Assessment and Cost Effective Analysis of LEED Certified Single-Family Homes in Kentucky

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Stephen Glossner

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_____

Director of Thesis
Dr. Hans Chapman

Master's Committee: _____, Chair
Dr.Ahmad Zargari

_____
Dr. Hans Chapman

_____
Dr. Sanjeev Adhikari

_____
Date

Assessment and Cost Effective Analysis of LEED Certified Single-Family Homes in Kentucky

Stephen Glossner, M.S.
Morehead State University, 2014

Director of Thesis: _____
Dr. Hans Chapman

The purpose of this thesis was to assess the distribution of LEED certified, single-family homes in Kentucky as well as to analyze the cost effectiveness of building a new construction, LEED certified, single-family home based on monthly utility efficiency in five selected counties in Kentucky. The estimated added LEED construction cost was calculated as well as its respective payback period based on expected utility savings of LEED certification. Descriptive statistical analysis was performed on the data collected and calculated to compare the results within each county and compare the counties to one another. The findings from this study regarding LEED certified homes in Kentucky show that the LEED Certified and Silver level had the shortest payback periods. This study also shows that the total thirty year mortgage period cost of a traditional home and LEED Certified home had little difference.

Accepted by:

_____ , Chair
Dr. Ahmad Zargari

_____
Dr. Hans Chapman

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Dr. Sanjeev Adhikari

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Table of Contents

List of Tables

Table of figures

List of Equations

Chapter I: Introduction

General Area of Concern

It is clear that sustainability is going to be a significant factor in all construction fields as energy prices continue to increase and resources become increasingly scarce. There are many organizations that set standards as to the criteria that sustainable projects should abide by. One such organization is the United States Green Building Council and their Leadership in Energy and Environmental Design (LEED) program. Since 2000, The LEED program has been at the forefront of sustainability in the commercial industry (Schmidt 2008). In 2008, an estimated 5% of public buildings in the United States were LEED certified (Schmidt 2008).

The number of LEED certified residential units have significantly increased annually since the LEED for Homes program's conception in 2007 (Kriss 2014).

- In 2007, 392 certified residential units
- In 2008, 900 certified residential units
- In 2009, 3,000 certified residential units.
- In 2012, 15,000 certified residential units
- In 2013, 17,000 certified residential units

This trend is likely to continue into 2014. This level of annual increase is not apparent when considering the increase of LEED certified homes at the state level. Some states have seen, or exceeded, this level of increase and others have not. The state of Kentucky only has 55 homes that were certified between 2008 and 2013, and 46 of those 55 homes were part of a military community established in Fort Knox (USGBC 2014).

There could be several factors contributing to this low number. The information that is available to the public is lacking in Kentucky. There is an unknown cost associated with constructing LEED buildings. McGraw Hill Construction identified the cost perception as a top obstacle to green building for both homeowners and homebuilders. Changing this cost perception is the main priority for the UGBC and green building community in its entirety (Schmidt 2008). Providing information about the LEED program, and not only the costs that are associated with LEED but the potential for savings as well, is essential.

Purpose of Study

In the United States, increasing significance is being placed on the practice of sustainability mostly impart to energy price increases and environmental concerns. In 2010, the United States consumed 95 quadrillion Btu of energy accounting for 19% of the world's energy consumption for that year. Of that 19%, 81% was produced by fossil fuels and only 9% was produced by renewable energy sources (U.S. Energy Information Administration 2013). This has pushed for the practice of sustainable design to become the standard for new construction projects, especially in the residential sector. One program that has been recognized as an industry leader for green rating systems is the LEED (Leaders in Energy and Environmental Design) certification program led through the U.S. Green Building Council (USGBC). This program evaluates construction projects on the various sustainable design features and materials and offers four levels of certification.

In the United States, there were 12,758 LEED certified residential projects between the year 2006 and 2013. Some states have a significant number of LEED certified residential projects; Texas has 2079, California has 972, Ohio has 318, and Tennessee has 274. However, the state of Kentucky only has 55 certified LEED residential projects. According to the 2012

Kentucky Energy Profile from the Kentucky Energy & Environmental Cabinet, Kentucky ranked 3rd highest in the United States for residential energy consumption per capita, at 93.8 million Btu per Capita in 2010 and ranked 10th highest in the U.S. for residential electricity consumption per capita, at 6.22 MWh per Capita in 2011. The building of sustainable residential projects is crucial as fossil fuel prices continue to rise and the health of the environment becomes more of a priority. The LEED program is one method that can be utilized to lessen resource consumption and lessen the construction industry's impact on the environment.

One of the contributing factors to low number of LEED certified residential projects in Kentucky could be the lack of organized information pertaining to LEED certification of residential projects, specifically the cost and economic information, of LEED certified versus typical code built single-family homes in Kentucky. The LEED for homes rating system has only been officially recognized since 2008 resulting in a very limited available data. This lack of available data makes it difficult for individuals to be informed about LEED homes and how they compare to traditional code built homes. One of the most significant factors for homebuilders and homebuyers alike when considering building new home is cost; especially when considering a new idea such as LEED. Though there are many benefits to a LEED certified home, both financially and environmentally, they are overshadowed by the cost uncertainties.

The primary purpose of this study was to assess the distribution and cost effectiveness of LEED certified single-family homes in Kentucky. The secondary purpose was to supply more information to homebuilders and potential homebuyers in Kentucky (Fayette, Jefferson, Boone, Kenton, Campbell, Rowan, and Morgan County) regarding the cost effectiveness of LEED certified single-family homes. The underlying purpose of this study was that the findings would be to attract more LEED certified residential projects to Kentucky by showing the cost difference

between traditional and LEED certified homes is not significant over the course a 30 year mortgage period.

However, not enough usable data was able to be collected for Rowan and Morgan County. As an alternate, Spencer County was chosen to be representative of the eastern Kentucky counties. Spencer County was chosen because it is also a rural area with comparable population, number of households, and number of housing units to Rowan and Morgan County (U.S. Census Bureau, 2014). For the remainder of this study Spencer County will be used as a representative of Rowan and Morgan County.

Objectives

- Assess the distribution of LEED certified homes in Kentucky.
- Determine the estimated added construction cost of a LEED certified single-family home in the selected counties of Kentucky (Fayette, Jefferson, Spencer, Boone, Kenton, and Campbell County).
- Analyze the cost effectiveness of a LEED certified single-family home in the selected counties of Kentucky (Fayette, Jefferson, Spencer, Boone, Kenton, and Campbell County).

Assumptions

1. An inflation rate of 2.0% per year was applied for any cost figure not based in 2013 dollars.
2. The added construction cost for LEED certification was paid in full prior to construction (payback period).
3. The energy efficiency figures calculated by the USGBC are accurate and are represent a normally distributed sample of all fifty states.
4. The single family price and cost breakdown figures calculated by the NAHB are accurate and represent a normally distributed sample of all fifty states.

Limitations

1. Single-family homes (attached or detached) only were used in this study. Low-rise and mid-rise multifamily residential projects were not considered.
2. Federal and Municipal tax credits issued for energy efficient new homes or LEED certified homes were not considered in this study.
3. The results from this study are reflective of the selected counties and not the state of Kentucky in its entirety.
4. Location of home was not considered in construction cost estimation (i.e. proximity to transit systems or school districts).
5. Soft costs (certification and registration fees) were not considered in the cost of LEED certification.

Definition of Terms

USGBC: U.S. Green Building Council

LEED: Leaders in Energy and Environmental Design

NAHB: National Association of Home Builders

LEED for Homes 2008 Eligibility: Single-family homes, low-rise multi-family homes, and mid-rise multi-family homes.

Single-Family Detached Home: Single-family residential structure that is a standalone structure and does not share any walls with neighboring structures.

Single-Family Attached Home: Single-family residential structure that is not a standalone structure and shares at least one wall with a neighboring structure.

Low-rise multi-family homes: Multi-family residential structure of one to three stories.

Mid-rise multi-family homes: Multi-family residential structure of four to six stories.

LEED Home, Certified LEED Home: LEED for Homes criteria must be verified by an outside third party. Verification activities include: documentation review, field inspection, and performance testing. When the verification has been successfully completed, the home will be certified as a LEED home (Certified, Silver, Gold, Platinum) according how many credits the home received during the verification process (USGBC 2005).

Inspection: The process of performing the necessary in-field inspections to confirm that each of the builders' targeted measures in the LEED for Homes Rating System has been installed. Only raters trained by and operating in conjunction with an approved LEED Program Provider can perform inspection services for a LEED Home. (USGBC 2005).

Performance Testing: The process of conducting the necessary in-field performance testing to confirm that each of the builder's targeted measures in the LEED for Homes Rating System are compliant with the specified performance requirements. Only raters trained by and operating in conjunction with an approved LEED Program Provider can provide these performance testing services for a LEED Home (USGBC 2005).

Rating: The process or scoring each of the credits. All the credits are added up giving the total number of points achieved for each of the LEED measures successfully installed, and determining the LEED for Homes performance level achieved (USGBC 2005).

Certification: The formal process of assessing and approving the performance level of a LEED Home, after the Provider has conducted a detailed review of the information compiled in the field by the green rater. Certification can only be given by an approved LEED for Homes Program Provider (USGBC 2005).

Green Rater: Individual who performs field inspections, HERS-related software Analyses and performance testing for a LEED for Homes Provider (USGBC 2005)

LEED Certified Level: at least 45 LEED credits achieved

LEED Silver Level: at least 60 LEED credits achieved

LEED Gold Level: at least 75 LEED credits achieved

LEED Platinum Level: at least 90 LEED credits achieved

Residential Sector: The unoccupied or occupied, rented, owned, one or multi-family houses, mobile homes that does not include institutional housing

Significance of Study

The LEED for Homes rating system is a new system that has officially been in existence since 2008 causing unawareness and uncertainties. In relation to this unawareness, many individuals have a preconceived notion that LEED certification equates to substantially higher costs (Mullen, 2014). There are many benefits to LEED certified homes including enhanced property value, healthier indoor environments, and utility savings that average 20 to 30% better than a traditional code built home (Kriss 2014). In order to increase the overall number of LEED certified residential units in Kentucky the residents need the appropriate information and currently, it is not readily available.

This study will provide a foundation for future work relating to LEED certified homes in Kentucky. As the number LEED certified residential projects increases, so will the data available for a more in-depth analysis. The framework created by this study can be utilized in future studies that will yield more accurate findings. As this study relied heavily on estimations because of the limited nature of the available data, future studies can replace the estimated figures with actual data which provide a more accurate analysis of the cost effectiveness of LEED certified homes in Kentucky. Due to the limited number of LEED certified single-family homes that exist in Kentucky, this study focused on the major metropolitan areas of Kentucky. As more residential projects become LEED certified and the dispersion of these projects throughout Kentucky increases, it will allow for this study to be expanded on to include more regions. By including more regions, the findings will become more indicative of the state as a whole and not just limited to the major, metropolitan areas.

It is unlikely that energy and water costs are going to decrease but more likely that the cost of these resources will continue to increase causing householders to be more conscious

about managing their resource consumption (Ghetty et al. 2008). As the utility costs continue to increase so will the need for efficiency to reduce those utility cost. Sustainable designed residential projects have proven to be more efficient in resource consumption than typical code built homes. This study is significant for the residential construction industry in Kentucky because it would show where the concentrations of LEED certified residential projects are in Kentucky. This is significant for two reasons. The first is that it communicates to the homebuilders that these are the areas where the number of LEED certified residential projects is likely to increase in the future. This could allow the homebuilders in the concentrated areas to increase their sales by preparing for a potential trend of residential projects seeking LEED certification. The second reason this study is significant is, it shows homebuilders who are not located in the concentrated areas who may be seeking to build LEED certified projects where they will most likely have success in doing so.

This study is most significant for potential homebuyers, especially those who are looking to build a new home. The geographical analysis of the study shows where the LEED certified residential projects are concentrated. For potential homebuyers considering buying a LEED certified home this study shows the locations where the buyer will have the best chance of finding a LEED certified home in Kentucky. More importantly for these types of homebuyers this study shows the cost effectiveness of building LEED certified home in terms of added cost, utility savings, payback period and breakeven point according to geographical location. For all intents and purposes a potential homebuyer can compare the estimated cost of building a LEED certified home in the three major metropolitan areas of Kentucky. Homebuyers can compare the differences in potential monthly utility savings, payback periods, breakeven points at the county level. This study gives homebuyers a range of possible added cost and monthly utility savings

associated with building a LEED home. The range of possible added cost and monthly utility savings can be compared to other counties. Deciding to build or buy a new home and where has countless variables making the decision process difficult and strenuous. The more information the homebuyer has at their disposal the less strenuous the decision becomes.

Conservation is becoming the standard for building practices and it is important that individuals are aware of these sustainable building practices and how they compare to traditional code built homes. Conservation and sustainability encompasses the total impact of a building on the environment. According to (Ghetty et al. 2008) the three most common motivations for making home modifications to become more sustainable are saving money, desiring a comfortable home environment, and – to a lesser extent – to be environmentally friendly. A LEED certified home meets these three qualities but the initial added cost deters the public to pursue LEED certification. This study is important because it outlines the potential added compared to the utility cost savings. This presents the cost effectiveness of LEED certified single-family homes according to geographical location to the public. It is important for individuals to understand not only the financial differences between LEED certified and code built home but the environmental differences as well.

The LEED for homes rating system is quite new resulting in very limited data especially in the state of Kentucky. However, there are 269 single-family homes and multi-family units registered to be LEED certified which is a dramatic increase to 55 residential projects currently certified (Mullen 2014). As the number of LEED certified residential projects in Kentucky increase so will the number of related research studies. This study is a foundation that many other future works from both academia and industry can build upon giving more insight into LEED residential projects in Kentucky.

Chapter II: Literature Review

Energy Use in Kentucky

The need for an increase in energy efficient and environmentally conscious residential projects in Kentucky is apparent when reviewing the 2012 Kentucky Energy Profile. This document reports that Kentucky ranked 3rd highest in the U.S. for residential energy consumption per capita, at 93.8 million Btu per Capita in 2010 and ranked 10th highest in the U.S. for residential electricity consumption per capita, at 6.22 MWh per Capita in 2011 (Patrick et al. 2012). In Appendix A, the entirety of the residential section of the 2012 Kentucky Energy Profile can be found. The annual residential energy consumption has been increasing for years in comparison with other states that have maintained, or even reduced, residential energy consumption (Patrick et al. 2012). Another noteworthy finding from the 2012 Kentucky Energy Profile is the graph displaying the residential electricity consumption per state GDP dollar. In 2012 Kentucky was ranked 6th in the U.S. regarding residential electricity use to one dollar of the state GDP, at 0.17 kWh per U.S. GDP (Patrick et al. 2012)

LEED Program Background

The United States Green Building Council was established in 1993. In April of that year the first council meeting was held and consisted of 60 construction industry firms and few nonprofit organizations (USGBC.org 2014). The Leadership in Energy and Environmental Design (LEED) program was launched in March 2000. At the time the USGBC was founded there was much conjecture on what a "green building" was and how develop a uniform code to standardize the green buildings (Kriss 2014). The LEED program has a very humble conception according to Scot Horst, USGBC's senior vice president of LEED who said "There's all these amazing things that people are doing, so let's write the down in a list, and say that if you do so

many of them, that's an environmental structure.". The LEED program has since evolved from a list of best practices to highly organized method of rating green building. There are five LEED programs, each with specific project types and credits. In 2000, there were 51 projects that took part in the very first LEED for new construction rating system (USGBC 2012). There are five LEED programs, they are as follows:

- LEED for Building Design and Construction (LEED BD+C): Buildings that are new construction or a major renovation
- LEED for Interior Design and Construction (LEED ID+C): Interior spaces that are a complete interior fit-out
- LEED for Building Operations and Maintenance (LEED O+M): Existing buildings that are undergoing improvement work or little to no construction
- LEED for Neighborhood Development (LEED ND): New land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix
- LEED for Homes (LEED H): single family homes, low-rise multi-family, and mid-rise multi-family

The LEED program is a set of building standards and practices that operate on a credit based rating system organized by categories. There are five of these main credit categories each with a set number of possible LEED credits. Some categories have prerequisites that have to be met and no credit is awarded for. The LEED for Homes rating system began as a pilot program in 2005, and in 2006 the first LEED for homes project is certified in Oklahoma City, OK (USGBC 2012). The LEED for Homes program became official in 2008 (USGBC). There are 8 credit categories for the LEED Homes rating system and each category is divided into various subcategories. Each

individual subcategory has a specified number of possible LEED credits. The LEED for Home categories and subcategory credit values can be found in Appendix B.

There are four levels of LEED certification that a home can achieve based on the number of LEED credit the home acquires throughout the construction process. There are two versions of the LEED for Homes rating system, LEED for Homes v2008 and LEED BD+C: Homes, each with different certification levels. Table 1 shows the difference in required LEED credits for each of the LEED levels between the two versions of the LEED for Homes rating system.

Table 1: Difference in Number of LEED credits Required for the Two Versions of LEED Certification (USGBC 2012)

LEED Level	LEED v4 BD+C: Homes	LEED for Homes v2008
Certified	40-59	45-59
Silver	50-59	60-74
Gold	60-79	75-89
Platinum	80 +	90 +

Prior to the establishment of the LEED for Homes rating system in 2008, a single family home could still be LEED certified but it was certified under the LEED BD+C rating system. The credit requirements und the LEED for Homes v2008 are more specific to residential projects whereas the LEED v4 BD+C focused on commercial projects.

The LEED for Homes certification process consists of four steps: registration, verification, review, and certification (USGBC 2014). The registration step is a declaration of intent to pursue LEED certification. There are some perquisites that need to be met before registration can occur. The building must be in a permanent location on existing land, reasonable LEED boundaries must be used, and the project must comply with project size requirements (USGBC 2014). Next, the verification team is chosen, which consists of three responsibilities, they are as follows:

- LEED for Homes Provider Organization – Oversees the certification process. The LEED Provider organizations work closely with Green Raters and provide quality assurance of their verification services (USGBC 2014).

- LEED for Homes Green Rater – Provide the required on-site verification for LEED for Homes projects (USGBC 2014).

- Energy Rater – LEED for Homes requires that the project is performance tested by a qualified energy rater. The Residential Energy Service Network (RESNET) administers the credentials to the energy raters, or Home Energy Raters.

Once the verification team is chosen the verification process can begin. There are four stages to the verification process they are described as follows:

- Preliminary rating – An Integrative Project Planning Prerequisite requires a preliminary meeting with the verification team early in the design process to develop an action plan that included: the targeted LEED certification level, the LEED for Homes credits selected to pursue to meet the target level, and the individuals accountable for meeting the LEED for Homes requirements for each selected prerequisite and credit (USGBC 2014).

- Mid-construction verification visit – During this visit the Green Rater and Energy Rater will verify certain building systems that are only visible while the walls remain open. This visit also allows the Green Rater to observe the projects complained with credit requirements that are fulfilled overtime, such as construction waste management (USGBC 2014).

- Final Construction verification visit – This visit takes place once construction and landscaping is complete. The Green Rater verifies that the project has met all remaining prerequisites and credit requirements, and the energy rater conducts a final performance test (USGBC 2014).

- Supplemental documentation – Some prerequisite and credit requirements cannot be verified through site visits alone but require the appropriate documentation as well. The verification team will ask to see documentation such as project plans or material specifications (USGBC 2014).

The next stage following verification is the review stage where the Green Rater submits the appropriate documentation to the LEED for Homes Provider for their quality assurance review. Upon completion of the quality assurance review, the Provider will submit the documentation to Green Building Certification Institute (GBCI). The GBCI will respond with its preliminary review 20-25 business days indicating which prerequisites and credits are anticipated to be awarded during the final review, pending further information, or denied (USGBC 2014). This preliminary review can be accepted as the final review or new or revised documentation can be submitted for the final review. After the final review has been submitted the project team can accept the results to begin the certification process or submit a revised application for an appeal review. Once the final review is accepted the project is deemed "closed out" and no new or revised documentation will be reviewed. The total number of credits the project was awarded in the final review will determine which LEED certification level the project will receive. The LEED level credit requirements were listed above.

Cost Premium Associated with LEED Certification

The LEED for Homes rating system, championed by the USGBC, is a green rating system that was specifically designed for single-family homes, low-rise multi-family and mid-rise multi-family residential projects. This rating system has only been available since 2008 resulting in a limited amount of available data regarding cost premiums and energy efficiency for LEED certified residential projects. For high occupancy, multi-family projects the UGBC states that projects seeking the Certified level costs no more than a conventional project, and projects seeking Silver or Gold can increase the total project cost by 1 to 2% (McCormick 2008). However, the majority of the research done regarding LEED certification cost premium focuses on the commercial buildings i.e. schools and office buildings. The research on commercial LEED certified buildings can still give insight into the associated cost premiums with LEED certification. Kats et al (2003) is one of the most cited references regarding the cost LEED certification. This study reported that the cost premiums for LEED certification tend to increase as the level of LEED certification increases as shown in Table 2. The study also reported findings that the average premium for green buildings equates to $3 to $5 per square foot (Kats et al. 2003). Stegal (2004) analyzed the cost of a new residence hall construction and reported that the cost premium for it to be LEED certified to be between 1 and 2.8%.

Table 2: Cost Premiums with LEED/Green Buildings (Kats et al. 2003).

Certification Level	Average Cost Premium
Certified	0.66%
Silver	2.11%
Gold	1.82%
Platinum	6.50%
Average	1.85%

Matthissen and Morris (2004) preformed a credit-by-credit cost analysis of 138 buildings, 45 of which were seeking LEED certification and 93 were not. They found LEED certified cost premiums similar to those of (Kats et al. 2003), varying from a 1 to 10.3% cost premium. They also found that the cost variation of both LEED and non-LEED varied significantly and that the cost variation between the LEED certified buildings was within the cost variation of the non-LEED certified buildings. Essentially meaning that LEED certified buildings often cost less than non-LEED certified buildings. Matthissen and Morris repeated (2007) repeated their study using 221 buildings, of which 83 were seeking LEED certification. Their results were similar to their previous study. It is expected to have some type of cost premium, the amount however varies considerably. However, the chief executive officer of Intertech Design Services reports that the construction expenses of pursuing LEED certification can increase a project's cost by 10% to 30% and the certification fees can account for 5% to 15% of the total construction cost (Vamosi 2012). He also states that architects and engineers usually demand higher fees for green designs and green-design professionals charge 1 to 2% more for a LEED-certified building design (Vamosi 2011). They also analyzed the green premium versus LEED certification level across six different cities. Their result was that there is evidence of a correlation between LEED certification level and associated cost premium as shown in Table 3.

Table 3: Green Premium versus LEED Certification Level (Matthiessen & Morris 2004).

Location	Platinum	Gold	Silver
USCB	7.80%	2.70%	1.00%
San Francisco	7.80%	2.70%	1.00%
Merced	10.30%	5.30%	3.70%
Denver	7.60%	2.80%	1.20%
Boston	8.80%	4.20%	2.60%
Houston	9.10%	6.30%	1.70%

One factor that significantly contributes to the added cost of LEED certification came to light after an interview with Mr. Mullen the Director of Residential Development for USGBC. The level of experience the builders and subcontractors with green building or the LEED certification process can dramatically affect the added cost positively or negatively. Mr. Mullen stated that a builder who has built LEED certified homes before would be able to do so for less than a builder who is building a LEED home for the first time. Mr. Mullen gave two scenarios that highlight experience as a factor in added LEED cost. Scenario one, a homebuilder is approached by a client who is requesting a LEED certified Gold home. The builder has no experience with building under LEED guidelines and in the past has strictly done code built homes. Scenario two, a homebuilder is approached by a client who is requesting a LEED certified Gold home. The builder has built LEED homes in the past and currently only builds Energy Star Certified homes. The homebuilder who has no LEED experience would have a higher cost because of the unfamiliarity with the LEED program (Mullen 2014).

A study done by (Mapp et al. 2011) compared the cost of eight non-LEED banks and two LEED certified banks with similar building types and sizes located in western Colorado. The purpose was to assess the cost directly associated with seeking LEED certification using total building cost, square footage cost, soft costs, and hard costs. Findings from this study show that when the total building cost per square foot of the LEED certified banks were compared with the eight non-LEED certified banks they were within the square footage costs for all ten banks (Mapp et at. 2011).

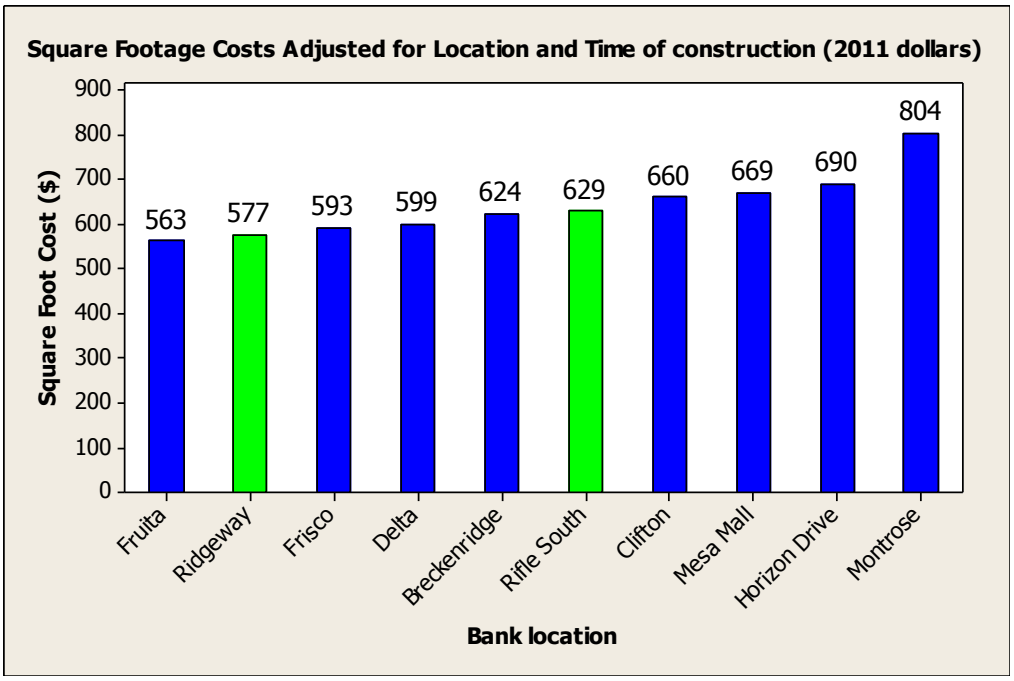

Figure 1: Bar Graph of Square Foot Cost for Ten Bank Construction Project (Mapp et al. 2011).

Figure 1 shows the total building cost per square foot for all ten banks included in the study. This study also estimated the direct cost associated with the LEED certification and found that the direct costs LEED certification was below 2% of the Total Project Cost and between 1.5% and just over 2% of the Total Building Cost (Mapp et all 2011). This study concluded that across very similar projects, it was possible to achieve LEED certification for minimal additional costs and the costs associated with the LEED projects were always within the overall range of the non-LEED projects (Mapp et al. 2011).

There have been numerous studies that focused on the cost and benefits of sustainable design. One study that often cited regarding sustainable costs and benefits is the report provided by Kats et al. (2003) where they calculated the net present value (NPV) of sustainable benefits for commercial buildings in the state of California shown in Table 4. The calculations they used were based on Microsoft's Excel's standard NPV formula. The authors chose a 20-year payback

period and it is assumed they used a 5% minimum acceptable rate of return (MMAR). In their study federal and municipal tax credit or incentives associated with the incorporation of sustainable design features or techniques. In doing this, it is likely that the NPV is underestimated in regions where these tax credits or incentives exist (Matthiessen & Morris 2004).

Table 4: Financial Benefits of Green Buildings (Kats et al. 2003).

Net Present Value (NPV) Over 20 Years	
Category	NPV per ft2
Energy	$5.70
Emissions	$1.18
Water	$0.51
Waste	$0.03
Commissioning	$8.47
Productivity and Health (Certified/ Silver)	$36.89
Productivity and Health (Gold/ Platinum)	$55.33
Cost Premiums for Green Construction	($4.00)
NPV (Certified/ Silver	$48.87
NPV (Gold/ Platinum)	$67.31

In Table 4,which was taken from the (Kats et al. 2003) study, shows the LEED buildings grouped by LEED certification levels into two groups, (Certified/Silver) and (Gold/Platinum). In doing so they found that Productivity and Health benefits accounted for about 70 and 82% of the respective NPV, and the utility savings accounted for around 12 and 9% (Kats et al.) It is important to mention that the utility savings alone were greater than the cost premium (Matthiessen & Morris).

Reposa (2009) compared the applicability, requirements, verification, fees, and construction cost for LEED for Homes to two other NAHB residential green rating programs.

He found that the fees associated with LEED for Homes range from $50 to $100 for enrollment, $250 to $400 for certification, $300 to $1,000 for the provider, $100 to $150 for initial dry wall inspection by Green Rater, and $350 to $700 for second inspection and document review by the Green Rater. This resulted in a total added cost of fees for LEED certification to be $1,050 to $2350. Reposa (2009) also reported that the cost of fees could increase depending on the level of familiarity the subcontractors have with the LEED for Homes rating system. Unexperienced subcontractors may require on the job training costing approximately $150 per. It is important to note that subcontractors who are inexperienced with the LEED program and its procedures are a significant factor in the added cost in both fees and construction. The level of experience causes significant variability in the added cost of LEED for Homes certification. Mr. Mullen, the Director of Residential Business Development for the USGBC confirmed that the experience of the general contractor and subcontractor can have a significant effect on the added cost for LEED certification.

Reposa (2009) reported the additional construction-compliance cost for the four levels of LEED certification shown in Table 5. Table 5 also shows a comparison of LEED costs to other comparable green rating programs. As shown in Table 5 the added construction cost for LEED certified is substantially higher than other green rating programs.

Table 5: Preliminary Comparison of Additional Construction Cost for Green Rating Compliance (Reposa 2009).

Rating System	Bronze/Certified	Silver	Gold	Emerald/Platinum
Green Building Guidelines	$1,900-$2,700 (1-2%)	$4,000-$6,000 (+, -3%)	$8,200-$11,000 (5-6%)	N/A
National Green Building Standard	$2,000-$3,000 (1-2%)	$4,000-$6,000 (+, -3%)	$11,500-$13,600 (+-8%)	$25,600-$31,200 (17-18%)
LEED for Homes	$6,400-$11,000 (4-6%)	$8,800-$13,800 (3-8%)	$19,300-$22,500 (+,-13%)	$29,800-$38,000 (20-22%)

It is important to note that the above figures from Reposa (2009) were estimated using only two model homes from varying geographic locations. These results may not reflect the most accurate estimated added construction cost for LEED certification in Kentucky based off of an interview with a homebuilder that built a LEED Gold certified single-family home in the Northern Kentucky area. The interviewed homebuilder built a LEED Gold certified single-family home and stated an estimated additional construction cost of $10,000.

Cost Benefits of LEED Certified Projects

Energy efficiency may be the first thing that comes to mind regarding LEED certified and other Green buildings. According to the U.S. Department of Energy Green buildings save an average of 30% to 50 % in energy costs compared to conventional buildings. However, in a study conducted by the Chicago chapter of the U.S. Green Building Council the variety of occupancy types made it difficult to compare energy-use and efficiency (Vamosi 2011). Some LEED certified buildings performed worse than other non-certified buildings (Vamosi 2011). A study conducted by Alliance for Environmental Sustainability (AES) collected pre-occupancy

building energy performance data on 144 LEED certified residential buildings. This study found that a LEED home consumed 28% less electricity compared to a conventional home and the average annual electricity cost for a conventional home was $1,489; for a LEED certified home, that figure was reduced to $1,011. The reduction in natural gas intensity for LEED home was 48% lower than that of a conventional home reducing the annual natural gas cost from $1,290 to $633 (AES.org). Another noteworthy finding from this study was the reduction of pollutants for LEED homes compared to conventional homes; the LEED homes averaged a reduction in carbon dioxide by 7 lbs., sulfur dioxide by 38 lbs. and nitrous oxide by 28 lbs. (AES.org). The most significant finding from the AES study was cost breakdown and reduction percentages of LEED homes compared to conventional homes according to LEED certification level, as shown in Table 6. Some noteworthy he characteristics of this table are the annual utility savings and the total utility cost savings over a 30 year period.

Table 6: LEED Cost and Utility Percent Reduction (AES.org).

Annual Savings		Platinum	Gold	Silver	Certified
Total Energy	Reduced %	41	46	29	29
	Savings %	46	42	24	24
Electricity (KWH)	Reduced %	31	47	23	10
	Savings %	39	47	22	9
Natural gas (CCF)	Reduced %	51	4	34	50
	Savings %	52	36	25	50
Emissions Reduction	CO2 (tons)	10	10	3.4	7
	Nitrogen Oxide (lbs.)	42	80	20	31
	Sulfur Oxide (lbs.)	28	62	10	20
Monthly Utilities	Conventional $	345	193	91	293
	LEED Home $	189	107	70	198
	Monthly Savings $	156	86	21	95
Annual Utilities	Conventional $	4,135	2,310	1,092	3,520
	LEED Home $	2,266	1,284	836	2,381
	Annual Savings $	1,869	1,026	256	1,139
Utility Costs over 30 Yrs.	conventional $	196,725	109,900	51,952	167,465
	LEED Home $	107,806	61,087	39,773	113,277
	30-year savings $	88,919	48,813	12,179	54,277

The annual utility cost savings figure for LEED Silver is low due to the fact that a large number of the LEED Silver homes analyzed for this study were built by Habitat for Humanity and were relatively small regarding square footage (AES.org). For the LEED Certified, Gold and Platinum homes the annual utility savings were substantial (AES.org). The utility cost savings over a 30 period as shown in Table 6 represents significant cost savings; LEED Certified homes saving $54,277 and LEED Platinum saving $88,919 over the course of 30 years (AES.org). In the first year, one such LEED Gold building containing 242 rental units saved $40,000 in utility costs (McCormick 2008). Though energy efficiency represents a large portion of the cost benefits associated with LEED certified buildings there are other benefits that may be overlooked. Many developers of LEED buildings say certification helps attracts buyers and renters because of a growing interest in sustainable lifestyles (McCormick 2008). Chris Achenbach, a partner and construction manager for Zocalo Community Development Inc. says, "Buyers are interested in doing the right thing. They recognize that LEED translates into lower energy costs, and they know a lot of extra scrutiny goes into design and construction, which leads to a higher-quality project (McCormick 2008)." According to the USGBC communication coordinator Ashley Katz, studies indicate that sustainable designed buildings produce 3.5% higher occupancy rates and 3% higher rental over conventional buildings, and increase the return on investment by 6.6% (McCormick 2008). According to a 2006 study by McGraw Hill Construction, Green buildings see an average increase of 7.5% in building value over conventional building. However, most of these figures were derived from commercial rather than residential construction projects (McCormick 2008). Jordan Barowitz, spokesperson for the Durst Organization, which partnered with Rose Associates to develop a rental project in New

York City says “The value of LEED certification is obvious – that you’re building a sustainable building. Over the long run, it is also less expensive to run (McCormick 2008).”

A study conducted by economists at the University of California, Berkeley and University of California, Los Angeles conducted an economic analysis of 1.6 million homes sold in California between 2007 and 2012, controlling for other variables known to affect the price of homes in order to isolate the value that a green label adds to a home (Kok & Kahn 2012). The green labels included in this study were Energy Star, LEED for Homes, and GreenPoint (Kok & Kahn 2012). The key finding from this study was that a green label adds a 9% price premium to the home (Kok & Kahn 2012). Two other results from this study are also noteworthy. First, the resale premium associated with a green label varies considerably from region to region in California, and is highest in regions with hotter climates. Second, the premium is also positively correlated to the environmental ideology and mindset of the region, by rate of registration of hybrid vehicles (Kok & Kahn 2012).

Chapter III: Methodology

Methodology and Data Collection Approach

The focus of this study was single-family homes certified in Kentucky under the LEED for Homes rating system. To answer the questions posed in the objectives of this study the following research methods, and their corresponding strategies, were performed as stated below:

- Distribution of LEED certified homes in Kentucky and comparative analysis between LEED homes in Kentucky and in United States.
- Estimation of the added construction cost for LEED certified single-family homes in selected counties of Kentucky (Fayette, Jefferson, Boone, Kenton, Campbell, and Spencer County).
- Cost effective analysis of the added construction cost for LEED certified single-family homes in selected counties of Kentucky using pay-back period and 30 year fixed mortgage period analysis. (Fayette, Jefferson, Boone, Kenton, Campbell, and Spencer County).

Strategy of First Objective

"Assess the distribution of LEED certified homes in Kentucky."

To assess how Kentucky compares to the U.S. the total number of LEED certified residential projects all fifty states were ranked, from 1st to 50th, based on the total number of LEED certified residential projects each state currently contained through 2013. The state with the greatest number of LEED certified residential projects was ranked 1st and the state with the least number of LEED certified residential projects was ranked 50th.

To assess how Kentucky compared to other states in the region the total number of LEED certified residential projects in Kentucky was compared to all bordering states (OH, TN, VA, IN, MO, IL, and WV). Descriptive statistical analysis was used to compare the distribution of LEED levels in Kentucky to the rest of U.S. based on LEED level percentage of total number of LEED certified single-family homes.

Strategy of Second Objective

"Determine the estimated added construction cost of a LEED certified single-family home in the selected counties of Kentucky."

It is apparent that there is an added construction cost associated with building LEED certified homes. For this study Descriptive statistical analysis was used, in conjunction with data and findings from the USGBC and NAHB, on a sample size of least 20 homes per county to estimate the added construction cost of each LEED level in each county and analyze the results. Multiple listing services were used to collect the sample population for each county. In order for a home to qualify to be used in the sample population the following criteria had to be met:

- Single-family
- New Construction
- 3-4 bedrooms
- 2-3 bathrooms
- No added sustainable features
- No added value items (such as a pool, more than one acre lot, etc.)

The estimated added construction cost for LEED homes was used as opposed to real reported construction cost for two reasons. First, the very limited number of LEED certified

single-family homes in Kentucky. Secondly, projects of interest are private residences making the information regarding the home not open to the public and difficult to obtain. The estimated added construction cost was figured from a combination of national averages provided by the National Association Home Builders (NAHB) and after sale value of homes in the selected counties. The added LEED construction cost is a two stage process. First, the construction cost for code built homes must be determined. Secondly, the added LEED construction cost can be extracted from the code built construction cost.

Construction Cost Estimation for Code Built Single Family Home

The NAHB periodically conducts a study regarding cost of a new construction single-family home based on surveys taken from homebuilders across the United States. This study breaks down the total cost into seven categories according to cost and percentage of the total sale value of the home. The 2013 NAHB survey shows the construction cost of a home was 61.7% of the total value of the home. The NAHB cost breakdown chart in its entirety can be found in Appendix C. for the purposes of this study the construction cost of the sample homes were obtained using the findings from NAHB 2013 survey.

Added LEED Construction Cost Estimation

Initially a problem surfaced when attempting to estimate the added cost of LEED certified homes. The Director of Residential Business Development for the USGBC made it known that the there are many variables that have a significant effect on the added cost of LEED certification. The greatest being the experience the contractor and subcontractors have with LEED and green building techniques. This was resolved by using an estimated added percentage of the construction cost. For the purposes of this study the added construction cost percentages were as follows:

- LEED certified: 4%
- LEED Silver: 7%
- LEED Gold: 10%
- LEED Platinum: 13%

These percentages were figured through communications with LEED professionals and homebuilding organizations that have previously built LEED certified homes. The average added construction cost of a LEED Certified level home stated by the Director of Residential Business Development for the USGBC was around 3%. For this study a 4% added construction cost for a LEED Certified level home was used. The added construction cost for a LEED Gold single family home reported by a homebuilding organization in Covington, Ky. was 9% (Protronio 2014). For this study a 10% added construction cost for a LEED Gold level home was used. The Silver and Platinum level percentages (7% and 13%) were based on intervals using the Certified and Gold level percentages.

The added percentages for all four levels of LEED certification was applied to each of the construction costs as shown in Equation 1. Each sample home's construction cost yielded four figures representing the added cost for each level of LEED certification.

Equation 1: Extracting the added construction cost from the home list price

$$(List\ Price \times 0.617) \times (\ 0.04, 0.07, 0.10, and\ 0.13) = Added\ LEED\ Construction\ Cost$$

Strategy of Third Objective

"Analyze the cost effectiveness of a LEED certified single-family home in the selected counties of Kentucky."

The added LEED construction cost data was used for the payback period analysis and 30 year mortgage analysis with the addition of monthly utility costs for traditional and LEED certified single-family homes. Descriptive statistical analysis was performed on the payback period results for each LEED level in each county to compare the payback periods internally and against the other counties.

Monthly Utility Cost of Traditional Home

The monthly utility cost of a traditional home is required for the payback period analysis and the 30 mortgage analysis. The original method was to use data provided by the 2010 Kentucky Energy Report. The 2010 Kentucky Energy Report provides the average monthly electric cost, cost of electricity in Cents/ kWh, and electricity consumption in MWh per month for each county in Kentucky. However, a problem arose using this method. The data in the 2012 Kentucky Energy profile only reported the electricity use per household and the cost per kWh for each county. The problem was that using electricity alone as the utility cost was not accurate as some areas use natural gas in addition to electricity. The monthly utility cost method was revised using two different methods; one used for the payback period analysis, and the other used for the 30 year mortgage analysis

Utility Efficiency of LEED Certified Homes

The initial method for analyzing the utility efficiency between LEED certified sing-family homes and traditional homes was to obtain the energy and water efficiency figures of the LEED certified homes in Kentucky and categorize them by LEED level. Further investigation revealed an issue in using this method. The issue was the limited number of LEED certified homes in Kentucky resulting in very little accessible data on the utility efficiency of LEED certified homes.

The revised method was to use the data provided by the USGBC on the utility efficiency of LEED certified homes. According the USGBC, LEED for homes projects, on average, are 20% to 30% more efficient than a typical residential project built to code (USGBC 2014). The LEED for Homes program mandates that a home must be Energy Star certified before it can be LEED certified. The Energy Star program states that Energy Star certified homes are at least 15% more efficient compared to traditional code built homes. Based on the Energy Star prerequisite a LEED home is, at minimum, 15% more utility efficient than a traditional code built home. The percent reduction figures chosen for this study are as follows and apply to both the payback period analysis and 30 year mortgage analysis:

- LEED Certified – 15%
- LEED Silver – 20%
- LEED Gold – 25%
- LEED Platinum – 30%

Chapter IV: Data Analysis

Distribution of LEED Certified Single-Family Homes in Kentucky

As stated previously, there are a total of 55 LEED certified single-family homes (detached and attached) in the state of Kentucky. Nationally there are 12,757 certified single-family homes (detached and attached) according to the LEED for Homes Certified Projects List provided by the USGBC. Figure 2 shows the percentage of each LEED level from the total number of certified projects in the U.S. as of 2013. The LEED Silver level has the highest percentage of the certified projects at 34% as shown in Figure 2.

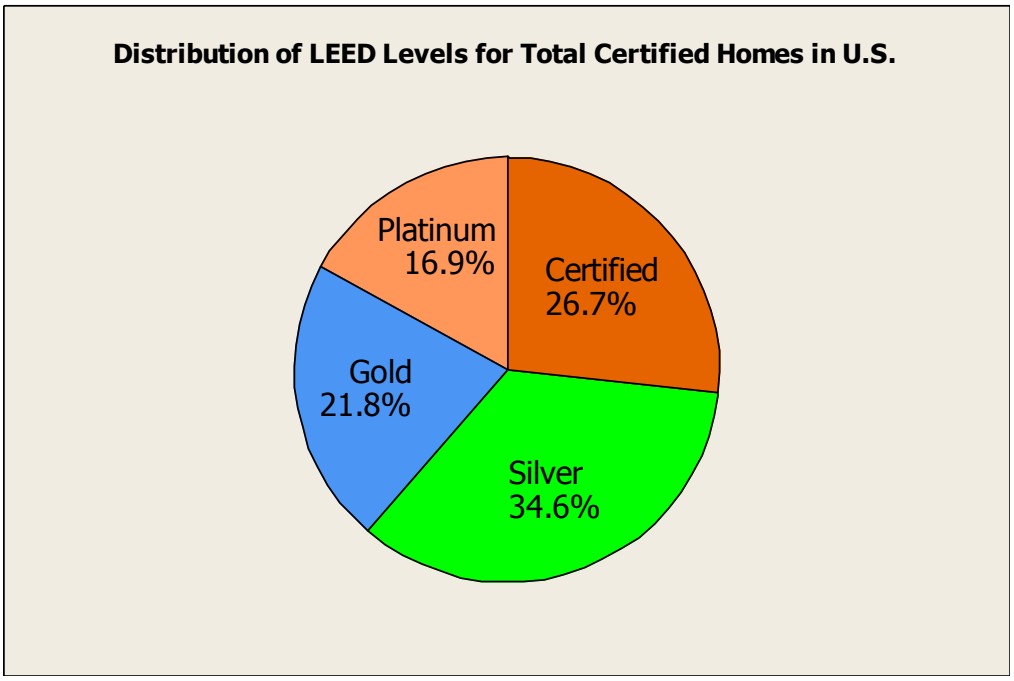

Figure 2: Distribution of LEED Levels Based on Percent of Total Number of Single-Family Certified Homes.

The majority of the LEED certified single-family homes in the U.S. were comprised of the two lower LEED levels (Certified and Silver), at 61% of the total LEED certified single-family homes also shown in Figure 2. In Kentucky 50 of the 55, over 90%, of the certified

single-family homes in Kentucky have achieved the LEED Gold level of certification. It is important to remember that 46 of the 50 Gold certified homes are part of a military community established in Fort Knox.

A regional analysis was performed by comparing the total number of LEED certified single-family homes between Kentucky and all bordering states in order to assess the presence of LEED certification in the geographical region surrounding Kentucky. There were eight states included in the regional analysis and Kentucky was second to last for total number of LEED certified single-family homes as shown Figure 3. Ohio has the highest number of LEED certified single-family homes in the region and it is important to note that there are tax incentives for Green and LEED projects. The most significant of these is in the city of Cincinnati, which states 100% property tax abatement for 15 years for building a new construction LEED certified home (DSIRE.org 2013). This type of incentive does not exist in the state of Kentucky.

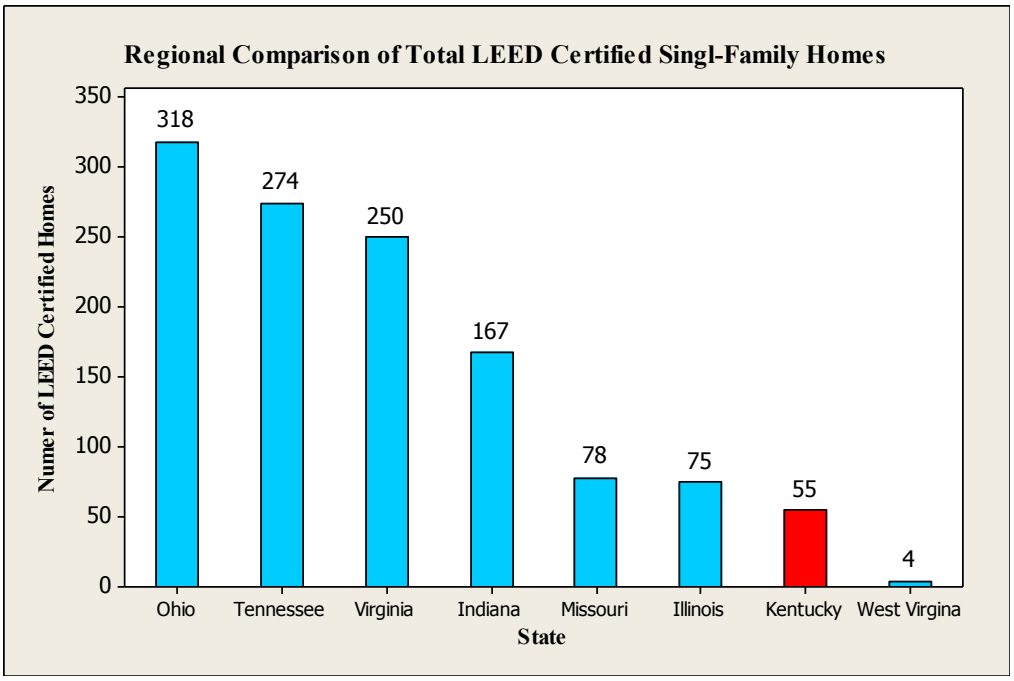

Figure 3: Comparison of Kentucky vs. Bordering Stats on Total Number of LEED Certified Single-Family Homes.

A U.S. ranking of all fifty states was also performed using the information from the LEED for Homes Certified Project List provided by the USGBC to rank the states according the total number of LEED certified single-family homes (attached and detached) contained in each state. Kentucky was ranked 32rd in the nation with 55 homes. The state with the most number of LEED certified single-family homes was Texas with 2,079 homes, and the state with the lowest was North Dakota with 0 homes. The ranking list in its entirety can be found in Appendix D.

Cost Effectiveness of LEED Certification (Payback Period and Economic Analysis)

For Fayette, Jefferson, Spencer, Boone, Kenton, and Campbell County the payback period for each LEED level was calculated by dividing the added construction cost by the respective utility savings per month. The utility cost used in the payback period analysis was based on a cost per square foot. The average monthly utility cost in Kentucky in 2011 was $148 (Wheeland 2012). The $148 monthly utility cost was based on expenditure tracking on utilities from January through October, 2011. Accounting for 2% inflation the monthly utility cost in 2013 translates to $154. The $154 was divided by the median square footage of all six counties (2116 sq. ft.) yielding $0.073 per square foot. The estimated utility cost for each sample home was calculated by multiplying its square footage by $0.073.

The mortgage analysis used a 30 year fixed mortgage period with a constant interest rate of 4.25% for all six counties. The mortgage analysis was performed on each county using the median values of home cost and added LEED cost calculated in the descriptive statistical analysis, and the cost of living index utility cost. The total fixed mortgage monthly payment was calculated using Equation 2. The 30 year mortgage analysis was performed comparing the traditional home to the LEED Certified level under the following conditions:

- 15% down payment (Traditional Home) and 4.25% interest rate
- 15%, 18%, and 20% down payment (LEED Certified Level) and 4.25% interest rate

Equation 2: Equation for calculating a fixed monthly mortgage payment.

$$EMI = \frac{(P * r) * (1 + \frac{r}{12})^n}{(1 + \frac{r}{12})^n - 1}$$

P = principal barrowed amount

r = annual interest rate

n = number of monthly payments

EMI = fixed monthly payment

The utility cost for the 30 year mortgage period used the national average monthly utility cost and a cost of living index. The national average utility cost in 2011 was $163 in 2011 (Wheeland 2012). Accounting for inflation, the national monthly utility cost in 2013 translates to $169.58. The cost of living index used uses the national average at 100 and assigns locations a score either greater or less than 100 representing that locations utility cost in relation to the national average (bestplaces.net 2012). For this study the cost of living index score for each county was expresses as a percent then multiplied by $168.58, yielding a utility cost unique to each county.

Fayette County

Payback Period

The sample population for Fayette County is comprised of 22 new construction single-family homes with corresponding square footages from varying zip code areas. Table 7 shows the sample population of new construction home costs, square footage, and utility cost.

Table 7: Fayette County Traditional Home Sample Population.

Traditional Home Sample Population			
	Home Cost ($)	Square Feet	Monthly Utility Cost ($)
	169300	1950	142.35
	183200	2181	159.21
	188842	1855	135.42
	191950	1976	144.25
	196679	2423	176.88
	198243	1853	135.27
	205433	2274	166.00
	208908	1938	141.47
	229900	2551	186.22
	233248	1938	141.47
	239900	2456	179.29
	239900	2265	165.35
	245640	2127	155.27
	249500	2005	146.37
	263860	2410	175.93
	268280	2464	179.87
	269000	1804	131.69
	269900	2100	153.30
	280900	2300	167.90
	291500	2397	174.98
	312178	2465	179.95
	313872	2884	210.53
Median	**239900**	**2223**	**162.28**
Average	**238697.087**	**2210**	**161.32**

The data in Table 7 was used to estimate the added construction cost, monthly utility cost savings, and payback period for each of the four LEED levels. Table 8 shows the average and median values calculated for each of LEED levels in Fayette County. From Table 8, building a LEED Certified level new construction single-family home in Fayette County will cost nearly $6,000 more when compared to a traditional single-family home, but reduce the monthly utility cost by $24. At the current average monthly utility costs in Fayette County the monthly utility cost savings will pay back the added initial investment in just over 20 years.

Table 8: Median and Average values for All Four LEED Levels in Fayette County.

		Added LEED Cost	LEED Utility Cost Reduction	LEED Savings/ Month ($)	Simple Payback Period (yrs.)
LEED Certified	Median	5920.73	24.34	137.94	20.34
	Average	5889.69	24.20	137.12	20.36
LEED Silver	Median	10361.28	32.46	129.82	26.70
	Average	10306.97	32.26	129.05	26.73
LEED Gold	Median	14801.83	40.57	121.71	30.52
	Average	14724.24	40.33	120.99	30.55
LEED Platinum	Median	19242.38	48.68	113.60	33.06
	Average	19141.51	48.40	112.92	33.09

Under the conditions of this study and using a payback period of 30 years as the pass/fail value to determine if the added LEED construction cost is financially justified by the monthly utility cost savings the Certified and Silver level passed. The LEED Gold level payback period was slightly greater than 30 years, with a payback period of 33.52 years.

Economic Analysis

The values used for the economic analysis consist of the average traditional and LEED Certified level home cost, and the traditional and LEED Certified level monthly utility costs. Table 9 is a comparison of varying down payment percentages and how it relates to the total cost

of the home after the 30 year mortgage period. Table 9 shows the relationship between initial added costs versus savings over time for a LEED Certified level new construction single-family home compared to a traditional home in Fayette County.

Table 9: Thirty Year Fixed Mortgage Analysis of LEED Certified level Single-Family Homes in Fayette County, Ky.

Fayette County				
	15% Down (Traditional)	15 % Down (LEED Certified)	18 % Down (LEED Certified)	20 % Down (LEED Certified)
Total Home Cost	$239,900.00	$245,820.73	$245,820.73	$245,820.73
Down Payment	$35,985.00	$36,873.11	$44,247.73	$49,164.15
Mortgage Amount	$203,915.00	$208,947.62	$201,573.00	$196,656.58
Monthly Mortgage Payment	$1,003.14	$1,027.90	$991.62	$967.43
Monthly Elec. Cost	$159.41	$135.50	$135.50	$135.50
30 Yr. Mortgage Total	$361,130.12	$370,042.81	$356,982.48	$348,275.59
30 Yr. Elec. Cost Total	$57,387.60	$48,780.00	$48,780.00	$48,780.00
Total 30 Yr. Cost	$454,502.72	$455,695.92	$450,010.21	$446,219.73
Net Difference (Traditional vs. LEED Certified Level)		**-$1,193.20**	**$4,492.51**	**$8,282.99**

Table 9 shows the direct relationship between the percentage of down payment and net difference between the total 30 year cost of a traditional single-family home and the total 30 year cost of a LEED Certified level single-family home. A significant finding shown in Table 9 is that under the conditions of this study a LEED Certified level home would produce a net loss of $1,193.20 using a 15% down payment. However, when the down payment is increased to 18% there is a positive gain of $4,492.51 over the added construction cost during the course of a 30 year fixed mortgage period.

Jefferson County

Payback Period

The sample population for Jefferson County is comprised of 26 new construction single-family homes and corresponding square footages from varying zip code areas.

Table 10: Jefferson County Traditional Home Sample Population.

Traditional Home			
	Home Cost ($)	Square Feet	Monthly Utility Cost ($)
	188400.00	2365.00	172.65
	197354.00	2018.00	147.31
	197696.00	2200.00	160.60
	205900.00	1886.00	137.68
	208000.00	2198.00	160.45
	210000.00	2086.00	152.28
	217900.00	2101.00	153.37
	218870.00	1960.00	143.08
	223041.00	1886.00	137.68
	224900.00	2140.00	156.22
	233765.00	2101.00	153.37
	239900.00	2010.00	146.73
	254500.00	2221.00	162.13
	305600.00	2715.00	198.20
	140000.00	2770.00	202.21
	237900.00	1860.00	135.78
	230948.00	2997.00	218.78
	305600.00	2715.00	198.20
	325587.00	2997.00	218.78
	388696.00	2921.00	213.23
	399900.00	2456.00	179.29
	239900.00	1896.00	138.41
	211330.00	2300.00	167.90
	350000.00	2292.00	167.32
	299900.00	2232.00	162.94
	234755.00	2100.00	153.30
Median	**232356.50**	**2199.00**	**160.53**
Average	**249628.54**	**2285.50**	**166.84**

Table 10 shows the sample population of new construction home costs, square footage, and average utility cost. The data in Table 10 was used to estimate the added construction cost, monthly utility cost savings, and payback period for each of the four LEED levels in Jefferson County. Table 11 shows the average and median values for the LEED levels in Jefferson County. As shown in Table 11 shows, building a LEED Certified new construction single-family home in Jefferson County cost just over between $5,700 and $6,200 more than a traditional single-home, and reduces the monthly utility cost by $24. At the current utility cost in Jefferson County the monthly utility cost savings will pay back the added initial investment in just under 21 years.

Table 11: Median and Average Values for All Four LEED Levels in Jefferson County.

		Added LEED Cost ($)	LEED Utility Reduction ($)	LEED Monthly Utility Cost ($)	Simple Payback Period (yrs.)
LEED Certified	Median	5734.56	24.08	136.45	20.94
	Average	6160.83	25.03	141.82	20.65
LEED Silver	Median	10035.48	32.11	128.42	27.48
	Average	10781.46	33.37	133.47	27.10
LEED Gold	Median	14336.40	40.13	120.40	31.40
	Average	15402.08	41.71	125.13	30.97
LEED Platinum	Median	18637.31	48.16	112.37	34.02
	Average	20022.71	50.05	116.79	33.55

Under the conditions of this study and using a payback period of 30 years as the pass/fail value to determine if the added LEED construction cost is financially justified by the monthly cost savings the Certified and Silver level passed. The Gold level was slightly over the 30 year period with a payback period around 31 years. The results shown in Table 11 are similar those of Fayette County shown in Table 8. The cause for this similarity is that both Fayette and Jefferson had very similar housing cost and square footage. Since this study is using housing cost and

square footage as the basis for the LEED values this results in the two counties having similar results.

Economic Analysis

The values used for the economic analysis consist of the average traditional and LEED Certified level home cost, and the traditional and LEED Certified level monthly utility costs. Table 12 is comparison of varying down payment percentages and how it relates to cost savings over the course of the 30 year mortgage period. This table shows the relationship between added initial costs versus savings over time for a LEED Certified level new construction single-family home in Jefferson County.

Table 12: Thirty Year Fixed Mortgage Analysis of LEED Certified level Single-Family Homes in Jefferson County, Ky.

Jefferson County				
	15% Down (Traditional)	15 % Down (LEED Certified)	18 % Down (LEED Certified)	20 % Down (LEED Certified)
Total Home Cost	$232,356.50	$238,091.06	$238,091.06	$238,091.06
Down Payment	$34,853.48	$35,713.66	$42,856.39	$47,618.21
Mortgage Amount	$197,503.03	$202,377.40	$195,234.67	$190,472.85
Monthly Mortgage Payment	$971.60	$995.58	$960.44	$937.01
Monthly Elec. Cost	$178.07	$151.36	$151.36	$151.36
30 Yr. Mortgage Total	$349,774.62	$358,407.06	$345,757.40	$337,324.29
30 Yr. Utility Cost Total	$64,105.20	$54,489.60	$54,489.60	$54,489.60
Total 30 Yr. Cost	$448,733.29	$448,610.32	$443,103.39	$439,432.10
Net Difference (LEED vs. Traditional)		**$122.98**	**$5,629.91**	**$9,301.19**

Table 12 shows the direct relationship between the percentage of down payment and net difference between the total 30 year costs of a traditional single-family home compared to a LEED Certified level single-family home. A significant finding shown in Table 12 is that under the conditions of this study a LEED Certified level home would produce a net gain of $122.98 over a traditional home using a 15% down payment with a 4.25% interest rate. This trend continues as the down payment percentage increases. When comparing the results of the economic analysis of Jefferson county to Fayette county the utility cost per month is the main difference that causes the very different net difference results. The Sperling's cost of living index score for Jefferson County was 105, while Fayette County scored a 94. These indices were applied to the national utility cost of 169.58 yielding a utility cost of $178.06 for Jefferson County, and a utility cost of $159.41. The difference in utility cost was the reason for the difference in payback period and economic analysis.

Northern Kentucky (Boone, Kenton, and Campbell County)

Payback Period

The Northern Kentucky area is comprised of three counties: Boone, Kenton, and Campbell. These counties presented some challenges because there were two distinct areas of each county; one area was more representative of a metropolitan area while the other was more representative of a rural area. Due to this difference it was decided to combine the three counties into one area take sample home costs and square footages from the more metropolitan areas. These two areas can be seen in Appendix A by examining the color differences in Boone, Kenton, and Campbell County. The sample population for the Northern Kentucky is comprised of 20 new construction single-family homes and their corresponding square footages from

Boone, Kenton, and Campbell County. Table 13 shows the sample population of new construction home costs, square footage, and average utility cost.

Table 13: Northern Kentucky Traditional Home Sample Population.

Traditional Home			
	Home Cost ($)	Square Feet	Monthly Utility Cost ($)
	181000	2200	160.60
	181900	2149	156.88
	205990	2160	157.68
	224900	2357	172.06
	224900	2365	172.65
	230195	2197	160.38
	262900	2367	172.79
	194990	2200	160.60
	199000	1738	126.87
	192000	1775	129.58
	189900	1741	127.09
	234900	2357	172.06
	294900	2776	202.65
	199000	1931	140.96
	262900	2367	172.79
	182990	1883	137.46
	192000	1715	125.20
	235990	2160	157.68
	228131	1865	136.15
	239900	2105	153.67
Median	**215445**	**2160.00**	**157.68**
Average	**217919.3**	**2120.40**	**154.79**

The data in Table 13 was used to estimate the added construction cost, monthly electric utility savings, and payback period for each LEED level in Northern Kentucky. Table 14 shows the calculated average and median values for each LEED level in Northern Kentucky. As seen in Table 14, building a LEED Certified new construction single-family home in the Northern Kentucky area will cost around $5,300 more than a traditional single-family home, but reduce

the monthly utility cost by nearly $23. At the current utility cost in Northern Kentucky the monthly utility cost savings will pay back the added initial investment in just under 20 years. The added cost of LEED certification shown in Table 14 was slightly lower when compared to Fayette and Jefferson County.

Table 14: Median and Average Values for All Four LEED Levels in the Northern Kentucky Area.

		Added LEED Cost ($)	LEED kWh Usage Reduction	LEED Monthly Utility Cost ($)	Simple Payback Period (yrs.)
LEED Certified	Median	5317.18	23.65	134.03	19.82
	Average	5378.25	23.22	131.57	19.38
LEED Silver	Median	9305.07	31.54	126.14	26.01
	Average	9411.93	30.96	123.83	25.44
LEED Gold	Median	13292.96	39.42	118.26	29.72
	Average	13445.62	38.70	116.09	29.07
LEED Platinum	Median	17280.84	47.30	110.38	32.20
	Average	17479.31	46.44	108.35	31.49

Under the conditions of this study and using a payback period of 30 years as the pass/fail value to determine if the added LEED construction cost is financially justified by the monthly cost savings the Certified, Silver, and Gold levels passed. It is important to note that a LEED Platinum level single-family in Northern Kentucky with an added cost over $17,000 had a payback period just over 30 years.

Economic Analysis

The values used for the economic analysis consist of the average traditional and LEED Certified level home cost, and the traditional and LEED Certified level monthly utility costs. Table 15 is a comparison of varying down payment percentages and how it relates to cost

savings over the course of the 30 year mortgage period. This table shows the relationship between added initial costs versus savings over time for a LEED Certified level new construction single-family home in the Northern Kentucky area.

Table 15: Thirty Year Fixed Mortgage Analysis of LEED Certified level Single-Family Homes in the Northern Kentucky Area.

Northern Kentucky				
	15% Down (Traditional)	15 % Down (LEED Certified)	18 % Down (LEED Certified)	20 % Down (LEED Certified)
Total Home Cost	$215,445.00	$220,762.18	$220,762.18	$220,762.18
Down Payment	$32,316.75	$33,114.33	$39,737.19	$44,152.44
Mortgage Amount	$183,128.25	$187,647.85	$181,024.99	$176,609.74
Monthly Mortgage Payment	$900.88	$923.11	$890.53	$868.81
Monthly Elec. Cost	$168.45	$144.32	$144.32	$144.32
30 Yr. Mortgage Total	$324,317.13	$332,321.27	$320,592.29	$312,772.96
30 Yr. Elec. Cost Total	$60,642.00	$51,955.20	$51,955.20	$51,955.20
Total 30 Yr. Cost	$417,275.88	$417,390.80	$412,284.68	$408,880.60
Net Difference LEED vs. Traditional		**-$114.92**	**$4,991.20**	**$8,395.28**

The data shown in Table 15 had similar results to Jefferson County in that the net difference between a traditional and LEED Certified home was around $100. The major difference being that Jefferson County produced a net gain while Northern Kentucky produced a net loss. It is important to consider that the LEED Certified home had an added $800 in down payment cost and an added $8,000 in 30 year mortgage cost but the utility savings alone reduced the overall 30 year added cost to only $115 over a traditional home.

Spencer County

Payback Period

The sample population for Spencer County is comprised of 20 new construction single-family homes with corresponding square footages from varying zip code areas. Table 13 shows the sample population of new construction home costs, square footage, and average utility cost.

Table 16: Spencer County Traditional Home Sample Population.

Traditional Home			
	Home Cost ($)	Square Feet	Monthly Utility Cost
	199000.00	1444.00	105.41
	160000.00	1370.00	100.01
	160000.00	1300.00	94.90
	209300.00	1602.00	116.95
	179900.00	1362.00	99.43
	169900.00	1362.00	99.43
	200847.00	2016.00	147.17
	219900.00	2451.00	178.92
	159900.00	1800.00	131.40
	143558.00	1135.00	82.86
	209000.00	2086.00	152.28
	201000.00	2240.00	163.52
	216900.00	2464.00	179.87
	204500.00	1828.00	133.44
	199900.00	2016.00	147.17
	194500.00	1725.00	125.93
	245900.00	2243.00	163.74
	174900.00	2066.00	150.82
	162950.00	1724.00	125.85
	166000.00	1727.00	126.07
Median	**196750.00**	**1763.50**	**128.74**
Average	**189266.90**	**1796.40**	**131.26**

Table 13 reveals several significant differences between Spencer County and the previous two counties or areas. The first was the median and average square footage were significantly

lower. The difference in the median and average traditional home cost was lower as well. Table 17 shows the calculated average and median values for each of LEED levels in Spencer County. As seen in Table 17, building a LEED Certified new construction single-family home in Spencer County will cost nearly $5,000 compared to a traditional single-home, but reduce the monthly utility cost by almost $20. At the current utility cost in Spencer County the monthly utility cost savings will pay back the added initial investment in estimated just under 20 years.

Table 17: Median and Average Values for All Four LEED Levels in Spencer County.

		Added LEED Cost ($)	LEED kWh Usage Reduction	LEED Monthly Utility Cost ($)	Simple Payback Period (yrs.)
LEED Certified	Median	4855.79	19.31	109.43	19.70
	Average	4661.87	19.69	111.57	20.25
LEED Silver	Median	8497.63	25.75	102.99	25.86
	Average	8158.28	26.25	105.01	26.58
LEED Gold	Median	12139.48	32.18	96.55	29.56
	Average	11654.68	32.81	98.44	30.38
LEED Platinum	Median	15781.32	38.62	90.11	32.02
	Average	15151.09	39.38	91.88	32.91

Under the conditions of this study and using a payback period of 30 years as the pass/fail value to determine if the added LEED construction cost is financially justified by the monthly cost savings the Certified and Silver levels passed. It is important to note that a LEED Gold level single-family home in Northern Kentucky with an added cost around $12,000 was slightly over 30 years, with a payback period of about between 29 and 30 years.

Economic Analysis

The values used for the economic analysis consist of the average traditional and LEED Certified level home cost, and the traditional and LEED Certified level monthly utility costs. Table 18 is a comparison of varying down payment amounts and how it relates to cost savings

over the course of the 30 year mortgage period. This table shows the relationship between added initial costs versus savings over time for a LEED Certified level new construction single-family home in Spencer County.

Table 18: Thirty Year Fixed Mortgage Analysis of LEED Certified level Single-Family Homes in Spencer County, Ky**.**

Spencer County				
	15% Down (Traditional)	15 % Down (LEED Certified)	18 % Down (LEED Certified)	20 % Down (LEED Certified)
Total Home Cost	$196,750.00	$201,605.79	$201,605.79	$201,605.79
Down Payment	$29,512.50	$30,240.87	$36,289.04	$40,321.16
Mortgage Amount	$167,237.50	$171,364.92	$165,316.75	$161,284.63
Monthly Mortgage Payment	$822.71	$843.01	$813.26	$793.42
Monthly Elec. Cost	$179.76	$152.80	$152.80	$152.80
30 Yr. Mortgage Total	$296,174.87	$303,484.47	$292,773.25	$285,632.44
30 Yr. Utility Cost Total	$64,713.60	$55,008.00	$55,008.00	$55,008.00
Total 30 Yr. Cost	$390,400.97	$388,733.34	$384,070.29	$380,961.60
Net Difference (LEED vs. Traditional)		**$1,667.64**	**$6,330.68**	**$9,439.37**

Table 18 shows the direct relationship between the percentage of down payment and the net difference between the total 30 year cost of a traditional single-family home and the total 30 year cost of a LEED Certified level single-family home. A very significant finding shown in Table 15 is that under the conditions of this study, a LEED Certified level new construction single-family home in Spencer County would produce a net gain of almost $1,700.00 over the added construction cost during the course of a 30 year fixed mortgage period using 15% down payment, with a 4.25% interest rate, based solely on utility cost savings. This trend increases exponentially as the down payment percentage increase. This study reveals the circumstances under which LEED certification will have the shortest payback periods and the highest positive

gains over a fixed 30 year mortgage period. However it is important to note not all the LEED associated costs or potential gains are considered in this study. The soft costs (application and certification) fees are not considered. The potential water cost savings and municipal or federal tax credits were not considered.

Payback Period and Economic Analysis Summary

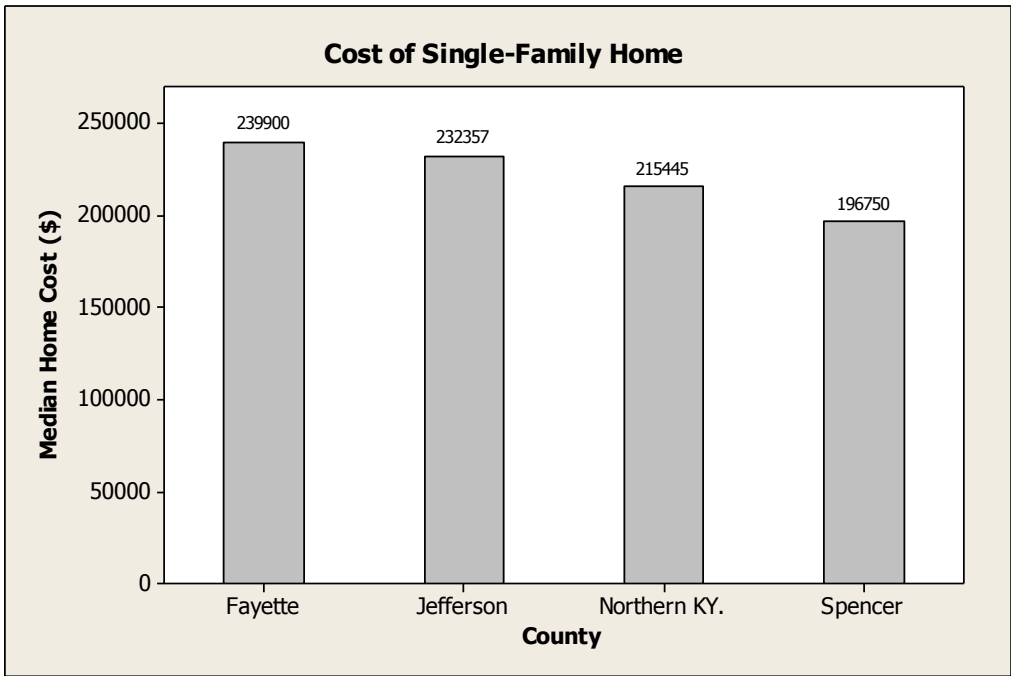

Figure 4: Median cost of a new construction single-family home in each of the four areas.

Figure 4 is a graphical representation of the median new construction home cost in the four county areas stated above. In Figure 4 it is shown that Fayette and Jefferson County have similar new construction home costs. It is also shown that Fayette County has the highest cost of new construction single-family homes and Spencer County has the lowest cost of new construction single-family homes.

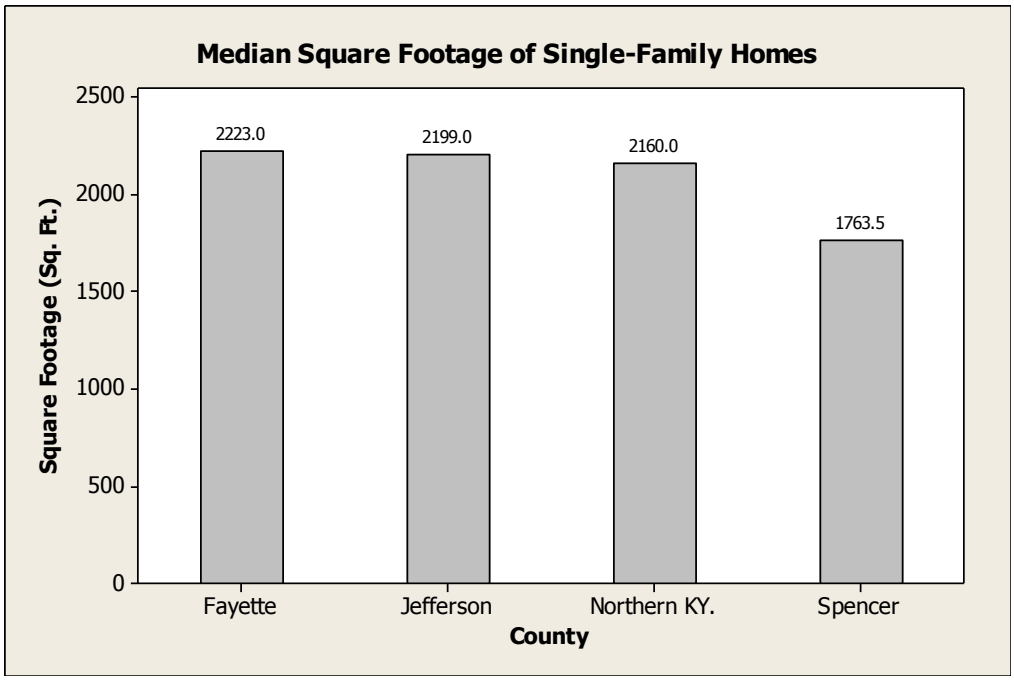

Figure 5: Median square footage of a new construction single-family home in all four counties.

Figure 5 shows the median square footage of the four areas. Figure 5 shows that Northern Kentucky was similar in square footage despite having a considerably lower median home cost. The relationship between home cost and square footage in Northern Kentucky translates to a higher cost per square foot than the other areas studied. Spencer County was the most rural area as the other three areas are more representative of metropolitan areas. The rural nature of Spencer County is most likely the cause for the lower home cost and square footage.

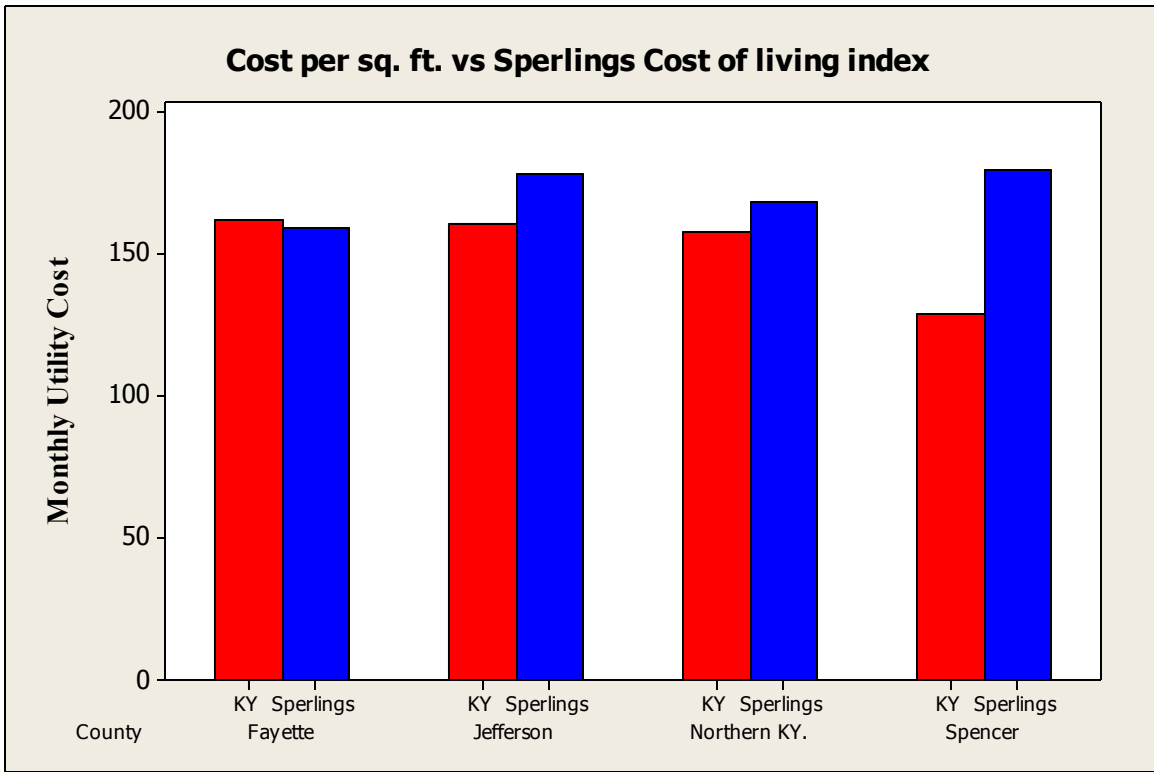

Figure 6: Comparison of methods used to estimate utility costs for each of the four counties.

Figure 6 shows the difference in monthly utility costs between the two methods that were used to estimate the monthly utility cost. The red colored bars represent the average monthly utility cost as stated retrieved from Mint.com users and their expenditures on utility cost in Kentucky between January-October 2010 and January-October 2011 accounting for 2% inflation per year. The blue colored bars represent the average national utility cost from the same source but applying the Sperling's cost of living index to the monthly utility cost. The only county to have a significant difference between the two methods was Spencer County. The reason for Spencer County's lower Kentucky utility cost was because it was based on a cost/ sq. ft. and Spencer County's median square footage was significantly less than the other three areas.

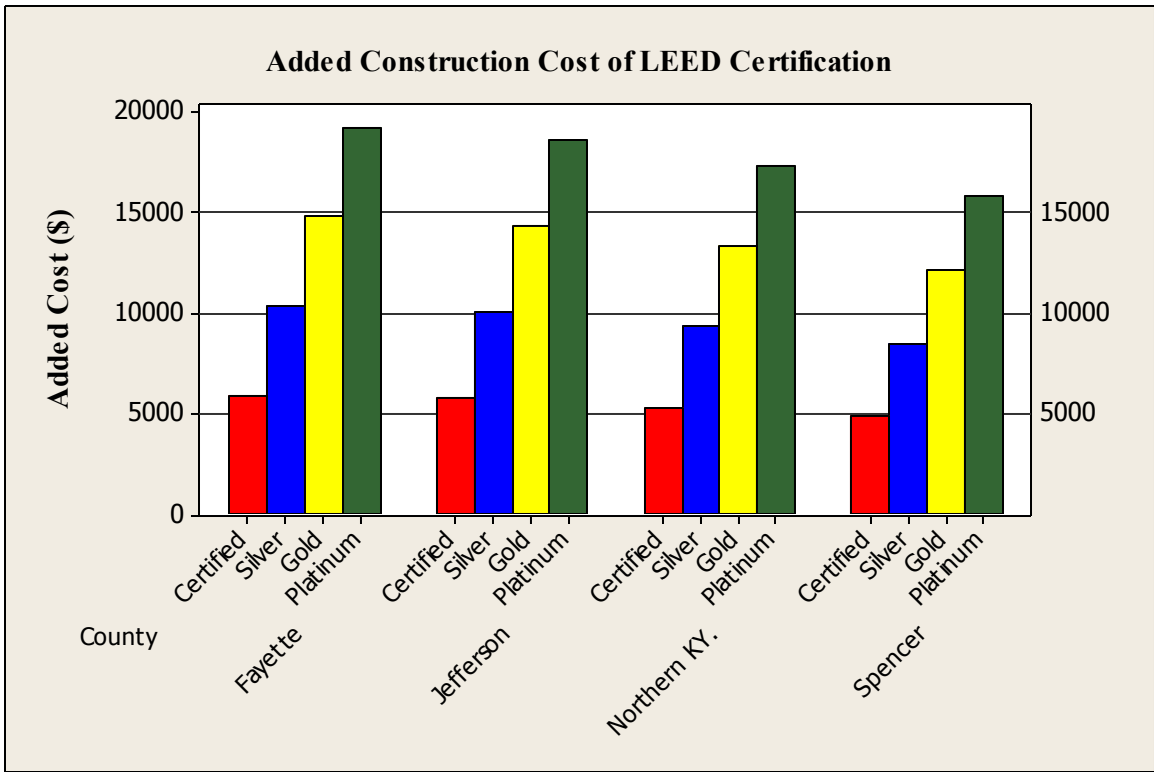

Figure 7: Comparison of the added construction cost for the four LEED levels in each county.

Figure 7 shows the added construction cost for each LEED level in each county. As stated above the added LEED cost between levels in an individual county was proportional. This is because the LEED cost for the four levels for one home was estimated using a percentage from the list price of that home. However, there is some variability in added LEED construction cost. It is important to note that based on the percentages used in this study the added construction cost for the LEED Certified level are minimal, ranging from nearly $5,000.00 to just under $6,000.00.

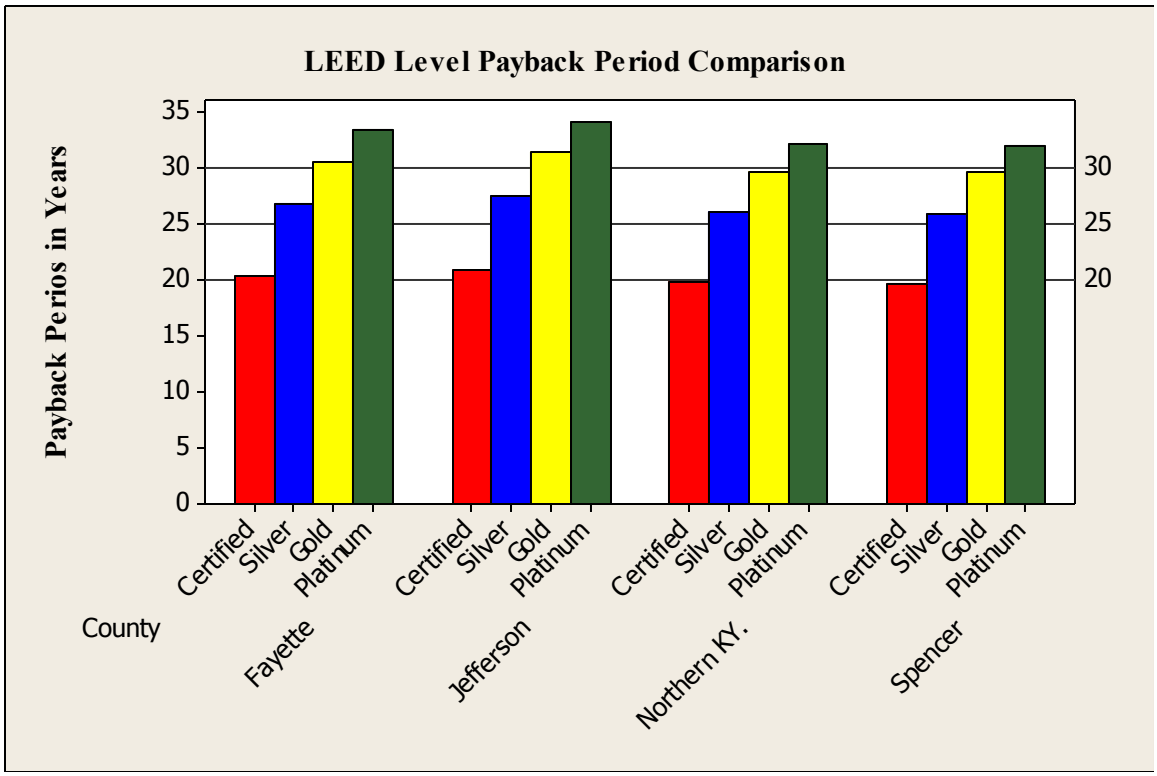

Figure 8: Comparison of the estimated payback period for the four LEED levels in each county.

Figure 8 shows the payback periods in years for each LEED level in each county. A significant finding shown in Figure 8 is that all four counties the LEED Certified level had a payback period between 19 and 21 years. The importance of this finding is that it shows the initial added construction cost associated with the LEED certification will be paid back before a typical 30 year mortgage period ends based solely on utility cost savings. Northern Kentucky and Spencer County were the only areas that a LEED Gold level home had payback period of less than 30 years. This is due to a lower median home cost and because the LEED cost was calculated using a percentage of the list price it resulted in a slightly lower added LEED cost than Fayette and Jefferson County. It is important to note that the LEED utility reduction percentages were conservative estimates and in actuality the efficiency may be greater than stated in this study. Figure 6 shows that the square footage of LEED certified home is a more

significant factor in determining the payback period than the LEED reduction in utility cost. This is evident when comparing Jefferson and Spencer County. Jefferson County had the highest monthly utility cost resulting in the greatest LEED utility cost reduction of the four counties, but Spencer County had the smallest median square footage of the four counties. As seen in Figure 8 Spencer County had the shortest payback period for all four LEED levels, although Northern Kentucky had very similar results to Spencer County. The payback period for each LEED level was very similar between all four counties used in this study. Under the conditions of this study the location of the LEED certified single-family home does not seem to be a significant factor in the payback period. However, it is important to consider the communication and multiple inspections by the green rater. The cost pertaining to proximity to these organizations was not considered in this study but could potentially be another aspect of the LEED costs in which case should be factored into the soft costs associated with LEED certification.

Table 19 shows the total 30 year cost net difference for a fixed 30 year mortgage period using a 15% down payment, with an interest rate of 4.25% for a traditional home and a LEED Certified level home in each county. The 30 year total cost is comprised of the total amount paid over the 30 year mortgage period (not including the down payment) and the total utility cost over the 30 year mortgage period.

Table 19: Total Thirty Year Cost Net Difference for Traditional vs. LEED Certified Level.

County	30 Year Total Net Difference ($)
Fayette	-1193.20
Jefferson	122.98
Northern KY.	-114.92
Spencer	1667.64

Table 19 shows that Jefferson and Spencer County produced a net gain, but Fayette County and Northern Kentucky produced a net loss over the 30 year mortgage period. Though the net gain or loss was small, especially considering it is over the course of a 30 year period, Table 19 has significance. Under the conditions of this study, the added cost of construction associated with LEED certification does not produce a significant net cost over a traditional home during a typical 30 year mortgage period. The importance of this finding is it showed that there is little difference, financially, between traditional homes compared to LEED Certified level homes.

Chapter V: Conclusion, Recommendations, and Future Research

Conclusion

Sustainable design will continue increase in acceptance and become the standard for building new construction projects, both commercial and residential. The rising cost of utilities and the increasing concern of environmental impact are the two main factors pushing the industry towards building LEED certified. This study focused on assessing LEED certified single-family homes in Kentucky and providing the general public of Kentucky with information regarding the relationship between the expected added cost of building LEED and the expected utility savings that is associated with the various LEED levels.

Kentucky's LEED certified single-family home was assessed through two rankings: one at the regional level comprised of all states that border Kentucky and the other at the national level comprised of all fifty states. At the regional level Kentucky was ranked second to last and at the national level Kentucky was ranked 32nd. It is important to note that population and the size of the state could be significant factors and were not considered in this study. Though Kentucky has a low number of LEED certified single-family homes, 90% of them LEED Gold which is significantly greater than the national LEED Gold percentage of 22%.

The added cost that is associated with building LEED certified single-family homes is one of the main concerns for the average individual in the market to build a new home. As stated in the beginning of this study the information regarding the added cost or the expected savings of LEED certification in Kentucky is not readily available to the public. This study found that the costs of the LEED Certified level to be very minimal; the average of the median values was just

under $5,500 for all four counties. The LEED level the reported the highest added cost was the LEED Platinum level in Fayette County at just over $19,000.

For individuals in the market to build a new home and considering LEED certification the payback period of the added cost mentioned above may be a deciding factor in choosing to pursue LEED certification. The payback period was calculated using the estimated monthly utility cost savings associated with each LEED level. For the purposes of this study, a 30 year payback period was used to determine if the added LEED construction cost was financially justified. A significant finding from the pay period analysis was that all the LEED Certified level single-family homes had a payback period between 19 and 21 years. Another finding was that the LEED Gold level payback periods were very close to the 30 year period, ranging from 29.5 to 31.5 years. The payback period for the LEED Platinum level was slightly longer than the Gold level by a margin of at most 4 years. It is important to note that some factors which could have significant effect on the payback period were not considered in this study. The soft costs of LEED certification were included in this study neither was the federal or municipal tax credits that may be available for LEED certification.

Finally, an economic analysis was performed using a 30 year fixed mortgage period. As most individuals need to fund their new construction home with a loan the economic analysis was performed using a standard interest rate 4.25%. The net difference between the total 30 year cost (utility cost and mortgage cost) of a traditional home and its LEED Certified counterpart was calculated. The results from the economic analysis were very significant in that the greatest net loss was only $1200.00 and the greatest net gain was $1700.00. This is significant because it shows that over the course of 30 year mortgage period the added construction cost LEED certification is essentially negligible. The economic analysis discovered other important factors

when considering building a LEED certified single-family and that is the down payment amount and mortgage interest rate.

This study has shown that individuals considering building a LEED certified single-family home under the conditions used in this study in Fayette, Jefferson, Boone, Kenton, Campbell, or Spencer County, A) The LEED Certified and Silver levels added construction cost have pay back periods less than 30 years, and B) if a 30 year fixed mortgage is used the overall added construction cost for a Certified level single-family home is very minimal.

Recommendations

There are several factors that are making it difficult for LEED certification to gain acceptance in the state of Kentucky. First, is the lack of federal and municipal tax credits that are available to LEED certified home owners. Currently there are very few of these tax credits that available in Kentucky making the only incentive to build LEED certified homes is environmental protection. The average person may not be inclined to accept the extra cost with LEED certification with the return being utility cost savings and a reduced strain on the environment. If monetary incentives existed for LEED certified homes the general public may be inclined to build LEED certified homes. Based on this study the following three recommendations were made. Second, is that there is a lack of knowledge regarding LEED certification in Kentucky. This applies to the general public and the homebuilding organizations. Based on the above mentioned factors and this study the following recommendations were made.

1. It is recommended that the legislators and policymakers of Kentucky to develop some type of state and municipal tax credits that make building LEED certified homes more financially appealing to both home owners and homebuilders. A case study of

municipal tax credits supporting LEED certification is the city of Cincinnati, OH. The tax incentive is 100% property tax abatement for 15 years for building a new construction LEED certified home (DSIRE.org 2013). As stated previously in this study Ohio has a total of 318 LEED certified single-family homes and 49% of those homes are in Cincinnati (USGBC 2014).

2. It is suggested that the banking industry provide lower interest rates on mortgage loans to those building LEED certified homes. As shown in the 30 year mortgage analysis portion of this study, a traditional home and LEED Certified level home using a an identical down payment and interest rate had very minimal difference in total cost between the two homes. A lower interest rate given to those building a LEED Certified home would directly aid in offsetting the added soft and construction costs of building LEED certified homes in Kentucky.
3. It is recommended that an increased partnership between USGBC and the homebuilding organizations exist in Kentucky. The education of the general public is a crucial factor in the acceptance of the LEED program but ultimately it the homebuilding organization that are responsible for the actual construction. Educating the construction companies on the LEED program is essential as they are in direct contact with the individuals building new homes putting them in the best position to promote the LEED program. The training of homebuilding employees and sub-contractors in LEED processes and procedures is equally as important as promoting the LEED program. As stated by the USGBC Director of Residential Business Development the experience of the contractors and sub-contractors represents the most significant variable in the cost of building a LEED certified home. The learning

curve for the inexperienced homebuilders to build a home to LEED standards adds to the overhead cost of the organization. Educating and providing training sessions for Kentucky homebuilders would directly reduce this overhead cost of building LEED certified residential projects in Kentucky. This could be achieved in a variety of ways starting with the education of the homebuilding organizations on LEED and providing these organizations with readily available information to distribute to their clients as needed. Training sessions could be held on a volunteer basis to start increasing the number of homebuilders, contractors, and sub-contractors that are familiar with the LEED program and procedures.

Future Research

This study could be a foundation for future works to use and continue to build upon. Currently the available data pertaining to LEED certified single-family homes in Kentucky is extremely limited. Though this study relied heavily on estimations the frame work created can be easily modified to incorporate more accurate data, replacing the estimated figures with real LEED data. This study focused on the state of Kentucky but the frame work can be easily applied other areas as well. As part of future research, a comparison using this same method in other states or counties and comparing the results would give insight the effect the geographical location has on the payback periods and economic analysis. The method presented in this study can also be used on the individual basis for those building a new construction home. Using this method, an individual would be able to analyze the benefits of pursuing LEED certification in the desired area based on local utility costs and typical new construction home costs.

More research is needed into finding a methodology for calculating the average utility cost and the reduction of the utility cost of LEED certified homes. The utility cost savings is one

of the main factors in calculating the financial justification of LEED certified single-family homes. The calculation of the average utility cost was the most challenging aspect in this study revolving around the proportion of electricity to natural gas usage. Some areas rely more heavily on natural gas for heating and vice versa. The future research should focus on this issue, and how to relate the average utility cost to localized areas. Though there are numerous social and environmental benefits to building LEED the cost is the main concern for the average person. Researching the best method to calculate an area's utility costs and the reduction of that cost due to LEED certification is essential to acceptance of LEED in Kentucky.

Thirdly future research is needed into the acceptance level by the general public and the homebuilders in Kentucky of LEED certified homes, and what factors would make pursuing LEED certification more attractive. For potential home occupants, incentives such as lower interest rate on mortgage, municipal utility tax credits, or federal tax credits. The homebuilders could be more interested in incentives such as federal tax credits, federal funding, or financial assistance from the USGBC itself. If the legislatures and policy makers were made aware that the idea of the LEED program is accepted by the public, but the current incentives in place are hindering the building of LEED projects, they may be more inclined to develop new tax incentives. A survey of individuals looking to buy or build a new home in Kentucky and asking opinions about LEED certification and what types of incentives would make pursuing LEED certification more appealing would show what types of incentives would be needed, specific to Kentucky, to increase the number of LEED certified homes. Similarly, a survey of the homebuilding organizations in Kentucky would give insight into the approval of LEED by the organizations that are building the homes. This type of survey could reveal the kinds of

incentives or assistance needed for the homebuilders to be more inclined to build LEED certified residential projects.

Research into the added resale value of a home due to LEED certification would complement the research into utility savings. Showing the residents of Kentucky that not only will a LEED certified home reduce the monthly utility costs, but the LEED certified home could have a higher resale value. Research into the added resale value associated with LEED certified homes has been done in other states. As mentioned previously, a study conducted by (Kok and Kahn 2012) reported that green labels, including LEED, added a 9% price premium to resale value of the home. Research into the possible added resale premium of LEED certification and other green labels in Kentucky has not yet been done.

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Appendix

Appendix A: 2012 Kentucky Energy Profile

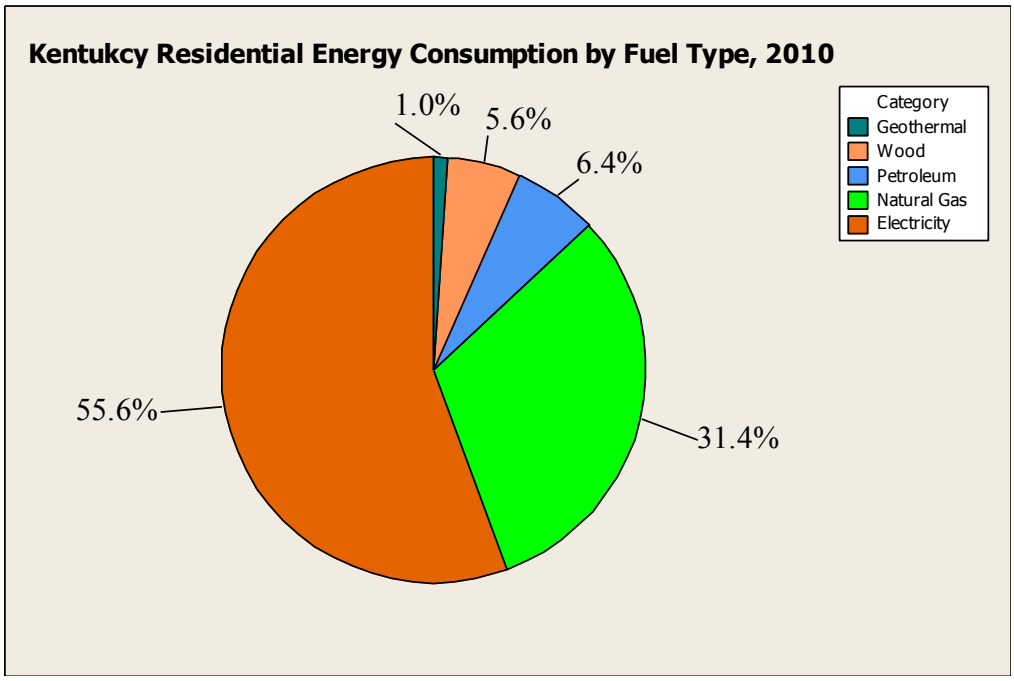

Figure 9: Kentucky residential energy consumption by fuel type in 2010, Consumption fuel type percentage (Kentucky Energy Database, EEC-DEDI, 2012).

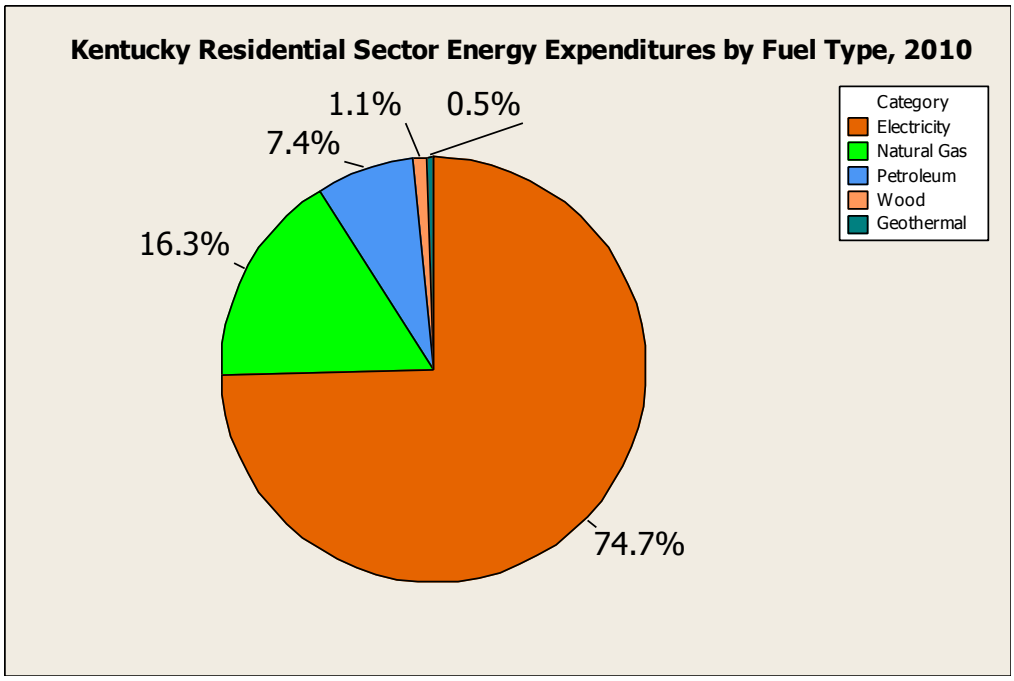

Figure 10: Kentucky residential sector energy expenditures by fuel type in 2010, Expenditures by fuel type percentage (Kentucky Energy Database, EEC-DEDI, 2012).

Table 20: Kentucky residential sector energy consumption and expenditures data by fuel type in 2010, by fuel type percentage (Kentucky Energy Database, EEC-DEDI, 2012**).**

Fuel Type	Billion BTU	Percentage	Million ($ US)	Percentage
Total Net	178972	100	3357	100
Electricity	99414	56	2497	74
Natural Gas	56060	31	545	16
Petroleum	11488	6	249	7
Wood	9967	6	37	1
Geothermal	1790	1	16	<1

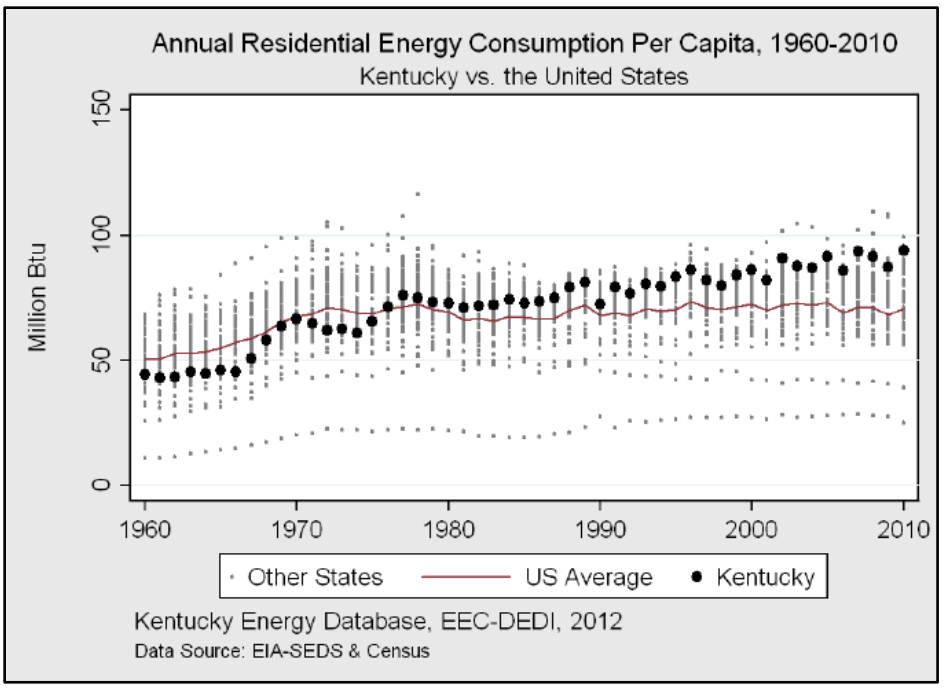

Figure 11: Annul residential energy consumption per capita from 1960 to 2010, Kentucky vs. the United States.

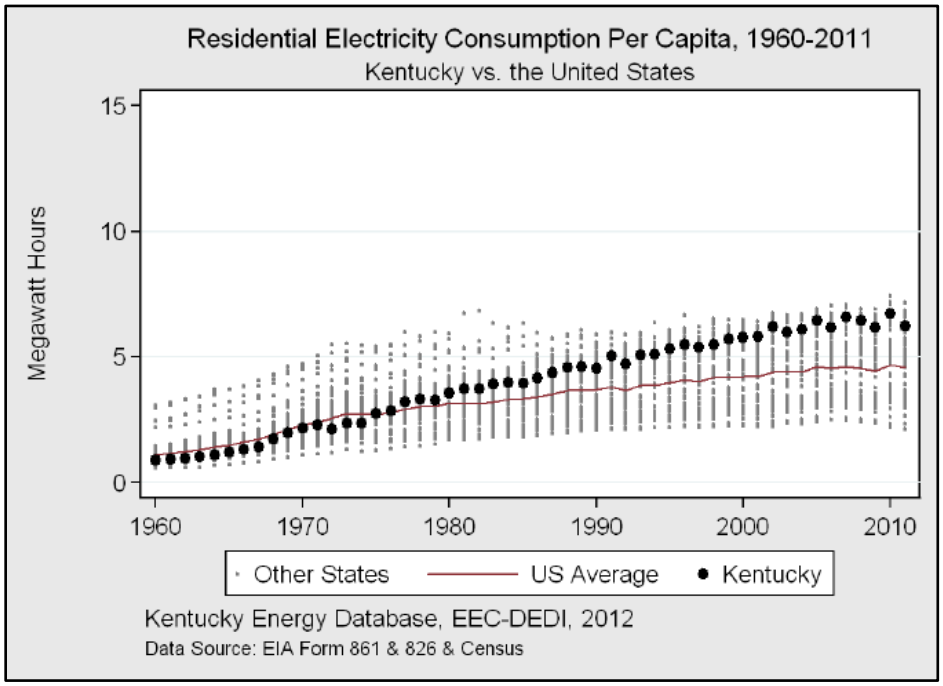

Figure 12: Residential electricity consumption per capita from 1960 to 2011, Kentucky vs. the United States.

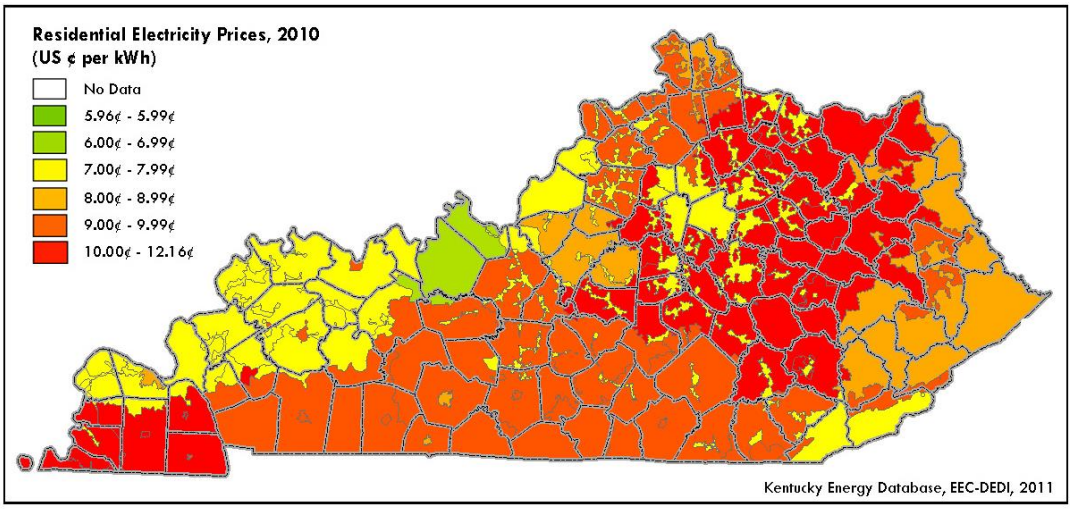

Figure 13: Kentucky average residential electricity prices, 2010 in US cents per kWh (Kentucky Energy Database, EEC-DEDI, 2011).

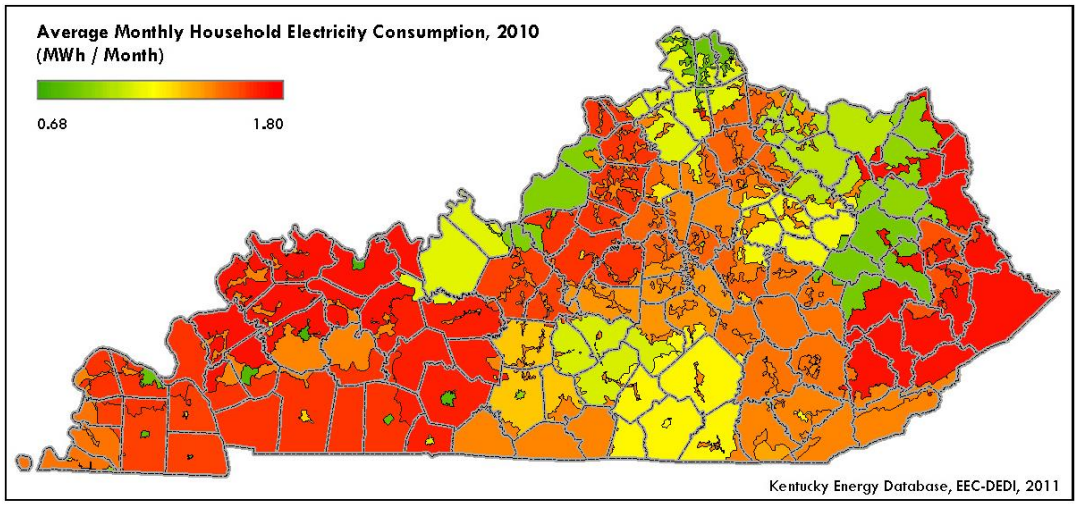

Figure 14: Average monthly household electricity consumption, 2010 in MWh per Month (Kentucky Energy Database, EEC-DEDI, 2011**).**

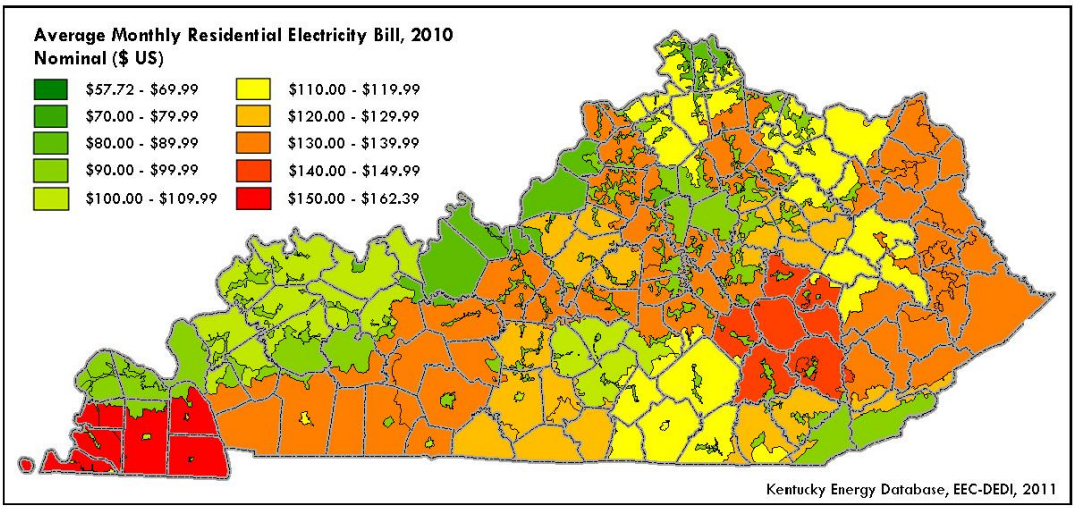

Figure 15: Average monthly residential electricity bill, 2010 in US dollars (Kentucky Energy Database EEC-DEDI, 2011).

Appendix B: LEED for Homes credit list and point values

1. Location and linkages – 10 points possible

    Site Selection – 2 points
    Preferred locations – up to 3 points
    Infrastructure – 1 point
    Community resources/transit – up to 3 points
    Access to open space – 1 point

2. Sustainable Sites – 22 points possible

    Site stewardship – 1 point
    Landscaping – up to 7 points
    Local heat island effect – 1 point
    Surface water management – up to 7 points
    Nontoxic pest control – up to 2 points
    Compact development – up to 4 points

3. Water efficiency – 18 points possible

    Water reuse – up to 5 points
    Irrigation system – up to 4 points
    Indoor water use – up to 9 points

4. Energy and Atmosphere – 55 points possible

    Optimize energy performance – up to 34 points
    Insulation – 2 points
    Air infiltration – up to 3 points
    Windows – up to 3 points
    Heating and cooling distribution system – up to 3 points
    Space heating and cooling equipment – up to 4 points
    Water heating – up to 6 points

5. Materials and Resources – 16 points possible

    Material efficient framing – up to 5 points
    Environmentally preferable products – up to 8 points
    Waste management – up to 3 points

6. Indoor Air Quality – 26 points possible

    EPA indoor airPLUS – 13 points
    Combustion venting – up to 2 points
    Moisture control – 1 point
    Outdoor air ventilation – up to 3 points
    Local exhaust – up to 2 points

Distribution of space heating and cooling – up to 3 points
Air filtering – up to 2 points

7. Innovation – 11 points possible

   Integrated project planning – up to 4 points
   Durability management process – 3 points
   Innovative or regional design – up to 4 points

8. Awareness and Education – 3 points possible

   Education of the homeowner or tenant – up to 2 points
   Education of building manager – 1 point

Appendix C: NAHB Single-Family Price and Costs Breakdowns 2013 Results

Table 21: Breakdown of Construction Cost for New Construction Homes, 2013 (Taylor 2014).

I. Sale Price Breakdown	Average ($)	Share of Price (%)
A. Finished Lot Cost (including financing cost)	74509	18.65
B. Total Construction Cost	246453	61.69
C. Financing Cost	5479	1.37
D. Overhead and General Expenses	17340	4.34
E. Marketing Cost	4260	1.07
F. Sales Commission	14235	3.56
G. Profit	37255	9.32
Total Sales	**399532**	**100.00**
II. Construction Cost Breakdown	**Average ($)**	**Share of Construction Cost (%)**
I. Site Work (sum of A to E)	**16824**	**6.83**
A. Building Permit Fees	3647	1.48
B. Impact Fee	3312	1.34
C. Water & Sewer Fees Inspections	4346	1.76
D. Architecture, Engineering	3721	1.51
E. Other	1799	0.73
II. Foundations (sum of F to G)	**23401**	**9.50**
Excavation, Foundation, Concrete, Retaining walls, and Backfill	23208	9.42
G. Other	373	0.15
III. Framing (sum of H to L)	**47035**	**19.08**
H. Framing (including roof)	36438	14.78
I Trusses (if not included above)	54621	22.16
J. Sheeting (if not included above)	2332	0.95
K. General Metal, Steel	1604	0.65
L. Other	1201	0.49
IV. Exterior Finishes (sum of M to P)	**35474**	**14.39**
M. Exterior Wall Finish	16876	6.85
N. Roofing	7932	3.22
O. Windows, Doors (including garage door)	10117	4.11
P. Other	557	0.23
V. Major Systems Rough-ins (sum of Q to T)	**32959**	**13.37**
Q. Plumbing (except fixtures)	11823	4.80
R. Electrical (expect fixtures)	9967	4.04
S. HVAC	10980	4.46

T. Other	189	0.08
VI. Interior Finishes (sum of U to AE)	**72241**	**29.31**
U. Insulation	4786	1.94
V. Drywall	9376	3.80
W. Interior	10536	4.28
X. Painting	8355	3.39
Y. Lighting	3008	1.22
Z. Cabinets, Countertops	12785	5.19
AA. Appliances	4189	1.70
AB. Flooring	12378	5.02
AC. Plumbing Fixtures	4265	1.73
AD. Fireplace	2057	0.83
AE. Other	506	0.21
VII. Final Steps (sum of AF to AJ)	**16254**	**6.60**
AF. Landscaping	5744	2.33
AG. Outdoor Structures (deck, patio, porches)	2891	1.17
AH. Driveway	3741	1.52
AI. Clean UP	2261	0.92
AJ. Other	1617	0.66
VIII. Other	**2265**	**0.92**
Total	**246453**	**100.0**

Appendix D: Total LEED Certified Single-Family Homes Ranking by State

Table 22: State Ranking of Total Number of LEED Certified Single-Family Homes (data source: USGBC LEED for Homes Certified Project List 2014).

Rank	State	Number of LEED Homes
1	TX	2079
2	CA	972
3	NC	839
4	NM	839
5	MS	767
6	LA	518
7	HI	459
8	FL	437
9	NY	369
10	PA	346
11	OH	318
12	MI	294
13	TN	274
14	SC	265
15	MA	248
16	AZ	236
17	GA	227
18	VA	227
19	CO	223
20	WA	216
21	OR	173
22	CT	167
23	IN	167
24	NJ	139
25	AK	129
26	OK	122
27	MN	85
28	NV	79
29	IL	73
30	MO	73
31	ID	70
32	**KY**	**55**

33	NH	44
34	ME	38
35	MD	36
36	UT	36
37	WY	36
38	AR	32
39	KS	29
40	AL	25
41	MT	24
42	WI	24
43	VT	20
44	DE	11
45	RI	8
46	WV	4
47	IA	3
48	NE	3
49	SD	2
50	ND	0

Appendix E: Data Tables for Payback Period Analysis

Fayette County

Table 23: Data Table of LEED Certified Level Calculated Values for Fayette County, KY.

LEED Certified				
	Added Cost ($)	Utility Reduction (15%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	4911.32	15.81	89.60	25.88
	3948.80	15.00	85.01	21.94
	3948.80	14.24	80.67	23.12
	5165.52	17.54	99.40	24.54
	4439.93	14.91	84.51	24.81
	4193.13	14.91	84.51	23.43
	4956.90	22.08	125.09	18.71
	5427.13	26.84	152.08	16.85
	3946.33	19.71	111.69	16.68
	3543.01	12.43	70.43	23.76
	5158.12	22.84	129.44	18.82
	4960.68	24.53	138.99	16.85
	5353.09	26.98	152.89	16.53
	5047.06	20.02	113.43	21.01
	4933.53	22.08	125.09	18.62
	4800.26	18.89	107.04	21.18
	6068.81	24.56	139.18	20.59
	4316.53	22.62	128.20	15.90
	4021.61	18.88	106.97	17.75
	4096.88	18.91	107.16	18.05
Median	**4855.79**	**19.31**	**109.43**	**19.70**
Average	**4661.87**	**19.69**	**111.57**	**20.25**

Table 24: Data Table of LEED Silver Level Calculated Values for Fayette County, KY.

LEED Silver				
	Added Cost ($)	Utility Reduction (20%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	8594.81	21.08	84.33	33.97
	6910.40	20.00	80.01	28.79
	6910.40	18.98	75.92	30.34
	9039.67	23.39	93.56	32.21
	7769.88	19.89	79.54	32.56
	7337.98	19.89	79.54	30.75
	8674.58	29.43	117.73	24.56
	9497.48	35.78	143.14	22.12
	6906.08	26.28	105.12	21.90
	6200.27	16.57	66.28	31.18
	9026.71	30.46	121.82	24.70
	8681.19	32.70	130.82	22.12
	9367.91	35.97	143.90	21.70
	8832.36	26.69	106.76	27.58
	8633.68	29.43	117.73	24.44
	8400.46	25.19	100.74	27.80
	10620.42	32.75	130.99	27.03
	7553.93	30.16	120.65	20.87
	7037.81	25.17	100.68	23.30
	7169.54	25.21	100.86	23.70
Median	**8497.63**	**25.75**	**102.99**	**25.86**
Average	**8158.28**	**26.25**	**105.01**	**26.58**

Table 25: Data Table of LEED Gold Level Calculated Values for Fayette County, KY.

LEED Gold				
	Added Cost ($)	Utility Reduction (25%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	12278.30	26.35	79.06	38.83
	9872.00	25.00	75.01	32.90
	9872.00	23.73	71.18	34.68
	12913.81	29.24	87.71	36.81
	11099.83	24.86	74.57	37.21
	10482.83	24.86	74.57	35.14
	12392.26	36.79	110.38	28.07
	13567.83	44.73	134.19	25.28
	9865.83	32.85	98.55	25.03
	8857.53	20.71	62.14	35.63
	12895.30	38.07	114.21	28.23
	12401.70	40.88	122.64	25.28
	13382.73	44.97	134.90	24.80
	12617.65	33.36	100.08	31.52
	12333.83	36.79	110.38	27.94
	12000.65	31.48	94.44	31.77
	15172.03	40.93	122.80	30.89
	10791.33	37.70	113.11	23.85
	10054.02	31.46	94.39	26.63
	10242.20	31.52	94.55	27.08
Median	**12139.48**	**32.18**	**96.55**	**29.56**
Average	**11654.68**	**32.81**	**98.44**	**30.38**

Table 26: Data Table of LEED Platinum Level Calculated Values for Fayette County, KY.

LEED Platinum				
	Added Cost ($)	Utility Reduction (30%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	15961.79	31.62	73.79	42.06
	12833.60	30.00	70.01	35.65
	12833.60	28.47	66.43	37.56
	16787.95	35.08	81.86	39.88
	14429.78	29.83	69.60	40.31
	13627.68	29.83	69.60	38.07
	16109.94	44.15	103.02	30.41
	17638.18	53.68	125.25	27.38
	12825.58	39.42	91.98	27.11
	11514.79	24.86	58.00	38.60
	16763.89	45.68	106.59	30.58
	16122.21	49.06	114.46	27.39
	17397.55	53.96	125.91	26.87
	16402.95	40.03	93.41	34.14
	16033.98	44.15	103.02	30.26
	15600.85	37.78	88.15	34.41
	19723.64	49.12	114.62	33.46
	14028.73	45.25	105.57	25.84
	13070.22	37.76	88.10	28.85
	13314.86	37.82	88.25	29.34
Median	**15781.32**	**38.62**	**90.11**	**32.02**
Average	**15151.09**	**39.38**	**91.88**	**32.91**

Jefferson County

Table 27: Data Table of LEED Certified Level Calculated Values for Jefferson County, KY.

LEED Certified				
	Added Cost ($)	Utility Reduction (15%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	4649.71	25.90	146.75	14.96
	4870.70	22.10	125.22	18.37
	4879.14	24.09	136.51	16.88
	5081.61	20.65	117.03	20.51
	5133.44	24.07	136.39	17.77
	5182.80	22.84	129.44	18.91
	5377.77	23.01	130.37	19.48
	5401.71	21.46	121.62	20.97
	5504.65	20.65	117.03	22.21
	5550.53	23.43	132.79	19.74
	5769.32	23.01	130.37	20.90
	5920.73	22.01	124.72	22.42
	6281.06	24.32	137.81	21.52
	7542.21	29.73	168.47	21.14
	3455.20	30.33	171.88	9.49
	5871.37	20.37	115.41	24.02
	5699.80	32.82	185.96	14.47
	7542.21	29.73	168.47	21.14
	8035.49	32.82	185.96	20.40
	9593.02	31.98	181.25	24.99
	9869.53	26.89	152.39	30.58
	5920.73	20.76	117.65	23.77
	5215.62	25.19	142.72	17.26
	8638.00	25.10	142.22	28.68
	7401.53	24.44	138.50	25.24
	5793.75	23.00	130.31	21.00
Median	**5734.56**	**24.08**	**136.45**	**20.94**
Average	**6160.83**	**25.03**	**141.82**	**20.65**

Table 28: Data Table of LEED Silver Level Calculated Values for Jefferson County, KY.

LEED Silver				
	Added Cost ($)	Utility Reduction (20%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	8137.00	34.53	138.12	19.64
	8523.72	29.46	117.85	24.11
	8538.49	32.12	128.48	22.15
	8892.82	27.54	110.14	26.91
	8983.52	32.09	128.36	23.33
	9069.90	30.46	121.82	24.82
	9411.10	30.67	122.70	25.57
	9453.00	28.62	114.46	27.53
	9633.14	27.54	110.14	29.15
	9713.43	31.24	124.98	25.91
	10096.31	30.67	122.70	27.43
	10361.28	29.35	117.38	29.42
	10991.86	32.43	129.71	28.25
	13198.86	39.64	158.56	27.75
	6046.60	40.44	161.77	12.46
	10274.90	27.16	108.62	31.53
	9974.64	43.76	175.02	19.00
	13198.86	39.64	158.56	27.75
	14062.10	43.76	175.02	26.78
	16787.78	42.65	170.59	32.80
	17271.68	35.86	143.43	40.14
	10361.28	27.68	110.73	31.19
	9127.34	33.58	134.32	22.65
	15116.50	33.46	133.85	37.64
	12952.68	32.59	130.35	33.12
	10139.07	30.66	122.64	27.56
Median	**10035.48**	**32.11**	**128.42**	**27.48**
Average	**10781.46**	**33.37**	**133.47**	**27.10**

Table 29: Data Table of LEED Gold Level Calculated Values for Jefferson County, KY.

LEED Gold				
	Added Cost ($)	Utility Reduction (25%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	11624.28	43.16	129.48	22.44
	12176.74	36.83	110.49	27.55
	12197.84	40.15	120.45	25.32
	12704.03	34.42	103.26	30.76
	12833.60	40.11	120.34	26.66
	12957.00	38.07	114.21	28.36
	13444.43	38.34	115.03	29.22
	13504.28	35.77	107.31	31.46
	13761.63	34.42	103.26	33.32
	13876.33	39.06	117.17	29.61
	14423.30	38.34	115.03	31.35
	14801.83	36.68	110.05	33.63
	15702.65	40.53	121.60	32.28
	18855.52	49.55	148.65	31.71
	8638.00	50.55	151.66	14.24
	14678.43	33.95	101.84	36.03
	14249.49	54.70	164.09	21.71
	18855.52	49.55	148.65	31.71
	20088.72	54.70	164.09	30.61
	23982.54	53.31	159.92	37.49
	24673.83	44.82	134.47	45.87
	14801.83	34.60	103.81	35.65
	13039.06	41.98	125.93	25.89
	21595.00	41.83	125.49	43.02
	18503.83	40.73	122.20	37.86
	14484.38	38.33	114.98	31.49
Median	**14336.40**	**40.13**	**120.40**	**31.40**
Average	**15402.08**	**41.71**	**125.13**	**30.97**

Table 30: Data Table of LEED Platinum Level Calculated Values for Jefferson County, KY.

LEED Platinum				
	Added Cost ($)	Utility Reduction (30%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	15111.56	51.79	120.85	24.31
	15829.76	44.19	103.12	29.85
	15857.20	48.18	112.42	27.43
	16515.24	41.30	96.37	33.32
	16683.68	48.14	112.32	28.88
	16844.10	45.68	106.59	30.73
	17477.76	46.01	107.36	31.65
	17555.56	42.92	100.16	34.08
	17890.12	41.30	96.37	36.09
	18039.23	46.87	109.35	32.08
	18750.29	46.01	107.36	33.96
	19242.38	44.02	102.71	36.43
	20413.45	48.64	113.49	34.97
	24512.18	59.46	138.74	34.35
	11229.40	60.66	141.55	15.43
	19081.96	40.73	95.05	39.04
	18524.34	65.63	153.15	23.52
	24512.18	59.46	138.74	34.35
	26115.33	65.63	153.15	33.16
	31177.31	63.97	149.26	40.61
	32075.98	53.79	125.50	49.70
	19242.38	41.52	96.89	38.62
	16950.78	50.37	117.53	28.04
	28073.50	50.19	117.12	46.61
	24054.98	48.88	114.06	41.01
	18829.70	45.99	107.31	34.12
Median	**18637.31**	**48.16**	**112.37**	**34.02**
Average	**20022.71**	**50.05**	**116.79**	**33.55**

Northern Kentucky

Table 31: Data Table of LEED Certified Level Calculated Values for Northern KY.

LEED Certified				
	Added Cost ($)	Utility Reduction (15%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	4467.08	24.09	136.51	15.45274664
	4489.292	23.53155	133.34545	15.89813109
	5083.8332	23.652	134.028	17.91192147
	5550.532	25.80915	146.25185	17.92171898
	5550.532	25.89675	146.74825	17.86109583
	5681.2126	24.05715	136.32385	19.67957066
	6488.372	25.91865	146.87235	20.86133601
	4812.3532	24.09	136.51	16.64713297
	4911.32	19.0311	107.8429	21.5056758
	4738.56	19.43625	110.13875	20.31667631
	4686.732	19.06395	108.02905	20.48688755
	5797.332	25.80915	146.25185	18.71859399
	7278.132	30.3972	172.2508	19.9528575
	4911.32	21.14445	119.81855	19.35622192
	6488.372	25.91865	146.87235	20.86133601
	4516.1932	20.61885	116.84015	18.25268787
	4738.56	18.77925	106.41575	21.02746382
	5824.2332	23.652	134.028	20.52058036
	5630.27308	20.42175	115.72325	22.97498615
	5920.732	23.04975	130.61525	21.40562624
Median	**5317.1826**	**23.652**	**134.028**	**19.81621408**
Average	**5378.24832**	**23.21838**	**131.57082**	**19.38066236**

Table 32: Data Table of LEED Silver Level Calculated Values for Northern KY.

LEED Silver				
	Added Cost ($)	Utility Reduction (20%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	7817.39	32.12	128.48	20.28
	7856.26	31.38	125.50	20.87
	8896.71	31.54	126.14	23.51
	9713.43	34.41	137.65	23.52
	9713.43	34.53	138.12	23.44
	9942.12	32.08	128.30	25.83
	11354.65	34.56	138.23	27.38
	8421.62	32.12	128.48	21.85
	8594.81	25.37	101.50	28.23
	8292.48	25.92	103.66	26.67
	8201.78	25.42	101.67	26.89
	10145.33	34.41	137.65	24.57
	12736.73	40.53	162.12	26.19
	8594.81	28.19	112.77	25.41
	11354.65	34.56	138.23	27.38
	7903.34	27.49	109.97	23.96
	8292.48	25.04	100.16	27.60
	10192.41	31.54	126.14	26.93
	9852.98	27.23	108.92	30.15
	10361.28	30.73	122.93	28.09
Median	**9305.07**	**31.54**	**126.14**	**26.01**
Average	**9411.93**	**30.96**	**123.83**	**25.44**

Table 33: Data Table of LEED Gold Level Calculated Values for Northern KY.

LEED Gold				
	Added Cost ($)	Utility Reduction (25%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	11167.70	40.15	120.45	23.18
	11223.23	39.22	117.66	23.85
	12709.58	39.42	118.26	26.87
	13876.33	43.02	129.05	26.88
	13876.33	43.16	129.48	26.79
	14203.03	40.10	120.29	29.52
	16220.93	43.20	129.59	31.29
	12030.88	40.15	120.45	24.97
	12278.30	31.72	95.16	32.26
	11846.40	32.39	97.18	30.48
	11716.83	31.77	95.32	30.73
	14493.33	43.02	129.05	28.08
	18195.33	50.66	151.99	29.93
	12278.30	35.24	105.72	29.03
	16220.93	43.20	129.59	31.29
	11290.48	34.36	103.09	27.38
	11846.40	31.30	93.90	31.54
	14560.58	39.42	118.26	30.78
	14075.68	34.04	102.11	34.46
	14801.83	38.42	115.25	32.11
Median	**13292.96**	**39.42**	**118.26**	**29.72**
Average	**13445.62**	**38.70**	**116.09**	**29.07**

Table 34: Data Table of LEED Platinum Level Calculated Values for Northern KY.

LEED Platinum				
	Added Cost ($)	Utility Reduction (30%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	14518.01	48.18	112.42	25.11
	14590.20	47.06	109.81	25.83
	16522.46	47.30	110.38	29.11
	18039.23	51.62	120.44	29.12
	18039.23	51.79	120.85	29.02
	18463.94	48.11	112.27	31.98
	21087.21	51.84	120.95	33.90
	15640.15	48.18	112.42	27.05
	15961.79	38.06	88.81	34.95
	15400.32	38.87	90.70	33.01
	15231.88	38.13	88.97	33.29
	18841.33	51.62	120.44	30.42
	23653.93	60.79	141.85	32.42
	15961.79	42.29	98.67	31.45
	21087.21	51.84	120.95	33.90
	14677.63	41.24	96.22	29.66
	15400.32	37.56	87.64	34.17
	18928.76	47.30	110.38	33.35
	18298.39	40.84	95.30	37.33
	19242.38	46.10	107.57	34.78
Median	**17280.84**	**47.30**	**110.38**	**32.20**
Average	**17479.31**	**46.44**	**108.35**	**31.49**

Spencer County

Table 35: Data Table of LEED Certified Level Calculated Values for Spencer County, KY.

LEED Certified				
	Added Cost ($)	Utility Reduction (15%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	4911.32	15.81	89.60	25.88
	3948.80	15.00	85.01	21.94
	3948.80	14.24	80.67	23.12
	5165.52	17.54	99.40	24.54
	4439.93	14.91	84.51	24.81
	4193.13	14.91	84.51	23.43
	4956.90	22.08	125.09	18.71
	5427.13	26.84	152.08	16.85
	3946.33	19.71	111.69	16.68
	3543.01	12.43	70.43	23.76
	5158.12	22.84	129.44	18.82
	4960.68	24.53	138.99	16.85
	5353.09	26.98	152.89	16.53
	5047.06	20.02	113.43	21.01
	4933.53	22.08	125.09	18.62
	4800.26	18.89	107.04	21.18
	6068.81	24.56	139.18	20.59
	4316.53	22.62	128.20	15.90
	4021.61	18.88	106.97	17.75
	4096.88	18.91	107.16	18.05
Median	**4855.79**	**19.31**	**109.43**	**19.70**
Average	**4661.87**	**19.69**	**111.57**	**20.25**

Table 36: Data Table of LEED Gold Level Calculated Values for Spencer County, KY.

LEED Silver				
	Added Cost ($)	Utility Reduction (20%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	8594.81	21.08	84.33	33.97
	6910.40	20.00	80.01	28.79
	6910.40	18.98	75.92	30.34
	9039.67	23.39	93.56	32.21
	7769.88	19.89	79.54	32.56
	7337.98	19.89	79.54	30.75
	8674.58	29.43	117.73	24.56
	9497.48	35.78	143.14	22.12
	6906.08	26.28	105.12	21.90
	6200.27	16.57	66.28	31.18
	9026.71	30.46	121.82	24.70
	8681.19	32.70	130.82	22.12
	9367.91	35.97	143.90	21.70
	8832.36	26.69	106.76	27.58
	8633.68	29.43	117.73	24.44
	8400.46	25.19	100.74	27.80
	10620.42	32.75	130.99	27.03
	7553.93	30.16	120.65	20.87
	7037.81	25.17	100.68	23.30
	7169.54	25.21	100.86	23.70
Median	**8497.63**	**25.75**	**102.99**	**25.86**
Average	**8158.28**	**26.25**	**105.01**	**26.58**

Table 37: Data Table of LEED Gold Level Calculated Values for Spencer County, KY.

LEED Gold				
	Added Cost ($)	Utility Reduction (25%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	12278.30	26.35	79.06	38.83
	9872.00	25.00	75.01	32.90
	9872.00	23.73	71.18	34.68
	12913.81	29.24	87.71	36.81
	11099.83	24.86	74.57	37.21
	10482.83	24.86	74.57	35.14
	12392.26	36.79	110.38	28.07
	13567.83	44.73	134.19	25.28
	9865.83	32.85	98.55	25.03
	8857.53	20.71	62.14	35.63
	12895.30	38.07	114.21	28.23
	12401.70	40.88	122.64	25.28
	13382.73	44.97	134.90	24.80
	12617.65	33.36	100.08	31.52
	12333.83	36.79	110.38	27.94
	12000.65	31.48	94.44	31.77
	15172.03	40.93	122.80	30.89
	10791.33	37.70	113.11	23.85
	10054.02	31.46	94.39	26.63
	10242.20	31.52	94.55	27.08
Median	**12139.48**	**32.18**	**96.55**	**29.56**
Average	**11654.68**	**32.81**	**98.44**	**30.38**

Table 38: Data Table of LEED Platinum Level Calculated Values for Spencer County, KY.

LEED Platinum				
	Added Cost ($)	Utility Reduction (30%)	Monthly Utility Cost ($)	Simple Breakeven Point (yrs.)
	15961.79	31.62	73.79	42.06
	12833.60	30.00	70.01	35.65
	12833.60	28.47	66.43	37.56
	16787.95	35.08	81.86	39.88
	14429.78	29.83	69.60	40.31
	13627.68	29.83	69.60	38.07
	16109.94	44.15	103.02	30.41
	17638.18	53.68	125.25	27.38
	12825.58	39.42	91.98	27.11
	11514.79	24.86	58.00	38.60
	16763.89	45.68	106.59	30.58
	16122.21	49.06	114.46	27.39
	17397.55	53.96	125.91	26.87
	16402.95	40.03	93.41	34.14
	16033.98	44.15	103.02	30.26
	15600.85	37.78	88.15	34.41
	19723.64	49.12	114.62	33.46
	14028.73	45.25	105.57	25.84
	13070.22	37.76	88.10	28.85
	13314.86	37.82	88.25	29.34
Median	**15781.32**	**38.62**	**90.11**	**32.02**
Average	**15151.09**	**39.38**	**91.88**	**32.91**