Swiss-US Cleantech: Efficient Commercial Building Renovations

Evaluating Collaboration Opportunities between Boston and Zurich

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Abstract

The Zurich University of Applied Sciences is evaluating decision making factors for green renovations in Boston and Zurich. Commercial property owners in both cities face the decision between refurbishing or demolishing (and reconstructing) existing buildings in order to improve energy efficiency. Using interviews with stakeholders in the sector, we evaluated opportunities for the promotion of growth and collaboration in the green renovation industries of Zurich and Boston. From our analysis, we concluded that both cities have impressive strengths in the sector but there is room for collaboration and mutual growth. We recommend that each city evaluate innovative approaches being used in Zurich, Boston, and elsewhere to promote energy efficiency in buildings.

Acknowledgements

With the conclusion of our project, we would like to thank everyone who played a role in its completion. This project has not only taught us about Swiss and U.S. energy efficient renovations in commercial buildings, but has also taught us how we can apply our knowledge and work to large-scale, global issues. From the start of our project in Worcester, MA, to its end in Winterthur, Switzerland, our group has had an unforgettable experience filled with enthusiastic and supportive people.

First, we would like to thank our sponsor, Professor Peter Qvist-Sorensen at ZHAW School of Management and Law for providing the opportunity to work on this project. His feedback and advice has been a major factor in shaping our project.

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Executive Summary

Increased emphasis on environmental responsibility and corporate responsibility has resulted in the generation of a new industry sector called 'Cleantech.' Short for "clean technology," the industry involves behavioral and process changes that prevent and reduce pollution and waste (Montalvo, 2008). Energy efficiency has become a prominent sector in today's Cleantech industry. Massachusetts in particular has invested time, money and manpower in the sector and continues to incorporate clean technology into areas such as the energy grid and 'green' building renovations. According to the American Council for an Energy Efficient Economy (ACEEE), Boston has ranked #1 out of America's 34 largest cities in the "City Energy Efficiency Scorecard," mostly due to its aggressive environmental policies, grants and incentives. Switzerland has a strong reputation for promoting sustainability and the use of environmentally conscious technologies, and the Zurich canton is particularly proactive with regulation and promotion of such technologies. Siemens ranked Zurich 6th out of the top 30 European cities in their "European Green City Index," largely because of its strict standards that encourage reduced building energy consumption. The differing tactics and strategies of Boston and Zurich present opportunities for growth and collaboration within the energy efficiency sector of these two regions.

The goal of this project was to evaluate opportunities for the promotion of growth and collaboration in the green renovation industries of Boston and Zurich. We compared Cleantech in the energy efficient renovation sector, and identified how each location can benefit from the other. The team divided the goal into the following five objectives. We:

1. Refined our assessment of Cleantech definitions, terms, and concepts;
2. Evaluated best renovation standards in the Cleantech industries in Boston and Zurich;
3. Identified the barriers and incentives for the application of energy efficiency within existing commercial buildings in Boston and Zurich;
4. Compared the legislative, cultural and financial factors that affect decision-making in both locations; and,
5. Highlighted opportunities for growth, innovation, and collaboration for the energy efficiency sector within the Cleantech industries of Boston and Zurich.

The team conducted a series of semi-structured, in-depth interviews with company representatives, regulators and academics in Boston and Zurich. Based on a comparative analysis of information gathered from both locations, we made a series of recommendations highlighting the opportunities for growth, innovation, and collaboration for the Cleantech renovation industry in Boston and Zurich Canton.

Conclusion 1: The per capita consumption of energy in the United States is more than Switzerland due to differences in cost of energy.

In the United States, where the cost of energy is much lower than in other nations, energy conservation is not a priority for citizens or for investors who experience a longer payback period than those in other countries. The topic of energy consumption is more prominent in Switzerland due to higher energy costs. Electricity in Switzerland is approximately 130.24USD/MWh, almost double the US price of 66.98USD/MWh. Residents are forced to adapt in order to maintain their quality of living, while businesses attempt to maximize potential profits and minimize costs. In comparison to the US, Swiss energy consumption is low. According to IEA estimates, Switzerland consumes 7,972kWh/pc compared with 13,227kWh/pc in the US. Environmental responsibility is not motivating enough to push people towards investments and commitment in energy efficient practices. A business model which yields monetary incentive is a more effective driver.

1.1 Recommendation: We recommend that the United States raise its energy costs through measures such as a carbon tax in order to exert greater pressure for energy efficiency. Until this happens, it is likely that energy efficient upgrades with high returns and very short payback periods, the so-called “low hanging fruit,” will dominate in the sector. Owning a green building may offer kudos and public relations benefits of various kinds, but these may also translate into more tangible economic benefits such as increased property values and the ability to attract tenants and charge higher rents.

Conclusion 2: Due to the short pay-back periods of many projects, the energy efficiency sector is becoming increasingly prominent within the Cleantech industry.

Initial investment costs in energy efficient technologies and practices vary widely depending on the project, but provide numerous opportunities for investments with relatively short payback periods, particularly when compared to sectors such as renewable energy. In recent years, renewable energy has become less attractive as an investment opportunity in Cleantech while energy efficiency projects and technologies have become increasingly attractive. By reducing energy consumption through energy efficiency, companies can then invest in renewable energy or other energy sources in the Cleantech sector.

2.2 Recommendation: We recommend that companies looking to become more environmentally responsible focus on improving the energy efficiency of their building stock.

Conclusion 3: While it is often difficult to change human behaviors to achieve energy savings, the use of automation systems and monetary incentives can minimize the effect of the "human factor."

Automation systems such as controls and smart building technology can be used to minimize the effects of the "human factor" and save money. Creating a more consistent and even energy distribution throughout the day that moves energy consumption to off-peak times and pricing can reduce energy expenses. Sub-metering increases individual accountability and has been used in residential homes to decrease energy consumption. Adding monetary and competitive incentives can have positive effects on human behavior and overcome fractured incentives that arise from tenants of a building not directly paying utility bills.

3.1 Recommendation: We recommend that companies and governmental institutions provide information on energy use through the implementation of automation systems and add additional financial incentives to encourage behavioral changes that promote greater awareness of energy consumption and the value of improved energy efficiency and conservation.

Conclusion 4: The cities of Boston and Zurich are both leaders in their respective nations in promoting and implementing energy efficiency in buildings.

The city of Boston was ranked "#1 Energy Efficient City" in the American Council for Energy-Efficient Economy's (ACEEE) *City Energy Efficiency Scorecard* in 2013. The Massachusetts state government has taken an active role in promoting energy efficient practices with its Green Communities Act of 2008 and Net Zero Energy Taskforce. The city of Boston has also been proactive; its recent Building Energy Reporting and Disclosure Ordinance "BERDO" is an innovative practice. Energy efficiency is a business opportunity in the Boston area due to benefits that building owners may reap from retrofitting. Green buildings are perceived as good business practice in the United States and are often used as a marketing tool. While energy efficiency can reduce utility costs, it can also enhance property value, attract tenants, and lead to increased rent and greater occupant productivity.

Zurich was ranked 6^{th} overall in Siemens' European Green City Index as a direct result of Zurich's efficiency, environmental performance and dedication to reducing its environmental footprint. Zurich has been a leader among all the cantons, taking a proactive stance with programs such as the 7 Mile Steps and the Master Energy Plan, which promote renewable energy and reduce CO_2 emissions. Zurich was also the first canton to implement the 2000W Society plan and the 2050 Plan. Mandated energy efficiency has advanced the sector in Switzerland, and has led to investment in building technology. Swiss companies have been conducting research and development in the sector for decades, leading to advanced and innovative technology. For example, current studies on geothermal heat pumps are being conducted in St. Gallen and decentralized HVAC systems have been tested in the IUCN building in Geneva.

4.1 Recommendation: We recommend Boston and Zurich pursue greater collaboration on the promotion of energy efficiency in buildings. There are many potential areas for fruitful exchange. In particular, Zurich can learn from Boston's business model for energy efficiency while Boston may benefit from Zurich's lead energy efficient technology and in developing mandatory government regulations.

Conclusion 5: While LEED has been used to promote stricter building codes in Boston, Minergie has been used more effectively to promote progressively more strict energy efficiency building codes in Zurich.

Massachusetts has mandated that new governmental buildings meet LEED certification. Through Amendment #37 of Zoning Code Article 80, Boston became the first US city to adopt LEED standards for private building construction. Similarly, Zurich was among the first three cantons to adopt the Minergie standards as a minimum building code. Contrary to Massachusetts and LEED, however, Minergie standards are continuously improved upon to keep a competitive edge over Zurich cantonal building codes. This "cat and mouse" relationship does not exist between LEED standards and Massachusetts state building codes.

5.1 Recommendation: We recommend that Massachusetts cooperate with LEED to emulate the competitive approach used by Minergie to continuously push for stricter energy efficiency building codes.

Conclusion 6: LEED and Minergie pursue different strategies for certifying green buildings.

LEED follows a holistic approach for certification by scoring buildings using various categories such as water management, building materials and energy efficiency. The use of these categories emphasizes a holistic approach to sustainability, but tends to dilute the focus on energy efficiency. By contrast, Minergie ranks solely on a building's energy consumption which pushes buildings toward optimal energy efficiency but tends to ignore other sustainability goals. LEED's holistic strategy requires the use of expert certifiers and limits the use of available building materials, which increases the costs of construction and certification compared with Minergie.

6.1 Recommendation: We recommend that LEED implement and promote energy efficiency as its top priority and attempt to lower certification costs.

Conclusion 7: LEED mandates reassessment of its certified buildings every five years to ensure standard qualifications are maintained.

LEED contains an innovative aspect in which it mandates reassessment of its certified buildings every five years to ensure standard qualifications are maintained. Minergie has yet to implement such a strategy, although, according to Adrian Altenburger, a “hand-over period” may be in progress in which standard qualifications must be maintained for two years prior to completing the certification process.

7.1 Recommendation: We recommend that Minergie adopt a reevaluation strategy similar to LEED standards.

Conclusion 8: LEED and Minergie have become an important part of marketing energy efficient buildings in their respective nations.

The widespread acknowledgement and reputation of LEED in the United States and Minergie in Switzerland make buildings with these standards desirable and therefore they have become effective marketing tools. Adding energy efficient technologies and practices to a building increases its property value giving certified buildings higher market value than non-certified buildings. The US EPA lists increase in occupancy rates, reduction of tenant turnover and a competitive edge in the real-estate market as benefits for energy efficient property owners (PECI, 2007).

8.1 Recommendation: We recommend that building owners pursue LEED/Minergie certification in order to gain marketing benefits.

Conclusion 9: Collaboration between Massachusetts and Switzerland in general, and between Boston and Zurich in particular, has great potential mutual benefits.

Massachusetts is a leader within the United States in terms of promoting Cleantech in general and energy efficiency in buildings in particular, and much of this innovation in technology and policy is centered in Boston. Similarly, Switzerland is a leader of Cleantech and energy efficiency in Europe, and Zurich has been one of the most proactive cantons and cities in Switzerland. Each place has strengths and weaknesses and much to learn from each other.

9.1 Recommendation: We recommend companies and government agencies in Boston and Zurich explore areas for future collaboration in the pursuit of energy efficiency and the promotion of the Cleantech sector in this area.

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Chapter 1: Introduction

Many developed nations have proposed or enacted a variety of policies and programs to combat the adverse impacts of climate change and resource depletion in response to growing concern among experts in academia, business, and government. Increased emphasis on environmental responsibility and corporate responsibility has resulted in the generation of a new industry sector called ‘Cleantech.’ Short for “clean technology,” Cleantech involves behavioral and process changes that prevent and reduce pollution and waste (Montalvo, 2008). This broad industry is typically broken down into 18 differing sectors ranging from recycling and waste to biofuels and biochemicals. Growth and development of Cleantech varies amongst sectors. Some sectors have experienced a decline in investments recently (e.g., renewable energy). The energy efficiency sector has become a prominent division in today’s Cleantech industry.

Since the 1970s, the United States has pursued various strategies to increase energy efficiency due to concerns about the price of oil and national security created by our vulnerability to sources. Although interest in energy efficiency has waned slightly in the last 30 years, growing concern about climate change has increased attention within the sector. The federal government has been trying to promote greater energy efficiency through measures such as the Corporate Average Fuel Efficiency or CAFE standards and the Environmental Protection Agency’s Energy Star program that rates products on energy consumption. Implementation of additional energy efficient technologies, however, varies tremendously from state to state.

Massachusetts in particular has invested time, money and manpower in the energy efficiency sector and continues to incorporate clean technology into areas such as the energy grid and ‘green’ buildings. According to the American Council for an Energy Efficient Economy (ACEEE), Boston has ranked #1 out of America’s 34 largest cities in the “City Energy Efficiency Scorecard.” Massachusetts’ environmental policies and laws are aggressive in comparison to other states, pushing businesses to invest in cleaner technology. The state promotes energy efficiency via tax breaks, loans, grants and incentives to fund projects that will allow companies to decrease energy consumption. While the region shows much success and growth, there is always potential for continual improvement through collaboration with other energy efficient cities throughout the world.

Switzerland has a strong reputation for promoting sustainability and the use of environmentally conscious technologies. Switzerland has maximized its use of hydroelectric power as a source of alternative energy, which provides 57% of electricity needs (Reichlin, 2011). Compared to the United States, Swiss energy consumption is relatively low. According to the International Energy Agency (IEA) estimates, Switzerland consumes 7972 kWh/pc compared with US consumption of 13227 kWh/pc. Also, the Swiss produce 5.06tCO_2/pc from all sources of energy compared to the US which produces 16.94 tCO_2/pc (IEA, 2013). While the US government promotes energy efficiency via economic incentives and educational programs, the Swiss government tends to use more mandatory measures, such as strictly regulated building standards. Zurich in particular has been recognized internationally for its aggressive legislation. Siemens ranked Zurich 6th out of the top 30 European cities in their "European Green City Index." The city has also been ranked as a European Energy Gold City for excellence in energy efficiency. While Massachusetts takes on a less strict strategy, the state government has also been acknowledged for its legislation regarding energy efficiency. Massachusetts was ranked #1 energy efficient state within the US in the *2012 State Energy Efficiency Scorecard* (Mackres, et al., 2013). Boston in particular contributed to this title. The city was ranked #1 energy efficient city in the American Council for Energy-Efficient Economy's (ACEEE) *City Energy Efficiency Scorecard* in September 2013. While both regions have shown success, the differing tactics and strategies of Massachusetts and the Zurich canton give opportunity for growth and collaboration within the energy efficiency sector of these two regions.

The goal of this study was to evaluate opportunities for the promotion of growth and collaboration in the energy efficiency sector of Cleantech industries in Boston and Zurich. The team compared and contrasted the cultural, economic and legislative factors that influence decision-making for energy efficiency renovations within existing commercial buildings. We compared building standards from each location and evaluated how each site may benefit from the other. The team conducted a review of the pertinent literature on energy efficiency policies and programs as well as interviews with various stakeholders, including academics, regulators, business owners and promoters of Cleantech and energy efficiency in both countries.

From these interviews, we found that not only does the price of energy act as the major stimulus for the adoption of energy efficiency strategies and technologies in buildings, but the frugal attitudes adopted by the Swiss in the past permeate all aspects of Swiss culture, including the ways in which they design, build, operate and regulate their residential and commercial buildings in order to save energy. Guidelines for the design and construction of more energy efficient buildings have been developed in both Switzerland and the United States with their private building standards Minergie and LEED, respectively. While each of these building codes have proven to be quite successful in their respective nations, each country can learn from the other in regards to these standards as well as other policies and programs. For example, the LEED program requires periodic evaluation of key parameters following construction in order to ensure the building continues to perform to the standards of its certification. Minergie does not yet require such reassessment; however, it is much more focused on energy efficiency than the LEED standard. Each of these countries and associated cities has strengths and weaknesses within the sector which leads to the opportunity for growth and collaboration.

Chapter 2: Literature Review

Growing concern regarding climate change and diminishing natural resources has created a demand for investment in technologies that limit the impacts of economic activity on the environment. These technologies and the industry they have generated have been collectively called "Cleantech" (Nagel, 2012). Within this industry are various sectors which focus on different environmental issues. The energy efficiency sector has particularly shown a significant amount of growth globally in recent years. Since buildings tend to be a major source of energy consumption in nations all over the world, sustainable practices have become prominent within the sector, especially within commercial buildings. Cities such as Boston, Massachusetts and Zurich, Switzerland have become national leaders within the energy efficiency sector. Technology, culture, economy and legislation all play important roles in the success of these regions.

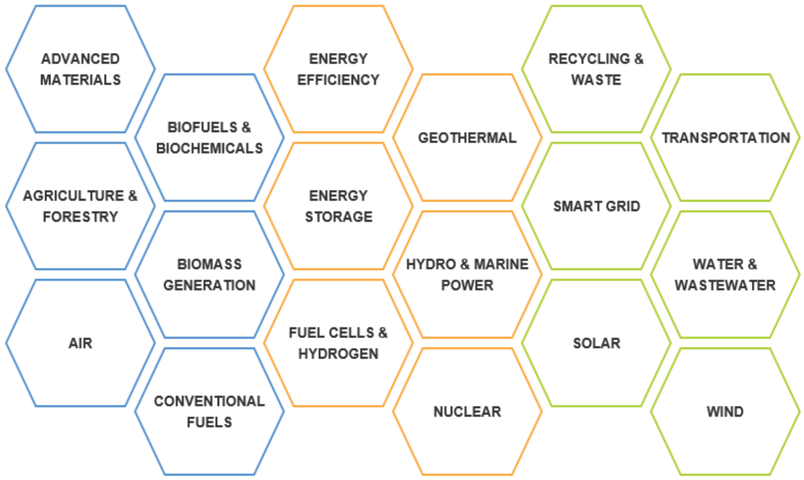
2.1 Environmental Technology Leading to Production of Cleantech

Increased interest in using technology to limit excessive consumption of the world's natural resources, reduce waste, diminish costs, and improve economic efficiency has led to the development of the "Cleantech industry." Many organizations, such as Cleantech Open, Cleantech Switzerland, and Cleantech Group, push for the increased implementation of Cleantech and the growth of the industry. As environmental concerns continue to escalate, many companies are adopting clean technology and seeking collaboration with Cleantech industries around the world. Since many companies and nations are turning to this idea for solutions to environmental problems, this begs the question- What is Cleantech?

2.1.1 What is Cleantech?

Cleantech, short for clean technology, is an ambiguous term that lacks a precise definition. It encompasses many products and services, and is typically broken down into 18 environmental sectors **(Figure 1).** These sectors include agriculture and forestry, biofuels, fuel cells, geothermal energy, recycling and waste and energy efficiency.

Figure 1: Cleantech Sectors



Source: Cleantech Group

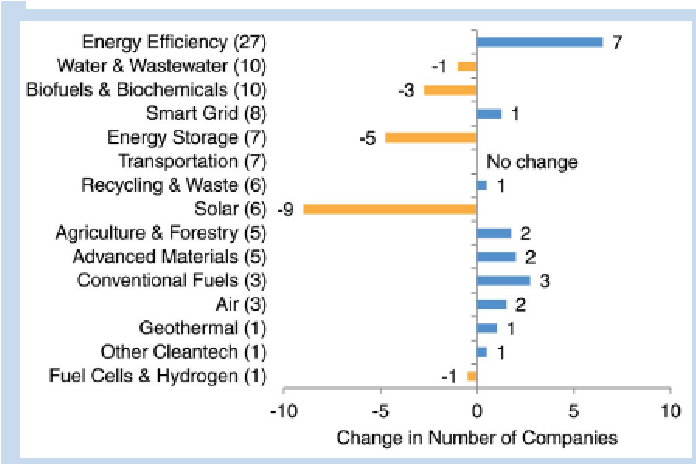
Professionals describe Cleantech in various contexts, some with positive connotation and others with negative connotation. Cleantech Group is a company that "helps its clients find, connect with, and embed innovation" while tracking Cleantech investments, relationships and transactions (Cleantech Group, 2013). Sheeraz Haji, the CEO of Cleantech Group, believes the term Cleantech represents "new technological and business model innovations that empower us to use natural resources more productively and responsibly. To do more with less energy, water, waste and land" (Haji, 2014). Furthermore, "The concept of Cleantech embraces a diverse range of products, services, and processes across industry verticals that are inherently designed to (a) Provide superior performance at lower costs, (b) Greatly reduce or eliminate negative ecological impact, and (c) Improve the productive and responsible use of natural resources" (Cleantech Group, 2013). Cleantech Group summarizes their conception of Cleantech as "doing more with less." Montalvo (2008) defines Cleantech simply as process changes that prevent and reduce pollution and waste. Similarly, David Rielly, National Energy Manager at the pharmaceutical company Novartis, defines Cleantech as "using new generation technology to drive down energy [consumption] and [promote] sustainability" (Personal communication, February 24, 2014).

While many professionals have high hopes for Cleantech, it is not unanimously viewed in a favorable light; particularly in the US and among some financial groups. Many groups believe that Cleantech is a distinctive sector identity created by venture capitalists as a set of technologies that emphasize market-driven strategies to combat climate change. Seen as a marketing term, Cleantech is viewed as being "born in investment circles in the first few years of the new millennium" (Caprotti, 2012). Nowadays, professionals often avoid the term "Cleantech" and tend to refer to specific sectors when discussing the industry.

2.1.2 Growth and Development of Energy Efficiency Sector

Some sectors in the Cleantech industry have seen more significant growth and development than others. In recent years, renewable energy has fallen behind while energy efficiency has become increasingly prominent. The need for energy and environmental technologies is a consequence of growing concern about the cost of energy, energy security, environmental impacts, environmental regulations and constraints on natural resources. As a result of these concerns, governments from all over the world have put in place a variety of environmental policies, programs, and regulations designed "first, to reduce energy use; second, to increase the usage of renewable energy" (Ernst & Young, 2012).

Figure 2: The 2013 Global Cleantech 100 Sector Winners and Losers 2013 vs. Average 2009-2012

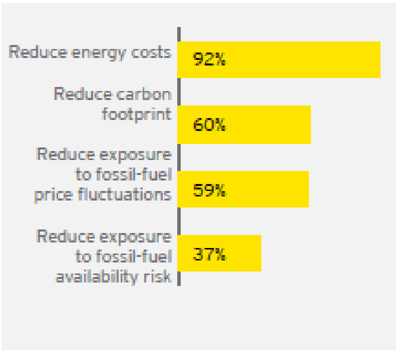


Source: Cleantech Group

Analysis of the Global Cleantech 100, Cleantech Group's annual compilation of the top 100 Cleantech companies internationally, highlights trends in the Cleantech industry and sectors of Cleantech. As solar power, energy storage and biofuel companies fall from the listing, energy efficiency Cleantech companies dominate the list for 2013, as seen in **Figure 2**. Out of 100 of the top companies, 27 focus on energy efficiency, 7 more than the previous year. Within energy efficiency, several subcategories exist; the top subcategories, as determined by Cleantech Group are lighting, efficient heating and cooling, home energy management, energy services, and efficient electronics.

2.1.3 Energy Efficiency Investment

Figure 3: Top Energy Efficiency Objectives



Source: Ernst & Young

Despite a decline in venture capital investment in the industry, Cleantech is continually supported by companies and by statistics. Sheeraz Haji, CEO of Cleantech Group, passionately disputes the negative perspective of Cleantech on his blog GreenBiz.com, stating that "the world needs Cleantech" (Haji, 2014). Many professionals agree with this claim and believe there are several factors driving the growth of clean technology. A survey of pure-play Cleantech companies highlights the five most important reasons why companies seek to increase their energy efficiency. Seventy-seven percent of companies pursued greater energy efficiency to reduce costs, while thirty-one percent did so to improve the reliability of their energy supply. Another 23% were concerned with carbon emissions and 15% with energy price volatility. Fifteen percent of the survey respondents indicated their choices were driven by concerns about regulatory compliance. From the same population, 92% of companies had the objective of reducing energy costs, seen in **Figure 3**. Sixty percent aimed to reduce their company's carbon footprint and 59% aimed to reduce exposure to fossil-fuel fluctuations (Ernst and Young, 2012).

According to David Rielly, investing in Cleantech benefits companies through the "triple-bottom line: people, planet and profit" (D. Rielly, personal communication, February 24, 2014). In other words, companies which utilize Cleantech will experience long-term benefits despite longer payback periods. These benefits include better quality and environmentally responsible employees, a decrease in environmental impact and eventually a gain in profit (D. Rielly, personal communication, February 24, 2014). The adoption of energy efficiency technologies ultimately saves organizations money by reducing consumption of energy (Tembo, 2009). While the long-term investment in Cleantech can be a financial disadvantage for companies, it is often assumed the investment will pay off in terms of energy savings, as well as more qualitative benefits such as attracting employees, investors, and customers based on the creation of a positive corporate image. More often than not, Cleantech companies advertise their environmental cognizance to appeal to their consumer audience (D. Rielly, personal communication, February 24, 2014). Many companies and institutions are adopting Cleantech practices for the "edge" or appeal that being a sustainable institution gives (G. Engbring, personal communication, February 19, 2014). Since Cleantech focuses on process changes that prevent and reduce pollution and waste, the final bottom line – environmental benefits – are transparent. Traditional end-of-pipe technology focuses on containing ecological impact; while some critics are dubious of the innovative nature of Cleantech (e.g., Caprotti 2012), many say it addresses the source of the problem and changes the process to result in less impact and waste (Tembo, 2009). The energy efficiency sector is an example of this concept. While this sector has long been established, the strategic business aspects have only been recognized in recent years and are being utilized all over the world.

2.2 Energy Efficiency in Commercial Buildings

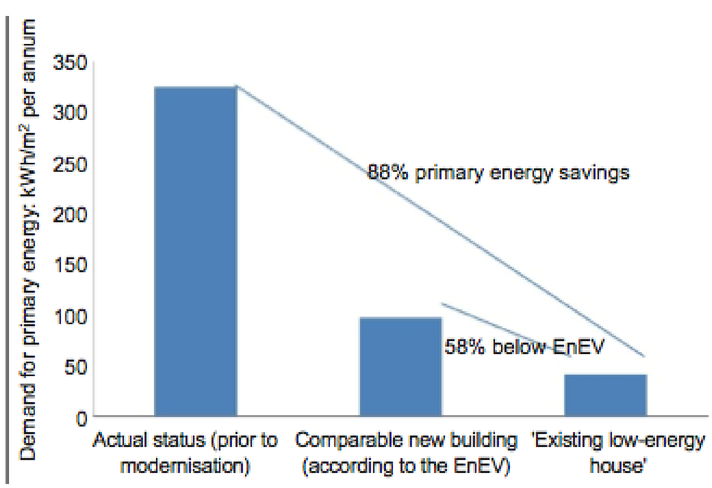
No matter the country, energy consumption in buildings comprises a substantial portion of overall national energy consumption. For example, in the US, buildings account for 40% of all energy consumed and contribute 8% of global greenhouse gas emissions. Office buildings in particular are responsible for a large portion of energy use among commercial buildings globally. This results in much room for improvement in regions around the world. To progress in the energy efficiency sector, countries are striving to improve building efficiency via new construction and retrofitting. The recent widespread recession has resulted in less new construction and greater attention to retrofitting and rehabilitating older building to improve energy efficiency.

2.2.1 Renovations vs. New Buildings

The decision between refurbishment or demolition and new construction of older buildings has been a controversial topic for those pursuing Cleantech energy efficient changes on their properties. The demolition of older properties can appear to be an attractive choice to enhance energy efficiency and functionality, especially when the buildings in question were constructed prior to the time efficiency became a priority (Power, 2008). Efficiency in these older buildings is noticeably lower than in new buildings. Critics of demolition, however, argue that it produces a more significant adverse environmental impact than renovations. Since most of the building materials in newly constructed buildings are newly processed and produced, the new buildings use almost eight times the resources over an equivalent renovation. The building process itself also wastes approximately 30% of the new materials, creating a far greater environmental impact when a majority of the demolition waste is disposed of through landfills (European Urban Knowledge Network, 2013). The negative outcomes of this construction apply significantly less in the renovation process since the materials, waste transportation, and overall operational scale apply on a much smaller scale (Power, 2008). Surprisingly, demolition also tends to be a more costly and slower process. Within Europe, it is rare for a demolished building cite to complete construction in less than 10 years even with government investment and guidance (Power, 2008). Some demolition and reconstruction projects can be prolonged up to 20 years. Integration of new efficient technologies within renovation bypasses the slow property planning process and reuses the existing infrastructures, making it a quicker option than demolition.

In 2005, the Zukunft Haus Programme in Germany demonstrated that renovating old buildings could achieve substantial energy savings compared with existing low-energy buildings and even exceed the new-build standards as seen in **Figure 4**. This new evidence led to the renewal of the KfW Carbon Dioxide Building Rehabilitation Programme by the German government in 2006 (Power, 2008).

Figure 4: Demand for Primary Energy

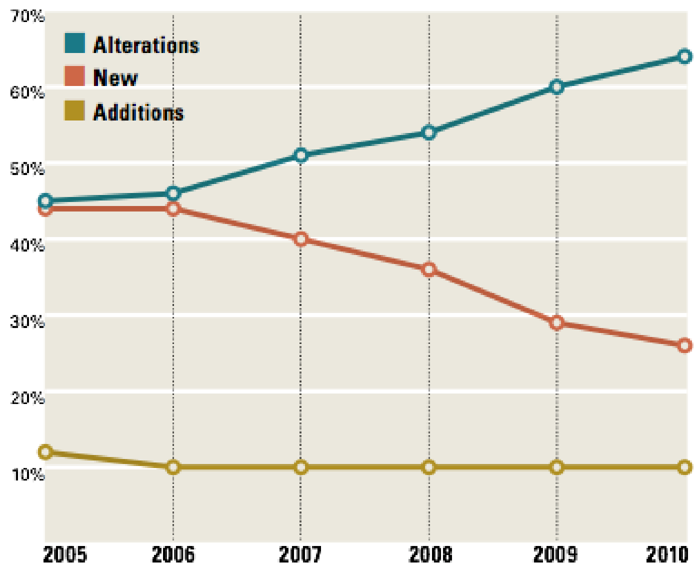


Source: Housing and Sustainability: Demolition or Refurbishment

Contrary to retrofitting existing buildings, the process of demolition and reconstruction may generate substantial adverse reaction in the affected community. The "ugly" site can damage adjacent properties by decreasing investment in the neighboring areas (Power, 2008). Losing value can then create a domino effect on the surrounding industries. In areas containing buildings of historical significance, renovations maintain the area's character and pride and act as a stimulus for investment. This further contributes to the area's long-term vitality and value.

The decision process involved in implementing energy efficient technology can be highlighted in the cultural differences between approaches to building construction and renovation in Switzerland and the US. Before the fluctuation of the real estate market, individuals and companies in the US frequently purchased and sold their properties. This trend led to investing in less expensive properties which had poor energy profiles. By contrast, Switzerland properties are seen as "once-in-a-lifetime" investments. Individuals and companies were more inclined to invest in buildings that are efficient and simultaneously more cost effective over time even if the initial costs might be slightly higher (Mosteiro-Romero & Krogmann, 2014). In comparison to a Swiss building lifespan of approximately 100 years, buildings in the United States are made to last until the arrival of new technology (Kneifel, 2009). Normally, this constitutes constructing for 25-50 year periods. Given Boston's historical significance, however, organizations such as LEED have pressured companies and institutions in the Metro West area to institute their energy efficient changes through the process of renovation (personal correspondence, David Reilly, February 24, 2014). Fluctuations in the US market that have accompanied the economic recession have further changed construction activity. With less available capital for new building construction, companies have begun to place a greater emphasis on renovation. Research conducted by McGraw-Hill Construction indicates that the 2010, investment in new construction of commercial buildings only reached $147 billion. This number is substantially lower than past years such as 2005, in which investments reached $670 billion. Major commercial retrofit and renovation on the other hand has grown from $31.4 billion to $41 billion from 2005 to 2010, respectively (Jones, et al., 2012). For the year 2014, renovation projects are anticipated to reach over $53 billion in funding. This trend is shown in **Figure 5** below and is expected to continue into 2015.

Figure 5: Commercial Construction Based on Number of Projects Started (2005-2010)



Source: McGraw-Hill Construction

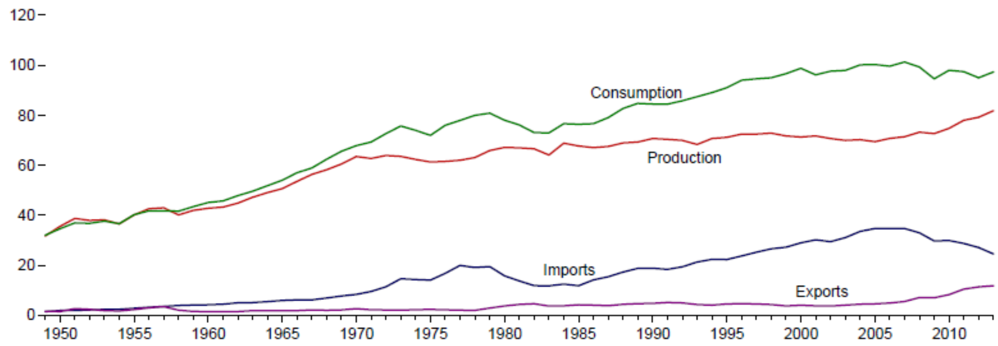
Given its popularity and growth in both locations alongside its combination of benefits, renovations accomplished with thoroughness and speed can be seen as both the less-expensive and easier option for quick energy efficient results in commercial buildings.

2.3 Energy Consumption in the United States

For decades, the United States has consistently ranked higher than other countries in primary energy consumption. As shown in **Figure 6,** between 1949 and 2005, overall primary energy consumption and production steadily increased from nearly 35 quadrillion Btu to 70 quadrillion Btu and 90 quadrillion Btu, respectively. These large increases over the span of 56 years caused US energy consumption to rise well above other nations in the Organization for Economic Co-operation and Development (OECD) (U.S. Energy Information Administration, 2014). Despite the 56 year rise, after 2006 energy consumption in the United States began to decrease annually. Due in part to economic recession between 2008 and 2010, the US decreased its overall energy consumption by 2% and was replaced as #1 in global listings of top energy consumers by China (D&R International, Ltd., 2012). Continuing the trend, between 2011 and

2012, the US decreased its energy consumption by another 2.8%, the most of any OECD nation (BP, 2013)**.**

Figure 6: Primary Energy Overview (Quadrillion Btu)

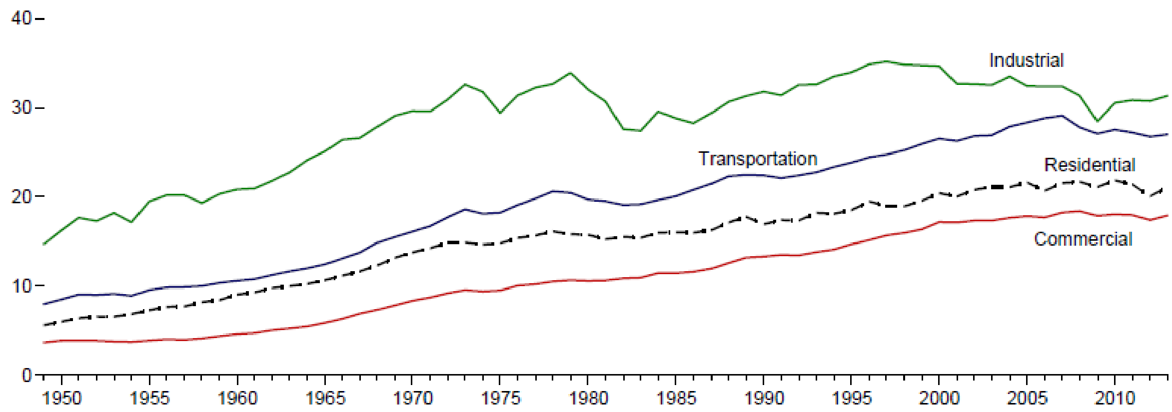


Source: U.S. EIA

2.3.1 Energy Consumption in US Commercial Buildings

Energy consumption in the United States is divided into four end-use sectors: transportation, commercial, residential and industrial. Consumption by end-use sectors has seen an overall increase between 1949 and 2013. The industrial sector consumes the most energy, followed by transportation, and then the residential and commercial sectors shown in **Figure 7** (U.S. Energy Information Administration, 2014)**.** Building energy consumption increased by 48% between 1980 and 2009 and in 2011, 41% of US energy consumption was attributed to buildings in the residential and commercial sectors versus 30% in the industrial sector and 29% in the transportation sector. In the building sector, 54% of energy was consumed in residential buildings and 46% in commercial buildings (D&R International, Ltd., 2012)**.**

Figure 7: Energy Consumption by Sector (Quadrillion Btu)



Source: U.S. EIA

Within buildings, energy end-usage includes space heating, lighting, and ventilation. In a survey of commercial buildings conducted in 2011 by the U.S. Department of Energy (DOE), energy end-use in each specific sector was analyzed. It was found that end-use consumption in commercial buildings varied from that of overall buildings and residential buildings. In residential buildings, space heating consumed the most energy at 27.8%, followed by water heating (12.9%), space cooling (15.1%) and lighting (9.7%) as seen in **Figure 8**. Commercial building end-use splits differed from residential end-use splits. Lighting, as displayed in **Figure 9**, was the highest end-use consumer, using 20.4% of all energy expended in commercial buildings, followed by space heating (15.5%), space cooling (14.6%) and ventilation (9.2%). In contrast with energy consumption in all buildings, commercial buildings expend more energy on lighting than residential buildings. Water heating only comprised 4.3% of energy use in commercial buildings. While both residential and commercial buildings expended large portions of energy on water heating and space cooling, commercial buildings also consumed energy in ventilation, a subsector which was inconsequential in residential buildings (D&R International, Ltd., 2012).

Figure 8: 2010 Residential Buildings Energy End-Use Splits

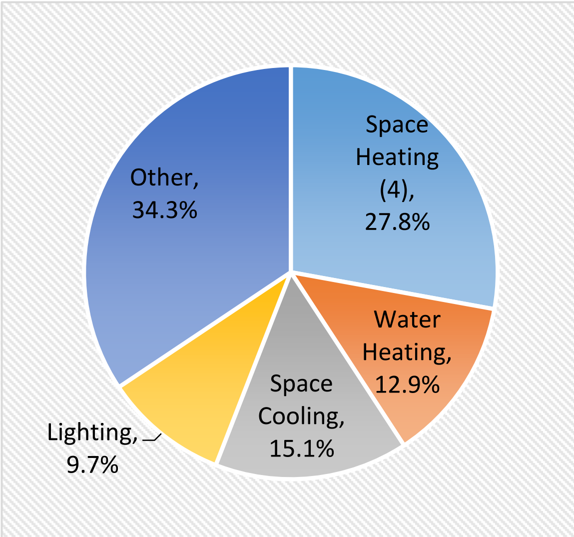
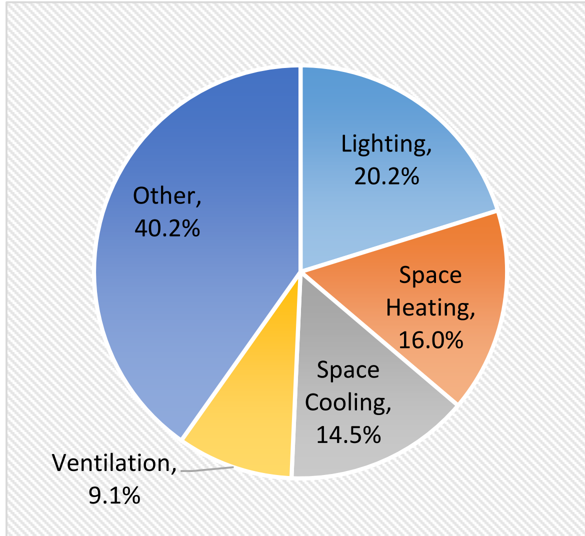


Figure 9: 2010 Commercial Energy End-Use Splots



Source: D&R International, Ltd.

Commercial buildings, such as offices, hotels, hospitals and schools, consume one-fifth of all energy used in the United States. Over $200 billion are spent annually on energy, mostly to power lighting, space heating, space cooling and ventilation systems, which put a strain on power grids during peak periods. In office buildings, which account for one-fifth of commercial buildings, energy costs comprise up to 30% of overall operating expenses (Commercial Buiding Energy Alliance, 2012). Typically, 30%-50% of building energy consumption annually is wasted either via inefficient use or heat loss through infrastructure (Retroficiency, 2013). Energy waste in sectors such as commercial buildings and the negative impacts which stem from excessive energy consumption have led to the development of energy efficient practices and products across cities in the United States.

2.4 Energy Efficiency in US

The cost of energy plays a huge role in success of the energy efficiency sector. In countries such as the United States, where the cost of energy is much lower, payback periods of investments within the sector are longer and citizens are much less cognizant of excessive energy consumption. This results in a lack of commitment to such practices across the country. However, as the global market becomes increasingly more competitive and environmentally aware, incorporating energy efficiency practices is becoming a strategic business tactic all over the world. The acknowledgment of energy efficiency as a business opportunity has been the stepping stone for the United States within the sector. Companies throughout the country are starting to commit to decreasing energy consumption of commercial buildings to save money, particularly on the East and West coasts.

2.4.1 Energy Efficiency in Boston

The adverse environmental impacts of excessive energy consumption are more evident in urban areas. Eighty-percent of total U.S. energy consumption and seventy-five percent of global greenhouse gas emissions can be attributed to cities. Improving energy efficiency is a strategy being utilized in many cities around the world. Adopting energy efficient practices has multiple positive effects on climate and energy portfolios, local health as well as the local economy, providing cost savings for residents and businesses and creating new jobs (Mackres, et al., 2013). Boston in particular is cognizant of energy overconsumption, particularly in commercial buildings which consume 54% of energy used annually. With the changing climate and fluctuating energy prices, the city has tried to promote the use of energy efficient technology to lower energy consumption. Having been one of the more sustainable cities in the U.S. for years, Boston was ranked #1 energy efficient city in the American Council for Energy-Efficient Economy's (ACEEE) *City Energy Efficiency Scorecard* in September 2013. With its score of 76.75 out of a total possible 100, Boston scored higher than other energy efficient cities such as Portland, New York City, San Francisco, Seattle and Austin. ACEEE examined city policies and programs in transportation, energy and water utilities, local governmental operations, community-wide initiatives and building policies. Boston scored well in all policy areas, ranking highest in community-wide programs and partnerships. The city also performed well in building policies with a score of 21.5 out of 29, placing its building policies second behind Seattle. Boston's environmental policies are an extension of those in Massachusetts, which was ranked #1 energy efficient state in the *2012 State Energy Efficiency Scorecard* (Mackres, et al., 2013). Among many other factors, the state and city initiatives play a prominent role in promoting the construction of energy efficient buildings within the Commonwealth.

2.4.2 Decision Making Factors

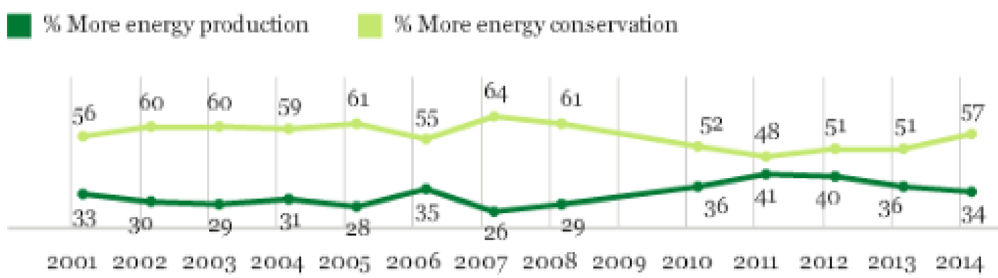
The decision to use this energy efficient technology for new buildings or retrofits is influenced by many aspects including national, state-wide, and municipal culture, economy and legislation. The "human factor," which varies from culture to culture, along with economic status of the region in question is crucial for the commitment to such technology because implementation requires investment and follow-through. Finally, the Massachusetts' state government has adopted a "lead by example" strategy for the promotion of energy efficiency practices within building infrastructure and therefore plays an important role as a decision making factor for green building and retrofitting.

2.4.2.1 Culture

Environmental priorities of individual businesses tend to parallel the environmental priorities of the surrounding area, and thus American businesses tend to parallel American opinion on the environment. In a 2014 poll, Americans prioritized the nation's energy problems in the lower 50% of 20 issues. While the economy, jobs and terrorism were rated as top policy priorities, only 45% of respondents rated energy as a top 10 priority (Pew Research Center, 2014). An American lack of interest in the environment was also displayed in a September 2013 survey which gauged public awareness of energy production in recent years. Only 48% of the public was aware of America's increase in energy production, showing that energy consumption has not widely registered with Americans (Pew Research Center, 2014). A survey conducted by SC Johnson compared the U.S. public's perception of environmental issues in 1991 to that in 2011. SC Johnson's survey reveals that Generation Y (i.e., Americans aged 18-31) is more likely to be engaged with environmental issues (SC Johnson and GFK Group, 2011). Behavioral studies performed by GreenerU also revealed that students are generally enthusiastic about environmental technology, however, do not "always follow through" (G. Engbring, personal communication, February 19, 2014).

Despite lack of prioritization, Americans do support green practices and green policies particularly those limiting energy consumption and greenhouse gas emission. Between 2001 and 2014, Americans have constantly supported energy conservation, with 57% of Americans saying energy conservation should be supported to solve the United States' energy problems as shown in **Figure 10**. Over 60% of Americans support green policies that would regulate or limit fossil fuel emissions (Moore & Nichols, 2014).

Figure 10: Americans' Preferences for U.S. Energy Policy Energy Production vs. Consumption

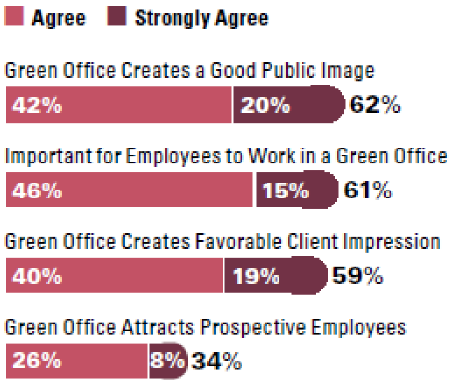


Source: GALLUP

Another survey conducted by SC Johnson compared the U.S. public's perception of environmental issues in 1991 to that in 2011. Americans as a whole are pushed toward environmentally-friendly practices such as recycling by financial incentives and penalties (SC Johnson and GFK Group, 2011). Another survey by GALLUP in 2012 asked citizens at what gas price they would have to change their lifestyle and make cutbacks in other spending areas. Answers ranged from under $4.00 to $10.00 or more. Most Americans answered that gas prices around $5.35 would force them to make changes in lifestyle and prices around $5.30 would force them to make cutbacks in other spending areas (Newport, 2012). While gas prices are rising, American gas prices are generally cheaper than other OECD nations. The survey revealed that if American gas prices were to increase near the range of other OECD nations, Americans would change their lifestyle to save money, supporting the finding that financial incentives account for 49% of incentives for Americans while penalties account for another 49% (SC Johnson and GFK Group, 2011).

Overall, Americans believe that "going green is good business" and give credit to large companies which adopt environmental technologies (SC Johnson and GFK Group, 2011). The public attitude toward green business practices is positive, as is the public attitude on green buildings. Green offices are highly important to tenants and occupants. **Figure 11** shows the

Figure 11: Importance of Green Office for Tenants/Employees



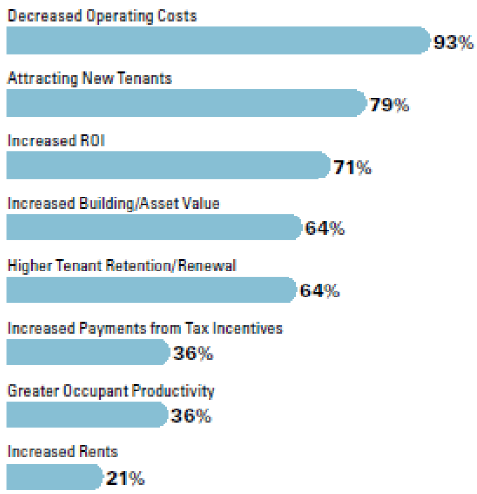
Source: The Business Benefits of Green Building SmartMarket Report

majority of tenants agree that energy efficient office buildings boost the company's public image and create a favorable client impression. Sixty-one percent of tenants also believe it is important for employees to work in a green office. Fifty-four percent of employees who work in green buildings report higher satisfaction after energy efficient renovations and are more satisfied with daylight and views, indoor air quality, energy conserving light, and temperature within their building than employees who do not work in green buildings (Bernstein, Russo, Fitch, & Laquidara-Carr, 2011). It is clear that in an increasingly competitive global market, energy efficiency practices have become a business opportunity in which companies in the Boston region are utilizing. This business tactic has been adopted into the Swiss culture as well.

2.4.2.2 Economy

Much of the financing for energy efficient projects in the U.S. is derived from governmental incentives, such as tax rebates and grants. Federal, state and local governments provide grants, tax-credits, and loans to industry building owners and Cleantech companies to sponsor energy efficient construction and technology (U.S. Environmental Protection Agency, 2010). While tax rebates are a good incentive for building owners, loans are provided to help owners finance their renovations. Unfortunately, government loans do not usually cover 100% of the project, they are typically quite small, loan payback periods are short, and loans may not be renewed (Buonicore, 2012). For projects in which governmental support is not feasible, private investments and outside opportunities for financing energy efficiency are available.

Figure 12: Expected Benefits from Green Features (According to Building Owners)



Source: The Business Benefits of Green Building SmartMarket Report

A survey of banks performed in 2011 revealed a high demand for energy efficiency renovation funds from companies and commercial building owners. The primary driver for investing in energy efficient technology was determined to be cost savings for companies and most loans for renovations focused on energy efficient retrofits. In a 2010 survey (**Figure 12)**, most building owners expected a decrease in operating costs, increase in return on investment and increase building value as well as attracting new office "tenants" or employees after performing renovations to improve energy efficiency (Bernstein, Russo, Fitch, & Laquidara-Carr, 2011). Building owners may assume that new tenants will be attracted to renovated buildings if they believe their operating expenses (i.e., utility bills) may be lower in a more energy efficient building. Of course, this depends on the leasing arrangements and whether the tenant or the owner pays the utility bills. Banks such as Bank of America, US Bank, JP Morgan Chase and Wells Fargo all provide opportunities for businesses to obtain loans for efficient renovations (Buonicore, 2012). Despite this demand, banks and private loans are rarely used in funding projects. In fact, in a study performed in 2011 by McGraw Hill Construction in accordance with the DOE, only 6% of surveyed companies used loans to finance green building retrofits as companies were reluctant to use loan money at the risk of incurring debt. While the economy has improved, previous lack of financing during the recession led to a decrease in private loans as well, and thus a lack of commitment to energy efficient renovations (Bernstein, Russo, Fitch, & Laquidara-Carr, 2011). Lenders are often wary of giving out loans due to creditworthiness of the borrower, making loans hard to obtain for companies that want to use private loans (Buonicore, 2012). Energy efficient renovations are usually not a strong enough motivator for companies to take out private loans.

The majority of companies that performed energy efficient renovations used internal company financing. Eighty-five percent of companies which performed renovations used capital expenses from the company, meaning the energy efficient retrofits were mostly performed in companies that could afford to expend its budget on energy efficiency (Bernstein, Russo, Fitch, & Laquidara-Carr, 2011). Companies choose to use capital expenses because it is the most direct method of obtaining financing; however there are various obstacles to self-funding retrofits. Only companies that can afford to use capital expenses can perform renovations and there may be a limitation on the amount that can be spent. Retrofit investments may also compete with other company investments within the capital budget (Buonicore, 2012).

Energy Service Companies (ESCOs) are companies that assist with financing large-scale retrofits. Contracts between ESCOs and companies usually cover a period of 5-10 years and can be classified as “shared savings”, “paid from savings”, and “guaranteed savings” contracts. “Shared savings” and “paid from savings” contracts are more common. In “shared savings” contracts, the ESCO and the building owner split the value of savings from the retrofit. In “paid from savings” contracts, which are the most popular, the building owner pays the ESCO a predetermined amount calculated using a percentage of the energy cost savings. A “guaranteed savings” contract guarantees that the energy cost saving will exceed a minimum value, which usually equals the financing payment for the renovation. The building owner pays a premium to cover the retrofit. Energy Service Agreements (ESAs) are provided by third parties. ESAs are “pay-for-performance solutions where energy efficiency is essentially being sold as a service” (Buonicore, 2012). ESAs pay for 100% of the retrofit and maintenance of the energy efficient technology. These agreements are only compensated if energy cost savings occur, unlike ESCOs which set an amount from projected savings. However, many of the same concerns are apparent for both ESCOs and ESAs. Neither are a prominent method of financing retrofits due to the building owner’s reliance on the strength of the ESCO/ESA and the complicated negotiation and documentation required. Additionally, energy cost savings, which are the primary basis of repaying both, can be projected but are difficult to measure directly. This leads to poor confidence in the energy savings verification process. Typically, large projects that cost more than $1million use ESCOs and projects that cost more than $750,000 use ESAs (Buonicore, 2012).

2.4.2.3 Legislation

National regulations and state programs have played a large role in influencing a decrease in energy consumption in the United States. U.S. building policies are either ‘barrier reduction’ policies which “push” energy efficiency through standards and mandates or ‘technology accessibility’ policies which “pull” building owners toward energy efficiency through rebates, subsidies, tax incentives and grants. Typically the U.S. enacts codes and standards governing the efficiency of products such as appliances and buildings through appliance standards and building energy codes (Amecke, et al., 2013). Appliance standards mandate the minimum efficiency level that appliances must meet. Building codes address design of buildings and long-term energy demands. While most federal efficiency legislation is aimed at energy usage in appliances, the U.S. has passed various building efficiency codes and incentive programs and has invested money in developing green building technology (Supple & Sheikh, 2010).

The U.S. government originally began to pass “lead by example” acts that mandated energy efficiency in federal buildings. The Energy Policy Act of 2005 mandated that all existing and new federal buildings must reduce their energy consumption by 30% by the year 2015 through energy retrofits and energy efficient appliances (Supple & Sheikh, 2010). Through the Energy Policy Act, a tax deduction was put into action until New Year’s Day 2014, defining a “deduction of up to $1.80 per sq. ft. of affected space for qualifying energy efficiency improvements in lighting, HVAC, and building envelope improvements” (Guerster, 2014). In 2005, Congress also passed a law that required states to adopt the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) national model commercial code in commercial buildings (Supple & Sheikh, 2010). The Energy Independence and Security Act of 2007, which pushed toward increase in building, products, and vehicle efficiency, was reinforced by the Executive Order 13514 issued by President Obama in 2009. Executive Order 13514 required federal agencies to meet these energy reduction goals via implementation of sustainable building, construction, operation, maintenance and deconstruction practices. Specifically, federal buildings designed in 2020 or later must achieve net zero energy by the year 2030. New construction and renovations of federal buildings must comply with the Guiding Principles of Federal Leadership in High Performance and Sustainable Buildings and currently existing buildings must reduce energy and water consumption through energy efficient renovations (Supple & Sheikh, 2010).

The federal government has little jurisdiction over individual state building codes and has been mainly active through incentives and initiatives. The DOE's Building Technologies Program supports research and development of efficient technology that can be integrated into the market quickly. The Better Buildings Initiative, a subsector of the Building Technologies Program, aims to improve already-existing buildings through tax incentives and financing opportunities. Founded in 2011 under President Obama, the initiative aims to make commercial buildings 20% more efficient over a 10-year span. Another subsector, known as the Commercial Building Initiative (CBI), aims to improve energy efficiency of new and existing commercial buildings by research technology and strategies to improve energy savings. Engaging commercial building owners, operators and builders, the CBI has smaller programs such as the Commercial Building Energy Alliances, which act as forums for building owners, the Solid-State Lighting (SSL) Initiative which works with industry partners to develop better solid-state lighting, the Appliances and Commercial Equipment Standards which works with product manufacturers to develop minimum efficiency standards for appliances and commercial equipment, and finally the Building Energy Codes which support the development of stricter building energy codes (Nadel, et al., 2013).

The Energy Efficiency and Conservation Block Grants (EECBG) were authorized by the Energy Independence and Security Act of 2007 and later funded by the American Revitalization and Reinvestment Act of 2009 (ARRA). Over $3.2 billion was allocated for grants; $2.7 million was specifically made available to states and cities aiming to develop energy efficient strategies, conduct audits and retrofits, and develop building codes, as well as other sustainable practices. As of mid-2013, 36.8% of grants were allocated to energy efficient retrofits and another 18.5% to financial incentive programs (Nadel, et al., 2013).

In addition to federal legislation, the state of Massachusetts has developed its own building laws, programs and incentives. In late 2007, Governor Menino issued the City of Boston's Climate Action Plan, which reviewed the link between greenhouse gases and climate change and described how greenhouse gas emission could be reduced through decrease in energy use and waste (City of Boston, 2009**)**. The Green Communities Act of 2008 was passed with unanimous support under Governor Deval Patrick. The act created new policies for energy supply and use, requiring the State Board of Building Regulations and Standards to adopt the latest edition of the international energy conservation code as a minimum standard as part of the state's building code. Under the law, Massachusetts aims to meet at least 25% of its electric load with "clean, demand side resources" such as energy efficiency, load management, and demand response by 2020 (United States Environmental Protection Agency, n.d.). Additionally, the act mandated that new buildings owned or operated by the state must minimize lifecycle costs through energy efficient technology and renewable energy sources (Hibbard, Tierney, & Darling, 2014). Through Executive Order 484, "Leading by Example – Clean Energy and Efficient Buildings," Governor Patrick mandated a 35% decrease in energy consumption from a 2004 fiscal year baseline by 2020 for state-owned and leased buildings. All new state buildings would be required to meet the Massachusetts Leadership in Energy and Environmental Design (LEED) Plus green building standard (United States Environmental Protection Agency, n.d.). For the first six years the Green Communities Act had been in effect, Massachusetts has gained a total of $1.2 billion in economic benefits and 16,000 new jobs. The demand for power was predicted to decrease, projecting the cumulative energy production to be 37TWh lower between 2010 and 2014 than it would have been without the act. The Green Communities Act has stimulated environmentally-friendly action by cities and communities in Massachusetts through its policies and funding. Through the act, Boston has received a $1 million grant to assist in energy consumption reduction programs. The Green Communities Act has been a significant catalyst in promoting energy efficient building construction and renovation in Massachusetts (Hibbard, Tierney, & Darling, 2014).

Massachusetts continues to strive to reduce building energy consumption. Governor Patrick initiated a Zero Net Energy Buildings (ZNEB) Task Force in March 2008 to move Massachusetts toward zero net energy building construction by 2030. On March 5, 2014, Massachusetts Department of Energy Resources (DOER) Commissioner Mark Sylvia announced a new initiative named The Pathways to Zero Net Energy Program. This initiative was formed to assist in the achievement of zero net energy buildings in various sectors (Mass.gov, 2014).

In 2008, the Boston Green Tech initiative began, highlighting Boston's commitment to green technology. The initiative attracted environmentally-friendly businesses to Boston. During 2008, the initiative brought the city $487.17 million in Cleantech sustainability investments. This amount accounted for 10% of total Cleantech investments nationally that year. The Sustainable Business Leader program, another initiative geared toward small businesses that was launched in 2008, assists small businesses in Boston with adopting sustainable practices (Local Leaders in Sustainability, n.d.). Mayor Menino also created educational programs such as "Renew Boston" and "Greenovate Boston" to educate the public while the private sector takes part in Sustainable Business Network, an organization created in 1988 by Laury Hammel to engage businesses in reducing negative impact on the environment (CBS Local, 2013).

While recent state regulations and programs have helped push energy efficiency in Massachusetts, Boston had participated in energy efficient building practices earlier in the decade. In 2003, the Mayor's Green Building Taskforce was created to unite industry and building experts in the promotion of green buildings (Geary, n.d.). The Task Force studied how green building practices could be implemented in Boston, and in 2007 a set of initiatives was passed in accordance with the Task Force's recommendations. The initiatives added Amendment #37 to the Boston Zoning Code Article 80. The Amendment required all new buildings larger than 50,000 sq. feet to earn a U.S. Green Building Council's LEED-New Construction score of 26, as determined by Boston city officials. The Amendment has resulted in 33 LEED certified buildings being constructed since its addition to Article 80. Boston was the first US city to adopt LEED standards for private building construction (Local Leaders in Sustainability, n.d.). In 2013, Boston became one of the few U.S. cities to adopt a Building Energy Reporting and Disclosure Ordinance (BERDO). The ordinance requires Boston's medium-sized to large-sized buildings (over 50,000 sq. feet) to report their annual energy use to the city of Boston. Every five years, buildings are required to perform an energy audit to assess where energy efficient changes can be implemented. All reports are available to the public.

Advertising environmental responsibility has become a powerful marketing tool as global warming has become a growing concern. As a result, building codes which call for energy efficiency have been created. The most common in the U.S. is the aforementioned Leadership in Energy and Environmental Design (LEED) Certification.

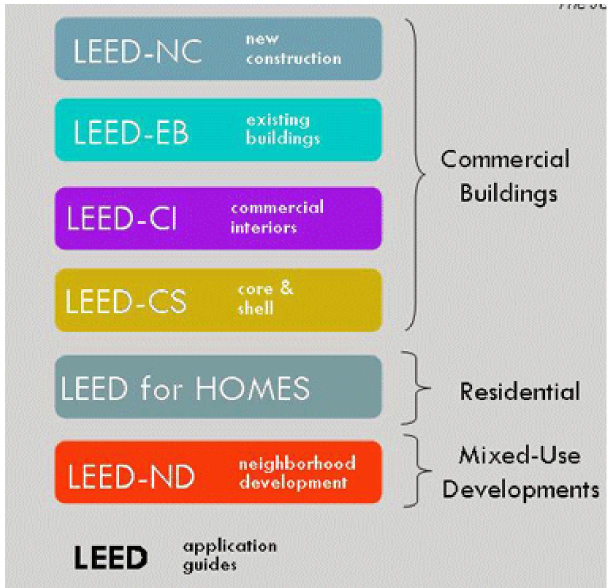
2.4.3 Leadership in Energy and Environmental Design (LEED)

The LEED Certification standard was created in 1998 by the United States Green Building Council (USGBC), a non-profit organization composed of various industry stakeholders including building contractors, architects, and environmentalist groups who share an interest in the promotion of green buildings in the US. According to the USGBC, LEED was created for a specific set of purposes. Primarily, LEED would act as a counteraction to negative environmental impact. The standard would also be used to create a standard definition of "green," prevent "green-washing," and promote a fully integrated building design process. Since this period, LEED has become the standard for green buildings in the nation (Council, 2014a).

Following the release of the LEED 1.0 pilot program in 1998, the standard has undergone a series of changes. The March 2000 release of the LEED 2.0 reflected the extensive changes of the original standard. The creation of a variety of programs including LEED for New Construction, LEED for Existing Buildings, LEED Commercial Interiors, LEED residential, and LEED Core & Shell were incorporated into the new document. Five Technical Advisory Groups (TAGs) were also added, one for each LEED impact area. These groups are composed of volunteers who were deemed experts in the building industry and work to resolve interpretation issues as well as find potential revisions. A LEED steering committee would also direct any technical difficulties that require further expertise to a technical Scientific Advisory Committee. Since its release, over 900 project teams have registered their buildings in 48 states within the US and 7 countries around the world for LEED certification.

LEED itself is divided into three categories: commercial buildings, residential, and mixed-use developments. Each category has specific LEED certifications, as shown in **Figure 13**. Commercial buildings are a major component of LEED, and the category is divided into more focused subcategories of New Construction, Existing Buildings, Commercial Interiors, and Core & Shell.

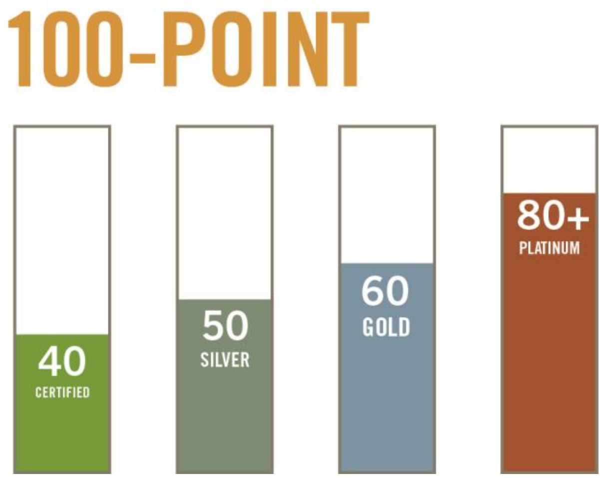
Figure 13: Categories of LEED



Source: Jacobs

The LEED certification in each category above is further narrowed into focused concerns about the environment and impact of the building being certified. These concerns translate into specific tasks and are assigned "points" which get added to a cumulative score. This score is then compared over the total number of points available which dictates the level of certification. LEED has four distinct levels of certification (**Figure 14**). Buildings obtaining 40% of the total 100 points are LEED certified. Buildings obtaining a higher percentage of points can obtain higher levels of certification, from Silver to Platinum, and are considered more sustainable (Council, 2009).

Figure 14: LEED 100-Point System



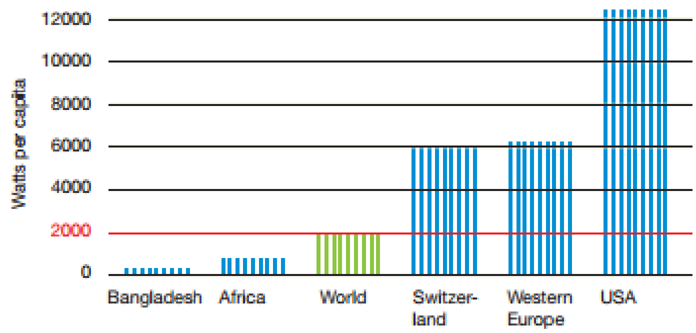
Source: Dispenza

Each version of LEED is continuously improved upon as technology changes and global competition rises. Increasing demand for minimizing energy consumption and environmental impact throughout the world creates a competitive nature to the innovative energy efficiency sector. LEED is a crucial aspect to the sector within the U.S. This standard has become part of the American vernacular and is an effective energy efficient practice as well as marketing strategy.

2.5 Energy Consumption in Switzerland and Zurich

In comparison to the United States, Swiss energy consumption is low. According to IEA estimates, Switzerland consumes 7972kwh/pc compared with US 13,227kwh/pc, and 5.06tCO_2/pc compared with 16.94 in the US (EIA, 2013). The average energy requirement per capita world-wide is 2000 watts, but this fluctuates enormously from country to country. While both the United States and Switzerland are well above this average energy requirement, Switzerland's energy requirement at about 6000 watts/capita is half that of the US at about 12,000 watts/capita (**Figure 15**).

Figure 15: Electricity Consumption Comparison, 2011



Source: On the Way to the 2000W Society

The European Green City Index created by Siemens ranks the top 30 cities from 30 European countries based on energy efficiency, environmental performance, and dedication to reducing their environmental footprint. Zurich was ranked 6th overall with a score of 82.31 out of 100, ranking 6th in energy efficiency and 9th in building efficiency (Siemens, 2013). Although the city's energy consumption remains slightly below Switzerland's average, it ranked the highest of all 30 European cities per unit of Gross Domestic Product (GDP). Average energy used per head in Zurich is about 95GJ, well above the European average of approximately 81GJ. A comparison of the city's energy consumption in relation to other countries around the world can be seen in **Figure 17.** This graph depicts primary energy consumption of each region with and without grey energy. Grey energy is the energy required for the manufacture, transport, storage, sale, and disposal of a product **(**Stadt Zurich Umwelt- und Gesundheitsschutz, 2011) On the basis of CO_2 emissions, Zurich ranked slightly higher with a 3rd place position. Its estimated CO_2 emission per resident is about 3.7tonnes. This amount is relatively low in comparison with the rest of Europe which averaged about 5tonnes (Siemens, 2013). **Figure 16** depicts Zurich's relation to both Switzerland and other countries based on average CO_2 emissions. The canton's lack of heavy industry and more limited reliance on fossil fuels can be seen as the primary reasons for the region's low score.

Figure 17: Zurich Energy Consumption Comparison

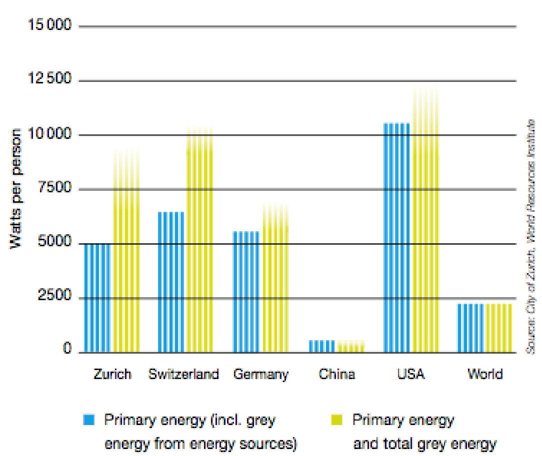
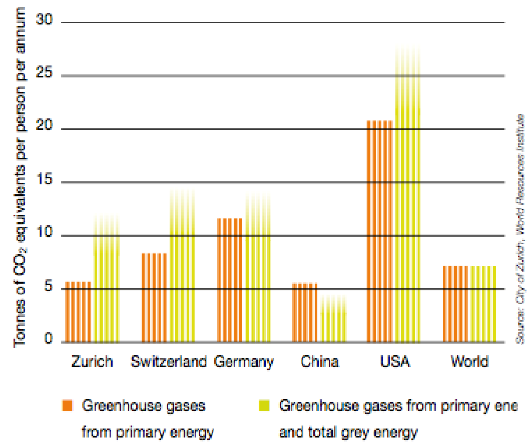


Figure 16: Zurich Greenhouse Gas Production Comparison



Source: On the Way to the 2000W Society

2.5.1 Energy Consumption in Zurich Commercial Buildings

Zurich sources its energy primarily from oil products, nuclear and hydropower, natural gas, and waste and biomass **(**Siemens, 2013). The canton's chief source of energy (33%) is nuclear power (**Figure 18**). This is likely to change over the coming years as the Nuclear Power Act of 2003 becomes fully integrated at the city level **(**Stadt Zurich Umwelt- und Gesundheitsschutz, 2011). Hoping to protect the population and environment from the potential risks of nuclear energy, it is meant to be phased out under the 2050 Strategy (SFOE, 2014). Zurich's energy consumption can further be broken down into three end-use sectors: transportation, households, and business and public administration. As shown in **Figure 19,** the household sector and business and public administration sector each consumed 41% of total energy consumption while transportation consumed the remaining 18% **(**Stadt Zurich Umwelt- und Gesundheitsschutz, 2011). Since Zurich's core business activities are primarily service related with minimal environmental impact in comparison to industrial business, the city holds a comparable advantage in its potential to combat environmental issues **(**Stadt Zurich Umwelt- und Gesundheitsschutz, 2011).

Figure 18: Zurich Primary Energy Sources

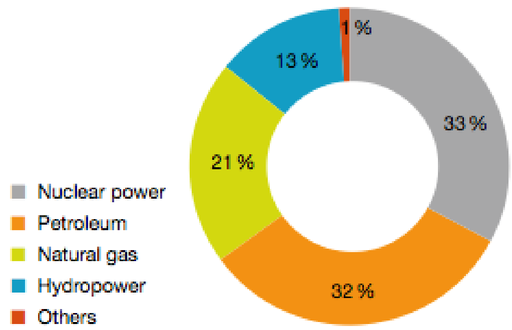
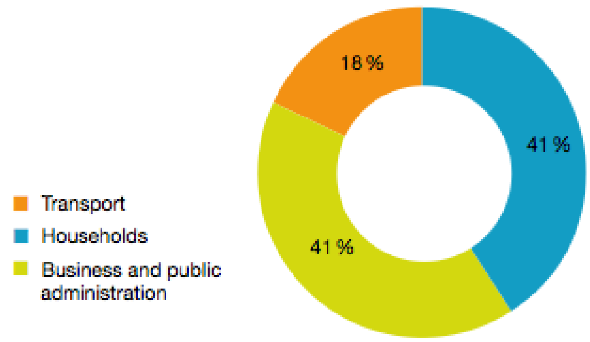


Figure 19: Zurich Energy Consumption by Sector



Source: City of Zurich

Some of the greatest potential for energy efficient improvements in the Zurich canton lies in the building sector. Approximately 40% of Europe's total energy consumption is attributed to commercial buildings (EUKN, 2013). In Zurich, buildings account for four-fifths of the city's energy consumption (Stadt Zurich Umwelt- und Gesundheitsschutz, 2011). Improving energy efficiency in buildings is "the target with the most obvious benefits attached, as it will not only reduce greenhouse gas emissions but it will allow people to save money" (EUKN, 2013). Furthermore, predictions indicate substantial growth in the global consumption of energy over the next 15 years. This includes an increase in energy consumption within the building sector due to continued construction and new energy uses (EUKN, 2013). Consequently, the need to improve energy efficiency in existing buildings remains a critical concern for the growing city.

2.6 Energy Efficiency in Switzerland

Switzerland is a country with a long history of energy efficient efforts. Unlike countries such as the United States, a strategic business model was not the stepping stone which influenced efficient approaches for companies in Switzerland. High energy prices have played a major role in the country's habits regarding energy consumption and conservation. For many years, strict energy policies and aggressive building codes have been mandated to promote energy efficiency and prevent the waste of natural resources as well as minimize negative environmental impacts.

2.6.1 Energy Efficiency in Zurich

The Zurich canton's efforts to promote and improve energy efficient technologies have been recognized on a national and global scale. In 2000, the city was awarded the national label "Energy City" for its promotion of renewables and overall energy efficiency **(**Stadt Zurich Hochbaudepartment, 2012). In 2005, it achieved higher status by becoming recognized as a European Energy Gold City, the highest possible standing, for continuing its tradition of energy efficient excellence particularly within infrastructure. Recently, the city was ranked 6th overall in the European Green City Index created by Siemens which ranks the top 30 cities from 30 European countries. This title is a direct result of the city's efficiency, environmental performance, and dedication to reducing its environmental footprint.

2.6.2 Decision Making Factors

Some Swiss cantons have shown more growth and development in governmental support for the sector than others. The Zurich canton in particular has shown much progress. In some aspects, the city and canton of Zurich is more advanced than Boston and Massachusetts when it comes to cultural, economic and legislative support of the energy efficient sector. The level of participation in practices within the sector of the canton relies heavily on the high costs of energy. This leads to more cultural and economic support since investments are more justified with lower payback periods. The laws and regulations of buildings in the city are also stricter and tend to mandate the use of efficient practices as opposed to suggesting the use of them. Differences in culture, economy and legislation between Boston and Zurich lead to opportunities for growth and collaboration of each location.

2.6.2.1 Culture

Environmental technology has long been used in Swiss society. Switzerland has fully utilized its water supply as a main source of alternative energy. Fifty-five percent of the country's generated electricity is derived from hydroelectric sources (Reichlin, 2011). Taking advantage of the natural landscape, the country has established a strong and progressive position protecting the environment, promoting alternative energy, and combating climate change. In combination with their familiarity in environmental protection, recycling, and public transport, the Swiss have a strong awareness of sustainability. According to David Rielly, "in Europe a

Cleantech ‘gene’ is inherited. They just understand it; they don’t talk about it. It’s a way of life.” This awareness for sustainability and environmental responsibility can be highlighted in the country’s high standard of living, environmental quality, and low levels of pollution (Reichlin, 2011). Europe’s exposure to high energy and material costs has also influenced the need for continued innovation, recycling, and reusing. In response to the American perception of environmental awareness, representative Reilly further elaborated on the concept stating that “we [Americans] take things for granted while Europe who is forced to import or produce all utilities is unable to afford such luxury” (D. Rielly, personal communication, February 24, 2014). Not surprisingly, the production of this citizen activism has allowed Swiss Cleantech developments and innovations to serve as a benchmark for both North America as well as European markets (Reichlin, 2011).

2.6.2.2 Economy

Financing energy efficient projects continues to be a common barrier for energy efficient renovation and construction within Zurich. Although the city shares a first-place position in the European ranking of energy efficient buildings, the Zurich canton offers no subsidies for their new Minergie buildings (Salvi & Syz, 2011). This may be a result of already existing inclination for property owners to take efficient measures since the cost of energy across Europe, and especially Switzerland, are much higher than the US (EUKN, 2013). Companies tend to use internal capital budget to invest in such practices since the potential long-term investments appear more attractive as energy rates increase and allow for a shorter payback return (Mosteiro-Romero, et al., 2014). Companies found in areas with lower energy prices, such as the United States, find difficulty justifying upfront costs without the guarantee of quick payback (D Reilly, personal communication, February 24, 2014).

To increase economic incentive for energy efficient practices, the Elektrizitatswerk der Stradt Zurich (ewz), a major electricity supplier in Switzerland, introduced an efficiency savings plan for its big customers in 2006 **(**Stadt Zurich Umwelt- und Gesundheitsschutz, 2011). The incentive grants 10% price reduction to companies which show a decrease in energy consumption. To receive the benefits of the discounted bill, companies would be required to accept an agreement to allow either the Zurich canton or the Energy Agency for the Economy (EnAW) to monitor the company's compliance.

The efforts of private organizations, such as the ewz, allow energy efficiency to continuously gain priority in Zurich. Financial resources and organizations that support the development of the sector continue to increase on a yearly basis within the city **(**Stadt Zurich Hochbaudepartment, 2012). Today, the Office for Building Construction (OBC) consists of about 100 full time employees dedicated to the implementation of the 7 Mile Steps Program, a list of sustainable development goals for city owned new and refurbished buildings (ICLEI, 2005). The OBC invests nearly US$330 million for its purposes yearly and an additional US$600, 000 is dedicated to the research and development of sustainability projects conducted by the Centers for Sustainable Building and Energy and Building Engineering.

2.6.2.3 Legislation

The city of Zurich has an extensive history of legislation promoting energy efficiency. In 1997, an Environmental Management System was formed by the city council based on the ISO 14001, a globally accepted standard for environmental management. The system created a list of various sustainability goals for new and renovated buildings owned by the city **(**Stadt Zurich Hochbaudepartment, 2012). Approved in 2002, the list became known as the 7 Mile Steps for Energy and Resource Efficient Building Construction and Management. The program combines several energy standards used both in Europe and Switzerland (ICLEI, 2005). Both new and refurbished buildings are required to meet their corresponding Minergie standards as well as Minergie specifications for lighting. In addition, new buildings are required to provide 40% of their total heating requirements through renewables while refurbished buildings are to provide at least 15%. The program has remained especially successful over the years by not only promoting efficiency and the use of renewables, but also requiring buildings to achieve an efficiency status beyond federal government regulation. A Master Energy Plan was also enacted in 2002 by city council calling for 15% reduction in CO_2 emissions and stabilized electrical power consumption in municipal buildings by the year 2010 **(**Stadt Zurich Hochbaudepartment, 2012). Together, the two projects have promoted over US$4 million in energy efficient construction projects. More than 4000 buildings have become Minergie certified with documented electrical savings of 750,000 kWh (about 35%) per year.

Subsequent policies have been enacted by the city since the 7 Mile Steps Program and Energy Master Plan. A plan which aims to limit the wattage per capita to below 2000W of consumption was created in Switzerland (Novatlantis, n.d.). The plan, called the 2000W Society, calls for citizens to reduce waste ranging in areas such as food and consumption to infrastructure changes without lowering quality of life (Novatlantis, n.d.). In 2008, the city tied its goals to the 2000W Society in its municipal code by means of a public referendum. A one-third reduction of energy per head and one-sixth reduction of greenhouse emissions were set as a benchmark for the year 2050 (Stradt Zurich, 2011).

A series of progressive energy and environmental policies has allowed Zurich to maintain a competitive position amongst its competing Swiss neighbors. It is the popular home of the two environmental parties competing on the federal level in Switzerland. Both the Green Party of Switzerland (GPS) and Green Liberal Party (GLP), founded in 2004 to promote solutions for environmental issues, have been well received by the city's population. The city has also been ranked as one of the "greenest" communities alongside Geneva and Basel based on its green index value. It contains approximately 20% of all Minergie buildings in Switzerland, and has the highest number of new Minergie buildings of all Swiss cities (Salvi & Syz, 2011). The decisions to use such energy efficient technologies for new buildings or retrofits in Zurich are influenced differently than those of the United States; however the legislative, economic and cultural aspects remain.

2.6.3 Minergie Standard

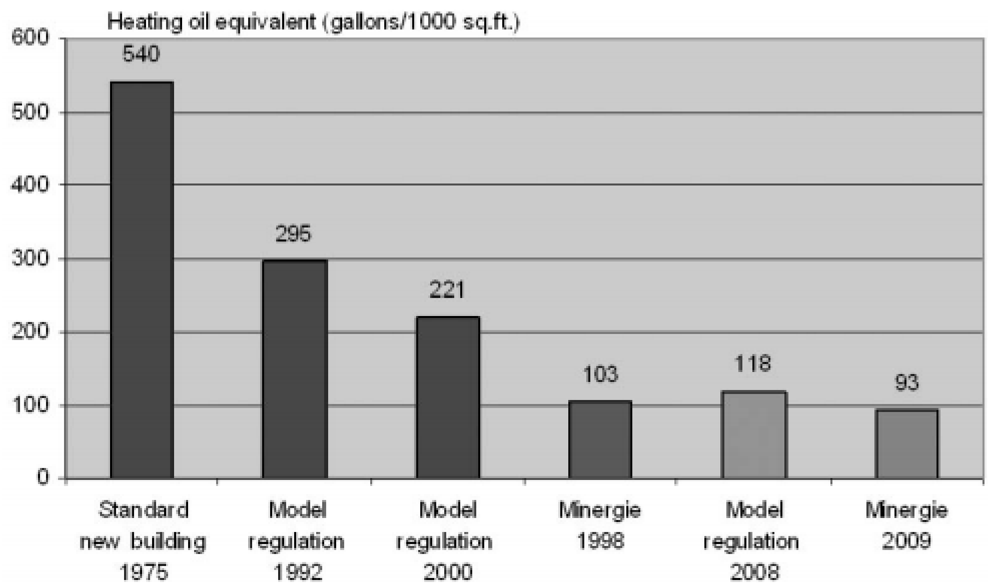
Policies applying to new building construction as well as renovation of existing buildings allow for the promotion of energy efficiency. As a result, the MINERGIE building standard was created in Switzerland and has become the mandatory minimum standard in many parts of the country. This standard has allowed the country as a whole to grow and promote the development of the energy efficiency sector.

Similar to the U.S' LEED standard, Switzerland's Minergie standard was created to challenge existing energy efficiency laws and to push the government into imposing stricter regulations (Minergie, 2010). While it is not a part of the Swiss Federal Government, Minergie is heavily supported by both federal and cantonal governments as it drives architects and developers to adopt energy efficient designs (Minergie, 2013). Due to the rapid development of new technologies narrowing of the gap between Minergie and cantonal building codes, Minergie has created new stricter standards to raise the bar on energy efficiency and encourage cantonal regulators to follow suit (Huber, 2012).

The Minergie standards focus solely on the reduction of energy use in buildings. The standard limits the building energy consumption to a maximum target energy usage measured in kWh/m^2. This target is primarily calculated during audits conducted to gauge energy usage measured by the control system of the building or estimated usage from utilities. Efficiency inside the building is also measured according to the power source used within the structure (e.g., solar, geothermal). These act as multipliers to the efficiency score, and promote the usage of renewable energy sources (Minergie, 2014).

Newer and stricter Minergie standards were created as new buildings began to exceed the original Minergie standard expectations. The goal of this standard is to encourage continuous improvement and promote the use of innovative efficiency practices to construct and renovate buildings. In 2003, Minergie – P was introduced as a stricter efficiency standard over the original Minergie standard. However, Minergie -P and the original Minergie standards were found to be insufficient in guiding the development of the most environmentally-friendly building designs. Consequently, Minergie produced the Minergie – ECO certification which establishes criteria for material selection when constructing environmentally-friendly buildings. Lastly, in order to continue challenging engineers in the energy efficiency field, the Minergie – A standard appeared in 2011. This standard aimed to push developers to create net-zero, or near net-zero buildings (Huber 2012). **Figure 20** below shows that governmental building codes have become increasingly stricter over time and are approaching the Minergie standard for heating gallons of oil per 1000 square feet. In order to distinguish Minergie buildings from those which merely meet local governmental building codes, the Minergie standard has become stricter. The idea is this “cat-and-mouse” competition between buildings standards will continue to force the adoption of increasingly strict regulations which will in turn promote the adoption of new technologies that achieve greater energy efficiencies.

Figure 20: Developing Governmental Building Codes vs. Minergie Standard



Source: Beyeler

2.7 Opportunities for Growth and Collaboration

While the Cleantech industry casts a wide net encompassing 18 varying sectors, some have shown more growth and development than others. The energy efficiency sector has begun to flourish gaining support from the culture, economy and legislature of nations around the world. This increasing prominence is due in part to the relatively low risks within the sector. Payback periods for energy efficient practices are relatively lower than the payback periods associated with practices within other sectors, such as renewable energy. However, the cost of energy highly influences commitment to the energy efficiency sector and therefore success varies from country to country. The United States and Switzerland have both exhibited much growth and development within the sector, specifically in Boston and Zurich respectively. Each city has adopted different strategies for the promotion of such practices and has strengths and weaknesses that may lead to the opportunities for growth and collaboration between the two sectors. In this report, the team will highlight these opportunities and create a list of recommendations for collaboration between the Boston and Zurich energy efficiency sectors.

Chapter 3: Methods

The goal of this project was to evaluate opportunities for the promotion of growth and collaboration in the green renovation industries of Boston and Zurich. We compared Cleantech in the energy efficient renovation sector, and how each location can benefit from the other. The team divided the goal into the following five objectives. We:

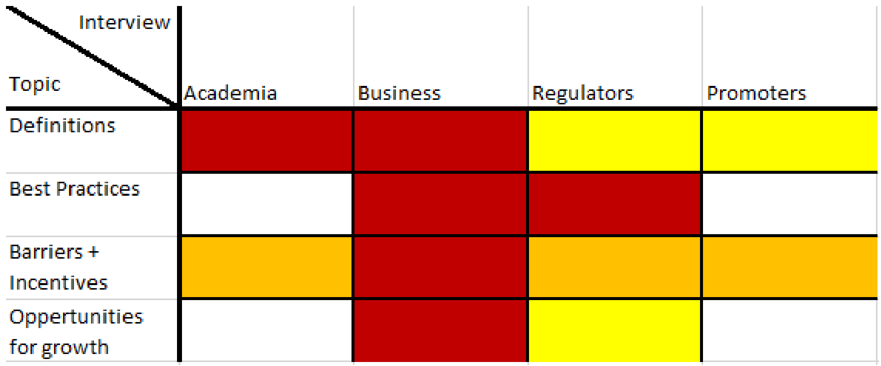
1. Refined our assessment of Cleantech definitions, terms, and concepts
2. Evaluated best renovation standards in the Cleantech industries in Boston and Zurich
3. Identified the barriers and incentives for the application of energy efficiency within existing commercial buildings in Boston and Zurich
4. Compared the legislative, cultural and financial factors that affect decision-making in both locations.
5. Highlighted opportunities for growth, innovation, and collaboration for the energy efficiency sector within the Cleantech industries of Boston and Zurich

Building on our initial background research, the team conducted a series of semi-structured, in-depth interviews with key informants and stakeholders in industry, government, academia, regulators, and other pertinent organizations. The interviews were structured to elicit information in each of the areas identified in the objectives. We discuss the general approach to our interview process below.

3.1 General Approach to Interviews

The team produced a primary script tailored to the interview subject. The scripts placed emphasis on their area of expertise in order to extract the most pertinent information. Adjustable structuring of the protocol allowed the addition or subtraction of questions to the general script to accommodate the area of focus. The list of target interviewees was also divided and categorized to better illustrate the concept in which both topic question and subject classification overlap. **Figure 21** below highlights this crossover by means of a heat map. The top of the chart indicates the five primary classifications of interview subjects, while the left indicates the specific information the team hopes to extract from the interviewee. The chosen color scheme identifies the ranges of high, moderate, and low focus. Darker shading of the cell reflects more concentrated questioning in that category. Development of the generalized script and the descent into the sub goals is explained below.

Figure 21: Heat Map of Interview Topics and Stakeholders



Although the team planned to conduct most of the interviews face-to-face, some interviews conducted in Switzerland with professionals in the US were done by Skype. A sample interview script used in interviewing Professor-Dr. Joachim Borth (ZHAW, Director of Environmental Engineering and Energy Conservation) is presented in **Appendix A**. As mentioned previously, not every interview was conducted with this exact script and the questions were modified as needed. The preamble explains the purpose of the research and solicits consent to utilize information and quote the interviewee in the group's final report. At least two members of the group were present for each interview. One member was designated the role of lead interviewer. He or she did not necessarily follow the script verbatim, but used it to direct and keep track of the questions asked and the topics covered. The second team member was designated as the scribe and took minutes of the interview, transcribing key points and direct quotes. The scribe also provided follow-up questions as needed to help keep the primary interviewer on track and ensure we pursued all pertinent lines of inquiry. If more than two members were present in the interview, a lead interviewer was assigned with a second interviewer designated for follow-up questions while the rest of the team took minutes. At the end of the interview, the team asked whether or not the interviewee knew of any pertinent literature or documents that would assist the project. Helpful information from these documents were folded into the literature review and allowed for verification of claims made throughout interview process.

3.2 Sampling Method

We used a snowball sampling technique to identify key informants in the US and Switzerland. We identified several key companies, agencies, and organizations based on our review of the academic and trade literature, as well as personal contacts. We asked interviewees to recommend other people whom we should interview. In both the US and Switzerland, we identified individuals with particular knowledge about the practice and promotion of clean technology, particularly with regard to energy efficient renovations in commercial buildings. In the US, we focused on organizations that are located in and around Boston that have expanded from Switzerland or partnered with a Swiss company or institution. In Switzerland we focused on similar organizations and companies in the Zurich Canton that have expanded from the US or partnered with an American company or institution.

A list of criteria was developed to limit the broad scope of possible stakeholders for interview. Primarily, the party involved had to fit the defined characteristics of 'Cleantech,' by promoting, practicing, or producing clean technology. More specifically, the company had to be working in the space of renovations in buildings. Academics also had to be conducting research in the energy efficient field in buildings. Expanding the scope of this category of stakeholder was necessary to get full breadth scope on what is being researched and taught to upcoming engineers. Limiting the spectrum of possible interview subjects allowed us to most effectively highlight opportunities for growth and collaboration between the two locations.

While in the Boston area, interviewing individuals who have experience with companies, organizations or institutions that have either expanded from Switzerland or have partnered with Swiss companies, organizations or institutions was crucial to the project's success. The team used the same criteria while in Switzerland when choosing interviewees, but chose those which have expanded and/or collaborated in Boston. Doing so allowed the team to compare industries in Boston and Switzerland and highlight opportunities for growth and collaboration between the two locations. Those companies also provided a model of Swiss-US Cleantech renovation practices which show the lacking areas of both regions and where they can learn from each other. The team conducted ten interviews with nine different individuals who met the criteria listed above. **Table 1** below displays the name, contact organization, title and categorization of each interviewee.

Table 1: Academics, Business Representatives and Regulators Interviewed

Name	Affiliation	Region	Title	Stakeholder Group
Joachim Borth	ZHAW School of Engineering	Zurich	Director of Energy and Environmental Technology Program	Academia***
Karen Oates	WPI	Worcester + Boston	Dean of International Studies	Academia
Amadeo Sarbach	ZHAW School of Architecture	Zurich	Professor	Academia***
Adrian Altenburger	Amstein-Walthert	Zurich	Construction client consultancy and project management	Business*
Gretchen Engbring	GreenerU	New England	Sustainability Program Coordinator	Business
Jay Fiske	Powerhouse Dynamics	Boston	VP of Business Development	Business
David Rielly[ŧ]	Novartis	Boston + Switzerland	National Energy Manager	Business*
Earl Jones	GE, Liberation Capital	Boston	Former Senior Executive (GE) Employee (Liberation Capital)	Regulator
Mitch Tyson	New England CEC	Boston	Co-Founder	Regulator**

*: Included Regulation questions

**: Included Business questions

***: Included Business questions

[ŧ]: Interviewed twice

3.3 Data Analysis

As interviews were conducted, commonalities and differences among different interviewees were pursued and analyzed. Different perspectives were be characterized for the different stakeholders. The team determined if any information could be applied in both locations. Through interview analysis and extended literature review of both the documents provided in interviews as well as new research done by the team, we highlighted opportunities for growth and collaboration between the two locations.

To conclude our project, we provided a report of recommendations highlighting the opportunities for growth, innovation, and collaboration for the Cleantech renovation industry in Boston and Zurich Canton (i.e., Objective #5). This section of our report will be valuable to both Swiss and American companies interested in partnering or expanding globally. These recommendations were made after sufficient evidence was gathered following the continued expansion of the literature review, evaluation of Cleantech practices, and the identification of the barriers and incentives both in Boston and Switzerland.

The evaluation of best renovation practices at both project sites provided us with models of established companies which have participated in renovation. Assessment of interviews with company representatives offered an understanding of the operation of Cleantech businesses in both locations. We compared operation standards for industry in Boston and Switzerland to identify similarities that can foster growth for companies. Analysis of differing regulations and policies that provide barriers or incentives at each location determined where collaboration would be easier or more difficult for businesses. This section of the report provided information to companies about where and possibly how businesses can expand.

Chapter 4: Findings

The group interviewed ten regulators, academic professionals, and business representatives in order to compare cultural, economic and legislative factors that influence energy efficient retrofit decisions. The team reached out to a total of 37 individuals hoping to connect with more interviewees; unfortunately busy schedules were unable to accommodate the scope of the project. However, by conducting these interviews and continuing research of literature, the team was able to perform a comparative analysis of energy efficient renovations in Boston and Zurich.

4.1 Energy Efficiency

Implementing energy efficient practices into buildings is usually the first action building owners all over the world take to reduce energy consumption because it is the cheapest method for reducing energy use, as shown by the Zukunft Haus Programme of Germany (Power, 2008). Companies looking to invest in energy efficient renovations first determine energy goals for energy saving projects through the auditing process. David Rielly, National Energy Manager of Novartis in Boston, explained that flat companies, or companies that are not expanding and growing, are more apt to reduce absolute energy consumption to a concrete goal while growing companies aim to reduce energy consumption by a certain percentage. The goal is passed down from the corporate board to individual divisions and then to building managers who hire audit consultants. From the audit results companies make a list of possible energy-saving projects and the 'low-hanging fruit' is identified based on the financial payback period of renovation projects. These 'low-hanging fruit' projects, or renovations with quick payback periods of one to two years, are ideal. Cost estimates for each project are calculated and the projects are then ranked based on payback, cost, the true lifecycle cost of the project and other factors the building manager deems significant for the building. The highest ranked projects are completed first and additional renovation projects are performed if the budget allows for it.

While building owners pursue energy efficient renovations to reduce energy consumption in individual buildings, the energy efficiency sector as a whole goes far beyond the scope of one building or company. Professor-Dr. Joachim Borth, the Director of the Energy and

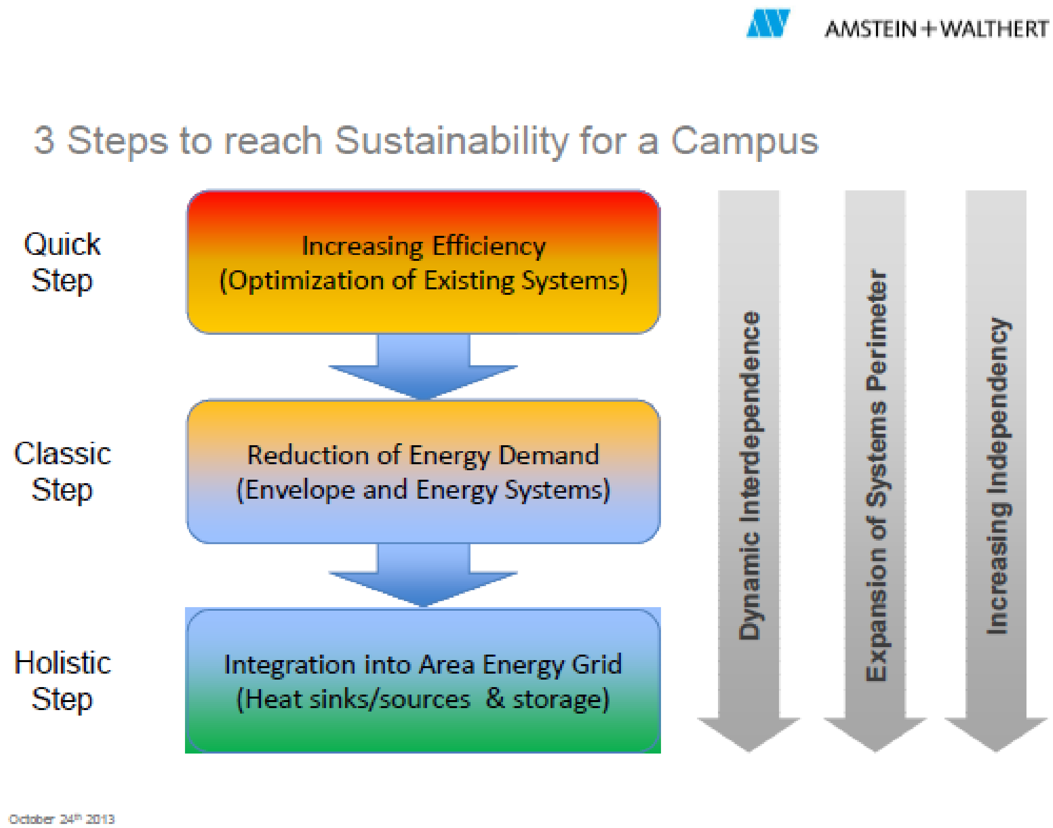
Environmental Technology Program at Zurich University of Applied Sciences (ZHAW), stated, “what [people] do in the [energy efficiency] field significantly reduces energy consumption. Energy efficiency touches a lot of fields of economy as well as a lot of people. Everyone is touched somehow” (personal communication, March 27, 2014).

4.2 Energy Efficiency Technology

Because energy efficiency is the most cost effective method of reducing waste, the market for energy efficient technology has grown over the past few years and continues to grow. A report from the Advanced Energy Economy and Navigant Research estimates that $150 billion was spent on energy efficient technologies globally in 2013 (Retroficiency, 2013). Many of these energy efficient technologies and practices are implemented in retrofits and renovations.

An ongoing project to renovate Harvard’s Cambridge Campus in Boston in conjunction with the Swiss Architectural Engineering firm Amstein + Walthert, has delineated three steps for reaching sustainability on the campus. These three steps consist of optimizing operations, reducing energy demand and integrating buildings into the energy grid. Shown in **Figure 22,** the firm plans to increase efficiency of buildings as a “quick step” through optimization of operations such as lighting, plug loads, HVAC systems and water use before renovating the envelopes and energy systems of buildings to reduce energy demand (the ‘classic step’). Finally, a ‘holistic step’ will be taken to integrate the buildings into the energy grid through heat sinks and storage (Altenburger, 2013).

Figure 22: 3 Step process for reaching sustainability



Source: Altenburger

4.2.1 Optimization of Operations

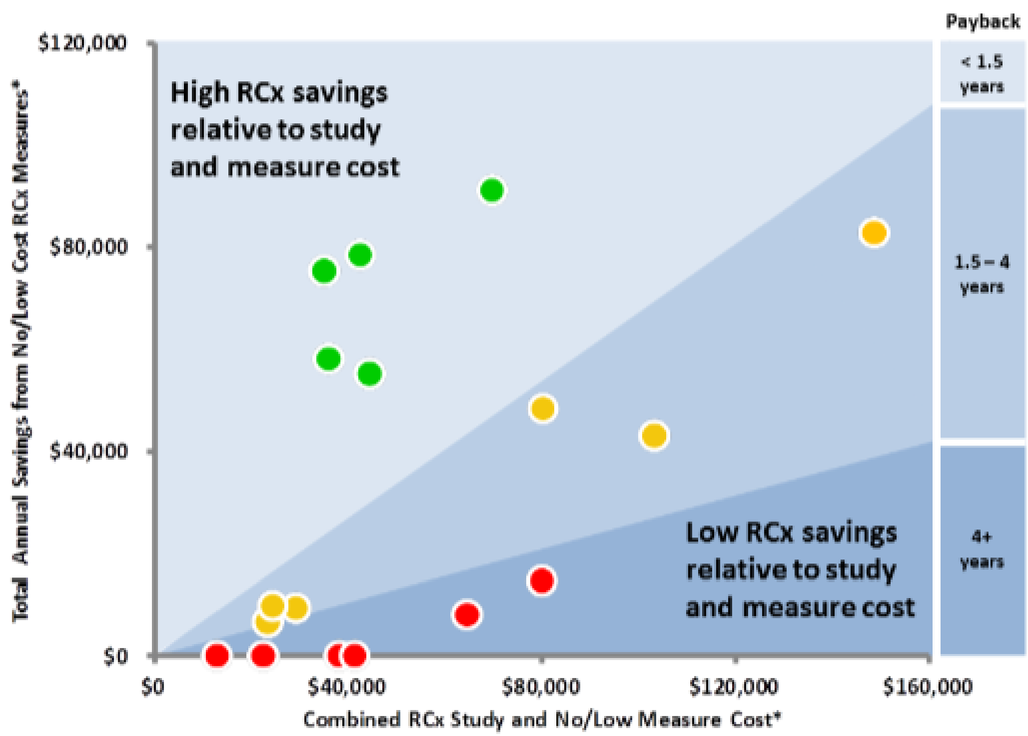
The first step of the proposed three-step sustainability plan, optimizing operations, can be accomplished with various strategies. Retro-commissioning, a quality assurance process for existing buildings, is one practice being used to save energy in commercial buildings. While auditing identifies opportunities for reducing energy consumption, retro-commissioning requires an in-depth evaluation consisting of testing and performance validation of existing building equipment. Retro-commissioning further optimizes building operations and equipment and "ensures that building systems are operating in accordance with facility requirements and design intent" (Hughel, 2009). Retro-commissioning can improve the building's overall performance by addressing equipment and system issues and by ensuring that staff is trained to operate equipment correctly as well as maintain the building (PECI, 2007). Mitch Tyson, cofounder of

New England Clean Energy Council (CEC), compares retro-commissioning to “rebooting” a building so it can run at its originally intended efficiency level. Retro-commissioning has been used increasingly in commercial buildings in past years such as Target stores, hotels such as the Marriott, and has been utilized in office buildings in America as well.

Retro-commissioning in Boston began in 1998 with the creation of a pilot retro-commissioning program by Boston Edison, a utilities company. The program aimed to provide local services and to educate building owners on the importance of retro-commissioning. In 1998, program retro-commissioned three office buildings at the Raytheon campus in Sudbury, Massachusetts. Thirty-four recommendations were made and twelve low-cost measures were implemented, saving Raytheon an annual amount of $121,234 with a project implementation cost of only $2,000 (Dodds, Baxter & Nadel, n.d.). Other retro-commissioning projects in the U.S. have resulted in positive outcomes. The Crown Plaza office building, originally built in 1979 in Portland, Oregon, was retro-commissioned in 2005.The 311,000 square foot building cost $47,100 to retro-commission and resulted in annual savings of $53,967 and 775,339 kWh. The 1.2 million square foot Ronald V. Dellums Federal Building, originally built in 1994, was retro-commissioned in 2001. The project cost $35,000 and saved the owner $66,981 annually. Both retro-commissions had a simple payback of less than a year and gained non-energy benefits such as increased equipment lifespan and better staff understanding of building operations. The U.S. EPA promotes performing a retro-commission as “the first step to identify cost-effective savings” before investing in other energy efficient renovations (PECI, 2007)**.**

Unfortunately, retro-commissioning requires a large amount of time for initial evaluation of buildings which can take up to two years. Clients pay an upfront cost for retro-commissioning services, but the estimated building savings are unknown until the evaluation is complete. Based on the upfront cost and the estimated savings, it may not be financially wise to do a retro-commission on certain buildings. Retroficiency, an energy audit company for commercial buildings in Boston, conducted a study on 17 retro-commissioned commercial buildings which provided varying results for payback period, costs and savings, as seen in **Figure 23**. Six companies had payback periods of over four years while another six had payback periods of one and a half to four years. Only 5 companies had a payback period of less than 1.5 years, signifying only five companies had high savings for the initial capital invested. Retroficiency highlights the advancement of interval data and energy analytics tools for auditing that can significantly shorten the period and lessen the cost of evaluation. Many utilities companies, such as Connecticut Light & Power, have begun to use interval data and energy analytics to assist in retro-commissioning decisions (Makofske, 2014).

Figure 23: Retro-Commissioning Study Review



* No/low cost measures defined as 1.5 year payback or less

Source: Makofske

The use of controls systems can also optimize processes in commercial buildings and reduce energy consumption. Jay Fiske, Vice President of Business Development for Powerhouse Dynamics believes that "even a little access to controls and analytics can lead to a lot of positive changes in energy intensive buildings" (personal communication, April 15, 2014). While Powerhouse Dynamics works primarily with restaurant chains in North America and the Caribbean, Fiske noted that across all commercial buildings, putting in smart thermostats and sensors can give an idea of how much money is lost through energy inefficient practices.

Installing controls technology “takes people out of the equation” and replaces them with automation (personal communication, April 15, 2014).

“Smart building technology” is a term that is increasingly used to refer to analytics technology that collects and analyzes energy-consumption data in buildings. Multiple smart building technology companies currently exist, and by 2017, $18 billion is expected to be invested in the industry (LaSalle, 2014). This smart building technology, like that of Boston startup WegoWise Inc., uses cloud-based computing to analyze utility costs and recommend areas in which buildings can operate more efficiently. The systems allow building tenants to control HVAC and lighting systems on their phone and other hand-held devices as well as through internet browsers on their computers and then interprets feedback from the system to determine what changes need to be made to system operation (Azevedo, 2014). Smart building technology requires an initial investment from capital expenditure, but helps reduce operational costs, has a quick return on investment, lowers energy consumption and can be used as a marketing tool (LaSalle, 2014).

4.2.2 Reduction of Energy Demand

While many savings are derived from operational changes, some savings are found through energy demand reduction. Building envelope renovations play a large role in energy demand. Building envelopes, which include aspects such as windows, insulation, and roofing, require a large amount of energy to provide interior building comfort (Gelfand & Duncan, 2011). The Federal Energy Management Program (FEMP) identified “new and underutilized building envelope technologies” that federal buildings lack. FEMP has suggestions for windows, roofs, and insulation technology that should be incorporated into renovations. Window films and smart windows made of glass that uses electrical energy to transition between light and dark states are recommended for reducing heat gained through windows. High R-value windows can be used for insulation, and aerogel insulation is recommended over current insulation materials due to its low thermal conductivity. FEMP suggests installing cool roofs that minimize solar absorption and lessen the need for cooling (Energy.gov, 2014). Building systems replacements, such as replacements to lighting, heating and cooling systems, also contribute to reduction of energy demand (Gelfand & Duncan, 2011).

4.2.3 Integration into the Energy Grid

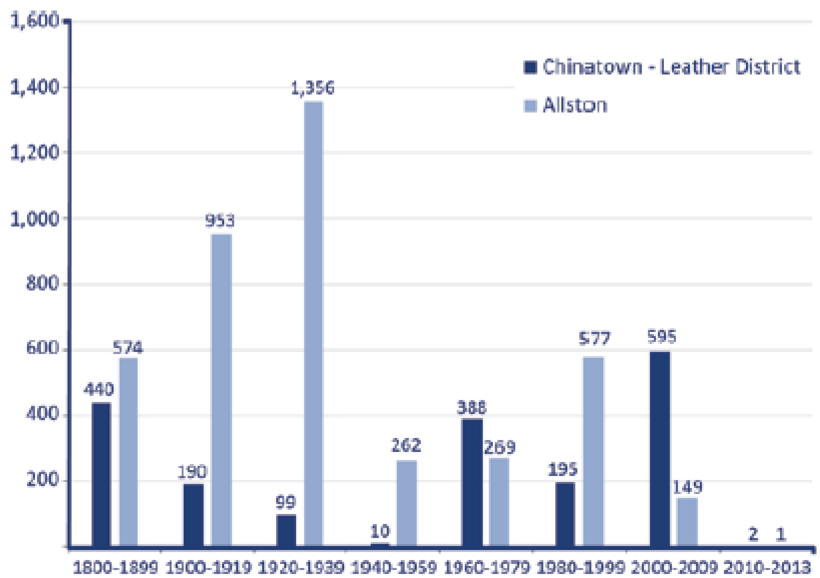
The last step to renovations, as seen in the Harvard renovation process, is to integrate buildings within the energy grid. The U.S. DOE has been working toward integrating buildings with energy grids and has hosted many workshops to discuss integration with building owners. In a report compiled in March 2014, DOE noted the current system of buildings does not exchange energy data information between buildings and the energy grid. The current system leads to disconnect between buildings in a grid and thus many energy and economic savings opportunity losses. The DOE sees the future of grid integration as “advanced automated buildings that cost effectively transact with the grid” (Hagerman, 2014). In order to achieve this goal, new technological advances need to be made in open architecture control systems, cost-efficient sensors, data analytics, and models for power distribution (Hagerman, 2014).

Research is currently focused on the future of renovations from grid integration to building systems and building envelopes. The development of smart HVAC systems which work with the local climate and energy efficiency lighting fixtures which use lower levels of light are projected for 2025 (Gelfand & Duncan, 2011**).** New technologies in energy efficiency are rapidly emerging with increased investment in building technology. With over $150.3 billion invested in building energy technology in 2013, the green building and renovation sector is growing at an extraordinary rate.

4.3 Boston

The typical lifespan of a U.S. building is 55-60 years (Amecke, et al., 2013**).** However, in comparison to other U.S. cities, Boston’s building stock is old. Most buildings are over 50 years old due to Boston’s 400 year history, and according to *Energy Efficiency and Commercial Real Estate*, 65% of Boston’s commercial buildings were built before 1930. The remainder of commercial buildings range in age due to rapid construction of buildings between 1960 and 1998 and are generally larger than older buildings. Boston’s building stock is diverse since buildings were constructed with differing styles over the span of centuries. In **Figure 24** below**,** a comparison of two districts in Boston displays how two neighborhoods show different patterns in building age. The two districts experienced new construction at different points in history, leading to different style and age of buildings. Commercial property in the city ranges from multi-million square foot skyscrapers to one and two story buildings. Boston's buildings cover 48 square miles, and with a population of 626,000, Boston is the 21st largest city in the U.S. The Greater Boston Metropolitan Area is the fifth largest city in the U.S. with 12,793 inhabitants per square mile (Newman, et al., 2013).

Figure 24: New Construction History of Alliston and Chinatown Districts



Source: Newman, et al.

Boston's size and span of building area leads to a large consumption of energy. The price of energy in U.S. commercial buildings between 1980 and present day fluctuated depending on end-use and the energy source. The U.S. DOE tracked costs of commercial electricity, gas and petroleum in 2011 and projected costs through 2035. Electricity, gas and petroleum cost 9.8, 8.0, and 3.5 cents/kWh, respectively, at the time of the study. All energy sources are expected to increase in price between 2011 and 2035 (Altenburger, 2013).

4.3.1 Culture

As previously shown by a SC Johnson survey, in the United States, green buildings are perceived as a good business practice. According to Earl Jones, former Senior Executive at GE and current member of Liberation Capital, there are three groups involved in the sustainability of companies: the corporate office, full of people who want their business to be environmentally ethical, employees who want to work at companies that are sustainable and finally shareholders who want to "put their money where their heart is" (personal communication, March 21, 2014). Jones' opinion aligns with that of Rielly, who believes that sustainable companies attract "good people" such as employees who want to work at a company that cares about the environment and stakeholders that want to invest in companies that contain "good corporate citizens" (personal communication, February 24, 2014).

Many Cleantech startups are located in the Boston area, contributing to research in the energy efficiency sector. Mitch Tyson, stated that a goal of New England CEC and Massachusetts CEC is to provide an environment in Boston that allows energy efficient startups to easily establish themselves and to make Boston one of the easiest locations to start a Cleantech company. In early 2012, an event was hosted by Mass Technology Leadership Council to discuss Massachusetts' potential to foster the Cleantech industry on a large scale (Fisher, 2014). Many people in the Boston area, particularly the younger population, support the city's move toward energy efficiency and take an interest in environmental issues.

Gretchen Engbring, Sustainability Program Coordinator of GreenerU, pointed out that while Boston's population is in favor of sustainable practices people do not always follow through with energy efficient practices (personal communication, February 19, 2014). Engbring cited a behavioral study of students in Massachusetts that showed students are in favor of energy efficiency in institutions, but tend not to turn off lights or unplug unused electronics. Habits, such as not unplugging electronics, account for 5-10% of electricity use whereas letting a faucet leak accounts for 13.7% of daily U.S. water use (Gelfand & Duncan, 2011). The "human factor" can inhibit energy efficiency; in addition to installing energy efficient technology, people must take responsibility for energy use and be proactive in energy saving practices. For most people who work in commercial buildings, energy efficient practices are not a priority due to fractured incentives and low energy costs. Since they are only tenants of the building and are not paying utility bills for the building, there is less incentive to adopt energy saving or waste reduction behaviors (Living Cities, et al., 2010). Unlike Europeans, Americans have eschewed energy saving habits due to the relatively low cost of energy in the United States over the past 30 years.

Environmental concern over energy consumption does not have enough weight to promote energy efficient behavior in Americans as shown in Pew Research Center and GALLUP polls (Moore & Nichols, 2014).

Often, the human factor can be minimized through the installation of controls systems. Fiske explained how Powerhouse Dynamic control systems show the effects human behavior may have on energy consumption. Fiske found that while it may be difficult to change human behaviors merely through education and awareness, monetary incentives can motivate people to adopt more energy efficient behaviors. Managers often receive bonuses based on energy costs saved. Fiske said changing behavior is about “converting time into money and keeping people accountable” (personal communication, April 15, 2014). Controls companies which calculate the amount of money spent every day by not having automation can lead to more accountability of building owners. Powerhouse Dynamics uses a 5-Minute Pledge program that tracks the behavior of employees and compares energy costs from various companies. By ranking facilities against each other, there’s a competitive nature between businesses. Unfortunately, while Fiske believes that having controls systems is a “no-brainer” that easily saves money, not all companies use controls systems to automate building operations. Controls systems also do not transfer easily from America to Europe because standards are different in both locations.

The human factor was analyzed in sub-metering studies of houses performed by New York State Energy Research and Development Authority (NYSERDA). Utility sub-metering is a system that allows property owners to monitor the electrical consumption of individual equipment in a building. Within multi-tenant residential buildings, landlords can use sub-metering to bill tenants for individual utilities use. The NYSERDA study found that 73% of residents of sub-metered residences used less energy than those who did not have sub-metering. Residents with sub-metering changed behavior by turning off appliances and lights when not in use, using natural light, and reducing thermostat and air-conditioning settings. Like Fiske, NYSERDA found that the financial incentive through sub-metering played a key role in behavioral changes. The study suggests implementing sub-metering into commercial buildings to achieve behavioral improvements (Gelfand & Duncan, 2011).

Complete renovation of existing buildings for the highest level of energy efficiency possible usually involves the renovation and transformation of the building's exterior and interior. Building owners often choose to renovate historic buildings rather than demolish and construct a new building. Generally, owners choose to not fully renovate, however, in order to preserve cultural heritage and provide community benefits through embellishment of the city scape and "uphold a standard of character" (Gelfand & Duncan, 2011). The significance of buildings associated with major historical events and architectural heritage are taken into consideration when renovating buildings. While old buildings are thought of as being less energy efficient, buildings constructed pre-1920 are more energy efficient than many modern buildings. Pre-1920 buildings are often better insulted because of thick exterior walls and have better quality windows and doors with good ventilation and natural lighting. Often for these buildings, only minor renovations such as interior insulation and replacement of mechanical systems are needed (Gelfand & Duncan, 2011) Due to Boston's varying building construction, as seen in **Figure 24** above, renovating buildings in Boston comes down to a case-by-case evaluation of each building.

4.3.2 Economy

Energy efficiency has become a business opportunity in the United States due to the many benefits building owners may reap from retrofits and retro-commissioning. Energy efficiency presents itself as an opportunity to save money, which is the primary reason for adopting sustainable practices as stated by professionals such as Rielly, Jones and Tyson. An estimated $370 billion in global savings annually can be achieved through energy efficient renovations (Retroficiency, 2014). Payback periods are an important factor when investing in retrofits. The ideal payback period for investors varies. Borth believed a payback of less than five years is ideal and Adrian Altenburger, architect at Amstein-Walthert and part of the Society of Engineers and Architects, stated that while a shorter payback is always preferred, a payback of five to six years is still very attractive. Rielly, on the other hand stated that five year paybacks are challenging to justify and that ideal payback periods should be one to two years. The US EPA regards two years as the typical payback period for retro-commissioning (PECI, 2007)**.**

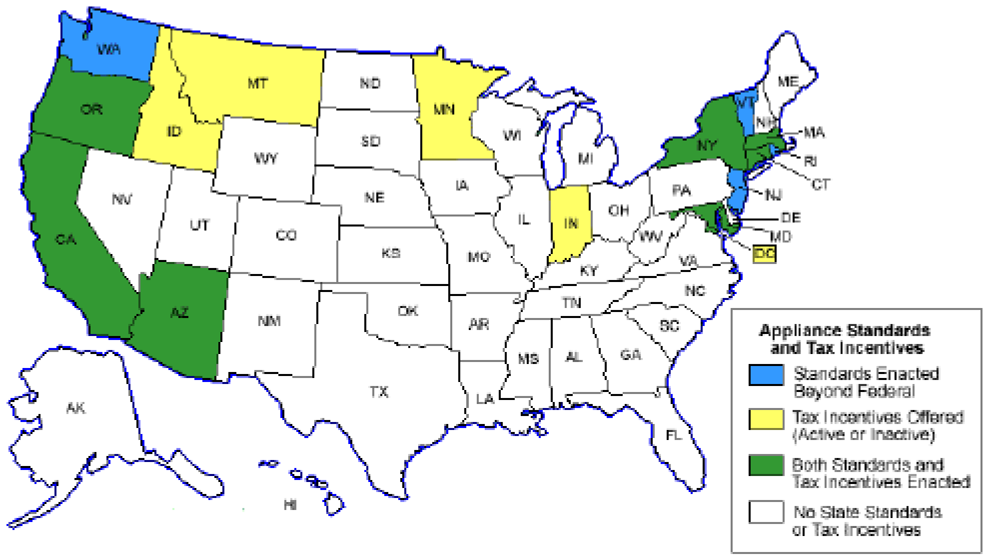
While energy efficiency can reduce utility costs, Tyson explained that it can also enhance property value. The US EPA agrees with Tyson's perspective listing increase in occupancy rates, reduction of tenant turnover and a competitive edge in the real-estate market as benefits of property owners (PECI, 2007).

While energy efficiency saves money, money is required to make an initial investment. Retroficiency calculated that it would cost $50 billion to audit every building in the United States alone (Retroficiency, 2014). Most companies cannot afford to invest in renovations and retrofits and need to use loans or other financial support for projects. Fortunately, the U.S. government provides incentives and grants and many private organization funding opportunities exist, as mentioned previously in the discussion of ESCOs and ESAs. Investments are difficult to financially justify in the US, however, because lower energy prices lead to longer payback periods, as noted by Rielly and Borth. A survey of commercial office building owners reported that funding can be a major barrier to energy efficient investments. Fortunately, funding opportunities are available and many owners are willing to incur debt for energy efficient renovations. However, debt limits prevent owners from taking advantage of loans and funding opportunities (A Better City, 2014).

4.3.3 Legislation

Boston and Massachusetts are committed to energy efficient buildings. The state government has implemented various sustainability laws as noted previously in the literature review, and Tyson, recalling Massachusetts' ranking in the ACEEE's Energy Efficient Cities and States study, believes that "Massachusetts has some of the best Cleantech laws in any state" (personal communication, March 27, 2014). Governor Patrick has pushed forward regulation that promotes clean energy for businesses. **Figure 25** below shows that Massachusetts is one of a number of states that have enacted standards beyond those imposed by the federal government and have tax incentives to promote sustainability. Massachusetts' advanced policies are recognized globally as innovative. Altenburger notes that the state government has taken an active role in energy efficient practices with its Green Communities Act and Zero Net Energy Building Taskforce, as mentioned prior in the literature review.

Figure 25: States with Efficiency Standards & Tax Incentives for Efficient Equipment and Upgrades



Source: IEA

Altenburger, who has worked as an architectural engineer in both Zurich and Boston, found the Building Energy Reporting and Disclosure Ordinance "BERDO" mandate to be a particularly significant development in legislature. The ordinance that requires commercial building owners to publicly report their building energy consumption gives accountability to building owners and will push toward more energy efficient practices. Commercial building owners were asked if BERDO would motivate them to invest in energy efficiency if their buildings scored on the lower end of the spectrum in comparison to similar buildings. Eighty percent of respondents would be more likely to invest if their buildings did not score well (A Better City, 2014).

With Boston's many policies and incentives, its ranking as number one energy efficient city is well-deserved. Most of the city's policies pull building owners toward energy efficiency and sustainability. Boston has, however, also enacted mandated standards through Amendment

#37 of Boston Zoning Code Article 80 in which Boston became the first US city to adopt LEED standards for private building construction.

4.3.4 LEED

LEED is one of the most widely known green standards in the U.S. Developed by USGBC, the standard focuses on more than energy efficiency. LEED promotes sustainability by recognizing performance in five categories: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality (Ruegge, et al., 2012). US professionals, Jones and Tyson, noted that LEED is the most prominent building standard in the US and has become part everyday vernacular. This is the standard's greatest strength, according to Jones and Tyson. LEED certification has become an industry standard which recognizes high performing green buildings.

Because LEED is well-known, it can be used as a great marketing tool for companies. There is a demand in real-estate for the level of quality in which LEED provides. LEED's reputation is becoming increasingly recognized within building markets (Bernstein & Russo, 2013)**.** Many building owners attempt to differentiate themselves on the real estate market by seeking LEED certification (PECI, 2007). A study of commercial buildings found that LEED buildings perform better on the market than non-LEED certified buildings. The study found that LEED certified buildings had occupancy rates 4.74% higher than the market and that rental rates for LEED buildings were 7.38% higher than the average rate. Generally, LEED certification leads to an increase return on investment (Bernstein & Russo, 2013). LEED has created a cultural drive to construct high level green buildings, and as Mitch Tyson puts it, "no one wants to build a building that's not LEED certified. There's an increasing pressure to go Gold or Platinum" (personal communication, March 27, 2014).

With higher certification, however, comes a higher initial building cost. The U.S. Green Building Council estimated that initial investments for buildings seeking to be LEED certified are on average 2% higher than typical green building investments. LEED silver investment initial costs are 2% higher than basic LEED certification and LEED platinum initial investment costs are 6.5% higher than basic LEED certification investments. However, running costs of LEED buildings tend to be lower, and savings of 10 times the initial investment costs can be achieved. (Ruegge, et al., 2012).

While LEED is most known for certifying energy efficient buildings, not all LEED buildings are necessarily energy efficient. LEED certification can be obtained by meeting the ASHRAE standards (U.S. Department of Energy, 2008). Professionals have found that LEED has its deficiencies. The public knows what LEED is generally, but does not know what the certification specifically entails. LEED does not encourage zero net energy buildings, a goal that Boston is embracing with its Zero Net Energy Task Force. Some architects have found that having a building LEED certified is a very expensive and complicated process not only because of the additional materials and construction costs, but also because of the time and effort required to obtain certifiers and complete all the paperwork associated with certification. Altenburger believes that LEED is uneconomical compared to Minergie since it requires specialized certifiers whose services are relatively costly. He says the standard leans toward being a business rather than a promoter of energy efficiency (personal communication, April 11, 2014).

The team discovered two main attributes of the LEED standard which promote energy efficient retrofits: one is LEED's emphasis on redeveloping brownfield sites, and the second is the requirement to monitor performance and reassess LEED-certified buildings periodically. As noted in the literature review, LEED has a certification for renovations which is easier to meet than for newly constructed buildings, promoting the renovation of old facilities or brownfields. The second characteristic of the standards is the reassessment of LEED-certified buildings every few years after initial certification. This part of the standard sets it apart from other building standards, such a Minergie. LEED buildings can be recertified as often as every year if the building owner chooses, however buildings are required to be reassessed and recertified at maximum every five years, ensuring that buildings are operating at the efficiency level at which they were first certified (Sims & Meier, 2012). This follow-through aspect of LEED makes it an effective and successful standard within the energy efficiency sector.

4.4 Zurich

Adrian Altenburger commented that buildings in Switzerland are generally built to last. In accordance with comments from other interviewees such as Professor-Dr. Borth of ZHAW School of Engineering and Professor Amadeo Sarbach of ZHAW School of Architecture, Altenburger said buildings have an expected overall lifespan of 80-100 years with continued renovation cycles every 25-30 years. This was consistent with the estimated life cycles of approximately 100 years discussed in the literature (Koch, et al., 2011).

Along with long lasting infrastructure, buildings in Switzerland are built with advanced systems. Strict federal regulations have led to the use of geothermal heating in Swiss residential buildings. Borth noted that geothermal heating only consumes one unit of energy for every three units of heating output. In other words, for one kW/h, a building will be heated for three to four hours. According to Altenburger, Swiss geothermal systems also only require energy when the system is used for heating. Due to thermodynamic systems, cooling occurs naturally without the use of energy for circulating pumps. The Zurich Sea is used to heat and cool buildings in its vicinity. Borth explained that these geothermal heat pump systems have pipes that extend into the ground and circulate a water-glycol mix. This technology extracts heat from the ground in the winter and creates a “heat sink” for cooling in the summer. Eighty-two percent of residential houses in Switzerland, along with ninety percent in the Zurich area, use heat pumps; however this technology is not as ubiquitous among commercial buildings, according to Borth. These systems remain primarily in pilot-programs for larger scale commercial buildings (Meggers, et al., 2012). An example of preliminary use of geothermal heating implemented in commercial buildings is the Hoffmann-La Roche campus located in Basel. This system uses the Rhine River to heat and cool the campus. Despite a lack of existing systems such as the one used at the Hoffman-La Roche campus, Borth, Altenburger and Sarbach all believe the future of this technology is leading to the application within the commercial building sector in Switzerland. Borth believes “innovation would be the use of combined heat and power systems, which is not done often in Zurich.” (Personal communication, March 27, 2014).Currently, further testing of geothermal heat pump systems is being done in St. Gallen, Switzerland.

Since heat loss accounts for a large portion of wasted energy, Switzerland has also developed systems for controlling heating and cooling within buildings. The Swiss government implemented strict building codes for insulation during the 1970's and most buildings have a double wall system. The outer wall protects the building while the inner wall acts as support for the infrastructure. Building codes require a certain width between the two walls where insulation padding is added to increase energy efficiency by decreasing heat loss. Sarbach noted, however, that renovating the walls of old buildings is very costly and often not possible due to the structural integrity of such buildings (personal communication, April 10, 2014).

Switzerland technology has led to the development of decentralized HVAC systems. These systems use fixed windows and fully sealable exterior doors to create an airtight building. Air-boxes draw in atmospheric air through vents located on outside balconies and is then filtered and its temperature regulated using heat recovery. At this point, the air is fed through floor vents at exchange rates higher when needed and lower when the space is unoccupied. Mathias Achermann, one of the first architects to implement this system at the IUCN building in Geneva, describes how the system is able to "breathe in unison with its users" (Holcim, 2012). Overall, the decentralized air system allows the structure of the building to be fully utilized to eliminate the pressure losses from traditional centralized ducting systems (Meggers, et al., 2012). Hansjurg Leibundgut, who conceptualized this idea, believes this system is "moving in a new direction in building design --- away from creating prototypes and towards creating high-efficiency systems ready for industrialization" (Holcim, 2012).

The practice of using high-efficiency windows and window glazing has also been implemented in Swiss energy efficient buildings for several decades. Triple glazed windows with exterior blinds extending from the bottom of the window allow for shading in the summer where the sun hits the glass while preserving the outside view. This system allows for the greatest amount of daylight. Prototype glazing procedures have also been in development in Switzerland. Leading research and development facilities are currently reporting the possible implementation of foil-inserts between the glass and vacuum glazing. The new glazing would not only serve to improve technical performance but also reduce manufacturing costs. However, these new technologies remain in their developing stages and will not be released into the market for several years (Jakob, 2003).

Lastly, the Swiss utilize wood framing for windows instead of plastic framing since wood can be easily recycled and sourced locally which encourages local industry and reduces transport costs. A key component of Swiss "modern architecture" is the design of large windows which yield the greatest amount of natural lighting. While such designs are energy efficient, the glass structures provide a more pleasant environment for employees who are not forced to feel the "pent-in" work environment of traditional office spaces.

While newer Swiss buildings are constructed with energy efficiency in mind, many of the buildings in Zurich are more than 100 years old and therefore less efficient. Renovating the insulation and infrastructure of these older buildings is often difficult. Sarbach noted in some cases, renovation of these older infrastructures may not result in economic savings. According to Sarbach, major opportunities to implement new technology in a building only arise every 40-50 years given the long life cycle of Swiss infrastructures. Swiss building owners also face a challenge of deciding which features to renovate. A majority of renovations are limited strictly to the building façade. Over the last 15 years, 40-60% of the facades from buildings constructed prior to 1975 were 'renewed' primarily through painting (Jakob, 2003).

The release of the 2035 Plan, which aims to phase out all nuclear power plants in Switzerland by the year 2035, raises the question of how the country plans to substitute their former nuclear energy supply (World Economic Forum & Accenture, 2013). Recent estimates suggest Switzerland will witness an "electricity gap" in 2035 of 15% and 25% in 2050 (Bretschger & Brunnschweiler, n.d.). Altenburger believes the future of Swiss technology lies in the development of a solution to this fast approaching issue. According to him, "we don't have an energy problem. The amount of solar energy hitting the earth is 100X greater than the entire world's energy demand. [Rather], we have a technology problem" (personal communication, April 11th 2014). Altenburger believes the future for both Switzerland and Zurich lies in the ability to provide a fully electric power source through the use of renewable energy, continuing the Swiss transition away from fossil fuels. However, the ability to store large amounts of electrical energy on the grid through renewable energy power generators has proven difficult. According to professionals, the future of Switzerland's energy efficiency sector lies in the research and development of an innovative smart energy grid that will allow for the storage and even distribution of energy.

4.4.1 Culture

As previously stated in the literature review, Switzerland has a relatively long history in promoting energy efficient practices that has encouraged the development of a culture of environmentally conscious citizens. According to David Rielly, in Europe "clean, green energy practices are like a gene; they [the Swiss] are born with it" (personal communication, February 24th 2014). For example, air-conditioning is a common staple for American homes and office buildings but is an unnecessary and rare luxury in Switzerland. Another example is the Swiss' willingness to adopt many environmentally-friendly behaviors, such as bicycling instead of driving and recycling. They also use technology to automate energy-saving behaviors. Automatic blinds, lights, and doors allow for the conservation of energy without conscious effort.

The long expected lifespan of Swiss buildings encourages the Swiss to focus on the long-term when constructing buildings, and according to Rielly and Sarbach, energy efficient measures are incorporated early in the design process (personal communication, April 10th 2014). Sarbach notes, it is not a question of whether or not the building will be energy efficient, but rather the extent of energy efficiency. Companies within the area are publically recognized for outstanding environmental performance. Minergie offers a well-known, prestigious label to businesses in the community. Altenburger states, "Having a Minergie label is a huge marketing bonus and marketing is everything" (personal communication, April 11th 2014). In one local example, AXA Winterthur received public recognition as well as additional business support for the energy efficient program they developed. Borth further elaborated, "The strongest benefit in this case was marketing. It's more important to do good things and speak about it. Financial benefits aren't a priority; you can't feel them like pride" (personal communication, March 27th 2014). The possibility of public admiration allows Zurich and Switzerland to create a competitive atmosphere among businesses that are willing to exceed the energy efficient measures of their rivals.

Of all driving forces behind the implementation of energy efficient retrofits, the cost of energy is the major incentive. Energy consumption is a more prominent topic within Switzerland than the United States due to the high-energy costs. Residents are forced to adapt in order to maintain their quality of living while businesses attempt to maximize potential profits. As Sarbach says, “high energy prices motivate; if energy has no value people won’t do it [invest]. People want to optimize if there’s a value, if you pay for it [energy], you’re forced to change” (personal communication, April 10th 2014). Performing further energy efficient renovations therefore can be justified through quick payback periods in which businesses readily see energy efficiency converted into savings. This is conclusive with the previous claims made in the literature. In a world driven by economy, financial savings is the primary incentive for energy efficient practices.

4.4.2 Economy

Zurich’s standing as a global financial leader has given the country the economic resources to perform energy efficient changes throughout the canton. The cantonal government has continually offered tax breaks to those companies performing energy efficient changes. Large banks such as the Zurich Cantonal Bank (ZKB) have also extended savings to those pursuing energy efficient renovations namely through lower interest rates on loans for retrofit projects. Additional fiscal incentives in the Zurich area, however, are limited. Businesses in Zurich possess a drive to continue their energy efficient practices. In combination with the high-energy prices previously discussed in the literature review, the city’s economy has little need to produce further monetary incentives regarding energy efficiency.

Due to the high initial investment required for higher level energy efficient renovations and minimal financial support from the cantonal government, Energy Service Companies (ESCOs) are used by businesses to provide additional financial assistance for retrofit projects. The SUSI Energy Efficiency Fund partners with technology providers for retrofitting projects in both commercial and residential buildings. The Fund covers the initial cost of the project after a contract is signed with the building’s owner. Investors are able to profit from the energy savings guaranteed by technology providers following an allotted period in which SUSI receives a majority of the energy savings. By allowing the costs of the retrofit project to be spread over a financing period in which the project can be paid for by operating budget savings, the building owner is not required to take the risk of providing a significant upfront investment. Performance contract payback periods can range from 3-20 years depending on the scale of the project. Typically, Energy Service Companies within Switzerland will focus on energy efficient measures with short and mid-term returns on investment periods of 4-9 years as opposed to deep renovation projects that focus on the building envelope require longer contracts of 15 or more years.

Although increasing the rate and thoroughness of energy efficient renovations is thought to be the most cost-effective, quick and measurable way to cut energy use in the building stock; fears of becoming “locked-in” have left investors uncertain about pursuing retrofit projects. This revolves around the idea that minor renovation projects carried out will produce sub-optimal energy savings. Since the renovation cycle for a building is typically 20-30 years, the energy saving potential is considered to be “locked” for an extended period, producing what is known as a lock-in effect. Due to their tendency to offer short-term returns on investments for energy efficient measures, ESCOs are commonly the initiators of a lock-in effect on deep energy retrofits. However, despite the adverse effects of this lock-in effect, companies continue to use ESCO related financial assistance to pursue energy efficient retrofit projects. Long periods of Energy Performance Contracts (EPCs) create opportunities for more deep retrofit projects with potential energy savings of 25-30%. These percentages are easy to financially justify the desired renovations, again, due to the high costs of energy in Switzerland.

4.4.3 Legislation

Energy efficient reform has progressed across Europe and Switzerland quite rapidly following the spike in energy prices after the oil crisis of the 1970’s. Federal and cantonal governments have taken major strides since to promote awareness of energy efficiency. Instead of promoting practices via incentives, the government has issued a series of strict mandates required for both residential and corporate buildings. Legislation such as the 2000W Society and regulations that mandate Minergie standards, mentioned previously in the literature review, have been strictly enforced in progressive areas such as Zurich. The Zurich canton was the first within Switzerland to adopt such aggressive measures in energy efficiency. As a country determined to maintain its high quality lifestyle, the cantonal governments fund development in new technologies as they continue to combat the high-energy costs through heavy-handed legislation. This aggressive strategy of mandating the use of such practices has not yet been implemented in areas such as the United States.

The energy efficiency sector within Zurich has begun to advance toward the possible implementation of renewable energies. As the deadline for the 2035 plan to close all remaining nuclear plants approaches, the pursuit of alternative energy and net-zero housing has become more prominent across Switzerland. Although the country has established hydropower supply from an early age, greater emphasis on more innovative actions such as advanced geothermal have been promoted by the Swiss government.

Although legislation has mandated energy efficient standards for new constructions and retrofits in Zurich, the government has provided little to no funding for the implementation of these measures or their transitions. Fiscal incentives have played a minor role in comparison to the command-and-control measures of the cantonal government (Jakob, 2003). According to Altenburger, there is “no real federal push to become energy efficient, it happens mostly on the cantonal level in the form of regulations.” This lack of oversight at the federal government level has left discrepancies across Switzerland from canton to canton. While the more prosperous cantons are able to excel due to their ability to fund and support energy efficiency, more rural areas are unable to implement the new technologies required to successfully adapt energy efficient renovations. Codes within these areas become especially lax leading to a weaknesses within the canton as a whole.

4.4.4 Minergie

Minergie has become the most prominent building standard within Switzerland. Like its US equivalent LEED, the major advantage Minergie has over other building standards is its recognition across the country. There is a demand for certified buildings which gives them an increased value; certified buildings sell at higher prices than noncertified building (Schoch, von Hunnius, 2010). The Minergie standard is binary since it does not have a ranking system. By placing a prime focus on reducing energy consumption in buildings, Minergie has been more successful in this focus than organizations such as LEED who rank through a series of categories such as cultural impact on the city. Minergie also offers a certification far more affordable than LEED. At approximately $700CHF, certification is significantly more economical compared to LEED (Salvi & Syz, 2011). Since Minergie standards closely follow SIA standards, almost any engineer or architect within this association is qualified to certify buildings making the process much less complicated compared to LEED.

Since Minergie is a private organization rather than government regulated, a constant competition is found between Minergie standards and the implementation of governmental laws seeking to match them. As Sarbach explains, "people are state of the art. If you achieve a high level, people still want to exceed it. It's a constant competition." As the difference between standards close, Minergie continues to update its existing standards creating an on-going competitive cycle that further pushes the boundaries of the already progressive energy efficiency requirements within Switzerland and Zurich.

Although Minergie has proved extremely successful since its founding, there are noticeable deficiencies within its policies. Unlike LEED, Minergie does not mandate regular checks on its buildings allowing the possibility for them to perform below their certified level over time. This leads to a lack of corporate accountability for maintaining certificate qualifications or performing further renovations within their existing certified buildings. As Altenburger states, "normally building owners don't know how efficient their buildings are running. During operating hours, no one cares." However, he did mention the potential addition of a "handover period" to the Minergie standard in which audits are routinely scheduled to ensure the building is performing to its certification. This process would ensure the building is being operated to its full potential, however after this two year period no further follow-up would be pursued. Inadequacy of implemented control systems is a common failure within corporate buildings that are not regularly monitored. According to Altenburger, the systems are often wrongly installed or operated incorrectly. David Reilly has also gone on to mention how after a period of time employee turnover results in a lack of new training and therefore wrongful use of these systems. Operators are then unable to recognize if the system is running at optimal performance. If certified buildings are not continuously reassessed, systems such as these will become ineffective and therefore the building would lose energy efficiency qualities.

Between the differing areas of weaknesses of the energy efficiency sectors of Boston and Zurich, there is mutual room for improvement. However, both have impressive strengths that have made each city leaders within the sectors of their respective countries. These strengths and weaknesses can be used to highlight opportunities for growth and collaboration between energy efficient renovation practices of the United States and Switzerland.

Chapter 5: Conclusions and Recommendations

Conclusion 1: The per capita consumption of energy in the United States is more than in Switzerland due to differences in cost of energy.

In the United States, where the cost of energy is much lower than in other nations, energy conservation is not a priority for citizens or for investors who experience a longer payback period than those in other countries. The topic of energy consumption is more prominent in Switzerland due to higher energy costs. Electricity in Switzerland is approximately 130.24USD/MWh, almost double the US price of 66.98USD/MWh. Residents are forced to adapt in order to maintain their quality of living, while businesses attempt to maximize potential profits and minimize costs. In comparison to the US, Swiss energy consumption is low. According to IEA estimates, Switzerland consumes 7,972kWh/pc compared with 13,227kWh/pc in the US. Environmental responsibility is not motivating enough to push people towards investments and commitment in energy efficient

1.1 Recommendation: We recommend that the United States raise its energy costs through measures such as a carbon tax in order to exert greater pressure for energy efficiency. Until this happens, it is likely that energy efficient upgrades with high returns and very short payback periods, the "low hanging fruit," will dominate in the sector. Owning a green building may offer kudos and public relations benefits of various kinds, but these may also translate into more tangible economic benefits such as increased property values and the ability to attract tenants and charge higher rents.

Conclusion 2: Due to the short pay-back periods of many projects, the energy efficiency sector is becoming increasingly prominent within the Cleantech industry.

Initial investment costs in energy efficient technologies and practices vary widely depending on the project, but provide opportunities for investments with relatively short payback periods, particularly when compared to sectors such as renewable energy. In recent years, renewable energy has become less attractive as an investment opportunity in Cleantech while energy efficiency projects and technologies have become increasingly attractive. By reducing energy consumption through energy efficiency, companies can then invest in renewable energy or other energy sources in the Cleantech sector.

2.1 Recommendation: We recommend that companies looking to become more environmentally responsible focus on improving the energy efficiency of their building stock.

Conclusion 3: There is a substantial amount of potential economic savings in the commercial building sector.

Commercial buildings are a substantial source of energy consumption in nations all over the world. Forty-one percent of U.S. energy consumption is attributed to buildings in the residential and commercial sectors. Half of that percentage is attributed to commercial buildings (D&R International, Ltd., 2012). In Europe, 40% of total energy consumption is attributed to commercial buildings (EUKN, 2013). In Zurich, buildings account for four-fifths of the city's energy consumption (Stadt Zurich Umwelt- und Gesundheitsschutz, 2011). Since commercial buildings contribute to a large portion of global energy consumption, there is a substantial potential for savings in the sector.

3.1 Recommendation: Commercial building owners should utilize energy efficient technology to save money.

Conclusions 4: Before starting an energy efficiency retrofit, an energy audit is performed to determine where the most money is being spent and where there is the greatest potential for savings.

Through energy audits, a company is able to determine where the most energy is being consumed throughout the building and identify where there is a greatest potential for savings. After the auditing process, a list is created of potential energy efficient renovation projects. From this list, building managers tend to choose projects with paybacks of one to two years to complete first. These projects are otherwise known as the low-hanging fruit.

Conclusion 5: When performing energy efficient retrofits, building owners utilize a three-step model toward sustainability.

The three-step process is utilized globally, and is currently being used by the Swiss architectural firm Amstein + Walthert AG in Harvard's Cambridge campus renovation project. The first step to a sustainable building is increasing building efficiency through optimization of current systems in the building. Retro-commissioning, a process which involves evaluating and correcting use of equipment in a building, and the use of automation systems such as controls systems and smart building technology is used to increase building efficiency by reducing the impact of human behavior on a building's energy consumption. The second step to a sustainable building is decreasing energy demand through renovation of a building's envelope and the systems within the building. Envelope renovations include reducing heat transfer through window replacements, improving insulation, and increasing efficiency of cooling. The final step is integrating a building within the energy grid. Research is currently being invested in smart grid technology which can evenly distribute energy within a community to reduce energy and financial losses. Through the use of technologies such as automation systems, system replacements and smart grids, institutions can maximize energy efficiency within buildings.

5.1 Recommendation: The team recommends that the Cleantech sector as a whole, invest money into the research of new energy efficient technology. The three-step process demonstrates how new technology such as retro-commissioning, automation systems, system and envelope replacements and smart grids can be utilized to improve energy efficiency of a building. Continued support of new technology can lead to further growth in the sector and to better "green" buildings.

Conclusion 6: Switzerland has invested time and money into efficient building technology which is more advanced than that of the United States.

Switzerland's long-standing investment in building technology has led to advancements and innovation. Residential buildings in Switzerland currently utilize geothermal heat pumps to regulate heating and cooling, however, this system is not widely implemented in commercial buildings. Current studies are being conducted in St. Gallen. Decentralized HVAC systems have tested in the IUCN building in Geneva. The airtight building recycles air within the building to eliminate pressure losses from traditional ducting systems. Advanced Swiss technology has been a key factor in efficiency in Swiss buildings.

6.1 Recommendation: The team recommends that Boston invest in energy efficient technology research and also adapt advanced Swiss technology for use in the Boston area.

Conclusion 7: Cultural aspects of a region affect energy consumption within that region.

Commitment to the energy efficiency sector depends on culture within a region, which can therefore impact the success of the sector within that region. Compared to the United States, Switzerland has a more generalized and homogenous commitment to the sector of energy efficiency. Due to its size and population, the cultural perspective on energy efficiency varies across the United States. Some regions, such as Massachusetts and Boston, are more dedicated to the environment than others. Both Massachusetts and Boston have made great strides in lowering energy consumption, green-house gas emissions and negative environmental impacts.

Conclusion 8: While it is often difficult to change human behaviors to achieve energy savings, the use of automation systems and monetary incentives can minimize the effect of the "human factor."

Automation systems such as controls and smart building technology can be used to minimize the effects of the "human factor" and save money. Creating a more consistent and even energy distribution throughout the day that moves energy consumption to off-peak times and pricing can reduce energy expenses. Sub-metering increases individual accountability and has been used in residential homes to decrease energy consumption. However, these types of systems rely on correct programming and are ineffective if not operated correctly. Adding monetary and competitive incentives can have positive effects on human behavior and overcome fractured incentives that arise from tenants of a building not directly paying utility bills.

8.1 Recommendation: We recommend that companies and governmental institutions provide information on energy use through the implementation of automation systems and

additional financial incentives to encourage behavioral changes that promote greater awareness of energy consumption and the value of improved energy efficiency, and conservation.

8.2 Recommendation: To ensure optimal results from the use of automation systems, the team recommends that these systems are installed and operated correctly. We suggest that building owners or managers re-assess the use of automation systems every five years to guarantee continual benefits from the system.

Conclusion 9: Many avenues exist for obtaining funding for energy efficient retrofits and projects.

In general, companies use their internal capital budget to finance projects. In Massachusetts, there is governmental and private assistance available for companies who cannot finance their projects as a capital expense. The government provides incentives, grants, tax-credits and loans. In the US, there are private financing opportunities through Energy Services Companies (ESCOs) and Energy Service Agreements (ESAs). There is much less financial support from the Zurich cantonal government, however, private assistance for investments in energy efficiency exist. Utilities companies participate in promoting and financing energy efficient practices. In 2006, Elektrizitatswerk der Stradt Zurich (ewz), a major electricity supplier in Switzerland, introduced a 10% price reduction to any company that could prove it increased energy efficiency. In both nations, there are many opportunities for financing energy efficiency projects in companies.

Conclusion 10: Massachusetts and the Zurich canton each have advanced policies that are recognized globally as proactive and innovative.

Massachusetts has recently become a national leader in energy efficiency policies. The Massachusetts state government has taken an active role in promoting energy efficient practices with its Green Communities Act of 2008 and Net Zero Energy Taskforce. The city of Boston has also been proactive; for example, the Building Energy Reporting and Disclosure Ordinance

“BERDO” mandate is a significant development in Boston’s legislation and the Net Zero Energy Building Taskforce is an innovative practice which the Zurich canton has yet to pursue.

Unlike the United States, Zurich has an extensive history focused on energy efficiency. Zurich has taken a proactive stance with programs such as the 7 Mile Steps and the Master Energy Plan, which promote the use of renewable energy and reduce in CO_2 emissions. While Boston has its Climate Action Plan, aiming to reduce CO_2 emissions, there is no legislative mandate for the promotion of renewable energy within the state. Zurich was also the first canton to implement the 2000W Society plan and the 2050 Plan. Zurich’s proactive government has resulted in the canton becoming home to 20% of all Minergie buildings in Switzerland and of the Green Part of Switzerland and the Green Liberty Party, which aid in the promotion of environmental policies.

10.1 Recommendation: We recommend that Massachusetts and Boston adopt Zurich’s mandated regulations policies. The state of Massachusetts and Boston can benefit from mandating sustainable practices as Zurich has done. Boston can benefit from adopting specific policies such as implementing renewable energy within commercial buildings, starting with governmental buildings in a “lead by example” strategy.

10.2 Recommendation: We recommend that both Boston and Zurich implement net zero habits. Zurich can benefit from creating a Net Zero Energy Building Taskforce, similar to that of Boston, to promote future net zero practices within the region. Boston can further implement net zero habits in governmental buildings to promote the use of net zero practices.

10.3 Recommendation: We recommend that the Zurich Cantonal government adopt policies that pull businesses toward energy efficiency, similar to those of Boston. Specifically, Zurich should implement a building energy reporting ordinance, similar to Boston’s BERDO policy.

Conclusion 11: While LEED has been used to promote stricter building codes in Boston, Minergie has been used more effectively to promote progressively more strict energy efficiency building codes in Zurich.

Massachusetts has mandated that new governmental buildings meet LEED certification. Through Amendment #37 of Zoning Code Article 80, Boston became the first US city to adopt LEED standards for private building construction. Similarly, Zurich was among the first three cantons to adopt the Minergie standard as a minimum building code. Contrary to Massachusetts and LEED, however, Minergie standards are continuously improved upon to keep a competitive edge over Zurich cantonal building codes. This “cat and mouse” relationship does not exist between LEED standards and Massachusetts state building codes.

11.1 Recommendation: We recommend that Massachusetts cooperate with LEED to emulate the competitive approach used by Minergie to continuously push for stricter energy efficiency building codes.

Conclusion 12: LEED and Minergie pursue different strategies for certifying green buildings.

LEED follows a holistic approach for certification by scoring buildings using various categories such as water management, building materials and energy efficiency. The use of these categories emphasizes a holistic approach to sustainability, but tends to dilute the focus on energy efficiency. By contrast, Minergie ranks solely on a building’s energy consumption which pushes buildings toward optimal energy efficiency but tends to ignore other sustainability goals. LEED’s holistic strategy requires the use of expert certifiers and limits the use of available building materials which increases the costs of construction and certification compared with Minergie.

12.1 Recommendation: We recommend that LEED implement and promote energy efficiency as its top priority and attempt to lower certification costs.

Conclusion 13: LEED mandates reassessment of its certified buildings every five years to ensure standard qualifications are maintained.

LEED contains an innovative aspect in which it mandates reassessment of its certified buildings every five years to ensure standard qualifications are maintained. Minergie has yet to implement such a strategy, although, according to Adrian Altenburger, a "hand-over period" may be in progress in which standard qualifications must be maintained for two years prior to completing the certification process.

13.1 Recommendation: We recommend that Minergie adopt a reevaluation strategy similar to LEED standards.

Conclusion 14: LEED and Minergie have become an important part of marketing energy efficient buildings in their respective nations.

The widespread acknowledgement and reputation of LEED in the United States and Minergie in Switzerland make buildings with these standards desirable and therefore they have become effective marketing tools. Adding energy efficient technologies and practices to a building increases its property value giving certified buildings higher market value than non-certified buildings. The US EPA lists increase in occupancy rates, reduction of tenant turnover and a competitive edge in the real-estate market as benefits for energy efficient property owners (PECI, 2007).

14.1 Recommendation: We recommend that building owners pursue LEED/Minergie certification in order to gain marketing benefits.

Conclusion 15: The cities of Boston and Zurich are both leaders in their respective nations in promoting and implementing energy efficiency in buildings.

The city of Boston was ranked "#1 Energy Efficient City" in the American Council for Energy-Efficient Economy's (ACEEE) *City Energy Efficiency Scorecard* in 2013. Energy efficiency is a business opportunity in the Boston area due to a combination of economic and "soft" benefits that building owners may reap from retrofitting. While energy efficiency can reduce utility costs, it can also enhance property value, attract tenants, and lead to increased rent and greater occupant productivity. Green buildings are perceived as good business practices in the United States and are often used as a marketing tool which incorporates a competitive aspect within the energy efficiency sector.

Zurich was ranked 6th overall in Siemens' European Green City Index as a direct result of the city's efficiency, environmental performance and dedication to reducing its environmental footprint. Mandated energy efficiency has advanced the sector in Switzerland, and has led to investment in building technology. Swiss companies have been conducting research and development in the sector for decades, leading to advanced and innovative technology. For example, current studies on geothermal heat pumps are being conducted in St. Gallen and decentralized HVAC systems have been tested in the IUCN building in Geneva.

15.1 Recommendation: We recommend Boston and Zurich pursue greater collaboration on the promotion of energy efficiency in buildings. There are many potential areas for fruitful exchange In particular, Zurich can learn from Boston's business model for energy efficiency while Boston may benefit from Zurich's lead energy efficient technology in developing mandatory governmental regulations.

Conclusion 16: Collaboration between the Massachusetts and Switzerland in general, and between Boston and Zurich in particular, has great potential to mutual benefits.

Massachusetts is a leader within the United States in terms of promoting Cleantech in general and energy efficiency in buildings in particular, and much of this innovation in technology and policy is centered in Boston. Similarly, Switzerland is a leader of Cleantech and energy efficiency in Europe, and Zurich has been one of the most proactive cantons and cities in Switzerland. Each place has strengths and weaknesses and much to learn from each other.

16.1 Recommendation: We recommend companies and government agencies in Boston and Zurich explore areas for future collaboration in the pursuit of energy efficiency and the promotion of the Cleantech sector in this area.

Conclusion 17: Time constraints and language barriers had negative impacts on the success of this project.

Given the time constraint on the project and the language barrier, it was difficult for the team to gain the full Swiss perspective with interviews and supplemental literature. If a second student group from the Zurich University of Applied Sciences worked with the Worcester Polytechnic students, this would eliminate the language barrier in which the team encountered when searching for supplementing literature as well as promote further collaboration between the two institutions.

17.1 Recommendation: For future projects, we also recommend collaboration between student groups from WPI and ZHAW.

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Appendices

Appendix A: Sponsor Description

Our sponsor, Professor Peter Qvist-Sorensen, is affiliated with the Zurich Hochschule of Arts and Sciences School of Management and Law (Zürich Hochschule Angewandte Wissenschaften, or ZHAW for short). ZHAW was established in 1968 in Winterthur, located just outside of Zurich. The school sought to expose students to an international perspective, more so than was typical at that time in Switzerland, taking on the motto “Building competence, crossing borders” (Sciences, 2014). The curriculum was designed to uphold this promise by offering courses in many different languages and creating and utilizing partnerships all over the world. These partnerships are mainly with universities and enable students to participate in exchange programs to gain a more rounded experience (Sciences, 2014). ZHAW was the first school in Switzerland to be accredited by the Foundation for International Business Administration Accreditation (FIBAA) in recognition of its internationalist perspectives (FIBAA, 2014). Courses in the department of Management and Law reflect the focus of the entire university by emphasizing math and science (Sciences, 2014).

Professor Qvist-Sorensen is an internationally acclaimed lecturer in International Business at ZHAW with more than 15 years of research and practical experience on corporate reorganization, turnover management, and company acquisition. After the development and subsequent sales of a series of successful companies around the globe, he continues to bestow his expertise by advocating for further education in international studies with specific focus on the growing area of clean technology and economics (Sciences, 2013). His ideas in clean technology have since been proven to be highly successful in countries such as Denmark, Australia, and more recently Switzerland. The Swiss incorporation of Cleantech alongside their research and development in the field has also gained acknowledgement worldwide among the experts in entrepreneurship and sustainability (Sciences, 2014). Professor Qvist-Sorensen is known for his dedication to the development and awareness of clean technology as well as its application in nations and organizations that are less familiar with practical and commercial approaches to environmental sustainability than the Swiss. ZHAW is known internationally in the clean technology field in large part due to the research and publications of Professor Qvist-Sorensen and his colleagues at ZHAW (Sciences, 2014).

Students and faculty at ZHAW School of Management and Law participate in research that advances its private and public sector partners. Substantial scientific research is funded in part by the Federal Government and the European Union while more consumer-oriented projects are conducted in collaboration with industry partners, such as Cleantech Switzerland (Switzerland, 2012b). Developed in 2009 by the Swiss government and Switzerland Global Enterprise, Cleantech Switzerland is an export platform for Cleantech businesses which aids companies such as Swisssolar and CleantechAlps in their global export endeavors. Through the use of central databases such as Cleantech Cube (http://www.cleantech-switzerland.com/en/cleantech_cube) and other marketing support, Cleantech Switzerland aims to bring Switzerland's Cleantech expertise to markets throughout the world (Switzerland, 2012a).

Cleantech, an abbreviation for clean technology, is an array of products and services that "provide superior performance at lower costs" while reducing negative impacts on the environment and using natural resources more efficiently. Cleantech Group divides Cleantech into 18 different industry sectors from over 22,000 companies worldwide as seen in Figure 1 (Group, 2012). Cleantech encompasses a large range of categories including forms of alternative energy, energy storage, transportation, and agriculture and forestry (Group, 2012). The Swiss government initiated the Cleantech Master plan in 2010 to bolster the development of the industry, both in Switzerland and in other regions of the world (Mombelli, 2013).

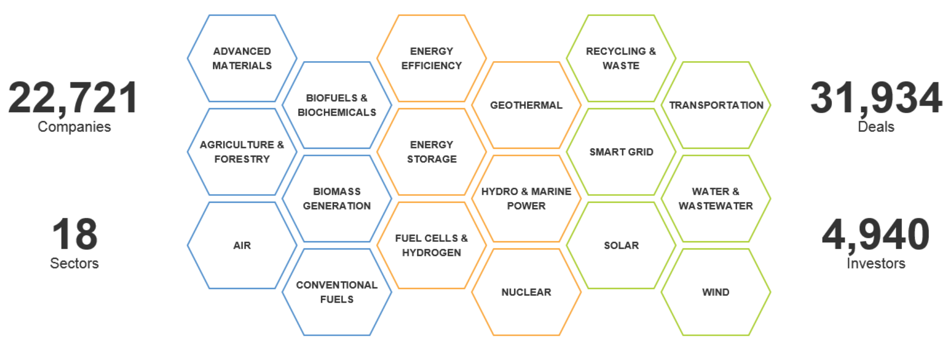

Figure 1: 18 Sectors of Cleantech (Group, 2012)

Cleantech interest is increasing for a number of reasons including the “increasing costs of conventional energy, the desire for energy security, and growing awareness and concern about the impacts of climate change” (Huggett, 2008). Other and more prominent motivations to utilize clean technology include monetary incentives, such as tax breaks issued by the government, as well as the marketing benefits and positive reputation that come as a result to joining the green movement. The need for clean technology only grows with each year as conventional energy sources will eventually deplete and the environment continues to be negatively impacted.

Appendix B: Chart of Goals and Objectives

Overall Research Question:	Which areas in the Zurich and Boston Cleantech industries regarding energy efficiency renovations in existing commercial buildings leave room for possible improvement and how can potential in the two sectors be better exploited
Overall Project Goal	Evaluate opportunities for promotion of growth and collaboration in the energy efficiency sector of Cleantech industries of Zurich and Boston
Subsidiary Research Questions:	**Project Objectives:**
What is the definition and history of Cleantech?	1. Refine our assessment of Cleantech definitions, terms, and concepts
What are the cultural differences between Boston and Switzerland in regards to Cleantech awareness and involvement?	
Who funds Cleantech?	
Who regulates Cleantech?	
What is the governmental role in Cleantech?	
What organizations lead in the Cleantech sector?	
What are the key subsectors of energy efficiency regarding renovations?	2. Evaluate best renovation standards in the Cleantech industries in Zurich and Boston
Which Cleantech companies have had the greatest success in energy efficiency?	
Which building standards are being used in both locations?	
What contributes to the success of each building standard?	
What governmental action has been successful in Zurich and Boston?	
What incentives exist to promote energy efficiency within existing commercial buildings?	3. Identify the barriers and incentives for the application of energy efficiency within existing commercial buildings in Zurich and Boston
What are the risks or barriers associated with applying energy efficiency within existing commercial buildings?	

How can these risks and barriers be overcome?	
What are the laws and regulations affecting energy efficiency renovations in Zurich and Boston?	4. Compare the legislative, cultural and financial factors that affect decision-making in both locations.
What are the cultural factors affecting commitment to energy efficiency renovations in Zurich and Boston?	
What are the financial factors affecting commitment to energy efficiency renovations in Zurich and Boston?	
Where can greater networking and collaboration benefit both Zurich and Boston?	5. Highlight opportunities for growth, innovation, and collaboration for the energy efficiency sector within the Cleantech industries of Boston and Zurich
What technological innovations prove most beneficial to the opposing sector?	
Where is the greatest area for growth in both Zurich and Boston?	

Appendix C: Interview Protocol for Stakeholders and Key Informants

Interview with (insert name and title here)

(Date, Time place)

Initial Contact by Phone or Email:

1. Introduce names
2. Introduce Context (WPI research project for ZHAW)
3. Brief Synopsis of project: Evaluating opportunities for the promotion of growth and collaboration of Cleantech industries in Boston and Switzerland
4. Set up an interview method and time

Pre-Interview

1. Tailor interview questions to stakeholder.
2. Assign group roles for the interview
    1. Interviewer -
    2. Notes -

Interview

Preamble:

Thank you for meeting with us today. As we've previously mentioned, we are a student research team from WPI. We're working on our junior capstone project. The goal of our project is to evaluate opportunities for the promotion of growth and collaboration in the energy efficiency sector of Cleantech industries within Boston and Zurich. The team will compare and contrast the legislative, cultural, and financial factors that influence decision-making for energy efficiency renovations within existing commercial buildings. We will compare building standards from each location and evaluate how each site may benefit from the other.

(Specific prefix here. Something similar to "Person X said that you are very knowledgeable in Y…) If our questions are too specific, just let us know and feel free to ask us for clarification. Before we start, we would like to know if we can quote/use information from today's interview in our final report. If you prefer, your name can remain anonymous. We will not publish any confidential information.

Definitions & Concepts: Cleantech Questions & Energy Efficiency – This section remained relatively unchanged between categories

1. From our research we have realized that the term Cleantech is quite vague, as I am sure you know, however we would like to know what your personal definition is?

2. What is the role of the energy efficiency sector within the Cleantech industry in the Zurich Canton? (What about in the Boston area? – if needed)
    a. Who is responsible for the promotion of sustainable practices in both locations? ie Federal Gov't, State Gov't, Individual Companies/Industries
    b. How prominent is the Energy Efficiency Sector within the Zurich canton? Are companies interested in investing in energy efficient practices?
        i. What about in the Boston area?
    c. Which sub-sectors are being invested in? ie. HVAC, Lighting, Windows
        i. Why?
        ii. Who invests in these subsectors? (Where is the money coming from)
    d. Which sub-sectors or systems have the highest return rates? Which ones have the shortest payback periods?
3. What is Zurich's (or Boston's) role in the Cleantech industry compared to other parts of the country?
4. What is the Switzerland's (or Massachusetts on a national scale) role in the Cleantech industry on a global scale?
5. Economic benefits are the obvious incentives for implementing energy efficient practices, what are some of the other benefits that motivate companies?

Best Practices: Renovation – The questions below were more skewed towards what we would ask an engineer or architect.

Transition: The scope of our project is Energy Efficient Renovations within existing commercial buildings.

1. What is the target lifespan of standard commercial office buildings in the Boston area? What is the average actual lifespan?
2. Do you see more companies renovating existing buildings or tearing down and constructing new energy efficient buildings in the Zurich (or Boston) area? Why?
3. In your opinion, which strategy is better? Why?
    a. Benefits of both
    b. Risks of both
    c. (FOLLOW UP) What is the general mindset on both of these strategies?
4. When a commercial building is renovated, which systems are more likely to be invested in?
    a. Which systems are easiest to implement?
5. What practices and techniques are used in Zurich that aren't used in Boston? (or vice versa)
    a. ex. Pre-fabricated wooden construction (other techniques would be placed here is backwards)

Laws and Regulations - The questions below were more skewed towards what we would ask an engineer or architect.

1. As an architect, did you renovate any of commercial facilities in Zurich/Boston?
   a. YES: What building standards did you encounter? Did they hinder the process or make it more difficult or expensive? ie MINERGIE/LEED
   b. NO: Are you familiar with building standards such as MINERGIE/LEED?
2. In your opinion, what are the strengths of this standard?
3. Are there any deficiencies? What are they?
4. Are there any other prominent laws, regulations or incentives that apply to energy efficient renovations that we should look in to?
5. From what you have talked about with us today, what are the deficiencies in the energy efficiency sector in Zurich (or Boston)?
6. As far as growth and development of the energy efficiency industry and governmental regulations, we've been told that the United States is behind Switzerland. Can you tell us why?

Conclusion – Same for all interviews

1. Do you know of any documents or surveys containing hard statistical data that would be relevant to our project? Any information regarding feedback, amount of energy and money saved, amount of money spent, average lifespan of buildings, etc..
2. The scope of our project recently changed to energy efficient renovations, we feel we would really benefit from speaking with an expert in sustainable construction. Do you know of any contacts that specialize specifically in energy efficient renovations who would be willing to talk to us? Possibly someone in the School of Architecture?
3. Thank you for your time today. We learned a lot (do a recap of what we learned)
4. Is there anything we didn't cover in our questions that you think we should know?
5. Can we follow up with you in the future if we come up with further questions?

Follow up

Send a thank you email (or a hand-written card)