Retrofitting Commercial Real Estate: Current Trends and Challenges in Increasing Building Energy Efficiency

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Abstract

The U.S. has invested billions of dollars to simultaneously improve its energy independence, create jobs, and reduce environmental impacts. Under the American Recovery and Reinvestment Act of 2009 alone, over 27 billion dollars were allocated to improving energy efficiency and renewable energy research and investment. While supply-side technologies receive the most press, energy consumption reducing technologies can also yield many of the same benefits. Currently, commercial real estate buildings constitute 18% of all U.S. energy consumption and have potential for significant reductions through cost-effective energy retrofits. Due to the complexities of the industry, however, these retrofits are not being installed. Our research is focused on identifying these complexities and establishing a better understanding of commercial building retrofits.

Building owners and tenants have primarily stayed away from energy efficiency upgrades to their buildings because of perceived high upfront costs and uncertain returns. To analyze this line of thinking, we examine 129 commercial building retrofit reports to explore financial trends and returns. In addition, we surveyed organizations that perform energy efficiency retrofits to gain better perspective about the market and the drivers that relate to it. For conformity, our research focuses on insulation, lighting, HVAC, and solar retrofit projects.

Our findings help build a foundation for understanding the current state of commercial building retrofits. The retrofit report data suggests that lighting is the least expensive retrofit while HVAC is the most expensive to install per square foot. Despite this, our surveys indicate that most organizations are primarily interested in HVAC commercial building upgrades. Both the retrofit report analysis and survey results suggest that decision makers expect a payback period between three and five years.

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I. BACKGROUND

With rising energy costs and the impetus to reduce greenhouse gas emissions, modernizing U.S. electric infrastructure and modifying current means of energy consumption have become a hot topic for politicians, business leaders, and academics alike. Often overlooked in favor of supply-side technologies (i.e. nuclear and wind power), energy reducing building retrofits can also yield many of the same supply-side benefits.

This is especially true for the commercial real estate sector as U.S. commercial buildings alone account for a fifth of total domestic energy consumption or approximately 100 billion USD in annual power costs (EIA 2006). Research has identified that the average U.S. commercial building has the potential to reduce its energy costs by approximately 22% through energy efficiency retrofits because most were built prior to 1990 and still use outdated, energy-inefficient technologies and building materials (EIA 2006). Through a diverse set of commercial building retrofit options, owners can cost-effectively reduce their building's energy consumption and environmental footprint. Despite these benefits, retrofit projects are still only slowly being implemented. The problem? Decision makers, such as building owners and tenants, have few resources to value a retrofit. This is especially true since retrofit returns are unique to each building and depend on local factors such as subsidies and electricity costs. Furthermore, the proprietary nature of commercial building contracts exacerbate the lack of public commercial retrofit data. This paper attempts to (1) frame the current roadblocks to commercial real estate retrofits, (2) identify areas of future study, (3) provide recommendations for policy makers and commercial building property affiliates.

This research paper is designed to expand the general knowledge of energy efficiency in the commercial real estate sector. In particular, we hope our paper will frame realistic expectations for commercial building retrofits to start a path toward more retrofit-friendly policies and contracts. Our initial research goal was to analyze the energy consumption of previously retrofitted buildings by lease structure, electricity price, finance methods, and retrofit type. We discovered that current public retrofit data did not provide sufficient details to analyze energy efficiency and commercial real estate in this way. For example, it was not feasible to explore the role of lease agreements in much depth due to their proprietary nature. Thus our goal became to provide a basis for future analyses of commercial energy efficiency retrofits. To do this, basic post-retrofit data was compiled from 129 industry and academic retrofit reports (Appendix E). We also consulted representatives from energy service companies (ESCOs), utility companies, and academic professionals to support our retrofit report data. Additionally, a template was developed for future studies to evaluate completed retrofits. The complete spreadsheet is available from the Institute of the Environment and Sustainability department web page at the University of California at Los Angeles (UCLA).

Based on our research experience, the main obstacle to retrofits is the proprietary nature of commercial building energy consumption. The information sharing problem can be rooted back to the nondisclosure agreements in most commercial building lease structures. As a result of nondisclosure agreements, the results from successful retrofit projects are rarely reported. Many commercial leases have another characteristic that hinders retrofit implementation. Under a conventional lease, the tenant pays the majority of the operational costs such as lighting and climate control. Therefore, owners have little incentive to retrofit their building's infrastructure because the savings would be primarily realized by the tenant. The problem is known in literature as the "split incentive". Since little post-retrofit data exists, prospective owners and tenants have little benefit data to weigh against retrofit costs. It is unsurprising then that approximately two-thirds of owners and tenants cited high first costs as a significant challenge to a green retrofit (McGraw-Hill 25). This underscores the importance to publish the costs and savings of completed retrofits to reduce uncertainty and encourage property owners to make rational retrofit decisions.

Context

The energy infrastructure of a building is rarely upgraded after the initial construction (Kats 2003) although the benefits of retrofits are financially appealing to both property owners and tenants. Property owners benefit from increased property values, reduced electricity costs, and rent premiums (Kats 2003). Similarly, tenants benefit from reduced electricity costs and, in some cases, improved worker productivity. Specifically, direct financial benefits were identified as the primary motivations to retrofit a building (McGraw-Hill 2009). Despite these benefits, decision makers often choose not to make energy efficient upgrades because of perceived high up-front costs (Langdon 2007). For this reason, we expected that the profit-driven investment goals would dictate retrofit decisions: the most popular retrofits would have low payback periods (and less risk) and high return on investments (ROI).

Funding is also a barrier to retrofits. Even if a building owner or tenant wants to install a retrofit, finding funding to do it is not a simple process. Most lenders do not have the expertise to perform an audit needed to develop fair rates or contract terms. Furthermore, the 2008 financial crisis has resulted in credit restrictions. As a result, retrofits are primarily being funded by only those with large pocketbooks: evidenced by company profits being the primary funding source for green retrofits (McGraw-Hill 2009).

The most common retrofits promote better insulation, optimized building management, and modern lighting technology (Kok 2010). Our project focuses on retrofits related to these three variables. One reason why these retrofit types are the most common is because they produce ROIs and are easily installed (Kok 2010). We also included rooftop solar panel installations in our analysis to compare how the popular technology compared with the more fundamental retrofit types. We felt that including solar was important, as many public and private resources are devoted to rooftop solar installations.

Environmental benefits are also associated with reduced energy consumption. For example, the average building certified by the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) rating system uses 32 percent less electricity resulting in approximately 350 fewer metric tons of carbon dioxide emissions (Deloitte &

Lockwood 2008). In another study, the simple replacement of single glazed windows with double glazed windows resulted in the reduction of natural gas and heating and electrical cooling energy consumption by more than 10 percent (Martin 2008). Considering the sheer volume of building energy use, small changes can aggregate to significant environmental and economic benefits.

Technology and Retrofits

Since decision makers are concerned with the large upfront capital needed for retrofit installations, it is important to explore the long-term benefits of energy efficient technologies from a cost-benefit perspective. One of the largest barriers that impedes the adoption of energy efficient retrofits in commercial properties is the building owners' false belief that energy retrofits are too expensive. Contrary to this belief, empirical evidence shows that green retrofits are often profitable (Binkley 2007).

The most common tools used for energy efficiency include energy efficient technologies for heating and air conditioning systems, improved insulation, and the use of more natural lighting. These retrofit options are often considered due to simple installation and proven monetary returns (Bonda 2007). Nevertheless, the benefits from retrofit technologies are ambiguous to its key stakeholders. The ROI of each retrofit technology depends on a multitude of variables including the current state of the building, the specific technology implemented, and the available financial incentives. Expectations vary widely on what types of retrofits offer the highest returns on their investments. In addition, owners of buildings may not know that many utility companies offer free or inexpensive energy audit (Binkley 2007).

Lighting

Buildings that use excessive or inefficient lighting systems may implement lighting system upgrades that range from simple changes to a complete replacement. Occupancy sensors and time clocks are examples of simple energy saving controls that can automatically reduce hours of lighting. LED technology is another lighting retrofit that provides significant energy savings of up to 70 percent over time, making the replacement worthwhile.

Heating, Ventilation, and Air Conditioning (HVAC)

A HVAC system provides buildings with adequate air flow, heating, and cooling. A relatively new technology, the continuous environmental management systems (EMS) can be installed to monitor energy use and automatically adjust temperature settings accordingly. Within each HVAC system, there is a set of components that could be also be improved. For example in one system, an old boiler, furnace, and heat pump can be improved to increase energy efficiency.

Insulation

Insulation upgrades including weather stripping, weather sealing, and the replacement of old doors and windows with high-performance versions, also provide improvements with a quick payback period. Upgrading windows may also increase personal comfort and productivity by reducing drafts and noise, attracting more occupants for residential buildings in large cities, and providing employees with a work-conducive environment (Katz 2008).

Rooftop Solar (Photovoltaics)

Rooftop solar panels directly convert the sun's radiation to electricity. Solar panels produce few emissions and require minimal maintenance beyond the initial installation. Solar power is also the only type of retrofit that adds to a building's energy supply, rather than reduce energy consumption in our study. The main drawback of rooftop photovoltaic power is that it is widely recognized as the most expensive type of renewable energy.

Government Financial Incentives

The government provides a large source of financial backing for energy efficient projects. Monetary incentives for commercial retrofits have been established at the federal, state, and local levels. These incentives make energy efficient retrofit projects more feasible to pursue. The Energy Policy Act of 2005 awards tax deductions to building owners who install interior lighting, building envelopes, hot water, heating, cooling, and ventilation systems (DSIRE). Corporations can also benefit from the Business Energy Investment Tax Credit by being awarded up to 30% of expenditures for the installation of renewable energy technologies (DSIRE**).** More recently, the American Recovery and Reinvestment Act of 2009 modified and expanded the government incentives set forth in Energy Policy Act and designated 12 billion dollars for energy efficiency programs and projects**.** The Recovery Act has allocated $37 million for efficient lighting projects and over $76 million for advanced energy efficiency projects (ARRA 2009).

Three specific subsections of the Recovery Act are particularly relevant to the commercial real estate sector: the Energy Efficiency and Conservation Block Grants, the Butter Buildings Initiative, and the State Energy Program. The Energy Efficiency and Conservation Block Grant (EECBG) Program has a total of $3.2 billion to allocate to energy efficiency and conservation programs and projects, including commercial real estate (ARRA 2009). The Better Buildings Program creates tax deductions and provides more financing opportunities for building retrofits, with the ultimate goal of a 20% increase in energy efficiency in buildings by 2020 (ARRA 2009). Under the State Energy Program, the California Energy Commission has allocated $226 million to disperse for energy efficient programs and projects (CEC 2011). More legislation is being sent through Congress to continue and expand upon such established federal incentives (USGBC 2011).

At the local level, many municipalities have taken measures to simplify the process and develop financial incentives for energy efficient installations from federal funding. Specifically, local municipalities have reduced or waived permitting fees, expedited the permitting process, provided tax deductions, offered revolving loan funds or grants, as well as technical and marketing assistance (USGBC 2011). Local utility companies have also created programs to incentivize commercial retrofits. In particular, the Los Angeles Department of Water and Power (LADWP) offers programs to encourage retrofits among the commercial real estate industry. The available programs and available government capital is favorable for the commercial real estate industry, yet is not seen to be utilized or documented in current research of the industry.

The PACE Bond
One popular type of local incentive is called a PACE bond. Within two years of the first PACE bond, states had already applied for $80M of federal funds to supplement their own PACE programs (ULI 27). A PACE bond has the basic structure of a typical government issued bond: in exchange for immediate cash, the government repays the borrowed money plus interest after a predetermined number of years. Bond revenues normally finance public goods such as bridges and dam construction. In this respect, PACE bonds are unique because PACE bond revenues are invested in private property in the form of solar panels and other energy efficiency upgrades. They are also 'revolving' – meaning that instead of a one-time payment like a subsidy, the initial investment is eventually recouped by the government. PACE bonds were originally developed in 2007 to allow Berkeley residents to install solar panels on their homes. Few homeowners had sufficient money to pay for a $20,000 photovoltaic system upfront even though the expected energy savings from installation would exceed $20,000 over a 20 year period (Jenkins 2009). PACE bonds allow these future energy savings to finance the initial upfront cost of the photovoltaic system. Applying PACE bonds to commercial real estate, the initial investment would finance a retrofit such as new insulation and ventilation systems instead of a solar panel.

Property owners must consult their mortgage broker before they can enroll in a PACE program. In order to reduce risk (and lower interest rates), the property tax increases derived from PACE programs are given a special priority termed a lien. The lien ensures the PACE program will be paid before other lenders if the property owner were to default on their payments (Timiraos 2010). Although liens have been used to fund local projects, brokers have especially weary of their application to PACE bonds. As a major setback to PACE bonds, a large government-backed mortgage broker, Fannie and Freddie Mac, announced that it will not allow any of the properties financed to use PACE bonds. In response, a PACE pilot program consisting of 300,000 homes has been proposed by Congress (Hiskes 2010). The PACE setback is one prominent example of how risk can hinder retrofits.

Profit Sharing & Leases

Lease agreements form the backbone of commercial real estate business. The terms agreed upon in the lease contract determine both the financial and maintenance responsibilities of the tenant and the owner. Thus, understanding the logistics of lease agreements is essential in order to implement energy efficient retrofits. A lease contract is an agreement made between the owner of the building or landlord, who is the lessor, and the tenant, who is the lessee. This contract validates the tenant's use of the owner's property to operate his/her business in exchange for monetary payments made to the landlord. In commercial real estate, the most common lease arrangements include full service gross lease, net lease, and percentage lease.

Under each of the lease arrangements, it is important to note that the lessee pays for utility expenses in accordance to the utility quantity used by each tenant. While there may be variations of these basic lease agreements, where the lessor agrees to cover utility costs, these variations are stated in the individual contract. The structure of these individual lease agreements plays a big role who will be willing (the lessor or lessee) to invest in energy efficient retrofits. Though an understanding of lease agreements would provide a more detailed understanding of the complex funding structure for undergoing an energy efficiency retrofit, we were not able to gain access to specific lease agreements.

A key issue that is preventing commercial properties from undergoing energy efficient retrofits is the split incentive problem. The incentive issue indeed takes root from the terms agreed upon by the lessor and lessee in a lease agreement. The split-incentive problem arises in a net lease, when the landlord is indifferent to reducing utility costs that are otherwise paid for by the tenant and the tenant's inability to control overall energy consumption. The split-incentive problem is also apparent in certain modified gross leases where the tenants' utility costs are capped and the tenant therefore has no economic incentive to conserve energy usage subject to the cap (Brooks 2008). Prior to our research, our group was indeed aware of such financial complications and thus sought to further learn of these complications through thorough assessment of current retrofit reports.

ESCOs (Energy Service Companies)

With rising energy costs, the market potential for energy efficient retrofits has just started to be explored. A 2008 McKinsey Global Institute study found that there are potential market profits of $170 billion annually at a 17 percent annual rate of return for offsetting energy consumption and lowering carbon emissions (Farell 2008). This finding represents a strong incentive for businesses to enter the energy efficiency market.

The ESCO business model has existed since the 1970s, but has historically struggled due to complicated contracts (McGraw-Hill 2009). From the supply side, ESCOs take advantage of deregulated energy markets and sell energy that they either created or purchased (Frank 2008). From the demand side, ESCOs offer building retrofits or redesign systems to reduce energy consumption. ESCO revenues are directly generated through from these energy reductions. After building owners receive a small percentage of the savings, future savings are given to the ESCO. While manufacturers are limited to their product line and utilities are limited by government-imposed regulations, ESCOs have much more freedom in their retrofit recommendations.

Understanding the role ESCOs have played in past commercial projects is vital in understanding the success or shortcomings of a retrofit. Whether the ESCO provides a percentage or all of the upfront retrofit cost, the ESCO allows the commercial sector an alternative mechanism to conventional lending sources. By conducting surveys and analyzing the available current retrofit reports our group will provide academics with a clearer picture of the financing involved in commercial real estate projects. Collection of such data will help those in the commercial real estate industry to understand the numerous forms ESCOs may take.

Research Gaps

We found that literature regarding both returns on commercial real estate retrofits and funding sources was lacking in availability and depth. This review was based on the reports of government agencies, the publications of various research groups and real estate companies, and journal articles. Few peer reviewed journal articles were used in this review because the academic literature on energy efficient retrofits in commercial real estate is sparse. The academic literature associated with commercial retrofits and associated financing mechanisms to accommodate longer payback periods associated with green-retrofits is sparse. The majority of technical literature is funded by the federal government (Lantz 2010, CEQ 2009, Bolinger 2009, Goldman 2005, Torcellini 2006). For this reason, these papers have a macro-level focus that describe how government can stimulate energy efficiency. Most literature also does not account for the different motivations for commercial, residential, and government retrofits. While one study did investigate the role of leases on energy retrofits, it was based off of UK data. Therefore, its relevance to the United States is questionable (Sayce 2007).

Our review found that most literature related to commercial real estate retrofits is empirical and based off of estimated figures rather than observed data. Without clear expected gains, building owners are reluctant to commit themselves to investments that have payback periods of fifteen to twenty years. Typical commercial real estate infrastructure improvements have payback periods no more than three years (Ellis 2008).

Thus, the quantitative data needed to analyze the cost and energy savings and building of a retrofit is not published or readily available.

Energy savings records from certain building retrofits exist, however the data is normally proprietary. For example, the US Green Building Council charges $100 per case (USGBC 2011). In contrast, the National Renewable Energy Laboratory's *Lessons Learned from Case Studies* provides free access to detailed energy audits of six buildings. However, the report focused on new 'green' buildings rather than retrofitted buildings. Similar to other reports, the NREL did not detail the specific ways that these buildings were financed.

While researching the government's role in financing green commercial projects we found that the government has already had success with clean energy finance programs. For example, the Oregon Small Scale Energy Loan Program (SELP) has a very low, 0.1%, delinquency rate (Lantz 2010). Although the low rate can be attributed to the program's willingness to restructure loans, it shows that clean energy loans can be very successful. In addition, the federal government has set aside $80M of federal funds to supplement their state PACE programs (ULI 2010). Nevertheless, studies analyzing the risk of green finance relative to other options are necessary for better investment decisions to be made. Additionally, government subsidies are very region specific because they can be endorsed or blocked by various levels of state and local government. Therefore, a universal model incorporating government subsidies cannot be created. A list of all U.S. green loan programs exists online, but it provides little information beyond their basic structures (DSIRE).

The data we collected about ESCOs was nonspecific and did not lay out the specific payback scheme for a given commercial project. Our group speculates that such information was not provided as a means to maintain the ESCOs competitive edge and not reveal the ESCOs “secret ingredient” financial model for other companies to replicate. It is because of this point in which our group firmly believes there is lack of uniformity and specificity in commercial real estate retrofit reports. ESCOs, commercial property owners, and all the other participants involved in commercial real estate exist in a realm where a competitive edge must always be sustained. ESCOs must distinguish itself in this competitive Darwinian market in order to survive another day. As a result we are discovering gaps in data and finding data to be very generic.

II. OBJECTIVES AND METHODOLOGY

Our project aims to describe the current state of commercial real estate retrofits, to gather and analyze commercial building retrofit reports to identify general trends. In this way, specific features could be related to desirable characteristics such as a low payback period and high rate of return. A sample conclusion we expected was as follows: a warehouse lighting retrofit generally costs $.50 per square foot and can achieve a 2 year simple payback period. This type of information could then assist property owners, financial institutions, and policymakers in making more informed retrofit decisions. We hope that, in gathering data from interviews and retrofit reports, each will provide distinct yet related insight into the market.

The goal of the retrofit report reviews is to gather case-specific, quantitative information. These reports allow for the identification of optimal retrofit qualities for specific building types. In addition, specific numerical values enable regressions and other statistical methods to be utilized.

The goal of the surveys is to learn how different organizations evaluate the retrofit process. The surveys focus on the type of retrofit, type of building, building age, location, local energy data and also procedural data to outline how different companies evaluate the retrofit process. Finance details such as desired payback periods, projected and actual rates of return, interest rates and the types of funding used are also investigated in our survey.

A synthesis of these two different data collection strategies then allows us to generate some recommendations for future green commercial building retrofits. By finding the variables that exist, we will create a template that allows both academics and businessmen to understand the vital factors that are to be considered in conducting a green commercial retrofit.

Definition of Case Study and Retrofit Report

In planning out our research project, our members agreed that our ability to aggregate and assess available case study reports will determine the success of our research. Prior to researching retrofit case studies, our groups sought to understand what a case study meant in both the financial and academic sense. In academia, a case study is a thorough report which analyzes one or more particular cases with the objective of making generalizations. Our research found that organizations that posted data online were terming this data as a “case study”, when in fact, the data is more basic that the term “case study” suggests.

After extensive Internet and database research, it was clear that a cohesive uniform retrofit “case study” report did not exist and thus led to our group’s creation of a new term, “retrofit report”, to reference the reports that were found. We introduced the term “retrofit report” to clarify that the industry term “case study” is not equivalent to the term “case study” used by academics.

We define "retrofit report" as a voluntary summary of geographic, financial, and qualitative information based on an already completed building retrofit. These reports do not have a standard form, though many list the same factors. Common "retrofit report" variables were:

1. Building name
2. Number of Buildings
3. Building Sector
4. Building type
5. Type of Retrofit (HVAC, lighting, insulation, solar)
6. Solar Type (passive, thermal, PV)
7. kW Amount for Solar Retrofit
8. Additional Improvements
9. Location: City, State
10. Installation Cost
11. Annual Savings
12. Year Project Built
13. Project Square Footage

Methodology

Our nine-member team split into two groups. The first group conducted retrofit surveys and the second collected and analyzed retrofit reports. The survey group members developed an extensive contact list and conducted surveys. Their work focused on creating the necessary background research, surveys, data recording and analysis. The retrofit report group members focused on obtaining retrofit reports, creating methods for the analysis of case studies, and identifying trends.

Survey Methodology:

Through background research, it was recognized that building owners, ESCOs, government, and utilities were the main players in making retrofit decisions; the survey questions were tailored to these organizations. The survey was broken down into four general categories: retrofits, evaluations, finances, and future. The retrofit section asked organizations for specific building qualities when performing retrofits (i.e. size, types, etc). The evaluation section related to the retrofit audit details. The finance section was related to rates of return and critical information. The future section asked organizations how they thought legislation, specifically AB32, would impact their business.

Prior to contacting organizations, our survey questions (Appendix A) were submitted to UCLA's Internal Review Board (IRB) for approval on March 3, 2011. All UCLA research incorporating human subjects, researchers must receive authorization from its IRB. This project received approval on March 15, 2011.

During the IRB review process, we compiled a list of 75 retrofit-associated organizations to survey. The list was generated via online searches, references from our client (Matt Ellis, CB Richard Ellis) and our project advisor (Paul Bunje, UCLA Center for Climate Change Solutions). The survey period began on March 28, 2011 and ended April 22, 2011. The responses were then analyzed and compared with the retrofit report data. The spreadsheet in Appendix B was used to track and compare survey responses.

Retrofit Report Methodology:
In order to compile case studies, we developed a spreadsheet that allowed members to enter key case study data in an easily organized manner. The categories regarded retrofit types, building types, total project costs, energy savings, finance details, location, and energy audit details. The report team then utilized CB Richard Ellis, print sources, government websites, and other online sources to gather appropriate data. Data collection began February 25th, 2011 and ended March 18th, 2011. Exogenous data retrieved from the Department of Energy, U.S. Census Bureau, and the National Oceanic and Atmospheric Administration, respectively.

The data was analyzed using tools in Microsoft Excel, MathWork's MATLAB, and ESRI's ArcGIS computer program. Exogenous data, such as electricity costs, political ideology, and temperature, were retrieved from the websites of the Department of Energy, U.S. Census Bureau, and the National Oceanic and Atmospheric Administration, respectively.

The results of the retrofit report research are available in Appendix E.

Final Conclusions
Final conclusions for the project were developed through the review of survey and retrofit report trends. We recommend that currently proprietary building information such as age, size, and energy consumption be recorded and made available for more accurate retrofit valuation. We develop a basis for this type of database through a pre- and post-retrofit template (Appendix C and Appendix D). These represent the main ideas of our research project and possible next steps in both academia and industry.

Hypotheses

The objective of the retrofit report group was to produce a spreadsheet that would allow the retrofit report group to summarize the existing population of "case studies." We expected that the spreadsheet would contain approximately 100 retrofit reports from the commercial real estate industry. Initial research and communication with private real estate firms lead us to assume that office buildings and warehouses constituted a majority of commercial real estate. While we expected to find retrofit reports from other building types, we intended to limit the data to office buildings and warehouses to provide more uniform data and to produce statistical significance during analysis. The following variables to be available in the majority of the retrofit reports: building square footage, age, location, type of retrofit, total cost, monetary savings per year, energy savings per year, payback period sources of funding and financing mechanisms.

Out of these variables, we expect the retrofit report group expected that the most useful variables would be payback period, total cost, and financing mechanisms.

After compiling a sufficiently sized data set, we were to identify characteristics of the most cost-effective building to retrofit based a building's type, size, cost, and retrofit type. The resulting ideal property would direct for commercial real estate companies interested in developing financially profitable mechanisms for retrofitting their own and their client's property. For future researchers and building stakeholders, we expected that the variables listed above would be useful in developing a sufficient if not ideal retrofit report template.

III. RESULTS

The following section of the paper will detail our initial expectations of data type, quantity, correlations, and usefulness. The section will also summarize the results of our retrofit report data collection and the survey data from ESCO, Utility and Government Survey.

Meta-Analysis

Through Internet research we compiled a list of retrofit reports, sorted the variables, and analyzed the data. The reports had inconsistent data sets, and many of them were missing information on several variables, resulting in blank variables within the Excel spreadsheet. Blank variables can be attributed to the publisher's lack of detail when creating these reports. Although some of the most obvious variables tend to be the most reported (i.e. building type, retrofit type), the missing variables may be the most useful for analytical studies (i.e. kW amount for solar retrofit, year to date savings, year of installation). Fortunately, some useful data was consistently reported in most of the reports (i.e. total cost of retrofit and how much energy savings there were in the first year).

The quantitative analysis and part of the qualitative analysis of this report was based off of the data collected from retrofit reports. Retrofit reports were found through Internet searches using various search engines including Google, Bing, Ask, and Yahoo. The following keywords or combination of keywords were entered in Internet searches: "case study", "energy efficient", "payback period", "green retrofit", "HVAC retrofit", "ESCO", "solar retrofit", and "insulation retrofit". Members of the retrofit report team spent over 100 hours of searching for retrofit reports. After finding the first seventy five reports, the remainder of the retrofit reports became increasingly difficult to find. Retrofit reports were also found in a published document obtained from the UCLA Library system. In total, data from 129 retrofit reports was collected and entered into an Excel spreadsheet.

Our final list consisted of a sample size of 129 reports compiled within a four week time period. The most consistent variables out of the 13 commonly found variables mentioned in the "definition of case study and reports" section were qualitative, including sector, retrofit type, and location. From this data, we were able to study the distribution and spread of these qualitative variables.

We decided it would be most beneficial to focus on the following data:

1. The type of retrofit including solar, insulation, lighting, and HVAC systems
2. Location of the building retrofit and the possible incentives involved related to the area
3. Retrofit returns to see how quickly installments were being paid off
4. Building type, whether it be government owned or private buildings

The largest problems we faced while sorting through the data inconsistent definitions, nonspecific data, reporting bias, and patchy data sets. These factors made analyzing the reports and coming to useful conclusions difficult.

Inconsistent Definitions: Varying scope of the same variable among different retrofit reports

- Financial variables did not define what was included. For example, total cost was sometimes reported as total cost of the equipment, total cost of the entire project, or completely undefined.
- Payback period was not always defined. Payback periods were labeled as “payback period”, “payback with incentives”, or “payback without incentives”.

Nonspecific Data: Reports were often over generalized.

- Reports would often just list the amount of money received as “Incentives.” Few reports included details about the incentive other than the overall type (government or utility). Even so, the level of government incentives was not reported.
- Few retrofits would provide details about the specific retrofit type and technology used.
- Many retrofit reports would not specifically indicate the sector, building type, or number of building

Reporting bias

- Some were companies publishing the information, how much from each company
- 34 retrofit reports were reported from one company
- Not all retrofit reports found were included in the data set. Some retrofit reports were determined to be too general because information was not reported in a format that could be compared to the rest of the database.
- People tend to report about successful retrofits and fail to report about retrofits that did not succeed

Patchy Data Set: Incomplete data set for each retrofit report

- Individual retrofit reports do not include all of the analyzed variables
- Different sets of variables were listed for each retrofit report
- Few retrofit reports contain the same set of variables

Graphical Results

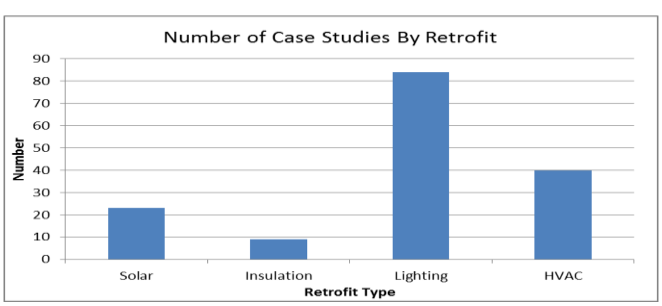

Figure 1. The number of retrofit reports by retrofit type.

The data suggests that lighting is the most common of all retrofit types, however this result only represents the number of available reports, not actual cases. The number of retrofit reports included in the data set is likely to be indicative of the real estate market's actual tendency to perform such a retrofit. Regardless, these are the proportions of the most commonly reported on retrofits. Lighting is likely the most reported retrofit due to its ease and accessibility. Lighting retrofits are cheap relative to the other three retrofit types and usually have a short payback period. The qualities are appealing to investors looking for quick turnaround times.

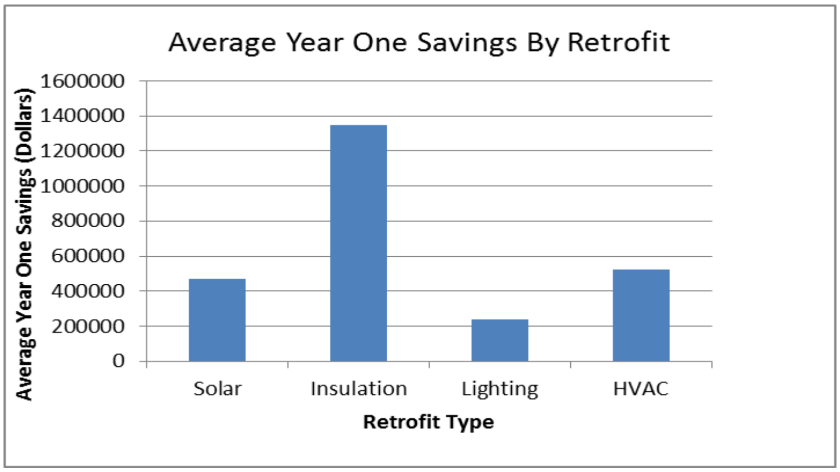

Figure 2. Savings made during the first year the retrofit was active. Data is sorted by retrofit type, including multiple retrofit projects.

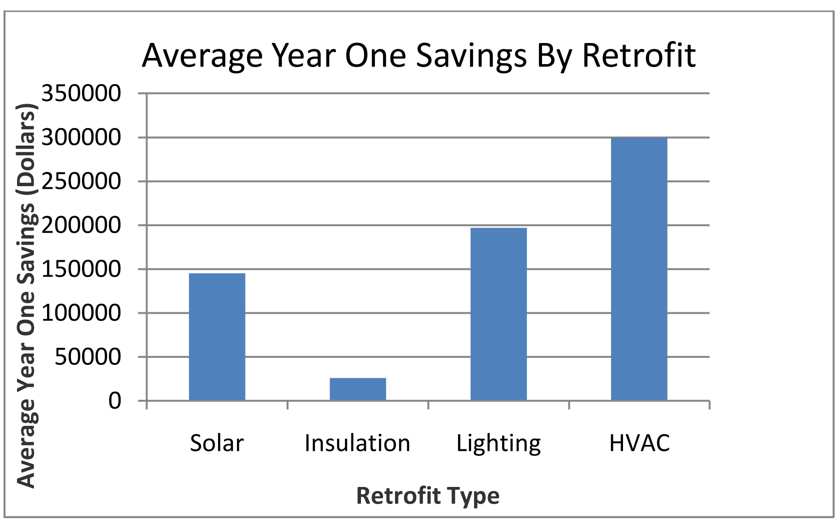

Figure 3. Savings made during the first year the retrofit was active. Data is sorted by retrofit type, excluding multiple retrofit projects.

Figure 2 and Figure 3 display the average savings over the first year of the retrofit. Some retrofit studies collected detail multiple retrofit types and the totals are combined into one financial summary. When yearly savings are totaled between separate retrofits they appear much larger in the data than they would be for a single retrofit.

The first chart shows average year one savings including the reports with multiple retrofits. This data gives a skewed representation of the actual savings since they report all totals including those with two or more retrofits. Since insulation has the fewest reports the data is more likely skewed from the summed averages.

Figure 3 shows the first year savings averages where all case studies with more than two retrofits are removed. Drawing from the changes from the previous graph you can see that the combined reports can significantly alter the data. It especially affects insulation retrofits. This picture gives a more accurate representation of the actual first year value of retrofits however the sample size of some of the retrofits (especially insulation) has been drastically reduced.

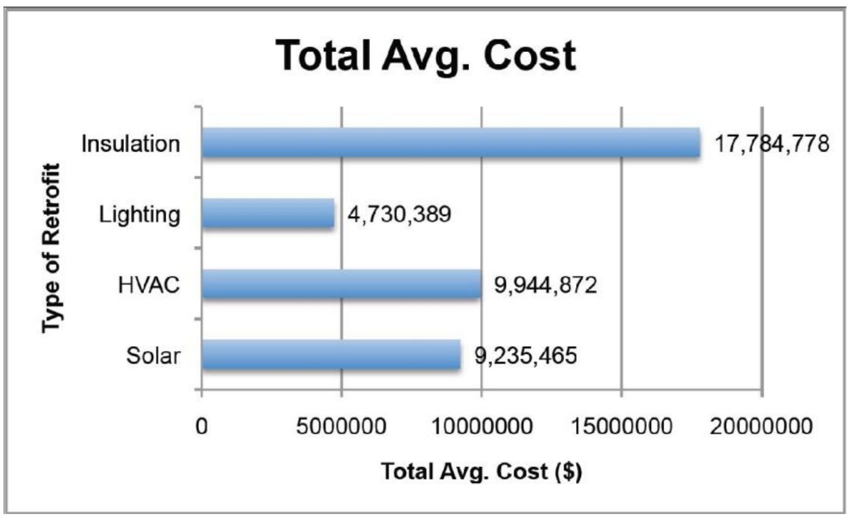

Figure 4. Total average cost of each of the four retrofits, including multiple retrofit projects.

The average cost chart exhibits the same problem as the average year one savings by retrofit type. The retrofit reports with combined totals between multiple retrofits increase the reported average cost of the retrofit. In this report we see that insulation is by far the most expensive retrofit. The problem is that since there are so few retrofits in that category the summed totals have been largely skewed. The other categories have more weight and are thus less skewed by the larger combined totals.

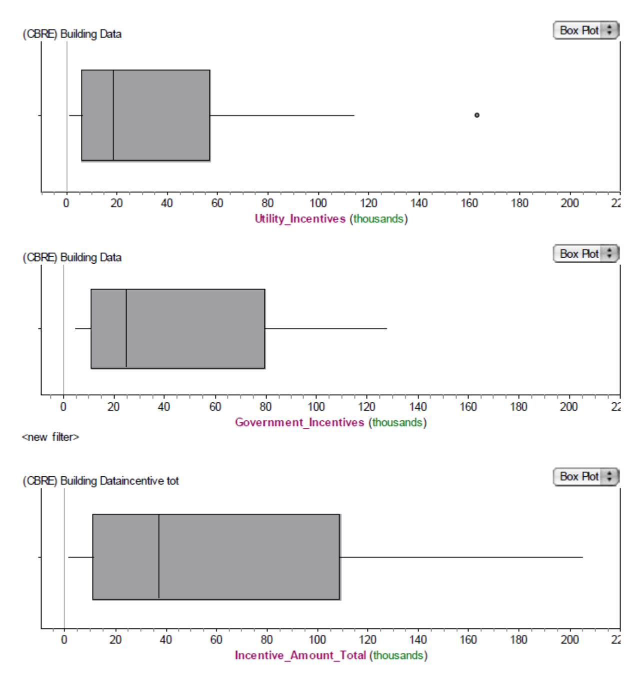

Figure 5. The first box plot displays the spread of incentives acquired for retrofits from utility companies. The second box plot displays the spread of incentives acquired from the government. The third box plot displays the combined total of all incentives of incentives acquired for all retrofits.

We calculated the spread of incentives acquired for retrofits to get a sense of what types of available funding are offered and where the most fruitful places to search are. The results show similar spreads for both government and utility incentives, both averaging near $20,000. For real estate owners seeking retrofits the two options of retrofits provide somewhat similar levels of incentives. The third graph reveals that the total incentives acquired are significantly higher than for government or utilities alone. This shows that real estate companies are receiving incentives from both sides and that the most effective method is to acquire as many incentives to fund the project as possible.

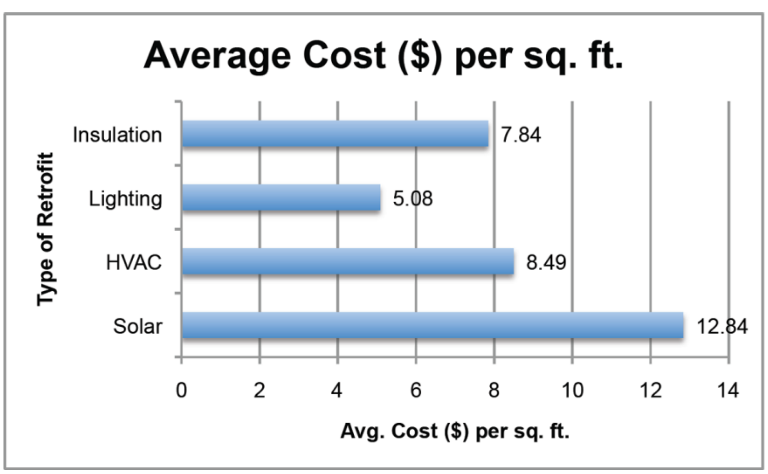

Figure 6. Average cost per square foot for each retrofit type.

Figure 6 details the average cost per square foot for a building for each type of retrofit . The graph shows that lighting retrofits are the least expensive, costing $6.84 per square foot compared to HVAC retrofits which are slightly less than double that price at $11.92 per square foot. This also shows that solar is significantly less expensive than HVAC and even less expensive than insulation.

The reason cost per square foot and not total cost was used was to help remove the inconsistency in building size from the retrofit report samples. The size of buildings ranged from 1160 square feet to over 8 million square feet. The size of the building will not only influence what types of retrofits are technologically possible, but also the capital cost, payback period and ultimately the feasibility of the retrofit. Additionally, the graph above contains all data points for entries that had both square footage and total cost and has not removed outliers. With a limited sample size any outlier will significantly impact the reported average cost. This is particularly true for insulation data as only five retrofit reports contained projects that used insulation retrofits. Payback period is also another important variable that is not taken to account in this correlation. The efficiency of each retrofit, as represented by cost per square foot, is an incomplete measurement of efficiency-- especially for larger companies with greater capital. The time to recoup the capital costs through cost savings is often a more dominant factor in business decisions. For example, many owners are unwilling to undertake projects with payback period beyond 7 years. Finally, though data on the type of solar retrofit was recorded, thermal, passive or photovoltaic, it is not included in the graph.

A source of error in retrofit report data is that many do not specify whether the total cost and payback period included an incentive amount. This highlights the need for a standardized database to gauge retrofit returns. In addition, our costs of solar may be inflated because photovoltaic technologies are generally less efficient and more expensive than solar thermal or passive solar technologies.

GIS Results

Five maps were created to identify possible spatial trends in our sample. Factors considered in this analysis were state electricity cost, political ideology, annual temperature variation, average incentive amount, and payback period. Electricity costs, political ideology, and temperature were exogenous data retrieved from the Department of Energy, U.S. Census Bureau, and the National Oceanic and Atmospheric Administration, respectively. In contrast, the average incentive amount and payback periods were derived values declared by retrofit reports. Large outliers and multiple retrofit reports that included multiple buildings were excluded from these analyses.

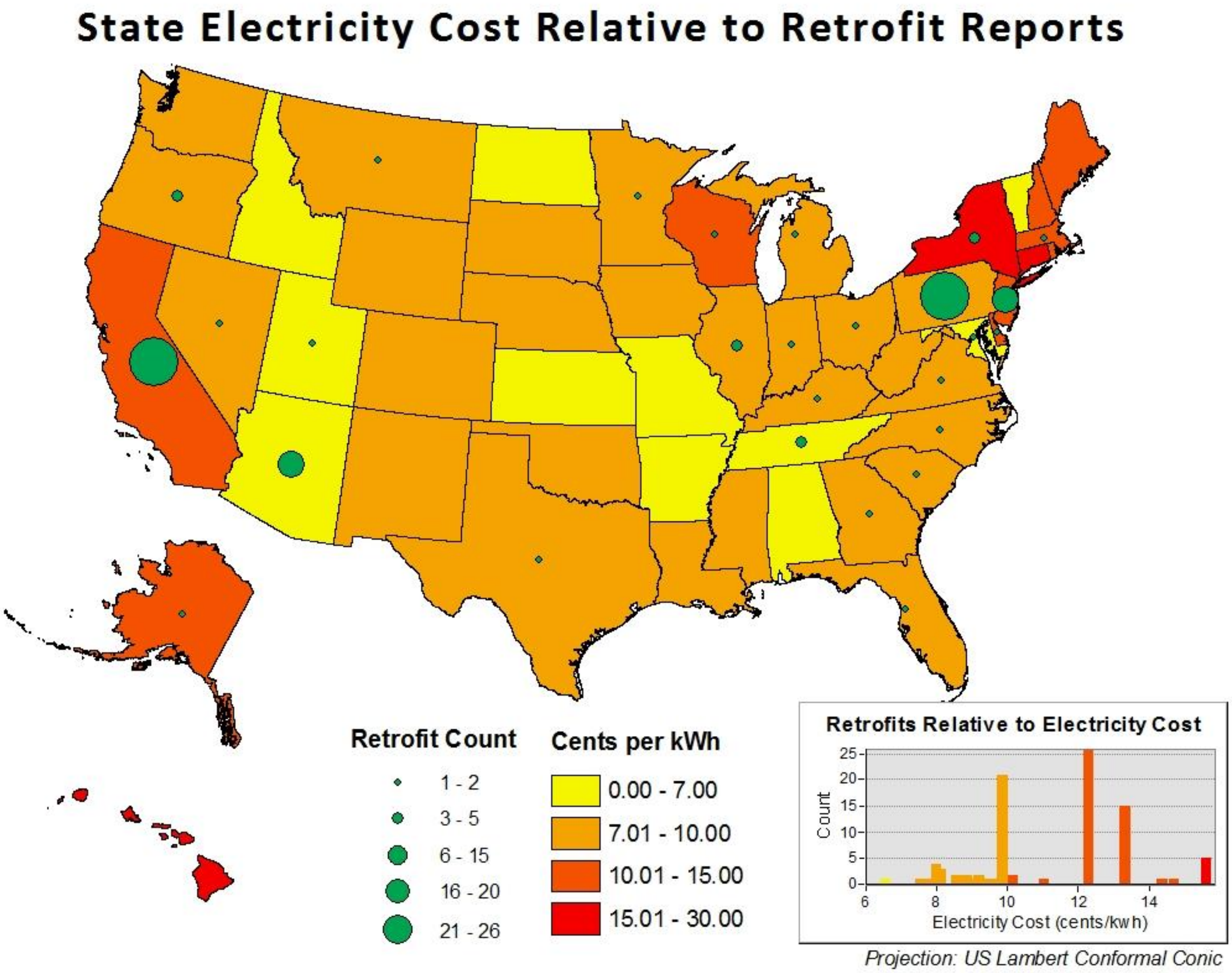

Figure 7. Commercial Electricity Cost versus Number of Retrofit Reports

Average commercial electricity fees ranged from $0.0645/kWh in Utah to $0.2800/kWh in Hawaii. However, the range was heavily skewed by Hawaii since the second highest rate was Connecticut at $0.1602/kWh. For perspective, the U.S. average is $10.56 cents/kWh.

As seen in Figure 7, Midwestern states have the cheapest electricity rates while the West and the New England regions have the most expensive. In general, the states that produced a large number of retrofit reports were from states with high electricity costs. However, high electricity rates were not necessarily indicative of retrofit reports. For example, the two states with the highest rates (Hawaii and Connecticut) were not represented in our sample of retrofit reports. In contrast, four out of twelve states within the lowest electric rate group (less than 7 cents per kWh) were found to have reports. It is interesting to note that the US Midwest, a region dominated by cheap energy, is almost void of retrofit reports.

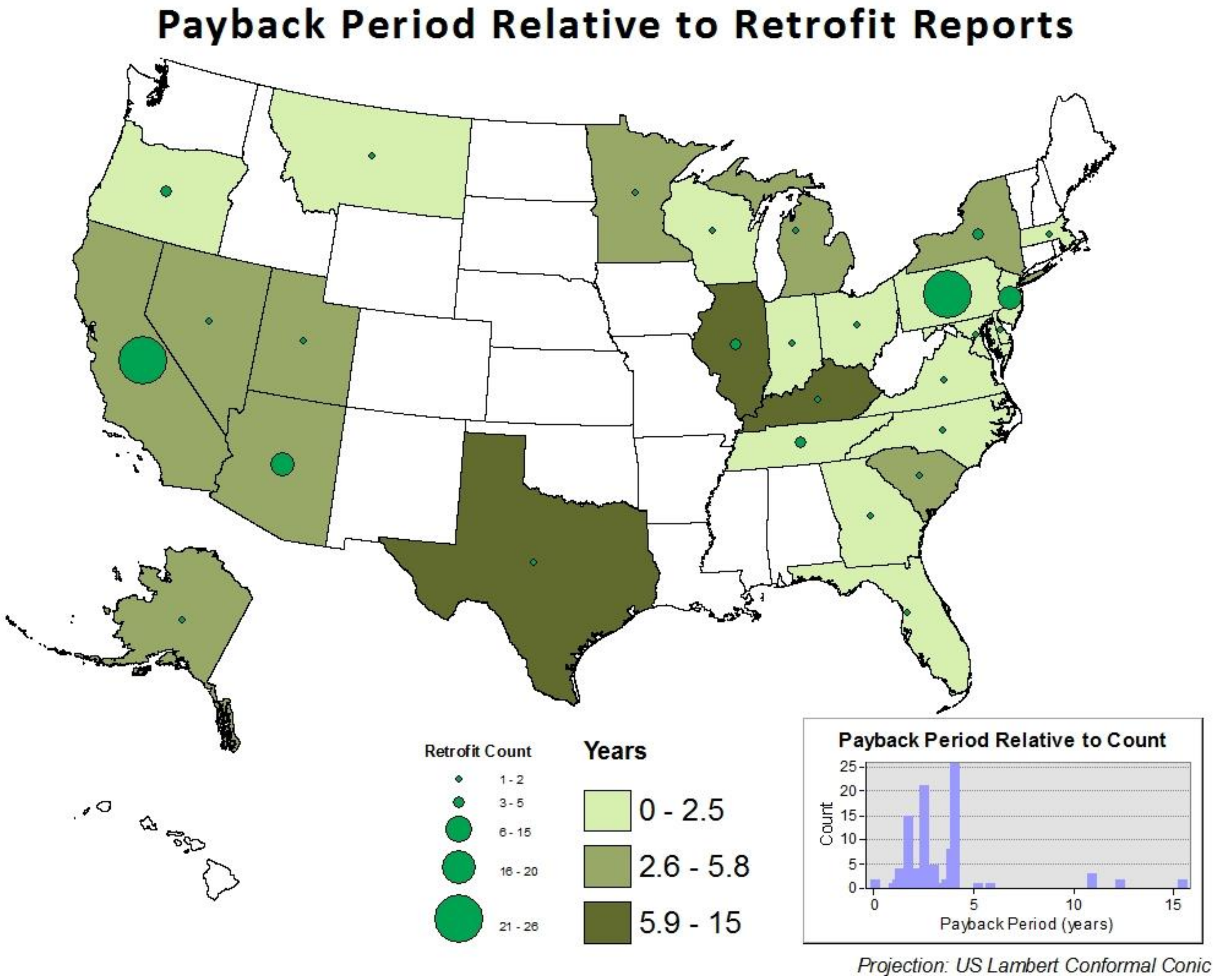

Figure 8. Average Payback Period Relative to Retrofit Case Studies

As seen in Figure 8, the payback period map shows the number of retrofit reports relative to the aggregate average payback of all projects in each state. Seen in the Figure 8 graph, the large majority of projects reported payback periods of less than five years. Only three states had payback periods larger than six years. Another observed trend was that payback periods seem to be influenced by region. For example, the block of California, Nevada, Arizona, and Utah are all classified within the 2.6-5.8 year retrofit block. Similarly, almost all the east coast is classified within the short-term project range from 0-2.5 years.

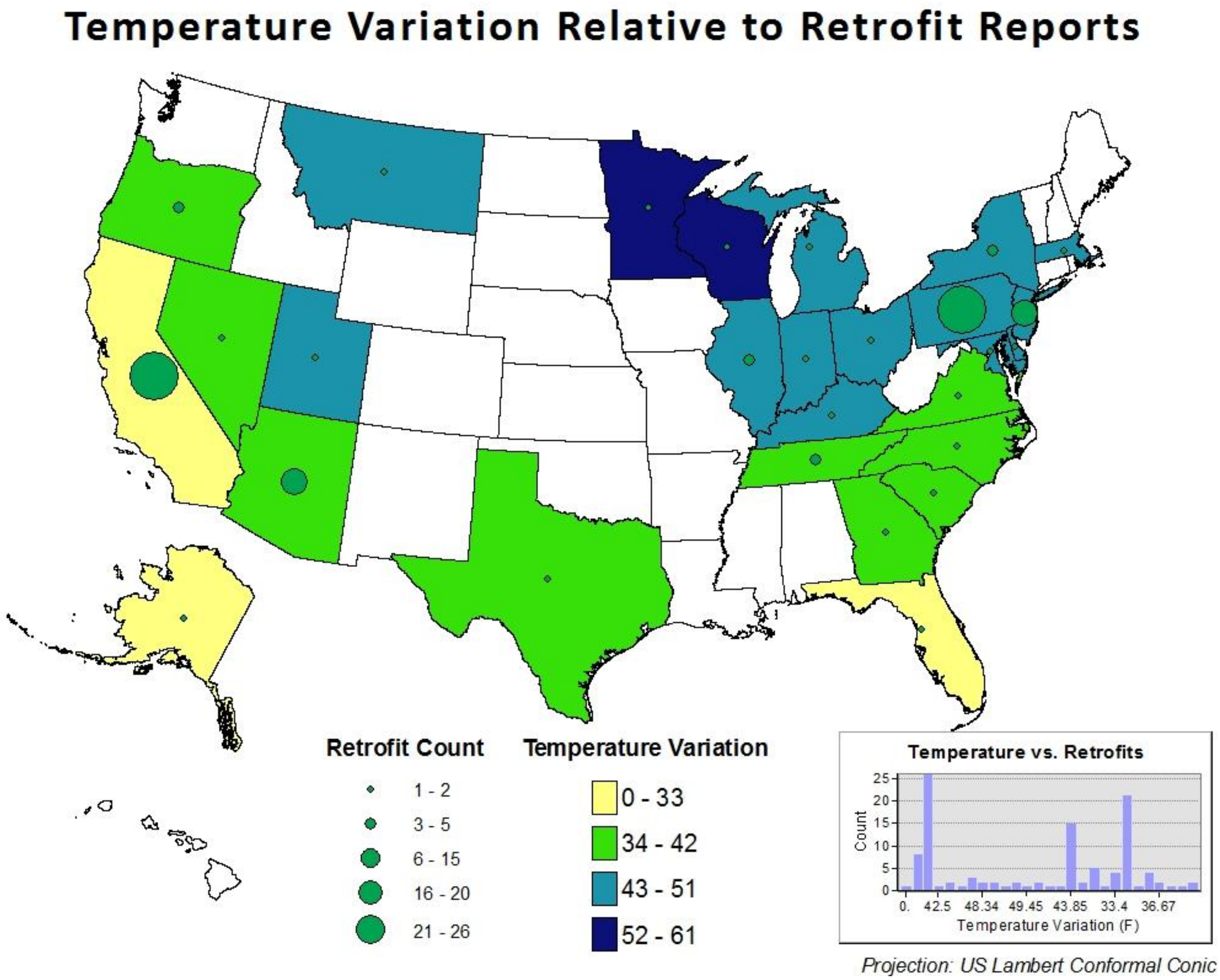

Figure 9. Average Temperature Variation Relative to Retrofit Case Studies

Figure 9 depicts the average temperature variation between December and July. The graph demonstrates that there is little evidence that more temperate regions report any more retrofits than regions with more climate variation. A possibility is that there are two peaks: one in temperate regions and the other in more extreme areas. Due to our small sample size, however, this is difficult to determine.

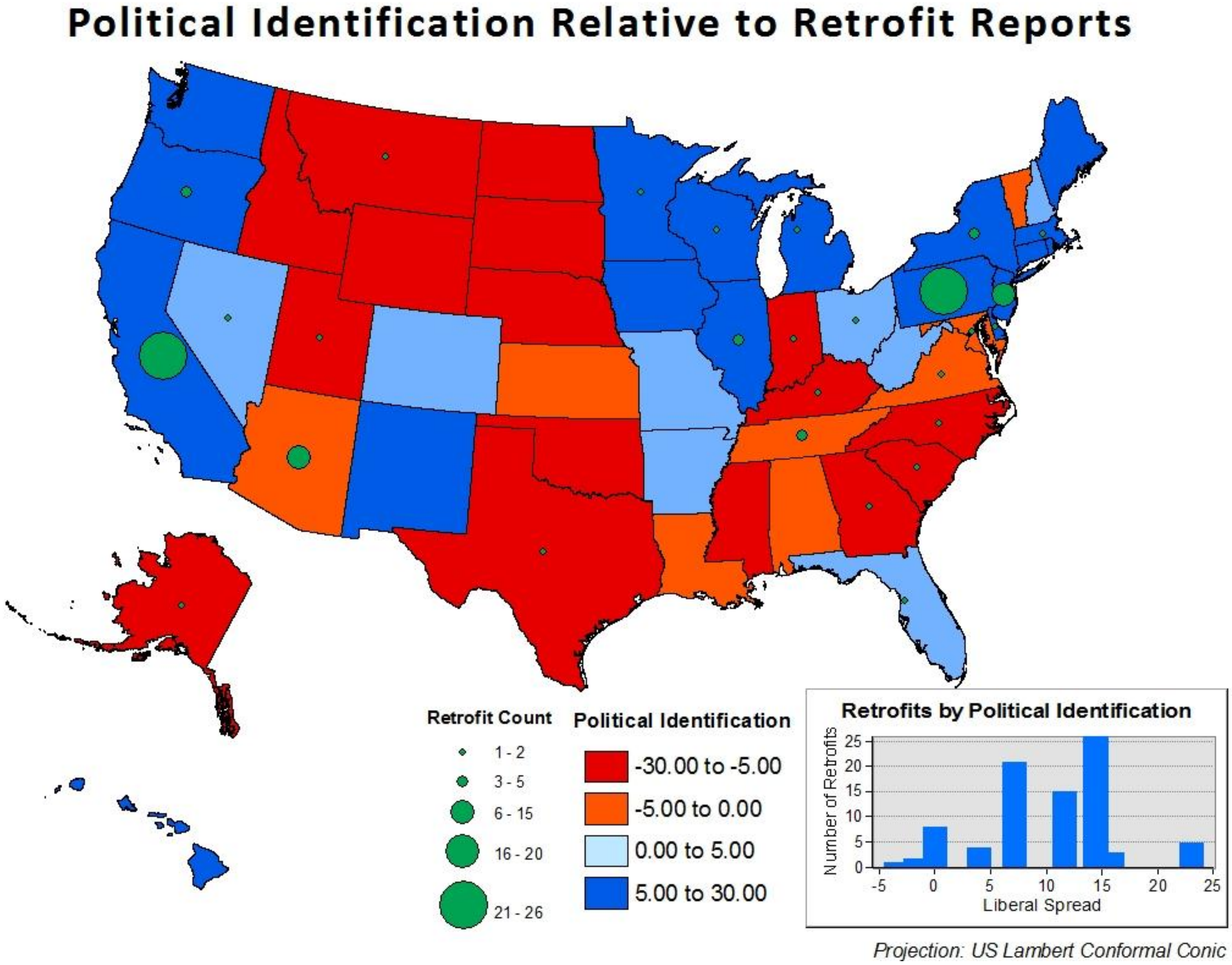

Figure 10. Political Party by State Relative to Retrofit Case Studies

Figure 10 shows the amount of retrofit reports relative to political spread. A state's political party was calculated by the percent difference between the liberal and conservative presidential vote since the 1992 election. Therefore, positive regions (represented by dark blue) were designated liberal states whereas negative regions (represented by crimson) are conservative.

Highly liberal states were generally very good indicators for a retrofit report. The graph in figure 10 shows that most of the retrofits occurred in states with more than 5% of a liberal spread. Furthermore, a small number of these states accounted for a large number of retrofits. In contrast, highly conservative areas were found to have very few retrofit reports.

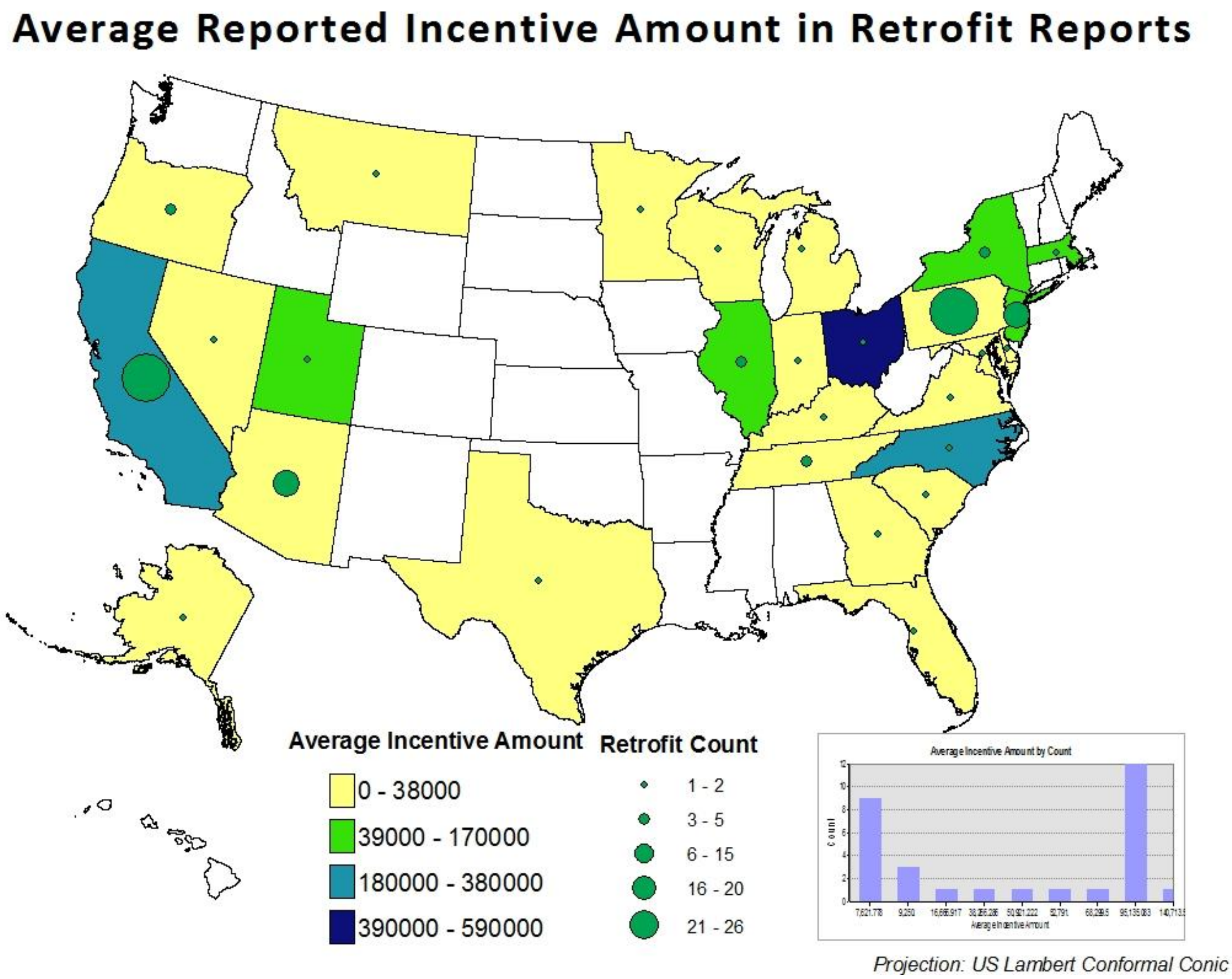

Figure 11. Average Incentive Amount Relative to Retrofit Case Studies

The incentive map shows the average incentive amount of each state. Generally the states with more retrofits have higher reported incentive amounts. An interesting outlier is Pennsylvania-- the state with the most retrofit reports, falls into the lowest incentive bracket.

Survey Results

We contacted 70 companies, including ESCO's and utility companies and were able to get survey responses from 6 companies. From the survey responses we were able to discern some trends regarding energy efficiency retrofits from the International Review Board certified survey we conducted. First, the current focus for retrofit projects concerning large, high-rise office buildings is on lighting improvements while projects concerning small, single-story structures is on heating and cooling systems improvements. The secondary focus for both large and small buildings is improvements to the ventilation infrastructure. The payback period average is between three to five years for private projects, though the payback period for schools and government buildings may be as many as twenty-five years. Average project time for installation is one and a half years, though the range is heavily scattered from six months to three years. All projects sought to take advantage of local government incentives, then incentives at the state and federal government levels respectively.

It is interesting to note that the payback period for energy efficiency retrofits is typified as being three to five years. This coincides with the three to five year investment option of short term mutual funds called equity linked saving schemes (ELSS). This could be a coincidence but such a similarity in time frame suggests that commercial real estate energy efficiency retrofits are handled in much the same way as stock market type investments.

IV. DISCUSSION

Qualification of Results

Our research has shown that there is a clear lack of data in the commercial retrofit market. While our initial goal was to identify and understand the components of a cost effective commercial retrofit, the stock of available data was too elementary and general to fully answer that question. Our research focused on finding even more basic questions, trying to find correlations and patterns among buildings that have already been retrofitted. First, our paper established a database of commercial building retrofits to create a foundation for future standardization and comparison among different commercial retrofits. As previous retrofit reports have reported random variables that are not useful for an economic analysis, this database offers a standardized resource where buildings can be compared and analyzed side by side. The database also allowed for the first sample analysis of commercial building retrofits. Lastly, our results have identified the weaknesses and holes of the commercial retrofits by analyzing the industry as a field of study. By identifying the gaps and problems with the available data set through a meta-analysis, we hope to bring more attention to this field for further research and investigation. Future researchers, building owners, tenants, and other key stakeholders have a standard to develop their own case studies and contribute to this field.

This paper focused on analyzing simple variables, including total cost, cost per square foot, annual savings, energy saved, and payback period, to determine profitability of a building retrofit through basic analysis. These simple variables were available and prevalent throughout our data set, which provided a larger sample size leading to more statistically relevant results. Trends from this data correlating any one of these variables to a certain retrofit type or building characteristic would provide a starting point for further study. It was difficult to relate variables due to the missing data within the database. Building retrofits are highly individualistic and can potentially be affected by location, climatic variables, ownership structure, and building profile. The profitability of a retrofit done on one building will differ from the profitability of that same retrofit performed on another building. The individualistic nature of retrofits makes industry wide comparison of specific building difficult.

Our results show some notable trends about the prevalence and costs of different retrofits. HVAC has the highest average cost per square foot, yet HVAC is the second most prevalent type of retrofit. The average year one saving of HVAC retrofits is comparable to that of solar, and still, more HVAC retrofits were completed in comparison. On the other hand, insulation has the highest average year one savings, an average cost per square foot similar to solar, and significantly lower than the cost per square foot of HVAC retrofits. Overall, insulation appears to be a profitable retrofit; however, our results indicate that few people are actually performing insulation retrofits. While the total cost of insulation projects is much higher than the other types of retrofits, the savings in comparison are still remarkably high enough that this type of retrofit would seem tempting.

This trend might be attributed to the perception of financial risk associated with different retrofit types. Stakeholders might be more hesitant to invest in a project with such a high capital cost without knowing the guaranteed return on their investment. This attitude is further supported by our data, which shows the prevalence and associated costs of lighting retrofits. Lighting retrofits were the most performed and the least expensive type of retrofit. While lighting also provided the least average year one savings, the average payback period fell below the 3-5 year standard that the industry wants (as evidenced from our survey results). Thus, lighting is perceived as a lower risk retrofit.

While the results indicate interesting points that were found from our analysis, it is by no means a comprehensive analysis. With a greater number and higher quality of retrofit reports, further studies may be able to identify more correlations that were not evident through the restrictive data set. Additionally, determining the profitability of a building retrofit involves more advanced financial analysis techniques. In a more advanced financial analysis, future researchers should consider financial mechanisms for obtaining the initial capital cost, and building performance over time.

It is also interesting to note the selection bias within the data set. A selection bias might be prevalent among the businesses and institutions publishing the retrofit reports. Many businesses have recently adopted sustainability into its company's core mission and goals. By publishing a retrofit report, these businesses want to portray themselves as an ecologically conscious business and may select certain favorable facts to publish. More commercial retrofits have been completed than noted in the database. While it is uncertain why information about these unpublished retrofits is being withheld, there is a potential that these retrofits may not be as profitable as the ones that are published. There was also a selection bias concerning which retrofit reports to include in the database. Most retrofit reports that contained key information such as total cost, annual savings, and payback period, were included. However, some retrofit reports did not disclose relevant numerical data. These retrofit reports were left out of the database because there is no mechanism to compare that building retrofit to the rest of our data set.

Lack of available data is a major deterrent for people. Studying long term data on a building and its performance is expensive, must pass through a lot of barriers, and financial data tends to be protected by non-exposure agreements. Potentially dealing with a rotating shift of tenants and owners presents another difficult scenario for obtaining data. Looking at energy efficient retrofits as a field of study, there is no standardization, which explains the haphazard nature of the retrofit reports. There also seems to be a lack of awareness that energy efficient retrofits are not just a maintenance issue within the building, but it can also be profitable financial decision for the buildings stakeholders.

For the same reason, researchers are not gathering data, building owners do not want to spend the time or effort collecting data. Building owners are also subject to the loophole of participating in retrofits to get data, but unable to benefit from the resultant research. It is necessary to have such information, however, the key stakeholders do not have any incentive to collect and make this data available. For an ESCO, publicizing data from building retrofits might compromise their business as it would give away their business strategy. One solution is to establish an open book policy, where all organizations that use the government incentives for building retrofits must report this data.

Surveys

When we reached out to 70 ESCO and utility companies to discuss the current state of the retrofit market as well as their specific company plans and objectives in performing and completing retrofits, we were expecting a large response. However, it was extremely difficult to get in contact with people who were willing to conduct the phone survey. Even when we were able to get in contact with the companies, many of them chose not to participate, usually for the sake of the privacy of the company. In conducting the surveys, we were hoping that companies would want to contribute to this area of research, and were disappointed when we were only able to complete 6 surveys. Therefore, our results have value, but they may not reveal the larger trends that are occurring in the retrofit business.

The survey results we did receive revealed that large, high-rise office buildings tend to focus their retrofits on lighting, while small, single story buildings tend to focus on heating and cooling. Both types of buildings however place a secondary focus on improvements in ventilation. These results correlate to the results we observed from the retrofit reports. The retrofit reports revealed that lighting is the most common type of retrofit and generally is the least costly to do. This then makes sense that larger buildings would perform this type of retrofit first, because it is the most cost effective, but may raise concern about why smaller buildings don't also follow this trend.

Another interesting thing to note is that both types of commercial buildings place a secondary focus on HVAC retrofits. Our retrofit report analyses conclude that HVAC retrofits are the most expensive type of retrofit to perform. Therefore, some motivation must exist to explain why ESCO's and utility companies promote these types of retrofits. Further research shows that HVAC retrofits have the potential to create some of the largest energy savings. Old HVAC systems are inefficient and often times have leaks. By installing new, updated systems that have a much higher level of efficiency, buildings are able to see large energy savings and thus experience a fast payback period. This is most likely the motivation for ESCO's working for building owners. They want to produce the fastest payback period, even though the retrofit itself is initially expensive.

In relation to payback period, the survey results showed that most companies prefer investments with payback periods between three to five years. Of the retrofit reports, the large majority of payback periods for energy efficiency achieve results in this short time frame. If companies were willing to assume longer payback periods, more retrofits would become available. The three to five year payback period coincides with the three to five year investment option of short term mutual funds called equity linked saving schemes. This could be a coincidence but such a similarity in time frame suggests that commercial real estate energy efficiency retrofits are handled in much the same way as stock market type investments. While energy retrofits are still developing and are continuing to make efficiency progress, the standards for fast payback periods may need to be re-evaluated.

While longer payback periods are typically associated with more risk and uncertainty, energy retrofits might need to be considered differently. They can have consumption smoothing benefits such as insurance against electricity cost increases. The availability of more data would allow a more thorough analysis of this assertion.

There is limited data reported on yearly payback periods, but if more reports showed the exact payback periods of a number of retrofits, it may encourage people that even if it isn't within a three to five year time frame, the return on their energy bills is still occurring, but at a slightly slower rate than desired. Other limitations in our survey included companies being unwilling to provide any numbers regarding costs of their retrofit projects, the anticipated savings, and the minimum rate of return that they expected to receive in order to conduct a retrofit project. This coincides with a number of other challenges that we faced throughout our research, which show that building retrofit data is very difficult to come across.

Challenges to Data, Collecting Data

One of the first and primary obstacles was data collection. First, a public database to find or post retrofit results does not exist. The reason is unclear but we speculate that there is a lack of motivation to post energy saving results due to a tragedy of the commons problem. Reporting data requires work, but does not yield any direct benefits to the reporter. For this reason, we recommend making government incentives contingent on the provision of past and future building data to a public database.

As data is currently being publicized, a reporting bias may occur because companies would only report the highly successful projects rather than mediocre ones just so they can catch the "green washing" trend. Secondly, there are very few print publications and research done since this is a new and burgeoning field and this is further exacerbated by the fast changing nature of the green retrofit industry.

The green retrofit industry is constantly changing through new technology, incentives, and market products. The incentives are volatile, especially in light of recent budget cuts. For example, the EEBCS was recently cut from the 2011 federal budget (EIA 2011). Also, there is a may be an "expiration date" where the relevance and analysis of data becomes obsolete (i.e. papers written twenty years ago may not be useful now).

Finally, the lack of uniform data is the biggest hurdle to current studies. Blank variables are due to the lack of detail when retrofiters are doing their reports although some of the most obvious variables tend to be the most reported (i.e. building type, retrofit type). It is the missing variables that actually would have been more useful for analytical studies (i.e. kW amount per retrofit, year to date savings, year of installation). Fortunately not all useful data is missing (i.e. total cost of retrofit and how much energy savings there were in the first year). The variables with the most input were the types of retrofits based are based on objective “yes/no” answers. This data helped generate pie charts that gave a visual presentation of what percent of the reported data did a certain type of retrofits. An example is 92% of the retrofit buildings did not do insulation retrofits despite the fact that it is not the most expensive. The variables with the least input were from incentive amounts because it varied so much. There was no connection between the site of the retrofit (whether it was built in a conservative or liberal state) or what type of building (whether it was government or private). Also energy savings per year, surprisingly, did not provide too much useful information because the buildings varied greatly on size and combination of retrofits. The most logical step is to make a universal template for the retrofit companies (Appendix C, Appendix D).

Resolutions

Due to the proprietary nature of pre- and post-retrofit energy consumption data, building owners, tenants, and conventional financiers (i.e. banks) face uncertain returns on retrofit decisions. Current conventional financial products such as loans and bonds are insufficient for widespread retrofit adoption because energy retrofit savings can only be approximated. From a financial-return perspective, a few percentage points are what separate good and bad investments. Therefore the difference between estimated and actual energy savings becomes significant—not only for the property owner but also for willing lending institutions. As a result, it is difficult to develop financing strategies with attractive terms for both lender and property owner. In order to reduce transaction costs for both lending institutions and retrofit buyers, a standardized contract should be developed.

Since retrofits are both region and building-specific, it is very difficult for knowledgeable retrofit decisions to be made without an audit from a third-party, such as Siemens, Johnson Controls, or a utility. Barriers include finding an appropriate audit company and paying for the audit itself. Without knowing the potential of retrofit returns or even the existence of potential retrofits, commercial building owners are unwilling to make this step. This is especially true since most commercial building owners have little retrofit expertise. By providing audit expertise and a financing method, ESCOs have found success: they identify profitable buildings, provide zero-risk returns to property owners, and offer ready-to-sign contracts. The popularity of ESCOs is seen from our retrofit report analysis-- many of the retrofit reports were taken from ESCO websites. The number may be depressed since buildings may have used ESCO services, but did not report it.

Because of their benefits, ESCOs will remain the most viable option for commercial real estate retrofits in the short-term. Conventional lending institutions simply cannot match the financial products without the expertise and guarantees provided by ESCOs. However, ESCOs are not perfect. They are primarily limited by four factors: complicated contracts, insufficient capital, low rates of return, and small market size.

ESCO contracts typically run for ten years, though they can often run as long as 15 years. Since most property owners cannot guarantee long-term ownership, ESCO services are primarily applied to government and institutional properties. Notably, approximately 82% of ESCO revenue comes from contracts with public and institutional owners (McGraw-Hill 11). While ESCOs will continue to play an important role in funding retrofits, they will exclude smaller property owners until shorter contracts can be offered. Under the ESCO model, the number of retrofits financed by ESCOs is limited by the amount of capital they can generate. We assume that since most of the existing building stock is more than 40 years old, the number of buildings is not the limiting factor. Further, the first buildings retrofitted will be the buildings that will yield the highest returns or those identified by ESCOs. Although other buildings could cost-effectively implement energy retrofits, many would be excluded until ESCOs grow in size and can identify all the buildings that could benefit from retrofits. Lastly, ESCOs are small in both size and scope. Thus, to make timely retrofits on a national scale ESCOs must experience rapid growth.

The political momentum for renewable energy resources, carbon legislation (i.e. AB32), and electric vehicles favor the cost of electricity to increase relative to the status quo. Therefore, the interest in energy efficiency retrofits as a profit maximizing strategy will likely increase.

A standard template to record retrofit data would encourage retrofits by providing much needed information. An accumulation of standardized data will allow for the comparison of previously retrofitted buildings (i.e. location, age, square-feet, retrofit type). In this way, a baseline or estimated rate of return can be extrapolated from previously retrofitted buildings. In addition, a building-in-question can be compared to previously retrofitted buildings. Unlike the ESCO model, building owners already have access to their energy consumption data and other critical building attributes. Therefore, a template would be valuable to allow commercial building owners to gauge the approximate value of a retrofit. Other beneficiaries would include property management groups, government officials, and lending institutions by running more detailed analyses. While one large public database would generate the largest sample size, multi-national organizations (such as CB Richard Ellis and Bank of America) can document these changes for internal use to formulate better investment decisions and contracts.

Most companies and property owners do not see retrofits as a profits center for a couple reasons. The green retrofit field is a new and changing with new technology where there is not much knowledge due to the lack of data. Since there’s not much data it’s hard to draw universal conclusions about the uncertainties within the field. Companies and investors find it hard to determine how much potential money (over-time benefits) can be earned without much raw data and the high initial costs make them think twice about their investment.

Companies are discouraged from investing because incentives are not always provided permanently by the government. Although the government has provided incentives for companies to invest in retrofits, incentives often expire after two years. As a resolution, the government could temporarily extend the incentives for a longer time period. Given this one-time extension, a sample size of long-term data can be established in order to judge retrofit returns.

This is interesting in the context of AB32, the Global Warming Solutions Act of 2006 that would require the California Air Resources Board (CARB) to develop regulations and market mechanisms to reduce California's greenhouse gas emissions to 1990 levels by 2020. Barring setbacks in the coming calendar year, mandatory caps will begin for point sources on January 1, 2012. AB32 will officially become effective meaning that companies will start shifting their strategies to comply with this act and therefore retrofitting will become a must in order to reduce their carbon footprint. While buildings will not be regulated, the price of electricity (an input price to labor) will increase. In addition, utilities may offer incentives for building owners to reduce their energy consumption. However, it is ambiguous how building retrofits will be affected once the mandatory caps begin in 2012.

Template

In the following section the goal is to present one our recommendations in the form of research templates for public and private use to help in analyzing and more importantly reporting data that will help the commercial real estate community move forward with analysis of viable retrofit projects and ultimately an expansion and growth of retrofitting.

Why Retrofit Reports?

Retrofit reports useful for a wide range of reason and to a wide group of companies, agencies and researchers. To begin, retrofit reports help illuminate market trends for a wide range of potentially important constituents in the retrofit business. Access to retrofit reports would allow companies to better explore the financial viability of building types. If there is sufficient information demographic data will help companies asses what general limitations exist for building size, use, capital and total costs, annual projected savings, payback periods and even a reasonable guess at the lease type. All of this information, combined with geographic data is a useful predictor for how feasible projects are for companies looking to start retrofitting. The data from retrofit reports is also useful for government entities at local, state and federal levels. By examining building and geographic data agencies can more accurately analyze the impact of their policies on regional scales to see if those policies are significantly impacting market trends and furthermore incentivize new or expand existing policy to similar areas that lack strong retrofitting trends.

Additionally, aggregated or individual retrofit reports are useful advertising tools for companies. If a company is an ESCO or similar institution that assists in retrofitting, these reports reflect a company's competence and ability to deliver savings to a client. For clients or companies that retrofit in-house the reports advertise a company's claim to environmental stewardship and responsibility and, especially for public companies, the reports can help build shareholder confidence and attract investors by demonstrating increased efficiency and smart management. These reports could also signal that a company is appropriately meeting local, state and federal guidelines or mandates, which helps ensure a company avoids current and potential future regulatory compliance issues on health, safety and the environment.

As discussed earlier in this paper, retrofit reports have also been critical in this research project. Our own efforts to catalog publicly available retrofit reports was part of our attempt to answer some basic research questions regarding retrofit trends in commercial real estate. Initially our goal was to find a sufficient pool of similar categories of retrofit reports and to use their total cost, cost savings, and payback period to identify characteristics in buildings that would assist companies in deciding how to begin retrofitting or improve the retrofits they were already undertaking. The characteristics we hoped to find can be summarized with this research question:

- What is the “ideal” building to retrofit?

The definition of “ideal” is subject to change for every company or institution looking to retrofit, but our initial goal was to highlight key variables to look at in a building that correlate most strongly with financially successful retrofits under a variety of scenarios. For example, a company looking to start retrofit might find it beneficial to focus on office buildings and lighting retrofits first if faced with low quantities of capital and wanted a payback period of 3 years.

These “ideal” buildings based on aggregated retrofit report data would hopefully provide a starting point and framework for companies entertaining the idea of a retrofit to either begin their own analysis of their buildings, or use our or similar data as a starting point for choosing which buildings might be good retrofits candidates and provide insight to efficient and profitable financing models for different building types.

The Challenges in Developing a “Model Template”:

As mentioned throughout this paper, one of the most important challenges to using retrofit reports according to our initial goals stemmed from the need for appropriate quality and quantity of retrofit reports. This challenge of sufficient data motivated our recommendation of a series “model templates” that can be used publicly or privately to address challenges in retrofitting and access to data. However, developing this “model template” that will be useful for companies looking to retrofit, current companies already retrofitting and other academic or institutional researchers is a fundamental problem.

For the template to be useful to multiple parties it must address different stages of retrofit research. For example, recommending a “model retrofit report” to a company that is looking to do retrofits but has no existing retrofits is not useful. As researchers we would recommend this “model retrofit report” because we want additional data so that we can examine general trends in retrofitting, but this is of no assistance to a company or institution that has no data to report. Our “model template” cannot be limited to asking for what data should be provided to help solve the challenge of financing retrofits, but also provide a template or starting point for companies and institutions to internally examine their own data to help them start retrofitting. Once these companies and institutions are able to retrofit, recommendations about reporting data then become useful. The figure below summarizes what is essentially a feedback loop for data and why it is important to target a “model template” to the multiple entities involved in cycling this data.

Figure 12. Cycle demonstrating constituents involved in commercial retrofit data and the need to address multiple entities in the recommendation process.

Outline of a “Model Template”:

Thus, in order to avoid the circular logic of recommending higher quality reports to solve the lack of reports in the first place, our “model template” is comprised of two distinct sections:

1.) Retrofit Template
- a.) Pre-Retrofit Analysis Template
- b.) Retrofit Report Template

2.) Retrofit Report Database

The purpose of “1a.) the retrofit template” is to address the needs of companies looking to retrofit but currently have not existing retrofits or sufficient access to retrofit data to predict what area of their real estate they need to retrofit. Therefore, the template’s focus is on providing suggestions for what data needs to be aggregated and analyzed either publicly or internally by companies in order to help companies select which buildings to retrofit. This template is primarily based on the categories listed in the Global Reporting Initiative (GRI), a series of recommendations on what factors companies should be measuring and reporting to appropriately assess their sustainability. The template contains a combination of a list of specific variables and categories that companies can internally select appropriate variables to serve as a proxy for a specific category in the GRI. This list of categories and variables can then be used to assemble a profile for each building in a companies portfolio and can ultimately be aggregated and analyzed to determine which buildings are most feasible. For example, after compiling data for all buildings a company may realize that their highest energy expenses come from a cluster of buildings in a cold climate with expensive electricity costs and therefore may find it most financially feasible to begin retrofitting those because the payback period will be the shortest.

The purpose of part 1b.) is to address the lack of publicly available data on retrofits based on a company's ability to report data. Without sufficient data of sufficient quality, it is extremely difficult for research to provide useful feedback and information on the field of retrofits. Therefore, part 1b.) the retrofit report template, provides guidance on what information needs to be reported by companies to be useful to researchers. Much of the data that would be helpful to researchers is the same data in part 1a.) but also contains data analyzing the cost and performance of the retrofit performed in addition to the initial parameters of the building retrofitted as documented in part 1a.)

Finally, even if companies were consistently reporting the data there is a lack of aggregation of the retrofit reports easily accessible and available for analysis by researchers. The last part of the "model template" is part 2.) the Retrofit Report Database. This is essentially a list of recommendations for ways to enhance and support the compilation and maintenance of a publicly accessible database that will help current and future researchers answer the initial questions posed by our research group, current market trends, and essentially enhance all of the uses of retrofit reports stated in the above section "Why Retrofit Reports." However, this Retrofit Report Database is only possible with increased quality and quantity of retrofit reports being published, which is what part 1b.) the Retrofit Report Template recommends, though companies are finding immediate challenges in retrofitting and thus cannot contribute to the retrofit report database, which is why 1a.) the Pre-Retrofit Analysis Template helps companies focus on existing data to start the process of retrofitting. Thus, each component of our "model template" is designed to address each stage of the data feedback loop. The figure below summarizes how each component fits into the feedback loop.

Figure 13: “Model Template” Recommendation

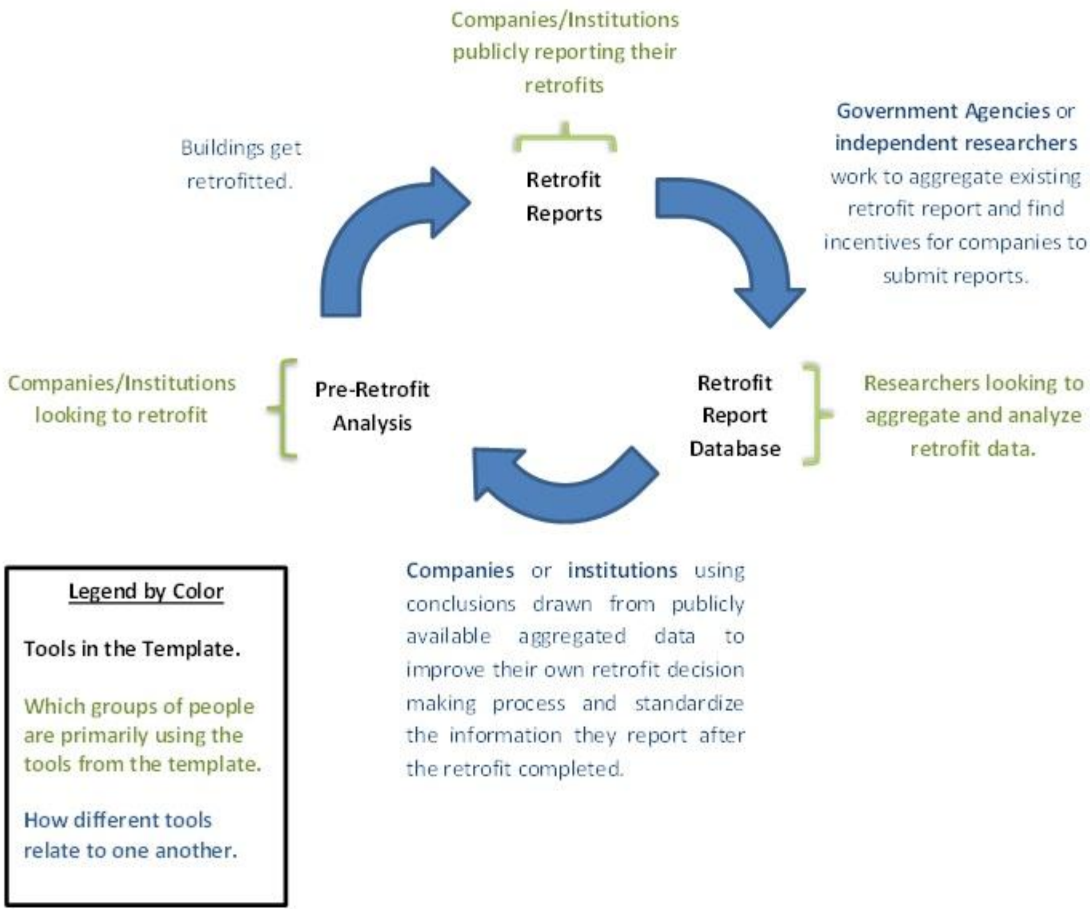

Figure 13. Feedback loop for how data on commercial retrofits is used, who uses it and how our model template” tools fit in this cycle.

Recommendation: “Model Template”

The metrics related to building parameters, financials, geography, and energy provide a clear picture of the embedded value or potential success of a retrofit. In order for decision makers to estimate the value of a retrofit, these key building characteristics must be known. Appendix C, a pre-retrofit template, lists the characteristics that should be recorded in buildings that are being considered for a retrofit. We recommend that these values be compared to reported values from similar, already-retrofitted buildings that reported data in Appendix D, a post-retrofit template. The post-retrofit template contains the same values as Appendix C, in addition to currently proprietary information such as specific annual energy savings. In this way, prospective building retrofitters could filter post-retrofit data by building characteristics (i.e. location, retrofit type, finance mechanism etc.) to estimate returns. Ideally, a post-retrofit database would be made publicly available by the Department of Energy or another related department. The advantage of a public database versus a private database is it would have a larger sample size and less uncertainty.

We acknowledge that we have only had limited experience dealing with a number of the listed variables. The variables covered in this report are marked and we have detailed their importance throughout. The variables we have not had the opportunity of exploring are also marked as such. We have considered what we believe are the best possible indicators based on our research and would highly recommend the inclusion of these factors in future reports or studies. Researchers and businesses alike will have the opportunity to ascertain the data in methods they deem feasible. Many factors reflect proprietary company information; others are indicators not yet measured such as specific electricity consumption. We believe that reporting each of the listed variables will enable more informed choices.

These templates provide general parameters for reporting on specific variables related to each retrofit. Future reports should gather and study them in the method they deem the most insightful. We have taken the concept provided by the Global Reporting Initiative (GRI) and have applied it to specifically metrics related to retrofits. The idea is to group related indicators of retrofit success so as to not limit what is reported on. We believe there are specific categories each containing numerous related variables pertinent to retrofits. For example the climate category is made up of a subset of variables including weather patterns, daily or monthly temperature averages, rainfall etc. Each of these variables can be important to forming a clear understanding of a retrofit's value however some are more pertinent to a specific retrofit type. It would be more useful to understand the average cloud cover and incident solar radiation for a solar retrofit while the monthly temperature average would be more revealing for an insulation or HVAC retrofit. For this reason we believe that discretion on what variables to report should be left to the institution preparing the report.

Recommendations for a Retrofit Report Database

The final component of the "model template" focuses on a way to aggregate all of the data published in retrofit reports for use by institutions, government agencies and any researchers interested in analyzing current trends in retrofits. As mentioned previously in the "Why Retrofit Reports?" the ability to analyze compiled data is potentially extremely valuable to government agencies, academics and ultimately provide useful insight for companies seeking to start retrofitting or improve their ability to retrofit or profitability from retrofitting their properties.

As detailed in the results section of this paper, as part of our research we have developed a preliminary form of this retrofit report database in form of an excel spreadsheet. To our knowledge, this excel spreadsheet is the only large scale attempt to aggregate retrofit reports on commercial real estate. Though our database suffers from an insufficient quantity and quality of retrofit reports we believe it can serve as a preliminary model for other institutions seeking to expand and create a larger retrofit database.

Recommendations for Future Research

The idea of this report was to build a foundation upon which to analyze the commercial real estate energy-retrofit market. We hope that future studies will explore more variables and be entitled to more private data. We would like to see better accounting of the variables associated with buildings and any retrofits made. Despite the lack of company data there are reports and studies that detail investments and savings incurred as well as the potential benefits and return periods of each type of retrofit. The problem is that the reporting standards are not always uniform. We would like to see common metrics between all reports and eventually standardized indicators. Similar to the way the Global Reporting Initiative has provided a sustainability reporting guideline, a clear set of reporting metrics pertinent to specifically a retrofit would strengthen the ability to value a retrofit.

One of the major tasks undertaken in this report was assembling a table of metrics which gave an accurate representation of the retrofit. We collected the majority of data from retrofit reports found on the web. However in the future data will preferably be provided from company data. The list of metrics needs to be expanded to include data from the largest number of assessments possible. More data will only solidify trends noticed in the market and highlight possible areas of profitability and investment strategies. Additionally, current reports circulating the market lack the company data that necessitated the retrofit in the first place. As we explain in The Challenges of Developing a "Model Template" section of this report there is need for reporting on many metrics in a company, whether pre or post retrofit, to determine how to make them successful. It is valuable to track the status of a building before the retrofit was installed. By doing so it is possible to understand what makes a retrofit valuable in the first place. Future studies that delve into the relationship between current company trends prior to retrofitting will be extremely helpful in determining which type of retrofit will be the smartest decision. For example building size, lease specifics, or energy bills might reflect the potential success of a particular retrofit.

This report should give an idea of where to start when looking deeper into commercial retrofits. We aim to clean up the clutter of information provided on retrofits and highlight what is actually important in the hopes that more accurate data and reporting will provide a clear picture of the embedded value in each retrofit.

Some key suggestions for further understanding of retrofits:

- Expand upon the data collected and number of retrofit reports
    - Improve the ability to locate trends
- Interview more related professionals
    - Better understand the industry conception
- Provide further differentiation between building types (size, function, ownership)
    - Explore retrofit performance relative to building type
- Ascertain fiscal reports regarding leasing and energy
- Explore financing mechanisms related to payback (On-Bill, etc)
    - Determine practical investment options and strategy

- Analysis of incentives by retrofit or location
- Spatial (GIS) analysis of retrofits
- Determine the most receptive or profitable locations
    - Spot trends in retrofits related to demographics
- Integrate future energy pricing models to determine projected value and savings of retrofits

Implications of Future Policy

Nearly 75% of the current commercial buildings in the US are twenty plus years old and will still be in use roughly fifty years from now. So what are the implications for the energy retrofit industry? While retrofit implementation and market size is expected to be large in the near future, many barriers still exist.

First, the over 4.4 million non-residential buildings exist in the United States (McGraw-Hill 2009). While emissions are relatively easy to monitor when dealing with a couple of large volume emitters (i.e. factories), the task of managing millions of different buildings, especially given distinct municipal and regulatory jurisdictions, is an extensive process. Second, a large amount of capital usually needs to be invested to retroactively fix older buildings with energy efficient technology such as expensive HVAC retrofits, solar panels and insulation. In a recession, developers with large funding pools will primarily be the only ones pursuing retrofits—especially since company profits are the main sources of funding for green retrofits (McGraw-Hill 2009). Therefore, small cap companies/decision makers are unlikely to participate.

Furthermore, the real estate green energy efficient is a relatively new market that is maturing alongside the carbon market. The carbon market features a cap-and-trade style trading mechanism. It works by recruiting volunteer organizations or nations to exchange the rights to issue greenhouse gasses credits. When all the states are listed, proper authorities and experts decide upon the total amount of gas emissions that the group can emit as a whole. Then the organization decides from within on how to allocate its credits with the total amount limit set to be lower than the amount emitted the previous year. During the year, if a member manages to emit less than the allowable amount, they can sell off their remainder to another member of the carbon market. It is imperative to note that the transactions do not change the total emissions of the group. Therefore, one company must emit a lower-than-allowable amount in order for another company to emit more.

The carbon market, however, is still an idea in its infancy stage as can be seen from the recent collapse of the Chicago Climate Exchange (CCX), a market that was famously predicted to become a “10 trillion dollar” giant. The collapse was attributed to the volatility of the carbon price. Based upon CCX historic data, the price of a ton of carbon fell to a dismal ten cents per share. In contrast, a ton of carbon in the European Trading Scheme traded at an approximate $17 in May 2011. With different market mechanisms, both domestic and international, complications arise when dealing with a commodity that is sometimes volatile and other times worthless. There have been steps taken to expand carbon markets such as California's AB32.

The ability to which a cap and trade system can affect the carbon price (and by extension, electricity prices) depends largely on the aggregate cap level. According to a December 2010 draft, the trading system will initially apply to large point sources, such as industrial facilities, beginning in 2012. In 2015, the cap and trade program will be expanded to include fuel distributors-- resulting in a twofold increase in permits from 165 million to 330 million (CARB 5). Although the cap and trade system would increase the costs of carbon emissions in 2012, the influx of new permits in 2015 may generate uncertainty about the future carbon costs. Therefore, infrastructure upgrades with long payback periods may be delayed until years after 2015 to see how the market price responds. In addition, if permits are over allocated resulting in a low carbon price, businesses may not scale back emissions to the extent forecasted by AB32.

The hesitancy of investors to consider funding projects that will reduce carbon emissions in order to then trade carbon credits as well as projects that will implement an energy efficiency retrofit is perhaps predominantly due to the unknown variable of payback time. Admittedly, it is difficult to calculate energy consumption and carbon emissions when usage is not held constant. This known variable of unknown potential can be overcome by constructing a simple mathematical model. The model, albeit linear for simplicity, can be easily built upon to account for a more complex understanding of a given business structure. The following equation defines the payback period:

P = payback period; I = interest rate per period; V_p *= present value;* V_i *= initial value;* S_p *= percent savings*

$$P = \frac{V_i}{S_p + I \cdot V_p}$$

To calculate when the more business-as-usual plan intersects with the retrofit plan, we can determine when payback is complete:

S= payment per period; S_a *= energy payment per period of business-as-usual;* S_b *= energy payment per period of retrofit project; E = energy used;* R_e *= cost of electricity; X = variable of time*

$$S_n = E * R_e$$

$$S_a \cdot x = S_b \cdot x + V_i \cdot I \cdot P$$

$$x = \frac{V_i \cdot I \cdot P}{S_a - S_b}$$

From this relationship we can see that payback period depends on the cost of the project and the percent savings (Note that S_a-S_b can give percent savings with units of dollars per year). More expensive projects that produce large cost savings may take just as much time to payback the initial retrofit cost as cheaper projects with small cost savings. More importantly, projects that may take a lot of time to payback and may cost a lot initially but come with fairly constant cost savings have the potential to become very beneficial after the payback period. Dramatic reductions to the payback period can also be had if the price of energy per unit consumed is increased. The business-as-usual plan may experience a drastic increase in the required amount of money to maintain current energy consumption levels while the retrofit plan is more moderated. A sudden spike in energy pricing, paired with the stepped rate system for energy pricing, yields an addition of cost savings that supports implementing an energy efficiency retrofit.

Building retrofits have significant potential to reduce U.S. carbon emissions. In addition to many being cost-effective to owners, retrofit investments can simultaneously stimulate job growth, increase company profitability, and decrease the country's greenhouse gas emissions. The advantage is that these benefits can all be achieved without substantial changes to our nation's energy infrastructure.

The American Reinvestment and Recovery Act allocated over 250 million dollars alone for energy efficiency retrofits (ARRA 2009). The money is being used by local government to leverage programs such as PACE bonds and other programs. While the government has maintained biannual Commercial Buildings Energy Consumption Surveys, which detail general aggregate statistics, it does not record energy consumption of individual buildings. Furthermore, under the 2011 Congressional budget agreement, the CBECS, which is the Nation's only source of statistical data for energy consumption and related characteristics of commercial buildings was terminated. In the case of a Chicago retrofit report, the simple payback period was reduced from 7.65 years to 4.72 years with government support of $52,791 (Appendix E). We propose that any retrofit project utilizes government or utility incentives should make their pre-and post- energy consumption data public in a national database. The database should be able to be filtered by project characteristics listed in Appendix D. In this way, prospective commercial building owners or tenants can easily gauge returns from previously implemented programs to determine if an energy audit is worth it to them. Financial institutions could also use the data to generate better contracts. An added benefit would be that few government resources would be needed to maintain the database since the data would be self-reported.

After assessing our survey data and reviewing the retrofit reports it was apparent that nearly all of the retrofits projects carried out consisted of 3-5 year pay back periods. From this we learned that the commercial real estate sector wants to see immediate returns and is unwilling to commit long term to see their profits. Fortunately, there have been leasing mechanisms that would help this situation. A great example of a response to the commercial real estate's sector's lack of patience is the city of New York's Model Energy Aligned Lease. The lease plan requires the city, the property owner, and the tenant to work together to benefits all parties. In the plan, the property owner can recover the costs it invests in energy efficiency from the tenants by using savings over the length of the projected payback period of a project (as opposed to the useful life of the improvements), thus shortening the amount of time it takes for owners to collect their investment and providing a significantly greater incentive for owners to invest (plaNYC).

The New York plan also provides significant assurances to tenants that the improvements made will benefit tenants. After energy efficiency improvements are made, tenants continue to accrue actual savings while they pay the owner 80% of the projected savings (assessed by independent engineers). This 80% creates a buffer if the projected savings do not exactly equal the actual savings. Moreover, after the payback period compensates the owner for the initial investment, the tenant will continue accrue all of the benefits of the energy savings. Thus, we are beginning to see specific financing mechanisms and leasing schemes which are complying with the demands of both the investor (property owner) and tenant (plaNYC).

Although the New York plan is a new lease structure that resolves the infamous split-incentive issue, it is apparent that there also are existing lease structures that may also settle or better deal with the property owner-tenant divide. In the “Reference Guide to the Model Green Lease” by B. Alan Whitson, the author provides his own thought on the ideal lease for green retrofits. Whitson indicates that even though the market favors net leases, he does not believe the lease model provides a suitable framework to incentivize the leasor or leasee to invest in green retrofits. He believes that reductions in energy cost directly increase a building’s value, thus primarily benefiting the landlord, and therefore a gross lease would be the proper lease type to align both parties in an agreement (Burket 2010). Through both the New York Plan and Whitman’s discussion of existing leases it is apparent that undertaking green retrofits is a complex manner and that the lease arrangement and financing will differ case by case.

V. Conclusion

The emphasis of modernizing the U.S. electric infrastructure has been primarily been on the supply-side through technologies such as wind and nuclear power. Yet, a potential-low hanging fruit is the modification of the current means of energy consumption. Energy reducing building retrofits also have the capacity to yield many of the same supply-side benefits at cost effective prices. With the coming of carbon-mitigation legislation such as AB32, decision makers have more incentive to implement energy saving measures. While such government policies will stimulate interest in energy retrofits, the industry will be continue to be stymied without bridging knowledge gaps between the building owner, tenant, and lending institutions.

From our retrofit report data we find that lighting is the least expensive retrofit while HVAC is the most expensive to install per square foot. Despite this, our surveys indicate that most organizations are primarily interested in HVAC commercial building upgrades. Both the retrofit report analysis and survey results suggest that decision makers expect a payback period between three and five years.

Based on our research experience, the main problem is that decision makers have few resources to value a retrofit, especially since retrofit returns depend on local factors such as incentives and electricity costs. The proprietary nature of commercial building contracts, such as lease structures and retrofit finance methods, exacerbate the lack of commercial retrofit data. In order to remedy this problem, we provide a basis for future analysis of commercial energy efficiency retrofits at a microlevel. While more government funding on a project by project case will stimulate the industry, we feel that decreasing barriers to knowledge is a more efficient way of promoting retrofits. By providing a public database of retrofit information, the government can allow private lending institutions to create more suitable terms and contracts geared for green retrofits. At a minimum, individual organizations can maintain their own internal databases without compromising their nondisclosure agreements.

Our research has led us to believe that the main obstacle to retrofits is rooted in commercial building lease structures. Under a common conventional net lease, the tenant pays the majority of the operational costs. Therefore, the owners have little incentive to retrofit their buildings since the savings would benefit the tenants. On the national level, retrofits are discouraged by the proprietary nature of energy consumption data so the results from successful retrofit projects are rarely reported. Since little post-retrofit data exists, owners and tenants have little benefit data to weigh against retrofit costs. This is why it’s important to publish costs and savings of completed retrofits to reduce uncertainty and instead encourage property owners to make wise retrofit decisions. While the series of complex relationships between the government, property owners, tenants, investment firms, and brokers could be a barrier, the commercial real estate benefits have significant potential. While one plan is unlikely to solve this, future studies should investigate solutions to individual problems so a holistic approach can be developed.

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Appendices

Appendix A: Abbreviated Survey Questionnaire

Please state the category that most represents your organization:

- ESCO
- Government agency
- Utility company
- Academic professional

Retrofits

- What type of retrofits would your organization be willing to undertake, from most to least likely: lighting, heating/cooling upgrade, solar panels, HVAC?
- What types of buildings does your organization usually see for retrofitting (high-rise offices, less than 5 floor offices, single-story offices)?
- Is there a typical floor space that is used to measure if a project is feasible or not?
    - If so, what is the square footage?
- Generally speaking, what criteria are necessary for a building to be retrofitted with energy efficiency upgrades?

Evaluations

- Do you conduct energy audits before entering a project?
  (answer coded as: Always, Sometimes, Never)
- What percentage of error do you allow in energy audits for determining project feasibility?
- Do you do in-house audits for buildings or do you outsource to another firm?
  What are your desires to retrofit?
- Do you usually seek to do a retrofit project or does someone approach you with the concept?
- If someone approaches, typically what category best describes them?
  (i.e. ESCO, Government agency, Utility company, Academic professional)

Financials

- What are the average payback periods your company would allow for an energy efficiency retrofit? The longest period?
- What are the average project periods your company typically involves itself with?
  The longest period?
- What is the minimum rate of return that your company wants to see possible before starting a project?
- What is the average rate you like to see?
- Do you charge interest for green retrofitting projects?
    - If yes, how much is typical?
    - If yes, what is the lowest rate allowable?
- What situations allow for a lowered interest rate? government subsidy?
- What types of funding do you try to utilize?
- Does your organization seek government subsidies?
    - For what purposes specifically?

[Specific to ESCOs]

- Do you have in-house contractors for installation of retrofits?
- If yes, do you prefer to use in-house contractors or contractors located locally to a project?
- Do you typically split the cost of the retrofit with the building owner or do you fund the retrofits outright?
- If there is a split, how is that usually structured?
- How often do you try to take advantage of government programs to subsidize the cost of a retrofit project?
- {How does your decision tree work}
- How does the process of a retrofit project start?
- What barriers appear?
- At what stages?
- In such a competitive market, does your business try to out-compete other ESCOs for similar projects or do you believe you appeal to a niche market?
- Especially with companies like ESCOS's available, why do you think people and companies choose not to invest in retrofits?

Future

- How do you think AB32 will affect your business?
  Is your organization making any changes to prepare for the implementation of AB32?

Feedback

- Do you have any questions for us?
- Would you be able to contribute any additional information that is of a case study nature to our project; including energy savings, type of retrofit, type of building, etc?

Appendix B: Tabular Survey Responses

	ESCO 1	*ESCO 2*	*ESCO 3*	*ESCO 4*	*ESCO 5*	*Utility 1*
Retrofit Preference 1	Lighting	Lighting	NA	Heating/Cooling	Heating/Cooling	NA
Retrofit Preference 2	HVAC	HVAC	NA	HVAC	HVAC	NA
Retrofit Preference 3	Heating/Cooling	NA	NA	Lighting	NA	NA
Retrofit Preference 4	Solar Panels	NA	NA	Solar Panels	NA	NA
Building Type	Less than 5 floors	High Rise	High Rise & Less than 5 floors	Single Story	Single Story	Single Story
Typical Floor Space	None	None	Varies	None	None	None
Criteria	Age, previous retrofit work	depends on client	Funding	None	energy usage (compared to square footage), equipment age	Cost effective opportunities present
Conduct Energy Audits	Sometimes	always	always	Always	Always	Usually
Allowable Error	20	depends on client	20	3 to 5	10 to 15	NA
In House Audits	usually	sometimes	sometimes	Always	sometimes	Always
Objectives		reduce operational cost of business while increasing energy output	lighting controls, energy management	deep-energy retrofits, resulting in increased savings and quality	save energy	projects with persistent savings
Who Approaches	Utility	Property owners and Governemnt	Varies greatly	Utilities, Governments, businesses	They always do	property owners, tenants, contractors
Payback Period	3-5 years	4-22 years	3 years (private)	5-10 years	3-5 years (private)	1-3 years
Maximum Payback	NA	25 years	public can be very high	NA	20 years for public	7-10 years

Project Period	1-2 years	14-18 months	1-3 years	1-3 months	varies	varies
Minimum ROR	20	depends on client	20 years	NA	NA	NA
Charge Interest	No	Financiers charge	6	NA	no	no
Types of Funding	Government	Government	Local incentives	NA	Government	NA
For what?	NA	Rate Reductions	NA	NA	NA	NA
In-house contractors?	No	Some	NA	NA	No	NA
Who Funds	Client	Both	NA	NA	depends on client	NA
Subsidize	yes, up to 70%	NA	NA	NA	Everytime	NA

Appendix C: Pre-Retrofit Report Template

Pre-Retrofit Template			
Pertinent Variables to Green Retrofits by Building			
Category	**Parameters**	**Relevance**	**Inc. in Report (Y/N)**
Building Characteristic	Total square footage	Sizing, scope and intensity of necessary retrofit.	Y
	Building Age	Current building efficiency.	Y
	Building Type	Draw commonalities with other similar buildings	Y
	Number of Units in Building	Determine expanse of retrofit	Y
	Number of residents/employees in the building	Indicator of power demand	N
	Number of Floors(Stories)	Expanse of heating systems, power demand and transmission	N
	Specifics of the building exterior: Materials, Color, etc.	Innate ability of the structure to provide natural heating, cooling	N
	Noticeable surroundings: trees, large shading, etc.	Obstructions to solar/natural shading	N
	Current insulation	Quality and effectiveness of current fixture	N
	Current lighting details	Quality and effectiveness of current fixture	N
	Current heating details	Quality and effectiveness of current fixture	N
	State	Relation to geographic trends ie income, policy, other demographics	Y

	City	Relation to geographic trends ie income, policy, other demographics	Y
	Annual building use activity (i.e. peak periods of use throughout the year)	Extent of effectiveness of the retrofit, duration of utilization	N
Energy/Resource Consumption	Monthly Energy Consumption in kWh-hr.	Indicator of savings and effectiveness of retrofit	N
	Energy demand by source within building, as specific as possible	Indicator of savings and effectiveness of retrofit	N
	Water usage(aggregate and rate)	Indicator of savings and effectiveness of retrofit	N
	Gas and heating	Indicator of savings and effectiveness of retrofit	N
	HVAC, lighting, energy productions details etc.	Indicator of savings and effectiveness of retrofit	N
Financial	Monthly utility bills	Indicator of savings and effetiveness	N
	Lease Structure	Indicator of pertinent finance mechanisms and investor sentiments	N
	Property Tax	Indicator of incentives, local government/authority support	N
	Monetary incentives acquired for retrofitting.	Indicator of incentives, local government/authority support	
Geographical	Climate: i.e. monthly average temperature and local weather conditions	Associate the impact of weather on resource consumption with retrofit	N
	Local policy and incentives regarding retrofitting.	Determine local receptiveness towards retrofitting.	N
	Local utility provider.	Determine trends and support from utility companies.	N

Appendix D: Completed-Retrofit Report Template

Retrofit Report Template			
Pertinent Parameters to Green Retrofits by Building			
Category	**Parameter**	**Relevance**	**Inc. in Report (Y/N)**
Building Characteristic	Total square footage	Sizing, scope and intensity of necessary retrofit.	Y
	Building Age	Current building efficiency.	Y
	Building Type	Draw commonalities with other similar buildings	Y
	Number of Units in Building	Determine expanse of retrofit	Y
	Number of residents/employees in the building	Indicator of power demand	N
	Number of Floors(Stories)	Expanse of heating systems, power demand and transmission	N
	Specifics of the building exterior: Materials, Color, etc. Post Retrofit	Innate ability of the structure to provide natural heating, cooling	N
	Noticeable surroundings: trees, large shading, etc.	Obstructions to solar/natural shading	N
	Current insulation Post Retrofit	Quality and effectiveness of current fixture	N
	Current lighting details Post Retrofit	Quality and effectiveness of current fixture	N
	Current heating details Post Retrofit	Quality and effectiveness of current fixture	N
	State	Relation to geographic trends ie income, policy, other demographics	Y

	City	Relation to geographic trends ie income, policy, other demographics	Y
	Annual building use duration (i.e. peak periods of use throughout the year) Post Retrofit	Extent of effectiveness of the retrofit, duration of utilization	N
Energy/Resource Consumption	Energy consumed monthly in kWh-hr. Post Retrofit	Indicator of savings and effectiveness of retrofit	N
	Energy demand by source within building, as specific as possible Post Retrofit	Indicator of savings and effectiveness of retrofit	N
	Water usage(aggregate and rate) Post Retrofit	Indicator of savings and effectiveness of retrofit	N
	Gas and heating Post Retrofit	Indicator of savings and effectiveness of retrofit	N
	HVAC, lighting, energy productions details etc. Post Retrofit	Indicator of savings and effectiveness of retrofit	N
Financial	Monthly utility bills Post Retrofit	Indicator of savings and effetiveness	N
	Lease Structure Post Retrofit	Indicator of pertinent finance mechanisms and investor sentiments	N
	Property Tax Post Retrofit	Indicator of incentives, local government/authority support	N
	Monetary incentives acquired for retrofitting.	Indicator of incentives, local government/authority support	Y
Geographical	Climate: i.e. monthly average temperature and local weather conditions	Associate the impact of weather on resource consumption with retrofit	N
Post-Retrofit	Retrofit by Type, make, and model	Specify method of	Y

	Energy Production in kW	Indicator of retrofit energy savings through direct production, capacity of retrofit	Y
	Installation Year	Indicates the duration of use	Y
	Year of retrofit report publication	Indicates time delay from installation to metrics collected and conclusions	Y
	Year of last retrofit report publication	Indicates when if ever another report has been made,	Y
	Total cost of retrofit	Helps determine value of energy or resource savings	Y
	Year to Date Savings	Helps determine effectiveness of retrofit	Y
	Payback period with incentives and without	Measure of the return on investment of retrofitting	Y
	Total Incentive Amount	Indicator of local support and actual value vs adjusted value of retrofitting	Y
	Incentives by Type	Indicator of local support and actual value vs adjusted value of retrofitting	Y
	Incentive Details i.e. names/program/during of incentive etc.	Indicator of local support and actual value vs adjusted value of retrofitting	N
	Cost per sq. foot of retrofit	Indicator of weighted cost; investment in relation to scope of project	Y
	Annual Avg Energy Savings as kWh	Indicator of effectiveness of retrofit	Y
	Annual Avg Energy savings as a %	Indicator of effectiveness of retrofit	Y

	Annual Energy savings as kWh	Indicator of effectiveness of retrofit	N
	Annual Avg Energy savings as %	Indicator of effectiveness of retrofit	N

Appendix E: Retrofit Report Data

The comprehensive retrofit report information can be viewed at:
https://spreadsheets.google.com/spreadsheet/ccc?key=0Au-q81xhCnLmdE85d0RmT2d2NUNJVVRBNGQ3Wl81Ync&hl=en_US#gid=0