A Thesis

entitled

Energy Assessment at a Health Care Facility

by

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Submitted to the Graduate Faculty as partial fulfillment of the requirements for the
Master of Science Degree in Industrial Engineering

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With the recent volatility in prices for coal and natural gas, energy conservation has become not only essential for environmental sustainability, but many organizations are finding it necessary to reduce their energy consumption for financial reasons. One of the most important initial steps that organizations must participate in before starting an energy reduction program is for them to conduct a full scale energy assessment.

While much of the focus of recent energy conservation efforts has been in the manufacturing and transportation industries, the healthcare industry is one that has often been neglected. What has made energy conservation even more of a necessity in healthcare has been the rise in costs associated with medical procedures and medical insurance.

One organization that is currently researching processes for conducting robust energy assessments is the Environmentally Conscious Design and Manufacturing Laboratory, funded by the University of Toledo College of Engineering and the Lucas County Solid Waste Management District. This lab, which has been in existence since 1996, has performed a number of solid waste assessments and has only recently been
performing energy assessments. Following the 2006 merger between the University of Toledo and the Medical University of Ohio, the research lab has taken much more of an interest in researching medical facilities.

The purpose of this is to examine how an energy assessment process can be adopted for use in a medical facility. Included in this study is a case study of an energy assessment that was performed on a 292 bed hospital in Northwest Ohio.
For Jenny. Without your confidence in me and without your support, I could have never seen this through to the end. You will always be the love of my life.
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I especially want to thank the employees of the hospital at which this research was conducted. I wish I could list you by name, but unfortunately, I cannot due to confidentiality reasons.

Finally, I want to thank my friends and family that have supported me while I was in graduate school. My mom and dad and all my grandparents have always given me so much love and guidance through the whole process. I especially want to thank my Grandpa Ron who motivated me to study engineering to begin with. I know he would be proud of the work that I’ve accomplished.
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Chapter 1

Introduction

1.1 Objective of the Hospital Energy Assessment Thesis

Research

The main objective of this thesis research is to serve as a set of guidelines for organizations that wish to conduct comprehensive energy assessments at a health care facility. This thesis research should be used by any organization that is looking to more fully understand its total energy consumption and thus its impact on the environment. Using this research, an organization can begin to reduce its energy consumption by updating its current fixtures and appliances, retrofitting new technology into existing fixtures, or creating sustainable practices for all employees to follow.

Included in this thesis research is the methodology for conducting a comprehensive energy assessment. The methodology is explained throughout the whole process, from the pre-assessment actions to the implementation of results and sustaining the gains that were made. This methodology is designed for an organization in any industry.
Also included in this thesis research is a case study of a large hospital in Northwest Ohio. The case study presents an example of how to apply the methodology for a health care facility. The purpose of the case study is to demonstrate the main areas of a hospital that should be examined during an energy assessment. It also gives suggestions as to what sorts of improvements could be implemented in a hospital to reduce the overall energy consumption from the lighting of the hospital facility.

This thesis research is not intended to be a set of step by step instructions for how to conduct an energy assessment. Each facility will present its own unique problems and opportunities. It is up to the researchers conducting the assessment to determine the best course of action for each facility based on the situation that the facility is facing.

1.2 The Importance of Reducing Energy Consumption

The two main benefits of reducing energy consumption are the economic benefits and the environmental benefits. While a facility may wish to conduct an energy assessment for either or both of the reasons, getting funding to make improvements to the facility is typically easier when the goal of the assessment is to reduce energy costs.

If hospital staff is looking to reduce the costs associated with energy consumption, two main reasons why an assessment was not typically carried out previously are that the staff did not understand the total costs that the hospital was currently incurring or the staff did not understand the costs associated with making improvements. One of the most important pieces of information that a researcher conducting an energy assessment can provide is a breakdown of the overall costs the
hospital is incurring from energy use. Oftentimes, seeing what costs are associated with certain fixtures or practices can result in changes to the culture or policies at the hospital.

Additionally, the hospital staff may not have had the time or expertise to research what options were available to lower the costs of energy consumption. Even though the hospital may have a sustainability committee, the employees that sit on that committee still have the primary responsibility of ensuring that the hospital is running smoothly and caring for patients. Their primary responsibility is not to improve on the situation of the hospital’s energy consumption.

Alternatively, the hospital staff’s focus could be on lowering the facility’s environmental footprint. While the hospital could have specific concerns, such as reducing the amount of solid waste generated by expired bulbs and equipment or reducing the amount of mercury that is being released into the environment, most facilities that want to reduce their environmental footprints want to reduce the amount of carbon emissions are released from the energy that is used by their facility.

Reducing the carbon emissions of a facility is important for a number of reasons. Research has shown that there is a link between the levels of carbon dioxide in the atmosphere and climate change, which could have a devastating effect not only on the global environment, but also any economic activities linked to the environment, such as fishing, farming, lumber production, tourism and other industries. There is also pending legislation within the United States and other countries to place a cap on the amount of carbon emissions a facility is allowed to produce. There could be financial ramifications if a facility has a higher than average carbon footprint.
1.3 Background of the University of Toledo Environmentally Conscious Design and Manufacturing Laboratory

This project has been made possible due to the resources and assistance of the University of Toledo’s Environmentally Conscious Design and Manufacturing Laboratory (ECML). The ECML was founded in 1996 with a partnership between the University of Toledo College of Engineering and the Lucas County Solid Waste Management District. The ECML was founded to promote environmental sustainability within Northwest Ohio.

The staff of the ECML includes both undergraduate and graduate students majoring in mechanical and industrial engineering. Since its inception, the ECML has conducted solid waste assessments at no cost to the business or organization.

In recent years, the ECML has expanded to two new areas of environmental conservation research. The 2006 merger between the University of Toledo and the Medical University of Ohio has allowed the ECML to begin to focus more on healthcare organizations. In addition, the ECML has begun to expand its research into comprehensive energy assessments.

1.4 Overview of Terms

Btu – A Btu (British Thermal Unit) is a unit of heat energy. One Btu is the amount of heat needed to raise the temperature of one pound of water 1°F. A match burning releases approximately 1 Btu.
HVAC – In most modern indoor facilities, the climate is controlled by a heating, ventilation and air conditioning (HVAC) system. All three uses of this system consume energy in some form and should be included in an energy assessment.

kW-h – A kW-h (kilowatt hour) is a unit of heat energy. One kW-h is equal to 1000 Watts over the span of one hour. One kW-h is equal to 3.6 megajoules.

MARR – MARR (Minimum Acceptable Rate of Return) is the percentage of interest that could be gained if capital investments had been made in another investment. MARR is used to compare a possible new improvement to how much money could be earned in a standard investment source with similar risk. MARR is typically between 8 and 10% and for this study, 8% was used.

NPW – NPW (Net Present Worth) is a calculation that is used to compare the costs of two projects with dissimilar life spans. Using the MARR, the NPW calculation figures how much each option will cost in dollars presently.

OPEC – The OPEC (Organization of Petroleum Exporting Countries) is an international group of countries that have a net export of petroleum. As of the writing of this thesis, there are 12 members, all located in the Middle East, Africa or South America.
Chapter 2

Energy Assessment Methodology

2.1 Energy Assessment Methodology

While every energy assessment varies depending on the scope of the assessment, the industry the company is in and a number of other factors. Despite these differences, most energy assessments follow eight steps.

Step 1 – Soliciting Energy Assessments
Step 2 – Pre-Assessment Meeting
Step 3 – On-Site Data Collection
Step 4 – Additional Data Collection
Step 5 – Data Analysis
Step 6 – Report Writing
Step 7 – Final Meeting
Step 8 – Project Follow-Up

Energy assessments typically take between 6 and 10 weeks to complete. Each of these steps is explained in detail during Chapter 2.
2.2 Soliciting Energy Assessments

There are a variety of ways in which the ECML selects companies and organizations to perform energy assessments for. The ECML has contacts with numerous government and professional organizations such as the faculty and staff of the University of Toledo, the Lucas County Solid Waste Management District, Keep Toledo/Lucas County Beautiful, the Toledo Regional Chamber of Commerce and several other organizations. Through networking with these organizations, clients are identified that meet the requirements for receiving an energy assessment. The client must conduct operations within Lucas County and must show a considerable interest in having an energy assessment conducted at their facility. A client must have support and enthusiasm of the executives of the organization for an energy assessment to be successful.

There are additional ways for an organization to be selected as a potential client. A larger organization with a high media visibility could be looking to create a positive public relations campaign and will contact the ECML directly to arrange an energy assessment. Alternatively, a former research assistant from the ECML could convince the management at his or her company to solicit an energy assessment from the ECML.

Once an organization is identified as a potential candidate for an energy assessment, the staff of the ECML sets up an initial meeting with the employee that will take the lead for the energy assessment.

2.3 Pre-Assessment Meeting

The purpose of the pre-assessment meeting is to determine the client’s feasibility as a recipient of an energy assessment as well as to develop a plan of action for the
assessment. There will be no fewer than two research assistants present at the pre-assessment meeting. Prior to the pre-assessment meeting, the project manager will select a principle investigator who will be chiefly responsible for coordinating the main events of the assessment. Both the project manager and the principle investigator assigned to the project are required to attend the pre-assessment meeting. Additional researchers may be needed for note taking and observing purposes.

The pre-assessment meeting will begin with the project manager giving an overview of the research laboratory and informing the client of the background and objectives of the laboratory. Once the client understands how the laboratory functions, the principle investigator will explain the process of conducting an assessment. During this explanation, the principle investigator may ask for feedback from the client to gauge how certain aspects of the assessment may work at the client’s facility.

There are a number of data that the research team wishes to ascertain from a pre-assessment meeting. The team will want to determine which areas of the facility consume the most energy. Depending on the type of facility, this could create a multifaceted assessment. For example, in a manufacturing facility, the machines on the shop floor will need to be studied in a very different way than the lighting in the offices. The research team will also wish to determine what resources the client is willing to put forth to improve the energy efficiency of their operations. This may include the time it takes to install new equipment, the personnel that they wish to allocate to this project and the capital investment necessary to see energy savings. Finally, the team will determine any energy saving improvements already completed by the client.
Following the explanation by the principle investigator, the client is free to ask questions or give suggestions to the research team. To conclude the meeting, it is the responsibility of the principle investigator to set up the next course of action with the client. Following the meeting, the client should give a brief tour of the facilities. This will give the research team an opportunity to identify areas that could benefit the greatest from an energy assessment.

2.4 On-site Data Collection

On the day of the energy assessment, the principle investigator must be sure to bring a clipboard, a pad of paper, a pen or pencil, and any information that was given during the pre-assessment meeting. In some situations, safety glasses, steel toed shoes, or other safety gear may be necessary for all those who will be performing the assessment. Additional measuring devices such as digital cameras, light meters, and thermal imaging cameras may be used if available to the research team.

During the assessment, the research team must be lead by a client employee for the duration of the assessment. This is to ensure that the research team is shown all relevant areas of the facility. This is also needed because the research team is likely to have questions regarding electrical devices. A final reason that a client employee is necessary is because the research team may enter into areas that are restricted, confidential, or unsafe and the client employee would be able to steer the team clear of such areas.

While there is no set number of research assistants that need to accompany the principle investigator on an energy assessment, it can be beneficial to have larger
numbers. In facilities that have multiple floors, time can be saved by splitting the team into two or more groups. The principle investigator is responsible for choosing a leader from each group. These group leaders should have experience with energy assessments and the judgment to make decisions on his or her own. For the reasons listed above, there should be one client employee with each group for the duration of the assessment.

Researchers will often find a variety of different areas to assess depending on the facility and the scope of the project. Due to this, it is difficult to create a single form that can be used for a comprehensive energy assessment. Each research assistant should be familiar with the formatting of the forms to be sure that all notes from the assessment are kept in a similar fashion.

2.5 Additional Data Collection

In order to complete the data analysis and the report, more data are needed than what can be gathered in the facility during the on-site energy assessment. Depending on areas being assessed, there are a number of other pieces of information that need to be collected. One very important part of the data analysis is a cost-benefit analysis of the improvements that were suggested. Because of this, it is essential for the researcher to obtain financial information. This includes the price that the client is paying per kilowatt-hour or whether the client is paying for the total energy consumption or if they are paying based on their peak energy consumption. It is also important for the researcher to determine what sort of seasonal effects the energy consumption is subject to. This is most commonly done by collecting one or more complete year’s worth of
electric or gas bills. Gas and electric bills contain much of the information that is necessary, including the cost per kilowatt-hour and sometimes the peak daily usage.

It is also important to know how much money is budgeted to improvement projects. Projects can range from several hundred dollars to replace light bulbs in the facility to hundreds of thousands of dollars to install alternative energy installations. A more expensive project does not necessarily result in a shorter payback period. The client must be in a strong financial position for several years after the improvements are made in order for larger improvements to be financially feasible.

A final area of data that needs to be collected is the improvements the client has already made to improve their energy efficiency. If the client is able to look back and see what worked well and what did not work well with former projects, there is a greater chance for success with new projects. It is also important for records to be well kept so future projects can follow the methodology of successful former projects.

It is also important to always keep the line of communication open between the researcher and the client contact person. There may be situations where the research team did not collect enough information to successfully complete the report. Being able to call or e-mail for additional questions is very important, especially when energy assessments are complicated or contain large amounts of variables.

2.6 Data Analysis

Upon completion of the data collection, the research team has the responsibility of analyzing the data. Much of the data analysis techniques have been developed with the
aid of resources available to the research staff. One resource that has shaped the data analysis methodology is the United States Energy Efficiency Toolkit for Manufacturers. This tool, which was developed by the National Association of Managers, is useful for determining eight major categories for energy efficiency improvements.

During the energy assessment on-site data collection, each team member is expected to take individual notes of improvement opportunities that were seen during the assessment. Following the on-site data collection, it is the responsibility of the project’s principle investigator to collect those individual notes and combine them into one document that contains all relevant data.

Once all the data is collected into one document, it is then the responsibility of the principle investigator to assign research tasks to members of the research team. While there are tools available to analyze the comprehensive data, there are many more resources for analyzing a single aspect of energy consumption. This is why it is important for the principle investigator to break the project into a number of smaller tasks for the research team to complete separately. Depending on the size and scope of the project, the tasks could be as small as summing the number of lighting fixtures in one area of the facility or as large as performing an economic analysis of various alternative energy options.

There are several areas of focus that should be considered when analyzing the data from an energy assessment. The first and most important is the overall energy consumption. One of the primary reasons that an organization may be looking to have an energy assessment conducted is to understand the amount of energy that they are
consuming. It is also important for the researcher to determine the economic aspect of the energy that is being used. This is where the total energy consumption calculated earlier is converted into a financial perspective. A third focus that the researcher may wish to take is to put the energy consumption into terms of the environmental impact that the organization has. There are many ways of doing this. The researcher could convert the energy usage into barrels of oil equivalencies or the average number of cars on the road. The researcher could also choose to put the energy consumption in terms of pounds or tons of carbon dioxide that are released into the air as a result of the energy use of the organization. This third area of focus is mainly important for public relations purposes or if the organization is looking to be LEED certified or another environmental certification.

2.7 Report Writing

Once all of the data have been analyzed, it is the responsibility of the principle investigator to gather the separate analyses into one report that can be presented to the client. It is never suggested that the other research team members write portions of the report, even if they conducted the data analysis portion. There are two main reasons for this. The first is that it is more difficult to maintain a solid continuity in terms of formatting when a report is written in several pieces by different people. The second reason the principle investigator should prepare the entire report is that he or she will be responsible for explaining the report to the client. If the principle investigator did not conduct the data analysis, the report writing stage is an excellent opportunity for him or her to become familiar enough with the project to be able to properly present the findings.
While the components of the final report will vary from project to project, there are several sections that should always be included. Energy assessment reports will always contain an introduction to what the research lab’s mission is, an overview of the methodology used during the energy assessment, a breakdown of the findings of the assessment, recommendations for energy improvements and a conclusion that summarizes the results of the project. The report should always be written in a way that is clear and easy to understand even to those with little technical background. While the principle investigator or another member of the team will likely present the findings, it is not always possible for this happen and the report should be understood without explanation.

2.8 Final Meeting

Once the data has been analyzed and the report has been written, it is the responsibility of the principle investigator to present the findings of the project to the client. It is up to the discretion of the principle investigator as to how the report is presented. The choice depends on the audience the client provides. Some organizations will have one or two employees present at the final meeting. In that situation, it would be best if the principle investigator sat down and walked through the report with the client. If the client schedules an event where more than two employees are present, it would be advisable for the principle investigator to prepare a slide show presentation.

Regardless of the format of the final meeting, it is important that the client has opportunities to ask questions and have discussions about the findings presented in the report. Based on the findings, the client may request additional studies to be conducted.
2.9 Project Follow Up

Approximately four to five months following the completion of the project, the project manager should follow up with the client. The purpose of this follow up is to assess the success of the initiative and this can be done by phone or by e-mail. The project manager should determine which recommendations of the report the client chose to implement and how successful or unsuccessful those improvements were. This is useful for making future recommendations on other projects. The client may wish for additional support so it is important for the project manager to inquire about that.
Chapter 3

Case Study – Mid-Sized Health Care Facility

3.1 Overview of Case Study

This case study examines an energy assessment conducted by the University of Toledo Environmentally Conscious Design and Manufacturing Laboratory. Due to confidentiality restrictions between the research team and the client, the name of the company has been omitted. Names of all employees working for the client have been omitted as well. This assessment was conducted during the fall of 2009 and the spring of 2010.

3.2 Organizational Overview

The organization that was the focus of this case study was a 292 bed hospital located in Lucas County, Ohio. The current facility was constructed in 1975. There are approximately 1,500 employees working in various fields at this hospital. As this is facility is a full hospital, it is staffed 24 hours a day, 7 days a week. There are 8 floors with the top 7 floors being mainly for patient rooms and the first floor housing operating rooms, emergency rooms, dining areas, offices, and a gift store. The hospital has peak energy consumption during regular business hours.
3.3 Areas of Current Energy Consumption

The hospital being studied consumed energy in a variety of forms. A large portion of the energy was consumed by the following areas: lighting; heating, ventilation and air conditioning; electronics and computer equipment; medical equipment; and miscellaneous transportation and food preparation equipment. Each of these areas will be explained further in this chapter. In addition, the hospital maintained backup electricity generating equipment, as required by law. The energy consumption of these generators will be explained further in this chapter.

3.3.1 Lighting

As the hospital was in operation 24 hours a day, much of the lighting was left on throughout the day. Notable exceptions included the patient rooms and certain areas such as labs, parking lots and the gift shop. Because of the prevalence of 24-hour lighting, the payback period for installing high efficiency lighting fixtures would be much lower than facilities that leave the lights off during the nights and weekends. A summary of all of the bulbs commonly used in the hospital can be found in Table 3.1. Specifics about each type of bulb can be found in the following paragraphs.
Table 3.1: A Summary of the Most Common Types of Lighting in the Hospital Facility.

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Model</th>
<th>Watts</th>
<th>Quantity</th>
<th>Hours Per Day</th>
<th>Hours Per Year</th>
<th>kW-h Per Year</th>
<th>Initial Cost</th>
<th>Life (Hours)</th>
<th>Life (Years)</th>
<th>Cost Per Year</th>
<th>Cost Per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof / Side of Parking Garage</td>
<td>High Pressure Sodium</td>
<td>GE LU250</td>
<td>250</td>
<td>22</td>
<td>24</td>
<td>8760</td>
<td>48180</td>
<td>$12.45</td>
<td>24000</td>
<td>2.74</td>
<td>$2,890.80</td>
<td>$131.40</td>
</tr>
<tr>
<td>Inside Garage</td>
<td>High Pressure Sodium</td>
<td>GE LU100</td>
<td>100</td>
<td>132</td>
<td>24</td>
<td>8760</td>
<td>115632</td>
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<td>24000</td>
<td>2.74</td>
<td>$6,937.92</td>
<td>$52.56</td>
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<tr>
<td>Parking Lot</td>
<td>High Pressure Sodium</td>
<td>GE LU400</td>
<td>400</td>
<td>55</td>
<td>14</td>
<td>5110</td>
<td>112420</td>
<td>$12.01</td>
<td>24000</td>
<td>4.70</td>
<td>$6,745.20</td>
<td>$122.64</td>
</tr>
<tr>
<td>Parking Garage Stairways</td>
<td>High Pressure Sodium</td>
<td>F40T12</td>
<td>40</td>
<td>24</td>
<td>14</td>
<td>5110</td>
<td>4906</td>
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<td>20000</td>
<td>3.91</td>
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</tr>
<tr>
<td>1st Floor</td>
<td>Fluorescent</td>
<td>F32T8</td>
<td>32</td>
<td>216</td>
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<td>6570</td>
<td>45412</td>
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<td>40</td>
<td>1136</td>
<td>14</td>
<td>5110</td>
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<td>20000</td>
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<td>109395</td>
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<td>$9.81</td>
</tr>
<tr>
<td>5th Floor</td>
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<td>109395</td>
<td>$1.83</td>
<td>25000</td>
<td>4.89</td>
<td>$6,563.69</td>
<td>$9.81</td>
</tr>
<tr>
<td>Exit Signs</td>
<td></td>
<td></td>
<td>6.5</td>
<td>215</td>
<td>24</td>
<td>8760</td>
<td>12242</td>
<td>$4.99</td>
<td>43800</td>
<td>5.00</td>
<td>$734.53</td>
<td>$3.42</td>
</tr>
</tbody>
</table>

1105722  
$66,343.33
Much of the energy consumed by the lighting came from T8 and T12 linear fluorescent tubes set into either a 3 bulb or a 4 bulb fixture. The choice to use these types of bulbs came mainly from the ease of changing out the bulbs as well as the low cost associated with purchasing new bulbs. These fixtures were found in the hallways on the floors that contained patient rooms and within the patient rooms themselves. A total of 1471 of these bulbs were counted during the energy assessment.

Another type of bulb that was commonly used by the hospital was the 60 Watt or 100 Watt incandescent bulb which was used primarily in common areas, such as at the nurses’ stations and in the waiting rooms and cafeteria. These were set into individual fixtures and were chosen for primarily the same reasons as the T8 and T12 bulbs used in the hallways and patient rooms: low maintenance costs and ease of replacement. These bulbs were used less frequently than other types of bulbs and the overall energy usage was negligible when compared with the overall energy usage of the hospital. Because of this, these bulbs were not counted during the energy assessment.

A third category of bulbs that was used commonly in the hospital is the high pressure sodium bulb. The hospital used high pressure sodium bulbs in much of their outdoor lighting. The hospital had three different models of these high pressure sodium bulbs to be used in three different areas of the hospital campus.

The first application of high pressure sodium bulbs was in the parking lots outside of the hospital. These bulbs were GE LU400 and were 400 Watt bulbs. There were a total of 55 parking lot light bulbs on the grounds of the hospital. These light fixtures were set on a timer and were on for a total of 14 hours per day, every day of the year.
Similarly, the hospital used high pressure sodium bulbs for the lighting on top of and on the outside of the parking structure. These bulbs were in clusters of four or two bulbs, depending on the location of the lighting fixture. The bulbs were GE LU250 and consumed 250 Watts of electricity. There were a total of 22 of these bulbs and they were left on 24 hours a day, every day of the year.

The third and final application of the high pressure sodium bulbs was within the parking garage itself. These bulbs were GE LU100 and consumed 100 Watts of electricity. A total of 132 bulbs could be found within the parking garage. Like the lighting on the outside of the parking garage, these lights were left on 24 hours a day, every day of the year.

### 3.3.2 Heating, Ventilation and Air Conditioning

A large portion of the energy that was consumed by the hospital that was studied came from the heating, ventilation and air conditioning (HVAC). The hospital had two large chillers that provided the air conditioning for the entire hospital. One chiller had a capacity of 500 tons and the other had a capacity of 700 tons. These chillers were located onsite in the basement of the facility.

The hospital also had eight steam generators for heating purposes. These generators ran on either oil or gasoline. The equipment could transition between the two fuel types depending on which fuel type was more economical in the current situation. Even during warmer months, the hospital must maintain one of the steam generators for the purpose of sterilizing medical equipment. During the warmer months, the steam was kept at 115°F and during the winter, the steam was heated to 180-190°F.
3.3.3 Electronics and Computer Equipment

The computer equipment located in the hospital was standard equipment that was similar in energy usage to equipment that could be found in many office complexes. As of the time when this study was conducted, there was no strong market for energy efficient computer equipment. Because of this, the payback period for replacing the computer equipment would be far too long to make the improvements economically feasible. This study did not investigate the replacement of any computer equipment or electronics. There will be a discussion later in this report about practices that the hospital employees can use to reduce the energy use of the existing equipment.

3.3.4 Medical Equipment

There are medical devices that use less electricity to function than what the hospital had, however many of these machines and equipment had a very high initial cost associated with purchasing them. Because of this, the team chose not to investigate the energy consumption of medical devices. The team did recommend that the hospital staff consider the environmental benefits when selecting new equipment during the routine replacement of supplies and equipment.

3.3.5 Miscellaneous Equipment

The final category of equipment that used energy was the miscellaneous equipment that was vital to the operation of the hospital. This included a range of different equipment including the elevators, the smoke alarms, the food preparation appliances, the vending machines and a number of other devices. As with the medical equipment, the team
determined that it would not be cost justifiable for the hospital staff to replace most of these devices due to the large initial costs associated with purchasing new equipment. In addition, replacing industrial sized refrigerators and the equipment needed to run the elevators would be a project that would go beyond the scope of the hospital’s current energy saving improvement initiative.

There was one area of improvement that the research team investigated in this category, however. It was determined that investigating the energy use of the exit signs throughout the hospital was feasible due to the large number of the signs. It was also relatively simple to make improvements to the signs. While there were several varieties of exit signs located throughout the hospital, the most common variety was the sign that consumed 6.5 Watts. These signs were left on 24 hours a day and 365 days a year as mandated by law. The research team did not take a full inventory of the signs, but estimated that there were approximately 215 exit signs throughout the inside of the hospital facility.

3.3.6 Backup Electricity Generators

Most of the energy that the hospital used came mainly from the electrical grid. The facility did have several on-site generators that were used to add additional capacity and were used as backup generators in case of power outages. The facility had two main generators on the property. These were both Caterpillar diesel generators, model number SR4B-HV. Table 3.2 details the amount of diesel fuel consumed by each generator when the generators were operating at 100%, 75% and 50% of capacity. The generators were
typically run at 75% capacity and therefore consumed approximately 116 gallons per hour.

Table 3.2: Fuel Consumption of the Diesel Generators at Varying Capacity Levels.

<table>
<thead>
<tr>
<th>Capacity Level</th>
<th>Fuel Consumption (gal/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% with fan</td>
<td>156.9</td>
</tr>
<tr>
<td>75% with fan</td>
<td>116.0</td>
</tr>
<tr>
<td>50% with fan</td>
<td>81.3</td>
</tr>
</tbody>
</table>

The generators had a nameplate generating capacity of 2.25 MW each and generated 3,350 hp. The facility had a 10,000 gallon tank on-site with 2 20,000 gallon tanks for reserves.

3.4 Data Analysis

One of the greatest challenges that the principle investigator and the rest of the research team faced when conducting the comprehensive energy assessment for the hospital was how to reconcile the different forms of energy generation and consumption that were found throughout the facility. As seen in the previous sections, the energy was being generated from a variety of sources, including electricity consumed from the grid, electricity generated by the onsite generators and steam and cold water being generated by the steam generators and chillers located in the basement. In order to compare the economical effects of the hospital’s energy consumption to the proposed improvements, the costs needed to be standardized.

For the purposes of the economical analysis, the research team attempted to calculate the present worth of the costs of the energy used by the facility. The research
team first calculated the number of hours each piece of electrical equipment operated for each day. When the manufacturer’s expected life (in hours) was divided by the total hours used per year, the assumed life (in years) of the electrical equipment was found.

The next step was to figure out the yearly energy costs of the electrical equipment. This was done by multiplying the manufacturer’s stated nameplate energy consumption by the number of hours the equipment would be running per year. This yielded the total kilowatt-hours per year that the device consumed. The rate that the hospital paid for electricity from the grid was US $0.06 which was used to calculate the total yearly cost for each electrical device.

In order to compare the total costs of the existing system versus the total costs of any proposed improvements, present worth calculations were made. The generalized equation for calculating the present worth is shown in Equation 3.1.

$$PW = \frac{C_i}{(1 + r)^0} + \frac{C_1}{(1 + r)^1} + \frac{C_2}{(1 + r)^2} + \ldots + \frac{C_n}{(1 + r)^n}$$

Equation 3.1: Present Worth calculation.

Where:

- $n$ = the number of periods of time the study is being performed on
- $C_i$ = initial cost of the equipment and any costs associated with installing the equipment
- $C_n$ = the cost associated with the period of time
- $r$ = the discount rate (the rate of return on an investment in financial markets with similar risk)
Examples of this analysis can be found in Section 4.2 – Cost Benefit Analysis.

### 3.5 Report Writing

Preparing the report for the hospital staff was completed following the data analysis. While the report followed a format similar to the standard report outlined in chapter 2.7 of this document, there were a few notable differences.

According to the US Department of Energy’s Energy Star program, one of the concerns that hospital administrators face is the minimization of risk when it comes to uncertainty of energy costs. To facilitate discussion of those concerns, the recommendations to the hospital were provided in a Microsoft Excel spreadsheet. In reports for other companies, the principle investigator would present the report in a Microsoft Word document for ease of reading. The spreadsheet allows the user to experience different scenarios, such as higher or lower MARR or changes in the price of energy.

One other significant difference was caused by data that were missed during the data collection phase. During other comprehensive energy assessments, it is important to collect the utility bills from the organization for at least one year. While conducting this energy assessment, the research team obtained a utility bill but could not put it to use for the report. The bill did not detail what the overall electrical usage of the hospital was. Therefore, all of the recommendations made in the report reflect only what was measured and not what the overall energy picture of the hospital was.
Despite the differences, this report followed the same outline as other energy assessment reports. The report began with a background of the research lab and of the health care organization. The report then detailed the methodology of an energy assessment. The raw data was presented as well as the data analysis and recommendations. The report also contained a section on how to sustain the improvements made as a result of the energy assessment.

### 3.6 Final Meeting

Following the completion of the energy assessment report, the principle investigator contacted the employee contact at the health care facility. A final meeting was arranged to discuss the results of the energy assessment as well as the recommendations that the team was able to conclude. The members of the research team requested that several significant people were in attendance at this final meeting. The operations manager was a necessary attendee due to his influence in making the decisions with regards to facility improvements. The team also requested that members of the maintenance department attend the meeting as it would be the maintenance department’s responsibility to replace light bulbs and other equipment. Finally, the team requested that an electrician be in attendance to verify the feasibility of the electrical improvements made to the facility.

To begin the meeting, the research team first presented an overview of the energy assessment methodology. Following that, the presenter outlined the data that were collected as well as how the data were analyzed. Finally, the presenter explained each recommendation and explained the method for calculating payback periods and MARR at the request of one of the hospital staff.
As the presenter was explaining each recommendation, the hospital staff was asked for their input into the feasibility of each. Some were readily accepted or plans were already begun to make similar improvements. Others were rejected due to prior investigations that had shown them to be infeasible. The reasons for the recommendations being infeasible were internal politics and regional energy regulations put forth by the utility company that the research team was not aware of.

Following the final meeting, the research team agreed to assist with monitoring the implementation. As this was not within the expertise of the research team, they chose to act in mainly an advisory capacity instead of taking an active role in the implementation. The research team then made arrangements to conduct a follow up assessment that would be less comprehensive within several months of the completion of the implementation of the recommendations.
Chapter 4

Recommendations, Implementation, and Sustainability

4.1 Overview of Lighting Recommendations

After completing the data analysis, the research team was able to make several recommendations to reduce the energy consumption of the hospital facility. These suggestions were made not only with the environment in mind, but also the financial health of the hospital. These specific recommendations that will be covered in this section were limited solely to the lighting of the hospital for several reasons. A general overview of other energy saving recommendations can be found in section 5.2 Other Areas for Energy Reduction.

As mentioned in previous sections of this study, the research team was unable to determine the total energy consumption of the hospital due to imprecise reporting from the electrical company. This made it difficult to know how much electricity was being used to heat and cool the building. There were no records of which days the heating was on or which days the air conditioning was running. In addition, it was beyond the scope of this study to determine which days were hotter and which days were cooler in order to determine how hard the HVAC system was working. Additionally, many of the recommendations to improve the air quality system in the hospital were too capital
intensive. The hospital staff was looking for recommendations that required lower upfront costs associated with them.

4.1.1 Recommendation 1 – Lighting Sensors on the Exterior of the Parking Structure

Upon studying the lighting in the parking structure, the research team determined that installing three light sensors on the exterior of the structure would reduce the energy consumption of the GE LU250 high pressure sodium light bulbs located there. The current situation was that these lights were left on 24 hours a day, 365 days a year. It was found that these bulbs could be set to a light sensor to reduce the unnecessary electrical consumption during the daytime. The appropriate light sensors were found to cost US $57 per unit and would take several hours to install each one. There were some concerns with this recommendation as turning these bulbs on and off each night could reduce the life of the bulbs. The economic analysis in the next section shows that the reduced cost of electricity offsets the shorter life of the bulbs.

4.1.2 Recommendation 2 – LED Tube Retrofits for the F40T12 Bulbs

The F40T12 bulbs were used primarily in the second floor hallways and patient rooms. An LED retrofit was found that would save the hospital a considerable amount of electricity but a marginal amount of money. At the current energy prices, this retrofit will break even over the life of the bulbs. There are a number of factors that could push the overall costs in favor of the LED option. If energy prices rise at all over the next five years, the LED bulbs will see a substantial savings over the current fluorescent bulbs. In
addition, the hospital may be eligible for government rebates for purchasing extremely low Wattage lighting that contains no mercury.

4.1.3 Recommendation 3 – LED Retrofits for Exit Signs

The data analysis of the exit signs of the hospital revealed that replacing the exit signs with low wattage LED lights would see a substantial savings over the life of the bulbs. The research team did not take a total inventory of all of the exit signs within the facility, so the research team chose to estimate the total number of signs at 215.

4.2 Economic Analysis

As mentioned in section 3.4, an economic analysis was completed on the data gathered during the energy assessment. In order to properly compare the existing energy situation with the proposed recommendations, the net present worth was calculated for both. This factored in the initial costs of purchasing new equipment, the costs of replacing existing equipment, the labor costs involved as well as annual costs based on the calculated energy consumed by each electrical system. The calculations were based on Equation 1.

For the economic calculations, a MARR of 8% was used. This was chosen because typical industry MARRs fall between 8% and 10%. The economic situation of the country at the time of the study is fairly poor, so a lower MARR was chosen.

When the research team was conducting the on-site data collection, it was determined that the hospital had arranged a contract with the utility company that provided the electricity at a cost of US $0.06 per kW-h. This is much lower than the commercial average for Ohio of US $0.1016 per kW-h but higher than the industrial
average for Ohio of US $0.0581 per kW-h. The rate of US $0.06 per kW-h was used for all the economic calculations in this research.

Table 4.1: Options for LU250 Lights

<table>
<thead>
<tr>
<th>Model</th>
<th>Option 1 - Light Sensors (3)</th>
<th>Option 2 - LED Spotlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE LU250</td>
<td>22 22</td>
<td>22</td>
</tr>
<tr>
<td>Watts</td>
<td>250 250</td>
<td>18</td>
</tr>
<tr>
<td>Hrs Per Day</td>
<td>24 14</td>
<td>24</td>
</tr>
<tr>
<td>Hours Per Year</td>
<td>8760 5110</td>
<td>8760</td>
</tr>
<tr>
<td>kW-h Per Year</td>
<td>48180 28105</td>
<td>3469</td>
</tr>
<tr>
<td>Initial Cost Per Unit</td>
<td>$ 12.45</td>
<td>$ 12.45</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$ 273.90</td>
<td>$ 444.90</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$ 330.00</td>
<td>$ 480.00</td>
</tr>
<tr>
<td>Life (Hours)</td>
<td>24000 22000</td>
<td>50000</td>
</tr>
<tr>
<td>Life (Years)*</td>
<td>2.74 4.31</td>
<td>5.71</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$ 0.06</td>
<td>$ 0.06</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$ 2,890.80</td>
<td>$ 1,686.30</td>
</tr>
<tr>
<td>NPW</td>
<td>$27,831.45</td>
<td>$17,847.68</td>
</tr>
<tr>
<td>MARR</td>
<td>0.08 0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The NPW calculation for this type of lighting used a lifespan of 18 years. 18 years was used because it is the lowest common denominator for the life spans of the three options: 3 years for the present situation (rounded up from 2.74), 4.5 years for the light sensors (rounded up from 4.31) and 6 years for the LED spotlights (rounded up from 5.71). The NPW calculation clearly shows that option 1 would be the most financially beneficial option for the hospital, as the NPW of the costs is much lower than either the existing situation or installing LED spotlights.
The results of the NPW calculations for this lighting fixture type yielded results that show that the existing solution is the most financially sound decision. The NPW calculations used 6 years, as the existing bulbs lasted for 2.74 years (rounded up to 3) and the LED spotlights lasted for 5.71 (rounded up to 6).
Table 4.3: Options for LU400 Lights

<table>
<thead>
<tr>
<th>Model</th>
<th>GE LU400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qty</td>
<td>55</td>
</tr>
<tr>
<td>Watts</td>
<td>250</td>
</tr>
<tr>
<td>Hrs Per Day</td>
<td>14</td>
</tr>
<tr>
<td>Hours Per Year</td>
<td>5110</td>
</tr>
<tr>
<td>kW-h Per Year</td>
<td>70263</td>
</tr>
<tr>
<td>Initial Cost Per Unit</td>
<td>$ 12.01</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$ 660.55</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$ 825.00</td>
</tr>
<tr>
<td>Life (Hours)</td>
<td>24000</td>
</tr>
<tr>
<td>Life (Years)</td>
<td>4.70</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$ 4,215.75</td>
</tr>
<tr>
<td>NPW</td>
<td>$ 29,779.60</td>
</tr>
<tr>
<td>MARR</td>
<td>0.08</td>
</tr>
</tbody>
</table>

While the research team was investigating the lighting that was found in the parking lot of the hospital, no clear alternatives were discovered to replace the existing situation. The lights were already on a light sensor and turned off when the sun was not out. The lights were also far too bright to be replaced with the LED lights that exist in the market today. At some point in the near future, LED technology may exist to replace the parking lot lights at this facility; however as of the preparing of this study, no financially sound technology exists.
Table 4.4: Options for F40T12 Lights

<table>
<thead>
<tr>
<th>Model</th>
<th>Option 1 - LED Tube Retrofits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F40T12</td>
</tr>
<tr>
<td>Qty</td>
<td>1136</td>
</tr>
<tr>
<td>Watts</td>
<td>40</td>
</tr>
<tr>
<td>Hrs Per Day</td>
<td>14</td>
</tr>
<tr>
<td>Hours Per Year</td>
<td>5110</td>
</tr>
<tr>
<td>kW-h Per Year</td>
<td>232198</td>
</tr>
<tr>
<td>Initial Cost Per Unit</td>
<td>$ 2.51</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$ 2,851.36</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$ 2,840.00</td>
</tr>
<tr>
<td>Life (Hours)</td>
<td>20000</td>
</tr>
<tr>
<td>Life (Years)*</td>
<td>3.91</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$ 0.06</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$ 13,931.90</td>
</tr>
<tr>
<td>NPW</td>
<td>$152,828.29</td>
</tr>
<tr>
<td>MARR</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The NPW analysis showed that either option would be approximately equal financially over the course of twenty years. The research team recommended that the LED lights be installed to lower the risk from price fluctuations. If, for example, the price per kW-h rises from $0.06 to $0.065, the existing situation’s NPW would be $164,000 and the LED retrofits would have a NPW of $162,000. Having the LED lights would reduce the effects of sudden changes in energy prices.
Table 4.5: Options for F32T8 Lights

<table>
<thead>
<tr>
<th>Model</th>
<th>F32T8</th>
<th>Option 1 - LED Tube Retrofits</th>
<th>Option 2 - LED Fixture Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qty</td>
<td>3561</td>
<td>3561</td>
<td>1187</td>
</tr>
<tr>
<td>Watts</td>
<td>32</td>
<td>15</td>
<td>43</td>
</tr>
<tr>
<td>Hrs Per Day</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Hours Per Year</td>
<td>5110</td>
<td>5110</td>
<td>5110</td>
</tr>
<tr>
<td>KW-h Per Year</td>
<td>582295</td>
<td>272951</td>
<td>260820</td>
</tr>
<tr>
<td>Initial Cost Per Unit</td>
<td>$1.83</td>
<td>$62.96</td>
<td>$245.00</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$6,516.63</td>
<td>$224,200.56</td>
<td>$290,815.00</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$8,902.50</td>
<td>$8,902.50</td>
<td>$2,967.50</td>
</tr>
<tr>
<td>Life (Hours)</td>
<td>24000</td>
<td>50000</td>
<td>50000</td>
</tr>
<tr>
<td>Life (Years)*</td>
<td>4.70</td>
<td>9.78</td>
<td>9.78</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$0.06</td>
<td>$0.06</td>
<td>$0.06</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$34,937.68</td>
<td>$16,377.04</td>
<td>$15,649.17</td>
</tr>
<tr>
<td>NPW</td>
<td>$259,570.50</td>
<td>$342,994.32</td>
<td>$398,789.71</td>
</tr>
<tr>
<td>MARR</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The results of this NPW calculation showed that the existing condition is the one that is most financially sound. Both types of LED lights had too high of an initial cost to offset the lower costs of energy. As mentioned earlier, until LED technology improves and costs are lowered, the hospital should choose to retain the lighting they currently have installed.
Table 4.6: Options for Exit Signs

<table>
<thead>
<tr>
<th>Model</th>
<th>Existing Signs</th>
<th>LED Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qty</td>
<td>215</td>
<td>215</td>
</tr>
<tr>
<td>Watts</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Hrs Per Day</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Hours Per Year</td>
<td>8760</td>
<td>8760</td>
</tr>
<tr>
<td>kW-h Per Year</td>
<td>12242</td>
<td>1883</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$ 4.50</td>
<td>$ 10.00</td>
</tr>
<tr>
<td>Initial Cost</td>
<td>$ 967.50</td>
<td>$ 2,150.00</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$ 537.50</td>
<td>$ 537.50</td>
</tr>
<tr>
<td>Life (Hours)</td>
<td>43800</td>
<td>43800</td>
</tr>
<tr>
<td>Life (Years)</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Energy Cost</td>
<td>$ 0.06</td>
<td>$ 0.06</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>$ 734.53</td>
<td>$ 113.00</td>
</tr>
<tr>
<td>NPW</td>
<td>$ 4,437.75</td>
<td>$ 3,138.69</td>
</tr>
<tr>
<td>MARR</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

This analysis of the exit signs was conducted differently than other analyses. Due to the vast number of exit signs at the hospital facility and the limited resources of the research lab, the research team chose to estimate the number of exit signs in the facility instead of take inventory of every sign.

The NPW calculations determined that the LED retrofits for the exit signs were the best financial solution. It is worth noting that there were several models of exit signs at the hospital with different Wattages. Most of the signs were 6.5 Watts or 5.6 Watts. After performing additional calculations, it was found that the recommendations hold true for all Wattages greater than 3.6 Watts.
4.3 Environmental Impact

The research team also chose to complete an analysis of the environmental impact of the proposed changes at the hospital. The team focused on two main areas when completing this assessment. These two areas were pounds of carbon dioxide emissions and the milligrams of mercury that were saved from being released into the environment.

In order to calculate the pounds of carbon dioxide that were being released and the amount that value was reduced by, the research team used data that was available on the United States Department of Energy’s website. The team found a 2000 CO$_2$ Emissions report that was instrumental in the data analysis. It was first determined what percentage of electricity was generated by each type of energy generation source within the East North Central Division of the US. The results can be seen in Table 4.7.

Table 4.7: Percentage of Electricity Generated by Types of Power

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>72.0%</td>
<td>0.7%</td>
<td>4.4%</td>
<td>22.9%</td>
</tr>
</tbody>
</table>

Other in this table refers to hydroelectric power, nuclear power, and other renewable energy sources.

The next step that the research team took was to determine how many pounds of CO$_2$ were emitted for each kilowatt-hour of electricity generated by each source. This was also found in the US DOE’s 2000 report. The results can be found in Table 4.8.

Table 4.8: Pounds of Carbon Dioxide Emitted for Each kW-h

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Petroleum</th>
<th>Gas</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds</td>
<td>2.061</td>
<td>2.759</td>
<td>1.63</td>
<td>1.131</td>
</tr>
</tbody>
</table>
From the data found in the previous two tables, the research team calculated a weighted average of the carbon emissions of the four types of energy generation. These calculations yielded a value of 1.834 pounds of CO$_2$ released into the atmosphere for each kW-h of electricity generated in the East North Central Division of the United States.

Additionally, the research team wanted to calculate the amount of mercury that was saved from being released into the environment from the recommendations. According to a United States Environmental Protection Agency study, an average of 0.016 mg of mercury is generated by power plants for each kW-h of energy produced.

Knowing these two values, the research team was then able to calculate the environmental impact of the recommendations made in this report. The results can be found in Table 4.9.

Table 4.9: Environmental Savings

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>kW-h Saved</th>
<th>CO$_2$ Emissions Reduction</th>
<th>Mercury Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommendation 1 - LU250</td>
<td>20,075</td>
<td>36,817.55</td>
<td>321.20</td>
</tr>
<tr>
<td>Recommendation 2 - F40T12</td>
<td>145,124</td>
<td>266,157.42</td>
<td>4,366.98</td>
</tr>
<tr>
<td>Recommendation 3 - Exit Signs</td>
<td>10,359</td>
<td>18,997.86</td>
<td>165.74</td>
</tr>
<tr>
<td>Total</td>
<td>175,557.70</td>
<td>321,972.82</td>
<td>4,853.92</td>
</tr>
</tbody>
</table>

Based on the previous table, it is clear that replacing the F40T12 bulbs will have the greatest environmental impact due to reduced energy generation.

Additionally, the existing F40T12 bulbs contain an average of 7.2 mg of mercury in them that need to be disposed of properly. Replacing those bulbs with LEDs which contain no mercury can yield a further reduction in mercury of 2045 mg annually. This mercury reduction has already been accounted for in Table 4.9.
4.4 Implementation

When the hospital staff chose to carry out the recommendations put forth by the research team, they had to be mindful of several issues. Improper implementation would have created a system that would not be as financially acceptable and would most certainly create different results than what was calculated in the economic analyses.

The main concern that the hospital staff had to address was the issue of timing of replacing the lighting fixtures. Recommendation 1, installing light sensors on the outside of the parking structure, was an improvement that could have been made immediately upon receiving this report. No loss of existing equipment or shortened life spans would results from completing this improvement immediately.

The other two recommendations were slightly different. In order to maximize the life of the existing bulbs, it was recommended that the hospital staff only replace the F40T12s and the existing exit sign bulbs when they burned out. This served two important functions. The first was that it reduced the amount of upfront capital required to install the new LED lights throughout the facility. Staggering the upgrades spread the costs over a matter of four or five years as opposed to a large initial purchase.

Waiting to install the new fixtures also resolved the issue of how to dispose of the existing light bulbs. If the hospital staff had replaced all of the existing bulbs immediately, they would have been left with a large inventory of new or partially used bulbs. These could not have been sold or used elsewhere, so the hospital staff would have been forced to throw away functioning bulbs and would have ended up losing money that they had invested in those bulbs. This lost money would have dramatically
changed the economic analyses that were conducted and may have altered the final recommendations put forth by the research team.

One final recommendation about the implementation of the new lighting fixtures was for the hospital staff to verify that the new lighting options would meet the needs of the hospital before completing a facility-wide upgrade. Several light bulbs of each type should have been purchased and installed as a pilot program before upgrading all of the lighting within the hospital.

4.5 Creating a Sustainable System

One of the most important lessons that the hospital staff had to take from this study was the importance of creating a culture that reduced energy costs. Notifying the hospital staff that was not involved with the study or the improvements of the successes that the hospital had achieved was vital to promoting that culture. Having this culture in place will be beneficial for the future because the green team will gain leverage at the hospital and will be able to make suggestions for improvement in the future.

It is also important that the staff at the hospital ensure that members of the green team are involved whenever new additions or renovations to existing areas are planned for the hospital facility. Many environmentally conscious recommendations are much more financially feasible if they are planned before a new building is constructed as compared to improvements to existing facilities.
The hospital that is constantly looking for continuous improvement when it comes to environmental issues is the hospital that will have a greatest competitive advantage, especially as costs associated with higher energy bills rise.
Chapter 5

Overall Conclusion

5.1 Remarks on Energy Assessments

This report has shown that there are many benefits, both economic and environmental, that result from the proper use of a comprehensive energy assessment. When performed correctly, energy assessments can give a hospital or other health care facility a competitive advantage over other health care facilities in the same area. There are several caveats, however, that the principle investigator must be aware of before beginning the process of conducting an energy assessment.

One issue to be aware of is the issue of word of mouth data. One very important way to gather information about the energy being consumed at a facility is to interview the employees that interact directly with the energy consuming devices. This could include maintenance supervisors, electricians, operations managers or environmental health and safety employees. The data gathered from these interviews are crucial to understanding the bigger picture about the energy situation of the facility. They are not, however, to be used definitively for cost calculations or for making recommendations. Any numbers that are given during the investigations should be double checked. If a
report was written with numbers that turn out to be inaccurate, the facility could end up with improvements that are not cost justifiable and would end up hurting the facility more than it would help it.

Another situation to be aware of is the possibility of data that is being altered for one reason or another. Employees may be misrepresenting their energy use because they feel as though their organization is not as environmentally friendly as it should be. Although rare, they could also be altering the data for more malicious reasons. They may have a vested interest in seeing some aspect of their facility either stay the same or change in a way that would be most beneficial to them. Always beware of hidden motives if it seems as though employees are giving you data that does not seem wholly accurate.

One final warning about incorrect information gathered from energy assessments comes from having preconceptions about what improvements need to be made at the facility. It is very likely that the client will have an improvement in mind, for example installing solar panels, without any evidence to support that plan of action. If this is the case, the energy assessment report may find that solar panels are not economically viable and the client will possibly create resistance to any alternative recommendations that are made. If this is the situation, showing the client the process of analyzing the data and explaining the graphs and tables in the report should clear up any preconceptions that the client may have.

To summarize this section, it is always important to be skeptical of all the data that is gathered from an energy assessment. One should never use the results of an
employee interview as the last word in performing the final data analysis or for making recommendations for improvement. All results should be backed up with solid, numerical evidence or the incorrect recommendations in the report could lead to negative consequences for the health care facility.

5.2 Other Areas for Energy Reduction

While the focus of the recommendations was improving the lighting within the hospital, there were several areas of the hospital that could be improved to reduce the total electricity usage. These areas include the HVAC system, the insulation of the building, the possibility of alternative energy, the electronic equipment and the water heating equipment. While there are a number of specific items that a researcher could focus on within these areas, there are two general rules that can be used for most systems.

The first guideline is to replace any outdated or obsolete equipment. As equipment ages, it becomes less and less efficient. These inefficiencies can create substantial wastes of energy and subsequently cost more for the hospital. Examples of this type of inefficiency include ductwork that is not insulated properly, window frames that do not create a solid seal or electronic equipment that does not meet current Energy Star ratings.

The second guideline for energy saving recommendations is to change practices that are creating waste. There are numerous opportunities within hospitals to turn off systems when they are not in use. Examples of this include having computers or printers enter hibernate mode when they are not being used or turning down the temperature of water heaters during the summer when warmer water is in lower demand.
While it is beyond the scope of this research to investigate these inefficiencies within the hospital, there are a number of tools that can be used to guide researchers who are looking to perform that level of investigation. One resource is a tool that is provided by the US Department of Energy’s Office of Energy Efficiency and Renewable Energy. The Industrial Technologies Program offers a collection of free software that can aid in conducting energy assessments and performing the data analysis. While this tool is designed for industrial customers, the software can be easily adapted for health care facilities. A link to the DOE’s web page can be found in the References section of this thesis.

5.3 Future of Energy Assessments

It has been clearly shown from the case study that there are numerous economical and environmental benefits for a health care facility to pursue a comprehensive energy assessment. In addition to these benefits, there are several possible occurrences in the future that would make energy assessments even more necessary and possibly even mandatory.

One such event that may happen in the United States and is already happening elsewhere in the world is carbon emission trading. In 2009, the United States House of Representatives approved a bill that mandates carbon emission trading. As of the writing of this report, the United States Senate has yet to vote on the bill, so there is no current national policy for carbon emission trading.

If this bill or another similar bill is signed into law by the United States government, many larger companies and organizations will be required to perform energy
assessments of their facilities in order to determine their levels of carbon dioxide emissions as well as other greenhouse gases. This will increase the need for a comprehensive standard that can be applied equally to facilities across many different industries. Any organization that voluntarily chooses to perform an energy assessment would gain a competitive advantage over their competitors, who may not be as prepared if the bill is ever signed into law.

Organizations may also gain another competitive advantage from voluntarily performing energy assessments of their facilities. There are a number of unforeseen events that may occur that would cause extreme volatility in the price of natural gas, coal and gasoline. The outbreak of war in the Middle East or other OPEC countries can cause gasoline prices to rise. Natural disasters which are stronger than expected can disrupt supply lines. Recession or depressions in the economy can hinder demand. Legal action against energy companies can have an effect on prices. These and other events can cause highly unexpected volatility in energy prices. Facilities that have performed comprehensive energy assessments and have implemented the recommendations successfully will be less affected by variation in energy prices. This would give organizations a competitive advantage over other organizations in the same industry.

Technology may also influence the increased use of energy assessments. Smart grids are becoming increasingly more popular, which is resulting in more transparency about energy consumption and conservation. Thermal imaging cameras and leak check systems are being used to determine structural deficiencies that are leading to energy being wasted on heating, ventilation and air conditioning. Additionally, hand-held
electricity meters are being used to measure the energy being consumed by large appliances and electrical equipment, resulting in a more well managed electrical system.

While conducting energy assessments is an idea that has been developed for as long as facilities have been installing electrical grids, there are a number of forces that are leading to an increased use of comprehensive energy assessments that will likely only continue to grow in demand.

5.4 Concluding Remarks

While this study resulted in lower overall costs for the hospital and decreased the environmental impact of the facility, there are many other aspects of energy reduction that could have been investigated. This study looked primarily at the lighting of the hospital but other areas include the use of alternative energy, installing a more energy efficient HVAC system, resurfacing the roof with either a green roof or a roof with a reflective surface, or implementing practices that would reduce the overall energy consumption of the facility. It is only with continued studies and research that the hospital will continue to reduce its environmental footprint.
References


