COMPARATIVE ANALYSIS OF ENERGY CONSUMPTION OF SELECTED BUILDINGS
ON MOREHEAD STATE UNIVERSITY’S MAIN CAMPUS

A Thesis
Presented to
the Faculty of the College of Science and Technology
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of the Requirements for the Degree
Master of Science

by
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Accepted by the faculty of the College of Science and Technology, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

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Director of Thesis
Ahmad Zargari

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Hans Chapman

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Nilesh Joshi

Date ___May, 2014_________________________
Currently there is a need for energy efficiency on the main campus of Morehead State University main campus. Evidence shows that there is room for improvement in order to lower the usage and cost efficiency at MSU. The purpose of this study is to propose, that Net Zero technology should be implemented towards the main campus of Morehead State University in the near future. The goal is to come up with a study of comparing selected current traditional buildings with the LEED buildings (Wellness Recreational Center and CHER building). To form this analysis will be applied using SPC software on Energy usage for year by year trends from 2012. In conclusion, Net-Zero construction has steadily increased since then, with the number of completed buildings more than doubling since 2008, according to the latest study. Thanks to advances in structural insulation, energy-efficient appliances, this will help the MSU campus in the near future.

As for energy efficiency, to make sure we have plenty of energy in the future, it's up to all of us to use energy wisely. We must all conserve energy and use it efficiently. It's also up to those who will create the new energy technologies of the future.
Accepted by: __________________________, Chair
Ahmad Zargari

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Hans Chapman

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Nilesh Joshi
The author would like express his helpful support to all the individuals who have reviewed this thesis and gave beneficial ideas to improve the quality of the thesis.

I would first like to thank Dr. Hans Chapman, my thesis Director, a member of my thesis committee for providing me with the right guidance to research energy efficiency and Net Zero Energy for my thesis. His advice during the tough times of my research encouraged me to fulfill numerous ideas to complete my thesis successfully and on time.

Secondly, I would like to thank Dr. Nilesh Joshi for going through my thesis and providing tips to help me. As an advisor during my undergraduate degree, he has helped me pursue the right path towards my background of Design and Energy efficiency.

Lastly, I would like to thank two very important people; Dr. Ahmad Zargari and Mr. Kevin Fulton. Dr. Zargari, my academic advisor, believed in me from day 1 as an undergraduate from when I signed up to pursue a degree in the AET Department. His constructive advice pushed me beyond measures to completely a successful thesis. I also want to thank Kevin Fulton for recruiting me to Morehead State University; He taught me how to be a humble, hard working person, without his words of encouragement and mentoring this thesis would not have been successful.
# Table of Contents

## CHAPTER 1: INTRODUCTION
- Overview .................................................................................................................. 1
- Purpose of Study ......................................................................................................... 2
- Objectives .................................................................................................................... 5
- Significance of Study .................................................................................................. 5
- Definition of Terms ...................................................................................................... 5

## CHAPTER 2: BACKGROUND AND REVIEW OF LITERATURE
- Net Zero Technology .................................................................................................. 7
- Leadership in Energy and Environmental Design (LEED) ........................................ 10

## CHAPTER 3: METHODOLOGY & FINDINGS
- Objective 1: Identify the current energy production and consumption of selected buildings on the MSU campus. .......................................................................................................................... 22
- This objective addresses the current Morehead State University Energy Conservation Program. The program is committed to a policy of effective energy management, conservation, efficiency, and sustainability.......................................................................................................................... 22
- Objective 2: Analyze the yearly electricity usage (KWh/square footage) for selected old and new buildings.......................................................................................................................... 27
- Objective 3: Determine the need for conversion toward future Net Zero Technology .......................................................................................................................... 36

## CHAPTER 4: CONCLUSION
- Recommendations ........................................................................................................ 41

## REFERENCES
- ................................................................................................................................ 43

## APPENDIX
- ................................................................................................................................ 44
LIST OF FIGURES

Figure 1: Current Net Zero Buildings in United States 2012 .......................................................... 8
Figure 2: Current Net Zero Buildings in United States 2014 (Barber, 2014) ................................. 9
Figure 3: Four Levels of LEED certification ..................................................................................... 11
Figure 4: Basic framework of the ESPC process ............................................................................. 12
Figure 6: Times Series of Old MSU Buildings ............................................................................... 24
Figure 7: Time Series of New Buildings ......................................................................................... 26
Figure 8: Times Series of Breckinridge and CHER ......................................................................... 29
Figure 9: Time Series of Fields Hall and Eagle Lake ................................................................. 31
Figure 10: Time Series of Recreational and Cooper Hall ............................................................ 33
Figure 11: Time Series of Space Science Center and Claypool .................................................... 35
Figure 12: ZEB and ZEC Buildings: Technology Penetration (Institute, 2012) .................. 38
Figure 13: Histogram of KWh usage of 8 selected Buildings on the Morehead State University Main Campus in 2012 ............................................................................................................ 45
Figure 14: Histogram of KWh usage of 8 selected Buildings on the Morehead State University Main Campus in 2013 ............................................................................................................ 45
Figure 15: Control Charts of Old Buildings .................................................................................. 46
Figure 16: Control Charts of New Buildings .................................................................................. 46
LIST OF TABLES

Table 1: Monthly kWh data for 8 Morehead State University buildings (4 old and 4 new) Year 2012.................................................................................................................................................................................. 22

Table 2: Monthly kWh data for 8 Morehead State University buildings (4 old and 4 new) year 2013.................................................................................................................................................................................. 23

Table 3: Square Footage of KWh data for 4 MSU old Buildings................................................................................................................................. 23

Table 4: Square Footage of KWh data for 4 MSU new Buildings................................................................................................................................. 25

Table 5: Energy Usage (KWh/sq. footage) for Breckinridge Hall (old) and Cher (new)........ 28

Table 6: Energy Usage (KWh/sq. footage) for Fields Hall (old) and Eagle Lake (new) .......... 30

Table 7: Energy Usage (KWh/sq. footage) for Cooper Hall (old) and the Recreational Center .. 32

Table 8: Energy Usage (KWh/sq. footage) for Claypool (old) and the Space Science Center (new)................................................................................................................................. 34
Chapter 1: Introduction

Overview

In modern day society, Morehead State University has been quoted as one of the safest universities in the south. Each year the University seeks for improvements whether it is academic excellence, student success, productive partnerships, improved infrastructure, resource enhancement, enrollment growth or retention gain.

The University is located in the foothills of the Daniel Boone National Forest in Rowan County. The over 700-acre main campus within the city limits of Morehead includes more than 50 major structures with a total replacement value of more than $650 million. The main campus includes 135 classrooms and 150 laboratories. Housing facilities include space for approximately 2,900 students in a variety of living styles, including traditional residence halls, suites and apartments. Recently the University has erected a space tracking system in partnership with NASA. The second component of the Space Science Center opened in 2009; a $16.6 million instruction and research support facility.

In addition in 2010 and 2011, Morehead State completed the first two energy efficient sustainable buildings on the main campus. The new Center for Health, Education & Research (C.H.E.R.), built to LEED standards, features integration with the Energy Management Systems (EMS) as well as lighting controls in 2010. The newly completed Student Recreation Center (LEED-Gold Certified) built in 2011 is also on the system, with lighting controls and a Green screen.
Purpose of Study

To explore ways of delivering highly efficient buildings whose reduced energy demand is satisfied by clean, renewable energy. Building off the broader concept of a green or sustainable building, the concept of the “net zero building” focuses on the energy dynamics and performance of the building. The focus on achieving deep energy efficiency centers on technologies as well as ways to connect buildings to the natural environment.

Considering the effects of climate change rise, and the increasing cost in the rise of the economy of eastern Kentucky, Net Zero Technology for building homes, offices and other structures is an efficient solution. Building an Institution in the Eastern Kentucky area would broaden the idea to the community. Taking a look at the Morehead State University Campus is the first step in promoting Net Zero to the Eastern Kentucky Area. As we look for another strategic plan to be implemented, there is a concern of energy sustainability costs on the main campus at Morehead State University. Although there are some efforts put in place to prevent this issue, more can be done to cut down the energy cost. Currently two buildings on the MSU campus meet Net Zero standards and have made an impact on energy efficiency. The purpose of this study is to propose, that Net Zero technology should be implemented towards the main campus of Morehead State University in the near future. The goal is to come up with a study of comparing selected current traditional buildings with the LEED buildings (Wellness Recreational Center and CHER building). To form this analysis will be applied using SPC software on Energy usage for year by year trends from 2012.
Description of Selected Buildings

Breckinridge Hall: Built in 1931, expanded in 1965 and renovated and expanded in 2002, this four-story classroom and office building was named in honor of Robert J. Breckinridge, former state school superintendent. A three-story building that houses the Department of Communication, Media and Leadership Studies; Hamilton Costume Shop; Hamm Speech Suite; Lucille Little Theatre; Yancy Television Seminar Room; Larry Netherton Production Room; and Morehead State Public Radio. (University, Campus Buildings, 2014)

Claypool: Built in 1968, this three-story classroom and office building includes a tri-level art gallery. It was named in honor of former art faculty members Naomi Claypool and Thomas Young. Ms. Claypool also was chair of the department. It includes the Strider Gallery, a classroom and office building for the Department of Art and Design; houses the main gallery and Strider Gallery (University, Campus Buildings, 2014).

Cooper Hall: Built in 1965, this four-story residence hall was upgraded in 2000 to improve fire safety. It was named in honor of former U.S. Sen. John Sherman Cooper. This Building is a four-story residence hall that houses 198 students (University, Campus Buildings, 2014).

Fields Hall: Built in 1926 and renovated in 1990, this three-story, coed, upper-class, academic honors residence hall was named in honor of Dora J. Fields of Olive Hill, first woman member of the Board of Regents and wife of former Gov. William J. Fields. It is listed on the National Register of Historic Places. The dorm is a four-story, coed residence hall for 125 upper-class students and those needing year-round housing (University, Campus Buildings, 2014).
**CHER Building:** Built in 2012, the CHER building is located at 216 West Second Street, the two-story facility houses the Department of Nursing; Department of Imaging Sciences; and Physician Assistant Program. A family medical clinic, operated by St. Claire Regional Medical Center, is located on the west end of the building (University, Campus Buildings, 2014).

**Space Science Center:** The Ronald G. Eaglin Space Science Center Building is a $15.6 million support facility containing classrooms, laboratories and offices. Opening in 2009, the two-story, state-of-the-art building encompasses 45,000 square feet of floor space (University, Campus Buildings, 2014).

**Recreational Center:** Built in August 2011, the center offers fitness and leisure activities along with space for social interaction among students. This state-of-the-art, 100,000 square-foot two-story facility was conceived and funded by students (University, Campus Buildings, 2014).

**Eagle Lake Apartments:** Built in 2002, this three-story structure contains 28 student apartments. It was named for its proximity to Eagle Lake. The building is a three-story structure with 28 one- and two-bedroom furnished apartments (University, Campus Buildings, 2014).
Objectives

• Identify the current energy consumption of selected buildings on the MSU Campus

• Analyze the yearly electricity usage per square footage for the selected buildings

• Determine the need for conversion toward future Net Zero technology.

Significance of Study

As mentioned in the introduction, there is energy sustainability through the Siemens Industry company in place today at the Morehead State University main campus along with the LEED certification recreational center on campus. With the use of SPC software answers this thesis will show the energy production and consumption of selected buildings compared to the LEED certified building.

The yearly data will provide a breakdown of the electricity cost and kilo watt usage between selected traditional buildings versus the LEED buildings (Recreational Wellness Center and CHER Building).

Definition of Terms

Net Zero Building & Zero Energy Building

Refers to a building that onsite generates at least as much energy as it uses over the course of a year using renewable resources.

LEED

Leadership in Energy And Environmental Design. The most widely used green building rating and benchmark system in the U.S. Maintained by the US Green Building Council

Energy Savings Performance Contracting (ESPC or ESP)
Developing and implementing a comprehensive project, which may include energy efficiency measures which are installed with an anticipation of payback with the cost savings of the more efficient building component. An ESPC project is delivered by an Energy Service Company (ESCO).

**Energy Service Company (ESCO)**

A Contracting company who will implement and contract out actual Energy Efficient Measures which will provide the savings. The ESCO can be a General Contractor, HVAC company, Building Controls or any organization with experience in both Energy and Contracting. Institute Building of Safety (IBTS) does not deliver or compete with ESCO services, rather a third party oversight and compliance agent of this and other processes in an ESPC.

**Siemens Inc.**

Siemens Infrastructure & Cities Sector, with approximately 87,000 employees worldwide, offers sustainable technologies for metropolitan areas and their infrastructures. Its offerings include complete traffic and transportation systems, intelligent logistics, efficient energy supply, environmentally compatible building technologies, modernization of the way power is transmitted and distributed, and smart consumption of electricity. The Siemens Building Technologies Division is the world’s market leader for safe and energy efficient buildings (“green buildings”) and infrastructures (Siemens, 2014).
Chapter 2: Background and Review of Literature

Net Zero Technology

The concept of a Net Zero Energy Building (NZEB), one which produces as much energy as it uses over the course of a year, has evolved recently from research to reality. Currently, there are only a small number of highly efficient buildings that meet the criteria to be called "Net Zero". As a result of advances in construction technologies, renewable energy systems, and academic research, creating Net Zero Energy buildings is becoming more and more feasible (Winter, 2013).

While the exact definitions of metrics for "net zero energy" vary (this is discussed below), most agree that Net Zero Energy Buildings combine:

Exemplary building design to minimize energy requirements

Renewable Energy requirements that meet these reduced energy needs

Regardless of the definition or metric used for a Net Zero Energy Building, minimizing the energy use through efficient building design should be a fundamental design criterion and the highest priority of all NZEB projects. Energy efficiency is generally the most cost-effective strategy with the highest return on investment, and maximizing efficiency opportunities before developing renewable energy plans will minimize the cost of the renewable energy projects needed. Using advanced energy analysis tools, design teams can optimize efficient designs and technologies (Winter, 2013).

Energy efficiency measures include design strategies and features that reduce the demand-side loads such as high-performance envelopes, air barrier systems, day lighting, sun
control and shading devices, careful selection of windows and glazing, passive solar heating, natural ventilation, and water conservation (Winter, 2013).

Once building loads are reduced, the loads should be met with efficient equipment and systems. This may include energy efficient lighting, electric lighting controls, high-performance HVAC, and geothermal heat pumps. Energy conversion devices such as combined heat and power systems, fuel cells, and micro turbines do not generate renewable energy. Instead, they convert fossils fuel energy into heat and electricity and are can be considered energy efficiency strategies (Winter, 2013).

As shown in Figure 1, the current zero energy buildings are located in a variety of U.S. climates. There are currently 21 zero Energy projects. Both California and Hawaii are well represented, with six and two buildings, respectively. The mild climate of these states certainly helps make
ZEBs achievable. Projects have however also been completed in the harsher climates of Minnesota, Wisconsin, and New York (New Buildings Institute 2012).

Figure 2: Current Net Zero Buildings in United States 2014 (Barber, 2014)

Figure 2 shows the progression from 2012 to 2014 present. ZNE buildings and districts are located in 36 U.S. states and Canada. In this figure 36 states with ZNE buildings, either verified or emerging have a dark solid color and reflect a wide variety of climate zones. ZNE Verified buildings are located in 17 states and the quantity per state is shown in the circle. California is a leader with ten ZNE Verified buildings, and Florida has three (New Buildings Institute, 2014).
Leadership in Energy and Environmental Design (LEED)

LEED, is the certification system of the U.S. Green Building Council that serves as a benchmark for the design, construction and operation of high-performance green buildings. Developed by the U.S. Green Building Council (USGBC) in March 2000, LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. LEED promotes sustainable building and development practices through a variety of rating systems. The rating systems recognize projects that implement strategies for better environmental and health performance. There are three levels of certification: Platinum, Gold, Silver and Certified (Larson, 2010).
The four levels of LEED Certification are shown in Figure 3, above. The number of points a project earns determines the level of LEED certification that project will receive. (U.S Green Building Council.org, 2014)

Benefits and Savings of LEED

LEED certification provides independent, third-party verification that a building or community was designed and built using strategies aimed at achieving high performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

There are both environmental and financial benefits to earning LEED certification. LEED certified buildings are designed to:

• Lower operating costs and increase asset value
• Reduce waste sent to landfills
• Conserve energy and water
• Be healthier and safer for occupants
• Reduce harmful greenhouse gas emissions
• Qualify for tax rebates, zoning allowances and other incentives in hundreds of cities (Council U. S., 2014)

Morehead State University Energy Saving Performance Contract

Morehead State University’s method for determining the appropriate requirements for the conversion involves analyzing the Energy Saving Performance Contract (ESPC) which allows Federal agencies to complete energy-savings projects without up-front capital costs and special Congressional appropriations.

Figure 4: Basic framework of the ESPC process
The basic framework of the ESPC process is shown in this simple model (Institute of Building Technology Safety 2014).

An ESPC is a partnership between Federal agency and an energy service company (ESCO). The ESCO conducts a comprehensive energy audit of Federal facilities and identifies improvements to save energy. In consultation with the Federal agency, the ESCO designs and constructs a project that meets the agency's needs and arranges the necessary funding. The ESCO guarantees that the improvements will generate energy cost savings to pay for the project over the term of the contract (up to 25 years). After the contract ends, all additional cost savings accrue to the agency (Energy, 2014).

The U.S. Department of Energy (DOE) energy savings performance contracts are indefinite-delivery, indefinite-quantity (IDIQ) contracts designed to make ESPCs as practical and cost-effective as possible. DOE awarded these "umbrella" contracts to ESCOs based on their ability to meet terms and conditions established in IDIQ contracts. DOE ESPCs can be used for any federally owned facility worldwide (Energy, 2014).

DOE energy savings performance contracts help Federal agencies meet energy efficiency, renewable energy, water conservation, and emissions reduction goals by streamlining contract funding for energy management projects. Other benefits include:

• Access to private-sector expertise in energy efficiency, renewable energy, water conservation, and emissions reduction

• Built-in incentives for ESCOs to provide high-quality equipment, timely services, and thorough project commissioning
• Infrastructure improvements to enhance mission support

• Healthier and safer working and living environments

• Flexible practical contract and procurement processes

• Objective technical support through the Federal Energy Management Program

• Smart project management that ensures building efficiency improvements and new equipment without upfront capital costs (Energy, 2014).

Siemens Industry, Inc. Building Technologies division announced that Morehead State University will save over $775,000 annually in utility costs through an Energy Savings Performance Contract (ESPC). This will accrue over $9.3 million in aggregate utility savings over the term of the 12-year agreement (Lewis, 2014).

Siemens is working with the university to complete a detailed facility infrastructure assessment and energy audit. Rather than continuing investments in the older coal plant and taking on further risk of increasingly stringent environmental requirements, Morehead opted to construct a new natural gas-fired plant that would be more cost effective and compliant over time. In total, the project will affect 30 campus buildings and consist of:

• A new, recently completed, 4,000-square foot natural gas-fired boiler plant to replace the university’s outdated coal-fired boiler plant, housing two new 900 horsepower steam boilers.
• Facility upgrades for many of the campus buildings’ HVAC and electrical systems. Siemens will replace older fan motors and belts, and install variable speed drives and, where necessary, dampers, valves and cooling coils

• Digital Energy Monitors on most campus buildings to track electricity consumption on a per-building basis

• Digital control upgrades that can be networked over the university’s existing IT infrastructure.

• Lighting controls and occupancy sensors.

In addition to lowering ongoing operating costs, the university will curb its CO₂ emissions by over 8,381 tons per year, the equivalent of planting 75.3 acres of trees or taking 1,491 cars off the road annually. The university also will avoid costs of over $4 million during the program primarily from reduced plant operations and maintenance fees, freeing much-needed budget dollars for other educational expenses. (A. Lewis, 2014).

According to the Morehead State Energy conservation Policy it is committed to effective energy management, conservation, efficiency, and sustainability. This policy is implemented through MSU’s Energy Conservation Program. The goals of the program are:

• Reduce overall energy-consumption.

• Identify energy, fuel, and water conservation opportunities as significant issues for the entire campus community.

• Promote energy and environmental awareness campus-wide (University, 2009)
During off-hours (evenings, weekends, and holidays), building temperatures will be adjusted to an unoccupied level. Special events or functions requiring occupied building temperatures during off-hours must be scheduled and pre-approved by the appropriate Vice President or Provost. The dates, times, and locations of special events or functions requiring occupied building temperatures during off-hours, must be reported to the Energy Conservation Manager at least two (2) working days prior to the event. Events that are a recurring part of the University’s operating calendar such as athletic events, night classes, orientation sessions and open houses, are not considered special events or functions and do not need prior approval (University, 2009).

- During summer months, every effort must be made to consolidate hosted events, such as band/cheerleading camps, etc., to single designated buildings. When possible, chillers will be turned off in all unoccupied buildings.

- In areas that have individual room-temperature control, controls will operate within a predetermined range based on building/HVAC-system design.

- The use of personal electric space-heaters on campus is not permitted.

- All building occupants (faculty, staff, and students) are requested to keep windows and outside doors closed.

- All supply and return air vents in offices, classrooms, and laboratories must be unobstructed at all times.

- Fleet vehicles should not be left idling.

- Building occupants are encouraged to use stairs rather than elevators whenever possible (University, 2009).
Campus Air Conditioning

The Energy Conservation Manager and the Facilities Management staff will begin to monitor long-range weather forecasts in mid-April. Based on the forecast information, the Facilities Management staff will commence the change-over from heating to cooling mode in all campus buildings (University, 2009).

Campus Heating

On October 1, the Energy Conservation Manager and the Facilities Management staff will begin to monitor long-range weather forecasts. Based on that forecast information, the Facilities Management staff will commence the change-over from cooling to heating mode in all campus buildings.

Purchasing and Efficiency Guidelines

Lighting

• Lights are to be turned off in offices, classrooms, laboratories, and storage areas when not occupied.

• Take advantage of natural light whenever possible.

• Fluorescent bulbs should be used in desk lamps, rather than halogen or incandescent.

• Occupancy sensors are to be installed in renovation and new construction projects when economically feasible (University, 2009).
• All renovation and new construction projects that involve lighting must be pre-approved by the Building Maintenance Superintendent to ensure that light levels meet building-codes, and are within industry standards adopted by the Office of Facilities Management.

**Computers, Printers and Peripherals**

• Personal computers, printers, and peripherals in offices, classrooms, and computer laboratories should be turned off at the end of each work day or class period.

• Plug small AC to DC transformers, commonly referred to as “wall-warts”, into power-strip surge protectors so they may be switched off when not in use.

• Personal computers should be set in an energy-saving operation mode.

• Enable “Sleep-Mode” on personal computers or turn off monitors when not in use.

**Energy Efficient Products Procurement**

• Limit computer and other electronic office equipment purchases to devices that are identified as ENERGY STAR products. These products are designed to use less power when sitting idle/unused. ENERGY STAR is a program combined of the U.S. Environmental Protection Agency and the U.S. Department of Energy to help consumers save money and protect the environment through energy efficient products and practices (University, 2009).

• Purchase of more expensive energy-efficient equipment can be justified when the extra cost is less than or equal to the resulting energy savings.
New Construction

- All new construction projects shall be reviewed to ensure that energy-efficiency and lighting levels meet building-codes and industry standards designated by the Office of Facilities Management.
- Renewable energy technologies, day-lighting and passive solar energy are to be incorporated when feasible.
- Utility meters to monitor energy and water consumption must be installed in new constructions and renovated facilities.
- Interior lighting will be fluorescent, whenever possible. New energy-saving fixtures, lamps and ballasts will be used to replace existing less efficient lighting whenever economically feasible and appropriate. Exterior lighting will be high-pressure sodium or metal halide (metal halide is preferred) whenever possible, and will meet minimum current safety requirements. Decorative lighting will be kept to a minimum. Lighting levels recommended by the most recent edition of the IES (Illuminating Engineering Society) Lighting Handbook shall be used as guidelines (University, 2009).
- The Energy Conservation Policy shall be adhered to for all construction projects.
- New construction and renovation projects must meet Commercial Energy Code Compliance, accepted building codes, and industry standards as designated by the Office of Facilities Management. Architects must show proof of codes and standards being met or exceeded (University, 2009).
Morehead State University Recreational Center

The Morehead State Recreational Center was completed in July 2011 and the project was valued at $20 million dollars. The building is LEED Gold certified. It is the first LEED certified recreation center in Kentucky and the first LEED building on MSU’s campus. Sustainable features include high-efficiency pumps, natural light sources, and recycling of 75% of waste. The building uses many different devices to help save on energy costs, paper usage and other resources. A geothermal well water system heats the pool water with very little electricity. Lighting controls use daylight to determine how much power should be used, CO2 sensors throughout the facility determine how much fresh air should be brought into the facility and the many controls throughout the facility help keep energy costs low in regards to heating and cooling. Light sensors throughout the facility are also motion-censored, helping reduce energy costs. The use of geothermal technology helps to maintain our building at a lower cost to the university, as well as other tools such as the pool cover that help reduce costs. Sustainable elements were achieved within the available budget, accounting for only 1.1% of the project’s construction cost. The University’s sustainable design goals were achieved and the facility will serve as a teaching tool for green design. This new facility is a key part of student life at MSU and continues MSU’s vision for the future (Li, 2013).

Morehead State University CHER Building

The new Center for Health, Education & Research (C.H.E.R.) was completed in 2010 and the project was worth $30 million dollars. The four-story 90,000 square foot building built to
LEED standards, features integration with the Emergency Medical Services (EMS) as well as lighting controls. The newly completed Student Recreation Center (LEED-Silver Certified) is also on the system, with lighting controls and a Green screen (Council U. S., 2014).

![LEED for New Construction 2.2 Gold certified on 10/09/2012](image_url)

**Figure 1: Activity Summary of Recreational Center Activity Summary for Morehead State**
Chapter 3: Methodology & Findings

This chapter describes the approaches taken to address the objectives in Chapter 1.

Objective 1: Identify the current energy production and consumption of selected buildings on the MSU Campus.

This objective addresses the current Morehead State University Energy Conservation Program. The program is committed to a policy of effective energy management, conservation, efficiency, and sustainability.

Table 1: Monthly kWh data for 8 Morehead State University buildings (4 old and 4 new) Year 2012

<table>
<thead>
<tr>
<th></th>
<th>BRECK</th>
<th>CLAYPOOL</th>
<th>COOPER</th>
<th>FIELDS</th>
<th>CHER</th>
<th>SSC</th>
<th>EAGLE LAKE</th>
<th>REC CNTR</th>
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<td>January</td>
<td>117,394</td>
<td>142,793</td>
<td>158,035</td>
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<td>86,812</td>
<td>14,899</td>
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<td>141,113</td>
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<td>87,368</td>
<td>14,447</td>
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<td>26,565</td>
<td>40,941</td>
<td>103,146</td>
<td>30,363</td>
<td>36,654</td>
<td>125,653</td>
</tr>
<tr>
<td>Nov</td>
<td>108,086</td>
<td>157,259</td>
<td>167,367</td>
<td>151,039</td>
<td>90,953</td>
<td>20,211</td>
<td>29,548</td>
<td>116,382</td>
</tr>
<tr>
<td>Dec.</td>
<td>106,851</td>
<td>34,226</td>
<td>20,872</td>
<td>26,564</td>
<td>94,545</td>
<td>14,557</td>
<td>19,694</td>
<td>108,585</td>
</tr>
</tbody>
</table>
Table 2: Monthly kWh data for 8 Morehead State University buildings (4 old and 4 new) year 2013

<table>
<thead>
<tr>
<th></th>
<th>BRECK</th>
<th>CLAYPOOL</th>
<th>COOPER</th>
<th>FIELDS</th>
<th>CHER</th>
<th>SSC</th>
<th>EAGLE</th>
<th>REC CNTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 2</td>
<td>103,381</td>
<td>34,695</td>
<td>25,198</td>
<td>38,048</td>
<td>97,864</td>
<td>16,128</td>
<td>22,702</td>
<td>108,703</td>
</tr>
<tr>
<td>Feb. 2</td>
<td>190,470</td>
<td>199,538</td>
<td>257,893</td>
<td>161,432</td>
<td>94,110</td>
<td>15,893</td>
<td>24,000</td>
<td>114,617</td>
</tr>
<tr>
<td>Mar. 2</td>
<td>241,390</td>
<td>207,057</td>
<td>259,496</td>
<td>167,236</td>
<td>99,917</td>
<td>13,589</td>
<td>29,175</td>
<td>96,922</td>
</tr>
<tr>
<td>April 2</td>
<td>184,391</td>
<td>76,643</td>
<td>34,667</td>
<td>52,287</td>
<td>125,529</td>
<td>16,840</td>
<td>30,048</td>
<td>114,230</td>
</tr>
<tr>
<td>May. 2</td>
<td>445,738</td>
<td>444,407</td>
<td>511,065</td>
<td>259,619</td>
<td>139,673</td>
<td>26,186</td>
<td>43,126</td>
<td>169,795</td>
</tr>
<tr>
<td>June.2</td>
<td>492,870</td>
<td>522,929</td>
<td>668,223</td>
<td>300,169</td>
<td>161,550</td>
<td>26,353</td>
<td>39,121</td>
<td>171,086</td>
</tr>
<tr>
<td>July.2</td>
<td>245,037</td>
<td>79,640</td>
<td>47,596</td>
<td>66,726</td>
<td>175,232</td>
<td>23,113</td>
<td>47,446</td>
<td>157,389</td>
</tr>
<tr>
<td>August.2</td>
<td>220,752</td>
<td>67,158</td>
<td>44,547</td>
<td>63,694</td>
<td>94,537</td>
<td>30,901</td>
<td>48,683</td>
<td>195,880</td>
</tr>
<tr>
<td>Sept.2</td>
<td>195,617</td>
<td>64,729</td>
<td>29,215</td>
<td>49,500</td>
<td>23,980</td>
<td>26,602</td>
<td>31,684</td>
<td>180,046</td>
</tr>
<tr>
<td>Oct.2</td>
<td>145,869</td>
<td>23,631</td>
<td>26,167</td>
<td>43,588</td>
<td>62,390</td>
<td>21,146</td>
<td>28,454</td>
<td>59,574</td>
</tr>
<tr>
<td>Nov.2</td>
<td>118,724</td>
<td>20,671</td>
<td>17,567</td>
<td>31,080</td>
<td>60,359</td>
<td>13,196</td>
<td>18,044</td>
<td>71,343</td>
</tr>
<tr>
<td>Dec.2</td>
<td>111,374</td>
<td>35,669</td>
<td>27,237</td>
<td>38,460</td>
<td>54,338</td>
<td>13,537</td>
<td>23,973</td>
<td>112,314</td>
</tr>
</tbody>
</table>

Table 3: Square Footage of KWh data for 4 MSU old Buildings

<table>
<thead>
<tr>
<th></th>
<th>Breckinridge Hall</th>
<th>Claypool Hall</th>
<th>Cooper Hall</th>
<th>Fields Hall</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.40</td>
<td>4.49</td>
<td>5.00</td>
<td>1.03</td>
</tr>
<tr>
<td>February</td>
<td>1.37</td>
<td>4.44</td>
<td>4.78</td>
<td>0.99</td>
</tr>
<tr>
<td>March</td>
<td>1.68</td>
<td>2.08</td>
<td>5.47</td>
<td>1.17</td>
</tr>
<tr>
<td>April</td>
<td>1.52</td>
<td>5.59</td>
<td>6.14</td>
<td>1.48</td>
</tr>
<tr>
<td>May</td>
<td>2.38</td>
<td>2.41</td>
<td>1.11</td>
<td>1.74</td>
</tr>
<tr>
<td>June</td>
<td>2.43</td>
<td>2.51</td>
<td>1.28</td>
<td>1.88</td>
</tr>
<tr>
<td>July</td>
<td>2.35</td>
<td>3.31</td>
<td>1.53</td>
<td>1.98</td>
</tr>
<tr>
<td>August</td>
<td>2.49</td>
<td>3.20</td>
<td>1.60</td>
<td>2.04</td>
</tr>
<tr>
<td>Sept.</td>
<td>2.33</td>
<td>2.92</td>
<td>1.13</td>
<td>1.57</td>
</tr>
<tr>
<td>Oct.</td>
<td>1.94</td>
<td>2.48</td>
<td>0.84</td>
<td>1.19</td>
</tr>
<tr>
<td>Nov.</td>
<td>1.29</td>
<td>4.95</td>
<td>5.30</td>
<td>4.38</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.27</td>
<td>1.08</td>
<td>0.66</td>
<td>0.77</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square footage for the old buildings is shown in Figure 6. The run chart indicates that during the spring semester the Kilo Watt usage was not consistent, it was either very high or low. During the summer break, the data shows to have a similar pattern for all the old buildings, but as the fall semester starts the same pattern is reflected as shown in the spring semester.
Table 4: Square Footage of KWh data for 4 MSU new Buildings

<table>
<thead>
<tr>
<th>Date</th>
<th>CHER</th>
<th>Space Science Center</th>
<th>Eagle lake Center</th>
<th>Rec Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.16</td>
<td>0.34</td>
<td>0.68</td>
<td>1.04</td>
</tr>
<tr>
<td>February</td>
<td>1.17</td>
<td>0.33</td>
<td>0.67</td>
<td>0.98</td>
</tr>
<tr>
<td>March</td>
<td>1.47</td>
<td>0.58</td>
<td>0.06</td>
<td>1.14</td>
</tr>
<tr>
<td>April</td>
<td>1.41</td>
<td>0.49</td>
<td>1.37</td>
<td>1.13</td>
</tr>
<tr>
<td>May</td>
<td>1.73</td>
<td>0.83</td>
<td>1.64</td>
<td>1.62</td>
</tr>
<tr>
<td>June</td>
<td>1.77</td>
<td>0.78</td>
<td>1.73</td>
<td>1.71</td>
</tr>
<tr>
<td>July</td>
<td>1.88</td>
<td>1.00</td>
<td>1.80</td>
<td>1.97</td>
</tr>
<tr>
<td>August</td>
<td>1.95</td>
<td>1.05</td>
<td>1.87</td>
<td>1.62</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.56</td>
<td>0.85</td>
<td>1.49</td>
<td>1.41</td>
</tr>
<tr>
<td>Oct.</td>
<td>1.38</td>
<td>0.70</td>
<td>1.40</td>
<td>1.24</td>
</tr>
<tr>
<td>Nov</td>
<td>1.22</td>
<td>0.47</td>
<td>1.13</td>
<td>1.15</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.27</td>
<td>0.34</td>
<td>0.75</td>
<td>1.07</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square footage for the new buildings is shown in Figure 7. The run chart indicates that less Kilo Watt usage was used for the new buildings than the old buildings. In addition, the patterns are similar except for Eagle Lake Apartments which had a significant drop during March. This anomaly occurred because of an error in the data used.
**Objective 2:** Analyze the yearly electricity usage (KWh/square footage) for selected old and new buildings.

In order to analyze the yearly electricity usage for the selected buildings of the Morehead State University main campus, data was collected from the Morehead State facility management building. The data used breaks down the kilo-watt usage of eight randomly selected buildings on campus. The eight buildings were broken down into categories of four new buildings (built in the last 20 years) and four old buildings (built in the 30 plus years).

The four new buildings selected were: The Eagle Lake Apartments, The Space Science Center, Recreational Wellness Center and the CHER building. The four old buildings selected were: Breckinridge, Claypool, Cooper and Fields. The tables below show the yearly kilo watt usage of 2012 and 2013.
Table 5: Energy Usage (KWh/sq. footage) for Breckinridge Hall (old) and Cher (new)

<table>
<thead>
<tr>
<th></th>
<th>Breckinridge Hall</th>
<th>CHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.40</td>
<td>1.16</td>
</tr>
<tr>
<td>February</td>
<td>1.37</td>
<td>1.17</td>
</tr>
<tr>
<td>March</td>
<td>1.68</td>
<td>1.47</td>
</tr>
<tr>
<td>April</td>
<td>1.52</td>
<td>1.41</td>
</tr>
<tr>
<td>May</td>
<td>2.38</td>
<td>1.73</td>
</tr>
<tr>
<td>June</td>
<td>2.43</td>
<td>1.77</td>
</tr>
<tr>
<td>July</td>
<td>2.35</td>
<td>1.88</td>
</tr>
<tr>
<td>August</td>
<td>2.49</td>
<td>1.95</td>
</tr>
<tr>
<td>Sept.</td>
<td>2.33</td>
<td>1.56</td>
</tr>
<tr>
<td>Oct.</td>
<td>1.94</td>
<td>1.38</td>
</tr>
<tr>
<td>Nov</td>
<td>1.29</td>
<td>1.22</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.27</td>
<td>1.27</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square foot between Breckinridge Hall and the CHER Building is shown in Figure 8. Breckinridge Hall clearly shows that the Kilo Watt usage is greater than the CHER Building which is built to be energy efficient.
Table 6: Energy Usage (KWh/sq. footage) for Fields Hall (old) and Eagle Lake (new)

<table>
<thead>
<tr>
<th></th>
<th>Fields Hall</th>
<th>Eagle Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1.03</td>
<td>0.68</td>
</tr>
<tr>
<td>February</td>
<td>0.99</td>
<td>0.67</td>
</tr>
<tr>
<td>March</td>
<td>1.17</td>
<td>0.06</td>
</tr>
<tr>
<td>April</td>
<td>1.48</td>
<td>1.37</td>
</tr>
<tr>
<td>May</td>
<td>1.74</td>
<td>1.64</td>
</tr>
<tr>
<td>June</td>
<td>1.88</td>
<td>1.73</td>
</tr>
<tr>
<td>July</td>
<td>1.97</td>
<td>1.79</td>
</tr>
<tr>
<td>August</td>
<td>2.04</td>
<td>1.87</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.57</td>
<td>1.49</td>
</tr>
<tr>
<td>Oct.</td>
<td>1.19</td>
<td>1.40</td>
</tr>
<tr>
<td>Nov</td>
<td>4.38</td>
<td>1.12</td>
</tr>
<tr>
<td>Dec.</td>
<td>0.77</td>
<td>0.75</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square footage between Fields Hall and Eagle Lake Apartments is shown in Figure 9. Fields Hall shows a slightly higher rate of Kilo Watt usage except for the month of November where there was a spike kWh/ square footage. There was also a dip at Eagle Lake in March.
Table 7: Energy Usage (KWh/sq. footage) for Cooper Hall (old) and the Recreational Center

<table>
<thead>
<tr>
<th></th>
<th>Cooper Hall</th>
<th>Rec center</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>5.00</td>
<td>1.04</td>
</tr>
<tr>
<td>February</td>
<td>4.78</td>
<td>0.98</td>
</tr>
<tr>
<td>March</td>
<td>5.45</td>
<td>1.136</td>
</tr>
<tr>
<td>April</td>
<td>6.14</td>
<td>1.131</td>
</tr>
<tr>
<td>May</td>
<td>1.11</td>
<td>1.62</td>
</tr>
<tr>
<td>June</td>
<td>1.29</td>
<td>1.70</td>
</tr>
<tr>
<td>July</td>
<td>1.53</td>
<td>1.9</td>
</tr>
<tr>
<td>August</td>
<td>1.60</td>
<td>1.62</td>
</tr>
<tr>
<td>Sept.</td>
<td>1.13</td>
<td>1.40</td>
</tr>
<tr>
<td>Oct.</td>
<td>0.84</td>
<td>1.24</td>
</tr>
<tr>
<td>Nov</td>
<td>5.29</td>
<td>1.15</td>
</tr>
<tr>
<td>Dec.</td>
<td>0.66</td>
<td>1.07</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square footage between Cooper Hall and the Recreational Wellness Center is shown in Figure 10. Cooper Hall shows a relatively high and low deficiency. The data shows the Kilo Watt usage being relatively high during the spring semester from January to April, however there is a significant drop during the month of May. During the summer break the graph shows usage to be relatively consistent and then begins to increase again during the start of fall semester. As for the Recreational Center data, the Kilo Watt usage is relatively low. The only time it increases is during the summer break period.
Table 8: Energy Usage (KWh/sq. footage) for Claypool (old) and the Space Science Center (new)

<table>
<thead>
<tr>
<th></th>
<th>Claypool</th>
<th>Space Science Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>4.5</td>
<td>0.34</td>
</tr>
<tr>
<td>February</td>
<td>4.43</td>
<td>0.33</td>
</tr>
<tr>
<td>March</td>
<td>2.08</td>
<td>0.57</td>
</tr>
<tr>
<td>April</td>
<td>5.58</td>
<td>0.49</td>
</tr>
<tr>
<td>May</td>
<td>2.41</td>
<td>0.83</td>
</tr>
<tr>
<td>June</td>
<td>2.51</td>
<td>0.77</td>
</tr>
<tr>
<td>July</td>
<td>3.31</td>
<td>1.00</td>
</tr>
<tr>
<td>August</td>
<td>3.2</td>
<td>1.05</td>
</tr>
<tr>
<td>Sept.</td>
<td>2.92</td>
<td>0.85</td>
</tr>
<tr>
<td>Oct.</td>
<td>2.48</td>
<td>0.7</td>
</tr>
<tr>
<td>Nov</td>
<td>4.95</td>
<td>0.47</td>
</tr>
<tr>
<td>Dec.</td>
<td>1.07</td>
<td>0.33</td>
</tr>
</tbody>
</table>
The relationship of energy usage per square footage between Claypool and the Space Science Center is shown in Figure 11. Claypool has an alternating increase and decrease of deficiency during the spring and fall semesters. During summer break the data shows a consistent pattern. The Kilo Watt usage is relatively low and it stays consistent except during its highest point when summer break occurs.
Objective 3: Determine the need for conversion toward future Net Zero technology

Upon reviewing the tables above, it is understood that the data given was not 100 percent accurate. Although there was some data that wasn’t relevant, the patterns show a slight trend that the newer buildings produced less Kilo Watt usage the older buildings due to the fact they were more energy efficient.

In consideration, this leads to a recommendation to keep track of data more efficiently whether it is during the semesters or the holiday breaks. In addition, Morehead State University must take action on finding a way to reevaluate the older buildings by implementing energy efficiency technology or Net Zero Technology to cut down on the Kilo Watt usage.

Since its inception, the Morehead State Energy Conservation Policy program initiatives have included:

• MSU has used building automation to monitor and control HVAC systems since 1980. In 2000, Siemens Building Technologies upgraded the system, installing APOGEE control panels and software in several campus buildings. Siemens also installed an In Sight Energy Management System (EMS) software server in the Rice Maintenance Building (Cooper, 2011).

• Lighting Upgrades - In 2004, MSU entered into a performance contracting agreement in which older 40-watt fluorescent tubes were replaced with high-efficiency T8 tubes which typically use 32-watts. (Cooper, 2011)

• Recent upgrades to the EMS during the early part of 2009, included new field panels in the Academic Athletic Center and the Claypool-Young art facility.

• Current proposed projects include monitoring individual building electrical-usage, and an HVAC-Equipment preventive maintenance program.
• Building Renovations - Nunn Hall, Alumni Tower, Mignon Tower, and East Mignon building renovations include panels and controls for integration with the existing EMS. (Cooper, 2011)

• New Construction - MSU's Space Science Center was the university's first facility to have both HVAC and lighting controls. The new Center for Health, Education & Research (C.H.E.R.), built to LEED standards, features integration with the EMS as well as lighting controls. The newly completed Student Recreation Center (LEED-Gold Certified) is also on the system, with lighting controls and a Green screen.

• Electric Vehicles - In 2008, the office of Facilities Management purchased several Chrysler GEM electric trucks to replace older gasoline-powered vehicles in the service fleet (Cooper, 2011)

    The first step in creating a Net Zero Energy Building is reducing the energy usage by improving building insulation, reducing plug loads and installing an efficient HVAC system so the overall buildings electrical load can be reduced dramatically. This means using an integrated design approach to a building’s layout, envelope, mechanical systems, and electrical systems to achieve the high levels of energy efficiency (Barber, 2014).

    Building control systems have always been the most overlooked, underrated or subject to budget constraints in commercial buildings; Today these systems are at the top of list of tech advances for both commercial and residential ZEBs. As lighting is responsible for 20 percent of the total energy and 38 percent of electricity consumption in commercial buildings, lack of energy management controls can lead to 50 percent higher energy costs and add 25 percent more to the operations and maintenance budget, according to the NBI report (Barber, 2014).
Recent tech advances towards performance-based integrated whole building energy management control equipment options are providing one of the means of growth in both commercial and residential ZEBs; this including the expanded use of analytics, occupancy sensors, lighting controls, plug load controls and energy management automation services (Barber, 2014).

Figure 11: ZEB and ZEC Buildings: Technology Penetration (Institute, 2012)

Figure 12 presents the technology penetration of 11 design strategy categories reported in the zero energy-capable buildings. First, the typical case study does not necessarily mention every efficiency measure used, nor does it clearly define the details of measures that are mentioned. Thus, this summary is primarily an indication of the types of strategies that have been considered noteworthy. In addition, these summaries represent the entire set of documented
cases, across a wide range of climates. Climate responsive design is a necessary part of optimized design, but the current data set is not large enough to show differences by region in strategies used. As more documented examples are consolidated, important breakdowns such as analysis by climate will become possible. (Institute, 2012)

More than 85% of the studied cases report designs incorporating day lighting. Most reports, however, do not provide sufficient detail to know whether effective automated controls were installed to maximize the potential energy savings, nor how well the day lighting was balanced with an appropriately managed ratio of window to wall area. Approximately two-thirds reported high efficiency lighting, including occupancy-based controls and/or high efficiency lamps (68%). More than 50% of the buildings also report using a high performance envelope with increased insulation and well-insulated glazing. Half of the buildings use natural ventilation. These strategies align well with the proven design approach of starting with a good building envelope, access to natural light and ventilation, and an integrated design of building systems.

The remaining features are less consistent across all buildings, but still occur with relatively high frequency. High efficiency HVAC systems with heat recovery are cited in about one-third of the cases, as are cool roofs. 30% report using radiant heating/cooling systems, and about that many report the use of ground-source heat pumps. Under floor or displacement ventilation is used in 15% of projects (Institute, 2012).
Chapter 4: Conclusion

Net-Zero construction has steadily increased since then, with the number of completed buildings more than doubling since 2008, according to the latest study. Thanks to advances in structural insulation, energy-efficient appliances, new government incentives and the falling price of solar, expensive green-building projects. (Johnson, 2012).

This classification system is meant to encourage, when possible, energy efficiency strategies followed by the use of footprint and on-site to power buildings. Designers will also create more energy-efficient, high-performance buildings if the buildings must generate their own energy. The lower end of the NZEB classification also provides a means for high energy use buildings to minimize environmental impact through NZEB design strategies. This NZEB classification system is applicable to both single building projects as well as a set of buildings in a community or campus (Pless, 2010).

As for energy efficiency, to make sure we have plenty of energy in the future, it's up to all of us to use energy wisely. We must all conserve energy and use it efficiently. It's also up to those who will create the new energy technologies of the future.

All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as solar, wind, geothermal, wave power and hydrogen. (Quest, 2012)
Recommendations

In this case for improving ways the Morehead State University Main campus, Net Zero is the way to pursue if following action occurs:

Practical guidance to help identify opportunities

The marketplace needs clear summaries of the conditions where ZEB’s are most feasible (anticipated loads, climate), and the path to move toward those goals. Ongoing communication can be fostered by continually updating a set of case studies showing clear definition of the processes and techniques used, results, and lessons learned with varying climates, building types and settings. Clear studies of avoided costs (both initial design and construction savings and ongoing energy savings) from energy efficiency focused integrated design can help explain the potential and support needed financing of first costs.

Encourage measurement and communication of results

ZEBs are already entering a “second generation” of more typical building types and ownership patterns, and lessons learned from these examples could accelerate the interest at both the market and policy levels towards zero energy and zero energy-capable buildings. For the most useful lessons, ZEB owners must measure their total energy use in a way that gives insight into successful strategies and to areas for further improvement. Knowing the annual totals for on-site energy use and purchased energy is the essential first step. Sub metering or other analysis to identify areas for further improvement is also required to put that information to good use. Communication of these results should extend beyond the owner/operator, going back to the
design team for incorporation into their future efforts, and to program sponsors for evaluating overall results (Institute, 2012).

**Develop a better basis for benchmarking performance:**

As more successful zero energy-capable buildings emerge, we can shift the benchmarking focus from a broad peer group based on past commercial building national average EUIs to a forward-looking target based on demonstrated results of industry leaders. Two things are needed to improve the relevance of this forward-looking basis. Firstly, a larger pool of documented very high performance results will help demonstrate achievable levels for a greater portion of building situations. Meaningful benchmarking also requires being able to identify true efficiency across buildings with a wide range of occupancy schedules and plug load requirements (Institute, 2012).
References


Figure 12: Histogram of KWh usage of 8 selected Buildings on the Morehead State University Main Campus in 2012

Figure 13: Histogram of KWh usage of 8 selected Buildings on the Morehead State University Main Campus in 2013
Figure 14: Control Charts of Old Buildings

Figure 15 shows that there is statistical control of the data for kilowatt-hours per square footage for the selected old buildings.

Figure 15: Control Charts of New Buildings

Similarly, Figure 16 shows that there is statistical control of the data for kilowatt-hours per square footage for the selected new buildings.