtain this percentage, then average the result obtained for all states.

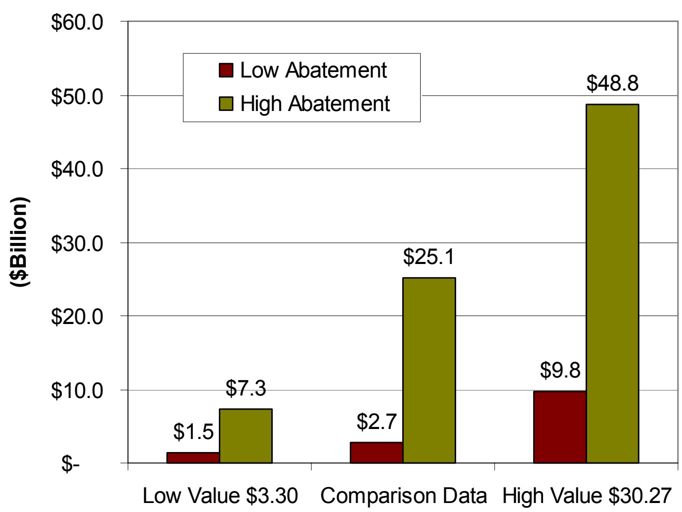
7.1 Comparison Data

The combined energy efficiency and carbon values range from $41.8 billion to $250 billion as shown in *Figure 31*. The carbon value calculated above can be compared to the estimate I calculated in *Figure 32* based on World Resources Institute and McKinsey data. This yields a range of $2.74 billion to $25.1 billion. This outcome falls within the range of prior calculations and is illustrated in *Figure 33*.

Figure 32: Table Estimating Value of Comparison Case.

Global Commercial Real Estate Market	$7,900	$Billion	
US Commercial Real Estate Market	$4,029	$Billion	(51.0%)
Potential Global Emissions[57]	26.7	Gigatons	
Potential Real Estate Emissions	3.7	Gigatons	(13.86%)
US Real Estate Share of Carbon Abatement	1.89	Gigatons	
Commercial Share of US Real Estate[58]	0.83	Gigatons	(44.0%)
US Commercial Real Estate Low Carbon Value	$2.74	$Billion	($3.30)
US Commercial Real Estate High Carbon Value	$25.1	$Billion	($30.27)

Figure 33: Value Range - Carbon Offset Estimates vs. Comparison Case.



The projections vary, but my estimates based on two different sources of data fall roughly in line across both high and low abatement and value scenarios. The first scales up from the case study

[57] Enkvist, Per-Anders, Tomas Naucler, and Jerker Rosander. "A Cost Curve for Greenhouse Gas Reduction". The McKinsey Quarterly. McKinsey & Co. 2007. Accessed online 25 June 2007.
[58] Baumert, Kevin A., Timothy Herzog, and Jonathan Pershing. "Navigating the Numbers; Greenhouse Gas Data and International Climate Policy." World Resources Institute. 2005.

and the second reduces down from aggregate global data supplied by McKinsey and the World Resources Institute. They indicate that the absolute values are large enough to warrant attention and further investigation. Owners who are aware of the energy savings potential and who also value carbon offsets can potentially tap into a significant revenue source to subsidize energy savings projects that are eligible to accrue carbon offsets.

7.2 Characteristics of Suitable Assets

My research and calculations have identified the potential value to the real estate industry resulting from energy efficiency and carbon offsets. In the list that follows I have compiled assets characteristics that are the most likely candidates for energy retrofits. The types of assets most suitable for energy efficiency can be described as:

- Obsolete or poorly maintained mechanical and electrical systems.
- The owner has the ability to accrue benefits to the energy savings.
- At least twenty years old and have not undergone systems retrofits replacement.
- High energy consumption relative to their competitors in a region and sector.
- Areas lacking stringent energy code provisions.
- Areas with commercial energy efficiency incentives.
- Inefficient exterior envelope systems (i.e. inefficient window wall systems).
- Owned and managed by non-industry leaders.
- Owned by entities that lack comprehensive energy efficiency and environmental responsibility programs.
- Use of less efficient energy sources (fuel oil vs. natural gas vs. geothermal) than what is currently available in the marketplace.
- Not equipped with building management systems and daylight monitoring.
- High peak time period power demands.
- Lacking energy recovery systems.
- Sectors where energy efficiency has not been a priority.
- Larger buildings or portfolio of buildings.

Real estate assets most suitable for carbon offset creation and trading can be described as:

- Located in a region with higher carbon emissions from utility power.

- Owner has clear rights to the environmental characteristics of the asset.
- Opportunity to switch from high emission fuel sources to lower emission sources (i.e. fuel oil to natural gas).
- Assets owned by entities that lack comprehensive energy efficiency and environmental responsibility programs.
- Assets not equipped with building management systems and daylight monitoring.
- Non-unique assets that can be benchmarked effectively within their sector.
- Ability to meet compliance period of carbon offsets.
- Geographically proximate assets where offsets can be aggregated.
- Expertise in energy efficiency and carbon credits on staff.
- Recertification capability to ensure long term value, especially upon asset disposition.
- Assets in sectors where energy efficiency has not been a priority.
- Larger buildings or portfolio of buildings.

There are a number of factors that make certain asset classes more attractive than others. In general, assets that are twenty or more years old and have not been well maintained, or have not undergone capital systems upgrades are worth scrutiny. Assets that are occupied by tenants with triple-net leases may have fewer incentives for building owners to invest in energy efficiency improvements. Additionally those assets located in areas where energy costs and carbon prices are highest will provide the most attractive returns on comparable retrofit investments. In all cases due diligence is required to balance the risks, costs, and opportunities of energy efficiency retrofits. But the opportunity for at least a modest level of improvement exists in virtually all real estate assets.

Chapter Eight

8.0 Conclusions

Energy efficiency improvements can be captured by building owners today to improve asset level cash flow, attract tenants, and reduce exposure to increasingly volatile energy prices. This is to some degree a known quantity – energy consumption has a real cost and reducing energy consumption has a quantifiable financial benefit. In contrast, greenhouse gas emissions are not as well understood, and the real estate industry has been largely indifferent to efforts to reduce emissions in other industries and in other parts of the world. My research examined the voluntary and regulated carbon markets to identify potential economic value that could be created by real estate if and when these markets develop a framework for real estate participation. My case study analysis concludes that this market presents an opportunity for real estate to become a provider of low cost carbon offsets to other industries that seek carbon abatement. In turn, real estate will benefit from higher asset values, improved building operational efficiency, and less vulnerability to rising utility costs. Globally the demand to abate greenhouse gas emissions can and should be addressed through the most economically feasible methods available today - energy efficiency improvements. The right market system and effective global participation that includes the real estate industry will allow much of this value to be unlocked.

8.1 Market Structure

Before this can happen, uncertainty surrounding the structure and implementation of the US greenhouse gas markets must be resolved. Real estate-specific protocols need to be developed that allow the industry to accrue offsets and supply them to the market. If the real estate industry can address concerns that real greenhouse gas emission reductions are occurring as offsets are accrued, this will alleviate the major market uncertainty today, that of additionality. In spite of the uncertainty today, leading real estate professionals firmly believe the carbon market is imminently arriving and will play a significant role in the future.

8.2 Case Study Summary

Through the Boston case study, I examined energy efficiency retrofits, and demonstrated how carbon credits could be accrued. I capitalized the offsets to determine if they are sufficient to fund further energy efficiency measures. In the case study the answer was a clear ‘yes’, exemplified by IRRs between 26% and 176% resulting from investments in energy efficiency and carbon offsets.

The case study also shows that the potential for significant value creation from energy efficiency improvements and from aggregating and selling carbon offsets is a targeted opportunity. The best building candidates are in states where energy prices are higher and where carbon emissions from primary sources (power plants) are greatest. Depending on the state, carbon value varied from less than 1.0% to over 38% of the total combined value of energy efficiency and carbon offsets. On average for the case study, carbon offset value ranged from 3.6% to 24% of the energy efficiency savings across all states when measured in low and high carbon price scenarios. As a result, assets in certain states benefit disproportionately from energy efficiency and carbon offsets.

Net asset value in the case study increases from 1.1% in a low carbon price scenario to 5.5% in a high carbon price scenario. In the low carbon price scenario nearly all this value resulted from energy efficiency, not carbon offsets. This indicates that if the carbon market develops slowly or inhibits real estate participation, the carbon value may not be worth capturing. But if prices rise as anticipated, a significant new source of revenue may be tapped.

Another area my research examined was the long term growth in energy costs compared to flat rental revenue. I also showed a low correlation between carbon markets and the office rental market, indicating that income from carbon offsets is not subject to the same influences as rental income and provides steady cash flow independent of local office market conditions. If carbon value is aggregated across a pool of assets there could be even greater stability and flexibility to obtain a steady cash flow from carbon offsets. In the same way, financial institutions that can pool carbon offsets from buildings may create securities based on a diverse pool of underlying real estate assets. As the value of carbon offsets grows, financial products like these are likely to enter the market.

8.3 Real Estate Industry Value Summary

The US commercial real estate market is $4.03 trillion, or 51% of the $7.9 trillion global market. Together commercial real estate efficiency improvements and carbon offsets could be worth between $41.8 billion and $250 billion per year globally. Of this total, the value of energy efficiency savings alone is between $40.3 and $201 billion annually. This represents between 1.0% and 6.1% of the total US market value. The potential value of the associated carbon offsets is currently low, but political and market forces are expected to push prices higher. The range of carbon offset value lies between $1.5 billion and $7.3 billion annually at current voluntary market prices. At compliance market prices the value increases to between $9.8 billion and $48.8 billion. To realize this value, a regulated greenhouse gas emissions market would have to develop that offers real estate the opportunity to supply carbon offsets. In this scenario, the carbon value alone ($48.8B) has the potential to add up to 1% to the current total value of US commercial real estate.

My research and case study exploration indicate that there is the potential to find untapped value in two ways; through energy efficiency improvements and through carbon offset creation. The former can be pursued today; the latter is in its infancy but there is significant economic potential that may be tapped as the market develops. Real estate industry advocates are advised to seek avenues to ensure the industry's participation in this growing market. Real estate professionals are advised to take stock of opportunities in their existing assets, and to follow this market closely in the coming years to understand the risks and capture the opportunities it will provide.

Appendix A: State by State Electricity Prices and Carbon Emissions

State	State annual NOx output emission rate (lb/MWh)	State annual CO2 output emission rate (lb/MWh)	State annual NOx output emission rate (lb/kWh)	State annual NOx output emission rate (lb/kWh) GWP Potential	State annual CO2 output emission rate (lb/kWh)	Total Effective CO2 Emissions (lbs. per kWH)
AK	3.679	1106.484	0.004	1.089	1.106	2.195
AL	2.098	1298.652	0.002	0.621	1.299	1.920
AR	1.726	1280.254	0.002	0.511	1.280	1.791
AZ	1.770	1218.864	0.002	0.524	1.219	1.743
CA	0.342	700.400	0.000	0.101	0.700	0.802
CO	3.002	1986.085	0.003	0.889	1.986	2.875
CT	0.723	754.186	0.001	0.214	0.754	0.968
DE	3.022	1803.732	0.003	0.895	1.804	2.698
FL	2.332	1348.031	0.002	0.690	1.348	2.038
GA	1.705	1388.331	0.002	0.505	1.388	1.893
HI	3.757	1654.736	0.004	1.112	1.655	2.767
IA	3.796	1943.284	0.004	1.124	1.943	3.067
ID	0.148	143.945	0.000	0.044	0.144	0.188
IL	1.541	1154.754	0.002	0.456	1.155	1.611
IN	3.614	2098.028	0.004	1.070	2.098	3.168
KS	3.994	1870.580	0.004	1.182	1.871	3.053
KY	3.514	2051.055	0.004	1.040	2.051	3.091
LA	1.665	1201.206	0.002	0.493	1.201	1.694
MA	1.316	1226.147	0.001	0.390	1.226	1.616
MD	2.475	1293.045	0.002	0.733	1.293	2.026
ME	0.962	771.833	0.001	0.285	0.772	1.057
MI	2.176	1412.673	0.002	0.644	1.413	2.057
MN	3.452	1587.518	0.003	1.022	1.588	2.609
MO	2.955	1881.391	0.003	0.875	1.881	2.756
MS	2.522	1408.978	0.003	0.747	1.409	2.155
MT	2.846	1572.928	0.003	0.842	1.573	2.415
NC	2.004	1217.818	0.002	0.593	1.218	1.811
ND	4.997	2386.309	0.005	1.479	2.386	3.865
NE	3.066	1503.084	0.003	0.908	1.503	2.411
NH	0.982	779.267	0.001	0.291	0.779	1.070
NJ	0.999	712.790	0.001	0.296	0.713	1.008
NM	4.548	1991.983	0.005	1.346	1.992	3.338
NV	2.514	1572.724	0.003	0.744	1.573	2.317
NY	1.059	907.159	0.001	0.313	0.907	1.221
OH	3.689	1778.971	0.004	1.092	1.779	2.871
OK	2.741	1726.042	0.003	0.811	1.726	2.537
OR	0.528	455.790	0.001	0.156	0.456	0.612
PA	1.890	1216.211	0.002	0.559	1.216	1.776
RI	0.322	1070.996	0.000	0.095	1.071	1.166
SC	1.419	914.816	0.001	0.420	0.915	1.335
SD	4.773	1215.369	0.005	1.413	1.215	2.628
TN	2.321	1266.009	0.002	0.687	1.266	1.953
TX	1.140	1471.637	0.001	0.337	1.472	1.809
UT	3.825	2120.814	0.004	1.132	2.121	3.253
VA	1.988	1210.537	0.002	0.588	1.211	1.799
VT	0.212	6.939	0.000	0.063	0.007	0.070
WA	0.443	359.933	0.000	0.131	0.360	0.491
WI	2.693	1712.915	0.003	0.797	1.713	2.510
WV	3.920	1988.026	0.004	1.160	1.988	3.148
WY	4.222	2277.504	0.004	1.250	2.278	3.527

Appendix B: IRR Analysis of Energy Retrofit Financing Examples

Retrofit Measures Cost	$(1,420,888)
Annual Electricity Savings	$ 427,224
Carbon Offset Value ECX	$ 50,670
Carbon Offset Value CCX	$ 5,524
Utility Incentive	$ 219,432
Financing: 10 yr. @ 6% interest	$ (189,297)
Financing: 4 yr. @ 6% interest	$ (400,435)

NOTES
Financing information based on discussion with Ameresco (ESCO) engineer
Assumes carbon credits are captured only during ESCO contract period
Assumes 10% transaction cost to create and sell carbon credits
Assumes lenders (B of A, CitiBank) will typically finance 100% of costs

#1 Energy Savings Only No Financing		Year 1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(1,420,888)									
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
TOTAL		(1,420,888)	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
IRR	26.4%										

#2 Energy Savings Only @ 100% 4 Yr.		Year 1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(400,435)	(400,435)	(400,435)	(400,435)						
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
TOTAL		(400,435)	26,789	26,789	26,789	427,224	427,224	427,224	427,224	427,224	427,224
IRR	38.6%										

#3 Energy Savings Only @ 100% 10 Yr.		Year 1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
TOTAL		(189,297)	237,927	237,927	237,927	237,927	237,927	237,927	237,927	237,927	237,927
IRR	125.6%										

#4 Energy Savings @ 100% + Carbon CCX		Year 1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
Carbon Offset Value (minus tx costs)	90%		4,972	4,972	4,972	4,972	4,972	4,972	4,972	4,972	4,972
TOTAL		(189,297)	242,899	242,899	242,899	242,899	242,899	242,899	242,899	242,899	242,899
IRR	128.2%										

#5 Energy Savings @ 100% + Carbon ECX		Year 1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
Carbon Offset Value (minus tx costs)	90%		45,603	45,603	45,603	45,603	45,603	45,603	45,603	45,603	45,603
TOTAL		(189,297)	283,530	283,530	283,530	283,530	283,530	283,530	283,530	283,530	283,530
IRR	149.7%										

#6 Energy Savings @ 100% + Utility Incentives		Year									
Upfront payment		1	2	3	4	5	6	7	8	9	10
Performance Contract retrofit measures		(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)	(189,297)
Contracted Energy Savings	100%		427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224	427,224
Utility Incentives up-front funded			109,716	109,716							
TOTAL		(189,297)	347,643	347,643	237,927	237,927	237,927	237,927	237,927	237,927	237,927
IRR	176.0%										

Example 1 shows the IRR based on out-of-pocket funding of retrofit measures by the owner.
Example 2 shows the IRR based on retrofits funded through a four year performance contract.
Example 3 shows the IRR based on retrofits funded through a ten year performance contract.
Example 4 shows the IRR based on retrofits funded through a ten year performance contract with low price carbon offset income.
Example 5 shows the IRR based on retrofits funded through a ten year performance contract with high price carbon offset income.
Example 6 shows the IRR based on retrofits funded through a ten year performance contract with utility incentives paid in year two and year three.

Appendix C: Case Study DCF for $3.30 Carbon Value Scenario

SF	1,028,345	
Est. sales price/RSF	$ 725	
Average rent	$ 52.00	
Gross Rent	$53,473,940	
Annual Energy Savings @ 6.75%	$ 427,224	
Energy Savings/RSF	$ 0.42	
Operating expenses Total	$ 12.72	
Utility Expense	$ 6.16	
Other Expenses*	$ 6.56	*Assumption
CCX Carbon Credits	$ 4,376	
ECX Carbon Credits	$ 40,135	
Discount Rate	4.50%	

BASE CASE

Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$ 6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$ 6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Real Estate Taxes		15%	($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$38,655	$858,995
NET OPERATING INCOME		($719,430)	**$32,374**	**$32,961**	**$33,557**	**$34,161**	**$34,775**	**$35,398**	**$36,030**	**$36,672**	**$37,323**	**$37,984**	$897,649	
IRR		6.16%												

CARBON CREDITS ECX

Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$ 6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$ 6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$427	$427	$427	$427	$427	$427	$427	$427	$427	$427	
Carbon Credit Sales				$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	$ 40.14	
Performance Contract DS			($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)		
Real Estate Taxes		15%	($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$39,122	$869,376
NET OPERATING INCOME		($719,430)	**$32,178**	**$33,232**	**$33,828**	**$34,432**	**$35,046**	**$35,669**	**$36,301**	**$36,942**	**$37,594**	**$38,255**	$908,497	
IRR		6.28%												

CARBON CREDITS CCX

Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$ 6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$ 6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$427	$427	$427	$427	$427	$427	$427	$427	$427	$427	
Carbon Credit Sales				$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	$ 4.38	
Performance Contract DS			($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)		
Real Estate Taxes		15%	($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$39,086	$868,581
NET OPERATING INCOME		($719,430)	**$32,178**	**$33,196**	**$33,792**	**$34,396**	**$35,010**	**$35,633**	**$36,265**	**$36,907**	**$37,558**	**$38,219**	$907,667	
IRR		6.27%												

UTILITY INCENTIVES

Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$ 6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$ 6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$427	$427	$427	$427	$427	$427	$427	$427	$427	$427	
Utility Rebates				$110	$110									
Performance Contract DS			($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)	($196)		
Real Estate Taxes		15%	($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$39,082	$868,484
NET OPERATING INCOME		($719,430)	**$32,178**	**$33,302**	**$33,897**	**$34,392**	**$35,006**	**$35,629**	**$36,261**	**$36,902**	**$37,554**	**$38,215**	$907,565	
IRR		6.27%												

Note: In these DCF models note the line for *Carbon Credit Sales* and for *Performance Contract Debt Service* in second and third examples. In the fourth example note the line for *Utility Incentives*.

Appendix D: Case Study DCF for $30.27 Carbon Value Scenario

RSF	1,028,345	
Est. sales price/RSF	$ 725	
Average rent	$ 52.00	
Gross Rent	$53,473,940	
Annual Energy Savings @30%	$ 1,899,765	
Energy Savings/RSF	$ 1.85	
Operating expenses Total	$ 12.72	
Utility Expense	$ 6.16	
Other Expenses*	$ 6.56	Assumption
CCX Carbon Credits	$ 20,471	
ECX Carbon Credits	$ 187,771	
Discount Rate	4.50%	

BASE CASE														
Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Real Estate Taxes	15%		($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$38,655	$858,995
NET OPERATING INCOME		($719,430)	**$32,374**	**$32,961**	**$33,557**	**$34,161**	**$34,775**	**$35,398**	**$36,030**	**$36,672**	**$37,323**	**$37,984**	$897,649	
	IRR	6.16%												

CARBON CREDITS ECX														
Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	
Carbon Credit Sales				$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	$ 187.77	
Performance Contract DS			$(866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)		
Real Estate Taxes	15%		($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$40,742	$905,384
NET OPERATING INCOME		($719,430)	**$31,508**	**$34,183**	**$34,778**	**$35,383**	**$35,996**	**$36,619**	**$37,251**	**$37,893**	**$38,544**	**$39,205**	$946,127	
	IRR	6.68%												

CARBON CREDITS CCX														
Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$ 1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	
Carbon Credit Sales				$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	$ 24.57	
Performance Contract DS			($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)		
Real Estate Taxes	15%		($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$40,579	$901,758
NET OPERATING INCOME		($719,430)	**$31,508**	**$34,020**	**$34,615**	**$35,220**	**$35,833**	**$36,456**	**$37,088**	**$37,730**	**$38,381**	**$39,042**	$942,337	
	IRR	6.63%												

UTILITY INCENTIVES														
Calendar Years Ending:			2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Effective Gross Income			$53,474	$54,276	$55,090	$55,917	$56,755	$57,607	$58,471	$59,348	$60,238	$61,142	$62,059	
Operating Expenses														
Utilities	$6.16		($6,333)	($6,428)	($6,524)	($6,622)	($6,721)	($6,822)	($6,924)	($7,028)	($7,134)	($7,241)	($7,349)	
Other Expenses	$6.56		($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	($6,746)	
Efficiency Savings				$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	$1,900	
Utility Rebates				$250	$250									
Performance Contract DS			($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)	($866)		
Real Estate Taxes	15%		($8,021)	($8,141)	($8,264)	($8,387)	($8,513)	($8,641)	($8,771)	($8,902)	($9,036)	($9,171)	($9,309)	Reversion
													$40,555	$901,212
NET OPERATING INCOME		($719,430)	**$31,508**	**$34,245**	**$34,841**	**$35,195**	**$35,809**	**$36,432**	**$37,064**	**$37,705**	**$38,357**	**$39,018**	$941,766	
	IRR	6.63%												

Note: In these DCF models note the line for *Carbon Credit Sales* and for *Performance Contract Debt Service* in second and third examples. In the fourth example note the line for *Utility Incentives*.

References

"Annual Energy Review 2006; Diagram 1: Energy Flow." Energy Information Administration. Washington DC. 2006.

Barker, Terry et al. "Climate Change 2007: Mitigation of Climate Change; Summary for Policymakers". Intergovernmental Panel on Climate Change. United Nations Environment Programme. 23 May 2007.

Baumert, Kevin A., Timothy Herzog, and Jonathan Pershing. "Navigating the Numbers; Greenhouse Gas Data and International Climate Policy." World Resources Institute. 2005.

Bayon, Ricardo et al. Voluntary Carbon Markets. Sterling, VA, Earthscan, 2007.

Better Buildings leaflet. European Commission. 2003. Accessed online 24 June 2007. <http://ec.europa.eu/energy/demand/legislation/doc/leaflet_better_buildings_en.pdf>

Brown, Marilyn A., et al. *Towards a Climate Friendly Built Environment*. Pew Center on Global Climate Change. June 2005. <http://www.pewclimate.org/docUploads/Buildings%5FFINAL%2Epdf>

"Buildings and Climate Change; Status, Challenges, and Opportunities". United Nations Environment Programme. 2007. <http://www.unepsbci.org/>

"Building Energy Codes Program". U.S. Department of Energy; Energy Efficiency and Renewable Energy Accessed 8 July 2007. <http://www.energycodes.gov/implement/state_codes/state_status_full.php>

"Buildings Must Be Part of Carbon Emissions Trading Scheme". Lend Lease press release. 4 June 2007. Accessed 24 June 2007. <http://www.lendlease.com.au/llweb/llc/main.nsf/all/news_20070406_llc_2>

"Carbon Dioxide Emission from the Generation of Electric Power in the United States". Department of Energy and Environmental Protection Agency. Washington DC. July 2000.

"Carbon Trading Fact Sheet." Clifford Chance Client Briefing. Clifford Chance. March 2006.

"The Voluntary Offset Market; a Primer". Clifford Chance. Client Briefing. May 2007.

Carr, Matthew. "Pollution Permits Burn European Consumers". Bloomberg.com. 18 June 2007.

"CB Richard Ellis Group, Inc. Announces Carbon Neutral Goal and Plans for Assisting Clients with 1.7 Billion S.F. of Properties Worldwide on Carbon Reduction Programs". CB Richard Ellis press release. 31 May 2007. Accessed online 27 June 2007.

"2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables; Table B4". Energy Information Administration. Washington DC. December 2006.

"2003 Commercial Buildings Energy Consumption Survey: Building Characteristics Tables; Table B9". Energy Information Administration. Washington DC. December 2006.

"CoStar Group Promotes Energy Efficient, Sustainable Green Buildings by Adding EPA's ENERGY STAR® Rating to Commercial Properties in its Database". CoStar Group press release. 12 February 2007. Accessed online 29 June 2007. <http://www.costar.com/Corporate/Press/Release.aspx?c=2620&ekmensel=8_submenu_76_link_2>

De Los Angeles Tapia-Ahumada, Karen. "Are Distributed Energy Technologies a Viable Alternative for Institutional Settings? Lessons from MIT Cogeneration Plant." *Massachusetts Institute of Technology*. September 2005.

Ebbert, Stephanie. "Mass Steps Up Climate Rules for Developers." Boston Globe. 22 April 2007. <http://www.boston.com/news/local/articles/2007/04/22/mass_steps_up_climate_rules_for_developers?mode=PF>

"eGrid2006 Version 2.1 (April 2007) Year 2004 Summary Tables. NERC Region Emissions." Environmental Protection Agency. Washington DC. April 2007. <http://www.epa.gov/cleanenergy/egrid/index.htm>

"Energy Efficiency Protocol for Warehouses." The Chicago Climate Exchange. Chicago, IL. 2006.

Enkvist, Per-Anders, Tomas Naucler, and Jerker Rosander. "A Cost Curve for Greenhouse Gas Reduction". The McKinsey Quarterly. McKinsey & Co. 2007. Accessed online 25 June 2007.

Kyoto *Protocol to the United Nations Framework Convention on Climate Change*. <http://unfccc.int/resource/docs/convkp/kpeng.html>

"Fireman's Fund Introduces Green Building Coverage". Insurance Journal. 16 October 2006.

"Global Mapping of Greenhouse Gas Abatement Opportunities". Vattenfall AB. January 2007.

"Green Businesses Get Insurance discounts". Progressive Investor. 21 June 2007. Accessed online 26 June 2007. <http://www.sustainablebusiness.com/features/feature_template.cfm?ID=1463>

"Investment Strategy Annual 2007." LaSalle Investment Management. 2006.

Loftness, Vivian et al. "Building Investment Decision Support". Carnegie Mellon University Center for Building Performance and Diagnostics. Pittsburgh, PA. 2005.

Mills, Evan et al. "The Cost-Effectiveness of Commercial-Buildings Commissioning; A Meta-Analysis of Energy and non-Energy Impacts in Existing Buildings and New Construction in the United States." *Energy Efficiency and Renewable Energy, Building Technologies Program, U.S. Department of Energy.* 15 December 2004. <http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html>

Mufson, Steven. "Companies Gear up for Greenhouse Gas Limits." Washington Post. 29 May 2007. Accessed 28 June 2007. < http://www.washingtonpost.com/wp-dyn/content/article/2007/05/28/AR2007052801050.html>

Musier, Reiner. *US Mandatory REC Markets – An Established Environmental Infrastructure. APX Inc*. 2006.

"President Clinton Announces Landmark Program to Reduce Energy Use in Buildings Worldwide". Clinton Climate Initiative press release. Clinton Foundation. 16 May 2007. Accessed online 26 June 2007. <http://www.clintonfoundation.org/051607-nr-cf-pr-cci-president-clinton-announces-landmark-program-to-reduce-energy-use-in-buildings-worldwide.htm>

Roine, Kjetil ed. Carbon 2007: A New Climate for Carbon Trading. Point Carbon. 13 March 2007.

See, Wee Chiang. *Carbon Permit Prices in the European Emissions Trading System: A Stochastic Analysis*. *Massachusetts Institute of Technology*. June 2005.

"The Voluntary Offset Market; A Primer". Client Briefing. Clifford Chance LLP. May 2007.

"Updated State-Level Greenhouse Gas Emission Coefficients for Electricity Generation 1998-2000". Office of Integrated Analysis and Forecasting. Energy Information Administration. Department of Energy. Washington DC. April 2002.

"UN Findings on Costs of Fighting Global Warming." Planet Ark. May 7, 2007. <http://www.planetark.com/dailynewsstory.cfm/newsid/41754/story.htm>