Supporting Energy Management in Industrial, Commercial and Institutional Properties

A Market Transformation Strategy for the City of Cambridge

DRAFT FINAL REPORT

A PROJECT DEVELOPED IN PARTNERSHIP BETWEEN:

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY COMMUNITY INNOVATORS LAB
GREEN ECONOMIC DEVELOPMENT INITIATIVE
AND
CITY OF CAMBRIDGE COMMUNITY DEVELOPMENT DEPARTMENT

MIT CoLab

CAMBRIDGE CDD@344
COMMUNITY DEVELOPMENT DEPARTMENT
344 Broadway

About This Project

The Massachusetts Institute of Technology's Community Innovator's Lab Green Economic Development Initiative (MIT GEDI) and the City of Cambridge's Community Development Department partnered in Spring 2013 on an "action research" project to identify strategies to grow the uptake of energy efficiency in commercial buildings in Cambridge. This report documents the findings of our research. This work is intended to support Cambridge's ongoing economic development and environmental initiatives.

About MIT CoLab Green Economic Development Initiative

MIT GEDI is a project of the Community Innovators Lab, a center for planning and development within the MIT Department of Urban Studies and Planning (DUSP), which focuses on advancing a socially just and environmentally sustainable economy. MIT GEDI conducts applied research; develops tools and resources for practitioners; disseminates knowledge; and partners with economic development organizations to design strategic planning initiatives intended to transform economic development practice. GEDI is generously supported by a grant from the Rockefeller Brothers Fund.

Executive Summary

Fostering stronger energy management – e.g., strategies to minimize buildings' energy costs and meet other energy-related goals – in institutional, commercial and industrial (ICI) buildings in Cambridge can contribute to a more prosperous local economy. The documented economic development benefits of supporting energy management include:

- Greater business profitability.
- Increased real estate values.
- Job growth, both from a growing energy services sector, as well as energy savings being reinvested in the local economy.
- Healthier buildings, with increased occupant productivity.

CONDITIONS IN CAMBRIDGE

The large majority of Cambridge's ICI energy use is concentrated in a relatively small number of large properties. These properties have the greatest potential to drive energy savings in Cambridge's ICI sectors; however, energy management market transformation efforts should also focuson smaller properties. Smaller properties are an important part of the local economy and stand to benefit from better energy management. Moreover, smaller properties make up a significant proportion of national ICI energy use; developing innovative means of serving these properties can serve as important precedents for other jurisdictions.

Massachusetts' state energy policy and ratepayer funded energy efficiency programs are relatively comprehensive, providing commercial buildings with the opportunity to engage in most potential energy upgrade opportunities. . Nevertheless, ICI buildings face a number of challenges to optimal energy management, including:

- Building owners, managers, and operators require guidance on energy management opportunities. They possess limited time to devote to energy management, and require ongoing learning and capacity development
- Building owners need for innovative financing mechanisms. Many building owners will only consider energy management with relatively short payback periods (~3 years). Most organizations interviewed for this project relied on cash-on-hand for energy upgrades, which may explain why properties tend to invest in energy upgrade projects on a piecemeal basis. Appropriate energy project financing mechanisms can extend viable repayment horizons, and allow for more comprehensive energy upgrades.
- Building owners and property managers have difficulty finding trusted energy contractors who can provide energy management services. This issue was especially pertinent in the small and medium sized building HVAC contracting sector; HVAC contractors typically focus only on keeping systems operating, and less on optimizing energy management and achieving energy savings.
- Building owners and managers noted the need for technical assistance in using building benchmarking systems such as ENERGY STAR Portfolio Manager, especially as benchmarking and disclosure policies move forward. Moreover, there is concern that ENERGY STAR

Portfolio Manager does not properly account for energy intensive lab spaces.

RECOMMENDATIONS

To address these conditions, we recommend that the City of Cambridge:

Promote energy management and facilitate capacity building opportunities for the ICI sector. Programming could include:

- Training in using ENERGY STAR Portfolio Manager, and potentially other energy benchmarking, tracking, and information feedback tools.
- A Speakers Series, providing training and information on a variety of building energy management topics, and opportunities for networking.
- Access to energy management and analytics systems and building by facilitating bulk purchasing of such services.
- Promotions and co-sponsorship of energy management training for existing property managers and building operators.
- A "Deep Energy Upgrade Gameplan" service, helping building owners identify key opportunities for deep energy improvements to their spaces.
- An "Energy Concierge" service, providing businesses guidance on the various energy management programs, services, and contractors available to them.

Partner with A Better City to deliver its energy challenge in Cambridge. The Challenge provides an outreach and technical assistance framework to support energy efficiency in the commercial building sector. The challenge should be open to all ICI building types.

Expand Financing Opportunities for Energy Management Upgrades. Consider adopting a Property Assessed Clean Energy (PACE) financing program, when available. Proposed state legislation would direct the Massachusetts Development Finance Authority to establish a PACE financing program. Local governments would have the option of opting into the program. PACE financing addresses many of the barriers to energy project finance, allowing for: Lower interest rates and longer terms, due to the secure lien of being on property tax bills; the ability to readily pass financing repayments onto future building owners; the ability to pass repayment through to tenants; and the likelihood of PACE's "off balance sheet" treatment.

Convene stakeholders to identify ways to integrate better energy management into HVAC contractors' services. HVAC contractors provide many ICI buildings in Cambridge with maintenance and repairs. However, interviewees suggested a "gap" in the market, with few service providers providing ongoing optimizing of operations for efficiency. The City can work with other stakeholders to identify strategies to improve energy management service provision in the HVAC contracting sector.

Consider establishing a Sustainable Laboratories Consortium. With its concentration of private sector, university and private research institute laboratories, Cambridge has the opportunity to work with the designers, managers and users of laboratories to push the envelope on sustainable laboratory design and advance best practices in efficient laboratory management. A Sustainable Laboratory Consortium could bring together laboratory designers and managers from universities, research institutes, biotech and pharmaceutical firms in Cambridge to consolidate knowledge of exiting best practices, identify opportunities for further energy savings, water savings and waste reduction and establish a prototype facility to test and development new sustainable laboratory energy and resource management designs, systems, and practices.

By engaging in these market transformation activities, the City can realize its environmental goals while supporting the local economy.

Table of Contents

I. Introduction

A. Purpose of this Report

This document reports the findings of a collaborative action research project between the Massachusetts Institute of Technology's CoLab Green Economic Development Initiative (MIT GEDI), and staff at the City of Cambridge's Community Development Department. The goal of this collaboration is to identify strategies that can grow good energy management practices in industrial, commercial and institutional (ICI) buildings in Cambridge, and thereby realize a stronger economy.

Chapter 1 of this report describes what we mean by "energy management" and describes the potential economic benefits of improving energy management.

Chapter 2 summarizes our research findings, indicating the current state of energy management practice in Cambridge.

Chapter 3 suggests roles that the City of Cambridge and its partners can play to enhance building owners' and managers' ability to realize strong energy management in their properties.

B. What is "Energy Management"?

"Energy Management" refers to efforts to minimize buildings' energy costs and meet other energy-related goals, such as environmental performance and healthy indoor conditions. This report focuses especially on strategies to speed the uptake of energy efficiency, which we define as deploying technologies and services that reduce energy consumption while providing the same energy services (e.g. lighting, air conditioning, etc.). Efficiency currently represents the greatest opportunity to achieve energy savings in buildings. However, energy management can also entail investments in: Distributed energy generation, such as building-scale solar photovoltaic installations; demand response, which entails decreasing electricity usage at peak demand times to avoid costs; behavior change campaigns, to achieve energy conservation; connections to district-scale energy infrastructure, such as district heating/cooling and microgrids; and other strategies. Such strategies over and above energy efficiency also increasingly represent strong means of reducing energy costs while realizing positive environmental outcomes. Moreover, in many cases, the same sorts of policies, programs and initiatives local governments may implement to realize energy efficiency can also help enable these other energy management activities. Thus, we use the broader term "energy management", to recognize that the City's actions can help foster a wide array of economical sustainable energy choices.

Comprehensive energy management requires action by multiple stakeholders in buildings – building owners; property managers; building operators; tenants; energy efficiency program administrators; third-party consultants and energy service providers; financiers; and others. Energy management can entail a whole host of initiatives by these stakeholders, including:

- Tracking performance, via energy dashboards and benchmarking building performance to historical usage and peer buildings.
- Operational improvements to existing equipment.
- "Commissioning", which entails a comprehensive detailed assessment of building systems to ensure that all systems are functioning optimally in accordance with their original design intent.
- "Energy upgrades", which entail the replacement of existing equipment. Standard energy upgrade measures can often entail energy savings in the range of 15-25 percent. "Deep energy upgrades" refer to comprehensive, customized, whole-building efforts to realize maximum energy savings; they present the greatest opportunities to save energy (perhaps 40-60 percent), but are rarely undertaken b building owners.

C. Economic Benefits of Energy Savings

Achieving the full potential of cost-effective energy efficiency opportunities can realize a wide array of economic development benefits.

Enhanced Business Profitability

Reducing operating costs by lowering energy spending realizes greater profits for businesses. Energy and other utilities comprise the largest non-labor operating costs for buildings in most regions of the USA. For example, energy and water account for 22 percent of office owners' operating expenses, equating to about $2.25 per square foot (RMI 2013).

The effect on businesses' net profits can be especially profound for businesses with low profit margins, and for whom energy costs make up a large percentage of their operating costs. Analysis by the National Trust for Historic Preservation provides a useful illustration of these dynamics: As restaurants and groceries have low profit margins and high energy costs, they can realize significant increases in their net operating income by reducing energy spending; the percentage increase in office property profits are not as great, though they can still result in large savings in aggregate and significant enhancements to the value of the property (see Figure 1).

Enhanced Value of Real Estate

Lower operating costs, healthier buildings, and a "green" brand can add to building values and rents, as occupants are willing to pay more to locate in such buildings. The Institute for Market Transformation's meta-analysis of national studies investigating the impact of LEED and ENERGY STAR rating on real estate performance has found consistently positive premiums on rents, sales price, and occupancy (see Figure 2).

Job Creation

Energy management can meaningfully increase the amount of employment opportunities available

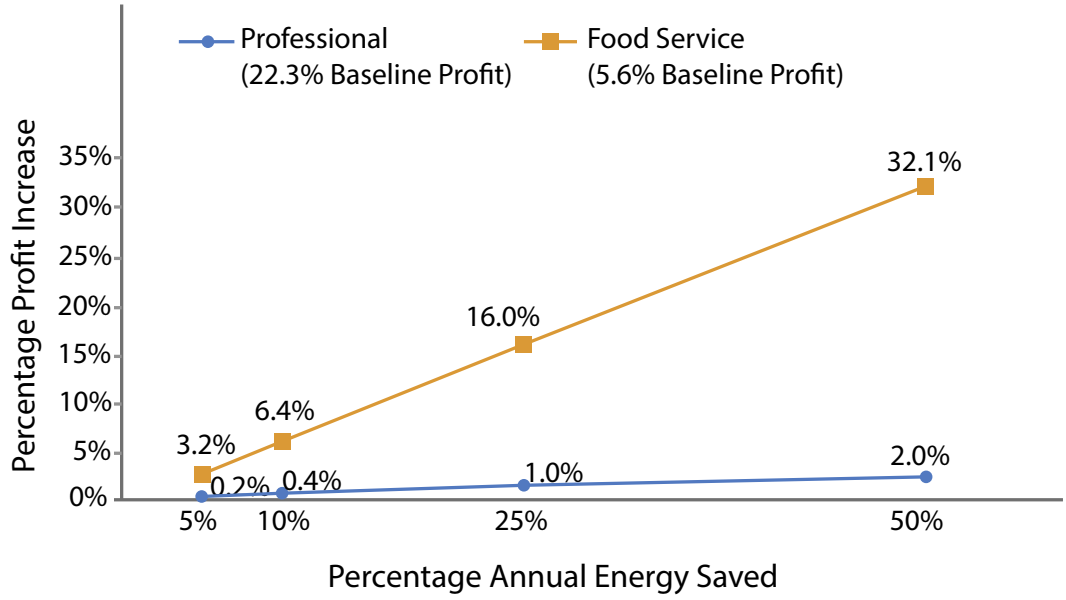

Figure 1: Increase in percent of profit associated with energy savings, using national average business energy costs and profit margins. Source: (NTHP PGL 2013) data from the IRS.

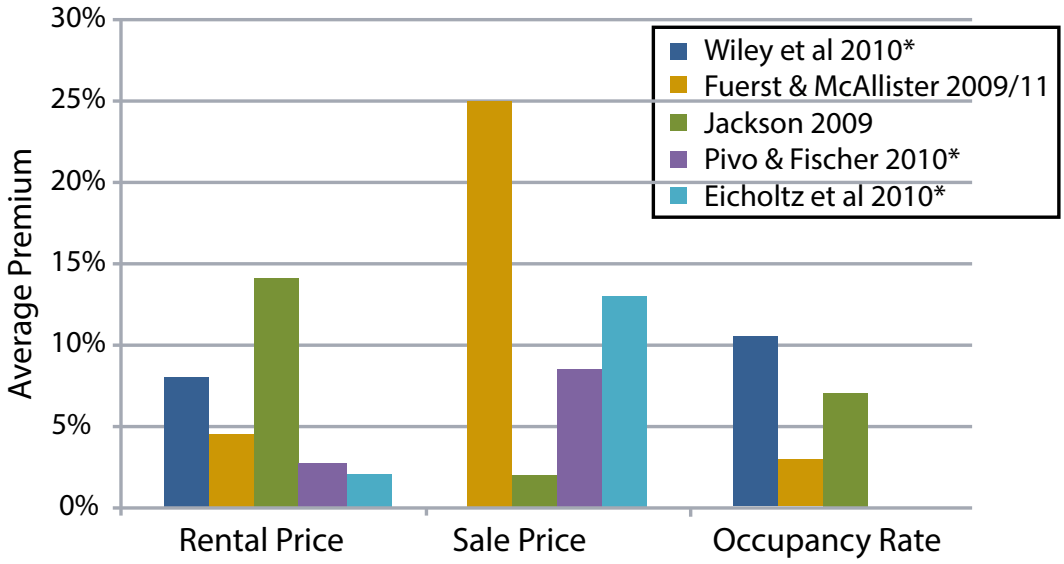

Figure 2: Premium associated with green rated commercial real estate - results from multiple national-scale studies. Asterix indicates that studies tracked only two of the three indicators of real estate performance. Source: Institute for Market Transformation.

in local economies. Energy efficiency engenders economic activity and a net increase in jobs in one of two ways:

- *Jobs are created due to investments in energy management* ("investment related jobs"): Short-term spending on energy projects leads to direct, indirect, and induced jobs. Job creation begins when an energy efficiency project is undertaken and workers are needed, thus leading to the creation of direct jobs. Indirect jobs are created when suppliers of energy management products (HVAC systems, insulation, etc.) bring on more workers to produce goods. Finally, all these workers spend their earnings in the local economy, realizing further economic activity and job impacts.

- *Jobs are created due to the reinvestment of energy savings* ("savings related jobs"): As energy savings are shifted away from spending on utilities, and towards more labor-intensive sectors of the economy, increased jobs and economic productivity are realized.* Thus, investments in energy efficiency entail an "import substitution" strategy, as less energy per unit of economic product will be need to be imported to the region. These import substitution effects are likely stronger in metropolitan regions, as most metropolitan regional economies do not have a large number of jobs in fossil fuel supply sectors.

The role of energy efficiency in realizing a strong economy is particularly potent in the Northeast States, including the Boston-Cambridge metropolitan region, as this area imports much of its energy and faces relatively high energy prices. A 2009 study commissioned by Environment Northeast estimated the economic impacts of achieving all cost-effective energy efficiency in Massachusetts. It found that over a fifteen-year period, achieving all cost-effective energy efficiency would realize 582,000 job-years of

* Nationally, the energy generation and distribution sectors have a job intensity of 10 jobs per $1 million spent in these industries. In comparison, the economy as av whole has 17 jobs per $1 million spent (Bell, 2012). Thus, shifting utilities spending to other economic sectors realizes job growth.

employment, and an increase in gross state product of $89 billion (ENE 2009). More than 85 percent of these projected economic benefits are due to energy savings diverting spending on utilities, and instead being redirected to other sectors of the economy.

Health and Productivity Improvements Associated with Building Design and Energy Management

Building energy upgrades can also realize health and productivity improvements for employees working in these buildings. Appendix 2 summarizes MIT GEDI's literature review of studies evaluating the link between energy management initiatives and improved occupant health. While more study is needed, the balance of evidence suggests that:

Energy-efficient building design and good energy management practices can improve worker performance. A number of studies have shown that measures such as temperature control, improved indoor air quality, lighting system quality, and access to the natural environment can both reduce buildings' energy use and improve the individual performance of employees working in those buildings. Workers accomplish their objectives in shorter amounts of time and in general demonstrate individual productivity gains. Some studies suggest that investments in efficiency and healthy buildings are also associated with decreased churn costs, or the costs associated with employees leaving a company and necessitating replacement.

Energy-efficient building design and good energy management practices can improve worker health. The balance of evidence suggests that investments in energy efficiency and improved building performance can realize positive impacts on workers' health and well-being. In particular, upgrades have been shown to address indoor air quality and reduce "sick building" syndrome.

The health and productivity benefits result in an even more compelling financial case for energy management. Employee and labor costs typically exceed the costs of space for firms by well over an order of magnitude (see Figure 3); therefore, small incremental improvement to occupants' health and productivity associated with energy management initiatives can realize substantial life-

Table 1: Modeled economic impacts of achieving all cost-effective energy efficiency in Massachusetts over 15 years.

	ELECTRIC	NATURAL GAS	UNREGULATED FUELS
Total Efficiency Program Costs ($ Billions)	7.6	2.4	2.0
Increase in GSP ($ Billions)	49	18	22
Maximum annual GSP Increase	2.8	1.0	1.2
Percent of GSP Increase Resulting from Efficiency Spending	13%	11%	10%
Percent of GSP Increase Resulting from Energy Savings	87%	89%	90%
Dollars of GSP Increase per $1 of Program Spending	6.4	7.5	10.9
Increase in Employment (Job Years)	331,000	112,000	139,000
Maximum annual Employment Increase (Jobs)	18,800	6,800	7,800
Percent of Employment Increase from Efficiency Spending	17%	15%	13%
Percent of Employment Increase from Energy Savings	83%	85%	87%
Job-Years per $ Million of Program Spending	43	47	70

cycle savings for building occupants. Thus, local governments have an interest in fostering such energy management initiatives, to build a healthier and more productive community. The challenge is creating market demand for such outcomes amongst owners and tenants, especially when research in this area is still relatively new and conditions in each building will differ.

These effects will likely be most pronounced when owners, design teams, operators and managers explicitly aim to improve indoor health and conditions as part of their energy management practices. Thus, improved health and well-being should be a key focus of energy management initiatives.

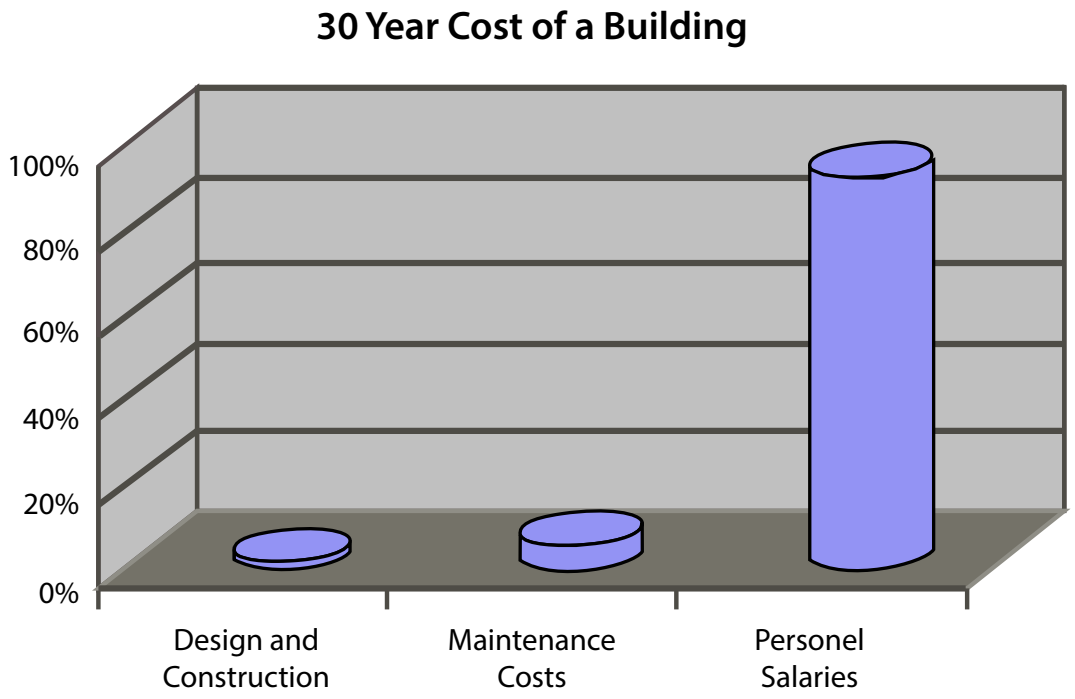

Figure 3: Costs associated with an office building. Source: (National Institute of Building Sciences 2010)

D. What is required to achieve good energy management?

Based on studies and experiences in multiple markets, achieving the full potential of energy management requires that:

Owners and financial decision-makers understand and prioritize energy management. Firms' ownership and senior management must recognize the opportunity that energy management represents, direct their staff to pursue these opportunities, and be willing to invest some time in considering energy projects. Too often, owners and chief financial officers are too busy to prioritize energy management.

Building management and operations staff that have strong understanding of energy management opportunities. These staff must possess proper training, experience, and sufficient time to develop and implement projects and manage services by third parties.

Building owners and managers have connections to highly skilled service providers. Many energy management projects require the assistance of expert third party advisors and project managers. There must be a sufficient number of skilled service providers.

Building owners have access to financing for energy management projects at attractive terms. Building owners have limited access to cash reserves and traditional financing; they typically prefer to spend their resources on their core business. Moreover, many properties are highly leveraged, and cannot accommodate further debt. Additionally, owners require project financing mechanisms that they can pass through payments to tenants, and that can be readily assumed by future owners.

Owners do not face "hold" barriers. Many building owners only intend to hold ownership of their property for a limited time. Thus, they will only be interested in energy management projects that pay back in a short period of time; that future owners will recognize the value of and pay for; or that that they can pass the financing and contract terms to the next owner.

Incentives be aligned between owners and tenants. Frequently, owners are expected pay for building upgrades, while tenants may reap the benefits of lower utility bills. To overcome this split-incentive, owners' require a means to pass the cost of the project on to tenants, or to recoup their spending with higher rent. Different financing mechanisms, green leases, or educated tenants that recognize the value of reduced energy use in their buildings, can all serve to ameliorate this barrier.

The Need for Market Transformation

In practically all real estate markets, these conditions are far from being realized. Thus, there is a strong movement to foster market transformation. Market transformation refers to efforts to reduce barriers to energy management, and realize more perfectly functioning markets by providing better quality information; reducing transaction costs; facilitating access to capital; and aligning structural incentives so that building owners, managers and tenants all have an interest in pursuing cost-effective energy management.

A myriad of different strategies are used to effect market transformation, and government, utilities, the private sector, and non-profit organizations all play important roles in these efforts. Massachusetts has a relatively strong energy efficiency policy and market transformation landscape. Many important market transformation activities, such as workforce development, business development, project financing innovations, and other activities, are being lead by other levels of government, utilities, and the non-governmental sector. Thus, this report focuses predominantly on how the City of Cambridge can support commercial buildings in better understanding and implementing energy management opportunities.

II. Market Conditions in Cambridge

As documented above, energy efficiency is associated with a range of economic benefits. However, markets for energy efficiency services are frequently impacted by a variety of barriers and imperfections, which limits the adoption of efficiency below what is economically optimal.

In order to better understand what conditions may be impacting markets for energy services in ICI buildings, MIT GEDI and the City of Cambridge engaged in an analysis of the energy management practices used by commercial buildings in Cambridge, and a review of broader policy and program trends. This characterization of the local industry was informed by:

- A review of existing publications and web materials on energy efficiency policy, energy programs, project financing efforts, in Massachusetts and the Boston-Cambridge metro area.
- Interviews with numerous local market participants, including energy service providers; building owners and property managers; efficiency program administrators; real estate organizations; and other stakeholders.
- Two focus groups, convening building owners and facility managers from both larger and smaller commercial buildings in Cambridge, to better understand their practices and perspectives on energy management.

A. Real Estate Analysis

ICI properties make up an important component of the energy use footprint of Cambridge buildings. Recent analysis by the Peregrine Energy Group suggests that more than 43 percent of Cambridge's energy footprint is consumed by these sectors. In the industrial sector, the overwhelming majority of energy use is consumed by "High Tech" facilities, notably the lab space that is common in Cambridge (PEG 2013). These laboratories present a unique component of Cambridge's energy management landscape, given their prevalence at universities, research institutes and private firms and more intensive energy needs than standard ICI real estate.

Energy consumption is concentrated in relatively few buildings. Just 93 buildings consume fully 50 percent of all building energy use in Cambridge (PEG 2013). Likewise, the large majority (81.7 percent) of commercial and industrial floor-space is located in buildings greater than 50,000 square feet (see Table 2), and energy use is similarly concentrated in these larger buildings. Nevertheless, there are important reasons to support energy management in smaller properties. The majority of Cambridge's Class B and Class C real estate are buildings less than 25,000 square feet. These buildings are an important part of Cambridge's economy and social fabric. Moreover, smaller buildings are typically less well served by ratepayer funded utility energy efficiency programs, and have fewer resources to devote to energy management, meaning that assistance from the City can be especially valuable. Lastly, the City of Cambridge seeks not only to improve the energy management of its properties, but also innovate and demonstrate good policies and practices that other jurisdictions can adopt. Nationally, buildings of less than 50,000 square feet consume 49 percent of all commercial energy use (NTHP PGL 2013). In order to catalyze broader national leadership in this important building sector, the City can support good practices in its own smaller buildings, as well larger ICI properties.

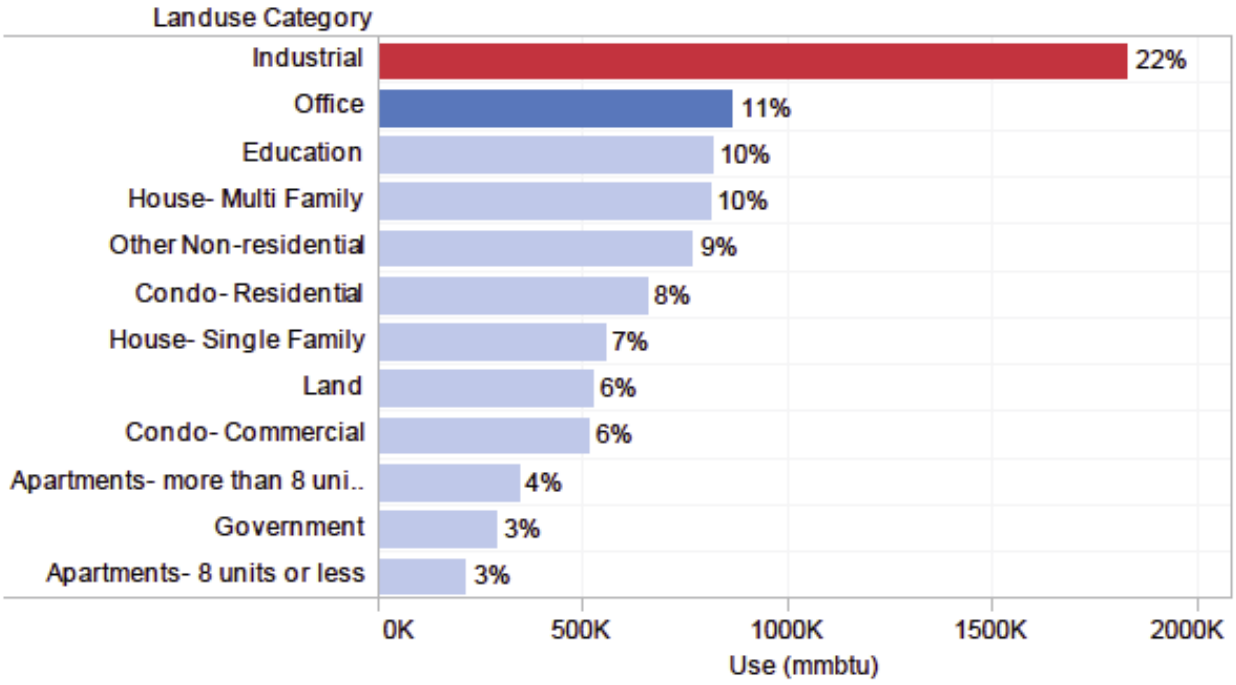

Figure 4: Energy consumption by land use. Source: (PEG 2013)

Table 2: Number of buildings and floorspace by building size amongst commercial and industrial properties in Cambridge. Source: (CoStar n.d.)

	CLASS A	CLASS B	CLASS C	TOTALS
Number of Buildings	102	201	308	611
% of number of buildings above 25K sf	99%	51%	25%	46%
% of number of buildings above 50K sf	98%	29%	9%	30%
# of owners	47	150	265	462
Rentable Area (sf)	19,594,482	9,226,932	6,759,738	35,581,152
% of total SF above 25K sf	99.8%	88.1%	70.5%	91.2%
% of total SF above 50K sf	99.7%	71.0%	44.2%	81.7%
% of total square feet	55.1%	25.9%	19.0%	100.0%

B. Energy Management in Commercial Real Estate

Interviews and focus groups with building owners and managers, efficiency program administrators, and energy service providers revealed important findings about the extent and quality of energy management practices in Cambridge real estate:

Many buildings, particularly large institutions, have taken leadership in implementing energy management projects. Various private, non-profit, and public organizations in Cambridge have all taken significant energy management actions. For example, Harvard and MIT have enacted rigorous internal policies to drive ongoing investment in energy management. Likewise, other private and non-profit representatives that were interviewed had strong energy management policies, and regularly explored means of saving further energy. These organizations often had dedicated staff tasked with realizing energy saving projects in their portfolios.

Notwithstanding the many leaders, opportunities to improve energy management in Cambridge properties remain. Our interviews found that energy saving opportunities are still widely available in buildings throughout the city. Often, staff tasked with energy management did not understand, or had not taken advantage of, the full range of utility programs available to them. The lack of participation may be concentrated in smaller properties; many interviewees from smaller properties had less time and facility with undertaking comprehensive energy management projects. However, our interviews suggested that even some larger properties and portfolios had not pursued a variety of low-cost energy management opportunities, and often did not know about technologies and programs available to them. Moreover, properties invest most often in piecemeal building improvements, rather than comprehensive energy upgrade projects; this practice may leave identified energy savings opportunities "on the table" in interim years between energy management investments. Furthermore, there is mixed understanding of best practices to gain the most benefit from energy saving improvements and to ensure that building energy systems operate with maximum efficiency.

Building owners and managers cite limited information about appropriate energy upgrades, and lack of time for energy managers to spend exploring opportunities, as critical barriers to pursuing energy management. A number of interviewees noted that facility managers require trusted sources of information to guide their pursuit of energy management. Many suggested that utilities alone were insufficient to provide such information. Additionally, they frequently reported that managers' time and capacity were crucial limiting factors in pursuing greater energy projects.

Building owners have difficulty finding trusted energy contractors who can provide energy management services. Along with time and information constraints, several interviewees noted that they had difficulty finding trusted contractors who could provide energy management services. This issue was especially pertinent in the small and medium sized building HVAC contracting sector; HVAC contractors provide HVAC preventative maintenance and repair services for many such buildings. Interviewees noted that HVAC contractors typically focus only on keeping systems operating, and less on optimizing energy management and achieving energy savings. They suggested it would be valuable to connect customers to vetted contractors, and to introduce a more explicit focus on maximizing energy savings among HVAC contractors , over and above the preventative maintenance services that currently predominate.

Tenants' demands play a critical role in driving investments in energy efficiency. Tenants play a critical role in driving energy efficiency, both in terms of the upgrades they invest in to improve their spaces, as well as the extent to which they demand that building owners invest in better energy management and improvements to

tenant spaces. Tenants are especially influential in properties using triple net leases; under such lease terms they assume responsibility for managing utilities, building operations and maintenance, and the cost of improvements to their spaces. Some tenants are knowledgeable about energy management. For instance, interviewees noted that many lab-space tenants have a sophisticated understanding of energy saving opportunities; likewise, large companies occupying office space may have company-wide energy management personnel, who advise local offices. However, many ICI tenants in Cambridge have very limited understanding of energy management. It is not their core business, and they cannot devote significant amounts of time to investigating energy saving opportunities in their buildings. Interviewees noted that providing actionable information and guidance to such tenants is important to improving energy management.

Many building owners will only consider energy management with relatively short payback periods (~3 years). A number of interviewees, particularly those from owner-occupied institutional properties (universities), larger lab spaces, and other properties concerned with energy management, cited quite long maximum pay-back periods for energy upgrades that they consider, up to a 10 year simple payback. However, the majority of properties cited much more limited "hurdle rates" – often on the order of three years. These properties would typically not invest in energy upgrade projects with payback periods beyond this timeline, leaving various energy efficiency opportunities on the table.

Building owners often rely on cash reserves. Our interviews suggested that most often, energy management projects are funded via owners' cash reserves. A number of interviewees noted they would be amenable to debt or other financing projects to get projects accomplished, however. The practice of relying on cash on hand might be one reason for the more piecemeal, less comprehensive, investments in energy efficiency.

Real estate organizations oppose building benchmarking and disclosure ordinances. However, some property owners were more sanguine about such policies. Both the Greater Boston Real Estate Board and the Associated Industries of Massachusetts expressed concerns about so-called "Benchmarking and Disclosure"* policies. They averred that such policies: do not contribute to building owners engaging in more effective energy management; do not meaningfully improve information transparency, as prospective tenants can already request energy bills; may disadvantage older properties; do not have means of ensuring owners' access to all utility bills, nor owners properly benchmarking their building; and are of only "symbolic" value. However, some focus group participants were less averse to such policies and believed that these policies could contribute to more awareness of energy use and increase attention to improving efficiency among building owners and managers.

Building owners and managers noted the need for technical assistance in using building benchmarking systems such as ENERGY STAR Portfolio Manager. Focus group participants noted the importance of providing training and guidance in properly using Portfolio Manager, or other benchmarking tools, especially if Cambridge mandates benchmarking and disclosure. They noted that some facility managers are not adequately versed in the use of such systems. There also was an appreciation of the value of peer learning and exchange on different tools and how to best apply benchmarking and energy management software.

There is concern that ENERGY STAR Portfolio Manager does not properly account for different building types, such as lab spaces. Some interviewees, particularly owners and managers of lab buildings, noted future benchmarking tools will need to better account for inherently energy intensive uses, such as lab space. They noted that lab spaces are not a recognized property type within Portfolio Manager. Lab spaces are thus compared with less energy intensive office

* Such policies require that buildings of a certain size benchmark their energy use against typical usage in other similar buildings; ENERGY STAR Portfolio Manager is a prominent such benchmarking system. They further require that buildings disclose their energy use to their local or state government. Such policies are intended to increase transparency around energy usage, and encourage building owners and managers to perform better relative to other area buildings.

space. These interviewees expressed concern that public disclosure of labs' scores can negatively impact their reputation. They noted that benchmarking systems should include recognition of lab spaces as a specific property type.

Concerns about accessing building energy data from utilities. Property owners cited difficulties in accessing energy consumption data from utilities, especially when all meter data must be accessed to facilitate benchmarking reporting. Likewise, area real estate organizations noted that cities need to support state legislation that requires utilities to populate energy disclosure databases, if cities intend to pursue such policies.

C. Energy Efficiency Programs

Ratepayer Funded Programs

The Mass Save ratepayer funded energy programs provide a relatively comprehensive suite of energy efficiency programs. These programs provide incentives for most types of energy efficiency and upgrade projects that ICI buildings in Cambridge might pursue; they also typically have pre-approved contractors authorized to conduct assessments and implement projects. However, interviewees expressed some concerns that smaller businesses have difficulty navigating these programs. Utility programs have emphasized institutions and large building as the fastest way to achieve mandated savings, and this has limited outreach and support provided for smaller businesses and property owners. Smaller businesses have to be especially proactive to be served by the programs, taking substantial initiative in scheduling assessments, pursuing financing, and implementing energy upgrade projects. Users noted that the programs can be convoluted.

Other Energy Management Promotions Programs

A number of other programs in the region help drive participation in energy upgrade programs.

A Better City's Challenge for Sustainability – The non-profit A Better City (ABC) has operated the Challenge for Sustainability program available to commercial buildings in Boston, and their broader members. The Challenge provides promotions and technical assistance for buildings, helping them conduct energy management, and undertake other green business initiatives. The Challenge is viewed by the City of Boston as an important vehicle to deliver future technical assistance, including building benchmarking training and other training resources. Challenge designers noted that there are opportunities to expand the Challenge for Sustainability to include a broader membership, including adding Cambridge buildings.

City of Cambridge Go Green Awards – The City of Cambridge provides its "Go Green Awards" recognizing businesses and institutions that have improved the environmental performance of their facilities. Interviewees noted that it would be valuable to make the awards higher profile, providing more outreach to solicit nominations and greater recognition of recipients.

Real estate organizations are amenable to support voluntary energy programs - Real estate organizations including the Greater Boston Real Estate Board, Associated Industries of Massachusetts, and MassBio noted that while they have not initiated extensive energy management promotions and technical assistance campaigns, they may be interested in assisting such efforts as they arise.

D. Energy Project Financing Mechanisms

Rate-payer funded programs offer cash incentives and rebates for energy upgrades. Since these incentives usually do not cover the full cost of a project, building owners require additional sources of project financing. MIT GEDI's research and interviews with market participants indicate that the most effective financing mechanisms for commercial building owners to undertake energy efficiency projects have the following features:

- Offer relatively low interest rates payable over a long time period, allowing projects to be "cash flow positive" with energy savings outweighing financing payments. This likely requires that outside security features or credit enhancements are provided for financing mechanisms.
- Cover 100 percent of projects' costs.
- Are "off-balance sheet", meaning financing is structured so as not to add debt to the property and allow repayments to be treated as an operating expense.
- Are structured so that financing repayments can be passed through to tenants under existing lease terms, to overcome "split-incentives" between owners and tenants.
- Be transferred to future property owners, overcoming "hold" barriers.
- Can cover all potential energy upgrade measures, including both energy efficiency and on-site energy generation.

Innovative project financing mechanisms have been introduced around the country, with varying ability to realize these criteria. Some mechanisms require actions by government or utilities, for instance to enable re-payment via property taxes or the utility bill. Other mechanisms can be implemented by the private sector independently; however, government can support greater adoption of these mechanisms by facilitating education, participating in pilots of financing products, and providing capital or credit enhancements to support their deployment. Table 3 reviews how prominent energy financing mechanisms perform relative to the criteria listed above. This list is not a comprehensive list of energy project financing mechanisms; rather, it serves to compare prominent financing tools. A forthcoming paper by MIT GEDI profiles many of these mechanisms, providing a more detailed description of how they function.

Existing financing mechanisms available in Cambridge

Financing mechanisms available to buildings in Cambridge include:

- The utility NStar offers business loans to support energy efficiency upgrades as part of the Mass Save program. Small businesses (<300kW) are eligible for a zero interest loan. Loans for larger businesses are also available.
- MassDevelopment has a Green Loan Program that provides loans of $50,000 to $500,000 to for-profit and non-profit businesses to bridge the gap between energy efficiency project costs and the rebates or subsidies provided by utility companies and state/federal incentive programs. A project must first be approved under a Massachusetts public utility program or for a state/federal energy efficiency incentive to apply for the Green Loan.
- Large buildings may access Energy Performance Contracts, as well as more novel Efficiency Service Agreements (ESAs) models, both delivered by energy service companies (ESCOs). ESAs are financing and project implementation structures designed to overcome some of the persistent barriers to energy efficiency in commercial properties. While none of our interviewees had engaged in such financing, major metropolitan regions of the Northeast are important markets for these relatively new financing mechanisms, and large buildings are presumed to have access to such financing.

Despite the availability of such financing, many smaller and medium size projects still face financing gaps. They will be better served by mechanisms that allow financing to be readily passed on to future owners, pass-through to tenants under existing lease structures, and are treated as off-balance sheet; the current suite of financing mechanisms do not meet these criteria.

PACE Financing

Property Assessed Clean Energy (PACE) offers a particularly strong tool to enable energy upgrades in commercial buildings. PACE is a transformative tool for energy project financing in commercial buildings because it:

- Allows for loans at better interest rates and longer repayment terms (up to 20 years) than is otherwise available. This enables deeper energy efficiency and greater savings for projects.
- Offers strong security, senior to other debts, due to its being repaid on the property tax bill. This helps raise the capital needed to fund energy efficiency improvements. PACE loans may be treated as "off-balance sheet". Recent analysis indicates that PACE repayments would likely not be considered debt under future FASB (Federal Accounting Standards Board) rules.
- Overcomes the split-incentive problem between building owners and tenants. PACE allows financing repayments to be passed through to tenants under most triple net leases and modified gross leases, so that tenants share in the costs of energy improvements as well as the savings.
- Significantly reduces hold barriers, as the PACE assessment passes with the property to future owners.

PACE in Massachusetts

Massachusetts currently does not have active commercial PACE programs. However, the Massachusetts Development Finance Agency (MassDevelopment) and the Department of Energy and Resources (DOER) have been active designing a PACE program, and enabling legislation has been proposed (Massachusetts Senate Bill 177, 2013). At the time of this writing, the legislation was still pending. . As proposed, the legislation directs the MassDevelopment to establish a statewide program that would administer a PACE financing program. The program would function as an "Open Market" program, allowing financing from multiple private and public sources. Municipalities would opt-in to the program via a council-approved agreement with MassDevelopment.

Table 3: Energy project financing mechanisms.

ENERGY PROJECT FINANCING MECHANISM	LOWER COST OF CAPITAL (REALIZED THROUGH STRONGER SECURITY)	LONGER TERM FINANCING FEASIBLE (10-20 YEARS)	100% PROJECT FINANCING	"OFF-BALANCE SHEET" - NO DEBT ON PROPERTY	OVERCOMES "SPLIT-INCENTIVE BARRIER" - COSTS CAN BE PASSED THROUGH TO TENANTS WITHOUT RENEGOTIATING LEASE	OVERCOMES "HOLD BARRIER" - FINANCING MAY BE READILY PASSED THROUGH TO FUTURE OWNERS WITHOUT NEGOTIATION
Financing mechanisms that do not require some sort of government/regulatory intervention						
Internal Property Owner Funds	N/A	N/A	N/A	√	×	×
Bank Debt	×	×	×	×	×	×
Lease	×	×	√	Unlikely – pending FASB	×	×
Energy Performance Contract	×	×	√	Unlikely – Pending FASB	×	×
Efficiency Service Agreement	× However, off balance sheet treatment could leave cash & credit available for other uses	×	√	Likely – pending FASB	√	× New owner must agree to service agreement.
Managed Energy Service Agreement	× However, off balance sheet treatment could leave cash & credit available for other uses	×	√	Likely – pending FASB	√	× New owner must agree to service agreement.
Financing mechanisms requiring government intervention						
PACE Repayment (Bank debt, EPCs, ESAs, MESA, may all be repaid via PACE)	√ Senior lien is a strong security.	√	√	Likely – pending FASB	√ Under most triple net leases	√ Financing payments pass automatically to new owner with property taxes.
On-utility Bill Repayment (Bank debt, EPCs, ESAs, MESA, may all be repaid via OBR)	√ Shut-off provision enhances security.	× Typically not. On bill tariffs may facilitate longer terms.	√	Depends on financing mechanism used in project financing.	√	√ Yes, if an on-bill tariff, and structured to pass with meter. × No, if an on-bill loan.

III. Market Transformation Plan

The analysis in chapter two suggests that improving energy management in Cambridge requires overcoming information and knowledge barriers, expanding access to appropriate financing tools, and increasing the motivation and incentives to undertake energy upgrade projects. This chapter suggests strategies for the City of Cambridge to support greater uptake of energy management in its ICI buildings in these four areas.

- Providing building owners, managers and operators better access to information, training, precedent projects, and contractors.
- Creating stronger impetus to participate in energy management.
- Expanding and improving project financing options.
- Initiatives to expand energy management capacity, knowledge and innovation within HVAC contractors.
- Since Cambridge houses a large concentration of laboratories which are large energy users and have special energy management issues, Cambridge can explore establishing a consortium to test and promote "sustainable laboratories".

A. Promote energy management and facilitate technical assistance for building owners, managers, and operators

Building owners and managers consistently stated that the City should facilitate technical assistance and education in energy management opportunities. They noted especially the value of greater interactions with: third-party sources of unbiased advice; their peer building owners and managers; efficiency program personnel; and service providers.

The City can facilitate greater opportunities for convening, education, and training relating to energy management. The City should also host various technical assistance and learning opportunities to inform buildings' energy management efforts. This section outlines a plan to expand outreach and engagement with commercial property owners and tenants around energy management and deliver information, training and technical assistance to significantly expand implementation of energy saving investments and management practices.

Program Administration Considerations

Seek to partner and align with other initiatives in the region – Cambridge should consider aligning its promotions and technical assistance efforts with existing efforts in the region, notably the A Better City's Challenge for Sustainability. As part of expanding the Challenge for Sustainability into Cambridge (discussed below), city staff should work with ABC to identify effective information, training, and technical assistance resources for Cambridge building owners. Other potential partners in expanding outreach, information and technical assistance services include:

- Greater Boston Building Owners and Managers Association
- Urban Land Institute Boston Chapter
- New Ecology Institute
- NStar and National Grid
- MassDevelopment Green Loan Program
- Massachusetts Clean Energy Center

Consider adding City staff to coordinate increased liaison with commercial buildings in Cambridge – The Cambridge Energy Alliance currently focuses predominantly on recruitment into residential programs. Providing substantial promotions and technical assistance to the commercial sector will require additional staff time. The City should consider adding a staff position to coordinate these activities, build partnerships to implement the plan and work to expand and improve the ICI energy management initiatives over time.

Program outreach and recruitment considerations

Aim to recruit and serve all commercial building types - Large buildings will likely realize the large majority of total energy savings achieved in Cambridge in the future. Thus, the City's programming should serve these buildings. However, enhancing the capacity building of smaller buildings can also help strengthen Cambridge's local economy. Moreover, workable models of energy management initiatives in smaller buildings are needed to inform national climate action efforts, as smaller buildings comprise a more significant portion of national energy use and emissions.

Focus especially on engaging ownership and financial decision-makers, in addition to facility and energy managers - Experience from other programs suggests that successfully catalyzing greater uptake of energy management requires buy-in from both senior financial management, as well as regular participation from energy/facility management staff. Buildings' financial decision-makers ultimately decide on the extent of energy

management activities to pursue, and their buy-in will be critical to speed the adoption of deep energy upgrades. However, many green building initiatives around the country have struggled to engage senior management. Cambridge should prioritize cultivating relationships with senior financial decision-makers. One opportunity is to have political leaders and leading building owners advocate for participation. Cambridge can also work with BOMA, ULI and other real estate associations to reach these key decision makers.

Technical assistance opportunities

Provide training in using ENERGY STAR Portfolio Manager, and potentially other energy benchmarking, tracking, and information feedback tools – Many property managers do not have experience with energy benchmarking platforms, and will need assistance in properly setting up projects in ESPM, and/or other building information tracking systems. The City should facilitate in-person trainings, webinars and/or a call number. A Better City anticipates providing such training in Boston, and the City should consider partnering with them to deliver this training.

Host an Energy Management Speakers Series, providing training and information on a variety of building energy management topics – Our focus group participants noted the value of engaging with peers on energy management topics, as well as receiving detailed, focused advice directly pertinent to the energy management challenges that they face. A regular Speaker Series could provide owners, managers, and operators exposure to novel techniques and services, and opportunities for peer-to-peer learning. This should be a short 1 hour lunchtime session that combines speakers on emerging topics and technologies with case studies of successful building energy management projects across building types in the Boston region.

Consider providing access to energy management and information systems - Increasingly, a variety of web-based services provide advanced energy tracking and dashboarding services, providing key information, analytics, and connections with energy management vendors for buildings. An energy challenge could facilitate access and training in other energy information systems, providing buildings with options to use such services. There may be an opportunity to provide discounted costs, when multiple buildings are aggregated. For example, the Seattle 2030 District provides its members with the opportunity to use the Lucid Building_OS energy tracking and dashboarding system (see text box below). The City and its partners could consider issuing a Request for Expressions of Interest to vendors of energy management and information systems suitable for small and medium sized to deploy their services amongst an aggregated group of buildings.

Seattle 2030 is a building district comprised of Downtown Seattle. The district's goal is to reduce the environmental impact of constructing and operating buildings and to educate and encourage collaboration between building owners and managers. The district is a public-private collaborative that uses the goals of the Architecture 2030 Challenge for Planning as guidelines, aiming to reduce energy use in the District 50% by 2030. Seattle 2030 uses the Lucid Buildings Dashboard to track buildings energy use, and also facilitates buildings use of Lucid's Building_OS comprehensive energy data tracking and dashboarding system.

Facilitate property manager and building operator training – Continuing education programs and credential programs aimed at improving the energy management skills of property managers and building operators are available in the region.* The City and its partners should work to recruit existing building managers and operators into training programs. MIT GEDI's interviews with industry participants suggest that investing in existing management and operations staff's skills is one of the most impactful energy management strategies.

Building owners and management firms are some-

* The Massachusetts Clean Energy Careers Training and Education Directory provides update lists of energy management trainings. See: http://ma.cleanenergyeducation.org.

times hesitant to invest in staff's skills, often due to concerns that staff will not remain with their current employer. The City should consider brokering a grant program that can co-sponsor training for existing building managers and operators.

Provide the Opportunity to Develop a "Deep Energy Upgrade Gameplan" When it comes to energy upgrades, buildings will pick the low-hanging fruit, but rarely venture further up the ladder. Indeed, opportunities for deep energy upgrades typically only occur for buildings at key junctures in their lifecycle – for instance, a change of ownership, re-financing, re-tenanting, or renovations.

To address these impediments to deep energy upgrades, an energy challenge could provide a service to help building owners develop a "Game-plan" to undertake deep energy upgrades. The Gameplan service should include a workshop with the owner, property management, designers, and financial consultants, aimed at identifying key opportunities to undertake deep energy improvements in existing buildings. Key points in buildings lifecycle should be identified when different upgrade opportunities may make sense.

The City and its partners could issue a Request for Expressions of Interest to organizations who can develop a process to help building owners develop their plans for deep energy upgrades. The City of Cambridge can test this Game Plan service in their own buildings.

Consider piloting an "energy concierge" program – A number of businesses noted that they would benefit by a service that would provide guidance on energy services, contractors, and programs. They City should consider facilitating an energy concierge program, providing staff to help businesses navigate energy management options. The City of Northhampton, Massachusetts, recently hosted a similar concierge program (Miller 2012).

B. Partner with A Better City to Expand its Energy Challenge into Cambridge

An "energy challenge" is an effective way to increase interest in energy efficiency and promote increase knowledge, capacity and investment in energy saving upgrades and practices. With a very successful energy challenge operated in Boston through A Better City (ABC), an easy way for Cambridge implement this best practice is to partner with ABC to expand its Challenge for Sustainability into Cambridge. The timing for this action is good since the Challenge for Sustainability's designers are considering expanding into Cambridge. An energy challenge also provides a focal point for delivering energy management information and technical assistance, so city staff should work with ABC and other partners to link the outreach, information and technical assistance services described above with the introduction of ABC's Challenge for Sustainability in Cambridge.

The City should open discussions with A Better City to identify how the Challenge framework could be expanded to Cambridge, and how additional technical assistance opportunities mediated by the City could be integrated into the broader challenge. One issue to explore is whether new award categories might be introduced in Cambridge, such as awards for small properties, educational institutions or laboratory buildings. Moreover, the City should coordinate with other local governments to align the challenges' delivery. Additional recommendations for maximizing participation and impact from a Cambridge Challenge include:

Aim for broad participation. Make benchmarking energy use and committing to consider energy management opportunities the only requirements for participating in the challenge – MIT GEDI believes that the challenge is likely to achieve the greatest energy savings, and associated economic development benefits, by cultivating a broad membership, covering much of the commercial floorspace in Cambridge as possible. Thus, participation should only require the simple actions of benchmarking performance, and considering energy management improvements. High levels of participation can be achieved: For example, the green building management program Envision Charlotte received written agreement to participate from 98% of the floor-space in their downtown core.

Market the program via existing networks and channels – Building owners and staff are most likely to participate when the challenge is endorsed and promoted by established networks, colleagues, and institutions. The City should seek to promote the program via the following communications and networks:

- Organizations representing the real estate sector, including: Greater Boston Real Estate Board, Associated Industries of Massachusetts, MassBio, Cambridge Chamber of Commerce, Urban Land Institute and others.
- Area utilities.
- Energy service providers.
- Existing City mailings and communications.

C. Expand Financing Opportunities for Energy Management Upgrade

Opt-in to PACE financing once possible. The City should strongly consider opting-in a future PACE program offered by MassDevelopment, providing enabling legislation is passed. PACE financing can be a "game changer", allowing for relatively secure lending at low interest rates, over long terms. PACE reduces "hold barriers", allowing financing to be passed to future property owners; reduces split-incentives, as it may be passed through to tenants under triple net leases; and may be considered off-balance sheet.

Work with MassDevelopment to market its Green Loan Program to Cambridge Business and Nonprofit organizations. Since this program is an existing mechanism to finance energy upgrades, Cambridge should help expand awareness and use of the program. City staff can meet with MassDevelopment to discuss creating a targeted marketing campaign to Cambridge business that might be organized around the implementation of the expand Challenge for Sustainability.

D. Support greater energy management services and innovation in the HVAC contracting sector

Our research suggests that building owners and managers demand greater energy management from HVAC contractors that provide maintenance and repairs to existing systems; such services should include ongoing operational improvements as well as systems upgrades. However, the HVAC contracting industry has not sufficiently defined how such energy management services fit into their broader offerings. Identifying how stronger energy management could be better integrated into the services currently offered in the market could realize substantial energy efficiency improvements in Cambridge and beyond. Moreover, this initiatives could work to promote innovation and disseminate energy management best practices among HVAC contractors.

The City should consider coordinating with regional stakeholders (including contractor industry associations, utility energy efficiency program administrators, the Massachusetts Energy Efficiency Advisory Council, and others) to identify strategies to integrate better energy management services into the suite of offerings provided by HVAC contractors. Priorities for such market transformation efforts include:

- Liaising with the HVAC contracting industry to understand their perspectives on the challenges and opportunities inherent in realizing stronger energy management as part of their suite of services.
- Defining and sharing energy management service standards, as differentiated from maintenance and repairs.
- Providing training to HVAC contractors in building "retuning", energy assessments, etc.
- Facilitating the integration of "smart", remote energy management tools into the service offerings provided by HVAC contractors.
- Facilitating test sites, where novel HVAC services can be deployed in real-world applications

E. Explore Creating a Sustainable Laboratories Consortium to test and promote advance energy efficiency and energy management within university, business and research institute laboratories

With its concentration of private sector, university and private research institute laboratories, Cambridge has the opportunity to work with the designers, managers and users of laboratories to push the envelope on sustainable laboratory design and advance best practices in efficient laboratory management. A Sustainable Laboratory Consortium could bring together laboratory designers and managers from universities, research institutes, biotech and pharmaceutical firms in Cambridge to consolidate knowledge of exiting best practices, identify opportunities for further energy savings, water savings and waste reduction and establish a prototype facility to test and development new sustainable laboratory energy and resource management designs, systems, and practices. With broad industry and university participation, this consortium could attract funding from corporate, foundation and government sources and establish Cambridge as leader in this field.

Further research and exploration is needed to test the potential for this concept. As a first step, the City could research whether any such consortiums already exist and if so whether there are new areas not addressed by existing efforts that could provide a focus for new initiative. Next, city staff should explore interest in the Sustainable Laboratory Consortium among industry, university and research institute leaders. If a research and development gap exists and there is interest among key stakeholders, a plan for the Consortium would need to be developed. Funding for this plan might come from the John Adams Innovation Institute and/or Massachusetts Clean Energy, with matching funds from participants and/or the City.

IV. Conclusion

As noted in Section 1 of this report, there is a compelling economic case to support stronger energy management practices in existing ICI buildings. Such efforts will stimulate job growth, enhance businesses' profitability, realize healthier buildings, and reduce buildings' environmental impacts. Our analysis suggests that a variety of barriers hinder markets for energy services in Cambridge. The City of Cambridge can address these barriers by:

- Developing energy challenge program, providing outreach and technical assistance to ICI buildings.
- Opting into a state PACE financing program.
- Advancing market transformation in the HVAC contracting services space.
- Establishing a Sustainable Laboratories Consortium.

These actions can realize meaningful progress towards a more prosperous and green Cambridge. The Table below suggests how different market barriers may be addressed by these different initiatives.

		BARRIERS			
		Building owner & managers knowledge and capacity	Greater social impetus to participate in energy management	Lack of access to project financing	HVAC contracting industry limited in energy management services
RECOMMENDATIONS	An Energy Challenge Program	√	√		
	Opting into PACE			√	
	Advancing market transformation in HVAC contracting services				√
	Sustainable Laboratories Consortium	√	√		

Appendix 1 – Good Energy Management Practices

The following subsections note some important energy management practices used in commercial buildings.

Adopting an energy management plan / policy

Building owners are increasingly adopting energy management policies to guide efforts to improve energy management in their portfolios, including energy savings targets and responsible managers. Adopting such a high level commitment is a good early step in the energy management process.

Tracking Performance - Energy dashboards, reporting and benchmarking

You can't manage what you do not measure and track. Increasingly, building owners, managers, operators, and tenants are making use of "energy dashboards". Such dashboards synthesize energy data from multiple sources (utility bill, equipment readings, and so on) and provide key information to the appropriate stakeholders involved in energy management (owners, managers, operators, and so on). Many firms also "benchmark" their buildings energy use to its historic use and that of peer buildings. The US EPA's Energy Star Portfolio Manager is the de facto national benchmarking platform, with 40 percent of commercial building space in the USA tracked in this system.

Operational improvements & commissioning

How buildings are operated profoundly influences their energy use. By some estimates, half of all cost-effective energy efficiency opportunities can be achieved just by no- or low-cost improvements to existing systems (EON 2013). Ensuring building operators are properly trained is critical. Likewise, many real estate firms are incorporating energy performance criteria into building operators' and managers' job description, to incent improved performance. Additionally, building operations can be aided by the assistance of a professional commissioning agent.

BUILDING COMMISSIONING OR "TUNE-UPS"

Commissioning services (or "tune-ups") involve a detailed assessment of building systems to ensure that all systems are functioning optimally in accordance with their original design intent, and correct any deficiencies. This service is typically provided by a specialist third-party commissioning agent. Commissioning encompasses a variety of techniques, including testing that equipment is in working order; calibrating sensors; reviewing building scheduling, and adjusting building air heating and conditioning set points accordingly; re-programming building controls; and other techniques.

Commissioning has traditionally been offered as a short-term service (perhaps lasting a few months), ideally repeated every two to five years to ensure the building remains in working order. However, novel "on-going commissioning" are increasingly becoming available. These services use data from building systems controls and meters, streaming this data through computer applications to identify energy saving opportunities in real-time.

Commissioning has tremendous potential to reduce energy use. The most comprehensive national survey of building commissioning projects reveals a median 22% savings in energy costs for office buildings (16% for all building types), with a payback time of 1.1 years. Yet, perhaps only five percent of the market potential of commissioning has been realized; the vast majority of appropriate buildings do not undertake regular comprehensive retro-commissioning (Mills 2011).

Capital upgrades

In addition to operational improvements, many energy efficiency opportunities involve the "upgrading" building equipment and systems with more efficient systems. Often, upgrades to systems occur only when systems reach the end of their life; however, savvy building owners and managers will pro-actively replace systems when doing so lowers net costs. Upgrades can be classified into two types: Standard and Deep Upgrades.

STANDARD UPGRADES

A variety of upgrades entail relatively prescriptive equipment replacements, which necessitate minimal interruptions to building users and thus can be implemented at most times in a buildings' life cycle. These standard upgrade measures involve lighting and simpler HVAC equipment replacements. Such standard upgrades typically yield 15-25 percent energy savings, with energy savings paying back the cost of upgrades in two to five years. These are the most common types of upgrades; Zhai et al (2012) report that a little over two percent of all commercial buildings in the USA receive some type of standard upgrade each year.

DEEP ENERGY UPGRADES

"Deep energy upgrades" are defined as those that aim to achieve greater than 40% energy savings. Deep energy upgrades include major HVAC systems redesign and improvements to the building envelope, in addition to the measures included in standard upgrades. Deep energy upgrades are best realized through an "integrated design process", involving the building owner; architect and engineering design teams; financial decision-makers and advisers; and building operations staff. These stakeholders engage in an iterative design process involving: identifying the optimal technical potential of the building; key constraints that necessitate scaling back elements of the technical optimum; and finally arriving at a technical and financial plan to upgrade the building (RMI 2013).

Frequently, deep upgrades can realize even greater financial performance that standard upgrades in terms of the projects' net present value, though deep upgrades may entail longer payback periods. However, unlike standard upgrades that can be deployed at most times in a buildings' lifecycle, deep upgrades often only make sense at certain milestones in a building's life, including:

- Renovation / redevelopment / adaptive reuse of an existing building.
- Near the end-of-life of roof, windows, siding, HVAC, or major lighting systems.
- New acquisition or refinancing.
- Major new tenants.

At these times, disruptions from major renovations are less of a concern, the deep energy retrofit may be coupled with other building improvements, and the building owner may have greater access to affordable financing.

Currently, there is low uptake of deep energy retrofits in American commercial buildings, although there is growing interest in such services.

Occupant/tenant engagement - Green Leases

Building occupants' behavior has a profound effect on buildings energy use. Many energy management efforts include occupant engagement, aimed at changing behaviors that effect energy use.

"Green leases" are an important strategy to engage tenants. Green leases include provisions that encourage both tenants and owners to pursue cost-

effective energy management strategies, and align their interests in pursuing good energy management. Important provisions include:

- "Pass through" provisions, whereby owners can pass the costs of energy management projects that save tenants on their utility bills through to tenants. Otherwise, buildings will face a "split-incentive" in energy use, whereby they are expected to invest in energy upgrades but tenants reap the financial benefits.

- Allowing the owners' energy service providers and/or building engineers to review tenants' space design during tenant improvements, to suggest better choices.

- Specifying tenants energy consumption targets and/or equipment that will not be included in the building (incandescent light bulbs, non-Energy STAR appliances, and so on).

A number of organizations, such as the national Building Owners and Managers Association or the Natural Resources Defense Council, have developed green lease language (BOMA 2011) (NRDC 2011). The adoption of green lease terms is growing rapidly in the commercial real estate market; nevertheless, in MIT GEDI's experience, the majority of building owners and property managers are not well versed in these tools, and require guidance and encouragement in their adoption.

Appendix 2 – Literature Review of Health Impacts Associated with Green Building Investments

CITATION (AUTHOR, DATE, TITLE)	KEY FINDINGS
Vivian Loftness, Volker Hartkopf, Beran Gurtekin, David Hansen, Robert Hitchcock, 2003, *Linking Energy to Health and Productivity in the Built Environment: Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity*	Improvements in indoor air quality, temperature control, lighting system quality, and access to the natural environment are linked to increased individual productivity. A range of design strategies, including increasing outdoor air ventilation rates, improving ventilation effectiveness through improved HVAC systems, and decoupling ventilation and thermal conditioning can lead to these productivity improvements. However, in order to achieve both health and energy savings it is important to pursue high performance technology that improves the IEQ of buildings without resulting in energy costs.
Olli A. Seppänen, William Fisk, 2006, *Some Quantitative Relations between Indoor Environmental Air Quality and Work Performance or Health*	This study looked at the change in performance per increase of 10L/s (liters per second) per person in ventilation rate. The result was a clear trend of increasing performance with increased ventilation rate up to levels of 16 L/s per person.
Romm and Browning, 1994, *Greening the Building and the Bottom Line*	After a building undergoes a lighting retrofit with parabolic louver fixtures and high-efficiency fluorescent lights, this study shows a 13.2% increase in productivity, a 25% reduction in absences, and a 69% energy savings in the lighting sector.
W. J. Fisk, D. Black, G. Brunner, 2011, *Benefits and costs of improved IEQ in U.S. offices*	The economic benefits of improving indoor environmental quality (IEQ) in the US building stock is estimated at $20 billion per year. The majority of these IEQ improvements can be achieved while also achieving energy savings, although a few are associated with small increases in energy costs.
Robert J. Rose, Jack Dozier, 1997, *EPA Program Impacts Office Zoning*	Temperature control is clearly linked to energy savings. On average, HVAC systems with independent controls for each room save 43% more energy than large-zone HVAC systems. Temperature control is further linked to worker productivity and comfort.
Amanjeet Singh, Matt Syal, Sue C. Grady, and Sinem Korkmaz, 2010, *Effects of Green Buildings on Employee Health and Productivity*	This study observed the effect on health and productivity for workers moving from conventional office buildings to those with green building ratings according to LEED. In two different case studies it was found that the improved IEQ in the green buildings led to reduced absences, lower reports of asthma and depression, and self-reported productivity improvements.
McGraw-Hill Construction, 2009, *Green Building Retrofit & Renovation*	A 2009 survey showed that 50% of tenants who moved into a green space did so partly because they anticipated productivity gains.

CITATION (AUTHOR, DATE, TITLE)	KEY FINDINGS
S. Abbaszadeh et al., 2006, *Occupant Satisfaction with Indoor Environmental Quality in Green Buildings*	Workers in green buildings self-report that they are more satisfied with the thermal comfort and air quality than occupants on non-green buildings.
Thayer, 1995, *Daylighting and Productivity at Lockheed*	This case study suggested that a building designed around daylighting, which integrates layout, window placement, type of glazing, and ceilings, results in 50% energy savings in lighting, ventilation, and cooling energy, and reduced absences 15% compared to the company's previous office building.
Figueiro et al., 2002, *Daylight and Productivity - A Field Study*	During the winter, workers in windowed offices with access to daylight spend 15% more of their time doing work-related tasks in the office and use 35% less electric lighting than workers without windowed offices.
Milam, 1992, *Underfloor Air Distribution HVAC Analysis*	Floor-based ventilation is linked to both first cost and energy savings. Underfloor air distribution systems saved 1.55 kWh per square foot more than ceiling-based air ventilation system. Increased ventilation is one of the most basic ways to improve building IEQ and worker health and productivity.
National Lighting Bureau, 1989, *Lighting and Human Performance: A Summary Report*	The NLB identified a 6% increase in worker productivity, accompanied by a 65% decrease in lighting energy consumption when a building was retrofitted with high-efficiency fixtures and full-spectrum fluorescent lights.
Jones Lang Lasalle, 2012, *Connected City*	Cities that invest in smart grid technology improve the effectiveness of energy production and distribution and implement programs that encourage energy efficiency at a corporate level. This, in turn, leads to productivity improvements within corporations and for the entire city.
U. Haverinen-Shaughnessy, D. J. Moschandreas, R. J. Shaughnessy, 2010, *Association between substandard classroom ventilation rates and students' academic achievement*	Improved student and teacher health, decreased absences, increased productivity, and reduced operational costs are all benefits of improving IEQs within the classroom. The most basic step to improving IEQ is providing good ventilation, which this study shows is linked to improved academic achievement in fifth graders.
Nicklas and Bailey, 1996, *Energy Performance of Daylit Schools*	Students in daylit classrooms perform 3% above the average performance of all students in the county, and daylit schools use 60% less energy than non-daylit schools.

Works Cited

Belzer, D. (2009). *Energy Efficiency Potential in Existing Commercial Buildings: A Review of Select Recent Studies.* Pacific Northwest National Laboratory.

BOMA. (2011). *Commercial Lease: Guide to Sustainable and Energy Efficient Leasing for High-Performance Buildings.* Retrieved 08 25, 2013, from BOMA International: http://store.boma.org/products/commercial-lease-guide-to-sustainable-and-energy-efficent-leasing-for-high-performance-buildings

Christie, S. o.-G. (2012, 11 28). *Christie Administration Releases Total Hurricane Sandy Damage Assessment of $36.9 Billion.* Retrieved from http://www.nj.gov/governor/news/news/552012/approved/20121128e.html

CoStar. (n.d.). *CoStar Properties Database.*

CoStar Office Report. (2013). *The CoStar Office Report First Quarter 2013.* CoStar Group Real Estate Information.

DOE BTO. (2012, 08 29). *Draft Job and Task Analysis.* Retrieved 09 1, 2013, from Department of Energy - Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/buildings/commercial/workforce_jta.html

ENE. (2009). *Energy Efficiency in Massachusetts: Engine of Economic Growth*. Boston: Environment Northeast.

ENEROC. (2012). *New Jersey Energy Efficiency Market Potential Assessment.* Walnut Creek, CA: EnerNOC Utility Solutions Consulting.

EON. (2013, 2 13). *Operational Improvements Can Double Energy Efficiency Savings in Commercial Buildings: Data from FirstFuel Software Shows Half of Energy Savings Reside in Low/No-Cost Operational Changes; Represents $17 Billion Savings Opportunity.* Retrieved from Enhanced Online News: http://eon.businesswire.com/news/eon/20130206005560/en/FirstFuel/Energy-Efficiency/Operational-Improvements

Finger, G. (2013, May 13). BPU Ombudsman. (A. Slavin, Interviewer)

Hardcastle, A. (2013, 6 4). Senior Research Associate. (E. Johnson, & B. McEwen, Interviewers)

McGill, C. (2013, May). Director of Grants and Funded Programs - once director of Workforce Development. (A. Slavin, Interviewer)

McKinsey & Co. (2009). *Unlocking energ efficiency in the US economy.*

Miller, L. (2012). *Energy Concierge Services: Analysis of a Public-Private Partnership Model for Commercial Energy Efficiency.* University of Massachusetts - Amherst - Center for Public Policy and Administration - Masters Capstone Project.

Mills, E. (2011). *Commissioning: Capturing the Potential*. ASHRAE Journal.

Murphy, M. O. (2013, May). Project Manager, State Energy Sector Partnership Initative, State Employment and Training Comission. (A. Slavin, Interviewer)

National Institute of Building Sciences. (2010, 06 28). *Life-Cycle Cost Analysis.* Retrieved 09 1, 2013, from National Institute of Building Sciences Whole Building Design Guide: http://www.wbdg.org/resources/lcca.php

New Jersey's Clean Energy Program. (2013, July). Retrieved July 2013, from New Jersey Office of Clean Energy: http://www.njcleanenergy.com/commercial-industrial/home/home

NRDC. (2011). *Energy Efficiency Lease Guidance.* Natural Resource Defense Council Center for Market Innovation.

NTHP PGL. (2013). *Realizing the Energy Efficiency Potential of Small Buildings.* Seattle: National Trust for Historic Preservation - Preservation Green Lab.

PACENow. (2012, June). *About Us.* Retrieved August 2013, from The New Jersey PACE Program: http://njp-org.conservationtechnologies.net/about-us/

PACENow. (2012). *What is Pace?* Retrieved August 2013, from PACENow Financing Energy Efficiency: http://pacenow.org/about-pace/what-is-pace/

PACENow. (2013). *Annual Report.* PACENow.

PEG. (2013). *Electricity and Natural Gas Use in K2C2.* Boston: Peregrine Energy Group.

Public Service Enterprise Group Incorporated. (2013). *PSE&G Energy Efficiency.* Retrieved July 2013, from PSEG: http://www.pseg.com/family/pseandg/energyefficiency/index.jsp

Ringhof, S. (2013, Aprl 26). PSE&G Market Strategy and Development. (A. Slavin, Interviewer)

RMI. (2013). *Category expenses by building type for commercial sector.* Retrieved 09 3, 2013, from Rocky Mountain Institute: http://www.rmi.org/RFGraph-commercial_building_category_expenses

RMI. (2013). *Rocky Mountain Institute.* Retrieved 08 25, 2013, from Retrofit Depot: http://www.rmi.org/retrofit_depot

Satchwell, A., Goldman, C., Larsen, P., Gilligan, D., & Singer, T. (2010). *A Survey of the U.S. ESCO Industry: Market Growth and Development from 2008 to 2011.* Berkeley: Lawrence Berkeley National Labortatory, Environmental Energy Technologies Division.

State of New Jersey. (2012). *New Jersey's Unified Workforce Investment Plan: New Jersey's Talent Connection.* State of New Jersey.

Sweet, W., Zervas, C., Gill, S., & Park, J. (2013). Hurricane Sandy Inundation Probabilities Today and Tomorrow. *Special Supplement to to the Bulletin of the American Meteorological Society: Explaining Extreme Events of 2012 From a Climate Perspective,* 94(9), 517-520.

US Department of Energy. (2012, August). *Building Techonlogies Office - Commercial Buildings.* Retrieved July 2013, from U.S. Department of Energy - Energy Efficiency and Renwable Energy: http://www1.eere.energy.gov/buildings/commercial/workforce_jta.html

US DOE BTO. (2013). *Draft Job and Task Analysis.* (US Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Office) Retrieved June 4, 2013, from http://www1.eere.energy.gov/buildings/commercial/workforce_jta.html

US DOE EERE. (2012). *Energy Expenditures per Square Foot of Commercial Floorspace and per Building, by Building Type.* Retrieved 09 4, 2013, from Buildings Energy Data Book: http://buildings-databook.eren.doe.gov/TableView.aspx?table=3.3.9

US EIA. (2012). *Commercial Sector Energy Expenditure Estimates, 2011.* Retrieved from US Energy Information Administration: http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_sum/html/sum_ex_com.html&sid=US

US EIA. (2013, 8 8). *New Jersey - State Profile and Energy Estimates.* Retrieved 9 4, 2013, from USA Energy Information Administration: http://www.eia.gov/state/data.cfm?sid=NJ#Prices