

Home and Business Energy Reduction

**The Ohio State University, School of Environment and
Natural Resources, EEDS Capstone Course**

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Executive Summary

We are a group of five students within the Environment, Economy, Development, Sustainability (EEDS) major, taking part in a capstone project course directly related to our studies. The focus of our project is to reduce energy consumption community-wide by 20% over the next five years within the residential and commercial sectors. This 20% reduction is a goal within *Green Memo III*, set forth by the City of Columbus and Mayor Michael B. Coleman. Focusing on five objectives, we conducted research, gathered data on best practices from cities that have been making strides in this area, reached out to key energy providers, and provided a cost-benefit analysis on the financial feasibility of our goals. We hope to advise Columbus decision makers on how to effectively target homes and commercial buildings in order to market energy efficiency programs. We believe these programs will effectively reduce overall energy consumption and greenhouse gas (GHG) emissions for the City of Columbus.

Our research has given us insight into what Columbus is already doing to reduce GHG emissions, what GHG and monetary savings would result from a given reduction in energy use, and what it will take for Columbus to effectively achieve these goals within the allotted timeframe of five years. Columbus already has several programs in place to address energy usage and GHG emissions at the home and business level, such as Columbus GreenSpot. GreenSpot incentivizes homes and businesses to become more sustainable, and to set goals to actively reduce energy use and increase education on topics of sustainability. We recommend that GreenSpot take on key initiatives and programs set forth by the cities of Philadelphia and Chicago to more accurately track reductions, and better engage the target audience (homes and businesses). We also recommend that programs be added to increase outreach and educate

residents of the City of Columbus on what it takes to be sustainable and what actions can be taken to create a more sustainable city.

A thorough cost-benefit analysis has provided us with a conservative estimate of the economic benefit of a 20% reduction in energy use community-wide. The estimated economic benefit of a 20% reduction in energy use is in upwards of \$39 billion over a five-year period in the best-case scenario. With this estimate, benefits outweigh the costs supporting the fact that this initiative is something that Columbus should pursue further.

Introduction

Our project responds to Goal B, Objective B.1 from Columbus Green Memo III- **Reduce energy consumption community-wide by 20% (as measured on a per-capita basis) over next five years**. The 20% reduction objective is our main goal for the research conducted in this project. From this goal, we developed five of our own objectives to conduct thorough research within the allotted five-year time frame.

Objective One was to determine how much of an impact results from a specific percentage of homes or businesses switching to utilize the energy incentives. This objective required a thorough cost-benefit analysis using data collected from several sources, and taking into account multiple social costs of carbon and inflation rates.

Objective Two involved finding other cities in the Midwest and surrounding areas such as Chicago and Philadelphia that have implemented sustainability initiatives intended to reduce GHG emissions. Multiple case studies were conducted on various cities that excelled in home and business energy reductions. The cities that were originally researched were Chicago, San Francisco, Boston, and Philadelphia. After further analysis and research the focus of our report was then narrowed down to Chicago and Philadelphia. These two cities have developed and implemented successful sustainability initiatives that are comparable to those proposed by GMIII.

Objective Three included researching methods to market utility incentives provided by Columbus energy providers, and researching how to present these incentives so that more Columbus homes and businesses will utilize the energy reduction benefits. We reached out to AEP Ohio and Columbia Gas of Ohio, two major energy providers/distributors in the city of Columbus, both of which market utility incentives to customers.

Objective Four was to identify a plan that will have the most feasible performance standards as well as market the incentives offered by the energy companies to the public in a more effective way. This objective, similar to Objective Three, involved researching current marketing techniques as well as cities that actively track and require performance standards.

Objective Five involved determining methods to effectively penetrate the residential and commercial energy markets within the City of Columbus. How do we actually get people to *want* to reduce their energy use and increase the efficiency of their home or business? This is the question we hoped to address. All objectives were used to identify what it will take for Columbus to achieve its goal of 20% reduction in energy use community-wide.

What is Columbus Doing?

Our research began by determining what the City of Columbus has already done to reduce greenhouse gas emissions within the residential and commercial sectors. A program of interest is GreenSpot, a program that is designed to incentivize homes and businesses to reduce energy use, and to become more sustainable as a whole. GreenSpot now has over 10,000 members including businesses, households, and community groups. Our contact at GreenSpot, Mr. Dave Celebrezze, explained that each member pledges certain energy reduction, education, outreach, and resource conservation goals to become more sustainable (and to save money). He also explained several ‘assumptions’ that can be made in terms of estimating reductions and total resources conserved. These assumptions, ranging from millions of gallons of water saved to number of appliances unplugged, provide some idea of the reductions already taking place at the home and business level in Columbus. GreenSpot is making fantastic strides to address

sustainability and energy reduction around the city, and could be an important tool to achieve the GHG reduction goals set forth by Columbus.

Benefit-Cost Analysis

It is well known that achieving a 20% reduction in energy consumption will also decrease associated greenhouse gas emissions. The first objective of this project was to determine the financial feasibility of achieving a 20% reduction in energy consumption. The method used to analyze the feasibility of this project was Benefit-Cost Analysis (BCA). In general, BCA involves taking the present value of a stream of cash flows (benefits) and comparing them to the present value of the associated costs of a project (costs). For this specific project, the yearly cash flows from 20% energy savings on a per-household and per-firm basis were determined. We then determined the costs of undertaking the project and subtracted them from the benefits (benefits minus costs). The present value of benefits minus the present value of costs equals the net present value (NPV) of the project. A positive NPV denotes a project that has benefits greater than costs, and thus the project should be undertaken. With the background knowledge on how the BCA methodology was performed, we can now examine the specifics of this financial analysis.

To begin, 10 years of historical data was collected from the Public Utilities Commission of Ohio (PUCO) on average monthly consumption of energy and average monthly energy bills for the residential and commercial sectors. This data was then annualized. Once the yearly bill averages were obtained, the annual bill was then multiplied by 0.80 to determine the energy bill with a 20% reduction in energy consumption. For this calculation, we assumed that a 20% reduction in energy consumption equals a 20% reduction in the energy bill. The original bill

was then compared to the bill representing 20% less energy consumption. This resulted in the dollars saved on the energy bill from decreasing consumption by 20%. Added to these dollar savings is the social cost of carbon dollar benefits per metric ton of CO₂ avoided. The social cost of carbon rates of 5%, 3% and 2.5% were used to determine how to value each metric ton of CO₂ avoided (Social Cost, 2013). Figure 1 below depicts the EPA’s valuation of the social cost of carbon.

Social Cost of Carbon (SCC)	Discount rate	SCC \$/Metric Ton CO2
r:	5.0%	12
r:	3.0%	39
r:	2.5%	61

Table 1: Social Cost of Carbon

Adding the dollar savings from the energy bill for a 20% reduction in energy consumption along with the social cost of carbon dollar benefits of not emitting a certain amount of CO₂ results in the average total dollar savings per year. These figures were then multiplied by estimates of the residential and commercial firm population in Columbus obtained from the US Census Bureau. These estimates were 325,958 residential households and 56,957 firms in Columbus (State, 2015). Multiplying the average total dollar savings for both the residential and commercial sectors by their respective populations gave us an aggregate estimates of the total dollar savings city-wide, per sector, if Columbus were to undertake this project.

The total dollar savings city-wide for 2013-2015 were utilized to generate a 3-year weighted average to determine the total benefits, which were then compounded out to year 2020 at rates matching inflation of 5% and 2% to give a realistic flow of annual dollar savings with 100% participation in the Columbus project, see Figure 1 on the following page.

Benefits	
3 Year Weighted TOTAL Savings/yr 5%	\$178,226,501
3 Year Weighted TOTAL Savings/yr 3%	\$201,823,311
3 Year Weighted TOTAL Savings/yr 2.5%	\$221,050,341
Benefits	
3 Year Weighted TOTAL Savings/yr 5%	\$5,693,156,246
3 Year Weighted TOTAL Savings/yr 3%	\$6,466,844,154
3 Year Weighted TOTAL Savings/yr 2.5%	\$7,097,256,523

Figure 1: Weighted Average Total Savings per Year (Residential Top, Commercial Bottom)

Once the above numbers were compounded out to year 2020, the present value of the benefits was determined for each social cost of carbon rate and for each inflation rate with 100% participation, see Figure 2 below.

Total PV Savings 2015 \$ (infl=5%)		Total PV Savings 2015 \$ (infl=2%)	
5%	\$1,122,826,955	5%	\$1,090,746,185
3%	\$1,271,486,857	3%	\$1,235,158,661
2.5%	\$1,392,617,147	2.5%	\$1,352,828,086
Total PV Savings 2015 \$ (infl=5%)		Total PV Savings 2015 \$ (infl=2%)	
5%	\$35,866,884,348	5%	\$34,842,116,224
3%	\$40,741,118,169	3%	\$39,577,086,222
2.5%	\$44,712,716,098	2.5%	\$43,435,209,923

Figure 2: Present Value Savings (Residential top, Commercial bottom)

It is important to note that when calculating the above present values of the cash flows (dollar savings), the cash flows were only compounded from year 2015 to year 2020. A more detailed analysis would have projected the dollar savings out 15-20 years, representative of the life of typical energy efficient products one might install to make a building more efficient. Including these additional cash flows in the calculations would have drastically increased the present values.

Once the present values were calculated, analysis of the project benefits was complete. We then estimated the average costs of an energy audit and an energy efficiency project aimed at reducing 20% of energy usage for both the residential and commercial sectors. For the residential sector, conservative estimates of the average costs of an energy audit and an efficiency project were \$100 and \$3,500, respectively. For the commercial sector, experts estimated the average cost of an energy audit to be \$8,000- \$12,000 (Gudeman, 2015). To ensure overly conservative estimates, the high end of that range was used in the analysis. We conservatively estimated the cost of a commercial efficiency project at \$90,000. It is important to note that, except for the cost of a commercial audit, these cost figures were all estimated by the reporting team but can be changed and easily integrated into the financial analysis when more accurate estimates are available. When information was not available, we attempted to highly overestimate the costs so as to not skew the results in favor of doing the city-wide project.

To find the aggregate costs of the project with 100% participation, the total average cost was calculated by adding the cost of the audit to the cost of the efficiency project for both sectors separately. These figures were then multiplied by their respective population numbers from the US Census Bureau. This calculation resulted in the total city-wide project costs of just under \$1.2 billion for the residential sector and just over \$5.8 billion for the commercial sector. It is assumed that these costs would be fully outlaid in year 1 of undertaking the project.

Finally, with present values of the total city-wide costs and total city-wide benefits calculated, the Net Present Value (NPV), which can also be referred to as economic benefit, was calculated with the equation: Total Benefits minus Total Costs. An NPV greater than zero indicates that the project is a smart financial decision and that the project should be

undertaken. Figure 3 on the following page shows all net present values at varying inflation rates and social cost of carbon rates.

5% Inflation		5% Inflation		
Net Present Value of Initiative (100% Participation)			NPV with 20% Participation	NPV with 50% Participation
When SCC r=5%	\$30,057,270,348	When SCC r=5%	\$6,011,454,070	\$15,028,635,174
When SCC r=3%	\$34,931,504,169	When SCC r=3%	\$6,986,300,834	\$17,465,752,085
When SCC r=2.5%	\$38,903,102,098	When SCC r=2.5%	\$7,780,620,420	\$19,451,551,049
2% Inflation		2% Inflation		
Net Present Value of Initiative (100% Participation)			NPV with 20% Participation	NPV with 50% Participation
When SCC r=5%	\$29,032,502,224	When SCC r=5%	\$5,806,500,445	\$14,516,251,112
When SCC r=3%	\$33,767,472,222	When SCC r=3%	\$6,753,494,444	\$16,883,736,111
When SCC r=2.5%	\$37,625,595,923	When SCC r=2.5%	\$7,525,119,185	\$18,812,797,962
5% Inflation		5% Inflation		
Net Present Value of Initiative (100% Participation)			NPV with 20% Participation	NPV with 50% Participation
When SCC r=5%	-\$50,621,845	When SCC r=5%	-\$10,124,369	-\$25,310,922
When SCC r=3%	\$98,038,057	When SCC r=3%	\$19,607,611	\$49,019,028
When SCC r=2.5%	\$219,168,347	When SCC r=2.5%	\$43,833,669	\$109,584,173
2% Inflation		2% Inflation		
Net Present Value of Initiative (100% Participation)			NPV with 20% Participation	NPV with 50% Participation
When SCC r=5%	-\$82,702,615	When SCC r=5%	-\$16,540,523	-\$41,351,307
When SCC r=3%	\$61,709,861	When SCC r=3%	\$12,341,972	\$30,854,930
When SCC r=2.5%	\$179,379,286	When SCC r=2.5%	\$35,875,857	\$89,689,643

Figure 3: Net Present Values (Residential top, Commercial bottom)

The above summary NPV figures are all positive in the residential sector except when using the social cost of carbon rate of 5%. Using this rate is not advised as it means the City of Columbus only values the reduction of 1 metric ton of CO₂ at \$12 (Social Cost, 2013). This valuation of carbon does not fall in line with the rest of Columbus’ sustainability initiatives. All other NPVs for both the residential and commercial sectors at any participation rate are well above zero. At 100% participation, NPV ranges for residential are \$61 million-\$219 million and for commercial are \$33 billion-\$39 billion. The analysis also revealed stunningly high returns on investment (ROI) for the commercial sector (ranges from 500% to 670% ROI), with moderate ROI for the residential sector (ranges from -4% to 19% ROI).

The large NPVs as well as strikingly high ROIs for the commercial sector lead us to believe with great certainty that Columbus would grossly benefit from undertaking the project of decreasing energy consumption by 20%, starting with targeting the commercial sector.

Chicago and the Green Business Challenge

As a part of objective two, one of our goals was to research and determine best practices from other Midwest cities. These cities included Chicago, Philadelphia, Boston, and San Francisco. One city program that we identified whose practices we believe would work well in Columbus is the Chicago Green Business Challenge. The Green Business Challenge lays out a rubric and point system that home and business owners can follow to gain points by reducing not only their energy consumption but also their waste and water consumption, as well as their transportation emissions. However, for the purpose of our project we only focused on the energy portion of the rubric.

The Green Business Challenge accomplishes the task of bringing homeowners and building managers together by gaining recognition from the mayor and media by improving their operations, energy efficiency and sustainability. Chicago has seen a great deal of participation from this program due to three specific reasons. First, many home and business owners want to make a change in their energy consumption but they do not know how or where to start. Second, people, especially business owners, want recognition. If home or business owners excel at the challenge, they want the mayor and the media to recognize their organizations as ‘green’ or ‘environmentally friendly.’ Finally, keeping score makes it competitive and fun. Chicago has realized that it is one thing to lecture people about how they can improve their building or home, but it is an entirely separate thing to provide a challenge that will allow them to compete with

neighboring homes or businesses. People in Chicago have referred to this as “Gamefication,” an idea that competition between businesses and homes is effective for reducing their energy consumption.

The Green Business Challenge is something that begins with the management of the organizations in the buildings. The first step of this challenge is for companies to have employees create their own ‘green team’ for their business or organization. Once this is done members that are a part of the organizations ‘green team’ can start achieving points for their organization. As you can see in Table 2 in the appendix, for each member who participates in energy reduction practices such as conducting an energy audit at home, they gain points for their organization as a whole. In addition, the organization gains higher amounts of points for the bigger projects they conduct at the office. An example of this, seen in Table 2 of the appendix, is lighting retrofits or installing a new submeter for the office.

There are two components that Chicago has laid out that have led to the success of the Green Business Challenge. First, the Chicago Green Business Challenge lays out tools and information to improve resource efficiency, reduction in energy costs, and a reduction in greenhouse gas emissions. It also builds an extensive set of data and reporting options to help people and their community track their energy consumption in a user-friendly and interactive online system. Second, there is already a designed program and set of well-defined, realistic goals that most homes and businesses can achieve. This combination of a structured rubric and the competition between homes and businesses has led to the success of this program in Chicago.

Philadelphia

After looking at ways to increase sustainability in commercial buildings, we researched how to accomplish this with residential buildings. The first step was to determine a city that is advanced in sustainability measures with regards to residential homes. When looking at the data we collected, Philadelphia, Pennsylvania seemed to be the logical city for Columbus to take after. We determined that the cities have comparable building ages, comparable in size, and Philadelphia has greatly advanced in their sustainability efforts. We looked for an area in Philadelphia that we could compare to an area in Columbus and found that the historic district in Philadelphia is comparable to German Village in Columbus. These two areas are comparable to each other because all of the homes were built around the same time; the 1920s.

It can be even more expensive to install energy efficient upgrades in older homes, but the city of Philadelphia has taken many steps to make this transition easier on the residents. In the beginning, people were hesitant about having an energy audit and even more concerned about installing any of the new energy saving recommendations. The city conducted around 2,300 meetings with various members of the city to try and help the citizens better understand the full effects of the energy efficient upgrades (Upgrades, 2013). These meetings were not only done to show residents how much they could save, but to also show them how they could benefit the city overall. The number of meetings may seem excessive, but they helped the residents become fully aware of how much money they were going to have to initially spend and how much money they would save in the long run. They have implemented low interest loan programs and partnered with third party financial companies to incentivize residents to install energy efficient upgrades (Upgrades, 2013).

Initially, it was hard to get residents to have energy audits conducted, and even harder to get them to make any upgrades. Before the energy retrofits in Philadelphia, the historic homes were losing 10 times as much air as newer homes that are the same size (Upgrades, 2013). Once some residents started the process of the audits and installing the upgrades, they quickly realized how much money they were actually saving. It seems that through word of mouth, people who had the audits and implemented the upgrades were letting other people know how much money they were saving. Throughout the next couple years, many more residents started taking advantage of the low-price audits and installing energy efficient upgrades. In 2013, just the historical area of Philadelphia had 19 energy audits conducted and 9 of those homes had refits. The estimated annual savings per refit is \$1,981 (Upgrades, 2013). Those nine residents were able to take advantage of the energy audit and energy efficient upgrades and are now saving a large sum of money because of it.

Philadelphia also created an interactive map of their city that broke the city down into neighborhoods and allowed everyone to see how each neighborhood was doing. The map breaks down the following: refits performed, average home age, energy audits conducted, and estimated savings per refit. This allows residents in each neighborhood so see how much money other people in their same neighborhood are saving. Once people actually start seeing the results of their neighbors, they are much more likely to have energy audits and install energy efficient upgrades because they want to save money too. Everyone wants to see their neighborhood doing well, so this interactive map creates a competition among neighborhoods as they try to one up each other by having the highest annual savings.

After analyzing this data, we believe that German Village is a good place for Columbus to start with encouraging sustainable residential homes. The success that the historical area in

Philadelphia saw should transfer and show similar results in Columbus. If the city takes the same approach as Philadelphia and holds many meetings with the residents, informing them of all of their options, then Columbus should see similar success.

San Francisco & Boston

The two cities, Philadelphia and Chicago, were both examined thoroughly and were shown to have key variables that could be transformed into what Columbus is currently doing more so than Boston or San Francisco. With that said the two other cities both had great success in their respective communities and could be used in Columbus with more time and planning. The cities that were also researched and compared to Columbus were San Francisco and Boston. Both of these cities have strong energy incentives and are rated in the top five in the American Council for an Energy Efficient Economy (ACEEE). The ACEEE ranks cities in the United States on several components that determine the energy efficiency. One category the ACEEE uses and was heavily researched is the Energy and Water Utilities rating, which gives a description of what the city is doing and how well they are doing it (City Scorecard, 2014). Boston and San Francisco were both high in this category for a variety of reasons that could be transitioned to Columbus, giving the community a more unique and effective way to market utility incentives to reduce the overall energy consumption city-wide.

San Francisco was a very impressive city that is doing a great deal to cut down on energy consumption. The city's main focus for reducing energy consumption for residential and commercial buildings was interaction between customers and residents with their online resources. The utility company in San Francisco, Pacific Gas and Electric, in particular has many programs set up so that the customers easily learn about the programs available and see how they

compare with others. By providing this information to the people, it not only sparked interested but decreased consumption as well.

One resource Pacific Gas and Electric uses to help customers is their online interactive webpage, My Energy. My Energy is set up through Pacific Gas and Electric that allows customers to search many different aspects that are related to their energy bills. For example, customers are able to see interactive graphs that show their energy consumption in the past. The customers are also able to compare how much they are spending versus other nearby neighborhoods (MyEnergy, 2015). As explained previously, this ability to compare yourself against neighbors creates “gamefication”, the ability to compete. This idea is a very effective incentive that can be just as important as spending large amounts of resources on complicated marketing techniques.

To go along with the idea of using more interactive energy incentives, Boston has set up unique incentives through many different programs. Currently, Boston residents and commercial energy users have three programs available that allow them to learn about incentives offered, asses their energy performance, and offer tips for customers to save on energy. The city has many programs set up to increase energy awareness, but what is most often used among the community members is the state wide initiative Mass Save. Mass Save, now going on its seventh year, was created to provide residents with a wide range of services, incentives, training, and information about energy efficiency and how to save money on energy bills (Save, 2015). Mass Save is providing benefit through the creation of a single area for the most effective energy saving programs for residents and businesses. This allows people to search one place for the programs they find most attractive, rather than shopping around multiple utility companies. Mass

Save is also interactive, making it easy to navigate. This program is also on Facebook and Twitter with a combined following of over 90,000 people and counting (Annual, 2013).

These analyses of Boston and San Francisco highlight the importance of user-friendly, interactive resources to save energy. It is vital to teach and offer effective programs, something that Columbus currently does. But it is equally important to have residential and commercial owners' participation. Having programs that let people view their own energy situation and compare that with surrounding neighbors is a prime opportunity to increase participation. Other cities have achieved large success rates partially due to interactive resources, which is why they should be a large focus for Columbus. Boston and San Francisco have put a great deal of focus into creating more user-friendly programs and have experienced the benefits also achieved by Chicago and Philadelphia.

Recommendations

Recommendation One – GreenSpot Challenge:

We believe that GreenSpot, a program that is already sponsored by Columbus, should be modified to better fit the City of Columbus. We hope to see GreenSpot built upon by accomplishing three things. One, we believe GreenSpot members should follow the rubric that is attached in the appendix (Table 2). This approach will build support through targeting the commercial sector but will also continue to trickle down to the residential sector. When organizations start to create their 'green teams' that will engage the employees, they will take what was taught to them and apply it to their homes, thus targeting the commercial sector but seeing results in the residential sector as well.

Another benefit of mimicking GreenSpot after the Chicago Green Business Challenge is that the Green Business Challenge not only focuses on energy, but also water consumption, waste consumption, purchasing decisions, and transportation- similar to GreenSpot's current initiatives. For the other sectors such as waste or water consumption, there are preexisting rubrics similar to what we have laid out from the Green Business Challenge. This means that if this policy is adopted, it will not only reduce energy consumption, but will also allow home and business owners to consider other aspects of their waste and GHG emissions.

Recommendation Two - User-friendly Interactive Resources:

In addition, Columbus should use energy reports obtained from the Chicago Green Business Challenge to create a user-friendly interactive resource of the energy data map of home and business GreenSpot members so that participants can compete and compare themselves to one another. This proved to be successful in Chicago, San Francisco, Boston and Philadelphia, as noted by high levels of participation in each city. San Francisco uses an interactive site that allows residential and commercial owners to see trends in their energy consumption as well as compare themselves to surrounding neighborhoods. By adopting a similar resource, people would be able to see their strengths and weaknesses and allow them to make the proper changes with strategic recommendations offered by the various resources.

Recommendation Three - Community Engagement:

Finally, Columbus needs to actively engage the community to inform residents on the importance of reducing their energy consumption. Community engagement has been a key factor to success in other cities, leading to great financial savings and environmental benefit. Columbus decision makers should convince the community that reducing energy and GHG emissions will make Columbus a more livable, competitive and sustainable city. To encourage residents,

Columbus could mimic the practices of Philadelphia. Philadelphia engaged the community by conducting over 2,000 town meetings to inform and guide home and business owners in the city. Naturally, people are skeptical of companies coming around and telling them all these different ways they can save money. Most people always think that there is a catch with installing energy efficient upgrades because they believe it is too good to be true. Philadelphia did a great job of having trusted city members the residents could relate to and speak with about the energy savings. With trusted officials running the meetings, the residents did not feel like they were getting scammed or lied to, which led to more energy audits being conducted.

Conclusion

After conducting research and analyzing data, we fully believe that Columbus can incorporate what Chicago, Philadelphia, Boston and San Francisco are doing in a cost effective manner. The overall objective of reducing energy consumption by 20% community-wide is a realistic opportunity to not only benefit the city in the next five years, but for years to come. What Columbus and the local utility companies have already done gives us great confidence that the city is on the right path and with the proper adjustments and additions to the existing programs, Columbus has the opportunity to become a leader in home and business energy reduction.

A major concern going into this research report was whether the cost would outweigh the benefits. However, after looking at past records combined with the projected social cost of carbon, the outcome was astoundingly positive. With a realistic social cost of carbon rate of 3% or 2.5%, Columbus can see large benefits from reduction of carbon emissions when participation is anywhere between 20% and 100%. At 100% participation, the net present value for reduction of energy consumption has a range from \$61 million to \$219 million for residential

and \$33 billion to \$39 billion for the commercial sector, depending on inflation rates and social cost of carbon rates. The data presented shows a huge benefit for 100% participation but the 20% participation is still very much positive. After obtaining such encouraging numbers we conclude that with proper plans of action, Columbus can greatly benefit from a 20% reduction in energy consumption.

To reduce energy consumption, Chicago, Philadelphia, San Francisco, and Boston were further examined after their past success in energy reduction in the residential and commercial sectors. Two main principles were determined to have a large responsibility of the success of each city. First being the use of user-friendly interactive resources and the second being actively informing residents and commercial owners on the many benefits of energy reduction. To achieve a 20% reduction in energy consumption, Columbus must look into both of these proven, successful practices. To incorporate what Columbus is already doing, it is recommended that the successful energy report from the Green Business Challenge in Chicago be infused with Columbus's GreenSpot to provide an interactive resource to create friendly but cost savings competition. Other cities including San Francisco also have interactive resources that provide residents and commercial owners with tools to compare energy bills as well as highlight benefits and weaknesses. Philadelphia, which has seen resounding participation rates, uses town meetings to better inform citizens on ways to reduce energy consumption. Columbus could create town meetings and introduce new interactive programs to meet the city goal of 20% energy reduction over the next 5 years.

Overall, Columbus has a great opportunity to become a leader in energy reduction as well as diminish the cost from carbon emissions. If Columbus properly takes the successful practices of other cities laid out herein and infuses them with what is already set up, the

participation in energy reduction could go up dramatically and achieve the overall goal. By calculating the overall benefits of energy reduction, the report has shown to be a realistic opportunity for years to come.

Next Steps

In regards to the Benefit-Cost analysis, we used population figures from the US Census Bureau to estimate the number of residential customers in Columbus and the number of commercial firms in Columbus. Future research should be done to find out the exact numbers for these figures. We conservatively estimated the costs of residential and commercial energy audits as well as the average cost of energy efficient projects for both sectors. Although these estimates were extremely useful, further research should be conducted to find exact numbers for the costs of these audits and projects. There also needs to be research completed on the legal implications of requiring energy audits and efficiency projects. Mandating energy audits could be complicated because there will inevitably be people who oppose the requirement. With these next steps completed, Columbus will be on the right track to reach their goal of reducing energy consumption by 20% over the next five years within the residential and commercial sectors.

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Home and Business Energy Reduction

Appendix

Dataset #1: Public Utilities Commission of Ohio

Source: Public Utilities Commission of Ohio website

<http://www.puco.ohio.gov/puco/index.cfm/industry-information/statistical-reports/ohio-utility-rate-survey/#sthash.OTe9pra8.fVA1JqfJ.dpbs>

Description: On the website there are summary reports for every month for the past 10 years (120 reports in total). Each report provides the average monthly energy consumption and energy bill data for the residential and commercial sectors for all major cities in Ohio. The data from Columbus was extracted and used for Benefit-Cost Analysis.

Table 2: Rubric for Energy Reduction- GreenSpot

Outreach		
Create a Green Team (Rally coworkers to support sustainability efforts in your office)		50
Add members to your green team (Grow your green team to grow your office impact)		10
*Recruit Peer Businesses (Successfully encourage your peer businesses to join the challenge)		25
Initiate a sector-based mini challenge (Develop a sustainability activity that is important to your business sector and challenge your peers)		150
Like us, Follow us, Join us (Follow the Green Spot website etc...)		25
*Engage your Network (Share your lessons learned with your social network.)		25
Total		
Energy		
Learn about energy management (Energy Audit)		150
Track monthly energy use (Track monthly Energy use)		350
Install a new sub meter (Install a new sub meter to track energy use in your space)		450
Conduct a lighting Audit (inventory all lighting fixtures and lighting controls in your office)		225
Retrofit lighting (Switch out less than 50% of light fixtures for more efficient ones)		525
Switch out light bulbs (switch out less than 50% of light fixtures for more efficient ones)		400
Conduct a pre-challenge plug load survey (Understand your offices energy consumption related to electronics and appliances)		325
Power down electronics (Reduce plug load by encouraging coworkers to change their habits)		550
Install appliance controls (Reduce plug load by installing appliance controls throughout your office)		525
Total		
Energy at Home		
At-Home lighting (replace incandescent bulbs with the compact fluorescent or LEDs)/ household		15
At-Home: Electronics and Appliances (Use smart strips in your home to reduce energy use of electronics and appliances)/ household		15
At-Home: HVAC install a programmable thermostat / household		15
At-Home: Track Energy use / household		15
*At-Home : Get an Energy Assessment (Identify opportunities to save energy through a home energy assessment) / household		15
Total		

* Indicates that that these were taken from Philadelphia. The rest were best practices from the Chicago Green Office Challenge.

Description: GreenSpot already lays out ways that businesses can reduce the energy they use, but we have created an energy reduction rubric to add onto the GreenSpot program. This rubric is taking GreenSpot to another level and setting a point system for certain energy reductions that

not only the business can use, but the employees can implement these energy reductions at their own homes and collect points for their employer. This rubric will create a competition among businesses in the Columbus area and those businesses will strive to be the biggest energy reducer.