WORCESTER ART MUSEUM: CAFÉ SUSTAINABILITY EVALUATION

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and
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Abstract

The Worcester Art Museum, in Worcester, Massachusetts, would like to become more energy-efficient and reduce their carbon footprint. Our goal was to aid the Worcester Art Museum’s efforts to increase their sustainability by assessing energy use at the Worcester Art Museum’s café, and to develop recommendations to increase the energy efficiency and sustainability of the café. Our team interviewed representatives from other museums, restaurants, and dining halls that have implemented green technology to determine best sustainability practices. We also performed an evaluation of the Worcester Art Museum’s café to obtain their baseline efficiency. Once this information was gathered, our team was able to provide the café with specific recommendations to increase their energy efficiency and sustainability.
Executive Summary

The Department of Energy considers energy efficiency to be one of the simplest and most cost effective ways to reduce carbon pollution and therefore fight climate change (energy.gov). Consumers who use energy efficient technology will experience reduced energy consumption, which results in an increase in overall savings. Cutting-edge energy efficient technology can help decrease the country’s reliance on fossil fuels as a source of energy. These technologies are designed to promote energy security, or the long-term accessibility of affordable energy, and are a cost-effective way for creating a sustainable energy future.

The Worcester Art Museum, in Worcester Massachusetts, would like to become more energy efficient and reduce their carbon footprint. They have been inspired by other museums and institutions that have taken up green initiatives. Our goal was to aid the Worcester Art Museum’s efforts to increase their sustainability by assessing energy use at the Worcester Art Museum’s café, and to develop recommendations to increase the energy efficiency and sustainability of the café. The museum’s integration of green practices can also demonstrate to other institutions within the Worcester community that it is possible to improve the efficiency of their operations. The Worcester Art Museum can serve as a model for other museums that would like to increase the efficiency and sustainability of a museum café, but are unsure as to what it might entail, or where to start.

Literature Review

The museum has a café, an indoor dining room, and outdoor seating located in their courtyard. The entrance to the museum also has a small satellite cart that serves beverages, soups, and pastries. However the focus of our project was on the main café, which is open Wednesday-Saturday from 11:30am-2:00pm. They serve salads, soups, sandwiches, and a variety of desserts, with their typical customer in the 50+ age category. The café also contains a variety of cooking and preparation appliances, including a stove, a dishwasher, a microwave, as well as numerous refrigerators. This meant that there were a number of changes the museum could make to improve its operation. To better understand the scope of these kinds of changes, we explored key topics around incentives for increasing sustainability as well as sustainability accreditation programs such as Leadership in Energy & Environmental Design, Energy Star, and the Green Restaurant Association. We began with identifying incentives for increasing sustainability.

Incentives for Increasing Sustainability

In recent years, households and institutions welcomed the idea of energy efficiency for a variety of social and economic reasons beyond the environmental impact. Studies have shown that that cost savings or competitiveness, and social responsibility are among some of the main motivations for businesses and companies to go green (Pratima & Kendall, 2000; Graci & Dodds, 2008). It has been observed that cost or financial savings are one of the most significant factors that influence decisions for implementing environmental initiatives (Graci & Dodds, 2008). Often, this adaptation of green initiatives also means an increase in efficiency. This in turn allows for an institution to gain a competitive advantage in its industry. By being energy efficient and embracing green practices, businesses can create products using less material, resulting in lowered expenses and competitive advantage for themselves (Abraham, 2009). There are also a number of indirect benefits from labeling and marketing a business as eco-
friendly such as an improved image, healthier and safer facilities, and attracting a higher volume of customers (Graci & Dodds, 2008; Pratima & Kendall, 2000). However the initial costs of implementing green technology can be significant and daunting to companies that do not have the funds to pay the initial costs. Thus it is important for organizations to commit to making sustainability a part of their vision (Abraham, 2009).

There are also some institutions that respond to ecological issues because they feel they have a social obligation to do so. Differing from the competitive advantage motivation, institutions that may decide to increase their sustainability for responsibility reasons might embrace green products, even if it is less profitable to do so. Institutions that embrace this reasoning change because of a sense of obligation or responsibility, as opposed to self-interest, and can have the added benefit of a higher satisfaction or morale within the institutions (Pratima & Kendall, 2000).

Effectively implementing a “greener” energy program can act as a potential marketing tool. Some environmentally conscious programs are well respected in the industry and have proven to be credible sources of information. Institutions whose facilities meet the criteria of programs such as the Energy Star, WaterSense and LEED receive endorsement from these organizations. These programs are backed and recognized by some of the largest companies in the nation including 35% of Fortune 500 companies. Here we describe some of the key certification programs in greater depth.

**LEED Certification**

The Leadership in Energy & Environmental Design (LEED) certification, introduced by the United States Green Building Council (USGBC), is a program that “provides third-party verification of green buildings” (LEED, n.d.). They use multiple rating systems catered to specific building types. Because of this, each type of building has different requirements that it must fulfill before becoming LEED certified. There are also different rankings of LEED certification. In order to be LEED-certified, a building needs to receive approximately 40 to 49 points on the LEED scale. To be certified as Silver, a building typically needs 50-59 points, while to be Gold 60-79 points, and to be Platinum, above 80 points. These points are awarded from categories such as sustainable sites, water efficiency, energy and atmosphere, materials and resources, as well as indoor environmental quality. There are additional credit categories that award points based on a business’ impact on its neighborhood and surrounding area.

There are many reasons why businesses are drawn towards LEED certification. The USGBC invests over $30 million a year in order to improve and operate the LEED program. Becoming more energy efficient and eco-friendly can inspire other businesses in the community to do the same. In addition to all of these benefits, LEED-certified buildings can reduce operation costs, and energy and water bills by an average of 40% (LEED, n.d.).

**Energy Star and Energy Guide**

Energy Star is a voluntary program established by the Environmental Protection Agency (EPA) that was designed to promote energy efficient products in order to reduce pollution and protect the environment. The intent of the labeling program is to allow consumers to more easily identify and purchase efficient products (Brown, Weber, & Koomey, 2002). The Energy Star label is earned by testing the energy star product against its less-efficient counterpart. Its performance and energy consumption are verified in order to ensure that the Energy Star product works more effectively than its conventional equivalent. Additionally, all Energy Star
appliances carry an EnergyGuide label (Learn More About EnergyGuide, n.d.). This yellow label helps unveil some of the hidden costs of the appliances, as well as aid in comparing energy consumptions of similar models. The EnergyGuide label will contain an appliance’s annual energy consumption rate or its energy efficiency rating, as well as a range of consumptions of similar models, and an estimated yearly operating cost (Carter, 2004). These Energy Star and Energy Guide labels can provide useful information when considering purchasing or comparing more energy efficient products.

**Green Restaurant Association**

The Green Restaurant Association (GRA), founded in 1990, is a national non-profit organization aimed at helping all basic sectors of the restaurant industry become environmentally sustainable. The GRA offers manufacturers of green technology a way to advertise their products through an endorsement program. They help distributors ensure that they are offering the best environmentally friendly options. The GRA also informs consumers about local restaurants who are green or have begun to take steps towards becoming green. The association provides restaurants with specific tips on how to become more environmentally responsible in all aspects of their operations. They have developed a point system in which restaurants can earn points by replacing existing equipment with earth friendly alternatives. They give these restaurants the title of 2-Star, 3-Star, or 4-Star Certified Green Restaurant, depending on how many points they have earned. Points are earned based on the percentage of the restaurants appliances or practices that meet the GRA’s standards in each criterion. The association has seven categories in which restaurants must improve their sustainability, these include: energy, water, disposables, chemical and pollution reduction, sustainable food, as well as sustainable furnishings and building materials. Green technology is changing and improving, so an important aspect of the GRA’s certification process is that they require their certified restaurants to earn more points each year. This promotes continued improvement in environmental sustainability. It is also notable that the GRA rewards the title of “Certified Green Restaurant SustainaBuild” to newly built sustainable establishments that meet their criteria (Green Restaurant Association, n.d.).

**Methodology**

To accomplish our goal, we completed the following objectives:

- Comparable analysis of museums, restaurants, and college dining halls that utilize green materials and practices, and compile a detailed document containing each museum’s features, drawbacks, and attributes
- Perform a site assessment to determine the baseline efficiency of the Worcester Art Museum café
- Conduct a cost analysis to replace kitchen based equipment with earth friendly alternatives
- Develop sustainability recommendations based on findings

In this section we discuss the specific methodological strategies we used to achieve these objectives. The Worcester Art Museum asked us to research other museums utilizing green technology to understand their strategies and effectiveness. The three museums evaluated were The Grand Rapids Museum, the Boston Museum of Science, and the Children’s Museum of Pittsburgh. In addition to these museums, our team also identified green restaurants and college
dining halls to gain a kitchen based perspective on increasing efficiency and sustainability. We conducted in-depth phone interviews with a green initiative expert from each establishment in order to acquire more detailed information regarding each organization’s green initiatives.

We also established a baseline of efficiency in the café area. This included a water audit, waste assessment, and an appliance evaluation. The basic water audit was designed to help the museum better understand how and where water was being consumed within their café. We conducted a waste assessment of the Worcester Art Museum’s café, which involved performing a facility walk-through and observing the café’s disposable products and practices.

Using all of the information we collected, we offered recycling, composting, and purchasing options that may aid in reducing the amount of waste that the museum café produces. An assessment of the current energy consumptions of the Worcester Art Museum’s café was necessary in order to determine the benefits of using energy efficient and earth friendly equipment. Using power consumption meters, we measured the amount of watts an appliance uses. We also evaluated light bulbs to consider whether they could be replaced with more efficient choices, such as compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs), and looked into the possibility of installing a motion detection lighting system. With all of this information, it was possible to calculate cost benefits that energy efficient appliances would provide.

Results

Once the three museum interview transcripts were coded, our team noticed certain trends between these museums. First and foremost, it is important to note that The Children’s Museum of Pittsburgh and The Grand Rapids Art Museum implemented green technologies by designing new structures in a sustainable fashion, both earning LEED Certification. The Boston Museum of Science modified their existing building to incorporate green technology and practices. Additionally, the implementation of green initiatives by each museum required significant amounts of money.

Our team noticed other trends forming between the three museum interviews. First, all of the museums have implemented recycling and composting programs. As far as lighting, every museum uses LED lighting and took part in rebate programs to reduce the cost of the lights. In terms of water conservation, dual flush toilets and waterless urinals are used in The Children’s Museum of Pittsburgh and The Boston Museum of Science. The Grand Rapids Art Museum took a different approach to recycling rainwater and snow and used this gray water in their bathrooms and water fixtures. Finally, when discussing visitor response to the museums’ initiatives, every museum indicated that although initiatives were appreciated by visitors at the time they were being implemented, many have come to expect this type of operation and are not greatly surprised by the museum taking steps to improve its operations and help the environment.

The site assessment allowed us to tour the café kitchen and evaluate the efficiency of their current refrigerators. We observed that the refrigerators were seemingly in good condition. We were surprised that the calculated payback periods to replace these refrigerators with energy efficient refrigerators was so large. This certainly indicates that it will not be cost effective for the café to purchase energy efficient refrigerators at this time. This solution can be evaluated again in the long term when the refrigerators are in need of an expensive repair or replacement. However, the payback period we calculated to replace the pre-rinse spray valve was approximately 2-5 years. This is a more reasonable number and could be a more practical solution for the museum. We also observed the café disposables and noticed they use plastic
take out containers, styrofoam cups, and plastic utensils. These are all items that could be replaced and improved upon.

Recommendations and Conclusion

Through our research, we have developed recommendations in order to aid the Worcester Art Museum café run in a more sustainable manner. These recommendations include user practices, energy efficient alternatives, as well as a suggested timeline for implementation. A few examples of our recommendations for the cafe are below:

- Replace two single-door refrigerators with one energy efficient two-door refrigerator
- Replace the current pre-rinse spray with one that conserves water and is more appropriate for their specific needs
- Have employees recycle paper, plastic and metal materials
- Implement a composting program
- Replace plastic straws, utensils, and take-out containers with compostable products

Through the use of more sustainable materials, the Worcester Art Museum café will be able to run a more energy efficient and environmentally friendly operation. We believe that our recommendations are the first steps of many that will lead to the Worcester Art Museum becoming a model of sustainability for the community.

Our time working with representatives from the Worcester Art Museum was a valuable experience for us. By working with Katrina Stacy, we were able to provide viable recommendations that would help the museum become more environmentally friendly. By implementing these changes, the Worcester Art Museum can become a part of the growing number of places around the world that are looking to make a difference in their community and the environment. They will help in the efforts of creating a sustainable energy future and hope that their initiatives attract the attention of others.
Acknowledgements

We would like to thank everyone from the Worcester Art Museum who assisted us in completing this project. We truly appreciated the support and guidance from our sponsor, Katrina Stacy. Her knowledge and connection to the museum was a great asset to our team. We would also like to thank Francis Pedone, Director of Operations, who aided us in completing the site assessment of the Worcester Art Museum’s café.

We would like to show our appreciation to the many individuals from the museums, dining halls, and restaurants that we interviewed. They provided our team with the necessary insight into the workings of green technology and practices in their respective establishments, which allowed us to provide the Worcester Art Museum with valuable advice and recommendations.

Finally, we wish to thank several professors who were an integral part of this project. A special thanks to Professor Looft for providing us with the necessary equipment and advice that allowed us to evaluate the café appliances. We would like to express our gratitude to our project advisors Ingrid Shockey, Chickery Kasouf, and Purvi Shah. Their continued support, critique, and encouragement throughout our project experience allowed us to develop our research and refine our work.
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Chapter 1: Introduction

The Department of Energy considers energy efficiency to be one of the simplest and most cost effective ways to reduce carbon pollution and therefore fight climate change (energy.gov). Consumers who use energy efficient technology will experience reduced energy consumption, which results in an increase in overall savings. Cutting-edge energy efficient technology can help decrease the country’s reliance on fossil fuels as a source of energy. These technologies are designed to promote energy security, or the long-term accessibility of affordable energy, and are a cost-effective way for creating a sustainable energy future.

The Worcester (MA) Art Museum would like to become more energy efficient and reduce their carbon footprint. They have been inspired by other museums and institutions that have taken up these green initiatives. The museum hopes to be one of the first locations in Worcester to run a green operation. By doing so, they hope to become a role model for the Worcester community and motivate others to follow in their footsteps. They describe their educational mission as “demonstrating ways of carrying on operations while helping to protect the environment” (Berkeley, 2008).

The museum has already begun the process of implementing some green initiatives. They are employing the use of recycled materials in art classes, as well as using non-toxic printmaking methods on recycled paper (Berkeley, 2008). So far the museum has focused on implementing its green initiatives in their galleries and office space.

The museum has a café that serves lunch to visitors, and other members of the community. They would like their café to be included in their green initiatives. By utilizing energy-efficient appliances and practices, the museum hopes to present itself as an eco-conscious and inviting establishment while also potentially reducing their cost of operation. Their goal is to create a café that is both sustainable, and earth-friendly. They also hope that by implementing more changes, the museum and its café will catch the attention of college students in the 18-21 year old age range. However, it remains to be seen as to whether or not these changes will attract a younger demographic of visitors to the museum.

Our goal was to aid the Worcester Art Museum’s efforts to increase their sustainability by assessing energy use at the Worcester Art Museum’s café, and to develop recommendations to increase the energy efficiency and sustainability of the café. The museum’s integration of green practices will also demonstrate to other institutions within the Worcester community that it
is possible to improve the efficiency of their operations. This will inspire others to do the same and eventually provide a more sustainable future for Worcester. The Worcester Art Museum can serve as a model for other museums that would like to increase the efficiency and sustainability of a museum café, but are unsure as to what it might entail, or where to start.
Chapter 2: Literature Review

In this chapter, we discuss background information for our project. Our team researched the possible incentives for businesses to increase their sustainability as well as certifications these businesses can receive by applying such practices. We also examined restaurants that have implemented green initiatives. These restaurants served as case studies, and allowed us to evaluate possible green alternatives that could be used at the Worcester Art Museum.

2.1 Site Description: The Museum Café

The museum has a sit down café, an indoor dining room, and outdoor seating located in their courtyard. The entrance to the museum also has a small satellite cart that serves beverages, soups, and pastries, shown below in figures 1 and 2. However the focus of our project was on the main café area.

![Figure 1: The Worcester Art Museum's Café](image)
The café is open Wednesday-Saturday from 11:30am-2:00pm. They serve salads, soups, sandwiches, and a variety of desserts, with their typical customer in the 50+ age category. The café also contains a variety of cooking and preparation appliances, including a stove, a dishwasher, a microwave, as well as numerous refrigerators. This means that there were a number of changes the museum could make to improve its operation.

While the physical setting for our project is clear, terms such as “sustainable” or “green” can be difficult to understand and have ambiguous meanings. Before we continue, we will clearly explain our working definitions for this paper.

2.2 Terminology

In this field, the terms green technology, eco-friendly, and sustainable are overused and almost meaningless. These terms are very subjective and can mean different things to different people. In order to avoid this ambiguity, we defined these terms with regard to our report. The term “green technology” is loosely defined by the United Nations Economic and Social Commission for Asia and the Pacific as “technology that has the potential to significantly improve environmental performance relative to other technology” (Low carbon, n.d.). In this report, when green technology is mentioned it refers to equipment designed to be more efficient than what is conventionally used, therefore minimizing its impact on the environment. The
phrase eco-friendly is defined as goods, services and activities or practices considered to inflict little or least harm on the environment (Stranks, 2008). We used the term eco-friendly more specifically to refer to products and practices that have been proven to not produce any harmful side-effects to the environment. This term was also employed interchangeably with environmentally friendly and green. Lastly the Environmental Protection Agency says “sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations” (Sustainability, n.d.). In this context, sustainability will describe an operation that can maintain itself through reusable equipment and practices.

2.3 Incentives for Increasing Sustainability

In recent years, many households and institutions welcomed this idea of energy efficiency for a variety of social and economic reasons beyond the environmental impact. Studies have shown that that cost savings or competitiveness, and social responsibility are among some of the main motivations for businesses and companies to go green (Pratima & Kendall, 2000; Graci & Dodds, 2008). Here we discuss them in greater depth.

It has been observed that cost or financial savings are one of the most significant factors that influence decisions for implementing environmental initiatives (Graci & Dodds, 2008). Often, this adaptation of green initiatives also means an increase in efficiency. This in turn allows for an institution to gain a competitive advantage in its industry. By being energy efficient and embracing green practices, businesses can create products using less material, resulting in lowered expenses and competitive advantage for themselves (Abraham, 2009). There are also a number of indirect benefits from labeling and marketing a business as eco-friendly such as an improved image, healthier and safer facilities, and attracting a higher volume of customers (Graci & Dodds, 2008; Pratima & Kendall, 2000). However the initial costs of implementing green technology can be significant and daunting to companies that do not have the funds to pay the initial costs. Thus it is important for organizations to commit to making sustainability a part of their vision (Abraham, 2009).

There are also some institutions that respond to ecological issues because they feel they have a social obligation to do so. Differing from the competitive advantage motivation, institutions that may decide to increase their sustainability for responsibility reasons might
embrace green products, even if it is less profitable to do so. Institutions that embrace this reasoning change because of a sense of obligation or responsibility, as opposed to self-interest, and can have the added benefit of a higher satisfaction or morale within the institutions (Pratima & Kendall, 2000).

In the past decade there has been a shift from using conventional equipment and practices to more environmentally friendly alternatives (Clements & Eyraud, 2012). Businesses and households alike are beginning to see the incentives for becoming more conscious of their carbon footprint and energy consumption. Switching to more sustainable tools and appliances can cut costs in water and energy consumption. Government agencies have devoted time and energy to developing programs that promote the positive effects of becoming more energy efficient and eco-conscious (energy.gov).

Effectively implementing a “greener” energy program can act as a potential marketing tool. Some environmentally conscious programs are well respected in the industry and have proven to be credible sources of information. Institutions whose facilities meet the criteria of programs such as the Energy Star, WaterSense and LEED receive endorsement from these organizations. These programs are backed and recognized by some of the largest companies in the nation including 35% of Fortune 500 companies.

2.3 Certification Programs

There are a variety of different programs that offer certifications to businesses that implement green technology. These programs can assist in making the transition to greener technology and practices as well as potentially provide avenues for marketability. In this section we will outline several of the better-known programs.

LEED Certification

The Leadership in Energy & Environmental Design (LEED) certification, introduced by the United States Green Building Council (USGBC), is a program that “provides third-party verification of green buildings” (LEED, n.d.). In order for a building to become LEED certified, they must first choose a rating system, register, submit a certification application, and then once a decision is reached, the building owner can either accept or appeal the decision. Each rating system is catered to a specific building type. Because of this, each type of building has different
requirements that it must fulfill before becoming LEED certified. There are also different rankings of LEED-certification. In order to be LEED-certified, a building needs to receive approximately 40 to 49 points on the scale. To be LEED-certified Silver, a building typically needs 50-59 points, to be Gold 60-79 points, and to be Platinum, above 80 points. These points are awarded from many different categories such as sustainable sites, water efficiency, energy and atmosphere, materials and resources, as well as indoor environmental quality. There are additional credit categories that award points based on a business’ impact on its neighborhood and surrounding area.

The LEED certification program allows businesses the flexibility to choose which credits to earn based on the company’s interests and specific goals (Todd, Pyke, & Tufts, 2013). There are minimum requirements for an existing building to be awarded LEED certification. A few examples of these are that the building must reduce indoor water use, practice best energy efficiency management, implement an energy efficient refrigeration management system, and practice a green cleaning policy. These baseline practices will allow a building to become LEED certified, but there are other steps the organization must take in order to receive a higher LEED certification ranking. A few examples are to switch to more energy efficient interior lighting, provide an alternative transportation method, and manage rainwater (LEED, n.d.). The LEED Certification program relies on gradual improvement based on constant evaluation of market conditions, emergence of new technology, and the identification of ways to raise criteria standards. The most recent changes to the program occurred in 2009. Each new version clarifies requirements, incorporates new technology, and addresses problems in the previous version (Todd et al., 2013).

There are many reasons for why businesses are drawn towards LEED certification. The USGBC invests over $30 million a year in order to improve and operate the LEED program. Becoming more energy efficient and eco-friendly can inspire other businesses in the community to do the same. In addition to all of these benefits, LEED-certified buildings can reduce operation costs, and energy and water bills by an average of 40% (LEED, n.d.).

The main goal of the LEED certification program is to facilitate positive results for the environment, develop a standard for measuring green, prevent green-washing and promote a holistic approach to the building design process (Scheuer & Keoleian, 2002). Being a third party source, LEED offers an outside and objective evaluation of a building’s sustainability efforts.
This allows the LEED program to be seen as a well-respected industry standard. Companies are able to use their certification status as a marketing tool to attract more customers. LEED certified buildings tend to be built based on life cycle value as opposed to the standard first cost value (NRDC, n.d.). Though initial costs of becoming LEED certified can be high, they are usually alleviated by the overall savings over the building’s lifetime.

Energy Star and Energy Guide

Energy Star is a voluntary program established by the Environmental Protection Agency (EPA) that was designed to promote energy efficient products in order to reduce pollution and protect the environment. The intent of their labeling program is to allow consumers to more easily identify and purchase efficient products (Brown, Weber, & Koomey, 2002). The Energy Star label is earned by testing the energy star product against its less-efficient counterpart. Its performance and energy consumption are verified in order to ensure that the Energy Star product works more effectively than its conventional equivalent. Additionally, all Energy Star appliances carry an EnergyGuide label (Learn More About EnergyGuide, n.d.). This yellow label helps unveil some of the hidden costs of the appliances, as well as aid in comparing energy consumptions of similar models. The EnergyGuide label will contain an appliance’s annual energy consumption rate or its energy efficiency rating, as well as a range of consumptions of similar models, and an estimated yearly operating cost (Carter, 2004). These Energy Star and Energy Guide labels can provide useful information when considering purchasing or comparing more energy efficient products.

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points by replacing existing equipment with earth friendly alternatives. They give these restaurants the title of 2-Star, 3-Star, or 4-Star Certified Green Restaurant, depending on how many points they have earned. Points are earned based on the percentage of the restaurants' appliances or practices that meet the GRA’s standards in each criterion. The association has seven categories in which restaurants must improve their sustainability, these include: energy, water, disposables, chemical and pollution reduction, sustainable food, as well as sustainable furnishings and building materials. Figure 3, below, presents a breakdown of the points required in each category, as well as the overall amount of points required to achieve each level of certification.

<table>
<thead>
<tr>
<th>Energy</th>
<th>2 Star</th>
<th>3 Star</th>
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<td>Water</td>
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<td>10 points</td>
<td>10 points</td>
</tr>
<tr>
<td>Waste</td>
<td>10 points</td>
<td>10 points</td>
<td>10 points</td>
</tr>
<tr>
<td>Disposables</td>
<td>10 points</td>
<td>10 points</td>
<td>10 points</td>
</tr>
<tr>
<td>Chemical &amp; Pollution Reduction</td>
<td>10 points</td>
<td>10 points</td>
<td>10 points</td>
</tr>
<tr>
<td>Sustainable Food</td>
<td>10 points</td>
<td>10 points</td>
<td>10 points</td>
</tr>
<tr>
<td>Sustainable Furnishings &amp; Building Materials</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>REQUIRED MINIMUM</td>
<td>100 Points</td>
<td>175 Points</td>
<td>300 Points</td>
</tr>
</tbody>
</table>

Figure 3: Breakdown of the GRA’s points required in each category (Green Restaurant Association, n.d.)

Green technology is changing and improving, so an important aspect of the GRA’s certification process is that they require their certified restaurants to earn more points each year. This promotes continued improvement in environmental sustainability. It is also notable that the GRA rewards the title of “Certified Green Restaurant SustainaBuild” to newly built sustainable establishments that meet their criteria (Green Restaurant Association, n.d.).

2.4 Assessment Strategies for Auditing Commercial Kitchens

Commercial kitchens consume energy in a variety of ways (as shown below in Figure 4) and use about 2.5 times more energy per square foot than any other commercial building (Tyson, 2010). Although food preparation can cause the majority of energy consumption within restaurants, there are other elements that one might not consider, such as lighting and HVAC can
account for a total of 41% of the total energy consumption.

Employing green practices and utilizing energy efficient systems throughout a restaurant can result in significant decreases in carbon emissions, and also lower energy costs, producing savings that would otherwise be paid to utility companies (Ezcurra, 2009).

**Food Preparation Appliances**

Commercial kitchens include a variety of appliances involved in the preparation of food including ovens, fryers, and ranges. Leaving these types of equipment on standby costs money so implementing startup and shutdown plans to only use the equipment when necessary, as well as reducing cooking and idling time can be simple ways to reduce the amount of energy being consumed (Idaho Power, 2010). Simple ways of saving energy when operating ovens include turning off back-up ovens during slow periods and completely closing the doors of ovens are still on. Also, ovens with a window can allow the kitchen staff to check on the cooking progress without opening the unit, which can result in a loss of 20 – 50°F each time (Midwest Energy, n.d.). Keeping an oven full and cooking in large batches is a more efficient use of the oven’s energy and will cut down on the amount of time the oven needs to stay on (San Francisco, 2009).
Finally, the self-cleaning option of an oven should be used as infrequently as possible and only if has recently been used so that it can take advantage of any residual heat and not have to expend as much energy (American Council, 2012).

Fryers appliances in the kitchen can spend at least 75% of the day idling (San Francisco, 2009). An electric fryer can use up to three times less energy than gas fryers during this idle time, but can unfortunately come at a higher price. Additionally, fryers fitted with an automatic standby mode can reduce oil temperatures when the fryer is not in use (Tyson, 2010). There should also be an effort to avoid overfilling a fryer because it prolongs cooking time. Leaving a little extra room within the fryer will allow foods to be cooked faster and more evenly. Regularly degreasing and cleaning the fryer will allow it to work at its optimum efficiency and give it a long lifespan (Energy Star Guide for Commercial Kitchens, n.d.).

Ranges are one of the most common pieces of equipment in food preparation. They are also normally manually controlled appliances. The user should maintain and adjust the burners for the ranges. Having them on at full blast may seem to be the easiest way of operating these appliances, but it can also be one of the more inefficient ways of operating them. A wavy or uneven yellow flame can be a sign for the range needing a cleaning and readjustment (San Francisco, 2009). Having an electric induction range can also offer very high efficiency compared to gas ranges. This is because induction cooking generates heat to the cookware itself, as opposed to passing heat from the appliance to the cookware (Tyson, 2010). If induction ranges are not feasible, gas ranges tend to be more efficient than traditional electric ones.

Refrigeration

Refrigerators and freezers are an essential part of a restaurant’s operation, but they can also be the biggest energy user. However, increases and advances in recent technology have also allowed the refrigerator to become one of the most improved appliances in terms of energy efficiency (Pennybacker, 2008). New technologies such as hot gas anti-sweat heaters and high-efficiency compressors have also provided large improvements in the energy performance of refrigerators. When compared to old standard models in 2001, converting to newer and more efficient refrigerators and freezers can reduce energy costs by 40 percent (Pennybacker, 2008).

If replacing an entire refrigerator or freezer unit is not a viable option, there are other aspects of a refrigerator, as well as user practices that can be employed to reduce the energy
consumption of any current refrigeration system. Keeping thermostats around 37-40°F (2.7-4.4°C) for refrigerators and 5°F (-15°C) for freezers typically allow these appliances run most efficiently and save the most amount of energy (Midwest Energy, n.d.). Both of these appliances should be kept full, but refrigerators should not be overloaded to the point that the items inside block airflow. Additionally, if the refrigerator has an incandescent light bulb, it can produce extra heat that the refrigerator has to work to cool. Replacing these light bulbs with compact fluorescent lamps (CFLs) can reduce a light’s heat output by 75 percent (Energy Star Guide for Restaurants, 2010). Efficient walk-in refrigerators should also have fully sealed and insulated walkways and walls. Old refrigerators can have holes or missing insulation due to damage or corrosion. It is possible to replace any missing insulation with expanding foam as a sealant, and use aluminum panels to create a new wall without having to replace the refrigerator entirely (Frabel, 2007). Finally, regular maintenance on refrigerators can be essential for performance. Dirty refrigerator condenser coils can cause an increase in energy usage, as well as premature failure (Energy Tips, n.d.). Cleaning these coils with a vacuum or coil brush around 4 times a year can prevent these avoidable situations from occurring.

*Heating, Ventilation, and Air Conditioning (HVAC)*

Heating, ventilating, and air conditioning can consume a restaurant’s energy in a variety of ways and is often an overlooked component because of the large focus on food preparation. A poor balance of kitchen ventilation can allow excess smoke and heat to build up within the kitchen, leading to higher cooling bills. If possible, kitchens should have its cooking appliances against the wall so that a hood overhang can capture as much of the heat and smoke as it needs. Also, hoods only use energy when they are operating. Most of the time, kitchens operate at less than 25% of its full capacity during the day, but the exhaust hoods can run at full power (EnergyIdeas, 2003). Installing infrared and duct mounted temperature sensors call allow the fans to switch between low or high speed depending on the amount of cooking that is currently happening (Frabel, 2007). This can all lead to a cooler kitchen environment and reducing the temperatures in the kitchen by as little as 3°F can cut cooling costs by 12-15% (Energy Star Guide for Restaurants, 2010).
Sanitation

Sanitation systems, such as dishwashers, are an important component in any restaurant. Pre-rinsing dishes can also lead to a large increase in kitchen’s water use. By adding an efficient pre-rinse spray valve to a kitchen’s pre-rinse procedure, the user can cut both water use as well as hot water consumption. Figure 5, below, demonstrates how drastic an amount of savings one could expect by just simply implementing this one little change.

<table>
<thead>
<tr>
<th>Hours of Spray Valve Usage</th>
<th>Water Savings gallons/day</th>
<th>Waste Water Savings gallons/day</th>
<th>Gas Savings therms/day</th>
<th>Annual Dollar Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hour/day</td>
<td>60</td>
<td>60</td>
<td>0.5</td>
<td>$300 - $350</td>
</tr>
<tr>
<td>2 hours/day</td>
<td>120</td>
<td>120</td>
<td>1.0</td>
<td>$600 - $700</td>
</tr>
<tr>
<td>3 hours/day</td>
<td>180</td>
<td>180</td>
<td>1.5</td>
<td>$900 - $1050</td>
</tr>
</tbody>
</table>

*Figure 5: Pre-rinse valve savings (Energy Tips, n.d.)*

Commercial dishwashers also use energy in a variety of ways from electrical energy, water usage, and soap and chemicals. Using high energy efficient and water efficient dishwashers can save up to 1,200 gallons of water a year, as well as any costs associated with heating up water (Pennybacker, 2008). Additionally, there are some efficient dishwashers that will not require the user to pre-rinse dishes. Simply scraping off dishes can be sufficient for these washers and this will completely eliminate the need and costs of pre-rinsing. There are low temperature dishwashers that can reduce the amount of energy being used to heat up water, as well as potentially provide savings in water and chemical treatment costs (Idaho Power, 2010). Finally, if possible, run dishwashers with full loads. The appliance will typically use the same amount of power and water for partial loads as it will for full loads so filling up the dishwasher without overcrowding can maximize efficiency (EnergyIdeas, 2003).

Sanitation with restaurants has typically been accommodated with harsh chemicals that can also be dangerous to the environment. The use of green cleaners in restaurants can be a very smart option because it can reduce health and safety hazards, especially around food. Green cleaners have come a long way in the past few years. However, they can come at slightly higher costs and some restaurants refuse to use green cleaners because they do not believe they have
become strong enough yet to handle sanitation within commercial kitchens (Pennybacker, 2008).

**Lighting**

Typical commercial restaurants may expect to have lights on anywhere from 16 to 20 hours a day. By using CFL light bulbs instead of traditional incandescent light bulbs, a restaurant can reduce its lighting energy usage by 75 percent (Energy Star Guide for Restaurants, 2010). Since these light bulbs do also do not generate heat like the incandescent bulbs, this change also has the added benefit of reducing temperatures, allowing for cooler environments without the need for extra air conditioning (EnergyIdeas, 2003). The figure below shows that replacing just eight incandescent light bulbs with CFLs can provide an annual savings of $330 and last 10-50 times longer.

![Annual Savings After Replacing Eight Incandescent Lamps with Eight CFLs](image)

*Figure 6: Incandescent vs. CFL light bulbs (Energy Star Guide for Restaurants, 2010)*

Furthermore, research shows that “if each of the 945,000 restaurants in the United States replaced only one incandescent light bulb with a CFL, more than 630 million pounds of CO emissions could be avoided each year, and the restaurant industry could save about $42.5 million annually” (Energy Star Guide for Restaurants, 2010).

In addition to just replacing light bulbs, strategically installing timers and sensors in lights can also help reduce the amount that they are used. Timers can help automatically turn off lights after a certain cycle when it’s known that they will no longer be needed. This can be especially useful for any outdoor areas. Additionally, in areas like storerooms where there isn’t a lot of traffic, installing motion sensors on lights will allow lighting in these places to only be used when a person enters the space (Frabel, 2007).
Buying Locally

Purchasing local foods can not only reduce the amount of emissions associated with the traveling that food products take, but they can also help to eliminate food safety risks. Industrialization has allowed larger amounts of food products being produced in fewer locations, resulting in greater transportation distances and emissions to the environment (Murray, 2007). Larger production suppliers also have a greater risk of contamination because of the high volume they are producing, the lengthy travel times of products, and the long storages (White, 2009). When purchasing locally, restaurants can know exactly where their food is coming from, as well as what practices their local farms implement to ensure food safety. Local farms may also use less pesticides, chemicals, and fertilizer because they are not using huge plots and want to preserve the land they are given (Murray, 2007). However, prices of local goods can sometimes be more than commercial suppliers (White, 2009). Factory farms and other less expensive alternatives are artificially inexpensive by shortcutting processes that provide proper care for animals, proper disposal methods, and using unfair labor practices. For this reason, “expensive organic” is greatly misunderstood (Factory farming, n.d.). Many restaurants decide to buy locally because although it is more expensive, it allows them to support their local economy. Some restaurants in the Worcester and Boston area that buy local food include: Armsby Abbey, Evo, B.Good, Area Four and GustOrganics. These restaurants alter their menus seasonally to account for the growing seasons of different foods. Buying local foods is a rewarding experience because the restaurant knows where their food is coming from, they can be assured that it is fresh, and they can support their local farms.

2.5 Case Studies

The Worcester art museum café can learn from many models of greener café standards. We evaluated a selection of green restaurants and cafés that present some key samples for success.

Taranta Restaurant

In 2000, Jose Duarte opened a Peruvian-Italian restaurant in Boston’s North End. The opening was a success and Taranta was quickly accepted by the Boston community and by food
critics alike. Duarte decided to partner with the Green Restaurant Association in 2007 in an effort to try something new and at the same time become more sustainable (Green Restaurant Association, n.d.). An environmental consultant was sent to the restaurant to provide Duarte with specific and attainable solutions to help him reach his goal. The first of these solutions was to no longer use Styrofoam at Taranta. Next, low flow spray valves replaced traditional pre-rinse spray units to conserve water, each of which had the potential to save 60 gallons of water per hour (Green Restaurant Association, n.d.). The low flow valves also save in water heating costs and sewer charges. Taranta implemented solar powered candles for the dining room tables, energy efficient light bulbs, an energy-saving hand dryer, and motion sensors in the bathrooms to reduce energy consumption. Switching to the hand dryer alone saved the restaurant over $1,300 per year in energy costs. Also each $19 energy efficient light bulb saved $25 per year in energy costs. They adopted a composting and recycling system that cut the restaurant’s garbage disposal bill in half (Green Restaurant Association, n.d.). The restaurant switched from plastic straws to PLA biodegradable drinking straws that are made of corn. PLA products are compostable therefore the restaurant can mix them in with other materials to be composted (PLA Biodegradable, 2007). These changes were all implemented in one year and resulted in Taranta becoming a certified green restaurant.

Taranta also buys local food, which reduces the gas consumption of the manufacturers’ delivery trucks. The restaurant delivery truck was converted to use leftover cooking grease instead of gas. Since 2007, Duarte has continued to make changes to Taranta to make it even more sustainable. In 2008, Duarte was featured in a CNBC news article “How to Put Some Green into Your Business.” Duarte told CNBC “We try to synchronize eco-friendliness into every business decision we make… We’re still finding ways to conserve. If you save energy, you save money” (Schwartz, 2008). In November of 2011, Duarte installed a Cooltrol system in the restaurant’s walk-in cooler and freezer. The system reduces compressor run time, which in turn reduces the amount of energy consumed by the refrigerator and freezer. The restaurant will now save an average of $400 per year in electricity (Cooltrol installed, 2011). He also helps spread awareness throughout Boston on the importance of taking steps towards becoming a sustainable community (Green Restaurant Association, n.d.).
Boston University Dining Halls

Boston University has a program that focuses on incorporating sustainability into the university’s culture. The Dining Services sector of the program serves food that is healthy and sustainable. They have three 4-Star Green Certified Restaurants and one 3-Star Green Certified Restaurant on campus. Boston University is the first university that the GRA has awarded a four star rating. BU buys locally grown and organic food products whenever it is possible, and they only use cage free eggs. They also use EcoLab cleaning products that lower energy and water consumption while maintaining efficiency. Boston University buys Energy Star kitchen appliances whenever replacements are needed. Dining Services at BU also implemented a composting and recycling system to avoid sending large amounts of waste to landfills. By no longer using trays in their dining halls, BU saved an estimated 35,000 gallons of water per week and reduced their food waste by 30%. BU composes 98% of pre-consumer waste and 95% of post-consumer waste. They donate food waste to composting facilities that resell it as soil amendment. They have also eliminated much of their paper good waste but switching to disposable containers and utensils made from compostable materials. BU promotes the use of reusable coffee mugs by offering a $.25 discount at all campus stores. They sell reusable to-go containers for $4.00, and each time a student uses one for a meal they receive a $.25 discount. The implementation of these procedures allowed BU to increase the amount of waste their dining halls diverted from landfills by 48% in four years. Below in Figure 7 are four charts that display BU’s rapid progress (Boston University, n.d.).
Boston University Dining Services also has a program to promote sustainable dining in the college community. “Make a Difference Monday” is a once a month program when the dining halls specifically showcase foods with a minimal carbon footprint. They do not offer red meat, but instead have sustainable fish, poultry and non-meat proteins. In addition, the fruits and vegetables are locally grown and organic. While the dining halls offer these foods on a daily basis, this program focuses on only offering earth friendly dining options in an effort to educate the community on the environmental benefits of sustainable food (Boston University, n.d.).

2.6 Summary

Through our research, we have learned important points that aided our understanding of the problem. We discovered reasons why institutions become sustainable, including competitive
market advantage, social legitimacy, and moral obligation. Becoming sustainable can also provide institutions with the opportunity to earn certifications from many different programs including LEED, Energy Star, and the Green Restaurant Association. We also learned how to go about auditing commercial kitchens, as well as measuring and replacing individual pieces of equipment. Finally, we looked at some examples of restaurants that have seen success in making the transition to becoming more sustainable.
Chapter 3: Methodology

The goal of our project was to assess energy use at the Worcester Art Museum’s café, and to develop recommendations to increase the energy efficiency and sustainability of the café. To accomplish this, our team completed the following objectives:

- Comparable analysis of museums, restaurants, and college dining halls that utilize green materials and practices, and compile a detailed document containing each museum’s features, drawbacks, and attributes
- Perform a site assessment to determine the baseline efficiency of the Worcester Art Museum café
- Conduct a cost analysis to replace kitchen based equipment with earth friendly alternatives
- Develop sustainability recommendations based on findings

In this chapter we discuss the specific methodological strategies we used to achieve these objectives.

3.1 Comparable Analysis of Green Museums, Restaurants, and College Dining Halls

The Worcester Art Museum asked us to research other museums utilizing green technology to understand their strategies and effectiveness. The three museums evaluated were The Grand Rapids Museum, the Boston Museum of Science, and the Children’s Museum of Pittsburgh. In addition to these museums, our team also sought out green restaurants and college campus dining halls to gain a more kitchen based perspective on increasing efficiency and sustainability. We performed an Internet search to determine what each establishment has done to make themselves environmentally friendly. In addition, we conducted in-depth qualitative phone interviews with a green initiative expert from each establishment in order to acquire more detailed information regarding each organization’s green initiatives. We chose this interview method because our questions were open-ended and required detailed responses that were different for each place interviewed (Doyle, 2004). This style is not standardized, so it allowed us to ask follow up questions when clarification was required.

We used teleconferencing units, and asked for permission to record the interviews using a
digital audio recorder. One team member also took notes in case the recording failed. The
interview questions are located in Appendices B and C.

We transcribed each interview directly after it was conducted. We created a fairly
standardized document for each museum located in Appendix D containing information on the
green technology they use, the cost benefits for each piece of technology, recommendations from
the representative, and visitor response to their initiatives. After all the interviews were
conducted we began the process of analyzing the collected data. Our team coded the transcripts
from each interview, a process which involved highlighting all pertinent information in different
colors organized by topic. We took note of trends found in the interviews, which are described
in more detail in the results section. We analyzed the museum interviews separately due to the
fact that their technology and practices varied greatly from what the restaurants and dining halls
had implemented. Once the information was analyzed, we created a comprehensive evaluation
form that contains the synthesized green technology and practices that we believe could benefit
the Worcester Art Museum.

Sample

The representatives interviewed from the comparable museum held different positions
and had different involvements with the green initiatives. The table below summarizes
information about the representatives and their positions, as well as details about the lengths of
the interviews conducted with them.

<table>
<thead>
<tr>
<th>Representative name</th>
<th>The Boston Museum of Science</th>
<th>The Children’s Museum of Pittsburgh</th>
<th>The Grand Rapids Art Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position</td>
<td>Paul Ippito</td>
<td>Chris Siefert</td>
<td>Tom Hilzey</td>
</tr>
<tr>
<td>Length of recorded interview</td>
<td>15:50</td>
<td>15:13</td>
<td>25:40</td>
</tr>
<tr>
<td>Length of transcribed interview (single-spaced)</td>
<td>4 pages</td>
<td>3 pages</td>
<td>3 pages</td>
</tr>
</tbody>
</table>

*Table 1: Comparable Museum Interview Sample*

These interviews totaled 56.43 minutes and their combined transcript was ten pages in length.
Although each museum had various reasons and different individuals influencing the decision to become sustainable, these specific representatives were chosen because they are the ones currently in charge of continuing to implement any future green initiatives.

For the restaurant and dining hall interviews, some of the representatives were unavailable to speak on the phone, so emailed responses were obtained instead. As a result, the emailed responses tended to be shorter than the interviewed ones, but they still provided insight and useful information about initiatives and practices. A table summarizing the representatives interviewed is below.

<table>
<thead>
<tr>
<th>Representative name</th>
<th>Position / Title</th>
<th>Phone interview or emailed response</th>
<th>Length of recorded interview</th>
<th>Length of transcribed interview (single-spaced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVOO Restaurant</td>
<td>Owner</td>
<td>Phone</td>
<td>15:40</td>
<td>3 pages</td>
</tr>
<tr>
<td>Amherst College</td>
<td>Executive Chef</td>
<td>Email</td>
<td>N/A</td>
<td>1 page</td>
</tr>
<tr>
<td>Georgia Institute of Technology</td>
<td>Sustainability Coordinator</td>
<td>Email</td>
<td>N/A</td>
<td>2 pages</td>
</tr>
</tbody>
</table>

*Table 2: Restaurant and Dining Hall Interview Sample*

These interviews totaled 15.40 minutes and their combined transcript was six pages in length. Again, these representatives were chosen to be interviewed because they were either the specific contact listed about inquiries to their green initiatives, or had involvement with the implementation. However, for Amherst College, our team initially contacted the Director of Dining Services but due to emergencies he was unable to respond and provided an alternative person, to reply to our questions.

### 3.2 Site Assessment and Evaluation

We performed an analysis to establish a baseline of efficiency in the café area. This included a water audit, waste assessment, and an appliance evaluation.
Water Audit

In addition to an energy audit, our team performed a basic water audit. This was designed to help the museum better understand how and where water is being consumed within their café. We began by determining the intended use of each water fixture in the kitchen. Fixtures that are used solely for filling up any large containers may not need to be changed, but others such as spray valves for rinsing dishes could potentially qualify for a newer model that has a reduced water flow. These fixtures were measured by conducting a timed-flow test. This involved filling a fixed size container with water from the fixture and measuring the amount of time it took to fill. We then converted this timed flow to the equivalent gallons per minute for the faucet by using conversion tables in Appendix A (South Florida Water Management District, 2013). Once this information was known, we compared these flow rates to high efficiency models and determined the best replacement.

Waste Assessment

We conducted a waste assessment of the Worcester Art Museum’s café. According to the U.S. Environmental Protection Agency, conducting a waste assessment allows for both establishing a baseline of data and identifying potential waste reduction options (U.S. Environmental Protection Agency, 2013). We performed a facility walk-through and observed amounts of waste being produced, as well as identified waste generating equipment or practices. Using the information we collected, we offered recycling, composting, and purchasing options that may aid in reducing the amount of waste that the museum café produces.

Appliance Evaluation

An assessment of the current energy consumptions of the Worcester Art Museum’s café was necessary in order to determine the benefits of using energy efficient and earth friendly equipment. Using power consumption meters, we measured the amount of watts an appliance uses. Given this information, we converted the wattage using the formula below.
Daily Kilowatt − hour (kWh) consumption = \( \frac{\text{Wattage} \times \text{Hours Used Per Day}}{1000} \)

*Equation 1: Daily kWh Consumption (U.S. Department of Energy, 2013)*

Multiplying the value from this equation by the number of days the appliance is used during the year gives annual kilowatt-hour consumption. We needed to estimate the energy consumption of appliances that were constantly using energy, such as refrigerators and freezers. The U.S. Department of Energy states that in order to determine the number of hours a refrigerator operates at its maximum wattage, you should “divide the total time the refrigerator is plugged in by three” because although they are constantly plugged in, they actually “cycle on and off as needed to maintain interior temperatures” (U.S. Department of Energy, 2013). We evaluated light bulbs to consider whether they could be replaced with more efficient choices, such as compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs), and looked into the possibility of installing a motion detection lighting system. With all of this information, it was possible to calculate cost benefits that energy efficient appliances would provide.

### 3.3 Cost Analysis of Earth Friendly Alternatives

Replacing kitchen equipment and practices with earth friendly alternatives can provide numerous environmental benefits, and generate a profit after a certain period. We performed calculations to determine the rate of return of money on numerous energy efficient appliances. By selecting Energy Star qualified appliances, we were to use the energy consumption estimates to provide a timeline for when these appliances may produce enough savings to both negate the initial cost of the appliance, as well as potentially generate a profit, when compared to the current appliances being used.

*Return on Investment*

Phillips and Phillips describe the return on investment metric as a way to see “how resource expenditures compare to benefits” and “is typically stated in terms of a benefit-cost ratio (BCR), ROI percentage, or payback period” (Phillips & Phillips, 2013). We decided to express the return on investment just as a payback period because it most clearly expressed the
amount of benefits an appliance would produce, as well as provide a timeline for when the energy efficient appliance may begin to generate positive profit. The following equation shows the standard formula the team used in calculating the payback period.

\[
\text{Payback Period} = \frac{\text{Project Costs}}{\text{Annual Project Benefits}}
\]

*Equation 2: Payback Period*

In our evaluation, project benefits represented savings in operations that an energy efficient appliance can provide. Project costs mainly represented the cost of acquiring the piece of equipment, but could have also included a variety of different costs such as other project materials or facilities cost if they were considered to be significant. Given this information, we determined whether or not it would be practical to replace the appliance. If the payback period was within a reasonable number of years and within the expected life of the appliance, then there was a stronger case to replace the piece of equipment.

### 3.4 Sustainability Recommendations

The Worcester Art Museum is a non-profit organization and they were willing to dedicate a limited amount of funds to upgrade the café. Based on our findings and calculations, we created a plan we deemed to be most feasible for the museum to implement in order for them to accomplish their goal of creating a green café. We presented these findings during our final presentation accompanied with a binder provided to the Worcester Art Museum outlining our specific recommendations.
Chapter 4: Results and Analysis

In this chapter, we present our results from our interviews with museums, restaurants, and dining halls, as well as the site assessment. The chapter then moves onto discussion on trends the findings revealed, as well as other ideas that emerge from our data. This section contains our findings from our first three objectives. Our fourth objective, the sustainability recommendations, will be discussed in chapter five.

4.1 Comparable Analysis of Museums, Restaurants, and College Dining Halls

Although the methodologies we used to collect data from the museums, restaurants, and dining halls were similar, our interview questions were different for each type of establishment. This caused our findings to differ for each type of establishment, therefore we discuss them separately in this section.

Comparable Museums

Three museums, The Children’s Museum of Pittsburgh, The Grand Rapids Art Museum, and The Boston Museum of Science, agreed to participate in the interviews. Our process included initiating contact with the museum representative, conducting the interview, transcribing the interview, and coding the data. Attached in Appendices E-G are the completed summaries containing pertinent information from each museum interview.

Our first interview was with a representative from the Children’s Museum of Pittsburgh. He informed our team that the museum was a new building project that incorporated sustainability as part of an initiative by their board, staff, and community. The building process itself was very eco-friendly and incorporated the use of locally manufactured and recycled building materials and certified low emitting adhesives, sealants, paints, carpets and wood. The Children’s Museum of Pittsburgh conserves electricity by purchasing all of their electrical power from renewable sources. In addition they use photovoltaic cells to power balloon lighting in their café. Although the representative informed us that because the cells were purchased in 2004, the technology was new and they have a very minimal impact on the museum’s efforts to conserve energy. The museum also designed a white roof to reflect sunlight and reduce the need for air conditioning. They have a vegetated roofing system as well which helps to cool the building and reduce the run time of the HVAC system. The representative noted that he had
Denzel Amevor, Alexander Chen, Allison Corriveau, Saraf Rahman

wished the museum implemented more vegetated roofs, but at the time the systems were new and the museum’s options were limited.

The museum implemented a wide range of sustainability measures that affected all areas of operation. They conserve water by using dual flush toilets, low flow urinals, aerators at all faucets and no irrigation system in their landscape. The museum also implemented a number of measures in their café. They use “green cups” from NatureWorks and potato based 100% renewable and compostable plates, containers and utensils. The café also has a composting system to limit the amount of waste sent to landfills. This demonstrates the vast and diverse changes The Children’s Museum of Pittsburgh implemented to become more sustainable.

The museum’s efforts and dedication earned them a Silver LEED Certification as well as the gratitude of the members of their community. As mentioned in our literature review, LEED Certification is difficult to obtain and requires hard work and dedication from the business seeking recognition. They received positive feedback from the community and many were thankful that the Children’s Museum of Pittsburgh was leading the way for other businesses in the area.

Next our team interviewed a representative from the Grand Rapids Art Museum (GRAM). This museum was also a new building project whose lead donor mandated that they go for LEED Certification. The museum set high standards for themselves and aimed to achieve Gold Certification. The museum conserves electricity by using an interior shading system to diffuse natural light, which allows the museum to use 70% ambient lighting from natural light. The Grand Rapids Art Museum uses recycled rainwater and melted snow for water features, sanitary purposes, and landscape irrigation. GRAM had a custom HVAC system installed, which is crucial to protecting the sensitive art in the building. They have also taken various measures to improve insulation including a white roof, three-layer UV filter glass in windows, Argon gas between glass window panels, low-emission coatings on all components, and light-colored concrete walls. These measures ensure that the building’s HVAC system is not used as much. In addition the museum uses a composting and recycling program, recycled paper products, and green cleaning products. The museum’s initiatives allowed them to save approximately $90,000 in energy costs per year.

Lastly, our team interviewed a representative from the Boston Museum of Science. In 2009, the museum spent approximately 3.5 million dollars on sustainable initiatives in order to
reduce the carbon footprint of their existing building. They contracted Johnson Controls, a company committed to helping businesses increase their sustainability, to perform a detailed energy audit and recommend solutions to help reduce their carbon footprint. The museum took part in NSTAR’s rebate program and replaced approximately 5000 incandescent light bulbs with LED bulbs. They implemented a demand control ventilation system in their kitchen exhaust fans, which senses whether or not there is smoke in the kitchen and runs accordingly. This prevents the constant removal of air from the building that has already been conditioned. They also installed a control system on their walk-in coolers and freezers. The museum used window films to reduce solar gain. The representative added that they were very efficient on the older windows that were too difficult and expensive to replace. When we asked the representative if there was any technology the museum would recommend, he said they have had success with variable frequency drives (VFD). When the museum’s units turn on in the morning they are not simply running at their highest capacity, they are slowly ramping up. VFDs can be installed on systems that do not require their electric motor to run constantly, for example an HVAC system. The VFD controls a system’s frequency and voltage to meet the requirements of the electric motor’s load. Therefore, implementing VFDs can reduce a building’s energy consumption (What is a variable frequency, n,d).

Our team inquired about the challenges the Boston Museum of Science faced when implementing green technology and the representative explained that whenever one is working with an existing building rather than a new build there are more challenges. They had old transformers that were in need of replacement, so they decided to convert to a more efficient electrical transformer with a 75-year payback period. The museum sought to improve some of the capital infrastructure in the process of implementing green technology. Lastly we asked the representative if he felt that the museum had attracted a younger age demographic since implementing green technology. He explained that the expectations of the younger audience are higher regarding sustainability. The younger age demographic is more in tune with green practices and they have come to expect it. The Boston Museum of Science is committed to sustainability and continues to make plans for future renovations to further reduce their carbon footprint.
Restaurants and College Dining Halls

The team also conducted interviews at a selection of green restaurants and college dining halls to obtain information more specific to café and kitchen areas, as opposed to the entire museum. One of the restaurants our team interviewed was EVOO in Cambridge, MA. EVOO prides itself on green operation and overall eco-consciousness. The efforts made by the restaurant earned them a LEED gold certification. The push for a green restaurant started with construction. When building, EVOO used as many local products and materials as possible. All of the restaurant’s lights, tables, and floor tiles are bought from vendors within a 150 mile radius. We found that this effort extends to their food purchases as well. The restaurant attempts to buy all of their food from local farmers. This causes EVOO to change its menu based on what is available seasonally and locally.

EVOO has incorporated many sustainability measures into their everyday operations. Their kitchen contains Energy Star and energy efficient refrigeration and dish equipment. All paint, glue, and chemicals used by the restaurant are made with either low or no volatile organic compounds, in order to do as little harm to the environment and to mitigate indoor air pollution. EVOO has also implemented a composting program and recycling program which includes reclaimed materials and biodegradable disposables. This allows the restaurant to divert their organic waste from landfills.

One of the biggest challenges EVOO faces is dealing with local vendors. Because the menu changes seasonally, EVOO deals with over 30 different farmers and distributors. The farms are sometimes inconsistent in the product they are growing and the quality varies depending on environmental conditions. EVOO also purchases whole animals in an effort to reduce waste. This is a very cost effective process because the restaurant uses as much of the animal as possible. This process is very labor intensive but the restaurant finds it to be rewarding. The representative admits that implementing some of their green practices comes at a higher price, however the restaurant considers the lower environmental impact worth the extra cost.

We also interviewed a representative from Amherst College. They have a large recycling program in which they recycle aluminum, plastic, cardboard, glass, food grease, as well as larger equipment and small wares/stainless. In addition, Amherst has a composting program and
utilizes compostable paper products. They divert approximately 8 tons of food waste from landfills each month. The representative informed us that the switch to compostable products was costly, as compostable paper supplies and potato-ware or corn products that have replaced plastic products are more expensive than conventional plastic and paper materials. The dining halls also use green cleaning chemicals, which tend to be more expensive for ware washing. Amherst College buys locally grown food whenever possible. Approximately 10% of their food products are grown on local farms. This supports local economy and reduces carbon emission from the delivery process. The representative told our team that the sustainable measures they have taken are helping the college reduce its carbon footprint. The Amherst community has shown an exceptionally positive and supportive response to the college’s initiatives. When we asked the representative if they had any advice for a museum that is looking to become sustainable, the representative said as one markets the importance of what they are doing to make a difference, the program will gain initiative and grow. They also suggested involving the students, as there are many that will actively engage and become advocates of the museum’s efforts.

The final interview we conducted was with a representative from the Georgia Institute of Technology located in Atlanta, GA. The dining services at Georgia Tech found that utilizing green technology offers significant savings on both energy and water usage while also positively influencing the surround community. However, they also found that implementing green technology requires a great investment upfront, especially in the beginning stages of implementation. Before implementing all of these programs and green technologies, there were some reservations regarding the financial impacts. Ultimately the institute found that being environmentally conscious outweighed the initial cost. The majority of the funds needed for this process were used to purchase energy efficient appliances. In addition, there were costs to train the employees and managers on how to use these technologies, as well as service agreements, and licensing fees.

Currently, the dining halls are using an on campus herb garden, which provides local herbs to two of their dining areas. In total, 30-35% of all produce served in these dining halls are locally grown. They have also implemented a bio-digester, which naturally converts food waste into water, as well as a composting program where all food waste is converted into compost and returned to campus as fertilizer during planting season. They have also implemented energy
efficient and water efficient appliances, lighting, and water fixtures. All napkins are made from recycled material, and all of the containers will decompose in 10 weeks if composted. In addition, the Georgia Institute of Technology dining services also uses a system offered by LeanPath, which tracks pre-consumer waste and provides a detailed report on the waste as well as recommendations to reduce waste. These changes had a positive impact as they increased campus awareness of the implemented programs, reduced utility usage, and lowered food costs. Implementing green practices has changed the way the kitchens operate in that the institution’s kitchen employees have created innovative uses for typically discarded items. The Georgia Tech community has welcomed the environmental initiatives, and works towards helping the school achieve their sustainability goals. By implementing their programs on a daily basis, dining services has been able to reduce energy, water, waste, and carbon dioxide emissions. The overall effect of these environmentally conscious changes has positively impacted campus life and campus dining, while also lowering Georgia Tech’s carbon footprint.

4.2 Site Assessment

Our team performed an appliance analysis on several pieces of café equipment in order to get a baseline of the café's current efficiency. We noticed that the refrigerator’s compressor had to be running in order to get an accurate reading, so we had to leave the refrigerators open for a few minutes before taking the reading. This allowed us to get the most accurate reading possible to determine how much energy each appliance uses per day. The café has five refrigerators and two freezers. In Appendix K we present the layout of the café kitchen and storage provided to us by the museum. Each refrigerator and freezer has a designated number. There was one refrigerator that we were not able to assess because its power cord was inaccessible. Instead, we took a photograph of its specifications and used the compressor information to obtain an approximate energy use online. We were able to successfully evaluate the remaining six refrigerators and freezers. Below is a table, which summarizes the energy use of the café’s refrigerators and freezers.
We also assessed other appliances in the café including the two microwaves, a commercial toaster, and a 6-range stove and oven. A certified list of comparable efficient appliances does not yet exist for these products. There was also no way for us to determine the efficiency of the stove and oven because it was a gas appliance. With no model number and no way of telling the age of the equipment our energy consumption approximation would be very inaccurate.

The café kitchen contained 3 water fixtures. Two of those fixtures were faucets to large sinks, and the remaining fixture was a pre-rinse spray valve. Without fully knowing the intended use of the large sink faucets, we did not think that it would be necessary to measure water flow in case they were meant to be used to fill pots or buckets. However, the pre-rinse spray valve had a clear measurement of 1.42 gallons per minute (GPM) labeled on the fixture itself. This water fixture could potentially benefit from being replaced with a more efficient model and cost analyses of alternatives are provided in the next section.

In addition, we observed that the café had twelve easily visible 34-watt, 48 inch fluorescent tubes. Switching to LED lighting is a common method to save electricity. We researched LED light bulbs and found that they could be expensive, ranging anywhere from $20-$50 per tube. However we found multiple rebate programs to assist companies that are trying to

Table 3: Raw Data for Café Refrigerators and Freezers

<table>
<thead>
<tr>
<th>Café appliance number</th>
<th>Brand</th>
<th>Model Number</th>
<th>Dimensions L x W x H (inches)</th>
<th>Volume (cu. ft.)</th>
<th>Measured Energy Consumption (Watts)</th>
<th>Daily Energy Consumption (kW/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>True Refrigeration</td>
<td>T-35</td>
<td>29.5x39.5x77</td>
<td>35</td>
<td>485</td>
<td>3.88</td>
</tr>
<tr>
<td>R-2</td>
<td>Traulsen</td>
<td>RRI132 HUT-FHS</td>
<td>32x30x77</td>
<td>39</td>
<td>630</td>
<td>5.04</td>
</tr>
<tr>
<td>R-3</td>
<td>Traulsen</td>
<td>RHT132 WUT</td>
<td>32.5x30x77</td>
<td>24.2</td>
<td>862.5 (estimated)</td>
<td>6.09</td>
</tr>
<tr>
<td>R-4</td>
<td>Frigidaire</td>
<td></td>
<td>21.5x41x34</td>
<td>83</td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>R-5</td>
<td>Delfield</td>
<td>6125-S</td>
<td>32x25x73.5</td>
<td>20</td>
<td>177</td>
<td>1.416</td>
</tr>
<tr>
<td>R-6</td>
<td>Hobart</td>
<td>Q2</td>
<td>34x54x76</td>
<td>48.9</td>
<td>665</td>
<td>5.32</td>
</tr>
<tr>
<td>Prep-Fridge</td>
<td>Randell</td>
<td>9040K-7</td>
<td>33x60x34.8</td>
<td>14.67</td>
<td>560</td>
<td>4.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model Number</th>
<th>Dimensions L x W x H (inches)</th>
<th>Volume (cu. ft.)</th>
<th>Measured Energy Consumption (Watts)</th>
<th>Daily Energy Consumption (kW/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>True Refrigeration</td>
<td>T-35</td>
<td>29.5x39.5x77</td>
<td>35</td>
<td>485</td>
<td>3.88</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RRI132 HUT-FHS</td>
<td>32x30x77</td>
<td>39</td>
<td>630</td>
<td>5.04</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RHT132 WUT</td>
<td>32.5x30x77</td>
<td>24.2</td>
<td>862.5 (estimated)</td>
<td>6.09</td>
</tr>
<tr>
<td>Frigidaire</td>
<td></td>
<td>21.5x41x34</td>
<td>83</td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>Delfield</td>
<td>6125-S</td>
<td>32x25x73.5</td>
<td>20</td>
<td>177</td>
<td>1.416</td>
</tr>
<tr>
<td>Hobart</td>
<td>Q2</td>
<td>34x54x76</td>
<td>48.9</td>
<td>665</td>
<td>5.32</td>
</tr>
<tr>
<td>Randell</td>
<td>9040K-7</td>
<td>33x60x34.8</td>
<td>14.67</td>
<td>560</td>
<td>4.48</td>
</tr>
</tbody>
</table>
Denzel Amevor, Alexander Chen, Allison Corriveau, Saraf Rahman

switch to LED lighting. There are two rebate programs that are concerned with green technology from which the museum could benefit. The first is the Energy-Efficient Commercial Building Tax Reduction which states that a building can earn back anywhere from $0.30 to $1.80 per square foot (Dsire, n.d.). Using the café layout map in Appendix K, we calculated the area of the kitchen to be 375 square feet. By using the above rates and area of the kitchen, we determined that the approximate amount of money the museum could earn as rebate ranges from $112.50 at $0.30 per square foot to $675 at $1.80 per square foot. A second, and more beneficial rebate program, is the energy-efficient appliance manufacturing tax credit. This program would provide more benefits for the museum because the eligible efficiency technologies are dishwashers and refrigerators. For dishwashers, the museum could receive anywhere from $25 to $75 depending on the energy and water efficiency of the machine. For refrigerators, the museum could receive $150 to $200 depending on the energy-efficiency rating (Dsire, n.d.). An issue with this rebate program, however, is that the tax credit expired at the end of 2011, yet it was renewed for certain appliances that were manufactured in 2012 and 2013.

4.3 Cost Analysis

Once we reviewed the findings from our site assessment of the Worcester Art Museum’s café, our team was surprised at the low energy reading that we recorded on the café’s two freezers. When we researched comparable energy star freezers we found that the energy efficient freezers consumed significantly more energy than our reading of the café’s freezers. For unknown reasons our freezer measurements were inaccurate and we were unable to determine the proper energy use of the freezers. Fortunately our energy readings on the remaining refrigerators were more accurate. We researched multiple energy efficient alternatives to each refrigerator and compared their energy use to determine which energy efficient refrigerator would benefit the Worcester Art Museum the most. Our data comparing these refrigerators is located in Appendix H. Once we found the most energy efficient refrigerators we compared them to the current refrigerators in order to determine the yearly energy and cost savings as well as the payback period. In the tables below we compared the most energy efficient refrigerators that are equivalent to the types of refrigerators that the café is currently using. Energy cost obtained from the U.S. Energy Information Administration (Electric Power, 2014).
<table>
<thead>
<tr>
<th></th>
<th>Café Refrigerator number: R-1</th>
<th>Energy Efficient Refrigerator</th>
<th>Café Refrigerator number: R-2</th>
<th>Energy Efficient Refrigerator</th>
<th>Café Refrigerator number: R-3</th>
<th>Energy Efficient Refrigerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Consumption (kW/day)</td>
<td>3.88</td>
<td>2.48</td>
<td>3.13</td>
<td>2.74</td>
<td>6.9</td>
<td>2.74</td>
</tr>
<tr>
<td>Dimensions (L x W x H)</td>
<td>29.5x39.5x77</td>
<td>52 x 34 x 78</td>
<td>36 x 36 x 39</td>
<td>35.5 x 35.5 x 83</td>
<td>35 x 24.875 x 83.25</td>
<td>35.5 x 35.5 x 83</td>
</tr>
<tr>
<td>Volume (cu.ft.)</td>
<td>35</td>
<td>50</td>
<td>39</td>
<td>36.2</td>
<td>24.2</td>
<td>36.2</td>
</tr>
<tr>
<td>Cost</td>
<td>N/A</td>
<td>$3833.57</td>
<td>N/A</td>
<td>$7277.49</td>
<td>N/A</td>
<td>$7277.49</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>$72.72</td>
<td>N/A</td>
<td>$20.26</td>
<td>N/A</td>
<td>$216.07</td>
</tr>
<tr>
<td>Payback Period (years)</td>
<td>N/A</td>
<td>52.72</td>
<td>N/A</td>
<td>359.27</td>
<td>N/A</td>
<td>33.68</td>
</tr>
</tbody>
</table>

*Table 4: R-1, R-2, R-3 Cost Analysis*

<table>
<thead>
<tr>
<th></th>
<th>Café Refrigerator number: R-6</th>
<th>Energy Efficient Refrigerator</th>
<th>Café Preparatory Refrigerator</th>
<th>Energy Efficient Refrigerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Consumption (kW/day)</td>
<td>5.32</td>
<td>1.82</td>
<td>4.48</td>
<td>1.104</td>
</tr>
<tr>
<td>Dimensions (L x W x H)</td>
<td>34x54x76</td>
<td>83x211x35</td>
<td>33x60x34.875</td>
<td>31x60x41</td>
</tr>
<tr>
<td>Volume (cu.ft.)</td>
<td>48.9</td>
<td>46</td>
<td>14.67</td>
<td>21.6</td>
</tr>
<tr>
<td>Cost</td>
<td>N/A</td>
<td>$9342.50</td>
<td>N/A</td>
<td>$2900.37</td>
</tr>
<tr>
<td>Energy Rate (cents)</td>
<td>14.23¢</td>
<td>14.23¢</td>
<td>14.23¢</td>
<td>14.23¢</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>$181.79</td>
<td>N/A</td>
<td>$175.35</td>
</tr>
<tr>
<td>Payback Period (years)</td>
<td>N/A</td>
<td>51.39</td>
<td>N/A</td>
<td>16.54</td>
</tr>
</tbody>
</table>

*Table 5: R-6 and Preparatory Refrigerator Cost Analysis*

These alternative refrigerators, although very energy efficient, result in large payback periods because of their price. Consequently, we attempted to find ways of replacing the refrigerators that would offer the shortest payback period. We found that replacing the two single-door
refrigerators, R-2 and R-3, with one double door refrigerator was very cost effective. The cost analysis for this replacement is shown in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Café Refrigerator number: R-2</th>
<th>Café Refrigerator number: R-3</th>
<th>Combined Refrigerators: R-2 and R-3</th>
<th>Cost Efficient Refrigerator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Consumption (kW/day)</td>
<td>3.13</td>
<td>6.9</td>
<td>10.03</td>
<td>2.48</td>
</tr>
<tr>
<td>Dimensions (L x W x H)</td>
<td>36 x 36 x 39</td>
<td>35 x 24.875 x 83.25</td>
<td>N/A</td>
<td>52 x 34 x 78</td>
</tr>
<tr>
<td>Volume (cu.ft.)</td>
<td>39</td>
<td>24.2</td>
<td>63.2</td>
<td>50</td>
</tr>
<tr>
<td>Cost</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$3833.57</td>
</tr>
<tr>
<td>Energy Rate (cents)</td>
<td>14.23¢</td>
<td>14.23¢</td>
<td>14.23¢</td>
<td>14.23¢</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>$392.14</td>
</tr>
<tr>
<td>Payback Period (years)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>9.77</td>
</tr>
</tbody>
</table>

Table 6: Cost Analysis of Replacing Both R-2 and R-3

Although this method causes a reduction in volume of 13.2 cubic feet, it does provide a great reduction in the number of years of the payback period. If the extra volume can be lost, this would be the most cost effective way of replacing the refrigerators.

We also evaluated the efficiency of the pre-rinse spray valve in the café. We found a number of options, which we compare to the current spray valve. This data can be found in Appendix M. The table below summarizes two of the spray valves with the smallest payback period.
<table>
<thead>
<tr>
<th></th>
<th>Old Baseline</th>
<th>Bricor Pre-Rinse Sprayer (0.6 GPM)</th>
<th>TS Brass B-0107-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>N/A</td>
<td>$79.95</td>
<td>$98.50</td>
</tr>
<tr>
<td>Flow Rate (gal/min)</td>
<td>1.42</td>
<td>0.60</td>
<td>0.65</td>
</tr>
<tr>
<td>Operating Hours (hours/day)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Operating Days (days/year)</td>
<td>208</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Water Cost per hundred cubic feet (CCF)</td>
<td>$3.51</td>
<td>$3.51</td>
<td>$3.51</td>
</tr>
<tr>
<td>Water Cost per gallon (1CCF = 748gallons)</td>
<td>$0.00469</td>
<td>$0.00469</td>
<td>$0.00469</td>
</tr>
<tr>
<td>Annual Water Consumption (CCF)</td>
<td>23.6919786</td>
<td>10.01069519</td>
<td>10.84491979</td>
</tr>
<tr>
<td>Annual Water Consumption (gallons)</td>
<td>17721.6</td>
<td>7488</td>
<td>8112</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$83.16</td>
<td>$35.14</td>
<td>$38.07</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>$48.02</td>
<td>$45.09</td>
</tr>
<tr>
<td>Payback period (years)</td>
<td>N/A</td>
<td>1.66</td>
<td>2.18</td>
</tr>
</tbody>
</table>

*Table 7: Pre-Rinse Spray Valve Cost Analysis*

The water cost rate of $3.51 was obtained through a recent water bill for the Worcester Art Museum. However, in order to complete the table above, we had to make some educated assumptions. First, we assumed that the spray valve was operated for an estimated one hour per day, and that the café operates 208 days per year, based on opening four days a week for every week of the year. The costs used for each fixture are based off of manufacturer’s retail price. However, there exist third party retailers that can offer these same fixtures are reduced costs, which will further reduce the payback period. Finally, it is important to note that spray valves around 0.65 GPM may not be able to properly clean baked-on residue so it is also important to select the best alternative based on the needs of the kitchen.

Our team also evaluated the café kitchen lighting and researched alternatives. However, due to the relative inexpensiveness of running lights, as well as the kitchen’s lighting not being terribly inefficient at 34W, LED alternatives again did not provide the desirable quick payback periods. The table summarizes the two most efficient alternatives found, and a full list of results
can be found in Appendix N.

<table>
<thead>
<tr>
<th></th>
<th>Old Baseline</th>
<th>Philips 4 ft. T8 20-Watt Cool White (4000K) Linear LED Light Bulb</th>
<th>TOGGLED 48 in. T8 18.3-Watt Soft White (3500K) Linear LED Tube Light Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>N/A</td>
<td>$29.99</td>
<td>$39.97</td>
</tr>
<tr>
<td>Operating Hours (hours/day)</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Operating Days (days/year)</td>
<td>208</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td>Watt Reading</td>
<td>34</td>
<td>20</td>
<td>18.3</td>
</tr>
<tr>
<td>kWh / day</td>
<td>0.119</td>
<td>0.07</td>
<td>0.06405</td>
</tr>
<tr>
<td>Annual kWh</td>
<td>24.752</td>
<td>14.56</td>
<td>13.3224</td>
</tr>
<tr>
<td>Energy Rate (cents)</td>
<td>14.23¢</td>
<td>14.23¢</td>
<td>14.23¢</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$3.52</td>
<td>$2.07</td>
<td>$1.90</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>1.45</td>
<td>1.63</td>
</tr>
<tr>
<td>Payback period (years)</td>
<td>N/A</td>
<td>20.68</td>
<td>24.58</td>
</tr>
</tbody>
</table>

*Table 8: Lighting Cost Analysis*

Again, some assumptions were made in calculating this cost analysis due to the lack of available information. Similar to the previous refrigerator cost analyses, the cost of energy was obtained from the U.S. Energy Information Administration (Electric Power, 2014). Additionally, the number of hours the lights are used each day were estimated from the hours of operation of the café. If the café lights are used more than the just the explicit hours of the café, then savings will increase further and the payback period will shorten.

**Discussion**

Once the three museum-interview transcripts were coded, our team noticed trends between these museums. First and foremost, it is important to note that the green initiatives
implemented by The Children’s Museum of Pittsburgh and The Grand Rapids Art Museum came through brand new structures being built, both earning LEED Certification, while The Boston Museum of Science modified their existing building. Additionally, the implementation of green initiatives by each museum required significant amounts of money. The chart below summarizes the costs experienced by each museum.

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<thead>
<tr>
<th>Museum</th>
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<tr>
<td>The Children’s Museum of Pittsburgh</td>
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<td>The Boston Museum of Science</td>
<td>$3.5 million</td>
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*Table 9: Museum Costs for Green Initiatives*

Although the costs for The Children’s Museum of Pittsburgh and The Grand Rapids Art Museum are inflated due to the fact that they include construction costs, it is still apparent that implementing green initiatives throughout a museum can become an expensive task. However, The Children’s Museum of Pittsburgh and The Grand Rapids Art Museum received funds from donors, which covered the cost of their building projects while The Boston Museum of Science invested money to perform the renovations because they were committed to becoming more sustainable.

Our team noticed other trends forming between the three museum interviews. First, each of the museums we interviewed has implemented recycling and composting programs. Each museum uses LED lighting and took part in rebate programs to reduce the cost of the lights. In terms of water conservation, dual flush toilets and waterless urinals are used in The Children’s Museum of Pittsburgh and The Boston Museum of Science. The Grand Rapids Art Museum took a different approach to recycling rainwater and snow and used this gray water in their bathrooms and water fixtures. Finally, when discussing visitor response to the museums’ initiatives, every museum indicated that although initiatives were appreciated by visitors at the time they were being implemented, many have come to expect this type of operation and are not greatly surprised by the museum taking steps to improve its operations and help the environment.

With the data and findings collected from the comparable museum interviews, it is clear that although each museum have small aspects of increasing their sustainability, such as
recycling and composting programs and LED lights, in order for a museum to gain recognition of their green efforts, they must commit to some larger scale changes throughout the museum and invest or raise a significant portion of money. However, with the focus of our project solely on the Worcester Art Museum’s café, there exists the possibility that the Worcester Art Museum could start small with their café and showcase green initiatives implemented within that area before expanding to include the rest of the museum. Another interesting finding through the museum interviews was how visitors are expecting these green initiatives more and more rather than being impressed by them. This finding may seem to suggest that although initial responses to green initiatives are positive, relying on this aspect to attract visitors in the long run may not be a viable option.

Once the interviews with the restaurants and dining halls were completed, our team gained valuable insight into the implementation of green technology and practices in a kitchen setting. We began our interviews by asking the representatives how they define green technology. The general definition that we gathered from the interviews was that green technology is any type of technology that reduces one's impact on the environment by decreasing energy use, water use, and greenhouse gas emissions. An important theme our team noticed is that all of the restaurants and dining halls implemented more green practices rather than energy efficient and water conserving technology. Some green practices that all three of the establishments implemented were recycling and composting programs. Each restaurant and dining hall also purchases local food as often as possible. This helps support local community and reduces emissions to the environment due to the short transportation of food. Two of the establishments use energy-efficient technology, and only one, EVOO, is LEED Certified. This suggests that restaurant sustainability is not only dependent on implementing green technology but is also affected by the restaurant’s practices and policies. Lastly, our team discovered that all the restaurants and dining halls implemented green technology and practices gradually. The changes were not all made at once, but rather over a large period of time to allow the kitchen staff and customers to get accustomed to the changes in operations and the menu.

The site assessment allowed us to tour the café kitchen and evaluate the efficiency of their current refrigerators. We observed that the refrigerators were seemingly in good condition. We were surprised that the calculated payback periods to replace these refrigerators with energy efficient refrigerators were so long. This certainly indicates that it will not be cost effective for
the café to purchase energy efficient refrigerators at this time. This solution can be evaluated again in the long term when the refrigerators are in need of an expensive repair or replacement. However, the payback period we calculated to replace the pre-rinse spray valve was approximately 2-5 years. This is a more reasonable number and could be a more practical solution for the museum. We also observed the café disposables and noticed they use plastic take out containers, styrofoam cups, and plastic utensils. These are all items that could be replaced and improved upon. This site assessment allowed our team to evaluate the museum’s current practices while our interviews with representatives from sustainable museums, restaurants, and dining halls allowed us to determine the best practices in green technology. With this information, our team was able to develop specific recommendations for the Worcester Art Museum that we discuss in the next chapter.
Chapter 5: Recommendations and Conclusion

The analysis of the data collected over the course of our 14-week project pointed to some key recommendations, and some suggestions for the path forward. We begin with our specific recommendations in order to help the Worcester Art Museum café run a more sustainable operation. We have separated our recommendations into two categories, recommendations with regard to appliances and those with regard to policies.

1. **Appliances:** The cafés refrigerators and freezers are in good condition and are not that old, so they are not terribly inefficient. Due to the long payback periods of replacing the cafés current refrigerators with energy efficient alternatives, we recommend that the Worcester Art Museum only replace each piece of equipment when it is in need of an expensive repair. However, they will probably not need repair or replacement for some time, so the museum should evaluate new energy efficient refrigerators at that time as new technology is always developing. Another alternative is to replace the two single door refrigerators with one energy efficient double door refrigerator. This is more efficient and less expensive than replacing them with two energy efficient refrigerators and it reduces the payback period.

   We recommend that the café replace their current pre-rinse spray with a more efficient unit. We researched multiple different models and concluded that the Bricor Pre-Rinse Sprayer (0.6 GPM) is the most efficient model, but its flow rate is fairly small so it will not effectively clean baked-on residue. The TS Brass B-0107-J however is still efficient and has a larger flow rate so it can more effectively clean baked on residue, but will result in a longer payback period. Our recommendation depends on how the current pre-rinse spray valve is used. If the café needs to clean baked on residue then they should install the TS Brass B-0107-J, but if not they can use the lower flow unit and experience a smaller payback period. We also assumed that the café used the current unit an average of one hour per day. If the unit is used more than that the payback period will be shorter, therefore it would be beneficial for the museum to replace the unit.

2. **Policies:** We have suggestions regarding specific practices in the café that could be improved. In order to reduce waste in the café, employees should recycle paper, plastic and metal materials as much as possible. The café could further reduce their waste by implementing a composting program. We recommend that the museum partner with Save That Stuff, a company located in Charlestown, Massachusetts that picks up organic waste. This organization
collects organic waste and converts it to compost, which is used to nourish plants. The café could also replace plastic straws, utensils and take-out containers with compostable products. The representative from the Children’s Museum of Pittsburgh informed us that their café used products from NatureWorks. A local partner of NatureWorks is The Mansfield Paper Company in West Springfield, MA. Based on our observations in our café site assessment, we have included specific compostable options that are equivalent to products the café currently uses. A detailed list of these is located in Appendix I. The café could also convert to eco-friendly cleaning solutions. The Mansfield Paper Company also sells a variety of green cleaning supplies. We have also included these references in Appendix J.

Our final recommendation regarding café practices is to buy local and organic food when available. When our team spoke to multiple representatives from kitchens that run green operations, every restaurant and dining hall explained that they buy local and organic food. This is a practice that will involve additional work for the café’s cooks, but it is very rewarding and appreciated by customers. This will require the café to have a seasonal menu, depending on what produce is available at the time. We recommend that the café make small steps to implement this practice so that it is not such a shock to the café employees and customers. We have included a list of local farms and produce suppliers that other nearby restaurants who buy local get their food from. Each of the farms that we have listed is dedicated to selling chemical-free and organic products to restaurants, cafés, and other food vendors. This list is located in Appendix L.

Below is a summary of our sustainability recommendations, which can help the café to determine when to implement these changes.
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<th>Short Term (1yr)</th>
<th>Midterm (2-5 yrs)</th>
<th>Long Term (6-10 yrs)</th>
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<td>Replace pre-rinse spray valve with low flow valve</td>
<td>Replace fluorescent lighting with energy efficient LED lighting</td>
<td>Replace old refrigerators with energy efficient alternatives</td>
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<tr>
<td>Implement composting and recycling program</td>
<td>Convert to compostable take-out containers, utensils and straws</td>
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<tr>
<td>Buy local and organic produce</td>
<td>Buy local and organic produce</td>
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<tr>
<td>Purchase green cleaning supplies to replace harmful cleaners</td>
<td>Replace refrigerators if in need of expensive repair with energy efficient alternatives</td>
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</tbody>
</table>

*Table 10: Sustainability recommendations*

The café can replace the pre-rinse spray valve in the first year because the low flow valve is fairly inexpensive and has a payback period of 2-5 years depending on the model chosen. A composting and recycling program can be implemented in the first year because it is significantly better for the environment than sending their waste to landfills. Regardless, the museum is paying for their waste to be hauled, so instead they could benefit the environment and pay for it to be composted. Once the café’s composting program is implemented they can begin to purchase compostable take-out containers and utensils. They could also implement green cleaning supplies in the first year. This is a very easy and simple measure the museum can take to benefit the environment.

The café should also begin to buy local and organic food in the short term or the midterm. This process is very involved and requires the café to purchase items from multiple local farms instead of one food supplier. The café could gradually implement this to give the cooks time to adapt to new produce and a seasonal menu.

The café should convert to LED lighting within 2-5 years because the payback period of purchasing these lights is fairly large. They should wait until their current lights are in need of replacement. Similarly, the café’s current refrigerators are in good condition and are not terribly inefficient. Energy efficient refrigerators should only be purchased when the current
refrigerators are in need of an expensive repair or replacement.

Conclusion

This report outlined the research and methodological strategies that we used to aid the Worcester Art Museum in their efforts to create a green café and increase their sustainability. After completing our research, our team assessed the feasibility of this initiative and developed recommendations for the Worcester Art Museum. We believe that our recommendations are the first steps in many that will lead to the Worcester Art Museum to becoming a model of sustainability for the community.

Through our interviews, we were able to gain a better understanding of how similar institutions have been effective in making a transition to green technologies. By speaking with these establishments, we are able to avoid any potential setbacks others have experienced and recommend products that have been seen to be successful. This also gave us insight on who makes the decision to go green and how the transition affected the establishment in the long run.

We also evaluated the current usages and practices of the Worcester Art Museum’s café. In doing so, we created a baseline from which the museum can improve upon. This helped us in targeting key areas of inefficiency so that we were able to develop specific recommendations for them to reduce their energy and water usage, as well as disposable costs. In addition to accomplishing their goals, these modifications will allow the museum café to experience other benefits such as running more efficient operations, reducing their impact on the environment, and saving the museum money.

By implementing these changes, the Worcester Art Museum will have completed the first step to accomplishing their greater goal of becoming a sustainable establishment. In the future, the Worcester Art Museum hopes to extend their green initiatives throughout the entire building. The museum will become a part of the growing number of places around the world that are looking to make a difference in their community and the environment. They will help in the efforts of creating a sustainable energy future and hope that their initiatives attract the attention of others.
Denzel Amevor, Alexander Chen, Allison Corriveau, Saraf Rahman

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Denzel Amevor, Alexander Chen, Allison Corriveau, Saraf Rahman

http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US42F


Denzel Amevor, Alexander Chen, Allison Corriveau, Saraf Rahman


Appendix A: Conversions to Gallons per Minute

### Cups per second to gallons per minute

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### Pints per second to gallons per minute

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Source: South Florida Water Management District (2013)
Appendix B: Interview Questions for Green Museums

- What does the term "eco-friendly" mean to you, specifically in the context of a museum?
- What is "sustainability" according to you? What sustainability challenges does a museum face?
- What is green technology? What green technologies are used in museums to overcome sustainability challenges?
- What drove your museum to implement green technology and practices?
- What specific green technology are you currently using and why were they chosen?
- What was the cost of implementing these green technologies?
  - What are some challenges besides costs that your museum faced while implementing green technologies and practices?
- Is there any technology that you would recommend or advise against?
- How have these green initiatives benefitted your museum?
- What has been the response of visitors to your initiative?
- Do you feel you have attracted a younger audience?
Appendix C: Interview Questions for Restaurants and Dining Halls

- What according to you is green technology?
- What according to you are some advantages and disadvantages of using green technology in a restaurant?
- Please tell us about the green technology and practices your restaurant is currently using?
- Was it a difficult decision to make at the organizational level?
  - Who was involved in this process?
- What were the costs involved in adopting green technology?
- Were there any setbacks or challenges you experienced when adopting green practices?
- Is there any technology that you would recommend or advise against?
- What are the positive and/or negative outcomes of adopting green technology in your restaurant?
  - Has implementing green practices changed the way your kitchen operates?
  - What has been the response of visitors to your green initiative?
  - Has it improved/deteriorated your image in the market?
  - Has it increased/decreased the customer entry or foot fall?
## Appendix D: Green Museum Interview Analysis Form

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<tr>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why the museum implemented green technology:</td>
</tr>
<tr>
<td>LEED Certification level:</td>
</tr>
</tbody>
</table>

### Technology the museum is using:

<table>
<thead>
<tr>
<th>Air:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Electricity &amp; Lighting:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Water:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Insulation:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Materials &amp; Products:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycling:</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Overall cost of build:</td>
</tr>
<tr>
<td>Challenges of implementing green technology:</td>
</tr>
<tr>
<td>Recommended green technology:</td>
</tr>
<tr>
<td>Ineffective green technology:</td>
</tr>
<tr>
<td>Overall benefits of green technology:</td>
</tr>
<tr>
<td>Visitor response:</td>
</tr>
<tr>
<td>Additional Notes</td>
</tr>
</tbody>
</table>
## Appendix E: Children’s Museum of Pittsburgh Interview Analysis Form

<table>
<thead>
<tr>
<th>Museum Info</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Children’s Museum of Pittsburgh</td>
</tr>
<tr>
<td>Location</td>
<td>Pittsburgh, Pennsylvania</td>
</tr>
<tr>
<td>Phone / Email</td>
<td>(412) 322-5058 ext. 227, <a href="mailto:csiefert@pittsburghkids.org">csiefert@pittsburghkids.org</a>.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact Info</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum Representative:</td>
<td>Chris Siefert</td>
</tr>
<tr>
<td>a. Title</td>
<td>a. Deputy Director</td>
</tr>
<tr>
<td>b. Phone / Email</td>
<td>b. 412-586-6030</td>
</tr>
<tr>
<td>Museum employee responsible for green technology decisions:</td>
<td>Chris Siefert</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Why the museum implemented green technology:</td>
<td>The board, staff, and the community were all interested in having a green museum.</td>
</tr>
<tr>
<td>LEED Certification level:</td>
<td>Silver</td>
</tr>
</tbody>
</table>

| Technology the museum is using: |  |
| Air: | ➢ indoor air quality meets industry standards for healthy emissions  
➢ no smoking in the facility  
➢ monitor carbon dioxide emissions and thermal comfort levels |
| Electricity & Lighting: | ➢ purchases 100% of electrical power from renewable sources  
➢ photo voltaic system powers balloon lighting in the café |
| Water: | ➢ Dual flush toilets  
➢ low flow urinals |
- aerators at all faucets
- no irrigation in the landscape

**Insulation:**
- White roof
- Vegetated roof

**Materials & Products:**
- adhesives, sealants, paints, carpets and composite wood are certified low-emitting
- The wood came from forests that are managed in a sustainable fashion
- Café uses “green cups” from NatureWorks™, potato based 100% renewable and compostable plates, containers and utensils
- use Green Seal Certified line of cleaning products

**Recycling:**
- salvaged valuable materials from existing historical buildings
- diverted over 60% of construction waste to recycling companies
- building materials use high quantities of recycled materials and were locally manufactured
- recycling programs
- composting system in the café

**Overall cost of build:** $10 million, 3% cost increase by using green technologies

**Challenges of implementing green technology:**
In 2004 people had unrealistic expectations for what was possible in the building project. Contractors were overzealous about their ideas and had to be reminded of what was achievable at the time.

**Recommended green technology:**
Vegetative roof, dual flush toilets

**Ineffective green technology:**
Due to the technology being newly developed, their photovoltaic cells had a very minimal impact.

**Overall benefits of green technology:**
Management, staff, board of directors, and every department became very excited about the project and became more motivated to educate the community by offering green programs. See additional notes for more details.
<table>
<thead>
<tr>
<th>Visitor response:</th>
<th>The community was grateful that the museum was implementing green practices because it not only provided a safe environment for their children but they were leading the way and doing the right thing.</th>
</tr>
</thead>
</table>
| **Additional Notes** | ➢ In recent years the majority of buildings are built using green technology and sustainable building materials.  
➢ Advertising that you’re building a new green building attracts donors.  
➢ “Everything Green”, a field trip that shows children how natural light, recycled materials, green building products and creative thinking combine to make a green building. Children also explore what they can do to create a greener environment in their homes and schools. |
Appendix F: Grand Rapids Art Museum Interview Analysis Form

<table>
<thead>
<tr>
<th>Museum Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Location</td>
</tr>
<tr>
<td>Phone / Email</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum Representative:</td>
</tr>
<tr>
<td>a. Title</td>
</tr>
<tr>
<td>b. Phone / Email</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Museum employee responsible for green technology decisions: | Tom Hilzey |

<table>
<thead>
<tr>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why the museum implemented green technology:</td>
</tr>
<tr>
<td>LEED Certification level:</td>
</tr>
</tbody>
</table>

| Technology the museum is using: |
| Air: |
| ➢ passive air conditioning via vapor misting |
| ➢ no HCFC (hydrochlorofluorocarbon) emissions |
| ➢ strict CO2 emissions monitoring throughout museum |
### Electricity & Lighting:
- an interior shading system to diffuse natural light through the museum
- lantern skylight system in galleries
- built-in skylight louvers in galleries, adjustable to accommodate varied exhibitions

### Water:
- recycled rainwater and melted snow are used in systems including toilets, planting irrigation, and fountains

### Insulation:
- light-colored concrete walls
- three-layer UV filter glass in windows
- insulating Argon gas between glass window panels
- low-emission coatings on all components
- white roof

### Materials & Products:
- earned a 20% credit for recycled building materials
- utilized local materials

### Recycling:
- The museum operates a strict recycling policy to decrease day-to-day environmental impact

<table>
<thead>
<tr>
<th>Overall cost of build:</th>
<th>75 million</th>
</tr>
</thead>
</table>

### Challenges of implementing green technology:
LED light quality is not fit for lighting up exhibits. One of the big advantages with LED is that they don’t emit UV light like the halogens do so there’s a lot of interest in getting it all converted but they just simply don’t want to do that at the expensive of how the art looks. The museum has converted some areas to LED already and any new renovations include LED lights

### Recommended green technology:
N/A technology is always developing and theirs is 10+ years old

### Ineffective green technology:
N/A technology is always developing and theirs is 10+ years old
<table>
<thead>
<tr>
<th>Overall benefits of green technology:</th>
<th>The museum reduced its energy cost by approximately $90,000 per year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visitor response:</td>
<td>Residents of Grand Rapids have come to expect all new building to be sustainable. They were the first LEED Certified art museum in the world, so they received a lot of positive press.</td>
</tr>
</tbody>
</table>
| 1. Additional Notes                 | • The Grand Rapids area already has a rich concentration of over 30 LEED® registered projects, which qualifies it as one of the most LEED-conscious regions in the country.  
• The HVAC system was designed specifically for the GRAM to meet the specific temperature and humidity needs of the art. |
Appendix G: Boston Museum of Science Interview Analysis Form

<table>
<thead>
<tr>
<th>Museum Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
</tr>
<tr>
<td>Location</td>
</tr>
<tr>
<td>Phone / Email</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contact Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum Representative:</td>
</tr>
<tr>
<td>a. Title</td>
</tr>
<tr>
<td>b. Phone / Email</td>
</tr>
</tbody>
</table>

| Museum employee responsible for green technology decisions: | Paul Ippito |

<table>
<thead>
<tr>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why the museum implemented green technology:</td>
</tr>
<tr>
<td>LEED Certification level:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology the museum is using:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air:</td>
</tr>
<tr>
<td>➢ Found where building envelope was losing energy via smoke testing</td>
</tr>
<tr>
<td>➢ Air is conditioned</td>
</tr>
<tr>
<td>➢ Demand control ventilation system in the kitchen</td>
</tr>
<tr>
<td>Electricity &amp; Lighting:</td>
</tr>
<tr>
<td>➢ Put 30 kilowatts of solar panels on the roof of the buildings</td>
</tr>
<tr>
<td>➢ Changed oil-filled electrical transformers for dry-type ones</td>
</tr>
<tr>
<td>➢ Switched out about 5000 incandescent light bulbs for LED lights</td>
</tr>
<tr>
<td>Water:</td>
</tr>
<tr>
<td>➢ Use waterless urinals</td>
</tr>
<tr>
<td>➢ Replaced the chiller and cooling tower</td>
</tr>
</tbody>
</table>
- Placed controls on the walk-in coolers and freezers
- Implemented a more efficient water filtration on the chilled water system

**Insulation:**
- Window films applied to reduce solar gain

**Materials & Products:**
- Have chosen more sustainable, longer-lasting materials

**Recycling:**
- Repurpose some of the materials
- Choose carpets based on recycled content

<table>
<thead>
<tr>
<th>Overall cost of build:</th>
<th>3.5 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of build:</td>
<td>2009</td>
</tr>
</tbody>
</table>

**Challenges of implementing green technology:**
Certain things work well, and some things do not work well. It is hard to tell without trying to implement it and it is also difficult to make these changes in an already established building

**Recommended green technology:**
Demand Control Ventilation, Window Filming, Building Envelope Technology, VFDs

**Ineffective green technology:**
N/A

**Overall benefits of green technology:**
The museum was able to improve some of its aged capital infrastructure, and have lowered its carbon footprint as well as its energy bills

**Visitor response:**
In the beginning, visitors enjoyed seeing that the museum was environmentally friendly. Now, it has come to be an expectation.

**Additional Notes**
## Appendix H: Appliance Analysis

### Preparatory Refrigerator

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Dimensions (L x W x H)</th>
<th>Volume (cu. Ft)</th>
<th>Energy (kWh/Day)</th>
<th>Cost ($) [Webstraunt.com]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delfield</td>
<td>UC4464N-12</td>
<td>64 x 31 x 40</td>
<td>21.6</td>
<td>1.38</td>
<td>$3789.00</td>
</tr>
<tr>
<td>Delfield</td>
<td>ST4464N-12</td>
<td>64 x 31 x 42</td>
<td>21.6</td>
<td>1.38</td>
<td>$3915.00</td>
</tr>
<tr>
<td>Delfield</td>
<td>UCD4464N-12</td>
<td>64 x 31 x 40</td>
<td>21.6</td>
<td>1.38</td>
<td>$5247.00</td>
</tr>
<tr>
<td>Delfield</td>
<td>D4464N-18M</td>
<td>64 x 31 x 44</td>
<td>21.6</td>
<td>1.38</td>
<td>$5638.00</td>
</tr>
<tr>
<td>Beverage Air</td>
<td>SPE60-24M</td>
<td>60 x 36 x 45</td>
<td>17.1</td>
<td>1.104</td>
<td>$2663.86</td>
</tr>
<tr>
<td>Beverage Air</td>
<td>SPED60-08-2</td>
<td>60 x 31 x 41</td>
<td>21.6</td>
<td>1.104</td>
<td>$2900.37</td>
</tr>
</tbody>
</table>

### R-1: True Refrigerator

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Dimensions (L x W x H)</th>
<th>Volume (cu. ft.)</th>
<th>Energy Use (kWh/day)</th>
<th>Cost ($) [Webstraunt.com]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbo Air</td>
<td>PRO-50R</td>
<td>52 x 34 x 78</td>
<td>50</td>
<td>2.48</td>
<td>$3,833.57</td>
</tr>
<tr>
<td>Adcraft</td>
<td>RF-2D</td>
<td>32.2 x 54 x 82.5</td>
<td>41.33</td>
<td>2.57</td>
<td>$2,235.02</td>
</tr>
<tr>
<td>ColdTech</td>
<td>CRRR466-2</td>
<td>32.2 x 53.98 x 82.48</td>
<td>41.33</td>
<td>2.57</td>
<td>$2,020-$2,600</td>
</tr>
<tr>
<td>Metalfrio Solutions</td>
<td>CFD-2RR</td>
<td>32.2 x 54 x 82.5</td>
<td>41.33</td>
<td>2.57</td>
<td>$2,546 [amazon]</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RHT232NUT-FHS</td>
<td>35 x 52.1 x 83.2</td>
<td>46</td>
<td>2.7</td>
<td>$8,979.30</td>
</tr>
<tr>
<td>True Refrigeration</td>
<td>T-35</td>
<td>39.5 x 29.5 x 78</td>
<td>31.2</td>
<td>2.89</td>
<td>$2,419.63</td>
</tr>
</tbody>
</table>

### R-2: Traulsen Refrigerator
<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Dimensions (L x W x H)</th>
<th>Volume (cu. Ft)</th>
<th>Energy Use (kWh/Day)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibson</td>
<td>RR18R</td>
<td>31x32x76</td>
<td>18.0</td>
<td>1.0</td>
<td>$1,095.00</td>
</tr>
<tr>
<td>Arctic Air</td>
<td>R22CWF</td>
<td>32x29.3x70</td>
<td>18</td>
<td>1.0</td>
<td>$1,199.00</td>
</tr>
<tr>
<td>Kelvinator</td>
<td>KRS220RH</td>
<td>29x32x76</td>
<td>19</td>
<td>1.0</td>
<td>$1,460.00</td>
</tr>
<tr>
<td>ColdTech</td>
<td>CRR229-1</td>
<td>32x29x83</td>
<td>20.6</td>
<td>2.24</td>
<td>$1,799.99</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RRI132LUT-FHS</td>
<td>35.5x35.5x83</td>
<td>36.2</td>
<td>2.74</td>
<td>$7,277.49</td>
</tr>
<tr>
<td>Beverage-Air</td>
<td>HR1W-1S</td>
<td>32x35x78.5</td>
<td>30.6</td>
<td>3.2</td>
<td>$5,5000</td>
</tr>
<tr>
<td>Turbo Air</td>
<td>Pro-77R</td>
<td>32x77x78</td>
<td>77.18</td>
<td>4.77</td>
<td>$6401.73</td>
</tr>
</tbody>
</table>

**R-6: Hobart Refrigerator**

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Dimensions (L”xW”xH”)</th>
<th>Volume (cu. ft.)</th>
<th>Energy Use (kWh/day)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traulsen</td>
<td>RHT232WUTFHS</td>
<td>83.25&quot; x 58” x 35”</td>
<td>46</td>
<td>1.82</td>
<td>$9,342.50</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RHT232NUTFHS</td>
<td>83.25” x 52.13” x 35”</td>
<td>51.6</td>
<td>1.96</td>
<td>$8,806.00</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RRI232HUTFHS</td>
<td>89.13” x 68” x 39.25”</td>
<td>79.5</td>
<td>2.57</td>
<td>$10,727.6</td>
</tr>
<tr>
<td>Traulsen</td>
<td>RRI232LUTFHS</td>
<td>83.75” x 68” x 35.56”</td>
<td>74.3</td>
<td>2.57</td>
<td>$9,917.82</td>
</tr>
<tr>
<td>MetalFrio</td>
<td>CFD-2RR</td>
<td>82.5” x 54” x 32.2”</td>
<td>48</td>
<td>2.57</td>
<td>$2,450.00</td>
</tr>
</tbody>
</table>
## Appendix I: Compostable Materials

<table>
<thead>
<tr>
<th>Type of Packaging</th>
<th>Distributor</th>
<th>Item name</th>
<th>Item number</th>
<th>Cost</th>
<th>Items per Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>12oz soup lids</td>
<td>Mansfield Paper Company</td>
<td>Wht Vntd Lid 8/12/16T 1000/CS</td>
<td>71870</td>
<td>$132.33</td>
<td>1000</td>
</tr>
<tr>
<td>Hinged Take-out Container</td>
<td>Mansfield Paper Company</td>
<td>9X9X3 Hinged Container 200/C</td>
<td>68005</td>
<td>$61.20</td>
<td>200</td>
</tr>
<tr>
<td>Small Hinged Take-out Container</td>
<td>Mansfield Paper Company</td>
<td>Hoagie Hinged Clamshell 200/C</td>
<td>68002</td>
<td>$50.28</td>
<td>200</td>
</tr>
</tbody>
</table>
Appendix J: Green Cleaning Products

<table>
<thead>
<tr>
<th>Cleaner Type</th>
<th>Distributor</th>
<th>Item name</th>
<th>Item Number</th>
<th>Cost</th>
<th>Items per case</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-Purpose</td>
<td>The Mansfield Company</td>
<td>Orange Plus</td>
<td>PL9706</td>
<td>$57.46</td>
<td>12</td>
</tr>
<tr>
<td>All-Purpose</td>
<td>The Mansfield Company</td>
<td>Parsley Plus</td>
<td>PL9746</td>
<td>$54.59</td>
<td>12</td>
</tr>
</tbody>
</table>
Appendix K: Café Layout
## Appendix L: Local Farms

<table>
<thead>
<tr>
<th>Farm</th>
<th>What is grown</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whittier Farms</td>
<td>Fruit, Vegetables, dairy, eggs, grains, baked goods</td>
<td>Sutton, Ma</td>
</tr>
<tr>
<td>Rocky Ridge Beef Farm</td>
<td>Fruit, vegetables, dairy, eggs, meat</td>
<td>North Brookfield, MA</td>
</tr>
<tr>
<td>Rocky Acres Farm</td>
<td>Meat</td>
<td>Sterling, MA</td>
</tr>
<tr>
<td>New Lands Farm</td>
<td>Fruit, vegetables</td>
<td>Sutton, MA</td>
</tr>
<tr>
<td>Living Earth Organic Farm</td>
<td>Fruit, vegetables, meat, grain</td>
<td>Rutland, MA</td>
</tr>
<tr>
<td>Harvey’s Farm &amp; Garden</td>
<td>Fruit, vegetables, grains</td>
<td>Westborough, MA</td>
</tr>
<tr>
<td>Harms Family Farm</td>
<td>Vegetables, honey, maple</td>
<td>Brookfield, MA</td>
</tr>
<tr>
<td>Foppema’s Farm</td>
<td>Fruit, vegetables, spreads, baked goods</td>
<td>Northbridge, MA</td>
</tr>
<tr>
<td>Bird of the Hand Farm</td>
<td>Fruit, vegetables, beverages, spreads, baked goods</td>
<td>Sterling, MA</td>
</tr>
</tbody>
</table>
Appendix M: Water Analysis

<table>
<thead>
<tr>
<th></th>
<th>Old Baseline</th>
<th>TS Brass B-0107-J</th>
<th>TS Brass B-0107-C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>N/A</td>
<td>$98.50</td>
<td>$98.50</td>
</tr>
<tr>
<td><strong>Flow Rate (gal/min)</strong></td>
<td>1.42</td>
<td>1.07</td>
<td>0.65</td>
</tr>
<tr>
<td><strong>Operating Hours (hours/day)</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Operating Days (days/year)</strong></td>
<td>208</td>
<td>208</td>
<td>208</td>
</tr>
<tr>
<td><strong>Water Cost per hundred cubic feet (CCF)</strong></td>
<td>$3.51</td>
<td>$3.51</td>
<td>$3.51</td>
</tr>
<tr>
<td><strong>Water Cost per gallon (1CCF = 748gallons)</strong></td>
<td>$0.004693</td>
<td>$0.004693</td>
<td>$0.004693</td>
</tr>
<tr>
<td><strong>Annual Water Consumption (CCF)</strong></td>
<td>23.69197861</td>
<td>17.8524</td>
<td>10.8449</td>
</tr>
<tr>
<td><strong>Annual Water Consumption (gallons)</strong></td>
<td>17721.6</td>
<td>13353.6</td>
<td>8112</td>
</tr>
<tr>
<td><strong>Annual Cost</strong></td>
<td>$83.16</td>
<td>$62.66</td>
<td>$38.07</td>
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<tr>
<td><strong>Annual Savings</strong></td>
<td>N/A</td>
<td>$20.50</td>
<td>$45.09</td>
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<tr>
<td><strong>Payback period (years)</strong></td>
<td>N/A</td>
<td>4.81</td>
<td>2.18</td>
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<table>
<thead>
<tr>
<th></th>
<th>Fisher 0.60 GPM Stainless Steel Vee-Jet Nozzle</th>
<th>Fisher 1.15 GPM Stainless Steel Vee-Jet Nozzle</th>
<th>Bricor Pre-Rinse Sprayer (0.6 GPM)</th>
<th>Bricor Pre-Rinse Sprayer (0.84 GPM)</th>
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<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$130.00</td>
<td>$110.00</td>
<td>$79.95</td>
<td>$79.95</td>
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<tr>
<td><strong>Flow Rate (gal/min)</strong></td>
<td>0.60</td>
<td>1.15</td>
<td>0.60</td>
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<tr>
<td><strong>Operating Hours (hours/day)</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td><strong>Operating Days (days/year)</strong></td>
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<td>208</td>
<td>208</td>
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<tr>
<td><strong>Water Cost per hundred cubic feet (CCF)</strong></td>
<td>$3.51</td>
<td>$3.51</td>
<td>$3.51</td>
<td>$3.51</td>
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<tr>
<td><strong>Water Cost per gallon (1CCF = 748gallons)</strong></td>
<td>$0.004693</td>
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<tr>
<td>Annual Water Consumption (CCF)</td>
<td>10.0107</td>
<td>19.1872</td>
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<tr>
<td>Annual Water Consumption (gallons)</td>
<td>7488</td>
<td>14352</td>
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<td>Annual Cost</td>
<td>$35.14</td>
<td>$67.35</td>
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<tr>
<td>Annual Savings</td>
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<td>Payback period (years)</td>
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<td>6.96</td>
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<td>2.35</td>
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## Appendix N: Lighting Analysis

<table>
<thead>
<tr>
<th>Cost</th>
<th>Old Baseline</th>
<th>Philips 4 ft. T8 19-Watt Cool White (4100K) Linear LED Light Bulb</th>
<th>Philips 4 ft. T8 20-Watt Cool White (4000K) Linear LED Light Bulb</th>
<th>TOGGLED 48 in. T8 18.3-Watt Soft White (3500K) Linear LED Tube Light Bulb</th>
<th>Philips 20-Watt T8 4 ft. Linear Bright White (3000K) LED Light Bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Hours (hours/day)</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
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<td>Operating Days (days/year)</td>
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<td>208</td>
<td>208</td>
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<tr>
<td>Watt Reading (kWH / day)</td>
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<td>19</td>
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<td>18.3</td>
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<td>Annual kWh</td>
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<td>23.44</td>
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