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Determining a Community Retrofit Strategy for the Aging Housing Stock Using Utility and Assessor Data

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DETERMINING A COMMUNITY RETROFIT STRATEGY FOR THE AGING HOUSING STOCK USING UTILITY AND ASSESSOR DATA

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DETERMINING THE LARGEST ENERGY OFFENDERS IN RESIDENTIAL RURAL AMERICA

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Residential buildings account for about 21.5% of the nation's primary energy consumption and carbon emissions, and about 38% of electricity use. The housing stock in the United States consists of over 128 million residences with over 60% being constructed prior to 1979 when building codes and regulations began standardizing building practices. Seeking an opportunity to understand and reduce consumption, the scientific community developed a number of model-driven auditing software. While these computer models have been successful in predicting usage patterns in newer residential structures, they have been inaccurate in predicting and analyzing energy use in aging housing stock, predominantly homes built prior to 1979. The problem then remains how these homes should be retrofitted and what is the best approach in analyzing and understanding consumption patterns, especially those that consume an inappropriate amount of energy. Using a rural community in Iowa, 480 older homes were used to expand on the scientific research of residential energy consumption and usage patterns. Analysis was accomplished using a three step process. First, historical utility data was paired with assessor data to identify BTU per Square Footage rankings using a multiple regression analysis together with the stepwise regression. Second, a qualitative survey was administered to identify homeowner perception and current usage patterns. Lastly, the building envelope on existing homes was tested to determine air exchanges per hour to the actual energy used.

The statistical analysis inferred the necessity of using actual historical utility data when determining the current home energy usage instead of computer simulation models. Older homes show no significant commonalities in regards to style, year built, condition, and/or appraised cost that would allow a precise computer modeled approach to energy savings calculations. The perception survey results supported previous research concluding awareness of energy efficiency techniques may actually lower base utility consumption. The on-site analysis indicated the building envelope provided the best opportunity for permanent improvement in comparison to other energy offender solutions; however, it was determined that more research is needed on the use of blower door and effective building envelope improvements. Even so, strategies were developed to address the challenges of residential energy offenders. It was concluded that actual historical data has a higher potential to be more accurate when trying to understand energy consumption and patterns.

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INTRODUCTION

1.1 Background of Residential Conservation Programs

As researchers around the country are now aware, the housing stock consumes over 49% of our entire energy supply in the building sector and over 50% of our electrical supply (1). What is perhaps more disheartening is that it is estimated almost 20% of the energy usage is caused by poor homeowner habits and historically poor building practices (2). While the commercial sector seemed to effortlessly convert to using "green" building practices, the residential sector has been stagnant with specific pockets or communities gaining momentum only to lose it due to economic slowdown or lack of government funding (3) (4) (5).

On its face, the residential building community is often blamed for this lack of sustainable transition, but as more and more character differences are discovered between the commercial and residential sectors, it is unfair of us as researchers to expect the same standards and results from what can truly be defined as two very different business models and industries. While the commercial sector is often supported (33% in 2008-2010) by government funding of building i.e. schools, government offices, libraries, etc., the residential sector is almost completely funded by individual private investors or homeowners. This characteristic difference allows the governing body to impose "green" or LEED (Leadership in Energy and Environmental Design) building standards on the commercial builder. Acknowledging the potential for future business, many of these commercial firms have made sustainable practices standard which ultimately influences the building attributes of their privately invested structures. This government influence has positively changed the commercial sector indefinitely.

The residential building sector has been less affected by these governmental influences than its commercial counterpart for a multitude of reasons. With government funded residential properties accounting for less than 1% of the entire building portfolio (2), it has had little to no influence on the building practices. Another character difference between the two sectors is the number of influential players involved. The top 400 contractors in the commercial sector capture almost 50% of the total revenue in the United States (7), while the top 100 builders across the country supply less than 5% of the housing stock (2). When trying to influence and change century old building practices, accessing and educating the commercial sector becomes a much more obtainable and effective task. Educating and training a residential sector in which 95% of the firms employee less than 10 people has often been linked to the lack of green momentum in the home building industry (3). Finally, the budget allocation for energy use has not been taken into account until recent years. A commercial building can incur yearly utility bills in the tens of thousands of dollars. When commercial investors are looking at a useful life expectancy in the building for over 50 years, the investment to save 15-20% of those utility costs makes energy efficient upgrades financially viable. These budget opportunities quickly become constraints in the residential sector. With the average stay in a home being less than seven years (6) and utility costs reaching only a few thousand dollars per year, the budget and salability of energy efficient upgrades become difficult.

Understanding that the residential building community has constraints differing from those in the commercial sector does not allow researchers to ignore the rising energy consumption problem. In fact, it is the duty of the applied sciences to investigate the current limitations and identify potential solutions to the residential energy crisis. While wind and solar technologies are advancing at institutions across the country, today kWh production from these sources range from $0.8 to $0.20 (4). This does not include the infrastructure costs and grid updates needed to accept this energy source on large scale programs. With utility companies across the country reaching infrastructure capacity during peak demand season, many are aggressively looking for ways to reduce demand. It may seem counter-productive for a company to actively look for ways to sell less of their product, but with unknown future government mandates, the option to invest $10 billion dollars on a new coal or nuclear plant is a decision that board members are unwilling to make. This opportunity for conservation has been seen as the solution with utility companies such as Nebraska Public Power District (NPPD), which is willing to invest up to $0.015 per kWh in conservation programs and incentives (5). Programs across the country have allowed residents to invest in loans for HVAC upgrades, perform energy audits, and become more educated on habitual changes that can lower their energy consumption and ultimately their monthly costs.

The issue at hand is that the research completed regarding what and where the best retrofit energy efficiency upgrades are in a home is still being analyzed and tested. It has been shown that upgrading HVAC systems, changing out old windows, and installing higher efficiency appliances can drastically reduce the consumption, but often at unreasonable prices. Attempting to convince enough of the marketplace to invest thousands of dollars into upgrades that often have little return on investment is difficult and realistically unsustainable without consistent government assistance. Educating homeowners on simple homeowner maintenances such as turning down the water heater, setting back their thermostat, and changing out old light bulbs with new CFL's has been seen as influential (3). However, the calculated savings are unknown and begin to diminish as homeowners forget or simply choose to return to their old habits (4).

Unlike their commercial counterparts, the residential building team rarely consists of professional architects, owner-investor groups, and general contractors. Instead, the residential sector focuses on a personal one on one relationship with one owner and one builder wearing different "hats" or job descriptions. With the residential builder acting as the owner's representative, the general, the laborer, and sometimes the designer, there is little opportunity to develop or implement new building practices or opinions outside the production builders. The residential builder is viewed as the building expert to the owner, so suggestions or procedures made are often approved by the owner without another consulting opinion. This building relationship, while personable, has hindered the movement towards green building and design.

Over 95% of the builders across the country employ less than 10 employees and have little to no formal training in terms of engineering and design (3). Many builders have been trained in the field by family or friends that introduced them to the home building business. Along with the hands on craftsmanship that has passed down from generation to generation, poor training on energy efficient habits have also been adopted.

While many owners perceive the compliance of codes process as a quality control procedure, the building inspector is responsible for minimum safety and fire code standards. In some areas the inspector often ignores energy efficiency procedures that the builder may or may not be using. With builders facing minimal profit margins and lacking the knowledge of building efficiency practices, energy efficient homes are not replacing the current housing stock at an effective rate, and the housing stock remains the leading cause of wasteful energy consumption (8).

Understanding that today's housing stock stands at over 128 million homes (6) and is currently replacing older homes at a pace of 500,000/year (2), the development of a truly market-driven residential retrofit business model is not only possible, but necessary. Prior to the energy crisis in 1979 which led to insulation and building envelope standards, it was common for homes to purposely be constructed for breathability which we consider today to be envelope leakage. The inefficiency of HVAC systems and the inexpensive energy costs made this envelope leakage desirable to allow for proper indoor air quality with little added cost to the occupant. While building practices post-1980 used proper building envelope sealing and mechanical ventilation systems, over 64% of the current housing stock is pre-1980 (6).

With unstable and rising energy costs and the acknowledgement that petroleum, natural gas, and coal supplies are being consumed at growing rates, the consumption of these energy supplies has turned the focus to residential retrofits. Unlike a "cash for clunkers" program, it is unrealistic to believe that citizens will demolish their inefficient home for a new, higher efficiency model. Homes, like family heirlooms, are passed down from generation to generation holding sentimental value as well as permanency of location at a time when people struggle to find an identity in this global world. The challenge then becomes finding the best approach to retrofit enough of the housing stock to affect the current and future consumption rate of residential housing.

To further calculate diminishing returns, this study expands on the research of valuing today's sustainability market. With the help of the commercial building sector, many people are going to work in "green" offices and recognize the benefits. Furthermore, marketers in the automobile industry, building materials, and a variety of other industries are using "green" as a selling tool and actually creating value. From this collaborative environment, the building sciences are considered to be at the crest of a "tipping point" in which actual value will be added to properties that utilize proven sustainable techniques (15) (16).

1.2 History and Case Studies

Private investors, non-profits, utility, and government based programs have all attempted to infuse energy retrofit models into the residential sector, some with more success than others. Private companies often struggle with payback projections and workforce training that makes their business unsustainable when any sort of government rebate or tax incentive runs out (4). The non-profit based groups tend to focus on senior citizens or low-income families by making improvements to homes. These groups are most often mission based and narrow in focus. The utility based programs often attempt to work with the homeowners and financial loan programs. While some of these programs are effective, they are state specific and still require a large financial commitment from the consumer. The long-standing government retrofit programs have exclusively targeted low-income housing, leaving 80% of the population unable to access these programs (7) (8). This "middle" class is the majority of homeowners that are considered too wealthy to qualify for government assistance but too poor to afford any substantial out-of-pocket upgrades. Highlighted in the following are a few examples of programs being implemented in the Midwest.

The South Central Kansas Environmental Development District developed a retrofit program in 2007 that made it possible for residents within a 13-county region to have an energy audit performed on their home and then retrofit it (9). The basis of the program was to allow homeowners to make energy improvements on their homes without a large financial burden. The cost of the retrofit would be financed through the SCKEDD and then paid back by the homeowner over an agreed upon period. While this program had strong momentum, it lacked sustainability due to the homeowner inconvenience and unethical business practices of contractors. Following the energy audit, homeowners were given a list of suggested upgrades, but the responsibility of contacting contractors and getting bids was placed solely on the homeowner. This project management role became too burdensome, and many people elected to end the process. When the homeowner's were able to schedule and hire the contractor, many of the costs of retrofits were sometimes 50 to 100% over market value. The contractors recognized that the financier of the work was a government agency and often overcharged for retrofits unbeknownst to the homeowner. These actions were caught too late by the governing oversight committee.

A number of utility monitoring services and homeowner educational tools have been proven to cut utility consumption usage (10). The monitoring services are often too expensive to build into existing infrastructure and privacy issues have made widespread use of the technology difficult. Education has been shown to change homeowner habits, but cannot be guaranteed to cut usage permanently. While a retrofit to the structure of the home can be a one-time investment, education and decision based improvements is often an ongoing investment, making the cost to financers and utility companies exponential.

In Hastings, NE a strictly residential retrofit energy company has partnered with local utilities on residential retrofits (11). Energy Pioneer Solutions, Inc. performs the energy audit, contracts the retrofits, and monitors the usage. The retrofit project is financed by the company and homeowners pay for the services over a two- to five-year period by sharing the cost savings. While the business model is innovative and creates true partnership with private investors, the utility company, and residences, it is still in the infant phases of success. Residential energy savings projections are still difficult, and training a labor force to perform weatherization work that guarantees energy savings with a limited budget requires superior project management.

It seems that current residential retrofits are cost ineffective and business models and contractors attempting to build a sustainable residential model have had little to no success without the help of governmental assistance in the form of tax incentives or grants. Still, it remains the responsibility of the research community to recognize the opportunity and provide proven techniques that exist in the residential marketplace.

1.3 Problem Statement

Residential energy consumption accounts for a large majority of overall energy use in the United States. Seeking an opportunity to understand and reduce consumption, the scientific community has developed a number of tools and technologies in an attempt to accurately analyze energy usage. Access to individual consumption data being limited and the need for a cost effective pre-analysis; a number of model driven auditing software have entered the marketplace. While traditional auditing methods have shown accuracy in predicting usage patterns in newer residential structures, there has been difficulty in predicting and analyzing the aging housing stock, especially in respect to pre/post retrofit saving calculations. The problem then remains how and what the best approach is when developing a community-based retrofit program.

1.4 Research Questions

Research Question #1: ***Can historical consumption data and property assessor data be efficiently used to analyze community based energy usage patterns?***

Research Objectives for Question #1

- Develop an energy analysis tool that could be used by private and public utility companies to identify a target residential market for energy conservation retrofits.
- Identify the subsector of the housing population that currently consumes the largest amount of energy per square foot of living space.
- Identify which housing characteristics play critical roles in identifying retrofit opportunities.

Research Question #2: ***To what extent do the homeowners' perceptions of energy efficiency in rural America affect their actual energy consumption?***

Research Objectives for Question #2

- Develop a community wide survey to assess individual perceptions of energy efficiency and green building.

- Conduct a statistical analysis of homeowners' perceptions to actual energy consumption to identify the amount of influence.

Research Question #3: ***Is there a direct relationship between the building envelope and actual energy consumption in the aging housing stock?***

<u>Research Objectives for Question #3</u>

- Develop a systematic approach of using property assessor data and historical consumption rates in the pre-auditing and auditing process.
- Conduct a statistical analysis of building envelope performance and actual energy consumption.
- Identify the role building envelope testing has in a community based retrofit project.

1.5 Importance of the Study

Residential retrofits remain the largest untapped opportunity to reduce our dependence on fossil fuels whether domestically or abroad. While the public and private community continues to invest in new energy sources, today wind costs $0.08/kWh and solar upwards of $0.20/kWh for large scale productions (4). By simply retrofitting residential properties, an energy company can produce savings through conservation at a cost of $0.03/kWh (4). Another reason to remain focused on residential retrofits is the human factor. One of the proudest times in a citizen's life is when they become a homeowner. This country thrived during the industrial revolution and post-World Wars with the common American dream to one day own a home. In today's economy where 1 in 45 homes will face foreclosure (8), unemployment is close to 10%, and many people have been faced with a pay freeze or cut, residential retrofits offer a way for citizens to save money immediately and lighten their family's financial burden, even if it is as little as $30/month.

Research in the area of specific residential retrofits is scarce, but with the opportunities recognized by the DOE, NREL, Berkeley labs, and research universities across the country, new work is being published every day. Current related research is found in the commercial sector but has often been misused in a residential application (18). Commercial properties and occupancy habits remain fairly consistent and building practices have been standardized for years. This makes calculating energy usage and savings in the commercial sector much easier and more accurate. When dealing with a residential application, many homes built in the same period and style are often done using various framing and design techniques. Couple these building differences with the specific unique homeowner habits, and it becomes difficult to accurately use commercial science on a residential retrofit (9) (10) (11).

1.6 Scope of the Study

Understanding the differences between the two sectors does not discount residential retrofit possibility; it simply means a specific scientific methodology needs to be developed. To believe that researchers can create a "one size fits all" retrofit method is naïve, but this study attempts to show that there is the possibility to create specific retrofit models for house styles i.e. ranch homes, two-stories, split entry, etc. that are also period specific i.e. 1880 – 1920; 1920 – 1940; 1940 – 1960, etc. This study began by investigating the housing stock in these subcategories to establish a much better understanding of materials used, building techniques, and retrofit opportunities (specifically building envelope improvements). It is important to note that this study includes data from one specific climate zone and these subcategories and retrofit prescriptions will most likely differ in each of the United States climate zone regions.

There are two specific technologies that will further the accuracy of residential retrofits. First, the blower door science has improved to the point where it can accurately measure how much a building envelope is leaking and easily convert this leakage to heat loss (12) (14). By pressurizing the home, a contractor has the ability to not only measure the amount of leakage but visually see and feel where the leakage is occurring i.e. attic, basement penetrations, rim joists, windows, outlets, etc. By adding the use of a thermal imaging camera, a researcher or energy auditor can measure the temperature difference and heat loss of windows and exterior walls. While this measuring technique is being widely used, much more data needs to be collected before assigning energy loss values to financial savings calculations (13).

To address the feasibility of accurately calculating diminishing returns, a better system of effectively monitoring energy consumption after retrofit is needed. Little research has been done on the residential sector that uses actual historical utility data before and after a completed retrofit. Privacy issues have been a concern and accessibility to large enough data sets has often caused researchers to assume current home usage based on a certain amount of building characteristics (14) (17). Even the energy audits being performed using nationally recognized software such as HERS and BPI assume pre-audit usage when calculating potential savings.

1.7 Limitations of Research

- This study specifically analyzed residential homes in climate zone 2 as defined by the United States Energy Information Administration.

- This study did not attempt to verify the HVAC efficiency of the homes.
- This study assumes the county assessor's data is accurate in regards to property data used for energy consumption calculations.

1.8 Definition of Terms

- Blower door – Diagnostic tool used to measure the airtightness of a building. A blower door consists of a calibrated fan for measuring airflow rates and a pressure sensing device to measure air pressure created by the fan flow.
- BPI – Acronym for the Building Performance Institute. Recognized as a leader of technical standards for weatherization retrofit work.
- BTU – Acronym for British thermal Unit. A BTU is the amount of heat energy needed to raise the temperature of one pound of water by one degree F. This is a standard measurement for all forms of energy.
- Building envelope – Refers to how airtight or sealed a home is. The building envelope should be designed and constructed to allow the correct number of air exchanges in one hour in a building.
- CCF – Acronym for Centum cubic-feet. Typical unit in which industrial-consumption of natural gas or water is measured. Each CCF is equal to 100 cubic-feet.
- CFL – Acronym for compact fluorescent light.
- CFM – Acronym for cubic feet per minute. Blower door readings are taken traditionally at 50 CFM.
- Climate zone regions – The globe is divided into any of eight principal zones roughly by lines of latitude on the basis of climate characteristics.

- Degree days – A unit of measurement equal to the difference of one degree between the mean outdoor temperature on a certain day and a reference temperature, usually 65 degrees F. Used in estimating the energy needs for heating or cooling a building.
- DOE – Acronym for Department of Energy.
- Green – Refers to the concept of environmentally friendly practices.
- HERS – Acronym for Home Energy Rating System. A HERS score of 100 represents a standard home built to code.
- Housing Stock – The current number of homes in the United States.
- HVAC – Acronym for Heating, Ventilation, and Air Conditioning systems.
- KWh – Acronym for kilowatt hours. A unit of energy equal to 1000 watt hours. 1 kWh is equal to 3,412 Btu's.
- LEED – Acronym for Leadership in Energy and Environmental Design. Developed by the United States Green Building Council to rate sustainable buildings.
- NAHB – Acronym for National Association of Home Builders. NAHB is the largest residential building organization in the United States.
- NREL – Acronym for National Renewable Energy Laboratory. It is the United States primary laboratory for renewable energy and energy efficiency research and development.
- Retrofit – Refers to the process of remodeling or placing energy efficient materials into the home for energy conservation purposes.
- R-Value – Measure of thermal resistance in any material.

- Sustainability – Refers to the building practice of using recycled or reconditioned material to avoid consuming the earth's natural resources.

Chapter II

LITERATURE REVIEW

The following reviews the current United States housing stock as well as a detailed description of the City of Woodbine, Iowa. Previous research in the areas of residential utility analysis, community retrofit programs, homeowner perceptions, and the growing use of blower door technologies are summarized to give credit to the current research as well as contribute to the development of methodology chosen for this specific project.

2.1 United States Housing Stock

Every two years the U.S. Census Bureau, with sponsorship by the U.S. Department of Housing and Urban Development, releases the American Housing Survey. This report is the most comprehensive analysis of the size and composition of the current housing stock as well as available financial characteristics, neighborhood quality, and homeowner demographics i.e. sex, age, education, etc. (6). The AHS (American Housing Survey) is conducted on both the national and metropolitan level. The national survey gathers information every odd-numbered year from 55,000 housing units through random sample selection. The metropolitan survey is conducted every six years and is aimed at identifying divisions between central city housing and the greater metropolitan areas.

Understanding the current housing stock in the United States is critical prior to researching or developing a residential retrofit model that can sustain itself in a free market or capitalist driven society. Simplistically, the housing stock is often viewed in two or three categories: rent vs. own; first-time, move-up, or retirement home; or style i.e. ranch, split-level, or two stories. While these categories are sufficient for generalizing the housing population, a much more detailed understanding of the housing characteristics is needed. The following is a snapshot of the current housing stock in the United States taken from the 2009 American Housing Survey. The data from the AHS is available separately both in total inventory and occupied units. On its face, the occupied units are of more concern, but understanding the homes entering the marketplace plays a critical role for the future of retrofit models.

There are currently 125,494,000 year-round housing units in the United States marketplace, with 13,688,000 sitting vacant. The breakdown of the age of the home in Table 2.1 provided by the AHS gives this study a baseline for identifying characteristics and opportunities via period built.

TABLE 2.1: Breakdown of Residential New Homes (AHS 200)

- **2005 to 2009 — 7,052,000**
- **2000 to 2004 — 8,851,000**
- **1995 to 1999 — 8,495,000**
- **1990 to 1994 — 6,730,000**
- **1985 to 1989 — 8,515,000**
- **1980 to 1984 — 7,152,000**
- **1975 to 1979 — 13,290,000**
- **1970 to 1974 — 10,642,000**
- **1960 to 1969 — 14,747,000**
- **1950 to 1959 — 12,891,000**

- **1940 to 1949 7,626,000**
- **1930 to 1939 5,619,000**
- **1920 to 1929 4,983,000**
- **1919 or earlier 8,902,000**
- **Median year of U.S. housing stock is 1979**

The number of new construction homes' entering the marketplace has decreased significantly over the past 5 years. While the mid-2000 saw over 1,000,000 homes constructed, the years 2007 to 2010 have averaged just over 500,000 new homes (2). Understanding the number of homes in the marketplace and the replacement rates brings the realization that by simply building more energy efficient new homes, it will take over 200 years to remove the high-consumption homes being occupied today. With utility prices steadily rising, the need for a sustainable retrofit solution is no longer a good idea, but a necessity for the stabilization of energy consumption rates. Building envelope improvements and energy conservation techniques have been a focus since the energy crisis of 1979, though it wasn't until 2003 that the International Residential Code (IRC) was formally presented and adopted (9). This study identifies energy consumption rates of a housing stock in every time period, but aims to specifically address retrofit solutions in residences pre-1979 which make up over 63% of the entire housing stock in the United States.

2.2 Woodbine, Iowa

Woodbine is committed to Sustainable Design using natural and man-made resources efficiently to meet community needs while preserving its economy, culture, society and environment for future generations. (17) The green council of Woodbine is dedicated to a sustainable Woodbine through the following initiatives:

- Wise selection of construction sites and materials
- Preservation of existing building and systems
- Working for a compact community utilizing energy and water efficiently
- Enhancing a beautiful and prosperous community that visitors and residents will find appealing

The Iowa Department of Economic Development selected Woodbine as well as West Union, IA as a Pilot Green community or otherwise known as its Green Streets Initiative. The IDED assisted the City of Woodbine in developing a sustainable master plan which included a large downtown revitalization and was also to include a sustainable plan for the residential community. (18) Having successfully completed numerous projects including energy audits and retrofits of the business district, a community-wide recycling awareness project, implementing a student/community garden, and completing a 3 year Woodbine sustainability impact study, the City of Woodbine was ready for a residential implementation project. With the commitment of the City of Woodbine leadership as well as the State of Iowa's Department of Energy and Economic Development, Woodbine presented itself well for this study. The "Woodbine Project" offered an opportunity to analyze an entire community rather than a sample set. With a tract record of implementation, future research and post retrofit analysis opportunities are available when Woodbine begins implementing a residential retrofit program.

2.3 Residential Energy Audits

Residential energy audit tools have been under development for over two decades in an attempt to identify opportunities for energy efficiency improvements (10) (24) (25). A review of the literature analyzing residential energy auditing strategy and software was limited, with a number of citations dating to the early 2000s and a comprehensive auditing tool review prepared for the Department of Energy by SENTECH, Inc. (now part of SRA International, Inc.) in November of 2010.

To date, the most relevant and applicable energy related software tool guide can be accessed through the DOE's Energy Efficiency and Renewable Energy Building Technology Program (11). The database lists major features of auditing software available and provides unbiased strengths and weaknesses of each testing tool. The directory allows the user to sort usage preferences in regards to relevance of intended use, cost, input requirements, and a number of other applicable features.

From 2002 – 2004, the Lawrence Berkeley National Laboratory in Berkeley, CA analyzed multiple energy analysis tools focusing on residential capabilities. The LBNL evaluated 65 programs - 50 of them being web-based and 15 disk-based packages (12). Mills determined that there were significant differences in all of the auditing tools. Of the web-based tools, only twenty-one performed whole-house analyses and out of these, thirteen provided open-ended energy calculations, five permitted bill disaggregation and only three contained both functions. Of the 15 disk-based packages, six performed whole-house analysis and three performed both open-ended energy calculations and bill disaggregation. In their 2004 study, the wide inconsistency between all the auditing programs suggested that a national standard or benchmark needed to be developed prior to implementing actual energy retrofit strategies (13).

A review of Paradis's 2007 work was conducted in regards to a new software design for future programs (14). It was that author's opinion that while Paradis tool design has significance in the building industry, it is a much more applicable within the large commercial building performance sector and would be difficult to utilize in a residential setting.

Two relevant literary works with a focus on residential auditing accuracy were identified. Hendron et al. specifically researched the accuracy of high performance homes for the DOE's Building America Program. They identified simulation tools that met the requirements of HERS BESTEST and the International Energy Conservation Code. The study found significant differences based upon the energy software used. As a result, Hendron et al. 2003 identified four features that all auditing software must comply with:

1. Clearly defined reference home
2. Consistent set of operational assumptions that mimic realistic occupant behavior
3. Accurate predicted energy saving modeling
4. Reporting process that communicates effectively where energy savings are being realized and to what magnitude (15).

With the growing use of the HERS rating, or REMRATE software, Stein and Meir evaluated rating scores to actual billing data for 500 homes in four states. Disappointing the authors showed that while HERS rating analysis could be used to predict large population annual energy usage and cost, accuracy diminished significantly when analyzing individual homes to actual costs. Even more disappointing was the accuracy of the HERS rating when analyzing older, pre-1979 homes (16). Calibrating the HERS input with actual billing data showed no effect on the variance of the findings.

An attempt to evaluate home auditing software over the past decade by a variety of state energy offices have occurred. The State University of New Jersey reviewed four audit tools: Home Energy Checkup, Home Energy Advisor, Home Energy Saver, and Home Analyzer. These four programs were all web-based and focused on providing recommendations and education to homeowners (17). Kim et al. provided an overview for the State of Texas' energy office. The study did not test accuracy and usability of auditing software, but provided a summary of characteristics to allow the Texas energy office to further analyze options as part of their decision support system (18). A pilot study of 190 homes in the cities of Portland and Bend, Oregon were completed for the Energy Trust of Oregon. The pilot compared four energy auditing software tools for accuracy. Of the four tested - REM/Rate, SIMPLE, and Home Energy Saver I and II, SIMPLE was found to perform the best, but none were found to be scientifically accurate (19). Recommendations from the report suggest that future software developed should:

1. Be more accurate and require less time to input
2. Better prediction and reporting of actual energy usage
3. Standard normalized assumptions for base loads and plug loads.
4. Recommendations for energy improvements based on specific guidelines.

In 2010, the Department of Energy took the initiative to identify a standardized national program to assess the energy performance of houses across the country. The report prepared by SENTECH, Inc. was found to be the most comprehensive literary review of current auditing tools. Solicited by the DOE to examine the potential of a national residential energy program, SENTECH, Inc. provided a review of the variety and characteristics currently available that had potential national capability. Focusing specifically on the accurate analysis of residential properties regardless of climate zone, energy source, style, and building design, the study focused on the following software:

- REM/Rate
- BEACON Home Energy Advisor
- EnergyInsights
- Home Energy Tune-uP
- EnergyGauge
- TREAT
- National Energy Audit Tool (NEAT)
- Home Energy Saver Professional
- RealHomeAnalyzer

The findings of the comprehensive review found that no one tool is capable of capturing all the characteristics needed for a national home performance assessment program (34). No current auditing software is able to be accurate, have low cost and reasonable inputs, and the ability to generate improvement recommendations and associated costs. The audit tools as a whole to appear to address potential needs for a national program. The review did provide the DOE assistance for future development of a national software strategy (20).

2.4Utility Companies and Conservation

Utility providers threatened with unstable commodity supply pricing, peak demand overload, and a deteriorating grid system have looked at conservation as an avenue to stay competitive and provide the “green” image that customers are asking for. Historically, public utility providers have moved towards conservation faster than their private counterparts mostly due to direct citizen influences (36) (37). This project focused on the utility companies’ movement over the past two decades, the challenges of implementation, and privacy concerns of customer data.

Implementation of a renewable energy source such as wind or solar to an electrical grid system introduces challenges different from common energy sources. Unlike controllable sources such as nuclear or coal, wind and solar are both somewhat regulated by the natural environment in which we really on. These surges of power or lack of power supply has been found to put stress on parts of the power grid that are deteriorating or at maximum capacity (21). Three case studies are described in the following section that studied the impact of renewable energy, specifically wind energy, on the current power grid.

The Utility Wind Integration Group (UWIG) commissioned a study to evaluate the impact of wind generation on operating systems for one of its members, Northern States Power Co. in early 2000. The primary objectives of the study were to identify and quantify operating costs on real time controls of wind generation facilities and to determine how uncertain wind generation forecasts affects future operating costs associated with scheduling against conventional generating units (22). To further study actual impact cost, the authors established four operating scenarios:

1. Cost of wind generation forecast inaccuracy for day-ahead scheduling
2. Cost of additional load-following reserves
3. Cost of intra-hour load-following energy component
4. Cost of additional regulation reserves

From these scenarios, costs to accommodate wind into an existing electrical grid could be quantifiable ranging from $0.39 to $1.44 an MWh. The wide range was concluded to affect wind penetration levels, generation mix, and energy transaction pricing.

PacifiCorp, a large utility provider in the northwest United States, analyzed the impact of renewable energy sources on their grid by focusing on two categories. The first was the incremental reserve requirements of transitioning to the alternate energy source, and the second, the imbalance costs of using predominantly wind energy. By separating the two cost impacts, PacifiCorp was able to identify the differences in dispatch costs and unit start-ups that are imposed by the variability of the wind resource (23). PacifiCorp's integration costs were found to be much higher at approximately $5.50/MWh; $3.00 of that being attributed to imbalance cost and $2.50 for incremental reserve costs.

The final case study reviewed regarding utility grid implementation of renewable energy was conducted by Hirst for the Bonneville Power Administration. BPA is a federal agency operating in the Pacific Northwest under the US Department of Energy that runs 31 hydro dams, one nuclear plant, and one wind energy farm. Similar to both PacifiCorp's and Xcel's case study, Hirst broke the integration cost impacts into three subsections.

- Day-ahead unit commitment decisions concerning which units to turn on and when to do so.

- Intra-hour balancing to maintain the necessary balance between generation and load.
- Regulation track changes in the minute-to-minute balance between generation and load.

Hirst found the integration costs for the BPA operations to range from $1.37 to $2.17 per MWh.

All three case studies highlight the range of implementation challenges and cost differences in implementing large scale renewable energy sources into a utility company's current business operations. These specific challenges ultimately drive the decision makers when identifying when and at what level renewable energy sources become a viable sector of their business operation.

2.5 Utility Data Analysis

At the forefront of residential efficiency analysis is the ability to accurately calculate current energy consumption and thus potential energy savings. As the literature review has shown, baseline characteristic-driven software is inaccurate on an individual level, especially with concerns to pre-1979 single family residences (32). The issue then becomes the ability to access actual consumption data from either the resident directly or, more conveniently, the utility provider. This "smart" grid approach has been implemented in various regions across the country, with continuous resistance from customers who are concerned with individual privacy laws (41).

The U.S. Department of Energy has acknowledged that although the current electrical grid could be viewed as one of the greatest engineering achievements of the 20th century, it is increasingly out of date and overburdened (24). As technologies have advanced, the opportunity to utilize the current infrastructure by implementing "smart" systems has been seen as the most viable, economic solution. As a complete package, a Smart Grid would possess the following capabilities (24):

- **Intelligence** – capable of sensing system overloads and rerouting power to prevent or minimize a potential outage; of working autonomously when conditions require resolution faster than humans can respond and cooperatively in aligning the goals of utilities, consumers, and regulators
- **Efficiency** – capable of meeting increased consumer demand without adding infrastructure
- **Accommodating** – accepting energy from virtually any fuel source, including solar and wind, as easily and transparently as coal and natural gas; capable of integrating any and all better ideas and technologies – energy storage technologies, for example – as they are market-proven and ready to come online
- **Motivating** – enabling real-time communication between the consumer and utility so consumers can tailor their energy consumption based on individual preferences, like price and/or environmental concerns
- **Opportunistic** – creating new opportunities and markets by means of its ability to capitalize on plug-and-play innovation wherever and whenever appropriate
- **Quality-focused** – capable of delivering the power quality necessary – free of sags, spikes, disturbances and interruptions – to power our increasingly digital economy and the data centers, computers, and electronics necessary to make it run
- **Resilient** – increasingly resistant to attack and natural disasters as it becomes more decentralized and reinforced with Smart Grid security protocols

- **"Green"** – slowing the advance of global climate change and offering a genuine path toward significant environmental improvement.

With this new smart grid movement, utility regulators play an important role in insuring the information privacy rights of individual consumers. In 2000, the National Association of Regulatory Utility Commissioners' passed a resolution urging all state commissions to adopt general privacy principles. However, these adoptions of principles do not insure the consumer of the ever more prevalent information hackers across the globe (25).

2.6 Customer Perceptions toward Sustainability

Knowledge of the United States' impact on the global energy environment as well as a national education program in schools focusing on reduce, reuse, recycle programs has lead today's utility customers to be more informed on their own environmental impact. Couple this consumer savvy with a more competitive utility marketplace and the energy industry has been forced towards sustainability if for nothing else, customer loyalty and retention. This section identifies past market research on customer perceptions of renewable sources, specifically the electric utility suppliers.

Fahrar's work in 1993 and 1996 identified a trend nationally of consumers' preference for renewable energy as an electrical source. On a national level, solar and wind were preferred by over 90% of respondents, while nuclear and coal were found to be the most unfavorable with over 60% strongly opposing the energy source (26). During the study, the respondents were separated as either residential or commercial users, 88% of customers' still preferred new renewables as their main source of electricity (27). Fahrar's national study also showed customers favorability toward the utility investing in renewable energy and that they focus on minimizing the negative environmental impact of electricity production.

Two more recent local and regional studies were found in the Pacific Northwest and Colorado. (35) These studies confirm the survey data provided by Fahrar in regards to customer attitudes toward renewable energy use. Ferguson's work in the Pacific Northwest found a strong majority of consumers prefer renewable over conventional energy options, specifically wind and solar (28). A 1998 poll conducted by Fahrar and Coburn in the state of Colorado confirmed that wind and solar are the most preferable energy source. Both of the local studies found that consumers prefer wind and solar for more than just their environmental impacts. Safety, economic benefits, self-reliance, and U.S. energy diversity all were seen as positives by those surveyed (29)

Not only did the market research show that a majority of consumers preferred renewable forms of electric energy, but on a national scale were willing to pay more or forgo price decreases. Farhar and Houston reported that 57% to 80% of national samples said they were willing to pay more for renewable electricity (30). While the structure of the questions differed, Farhar and Coburn's 1999 Colorado survey indicated 76% were willing to pay at minimum $1 per month for renewable and a survey conducted of four Midwestern states by Tarnai and Moore showed 72% of respondents were "very willing" or "somewhat willing" to pay more for renewables (31).

The most comprehensive analysis of residential utility customer perceptions was completed by Farhar in 1999 for the U.S. Department of Energy. Farhar combined the data from 14 national and regional surveys from 12 utility service territories to provide an overview of 20 years of movement towards sustainability. Farhar summarized her findings into five specific points for utility companies and the Department of Energy to review when analyzing future renewable programs (32):

1. Customers favor renewable sources of electricity but may know little about them. Specifically wind and solar are the most favorable.
2. fifty-two to 95% of residential customers are willing to pay at least a modest amount for renewable sources of energy.
3. Willingness to pay follows a predictable pattern with an average majority of 70% willing to pay at least $5 per month more for electricity from renewable sources, 38% willing to pay at least $10 per month more, and 21% willing to pay at least $15 per month more.
4. A limited amount of data suggests that customers may be even more likely to pay more for electricity from renewable sources in a competitive market setting.
5. Customers may favor and remain loyal to utilities that provide power from renewable sources.

2.7 Blower Door Usage on Building Envelopes

The blower door is a diagnostic tool designed to measure the airtightness of buildings and to help locate air leakage in the building envelope (42). Historically, building airtightness measurements have been used for a variety of purposes that have included:

- Documenting the construction airtightness of buildings.
- Estimating natural infiltration rates in houses.
- Measuring and documenting the effectiveness of air sealing activities.

- Measuring duct leakage in forced air distribution systems.

The blower door consists of a powerful, calibrated fan that is temporarily sealed into an exterior doorway. The fan blows air into or out of the building to create a slight pressure difference between inside and outside. This pressure difference forces air through all holes and penetrations in the exterior envelope. By simultaneously measuring the air flow through the fan and its effect on the air pressure in the building, the blower door system measures airtightness of the entire building envelope. The tighter the building, the less air you need from the blower door fan to create a change in building pressure (42).

It takes about 20 minutes to set-up a blower door, conduct a test, and document the airtightness of a building (42). In addition to assessing the overall airtightness level of the building envelope, the blower door can be used to estimate the amount of leakage between the conditioned spaces of the building and attached structural components such as garages, attics, and crawlspaces. It can also be used to estimate the amount of outside leakage in forced air duct systems. And because the blower door forces air through all holes and penetrations that are connected to outside, these problem spots are easier to find especially when accompanied with chemical smoke or infrared cameras. The airtightness measurement can also help you assess the potential for back drafting of natural draft combustion appliances by exhaust fans and other mechanical devices, and help determine the need for mechanical ventilation in the house (42).

Commissioned by the Department of Energy through the Building America program, the Building Science Corporation set out to develop critical parameters when testing residential housing performance. Based in Massachusetts, the Building Science

Corporation is a leader in building envelope testing and protocol. The Building Science Corp developed what is called "SNAPSHOT", standing for Short, Non-destructive Approach to Provide Significant House Operation Thresholds (44). The technique developed establishes a set of critical parameters that every home must go through to test things such as the indoor environment, thermal comfort, air delivery and distribution systems, as well as their interaction with the building envelope. This data collected is then to be used to interact with auditing software such as REM or DOE-2 (44). The most significant part of the entire data collection as described by the Building Science Corp. is the building envelope leakage using a blower door test. The standard measurement should follow strict parameters outlined by:

- Blower Door Location (front door, garage door, etc.)
- Total CFM 50 (cubic feet per minute at 50 Pa)
- Add C & n values if available on multipoint test: provided in results of TECTite computerized blower door test; adds further information about leakage characteristics, and is statistically better data due to multipoint testing.
- If there is a conditioned space that is typically sealed from the main space (i.e., sealed conditioned attic, sealed conditioned crawl space, conditioned knee wall sections), please run the test with the access to that space open. It provides information on how well sealed the total conditioned space is. This is the number that should be reported for pass/fail criteria. (44)

The State of Massachusetts has established itself as a leader in large scale community retrofits with the use of blower door technology. Over a three year period, approximately 17,000 homes will have been weatherized (45). With an initial funding boost of $86 million from Recovery Act money, the state has armed 35 energy auditors and over 140 weatherization workers with blower doors, increasing the efficiency and cutting costs of every single retrofit (45). Similar stories of using the blower door to identify building envelope improvements and stream lining retrofits can be found in Maryland, Kansas, and Oregon.

CHAPTER III

METHODOLOGY

The methodology chosen for the research project was developed from past research projects in similar fields as outlined in the proceeding chapter. Careful consideration of specific scientific community standards was taken when establishing the research methodology in both the quantitative and qualitative studies.

3.1 Introduction

There are two types of research methodology: qualitative and quantitative. This research project used both qualitative and quantitative methodologies, and then employed analytical techniques and processes to review the data. Standardized testing procedures were used and documented whenever possible in an effort to normalize this project to previous and future residential sustainability projects.

3.2 Context and Access

The Woodbine project serves a variety of beneficiaries from individual homeowners and utility companies to the building science community looking to expand the database of residential retrofit analysis projects. Understanding the different desires and end users, the project researcher took careful consideration in the language and approach taken throughout the project. The importance of expanding this research project beyond the assessor and utility data analysis of this single community remained the foremost focus when developing and implementing the approach methodology for both the quantitative data analysis and the qualitative homeowner survey administered.

The end goal of the project was to develop a systematic approach to analyze and compare communities among the Midwest and in varying climate zones.

For a feasible community assessment in regards to both financial and resource allocation, access to accurate data was crucial. Property assessor data, as public information, was available through an online accessible data base. A majority of other municipal and county assessor offices either have or are currently in the process of converting individual property data online. The providing utility company became a willing participant in the research project. This provided access individual historical utility data. Woodbine Municipal Utility provides electricity, natural gas and water to its customers. This made communication and data access a smoother process than what could possibly be expected in differing communities. It should be noted that future researchers may find difficulty in accessing mass historical utility data due to differing state privacy laws and private utility providers' unwillingness to participate.

3.3 Participants: Number, Relevant Demographics, Sampling Methods

When researching residential utility usage, homeowner habits can differ significantly and, while as a scientific community does not know to what extent homeowner habits and family demographics affect utility usage, it is widely accepted that understanding residential demographics plays a vital role. While the residents of Woodbine, IA are similar to that of other Midwestern communities, each community will have its own set of habitual and community effects. The following describes the City of Woodbine demographics in detail.

3.3.1 City of Woodbine, IA Demographics

The City of Woodbine is similar to many small Midwestern communities. With a population of 1,564, the community is sustained by both agriculture and manufacturing. Woodbine is one of the few communities in the area that still has its own school district. The demographic information in Table 3.1 was provided by the online database provided by city-data.com.

<u>TABLE 3.1: Woodbine, IA Demographic Information</u>

- Population: 1,564
- Households: 647
- Population Density: 1,381.1 per square mile
- Racial makeup: 98.34% White; 0.70% Hispanic; 0.06% African American
- Median Age: 41 years
- Median Income per Household: $30,083
- Population below the poverty line: 10.4%
- Owner occupied homes: 70%
- Renter occupied homes: 28%
- Median house value: $108,833

It is important to understand the specific housing characteristics of Woodbine, IA. The age of the home is typical in the Midwest and the data provided by the U.S. Housing Census.

TABLE 3.2: Woodbine, IA Residential New Housing Information

- 2005 or later: 5
- 2000 to 2004: 49
- 1990 to 1999: 136
- 1980 to 1989: 42
- 1970 to 1979: 170
- 1960 to 1969: 68
- 1950 to 1959: 81
- 1940 to 1949: 81
- 1939 or earlier: 477

3.3.2 Research Participants

The research participants for this specific project included every single family residential unit within the Woodbine city limits. Every household included in the Woodbine Municipal Utility database was eligible for initial review and participation. All participants were given the opportunity to opt out of the research project during all phases.

3.3.3 Sampling Methods

3.3.3.1 BTU/SqFt/DD Participants

The size of the community of Woodbine allowed for a census study of every residential household for the initial BTU/SqFt/DD analysis. A census study typically provides the most accurate portrayal of a population analysis.

3.3.3.2 Homeowner Survey Participants

Every household that met the 36 months of continuous utility usage between the dates of January 2008 to December 2010 received an "Energy Use in Rural America" survey. The total participation of the survey included 480 residential households.

3.3.3.3 Selection of On-Site Analysis Participants

To choose the on-site analysis participants, a systematic sampling from the overall population list was used. After the required sample size was calculated, every Nth record was selected from the list of population members. To determine the Nth number, the researcher placed individual pieces of paper in a bowl numbered from 1-48. The numbers were mixed and then a random number was drawn from the bowl. The number 16 was randomly chosen as the Nth number for on-site selection.

3.4 Procedure

Every effort was made during the planning of the processes and procedures used in this research project to allow for future analysis not only for Woodbine, IA but also for similar communities in the Midwest and possibly across the United States. Because of this forward thinking approach, data gathered specifically from the property assessor and energy perceptions survey may seem irrelevant for the current research project, but holds invaluable information for future analyses.

3.4.1 BTU/SqFt/DD Calculations

Converting the electrical kilowatt hours and natural gas ccfs into BTUs required selecting a conversion factor to be used. It was determined that to maintain consistency, the identical conversion rates used by the Department of Energy would be used for this study. The following sections describe in detail the development of the completed calculation spreadsheet.

3.4.1.1 Assessor Data Collection

Harrison County, IA, much like many counties across the country, has converted the public county tax assessor information to be accessible online. Specifically, Harrison County, IA uses a web program known as *beacon* developed by The Schneider Corporation. *Beacon* is a government GIS program created specifically to provide public property assessor information and is widely used throughout the Midwest. The appendix contains a screen shot showing an example of the data provided on the beacon website. Chosen in the example is a randomly selected residential home in Harrison County, IA. Specific housing characteristics were extrapolated for each of the homes to be used on the BTU/SqFt/DD calculation spreadsheet. Notably useful are the real property images and footprint layouts provided by the beacon site. These photos allowed a much more visual picture of lot layout, roof pitch, topography, and shading challenges some properties may face.

3.4.1.2 Historical Utility Data Collection

Access to actual historical utility data information required direct assistance from Woodbine Municipal Utilities. As a “pilot” green community, as recognized by the State of Iowa Department of Energy, the Woodbine Municipal Utility consisting of 643 residential meters granted access to three full years of historical data. The data provided, in Microsoft excel format, was in three separate parts: electrical kilowatt usage, natural gas CCF usage, and water gallon usage. Each database was individually cleaned to remove properties that did not show 36 months of continuous usage for the dates January

2008 through December 2010. This cleaning of all three databases resulted in a final participation database of 480 residential properties. This monthly consumption data for each of Woodbine's residences allowed for the actual usage to be analyzed with the square footage to normalize consumption data and housing characteristics.

3.4.1.3 Historical Weather Data Collection

The residential properties could be compared to each other by calculating the BTU's per square footage obtained by the previously mentioned data collections. For future widespread comparison of communities, it is important to consider weather effects concerning energy consumption. To allow for the possibility of future research and comparisons, degree days for each of the 36 months were obtained from the national weather database. These degree days were used to further examine each individual home. What resulted was a final number for each individual home identifying its BTU's per square foot per degree day (BTU/SqFt/DD). This weather adjustment allows for a residence in Woodbine, IA to be more accurately compared to a residence in Kansas City, MO or Chicago, IL, for example.

3.4.2 Homeowner Perceptions Survey

The procedural approach for the homeowner perception survey was developed to be cost effective and result in a rate of return that would be scientifically significant to compare with the historical utility usage of the property. The intent of the survey was to gage overall community perspective in regards to sustainability and residential energy use and also to compare specific perceptions with actual historical usage. To notify the community of a pending survey and increase the return rate, an advertisement was placed in the local weekly newspaper, the *Woodbine Twiner*. The *Woodbine Twiner* is published every Wednesday and is widely read by the community. The appendix contains all published documents pertaining to the survey.

With assistance from Woodbine Municipal Utility, a 20-question survey was sent via UPS along with the May monthly utility bill to the 480 residents who met the 36-month utility usage requirement. Placing the survey with the utility bill not only cut postage cost for the researcher, but also helped increase participation by the survey being received by a known, trusted entity of the community. Prior to printing and distributing the consent form and survey, the research team completed all Internal Review Board requirements of the University of Nebraska to insure no identifiable discriminatory or ethical issues would arise. Careful consideration in regards to question verbiage and survey design was scrutinized with the understanding that given the demographics of the Woodbine community, many of the survey recipients would be elderly or had completed their education at the high school level.

3.4.3 On-Site Analysis

The purpose of the on-site inspection was twofold. The year built, style of home, and size all play a critical role in identifying correlations amongst property characteristics and energy consumption. The on-site analysis provided a verification procedure of the data. The analysis also allowed for further detailed data collection, specifically blower door performance and time period construction practices. Once the homes for the on-site analyses were identified using the systematic sampling procedure described previously, homeowners were sent a letter to allow them the opportunity to participate. Homeowners were given the option to participate and were allowed to schedule an appointment that worked for their schedule. The appendix contains an example of the letter that was sent to the chosen residents one month prior to scheduling.

For the on-site analyses, a systematic approach including a checklist/spreadsheet was designed to insure consistency from home to home. The on-site analysis began with introductions to the homeowner and a brief description of what would be included during the analysis and what they could expect in regards to analysis information and recommendations. A blower door test was performed on each property, so all combustible appliances were shut down to prevent possible back drafting during the pressurization of the home. The homeowners were asked questions regarding the comfort level they perceived in their home. Leaky windows, cold walls, and drafty spots were given extra attention during the analysis. Every home was approached the same, beginning in the basement and working to the top floor. Each floor was examined clockwise to establish a systematic data collection approach.

3.5 Instrumentation

When developing the data analysis portion of the study, it was important to consider the future usefulness, not only for the community of Woodbine, but also on a larger, more broad-based scale. A detailed spreadsheet was developed to allow the gathering of pertinent future use information and in a format that could be duplicated/useful to other researchers across the United States.

3.5.1 BTU/SqFt/DD

The following figure contains the spreadsheet that was used for each of the 480 homes identified as having 36 months of continuous utility usage for the dates January 2008 to December 2010. The spreadsheet created in Microsoft excel analyzed each of the 36 months individually by converting the electricity and natural gas usage into BTU's. The total BTU's were then divided by the square footage of the property provided by the online property assessor database, and finally divided by the total degree days for the given month. What resulted was a single number for each home identifying the BTU/SqFt/DD for the total 36 month period. Once each of the 480 residential properties had been labeled with an individual BTU/SqFt/DD, a ranking from 1 to 480 was developed for data analysis. Due to individual privacy concerns, all 480 homes are not provided in the appendix, but the complete ranking list is available with property addresses replaced with researcher developed account numbers.

FIGURE 3.1: BTU/SqFt/DD Spreadsheet Example

ID#	515790000	Year Built:	1970-1979	Style:	Split-Level	Central Air:	Yes	Average Usage of BTU/SQ.FT:	9,924.95
Address:	Example Only	Square Footage:	864	# of Bathrooms:	1	Assessed Value:	80000-90000	Average BTU/SQ.FT/DD:	35.31
City:	Woodbine, IA 51579	Basement Type:	Full	# of Bedrooms:	2	Rated Condition:	Very Good	Area Rank:	

Month	Kwh Usage	Charge	Cost/ Kwh	CCF Usage	Charge	Cost/ CCF	Water Usage (Gallon)	Charge	Cost/ Gallons	Total Utiltiy Costs	Btu (Elec)	BTU (Gas)	Total BTU Usage	BTU/SQ.FT	CDD	HDD	TDD	BTU/SQ.FT/DD
1/2008	1660	108.28	$0.07	8600	102.25	$1.19	7500	22.63	$0.0030	$233.16	5,663,920	8,832,200	14,496,120	16,777.92	0	1,368	1,368	12.26
2/2008	1700	110.6	$0.07	12000	147.28	$1.23	6300	19.93	$0.0032	$277.81	5,800,400	12,324,000	18,124,400	20,977.31		1,232	1,232	17.03
3/2008	1170	79.86	$0.07	8500	105.35	$1.24	4900	16.78	$0.0034	$201.99	3,992,040	8,729,500	12,721,540	14,724.00		877	877	16.79
4/2008	800	60.5	$0.08	6800	88.38	$1.30	5400	17.9	$0.0033	$166.78	2,729,600	6,983,600	9,713,200	11,242.13	2	526	524	21.45
5/2008	540	44.9	$0.08	4100	47.71	$1.16	5300	17.68	$0.0033	$110.29	1,842,480	4,210,700	6,053,180	7,006.00	30	195	165	42.46
6/2008	750	57.5	$0.08	1900	27.79	$1.46	5100	17.23	$0.0034	$102.52	2,559,000	1,951,300	4,510,300	5,220.25	135	0	135	38.67
7/2008	1150	81.5	$0.07	3000	45.75	$1.53	10000	28.25	$0.0028	$155.50	3,923,800	3,081,000	7,004,800	8,107.41	273	0	273	29.70
8/2008	1340	96.08	$0.07	2500	38.71	$1.55	10600	29.6	$0.0028	$164.39	4,572,080	2,567,500	7,139,580	8,263.40	160	2	158	52.30
9/2008	720	57.64	$0.08	1900	27.79	$1.46	5100	17.23	$0.0034	$102.66	2,456,640	1,951,300	4,407,940	5,101.78	54	109	55	92.76
10/2008	550	47.1	$0.09	2500	30.46	$1.22	5600	18.35	$0.0033	$95.91	1,876,600	2,567,500	4,444,100	5,143.63	17	403	386	13.33
11/2008	540	46.48	$0.09	5800	60.25	$1.04	5100	17.23	$0.0034	$123.96	1,842,480	5,956,600	7,799,080	9,026.71	1	831	830	10.88
12/2008	670	54.54	$0.08	9300	110.28	$1.19	4000	14.75	$0.0037	$179.57	2,286,040	9,551,100	11,837,140	13,700.39	0	1,368	1,368	10.01
1/2009	1390	99.18	$0.07	11400	134.39	$1.18	4600	16.1	$0.0035	$249.67	4,742,680	11,707,800	16,450,480	19,039.91	0	1,454	1,454	13.09
2/2009	850	65.7	$0.08	8900	105.69	$1.19	5000	17	$0.0034	$188.39	2,900,200	9,140,300	12,040,500	13,935.76	0	1,018	1,018	13.69
3/2009	530	45.86	$0.09	9100	107.99	$1.19	4800	16.55	$0.0034	$170.40	1,808,360	9,345,700	11,154,060	12,909.79	0	817	817	15.80
4/2009	600	50.2	$0.08	7200	89.77	$1.25	5500	18.13	$0.0033	$158.10	2,047,200	7,394,400	9,441,600	10,927.78	9	448	439	24.89
5/2009	560	47.72	$0.09	3500	27.24	$0.78	5100	17.23	$0.0034	$92.19	1,910,720	3,594,500	5,505,220	6,371.78	28	162	134	47.55
6/2009	540	46.48	$0.09	1800	15.71	$0.87	6200	19.7	$0.0032	$81.89	1,842,480	1,848,600	3,691,080	4,272.08	127	52	75	56.96
7/2009	1200	87.4	$0.07	1800	15.71	$0.87	4700	16.33	$0.0035	$119.44	4,094,400	1,848,600	5,943,000	6,878.47	70	30	40	171.96
8/2009	970	84.6	$0.09	1900	22.3	$1.17	5000	17	$0.0034	$123.90	3,309,640	1,951,300	5,260,940	6,089.05	94	55	39	156.13
9/2009	810	71.8	$0.09	1800	20.78	$1.15	5100	17.23	$0.0034	$109.81	2,763,720	1,848,600	4,612,320	5,338.33	12	137	125	42.71
10/2009	630	55.32	$0.09	3700	37.16	$1.00	4800	16.55	$0.0034	$109.03	2,149,560	3,799,900	5,949,460	6,885.95	0	685	685	10.05
11/2009	580	52.12	$0.09	5600	58	$1.04	3700	14.08	$0.0038	$124.20	1,978,960	5,751,200	7,730,160	8,946.94	0	678	678	13.20
12/2009	540	49.56	$0.09	8800	89.55	$1.02	1400	8.9	$0.0064	$148.01	1,842,480	9,037,600	10,880,080	12,592.69	0	1,318	1,318	9.55
1/2010	603	53.59	$0.09	11400	125.24	$1.10	2900	15.7	$0.0054	$194.53	2,057,436	11,707,800	13,765,236	15,931.99	0	1,602	1,602	9.95
2/2010	1357	101.85	$0.08	11200	119.2	$1.06	1000	10	$0.0100	$231.05	4,630,084	11,502,400	16,132,484	18,671.86	0	1,313	1,313	14.22
3/2010	630	55.32	$0.09	8400	89.88	$1.07	1700	12.1	$0.0071	$157.30	2,149,560	8,626,800	10,776,360	12,472.64	0	863	863	14.45
4/2010	580	52.12	$0.09	5000	56.69	$1.13	2200	13.6	$0.0062	$122.41	1,978,960	5,135,000	7,113,960	8,233.75	2	349	347	23.73
5/2010	590	52.76	$0.09	3700	39.82	$1.08	2600	14.8	$0.0057	$107.38	2,013,080	3,799,900	5,812,980	6,727.99	52	266	214	31.44
6/2010	910	79.8	$0.09	1800	22.46	$1.25	2400	14.2	$0.0059	$116.46	3,104,920	1,848,600	4,953,520	5,733.24	2	141	139	41.25
7/2010	1140	98.2	$0.09	1700	22.29	$1.31	2600	14.8	$0.0057	$135.29	3,889,680	1,745,900	5,635,580	6,522.66	154	0	154	42.35
8/2010	1450	128.35	$0.09	1900	24.45	$1.29	2900	15.7	$0.0054	$168.50	4,947,400	1,951,300	6,898,700	7,984.61	322	0	322	24.80
9/2010	930	85.19	$0.09	1700	21.79	$1.28	2600	14.8	$0.0057	$121.78	3,173,160	1,745,900	4,919,060	5,693.36	53	116	63	90.37
10/2010	680	61.56	$0.09	2600	28.61	$1.10	3000	16	$0.0053	$106.17	2,320,160	2,670,200	4,990,360	5,775.88	13	287	274	21.08
11/2010	610	56.87	$0.09	5000	51.5	$1.03	2700	15.1	$0.0056	$123.47	2,081,320	5,135,000	7,216,320	8,352.22	0	759	759	11.00
12/2010	880	74.96	$0.09	10300	103.78	$1.01	2800	15.4	$0.0055	$194.14	3,002,560	10,578,100	13,580,660	15,718.36	0	1,181	1,181	13.31

3.5.2 Homeowner Perceptions Survey

The survey and consent form were designed specifically for this research project by the individual researcher. The consent form and survey were approved by the University of Nebraska Internal Review Board. Both forms were delivered along with the May monthly utility bill and returned either with the payment or in person to the Woodbine Municipal Utility office. The office was given a lockbox provided by the researcher for the completed surveys to be placed in. For privacy reasons, the researcher was the only person allowed to see the completed surveys.

3.5.3 On-Site Analysis

The data collection spreadsheet that was utilized during the on-site visit can be found in the following figure. Of most importance on the spreadsheet are the volumes of air and blower door readings that assess the air exchanges per hour of each home. Also identified by this data collection spreadsheet were habitual practices, specifically conditioned air temperature settings.

FIGURE 3.2: On-Site Analysis Checklist

Property Address:			
Date of Audit:	Time:	Temperature:	Climate:

1 OCCUPANCY NUMBER		

2 HOUSE VOLUME		
Ceiling Height 1st		
Ceiling Height 2nd		
Ceiling Height Finished Basement		
Finished Basement Ft^2		

3 LIGHT BULBS	
Total # of Bulbs	
Special Bulbs	
Total # of Bulbs to replace	
Total # of Recessed Lighting	
Man Hours Required	

4 ATTIC	
Access *	
R-Value (Current)	
Penetrations *	
Additional Cellulose Needed (Inches)	
0 3 10	
Insulation ft2 required	
Radiant Barrier Needed (Sq Ft)	
Man Hours Required	

5 ENVELOPE	
Windows (Total #)	
Single-Glazed Windows (#)	
Window Quality *	
Approx. Window Area (Ft^2 Each)	
Doors (Total #)	
Storm Doors Needed (#)	
Approx. Door Area (Ft^2 Each)	
Basic Construction *	
Existing Wall Insulation *	
Type of Wall Insulation, if existing	
Siding *	
Cavity Depth	
Windows & Doors (Ft^2)	
Linear Ft of Walls for Foam	
Height of Walls	
Foam Required (Ft^2)	

6 BLOWER DOOR	
Volume	
Door Used	
AC50 (Air Change @ 50)	
Measured CFM(Avg.= 4000)	
Estimated CFM **After** (Avg. = 2500)	
Leakage (Ft^2)	
AC50 (After)	
Man-Hours Required (Number)	

7 THERMOSTATS	
Primary Thermostat Quality *	
Location *	
Second T-Stat Quality *	
Location *	
Average Summer F°	
Average Winter F°	
Man Hours Required	

8 FURNACE and AC		
Type / Fuel		
Age (Years)		
BTUh Output		
Cooling Tons		
Efficiency Rating *		
Filter size (L x W x Thickness)		
Replace *		
Outside A/C Unit Quality *		

9 DUCTWORK	
Uninsulated Attic (LF of ducts)	
Uninsulated Ducts (LF)	
Man Hours Required	

10 H_2O Heater	
Type (Fuel) *	
Gallons	
BTUh (Omit Commas)	
Replace	
Insulate 6' of pipe	
Man hours required	

11 BASEMENT	
Crawlspace Insulation Required? *	
Linear Feet, Perimeter	
Height of crawl to floor	
Total Area to be Insulated	
Square Feet, Crawl Area (L x W)	
6 Mil Poly to Cover Floor	
Sill Insulation Required? *	
Linear feet, caulk and batts	
Man-Hours Required (Number)	

13 APPLIANCES	
Refrigerator (Year Installed)	
Dryer (Fuel) *	
Range (Fuel) *	
Washer (Year Installed) *	
Freezer (Year Installed) *	
Extra Appliance *	
Install Media Smart Strip? #:	
Install Computer Smart Strip? #:	

NOTES:

3.5.3.1 Blower Door Use

Focusing intently on replication of process, this research used the blower door methodology outlined by the Building Science Corp as well as the Minneapolis Blower Door manufacturer and blower door provider. The Energy Conservatory standards were comprised to conform to the Canadian General Standards Board standard CGSB-149.10-M86 as well as the American Society for Testing and Materials (ASTM) standard E779-87. Prior to installing and operating the blower door, the researcher was trained by a professional energy auditor on the safety and requirements of the Model 3 Minneapolis Blower Door used for this project. Specifically, the following steps were taken on every property measurement to insure accuracy and safety of the property and researcher.

- Close all storm and prime windows
- Close all exterior doors and interior attic or crawlspace hatches which are connected to conditioned spaces.
- Open all interior doors to rooms that are conditioned.
- Adjust all combustion appliances so they do not turn on during the test.
- Be sure that fires in fireplaces and woodstoves are completely out. Take precautions to prevent ashes from being sucked into the building during the test.
- Turn off all exhaust fans, vented dryers, air conditioners, ventilation system fans and air handler fans.
- Blower door location priority was front door, back door, and if necessary garage door.
- Measurements were tested using DG-700 One-Point test @ 50 CFM

3.6 Data Analysis

3.6.1 BTU/SqFt/DD

The following data analysis techniques were used to explain the calculations contained in the initial BTU/SqFt/DD spreadsheet as well as the methods for analyzing correlations regarding housing characteristics/demographics and energy usage.

3.6.1.1 BTU/SqFt/DD Spreadsheet

A British Thermal Unit, or BTU, is the most widely used form of measuring an energy source. Energy can be provided by a variety of sources, so the conversion of said given source to a BTU allows researchers to compare differing sources commonly. The energy sources for the Woodbine project were provided in kilowatts for electricity and CCF's for natural gas.

The conversion for kilowatts to BTU's used was:

1 kWh = 3,412 BTU

The conversion for CCFs to BTU's used was:

1 CCF = 102,700 BTU

3.6.1.2 BTU/SqFt/DD and Assessor Data Correlations

A dataset consisting of 480 cases was used for the analysis. The main statistical tool used is multiple regression analysis, together with the stepwise regression in case that some variables did not contribute significantly to the model and needed to be removed. The variables that were included as possible predictors are:

- Assessed Value
- Style
- Condition

- Year Built

The variables were chosen based on their identifiable distinctions within the Beacon Assessor Data as well as their influence to effect household energy consumption. All these variables are coded as categorical variables, but assessed value and year built are interval variables in nature. Year built essentially corresponds to the number of (integer) decades since 1900, and Assessed value is the floor number of tens of thousands of dollars. The variables *Condition* and *Style* are categorical in nature, and they require to be dealt with using dummy variables. Condition has 6 categories, so 5 dummy variables were used (*Very Poor, Poor, Average, Good, and Very Good*) where *Excellent* was the baseline. On the other hand, Style has 6 categories, so 5 dummy variables will be used (*Single Story, OnePointFiveStory, Two-story, Split-Level, and Mobile Home*) where *Other* is used as the baseline. The formula to predict variable influence on energy consumption the multiple regression model is defined below. Where y is the average BTU/SQFT/DD and x is the identifiable variables chosen. The residual ε_i is assumed to be a normal random variable with mean zero and variance σ^2.

$$y_i = a_1x_{i1} + a_2\, x_{i2} + a_3x_{i3} + \ldots\, a_nx_{in} + \varepsilon_i$$

3.6.2 Homeowner Perceptions Survey

The residents' energy perceptions survey was developed not only for this research project, but for future research projects as well as for a glimpse of overall community perceptions. For this specific project, the questions used for individual usage comparisons of interest were:

- Question 10: How much do you feel your living habits contribute to your overall utility cost?

- Question 11: Have you done anything in the past 12 months to make it more energy efficient?
- Question 14: Have you changed your habits (turning down the thermostat, using less water, opening windows, etc.) in the past 12 months to help lower your utility bills?

To compare the results of these questions to the overall ranking list provided by the BTU/SqFt/DD analysis, the survey results for 92 return participants were coded as positive or negative. For question 10, participants were given 4 responses: "a lot, some, a little, none". Responses *A lot* and *Some* were coded as positive, responses *A little* and *None* were coded as negative. For questions 11 and 14, respondents were given a choice of either *Yes* or *No*. For this research comparison, "Yes" was coded as positive, and "No" was coded as negative. A multiple regression correlation analysis was run to determine the effects of homeowner habits and actual energy usage.

3.6.3 On-Site Analysis

A majority of the data collected during the on-site inspection was to verify the data previously collected by the assessor's data base. To analyze the blower door readings and overall home energy use a linear regression analysis was used. To assist the property resident in identifying their energy use and possible improvements a written report was provided by the researcher. As part of the written report, the air exchanges per hour were explained. The air exchanges per hour for home was calculated using the blower door reading along with the following:

<u>FIGURE 3.3: Air Change per Hour at 50 Pascals (ACH50) Formula:</u>

$$ACH50 = \frac{CFM50 \times 60}{\text{Building Volume (cubic feet)}}$$

3.7 Ethical Considerations

Careful consideration was given in regards to the ethical and accurate findings of this research. While acknowledged by the University Internal Review board as a "low ethical risk", the researcher acknowledges the small but possible conflict of interest of this project. Having been a resident of Woodbine prior to the year 2000, there was the possibility of survey results carrying with them a weighted positive view of homeowner energy perceptions. It should be noted that all of the on-site audits were performed on properties in which the researcher had no relationship or familiarity with. It is the researcher's opinion that the slight conflict of interest did not influence the scientific results of the research project. Other than the survey data collected, all other data is considered hard scientific data that is void of any opinion or relationship influences.

CHAPTER IV

RESULTS AND RESEARCH FINDINGS

4.1 Intent of Data Analysis

The purpose of this project was to construct of a quantitative model to estimate energy consumption, measured in BTU/SQFT/DD. Various predictors were used as possible drivers of the variation in energy consumption, based on a dataset containing 480 valid cases.

4.1.1 BTU/SqFt/DD Analysis

The intent of the BTU/SqFt/DD analysis was to establish a ranking system of actual historical energy consumption to compare to residence characteristics. The overlying issue to be addressed was to identify any characteristic similarities that led to overall energy consumption patterns. There was a 0% dropout rate for the initial BTU/SqFt/DD analysis or otherwise stated, of all of the qualifying participants, no property owner refused to have their home analyzed.

4.1.2 Homeowner Perceptions Survey

Understanding that homeowner habits play an important role in energy consumption, the perception survey looked to address direct opinions of positive or negative habits and actual historical energy consumption. Phase II of the Woodbine Project continues the scientific community's research on residential habits and sustained energy conservation. This research project had a 20% return rate of surveys making the results scientifically valid.

4.1.3 On-Site Analysis

As stated previously, the on-site analysis provided an opportunity for verification of property assessor data. The specific data analysis for the on-site analysis focused directly on the building envelope and calculating specific home's air exchanges per hour. The research objective addressed during this analysis phase strived to determine a direct link or correlation between building envelope performance and overall energy consumption. The opportunity for an on-site analysis was refused by 17% of selected participants.

4.2 Data Inputs and Tables

4.2.1 BTU/SqFt/DD Ranking

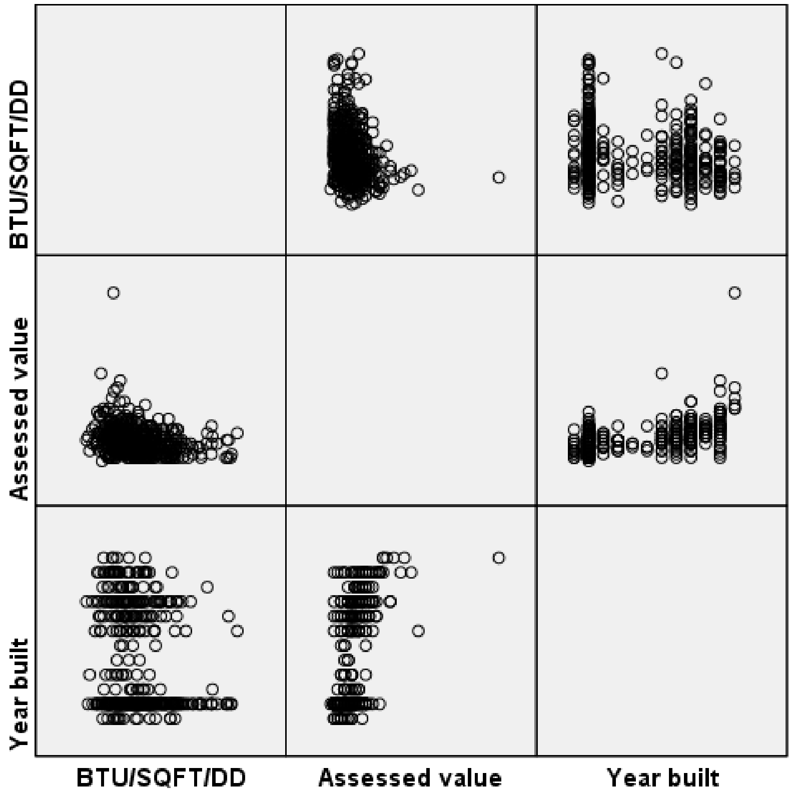
The individual BTU/SqFt/DD spreadsheet for each of the 480 residences resulted in a completed list of energy consumers rated from best to worst. The median BTU/SqFt/DD number for the community of Woodbine was a rating of 21.75. The completed table shown in the appendix includes the individual home characteristics acquired by the assessor online database.

4.2.1.1 Correlation Analysis

In the following paragraphs the results of a multiple regression analysis are presented, starting with an attempt of using the full model, and then using stepwise regression to drop the redundant variables. The statistical analysis tool SPSS was used for all data input calculations.

First, the following correlation matrix and scatterplot of energy consumption and the two interval predictors Assessed Value and Year:

Figure 4.1 Scatterplot of Assessed Value and Year Built



Based on the scatterplot, a rather weak association exists between the variables. The effect size of the association is rather low.

The following correlation matrix is obtained:

Figure 4.2 Correlation Matrix of Variables

Correlations

		BTU/SQFT/DD	Assessed value	Year built
BTU/SQFT/DD	Pearson Correlation	1	-.238**	-.166**
	Sig. (2-tailed)		.000	.000
	N	480	480	480
Assessed value	Pearson Correlation	-.238**	1	.582**
	Sig. (2-tailed)	.000		.000
	N	480	480	480
Year built	Pearson Correlation	-.166**	.582**	1
	Sig. (2-tailed)	.000	.000	
	N	480	480	480

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation between energy consumption and both Assess Value and Year Built is significant and negative, as it was also observed in the scatterplot, the strength of the association is quite weak.

4.2.1.2 Multiple Regression Analysis

The following multiple regression results were obtained:

Figure 4.3 Multiple Regression Analysis Calculations

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.323[a]	.104	.081	8.64273

a. Predictors: (Constant), OnePointHalfStory, Average, SplitLevel, VeryPoor, MobileHome, TwoStory, Assessed value, Good, VeryGood, Year built, Condition, Style

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4051.301	12	337.608	4.520	.000[a]
	Residual	34883.371	467	74.697		
	Total	38934.672	479			

a. Predictors: (Constant), OnePointHalfStory, Average, SplitLevel, VeryPoor, MobileHome, TwoStory, Assessed value, Good, VeryGood, Year built, Condition, Style

b. Dependent Variable: BTU/SQFT/DD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	26.412	1.793		14.732	.000
	Assessed value	-.314	.143	-.145	-2.194	.029
	Style	.497	1.032	.044	.481	.630
	Condition	-.233	.497	-.033	-.469	.640
	Year built	-.361	.154	-.140	-2.339	.020
	VeryPoor	.171	3.689	.002	.046	.963
	Average	.170	1.034	.009	.165	.869
	Good	.276	1.223	.012	.225	.822
	VeryGood	.274	1.432	.012	.191	.848
	TwoStory	-5.778	2.682	-.158	-2.154	.032
	SplitLevel	7.121	4.327	.101	1.646	.100
	MobileHome	-.846	7.305	-.006	-.116	.908
	OnePointHalfStory	-3.971	1.522	-.168	-2.609	.009

a. Dependent Variable: BTU/SQFT/DD

Based on the model obtained above, the linear regression model is significant overall, $F(12, 467) = 4.520, p < .001$. But in spite of the fact that the model is significant, it explains only 8.1% of the variation in Energy Consumption. Observe that several predictors are not individually significant, which suggests that some predictors are not useful for the model. The next step was to perform a stepwise regression.

4.2.1.3 Stepwise Regression Analysis

The following stepwise regression results are obtained:

Figure 4.4 Stepwise Regression Analysis Calculations

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.238[a]	.057	.055	8.76471
2	.267[b]	.071	.067	8.70714
3	.302[c]	.091	.085	8.62299
4	.315[d]	.099	.091	8.59374

a. Predictors: (Constant), Assessed value

b. Predictors: (Constant), Assessed value, SplitLevel

c. Predictors: (Constant), Assessed value, SplitLevel, SingleStory

d. Predictors: (Constant), Assessed value, SplitLevel, SingleStory, Year built

ANOVA[e]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2214.682	1	2214.682	28.829	.000[a]
	Residual	36719.990	478	76.820		
	Total	38934.672	479			
2	Regression	2771.253	2	1385.627	18.277	.000[b]
	Residual	36163.419	477	75.814		
	Total	38934.672	479			
3	Regression	3541.250	3	1180.417	15.875	.000[c]
	Residual	35393.422	476	74.356		
	Total	38934.672	479			
4	Regression	3854.782	4	963.696	13.049	.000[d]
	Residual	35079.890	475	73.852		
	Total	38934.672	479			

a. Predictors: (Constant), Assessed value

b. Predictors: (Constant), Assessed value, SplitLevel

c. Predictors: (Constant), Assessed value, SplitLevel, SingleStory

d. Predictors: (Constant), Assessed value, SplitLevel, SingleStory, Year built

e. Dependent Variable: BTU/SQFT/DD

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	25.729	.843		30.534	.000		
	Assessed value	-.517	.096	-.238	-5.369	.000	1.000	1.000
2	(Constant)	25.748	.837		30.758	.000		
	Assessed value	-.538	.096	-.248	-5.604	.000	.994	1.006
	SplitLevel	8.438	3.114	.120	2.709	.007	.994	1.006
3	(Constant)	23.643	1.056		22.389	.000		
	Assessed value	-.547	.095	-.252	-5.754	.000	.993	1.007
	SplitLevel	10.639	3.159	.151	3.368	.001	.947	1.056
	SingleStory	2.927	.909	.144	3.218	.001	.953	1.049
4	(Constant)	23.257	1.069		21.756	.000		
	Assessed value	-.406	.117	-.187	-3.466	.001	.651	1.537
	SplitLevel	11.993	3.216	.170	3.729	.000	.908	1.102
	SingleStory	3.414	.937	.168	3.644	.000	.892	1.121
	Year built	-.298	.144	-.115	-2.060	.040	.605	1.652

a. Dependent Variable: BTU/SQFT/DD

The best test model obtained includes only the following predictors: Assessed Value, Split Level, Single Story and Year Built. This model is significant overall, $F(4, 475) = 13.049$, $p < .001$, and it explains 9.1% of the variation in Energy Consumption.

The model is

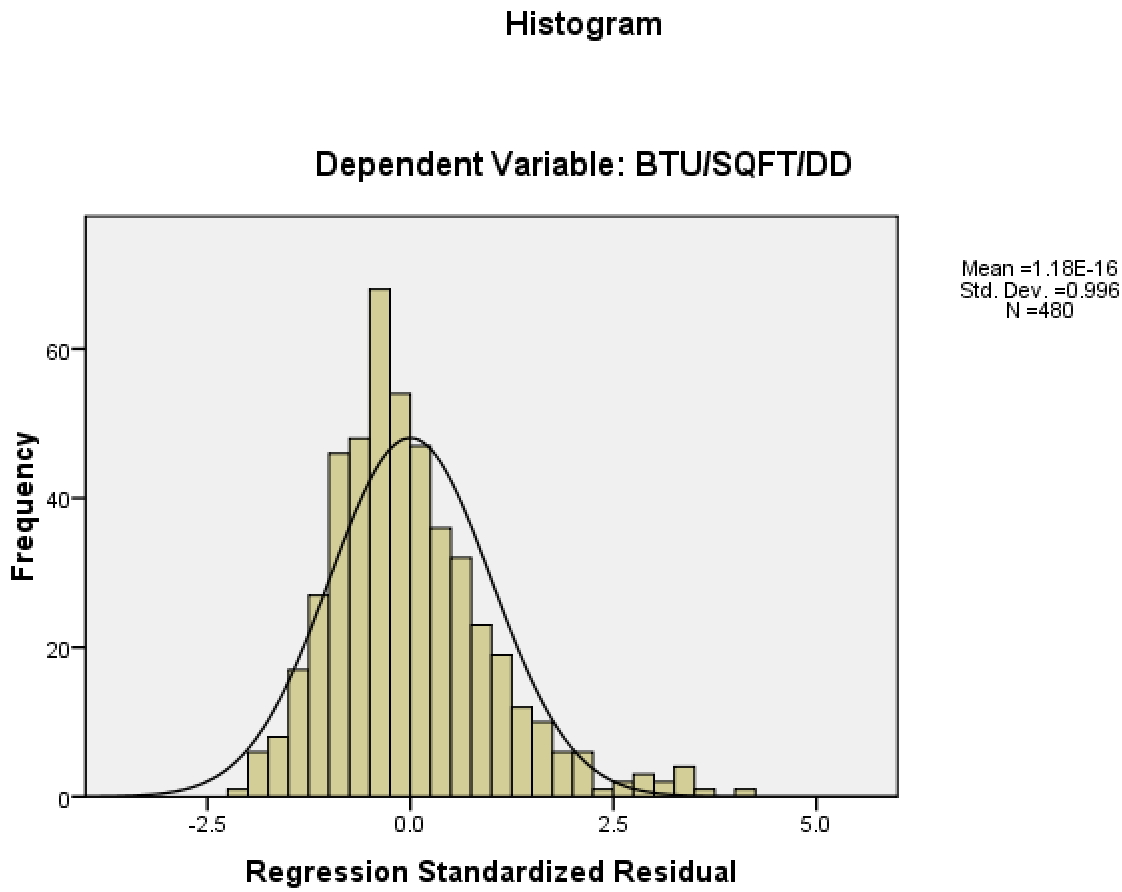
Energy Consumption = 23.257 – 0.406*Assessed Value + 11.993*Split Level + 3.414*Single Story – 0.298*Year Built

This model indicates that the variable Condition has no significant effect on energy consumption. In terms of the variable Style, only Split level and Single Story differ significantly from the baseline (Other). For an extra $10,000 of assessed value, the energy consumption decreases by 0.406 units on average. For extra 10 years of age, the energy consumption decreases 0.298 on average. Split level properties have a mean energy consumption that is 11.993 units higher than that of Other properties. Also, Single Stories properties have a mean energy consumption that is 3.414 units higher than that of Other properties.

4.2.1.4 Residuals Analysis

The following residual plots were obtained:

Figure 4.5 Histogram of Residuals



The histogram of residuals shows that the distribution appears to the relatively right-skewed.

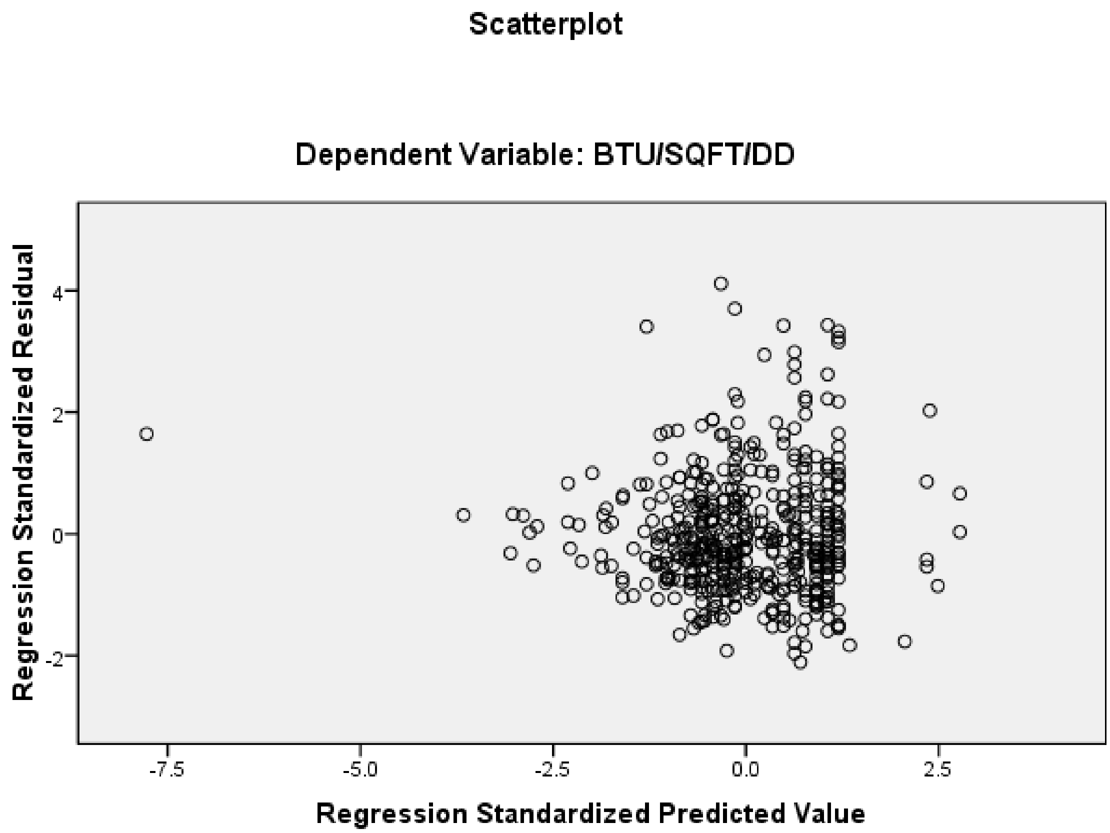
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Standardized Residual	.076	480	.000	.947	480	.000

a. Lilliefors Significance Correction

The normality test shows that the normality assumption is violated, $p < .001$.

<u>Figure 4.6 Scatterplot of Variables</u>



The plot above shows a clear "fanning-out" pattern, which indicates a clear heteroskedasticity problem. Based on the residual plots, some transformations could be attempted to satisfy the regression assumptions, but are not necessary for this research project.

4.2.2 Homeowner Perceptions Survey Results

92 of 480 administered surveys were completed in full given a return rate of just under 20%. The completed surveys were a representative sample of the population and provided results that meet the required margin of error, confidence level, and statistical power. The statistical calculations used the following:

- margin of error: 5%

- Confidence level: 95%
- Response distribution: 50%
- Power level: .8

The sample size or return of completed surveys for a statistically valid analysis resulted in n = 82. To assist in visually understanding the survey results, pie charts were prepared for each of the 20 questions on the survey.

While the survey provided overall information in regards to homeowner and community perceptions of the movement towards sustainability and renewable energy usage, questions 10 and 14 were specifically designed to investigate the effects of positive or negative homeowner perceptions on actual energy use.

4.2.2.1 Question 10: How much do you feel your living habits contribute to your overall utility costs?

Of the 92 completed surveys, 64 of those had a positive response indicating either “A lot” or “Some” in regards to Question 10. Of those 64 analyzed, 48 (or 75%) of the respondents had an actual BTU/SqFt/DD that fell in the lower 50% of the entire Woodbine community. The results from question 10 indicate that recognizing living habits on overall utility costs has an influence on sustainable lower energy usage over a 3 year period.

Solution: The following table shows the corresponding contingency table:

0bserved	Positive Response	Negative Response	Total
Lower 50%	48	9	57
Upper 50%	16	19	35
Total	64	28	92

The following null and alternative hypotheses were tested:

$$H_0: \text{ Response to Q10 and Energy usage are independent}$$
$$H_A: \text{ Response to Q10 and Energy usage are NOT independent}$$

From the table above the expected values were computed.

Expected	Positive Response	Negative Response
Lower 50%	39.6522	17.3478
Upper 50%	24.3478	10.6522

The way those expected frequencies are calculated is shown below:

$$E_{1,1} = \frac{R_1 \times C_1}{T} = \frac{57 \times 64}{92} = 39.6522, \quad E_{1,2} = \frac{R_1 \times C_2}{T} = \frac{57 \times 28}{92} = 17.3478, \quad E_{2,1} = \frac{R_2 \times C_1}{T} = \frac{35 \times 64}{92} = 24.3478$$

$$, \quad E_{2,2} = \frac{R_2 \times C_2}{T} = \frac{35 \times 28}{92} = 10.6522$$

Finally, the formula $\frac{(O-E)^2}{E}$ was used to get:

(fo - fe)²/fe	Positive Response	Negative Response
Lower 50%	1.7574	4.017
Upper 50%	2.8621	6.542

The calculations required are shown below:

$$\frac{(48-39.6522)^2}{39.6522} = 1.7574, \quad \frac{(9-17.3478)^2}{17.3478} = 4.017, \quad \frac{(16-24.3478)^2}{24.3478} = 2.8621, \quad \frac{(19-10.6522)^2}{10.6522} = 6.542$$

Hence, the value of Chi-Square statistics is

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 1.7574 + 4.017 + 2.8621 + 6.542 = 15.179$$

The critical Chi-Square value for $\alpha = 0.05$ and $(2-1)\times(2-1) = 1$ degrees of freedom is

$\chi_C^2 = 3.841$. Since $\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 15.179 > \chi_C^2 = 3.841$, then the null hypothesis is

rejected, which means that there is enough evidence to reject the null hypothesis of independence.

4.2.2.2 Question 14: Have you changed your habits in the past 12 months to help lower your utility bills?

Of the 92 completed surveys, 57 respondents recognized some habitual changes to help lower their utility bills. Of the 57 positive responses, 41 (or 72%) had an actual BTU/SqFt/DD that fell in the lower 50% of the entire Woodbine community. The results from question 14 would also indicate that consciously thinking about positive energy habits has a positive effect on lowering energy consumption.

Solution: The following table shows the corresponding contingency table:

0bserved	Positive Response	Negative Response	Total
Lower 50%	41	14	55
Upper 50%	16	21	37
Total	**57**	**35**	**92**

The following null and alternative hypotheses were tested:

H_0 : Response to Q14 and Energy usage are independent
H_A : Response to Q14 and Energy usage are NOT independent

From the table above the expected values were computed:

Expected	Positive Response	Negative Response
Lower 50%	34.0761	20.9239
Upper 50%	22.9239	14.0761

The way those expected frequencies are calculated is shown below:

$$E_{1,1} = \frac{R_1 \times C_1}{T} = \frac{55 \times 57}{92} = 34.0761, \quad E_{1,2} = \frac{R_1 \times C_2}{T} = \frac{55 \times 35}{92} = 20.9239, \quad E_{2,1} = \frac{R_2 \times C_1}{T} = \frac{37 \times 57}{92} = 22.9239$$

$$, \quad E_{2,2} = \frac{R_2 \times C_2}{T} = \frac{37 \times 35}{92} = 14.0761$$

Finally, the formula $\frac{(O-E)^2}{E}$ was used to get:

(fo - fe)²/fe	Positive Response	Negative Response
Lower 50%	1.4069	2.2912
Upper 50%	2.0913	3.4058

The calculations required are shown below:

$$\frac{(41-34.0761)^2}{34.0761} = 1.4069, \quad \frac{(14-20.9239)^2}{20.9239} = 2.2912, \quad \frac{(16-22.9239)^2}{22.9239} = 2.0913$$

$$, \quad \frac{(21-14.0761)^2}{14.0761} = 3.4058$$

Hence, the value of Chi-Square statistics is

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}} = 1.4069 + 2.2912 + 2.0913 + 3.4058 = 9.195$$

The critical Chi-Square value for $\alpha = 0.05$ and $(2-1)\times(2-1)=1$ degrees of freedom is $\chi_C^2 = 3.841$. Since $\chi^2 = \sum \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} = 9.195 > \chi_C^2 = 3.841$, then the null hypothesis is rejected, which means that there is enough evidence to reject the null hypothesis of independence.

4.2.2.3 Positive responses to both Question 10 and Question 14

Of the 92 completed surveys, 40 surveys indicated positive responses for both questions 10 as well as question 14. Of the 40, 28 of were identified in the lower BTU/SqFt/DD of the entire Woodbine community. With the 70% finding, all indicators would confirm that homeowner perception has an influence on energy consumption over a 3 year period.

Solution: The following table shows the corresponding contingency table:

0bserved	Positive Response to both	Negative response to at least one	Total
Lower 50%	28	29	57
Upper 50%	12	21	33
Total	**40**	**50**	**90**

The following null and alternative hypotheses were tested:

H_0 : Response to Q10 and Q14 and Energy usage are independent
H_A : Response to Q10 and Q14 and Energy usage are NOT independent

From the table above the expected values were computed:

Expected	Positive Response to both	Negative response to at least one
Lower 50%	25.3333	31.6667
Upper 50%	14.6667	18.3333

The way those expected frequencies are calculated is shown below:

$$E_{1,1} = \frac{R_1 \times C_1}{T} = \frac{57 \times 40}{90} = 25.3333, \quad E_{1,2} = \frac{R_1 \times C_2}{T} = \frac{57 \times 50}{90} = 31.6667, \quad E_{2,1} = \frac{R_2 \times C_1}{T} = \frac{33 \times 40}{90} = 14.6667$$

$$, \quad E_{2,2} = \frac{R_2 \times C_2}{T} = \frac{33 \times 50}{90} = 18.3333$$

Finally, the formula $\frac{(O-E)^2}{E}$ was used to get:

(fo - fe)²/fe	Positive Response to both	Negative response to at least one
Lower 50%	0.2807	0.2246
Upper 50%	0.4848	0.3879

The calculations required are shown below:

$$\frac{(28-25.3333)^2}{25.3333} = 0.2807, \quad \frac{(29-31.6667)^2}{31.6667} = 0.2246, \quad \frac{(12-14.6667)^2}{14.6667} = 0.4848$$

$$, \quad \frac{(21-18.3333)^2}{18.3333} = 0.3879$$

Hence, the value of Chi-Square statistics is

$$\chi^2 = \sum \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} = 0.2807 + 0.2246 + 0.4848 + 0.3879 = 1.378$$

The critical Chi-Square value for $\alpha = 0.05$ and $\left(2-1\right)\times\left(2-1\right) = 1$ degrees of freedom is $\chi_C^2 = 3.841$. Since $\chi^2 = \sum \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} = 1.378 < \chi_C^2 = 3.841$, then the findings fail to reject the null hypothesis, which means that there is not enough evidence to reject the null hypothesis of independence.

Individual responses for each of the survey questions have been developed into a pie chart for ease of interpretation. The complete survey data can be found in the appendix of the research project.

FIGURE 4.7: Homeowner Perceptions Survey Question 7

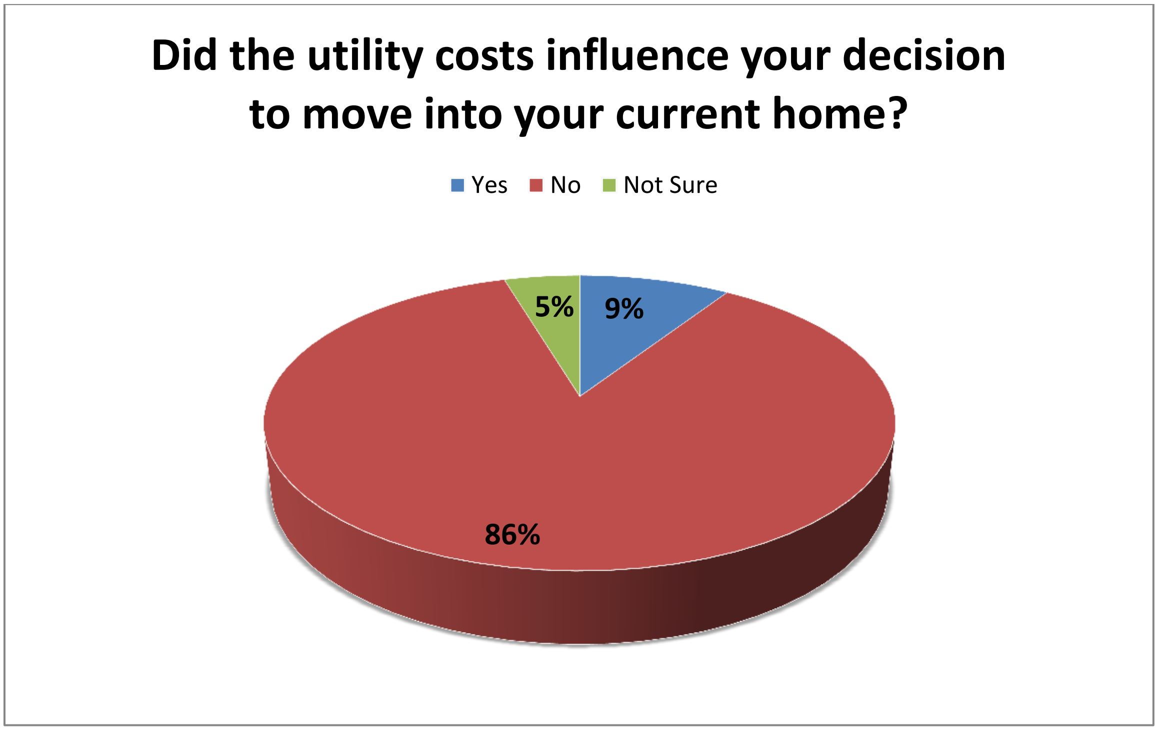


FIGURE 4.8: Homeowner Perceptions Survey Question 8

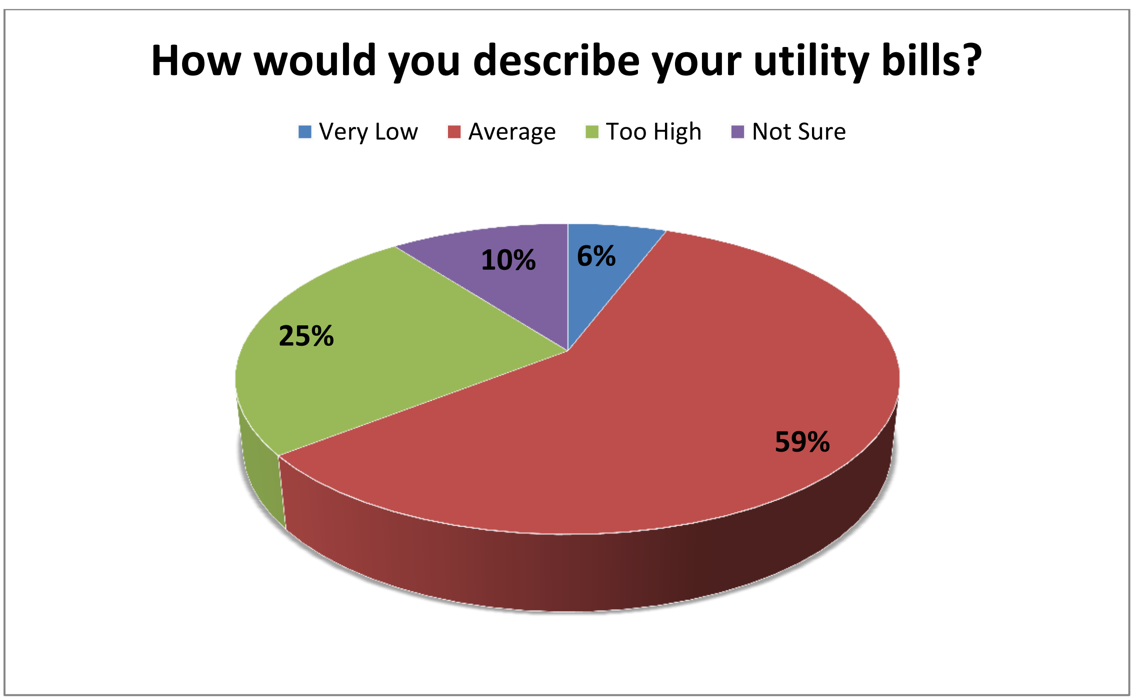


FIGURE 4.9: Homeowner Perceptions Survey Question 9

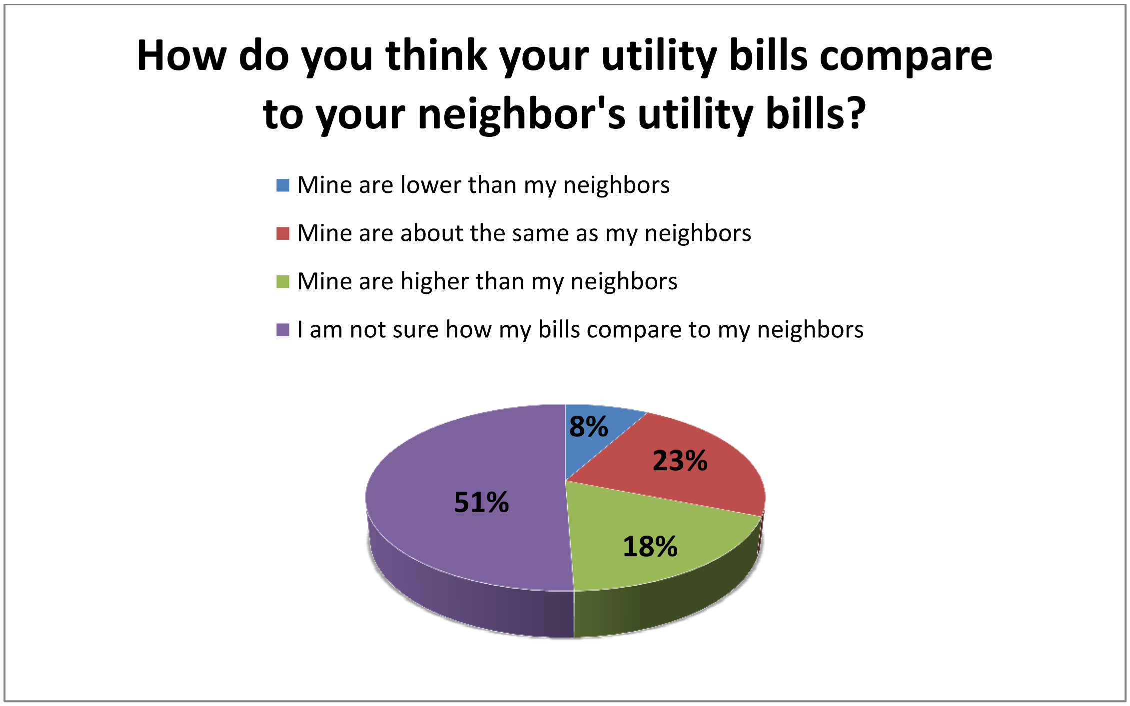


FIGURE 4.10: Homeowner Perceptions Survey Question 10

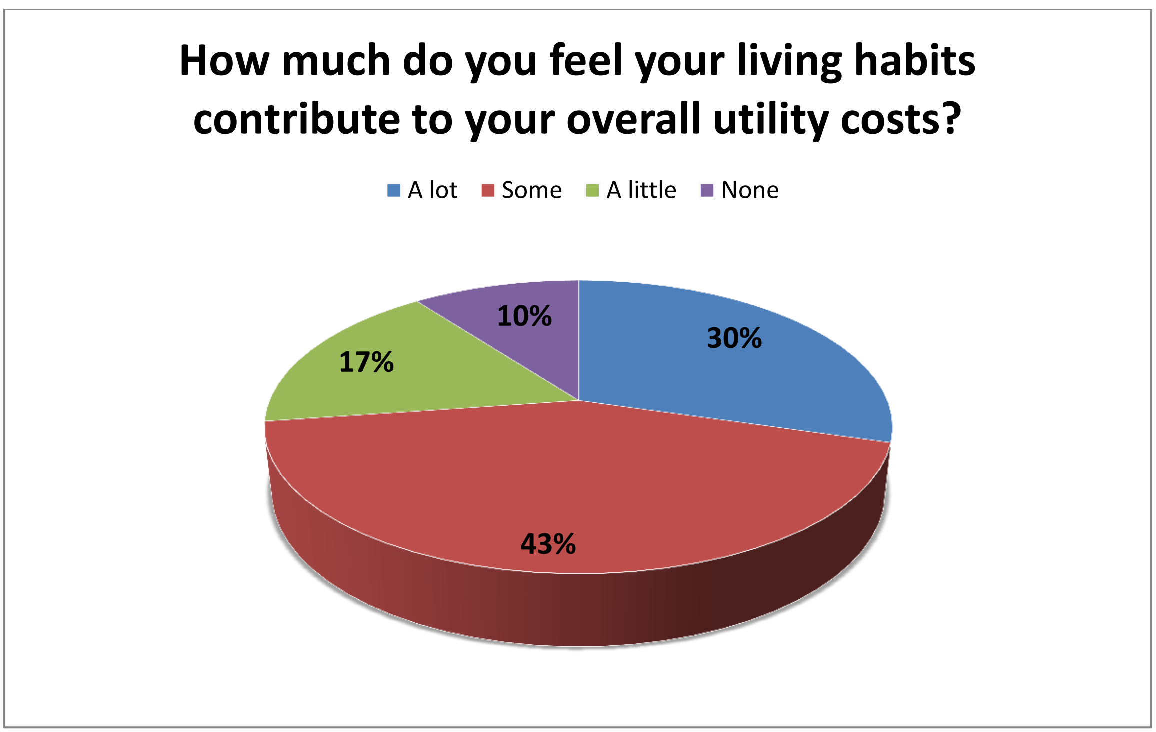


FIGURE 4.11: Homeowner Perceptions Survey Question 11

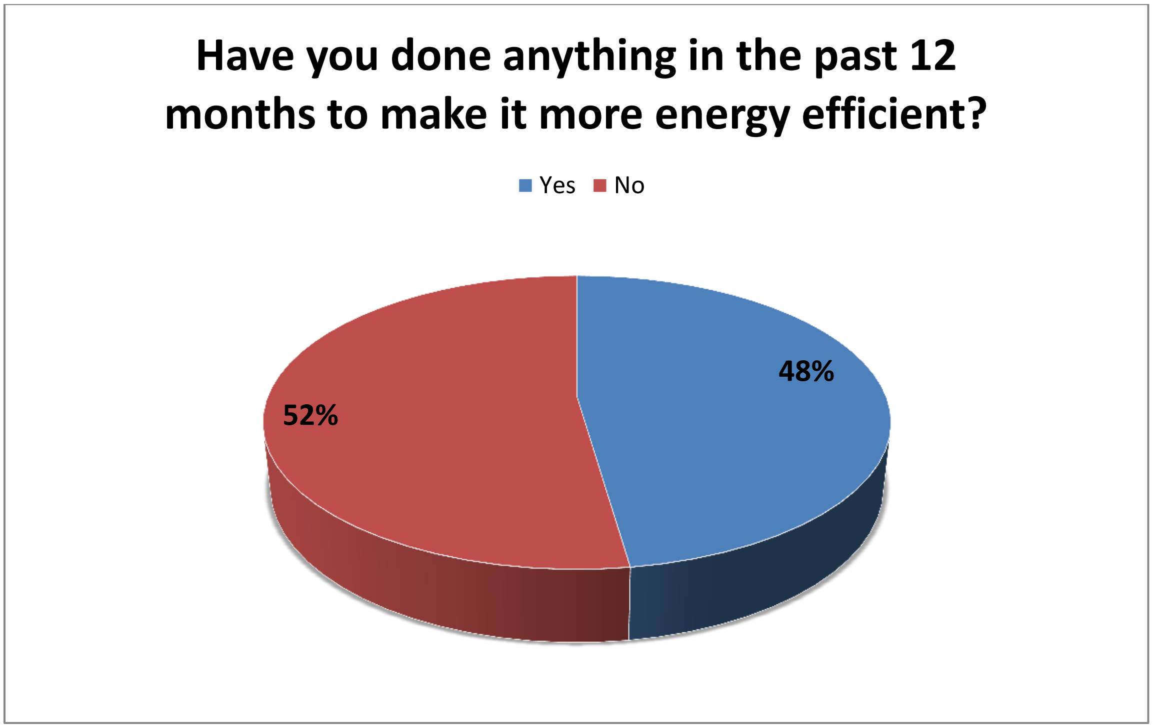


FIGURE 4.12: Homeowner Perceptions Survey Question 11A

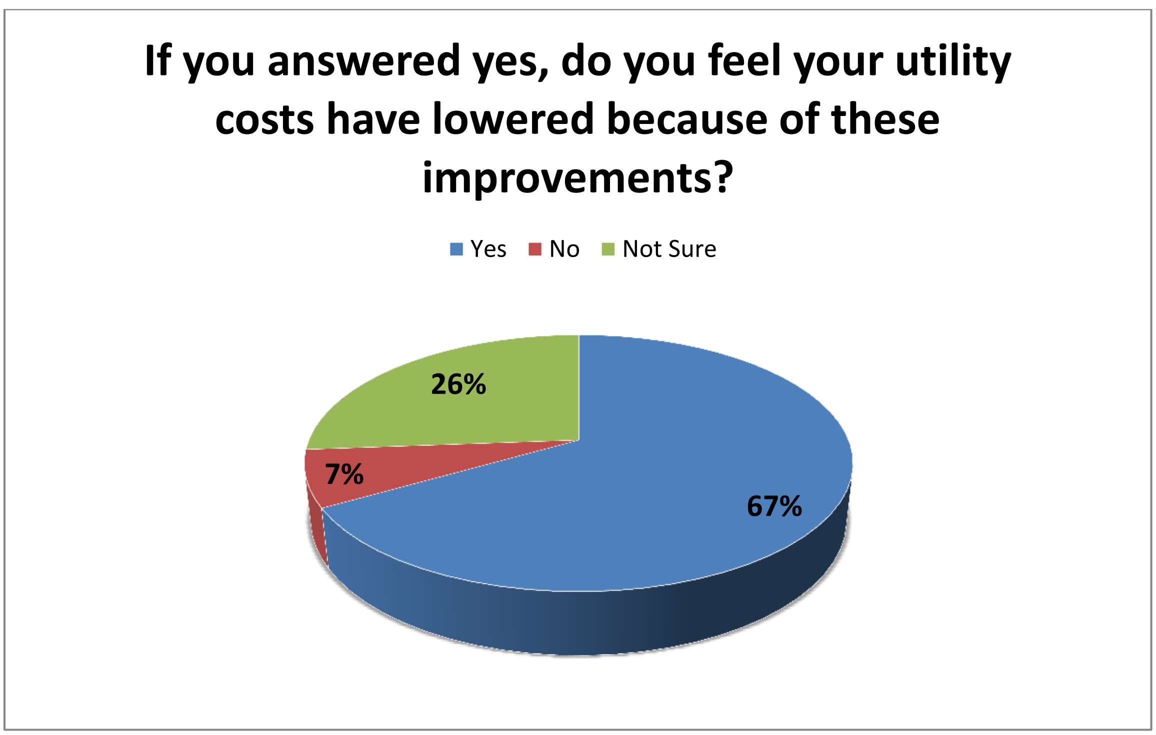


FIGURE 4.13: Homeowner Perceptions Survey Question 12

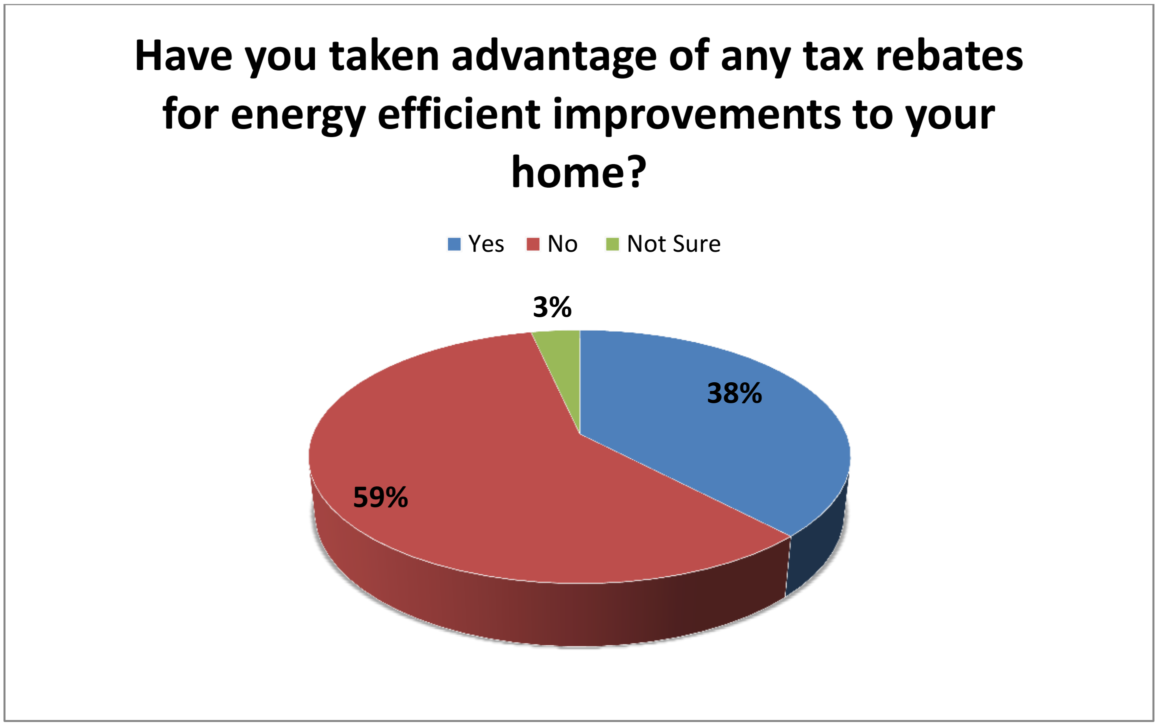


FIGURE 4.14: Homeowner Perceptions Survey Question 13

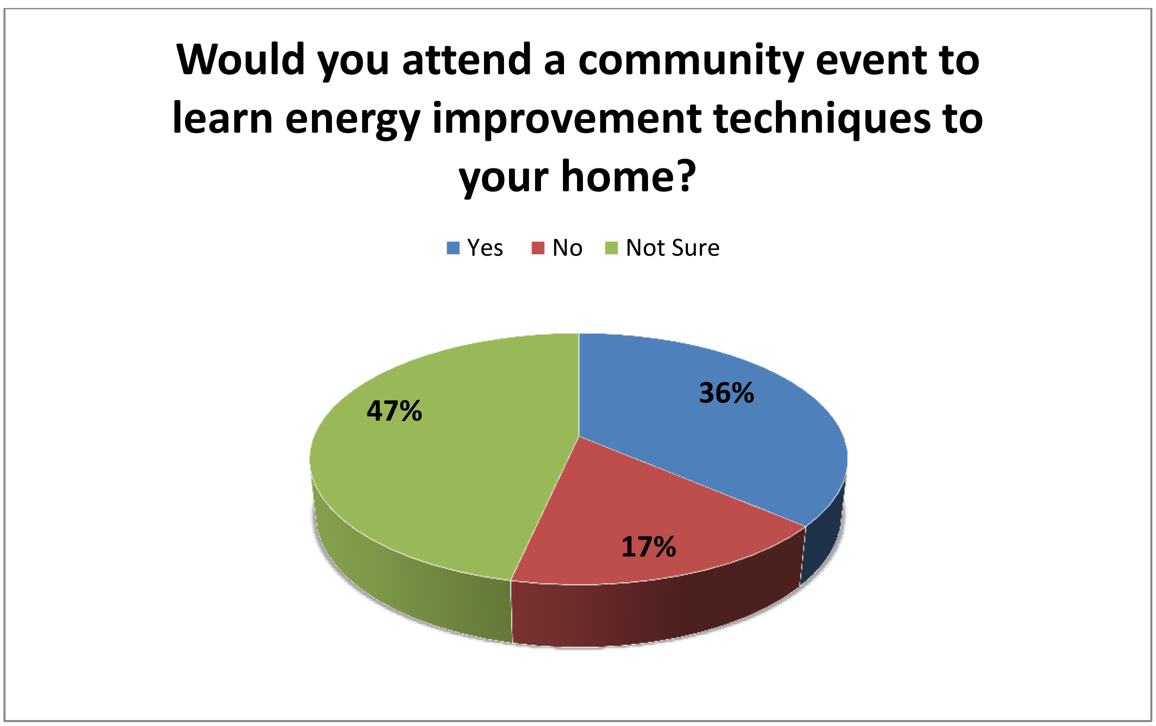


FIGURE 4.15: Homeowner Perceptions Survey Question 14

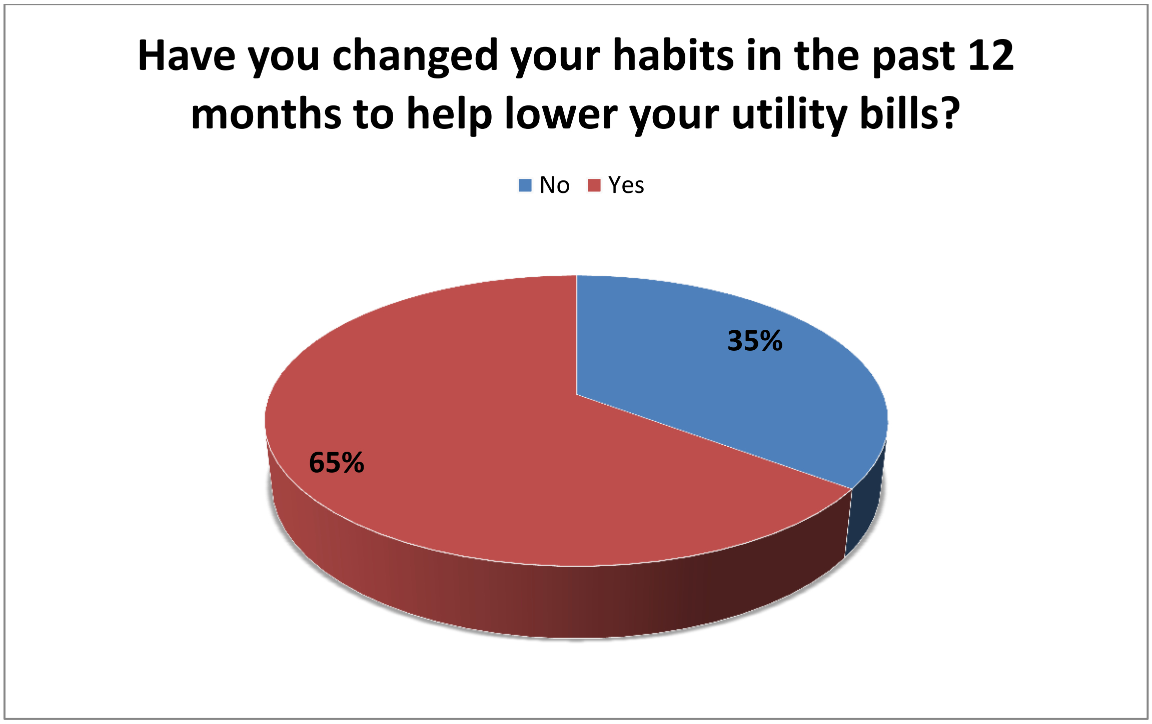


FIGURE 4.16: Homeowner Perceptions Survey Question 14A

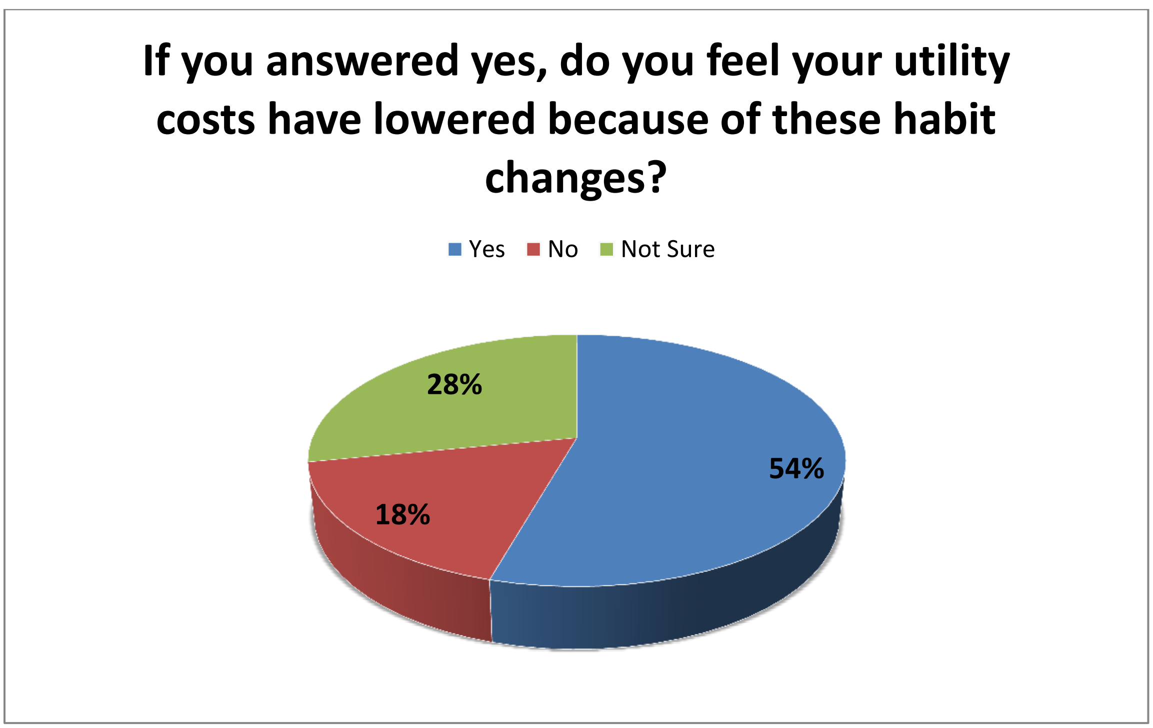


FIGURE 4.17: Homeowner Perceptions Survey Question 15

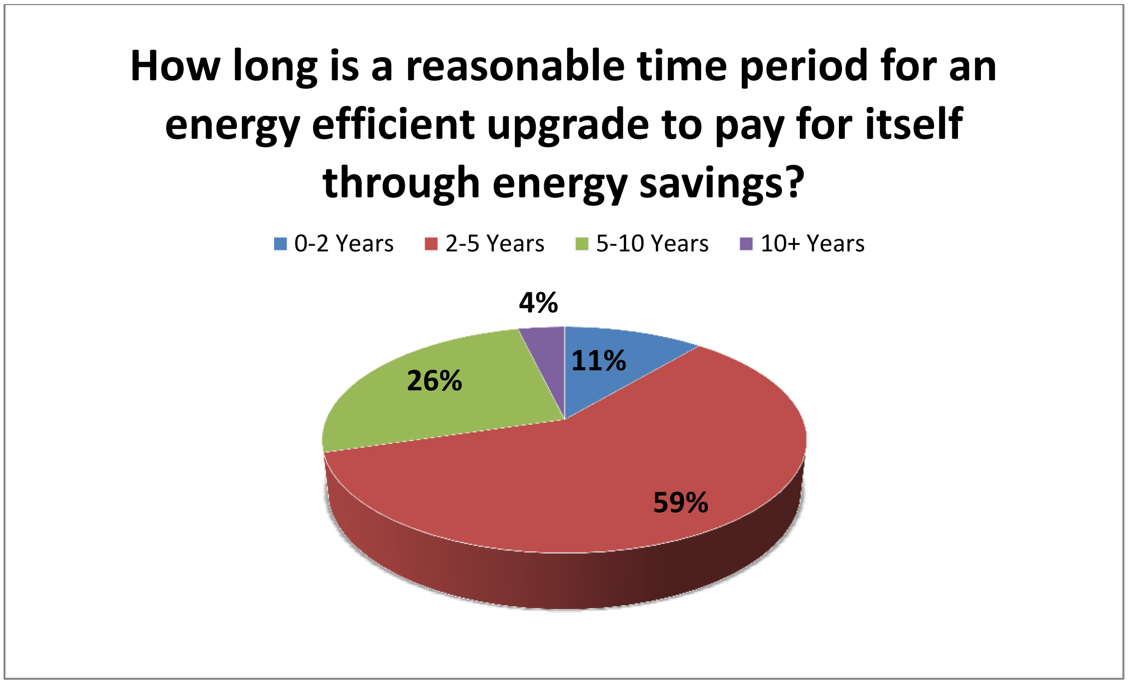


FIGURE 4.18: Homeowner Perceptions Survey Question 16

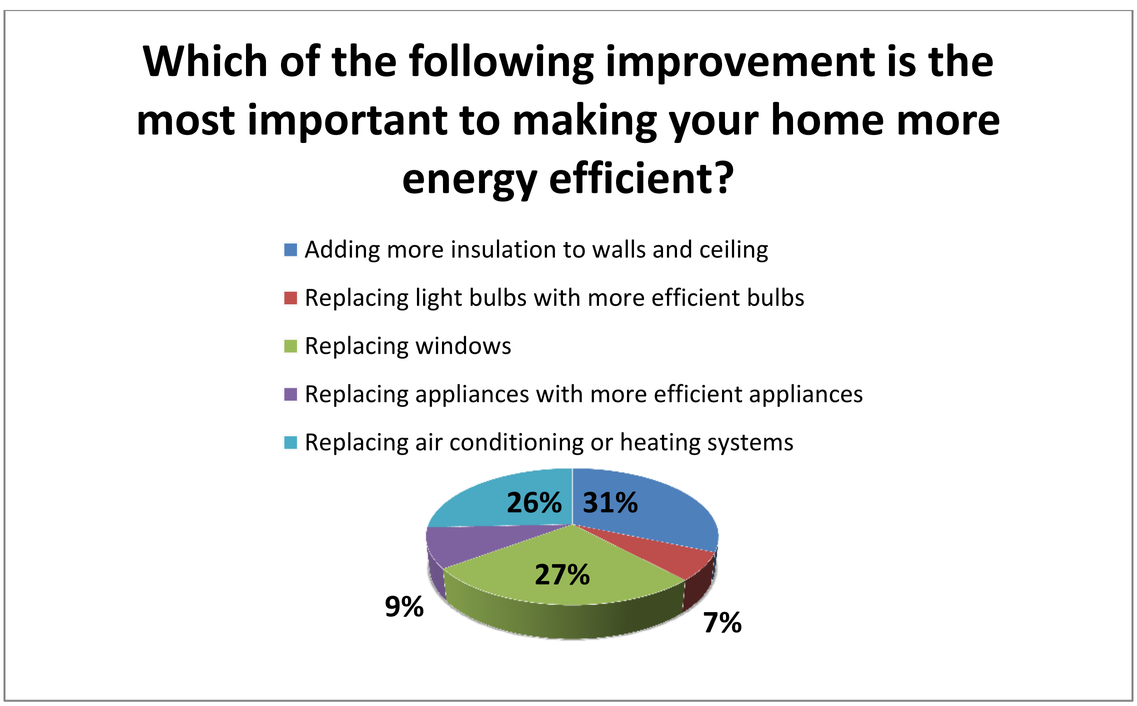


FIGURE 4.19: Homeowner Perceptions Survey Question 17

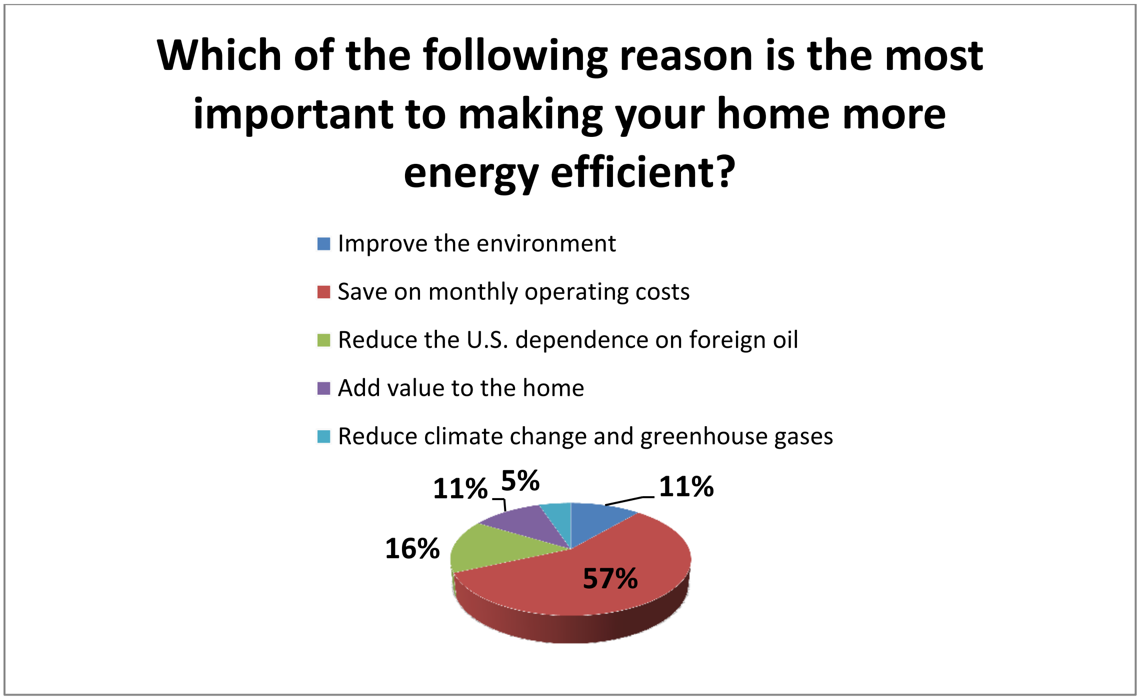


FIGURE 4.20: Homeowner Perceptions Survey Question 18

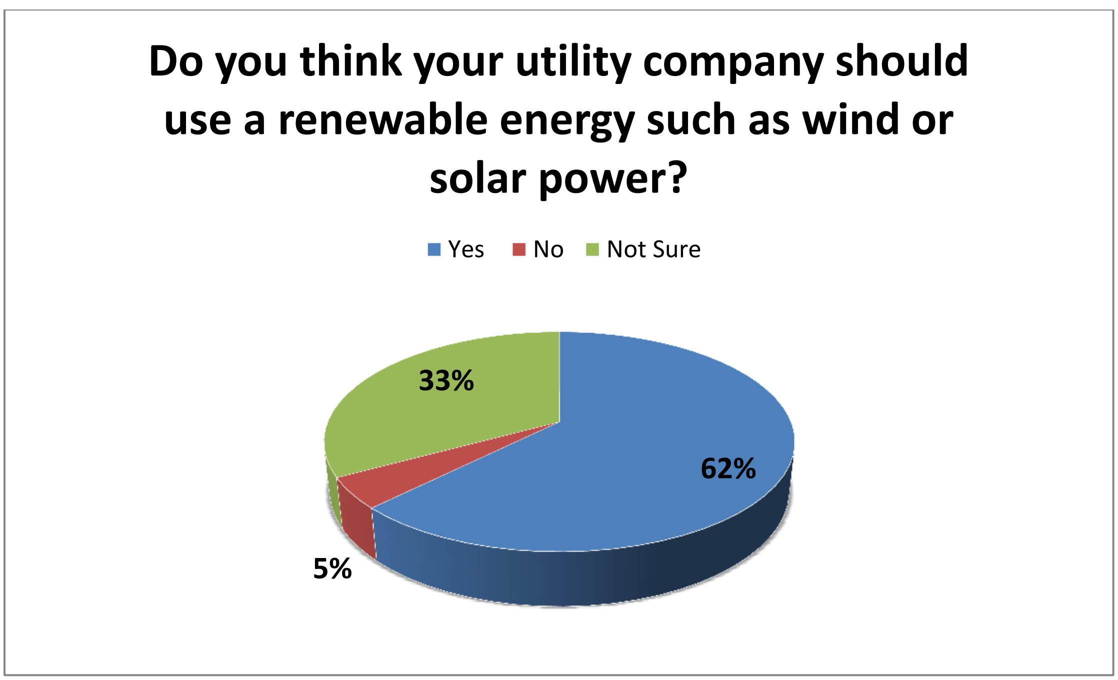


FIGURE 4.21: Homeowner Perceptions Survey Question 19

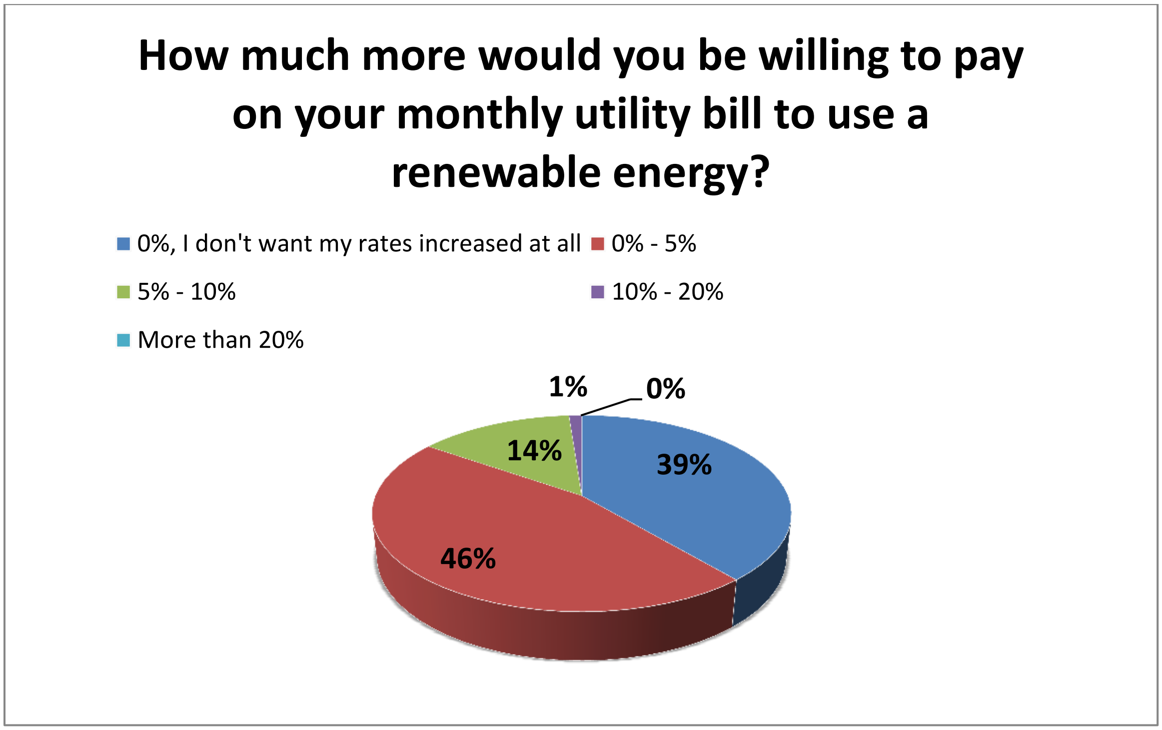
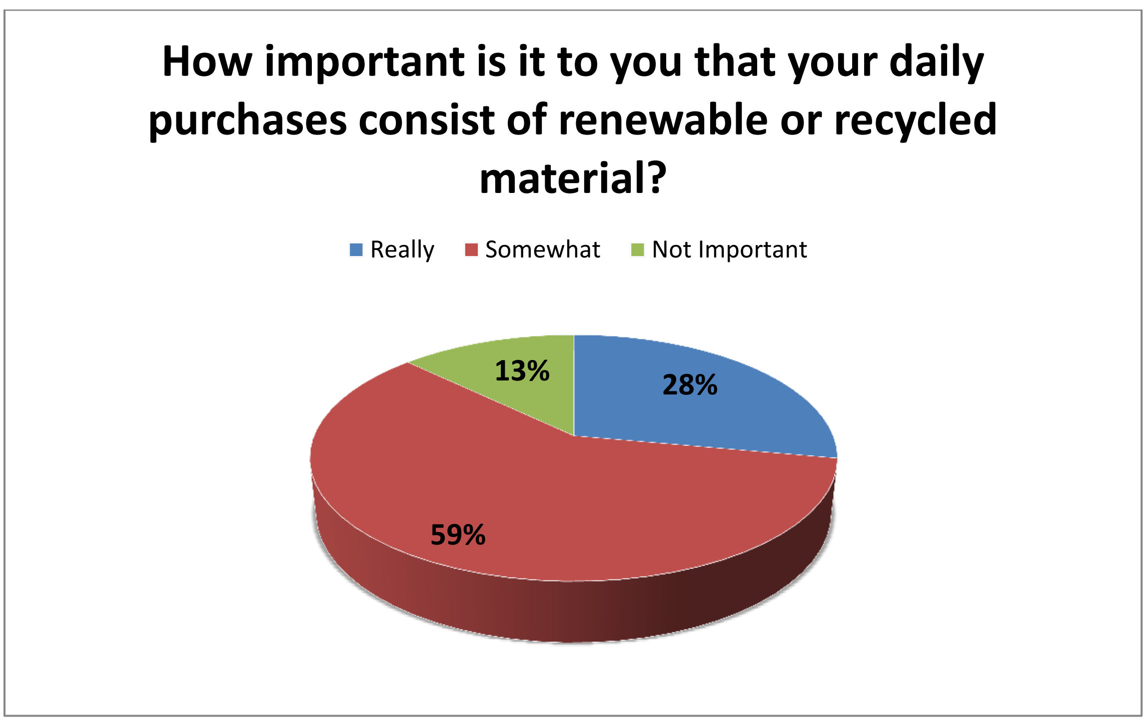


FIGURE 4.22: Homeowner Perceptions Survey Question 20



4.2.3 On-Site Analysis Results

The evaluation of the on-site inspection was focused on comparing the blower door infiltration reading and thus calculated air exchanges per hour to the actual energy use data collected. The blower door tests conducted on the sample set resulted in the following:

TABLE 4.1: Blower Door to BTU/SqFt/DD Comparison

			Ranking	
Test Home	**BTU/SqFt**	**AC@50**	**AC@50**	**BTU/SqFt**
1	21.58	9.56	12	10
2	29.85	5.98	4	18
3	14.01	3.45	1	2
4	21.85	6.21	5	11
5	16	10.04	14	4
6	24.79	13.08	18	13
7	22.05	16.83	21	12
8	25.12	10.96	16	15
9	16.11	14.51	19	5
10	30.02	8.87	9	19
11	27.28	9.85	13	16
12	16.58	12.41	16	6
13	14.76	7.08	6	3
14	28.04	8.03	8	17
15	31.73	5.14	3	21
16	9.29	5.05	2	1
17	18.95	7.26	7	7
18	19.03	12.58	17	9
19	31.1	10.92	15	20
20	18.98	9.05	10	8
21	38.46	20.64	22	22
22	24.97	9.25	11	14

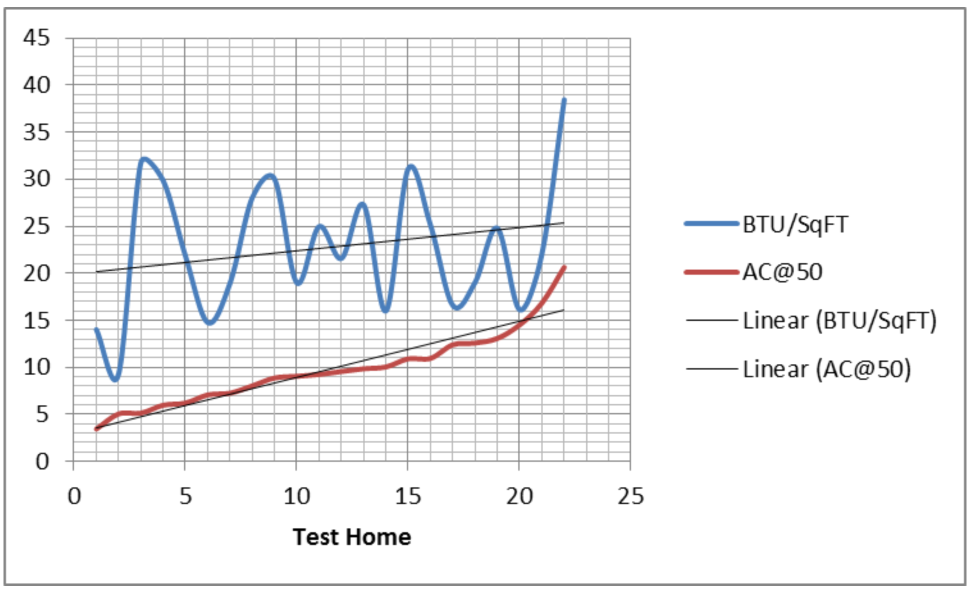
The regression analysis calculated for the BTU/SqFt/DD to ACH50 shows that there is little to no correlation in this study between the two. Understanding that air infiltration only contributes to a portion of energy consumption these results are not surprising, though it should be noted that the linear regression identifies a relationship to overall energy consumption and calculated air exchanges per hour.

TABLE 4.2: Linear Regression Results of ACH50

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.322877819
R Square	0.104250086
Adjusted R Square	0.05946259
Standard Error	3.947684598
Observations	22

FIGURE 4.23: Scatter Plot of AC@50 Results



General On-Site Report Summary

Each of the 22 homes audited were given individual summary reports for their participation in the on-site analysis. Listed below is the report that homeowners received. The general on-site report was standardized to insure every participant received the same information with an individualized report for each property concluding the report. The actual individual completed reports can be found in the appendix.

Figure 4.24: Sample On-Site Summary Report

First of all, thank you for allowing me to analyze your home from an energy consumption perspective. The data collected will be used to further the research in the field of residential energy efficiency, and the reports developed will be shared nationally with the U.S. Department of Energy. To help you better understand your own home's energy usage, I compiled a short report for you to have for future use.

Prior to visiting your home, I obtained three years of historical consumption data on your property. These monthly consumption numbers were converted to a unit of measurement called British Thermal Units (BTU's). The square footage data and weather data (degree days) were also obtained to help adjust your energy usage for the size of home and weather patterns in Woodbine, IA. Once the preliminary data was compiled each of the homes tested were given a standardized measurement of BTU/SqFt/Degree Day. You can think of this BSD for your home much like an mpg is used for vehicles. The lower the BSD, the better or less energy your home is using. For your comparison, the average home in Woodbine, IA currently has a BSD of 21.53.

To test the building envelope of your home, a blower door was used. The blower door measures the amount of air leakage in your home at 50 Pascals. A 50 Pascal pressure is roughly equivalent to the pressure generated by a 20 mph wind. The number given for the leakage is CFM (Cubic Feet per Minute). This number is then calculated with the volume of air in your home to give a number of air exchanges per hour. An average new energy efficient home will usually present a reading ranging from 600 to 1,000 CFM with 3-5 air exchanges per hour.

Property Address: Anywhere Street Woodbine, IA 51579

Date of Analysis: 6/7/11 **Time:** 0800

Temperature: 80F **Climate:** Warm, Humid

Current B.S.D.: 16.00 **CFM @ 50P:** 3200

Air Exchanges per Hour: 10.04

Overall Analysis:

The home analyzed is outperforming a majority of the homes in Woodbine in regards to energy consumption. This high performance is due to the positive homeowner habits and above average mechanical systems. CFL's were found throughout the home and the high efficiency furnace is in excellent condition. The building envelope is showing significant leakage in the attic and exterior walls. The homeowner should be commended on the basement rim joists sealant as it is performing very well. The recessed lights in the back room are leaking as well as the exterior wall outlets. It is recommended that a thermal picture be taken of the exterior when the temperature differential reaches 30 degrees to further analyze the possibility of exterior envelope improvements.

Thank you for your participation,

Nathan Barry, Principal Investigator

CHAPTER V

CONCLUSIONS

5.1 Research purpose

The purpose of this study was to address the problem of how and what the best approach is when developing a community-based retrofit program. Understanding that subsectors of the housing stock need to be addressed individually, three research questions resulted in the development of a community based study focusing on the aging housing stock. The methodology developed and tested during the Woodbine Project gave evidence of efficiently using historical energy data to analyze community opportunities, confirmed homeowner habits and perceptions role in energy efficiency, and inferred that building envelope improvements must be addressed in any retrofit strategy.

5.2 Research Question #1 Conclusion

Can historical consumption data and property assessor data be efficiently used to analyze community based energy usage patterns?

An energy analysis tool was successfully developed to identify which homes in a community would offer the largest opportunity for retrofit payback. The BTU/SQFT/DD tool designed by the researcher could efficiently be completed by an individual auditor or used to analyze an entire community to dissect actual utility consumption as compared to assumptions made by computer models. The online assessor data and utility information was completed in an average time of less than three minutes per home making it a cost effective tool to begin the auditing process.

The assessor data and energy consumption data correlations strongly supported the findings that a specific subsector cannot be identified when prequalifying homes for retrofit opportunities. Multiple unpredictable variables exist in homes built before 1979 to label a subsector of the housing population as the "target" for community based retrofits.

The characteristical data offered limited support in identifying which styles or housing characteristics offered the largest opportunity. While building characteristics offer opportunities for ease of accessibility and workability, when correlated directly with actual energy consumption a direct linkage could not be made.

5.3 Research Question #2 Conclusion

To what extent do the homeowners' perceptions of energy efficiency in rural America affect their actual energy consumption?

On a national scale, homeowner perception of energy efficiency has been conducted mainly by the National Association of Home Builders. The second research question of this project looked at the perceptions specifically of rural America. Identifying unique characteristical differences of rural America specifically an aging population and education level, this research set out to identify if similar findings of perceptions and energy consumptions existed.

The survey data collected by this research is consistent with the findings of NAHB's and McGraw-Hills green trends and perceptions studies. Unique to this study was the ability to statistically validate the qualitative data of the survey to the quantitative data of the actual energy consumption. The statistical analysis of the homeowners' perceptions survey not only showed that changing habits has a positive effect on lowering energy consumption, but by recognizing that habits regardless of actual changes play a critical role also influences the reduction. The results indicate that an educational or awareness program must be included in a community based retrofit program.

5.4 Research Question #3 Conclusion

Is there a direct relationship between the building envelope and actual energy consumption in the aging housing stock?

Research question three focused on identifying the relationship between the building envelope and actual energy consumption. Residential energy offenders such as lighting, windows, homeowner habits, HVAC, building envelopes, appliance, etc. have traditionally been placed into either a low-cost retrofit or deep retrofit categories. While the low-cost retrofits have been seen as easy, they are not permanent changes to the structure and thus to energy consumptions. Habits are always changing, lighting is switched frequently, and temperature of the home is being adjusted to match comfort level rather than energy usage. Conversely, deeper retrofits while more permanent, have often been seen as too costly or invasive for a large percentage of homes to adapt. With the use of the blower door to identify leakage amounts and location of air infiltration, the building envelope improvements can be the only permanent retrofit that can and should be included in the low-cost retrofit. This makes the building envelope improvement the best energy savings retrofit option.

Using the pre-audit BTU/SQFT/DD system developed through research question one, a systematic approach was developed identifying which homes offered opportunity for retrofits. Through the random sampling process, on-site properties were visited and infiltration leakage was measured along with a variety of other structural measurements identified in the on-site checklist found in the appendix.

The statistical analysis of air exchanges or leakage in comparison to actual energy data failed to validate the relationship between the two. However, a trend was identified that showed air exchanges per hour increase as the BTU/SQFT/DD number increases. Due to the multitude of variables that contribute to overall energy consumption a larger sample size is needed to statistically validate or discredit leakage correlations.

This research showed the opportunity and necessity of the building envelope measurements as part of the process of a community based retrofit. Coupled with the BTU/SQFT/DD information, the leakage information can identify immediately if building envelope improvements will have an effect on lowering energy consumption.

5.5 Problem Statement Conclusion

The research suggests that the best approach in analyzing and understanding consumption patterns in the aging housing stock is through a partnership with local utility providers. Access to actual historical home consumption is critical to the accuracy of pre-auditing retrofit candidates. With the variables of the housing stock, any computer simulation simply cannot predict savings calculations. Homeowner's can always provide personal consumption data, but the utility providers database allows the auditor to analyze the homes as a community and then comparatively on individual basis. Homeowner habits and lifestyle must also play a role in the data collection. Habitual information allows the pre-auditor to provide and assess what influence if any these are having on consumption patterns. All of the above mentioned pre-audit information can be collected prior to any visual inspection of the property. This pre-audit collection can allow community retrofit strategist to prioritize candidates and significantly reduce the audit investment time as well as increasing the potential of audits being performed on homes that will lead to retrofits with significant energy savings. Furthermore, when an individual property is identified as a retrofit candidate, the building envelope testing should be conducted immediately when arriving at a property.

5.6 Discussion

The Woodbine Project emphasized the challenges faced when addressing the residential housing stock in a systematic, standardized approach. While community-based studies on homes built post-1979 have shown promise with regards to identifying commonalities in energy consuming characteristics, communities such as Woodbine with a housing stock predominately of pre-1979 homes are unable to identify a common approach to addressing residential retrofits. The homes have either been remodeled or renovated to reflect a newer home or are deteriorated from age and neglect. With today's appraiser's data, any work performed on the home after build date is unavailable.

The property appraiser data was found to be insufficient when attempting to identify characteristics that lead to specific energy consumption; it is valuable though when coupled with actual property utility data. The Woodbine Project highlighted the necessity of using actual historical utility data when examining residential energy use. The housing characteristics that can be identified once a home is determined to be outside the median in regards to energy consumption can be extremely useful. The appraiser's data allows for an identifiable scope of work to be established, identifies hazards or challenges to a retrofit, and gives an estimated amount of material that may be required by providing square footage, house style, etc.

The homeowners' perception survey gave valuable information for this study as well as future community perspective studies. Surprisingly, this study upholds the argument that positive homeowner habits and perceptions of energy efficiency are effective when attempting to reduce household energy consumption.

The blower door tests conducted during the study also showed the opportunity and importance of an overall building envelope. The blower door tests on every home identified opportunities for improvements, many of them at low costs to the homeowner. The direct effect of the building envelope to the mechanical systems of the property in this researcher's view is the most critical element in residential building efficiency. Building envelopes that perform poorly on newer homes operating with high efficiency HVAC systems are disappointing, but envelopes that are performing poorly on properties operating with HVAC systems that are sometimes 50–60% efficient are detrimental to the homeowners' pocketbook and the community as a whole.

5.7 Directions for Future Research

Residential energy efficiency research has been conducted and pushed for over 30 years, but is still in its infant stage. With the Building America initiative sponsored by the United States Department of Energy, the residential research community is making swift strides in regards to data collection and standardized testing protocol. The current questions are still being researched: is historical utility data needed or can a computer model approach be accurate?; can a one-size-fits-all model be developed?; will homeowners and builders begin to see added value in energy efficient upgrades?; and finally, what is the tipping point when the market can self-sustain a residential retrofit program void of government influence or incentives? Industries and institutions across the country are searching for answers to these questions. The research performed in this project offers opportunity to be tested and built upon. The utility data and appraiser data approach was specifically developed to be replicated in other communities in both the same climate region and differing climate regions. By converting the supply of energy to BTU's, any energy source can now be converted and compared using a similar spreadsheet. Additionally, by including the degree days into the calculations, weather data from any climate can normalize the data and make it significantly comparative to the research in this project.

It is viewed as critical by this researcher that partnership or a vested interest by the supplying utility company is perhaps the most critical link in accurate residential utility analysis. With this being said, future research or legislative decisions need to be addressed that require utility information to become public information. Without the enforcement of this public policy initiative, there is no foreseen motive for private utility suppliers to willingly provide mass data information void of any major peak demand crisis. While computer programs are continually improving to provide a modeling system that more accurately represents a residential home, pre-1979 homes encompass a plethora of changes that no computer model can ever assess with 100% accuracy. Knowing that over 60% of the current housing stock includes homes that are built pre-1979, the reliance of a strict computer modeling system that provides accurate information is naïve.

Future research should and will continue to implement pilot projects in varying communities across the country. Increased partnerships with private industries will allow researchers and investors alike to develop retrofit practices that are not only accurate and sustainable, but also profitable for privatized business models.

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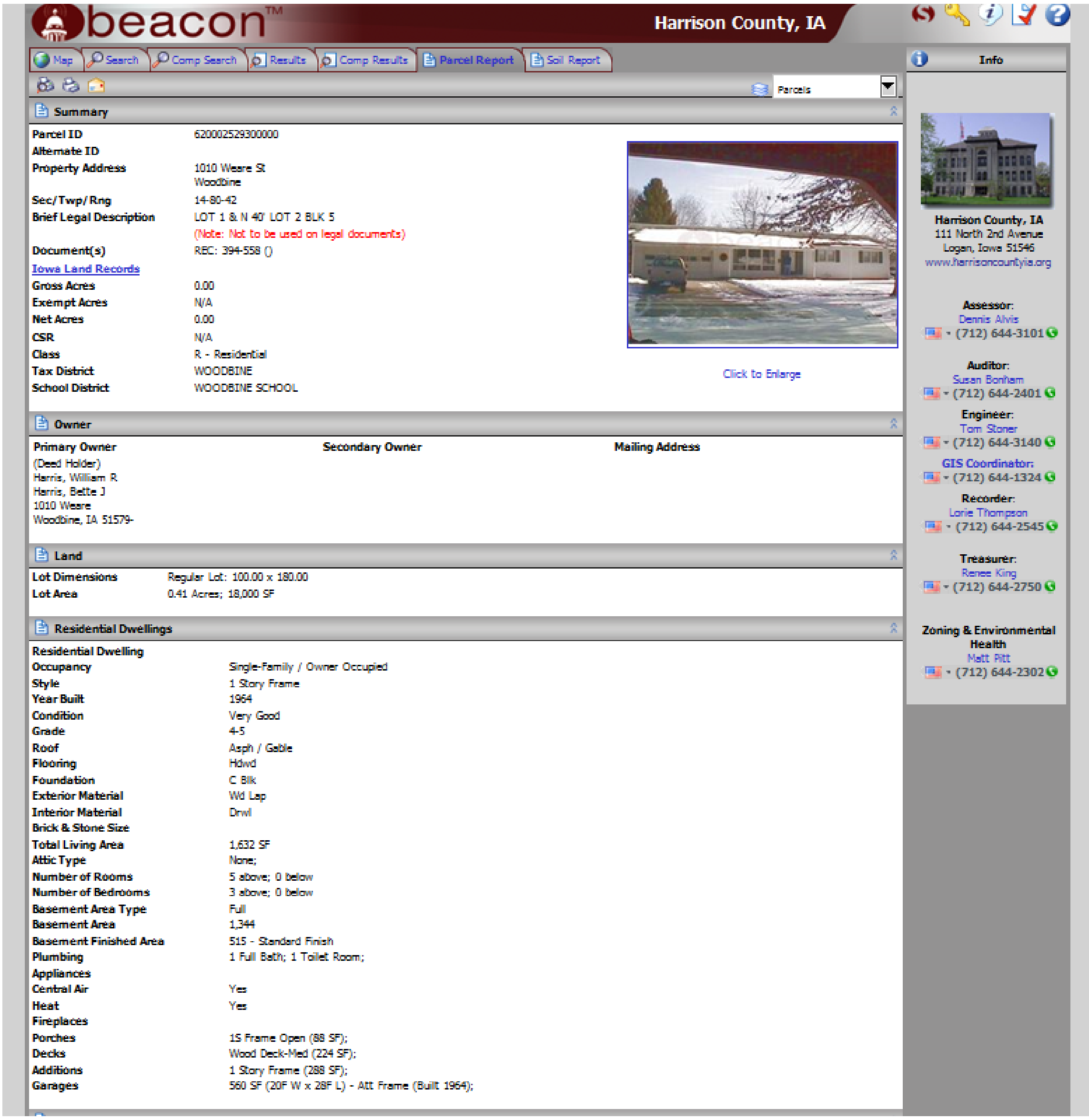
APPENDIX

A

BTU/SQFT/DD DATA

FIGURE A.1: Beacon Online Appraiser Data Example



beacon™ Harrison County, IA

Map | Search | Comp Search | Results | Comp Results | Parcel Report | Soil Report

Parcels

Summary

Parcel ID	620002529300000
Alternate ID	
Property Address	1010 Weare St Woodbine
Sec/Twp/Rng	14-80-42
Brief Legal Description	LOT 1 & N 40' LOT 2 BLK 5 (Note: Not to be used on legal documents)
Document(s)	REC: 394-558 ()
Iowa Land Records	
Gross Acres	0.00
Exempt Acres	N/A
Net Acres	0.00
CSR	N/A
Class	R - Residential
Tax District	WOODBINE
School District	WOODBINE SCHOOL

Click to Enlarge

Owner

Primary Owner	Secondary Owner	Mailing Address
(Deed Holder) Harris, William R Harris, Bette J 1010 Weare Woodbine, IA 51579-		

Land

Lot Dimensions	Regular Lot: 100.00 x 180.00
Lot Area	0.41 Acres; 18,000 SF

Residential Dwellings

Residential Dwelling	
Occupancy	Single-Family / Owner Occupied
Style	1 Story Frame
Year Built	1964
Condition	Very Good
Grade	4-5
Roof	Asph / Gable
Flooring	Hdwd
Foundation	C Blk
Exterior Material	Wd Lap
Interior Material	Drwl
Brick & Stone Size	
Total Living Area	1,632 SF
Attic Type	None;
Number of Rooms	5 above; 0 below
Number of Bedrooms	3 above; 0 below
Basement Area Type	Full
Basement Area	1,344
Basement Finished Area	515 - Standard Finish
Plumbing	1 Full Bath; 1 Toilet Room;
Appliances	
Central Air	Yes
Heat	Yes
Fireplaces	
Porches	1S Frame Open (88 SF);
Decks	Wood Deck-Med (224 SF);
Additions	1 Story Frame (288 SF);
Garages	560 SF (20F W x 28F L) - Att Frame (Built 1964);

Info

Harrison County, IA
111 North 2nd Avenue
Logan, Iowa 51546
www.harrisoncountyia.org

Assessor:
Dennis Alvis
(712) 644-3101

Auditor:
Susan Bonham
(712) 644-2401

Engineer:
Tom Stoner
(712) 644-3140

GIS Coordinator:
(712) 644-1324

Recorder:
Lorie Thompson
(712) 644-2545

Treasurer:
Renee King
(712) 644-2750

Zoning & Environmental Health
Matt Pitt
(712) 644-2302

Valuation

		2010	2009	2008	2007	2006
+	Land	$23,561	$23,561	$23,561	$23,561	$21,816
+	Building	$93,247	$93,247	$93,247	$93,247	$86,340
=	Total Assessed Value	$116,808	$116,808	$116,808	$116,808	$108,156

Taxation

		2009	2008	2007	2006
+	Taxable Land Value	$11,052	$10,741	$10,386	$9,939
+	Taxable Building Value	$43,742	$42,511	$41,104	$39,336
+	Taxable Dwelling Value	$0	$0	$0	$0
=	Gross Taxable Value	$54,794	$53,252	$51,490	$49,275
-	Military Exemption	($1,852)	($1,852)	($1,852)	($1,852)
=	Net Taxable Value	$52,942	$51,400	$49,638	$47,423
x	Levy Rate (per $1000 of value)	43.92459	44.23467	43.49845	44.00921
=	Gross Taxes Due	$2,325.46	$2,273.66	$2,159.18	$2,087.05
-	Ag Land Credit	$0.00	$0.00	$0.00	$0.00
-	Disabled and Senior Citizens Credit	$0.00	$0.00	$0.00	$0.00
-	Family Farm Credit	$0.00	$0.00	$0.00	$0.00
-	Homestead Credit	($136.33)	($156.61)	($151.89)	($155.81)
-	Prepaid Tax	$0.00	$0.00	$0.00	$0.00
=	Net Taxes Due	$2,190.00	$2,118.00	$2,008.00	$1,932.00

Tax History

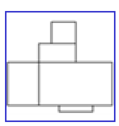
Year	Due Date	Amount	Paid	Date Paid	Receipt
2009	March 2011	$1,095	Yes	3/23/2011	23566
	September 2010	$1,095	Yes	8/17/2010	
2008	March 2010	$1,059	Yes	3/22/2010	23496
	September 2009	$1,059	Yes	8/13/2009	
2007	March 2009	$1,004	Yes	3/23/2009	23444
	September 2008	$1,004	Yes	8/19/2008	
2006	March 2008	$966	Yes	3/28/2008	23318
	September 2007	$966	Yes	8/17/2007	

Pay Property Taxes

Click here to pay property taxes for this parcel.

Photos

Sketches



No data available for the following modules: Commercial Buildings, Agricultural Buildings, Yard Extras, Sales, Tax Sale Certificates. Click here for help.

Table A.1: Completed Ranking of Woodbine BTU/SqFt/DD Results

BTU/SqFt/DD RANKING OF RESIDENTIAL HOMES FOR THE COMMUNITY OF WOODBINE, IA

ID#	Year Built	SqFt	Basement Type	Style	Assessed Value	BTU/SQ FT/DD	Area Rank
51579001	1970-1979	1,210	Full	Single Story	80000-90000	4.55	90%
51579002	1900-1909	3,086	Partial	Two-story	90000-100000	5.09	90%
51579003	1920-1929	1,092	Full	Single Story	50000-60000	5.64	90%
51579004	1970-1979	1,351	Full	Single Story	110000-120000	6.48	90%
51579005	1900-1909	1,184	Full	Single Story	70000-80000	6.66	90%
51579006	1950-1959	1,540	Full	Single Story	120000-130000	7.48	90%
51579007	1900-1909	1,548	Partial	1.5 story	70000-80000	7.77	90%
51579008	1970-1979	1,260	Full	Single Story	100000-110000	7.99	90%
51579009	1900-1909	1,066	Partial	Single Story	60000-70000	8.07	90%
51579010	1900-1909	1,292	Full	Single Story	70000-80000	8.20	90%
51579011	1900-1909	1,624	Partial	1.5 story	80000-90000	8.20	90%
51579012	1990-1999	1,633	Full	Single Story	160000-170000	8.24	90%
51579013	1970-1979	1,852	Slab	Single Story	100000-110000	8.79	90%
51579014	1960-1969	1,440	Full	Single Story	100000-110000	8.82	90%
51579015	1900-1909	1,834	Partial	1.5 story	80000-90000	8.87	90%
51579016	1990-1999	1,421	Full	Single Story	150000-160000	8.89	90%
51579017	1950-1959	1,692	Full	Single Story	100000-110000	9.29	90%
51579018	1960-1969	1,783	Full	Single Story	150000-160000	9.29	90%
51579019	1950-1959	4,424	Full	Single Story	270000-280000	9.50	90%
51579020	1900-1909	2,861	Partial	Single Story	90000-100000	9.61	90%
51579021	1900-1909	1,312	Full	Single Story	50000-60000	9.85	90%
51579022	1900-1909	1,523	Partial	1.5 story	60000-70000	9.94	90%
51579023	1980-1989	1,676	Full	Single Story	120000-130000	10.06	90%
51579024	Pre 1900	1,256	Full	Single Story	70000-80000	10.11	90%
51579025	1900-1909	1,380	Full	Single Story	80000-90000	10.16	90%
51579026	1990-1999	1,714	Full	Single Story	160000-170000	10.36	90%
51579027	2000-2010	2,176	Full	Two-Story	170000-180000	10.36	90%
51579028	1970-1979	1,272	Partial	Single Story	90000-100000	10.41	90%
51579029	1960-1969	1,584	Full	Single Story	110000-120000	10.49	90%
51579030	1910-1919	1,307	Full	Single Story	90000-100000	10.53	90%
51579031	1990-1999	1,633	Full	Single Story	160000-170000	10.97	90%
51579032	1900-1909	3,053	Full	Two-story	120000-130000	10.99	90%
51579033	1900-1909	1,539	Partial	1.5 story	40000-50000	10.99	90%
51579034	1900-1909	908	Partial	Single Story	40000-50000	11.03	90%
51579035	1970-1979	1,210	Full	Single Story	90000-100000	11.05	90%
51579036	1920-1929	982	Partial	Single Story	60000-70000	11.15	90%
51579037	1900-1909	1,359	Partial	1.5 story	40000-50000	11.16	90%
51579038	1900-1909	990	Full	Single Story	80000-90000	11.31	90%

51579039	1900-1909	2,172	Partial	Single Story	90000-100000	11.55	90%
51579040	1900-1909	1,256	Full	Single Story	90000-100000	11.63	90%
51579041	1970-1979	1,110	Full	Single Story	80000-90000	11.64	90%
51579042	1900-1909	3,054	Full	Two-story	160000-170000	11.67	90%
51579043	1900-1909	1,954	Partial	Two-story	70000-80000	11.73	90%
51579044	Pre 1900	2,512	Partial	Two-story	110000-120000	11.81	90%
51579045	1980-1989	1,344	Full	1.5 story	120000-130000	11.81	90%
51579046	1900-1909	552	Partial	Single Story	30000-40000	11.86	90%
51579047	1900-1909	1,748	Full	Two-story	80000-90000	11.90	90%
51579048	1900-1909	1,328	Full	Single Story	60000-70000	11.95	90%
51579049	1900-1909	1,320	Slab	Single Story	90000-100000	12.04	90%
51579050	1900-1909	776	Partial	Single Story	30000-40000	12.15	90%
51579051	1990-1999	1,598	Full	Single Story	170000-180000	12.29	90%
51579052	1980-1989	1,092	Full	Single Story	90000-100000	12.30	90%
51579053	1900-1909	768	Partial	Single Story	30000-40000	12.31	90%
51579054	1900-1909	1,514	Partial	Single Story	80000-90000	12.40	80%
51579055	1900-1909	1,812	Partial	1.5 story	100000-110000	12.41	80%
51579056	1970-1979	1,232	Full	Split-Level	130000-140000	12.42	80%
51579057	1900-1909	1,151	Slab	1.5 story	40000-50000	12.54	80%
51579058	1990-1999	1,162	Full	Single Story	120000-130000	12.57	80%
51579059	1990-1999	1,492	Full	Single Story	120000-130000	12.62	80%
51579060	1900-1909	1,550	Partial	1.5 story	70000-80000	12.63	80%
51579061	1900-1909	1,870	Full	Single Story	110000-120000	12.72	80%
51579062	1990-1999	1,024	Slab	Mobile Home	30000-40000	12.75	80%
51579063	1900-1909	1,418	Partial	1.5 story	90000-100000	12.75	80%
51579064	1900-1909	2,111	Full	1.5 story	80000-90000	12.76	80%
51579065	1900-1909	2,272	Partial	Single Story	140000-150000	12.80	80%
51579066	1900-1909	2,074	Partial	1.5 story	100000-110000	12.83	80%
51579067	1900-1909	1,140	Full	Single Story	80000-90000	12.87	80%
51579068	1900-1909	1,589	Partial	1.5 story	60000-70000	12.92	80%
51579069	1900-1909	1,260	Partial	Single Story	40000-50000	12.93	80%
51579070	1920-1929	1,560	Full	Single Story	120000-130000	12.96	80%
51579071	1900-1909	1,128	Partial	Single Story	50000-60000	13.01	80%
51579072	1970-1979	1,100	Full	Single Story	80000-90000	13.03	80%
51579073	1960-1969	1,676	Full	Single Story	120000-130000	13.12	80%
51579074	1970-1979	1,288	Full	Single Story	110000-120000	13.15	80%
51579075	2000-2010	2,477	Full	Single Story	200000-210000	13.23	80%
51579076	1970-1979	1,594	Full	Two-story	110000-120000	13.35	80%
51579077	1990-1999	1,036	Slab	Single Story	60000-70000	13.39	80%
51579078	1950-1959	918	Full	Single Story	70000-80000	13.53	80%
51579079	1900-1909	717	Slab	1.5 story	30000-40000	13.54	80%
51579080	1970-1979	1,392	Full	Single Story	100000-110000	13.58	80%

51579081	Pre 1900	1,860	Partial	1.5 story	50000-60000	13.64	80%
51579082	1990-1999	1,232	Full	Single Story	90000-100000	13.71	80%
51579083	2000-2010	6,348	Full	1.5 story	500000+	13.79	80%
51579084	1990-1999	1,548	Full	Single Story	130000-140000	13.96	80%
51579085	1990-1999	2,119	Full	Two-story	160000-170000	14.00	80%
51579086	1990-1999	3,526	Full	1.5 story	220000-230000	14.01	80%
51579087	1900-1909	900	Full	Single Story	50000-60000	14.06	80%
51579088	1900-1909	1,600	Partial	1.5 story	60000-70000	14.11	80%
51579089	1900-1909	1,700	Full	1.5 story	110000-120000	14.15	80%
51579090	1900-1909	1,084	Partial	Single Story	50000-60000	14.17	80%
51579091	1900-1909	1,397	Full	1.5 story	50000-60000	14.20	80%
51579092	Pre 1900	1,738	Full	1.5 story	50000-60000	14.21	80%
51579093	1900-1909	1,550	Full	1.5 story	80000-90000	14.27	80%
51579094	1900-1909	896	Partial	Single Story	30000-40000	14.42	80%
51579095	1960-1969	768	Full	Single Story	40000-50000	14.44	80%
51579096	1910-1919	2,088	Partial	Two-story	100000-110000	14.49	80%
51579097	1990-1999	1,387	Full	Single Story	130000-140000	14.50	80%
51579098	1900-1909	1,068	Partial	Single Story	60000-70000	14.52	80%
51579099	1900-1909	1,120	Full	Single Story	50000-60000	14.53	80%
51579100	1980-1989	1,008	Full	Single Story	70000-80000	14.62	80%
51579101	1970-1979	1,248	Full	Single Story	110000-120000	14.67	80%
51579102	1990-1999	1,456	Full	Single Story	120000-130000	14.70	80%
51579103	1920-1929	1,792	Full	Two-story	80000-90000	14.74	80%
51579104	1900-1909	1,504	Full	1.5 story	120000-130000	14.76	80%
51579105	1900-1909	944	Full	Single Story	50000-60000	14.80	80%
51579106	1900-1909	1,280	Partial	1.5 story	30000-40000	14.84	80%
51579107	1960-1969	1,632	Full	Single Story	110000-120000	14.91	70%
51579108	1950-1959	1,152	Partial	Single Story	70000-80000	14.92	70%
51579109	1970-1979	1,152	Full	Single Story	90000-100000	14.94	70%
51579110	1930-1939	1,100	Full	Single Story	70000-80000	14.99	70%
51579111	Pre 1900	744	Partial	Single Story	50000-60000	15.00	70%
51579112	1900-1909	1,114	Slab	Single Story	80000-90000	15.06	70%
51579113	1960-1969	832	Slab	Single Story	50000-60000	15.08	70%
51579114	1900-1909	1,755	Full	1.5 story	70000-80000	15.11	70%
51579115	2000-2010	2,026	Full	Single Story	230000-240000	15.12	70%
51579116	1900-1909	912	Full	Single Story	40000-50000	15.16	70%
51579117	1900-1909	1,104	Full	Single Story	60000-70000	15.21	70%
51579118	1900-1909	1,067	Full	1.5 story	50000-60000	15.21	70%
51579119	1920-1929	1,352	Full	Single Story	80000-90000	15.21	70%
51579120	1960-1969	1,217	Slab	Single Story	70000-80000	15.33	70%
51579121	1900-1909	1,024	Full	Single Story	80000-90000	15.39	70%
51579122	Pre 1900	1,256	Partial	Single Story	50000-60000	15.43	70%
51579123	1900-1909	1,712	Partial	1.5 story	50000-60000	15.45	70%

51579124	1970-1979	1,144	Full	Single Story	100000-110000	15.47	70%
51579125	1990-1999	1,485	Partial	Single Story	150000-160000	15.52	70%
51579126	1990-1999	1,257	Full	Single Story	120000-130000	15.60	70%
51579127	1990-1999	1,200	Full	Single Story	100000-110000	15.65	70%
51579128	1900-1909	1,085	Full	1.5 story	40000-50000	15.67	70%
51579129	1900-1909	1,344	Full	Single Story	110000-120000	15.78	70%
51579130	1900-1909	1,092	Partial	Single Story	40000-50000	15.78	70%
51579131	1900-1909	1,158	Slab	Single Story	60000-70000	15.91	70%
51579132	1980-1989	1,380	Full	Single Story	110000-120000	15.91	70%
51579133	1970-1979	2,072	Full	Two-story	190000-200000	15.94	70%
51579134	1900-1909	1,064	Full	Single Story	50000-60000	15.95	70%
51579135	1900-1909	1,248	Full	1.5 story	60000-70000	15.98	70%
51579136	1900-1909	836	Full	Single Story	90000-100000	16.00	70%
51579137	1900-1909	2,124	Partial	Two-story	90000-100000	16.00	70%
51579138	1950-1959	1,071	Slab	Single Story	70000-80000	16.08	70%
51579139	1950-1959	1,068	Full	Single Story	80000-90000	16.09	70%
51579140	1940-1949	941	Slab	1.5 story	50000-60000	16.10	70%
51579141	Pre 1900	1,424	Partial	Two-story	80000-90000	16.11	70%
51579142	1990-1999	2,435	Full	Single Story	250000-260000	16.13	70%
51579143	1900-1909	1,248	Partial	1.5 story	50000-60000	16.15	70%
51579144	1900-1909	1,007	Partial	Single Story	70000-80000	16.17	70%
51579145	1900-1909	1,096	Partial	Single Story	50000-60000	16.19	70%
51579146	1900-1909	1,070	Partial	Single Story	70000-80000	16.20	70%
51579147	1950-1959	1,552	Full	Single Story	140000-150000	16.25	70%
51579148	1900-1909	1,140	Full	Single Story	50000-60000	16.29	70%
51579149	1900-1909	1,895	Partial	1.5 story	80000-90000	16.45	70%
51579150	1900-1909	871	Partial	Single Story	40000-50000	16.49	70%
51579151	1900-1909	888	Partial	Single Story	50000-60000	16.52	70%
51579152	1900-1909	1,236	Partial	1.5 story	40000-50000	16.58	70%
51579153	1980-1989	952	Full	Single Story	100000-110000	16.58	70%
51579154	1900-1909	1,624	Partial	Two-story	50000-60000	16.64	70%
51579155	1980-1989	1,228	Full	Single Story	110000-120000	16.64	70%
51579156	1920-1929	916	Full	Single Story	80000-90000	16.65	70%
51579157	1900-1909	1,395	Partial	1.5 story	60000-70000	16.67	70%
51579158	1960-1969	832	Slab	Single Story	60000-70000	16.68	70%
51579159	1970-1979	1,938	Full	Two-story	140000-150000	16.86	70%
51579160	1970-1979	2,040	Full	Two-story	130000-140000	16.87	60%
51579161	1920-1929	980	Full	Single Story	50000-60000	16.94	60%
51579162	1960-1969	887	Slab	Single Story	50000-60000	16.96	60%
51579163	1980-1989	1,228	Full	Single Story	120000-130000	17.01	60%
51579164	1940-1949	1,390	Full	Single Story	120000-130000	17.06	60%
51579165	1900-1909	1,405	Partial	Single Story	70000-80000	17.07	60%
51579166	1900-1909	2,148	Partial	Two-story	110000-120000	17.10	60%

51579167	1970-1979	960	Full	Single Story	70000-80000	17.13	60%
51579168	Pre 1900	1,748	Partial	Two-story	80000-90000	17.22	60%
51579169	1900-1909	1,256	Partial	Single Story	50000-60000	17.30	60%
51579170	1970-1979	1,290	Full	Single Story	90000-100000	17.30	60%
51579171	1900-1909	1,190	Partial	1.5 story	40000-50000	17.33	60%
51579172	1900-1909	680	Full	Single Story	40000-50000	17.43	60%
51579173	1900-1909	2,073	Partial	Two-story	80000-90000	17.46	60%
51579174	1970-1979	3,300	Full	Single Story	190000-200000	17.56	60%
51579175	1960-1969	1,470	Full	Single Story	90000-100000	17.58	60%
51579176	1960-1969	1,120	Full	Single Story	80000-90000	17.60	60%
51579177	1900-1909	1,242	Slab	1.5 story	50000-60000	17.61	60%
51579178	1970-1979	1,248	Full	Single Story	110000-120000	17.67	60%
51579179	1960-1969	936	Slab	Single Story	70000-80000	17.85	60%
51579180	1900-1909	1,236	Full	Two-story	40000-50000	17.93	60%
51579181	1960-1969	1,752	Full	Single Story	150000-160000	17.95	60%
51579182	1960-1969	1,500	Full	Single Story	90000-100000	17.96	60%
51579183	1960-1969	1,040	Full	Single Story	90000-100000	18.02	60%
51579184	1900-1909	1,519	Partial	1.5 story	70000-80000	18.03	60%
51579185	1970-1979	1,188	Full	Single Story	90000-100000	18.07	60%
51579186	1900-1909	2,180	Partial	Two-story	60000-70000	18.09	60%
51579187	1900-1909	1,456	Partial	Single Story	80000-90000	18.14	60%
51579188	1920-1929	2,004	Full	Two-story	80000-90000	18.15	60%
51579189	1900-1909	1,040	Full	1.5 story	50000-60000	18.21	60%
51579190	1950-1959	1,260	Full	Single Story	90000-100000	18.23	60%
51579191	1900-1909	960	Partial	Single Story	50000-60000	18.25	60%
51579192	1900-1909	1,678	Slab	Two-story	60000-70000	18.28	60%
51579193	1900-1909	1,318	Partial	1.5 story	70000-80000	18.30	60%
51579194	1970-1979	1,760	Full	Single Story	140000-150000	18.32	60%
51579195	1970-1979	1,732	Full	Single Story	130000-140000	18.33	60%
51579196	1950-1959	864	Slab	Single Story	30000-40000	18.35	60%
51579197	1990-1999	1,320	Full	Single Story	140000-150000	18.36	60%
51579198	1970-1979	1,512	Full	Two-story	100000-110000	18.43	60%
51579199	1950-1959	1,564	Slab	Single Story	90000-100000	18.52	60%
51579200	1980-1989	1,490	Full	Single Story	130000-140000	18.53	60%
51579201	1900-1909	944	Partial	Single Story	40000-50000	18.59	60%
51579202	1900-1909	1,457	Partial	1.5 story	70000-80000	18.65	60%
51579203	1970-1979	1,248	Full	Single Story	110000-120000	18.70	60%
51579204	1960-1969	1,092	Full	Single Story	90000-100000	18.70	60%
51579205	1970-1979	1,344	Full	Single Story	120000-130000	18.74	60%
51579206	1970-1979	1,092	Full	Single Story	70000-80000	18.80	60%
51579207	1900-1909	1,071	Partial	1.5 story	40000-50000	18.82	60%
51579208	1970-1979	1,072	Full	Single Story	90000-100000	18.84	60%
51579209	1900-1909	1,096	Partial	Single Story	40000-50000	18.91	60%

51579210	1900-1909	760	Partial	Single Story	30000-40000	18.92	60%
51579211	1970-1979	1,144	Full	Single Story	100000-110000	18.95	60%
51579212	1970-1979	1,392	Full	Single Story	110000-120000	18.98	60%
51579213	1900-1909	1,498	Slab	1.5 story	60000-70000	18.99	60%
51579214	1900-1909	901	Full	Single Story	70000-80000	19.03	50%
51579215	1930-1939	1,176	Full	Single Story	60000-70000	19.05	50%
51579216	1990-1999	864	Full	Single Story	80000-90000	19.08	50%
51579217	2000-2010	2,114	Full	Single Story	170000-180000	19.12	50%
51579218	1980-1989	1,288	Full	Single Story	110000-120000	19.12	50%
51579219	1900-1909	1,311	Partial	1.5 story	80000-90000	19.30	50%
51579220	1990-1999	1,080	Full	Single Story	50000-60000	19.34	50%
51579221	1900-1909	1,011	Slab	Single Story	50000-60000	19.35	50%
51579222	1900-1909	896	Partial	Single Story	70000-80000	19.38	50%
51579223	1980-1989	1,280	Full	Single Story	90000-100000	19.47	50%
51579224	1910-1919	1,144	Partial	Single Story	60000-70000	19.47	50%
51579225	1960-1969	1,568	Full	Single Story	130000-140000	19.60	50%
51579226	1900-1909	1,383	Slab	1.5 story	30000-40000	19.64	50%
51579227	1900-1909	1,487	Slab	Single Story	50000-60000	19.73	50%
51579228	1960-1969	988	Full	Single Story	70000-80000	19.84	50%
51579229	1900-1909	1,032	Partial	Single Story	50000-60000	19.84	50%
51579230	1900-1909	888	Full	Single Story	50000-60000	19.91	50%
51579231	1900-1909	1,149	Partial	Single Story	40000-50000	19.95	50%
51579232	1910-1919	1,322	Partial	Single Story	60000-70000	20.05	50%
51579233	1900-1909	1,074	Partial	Single Story	50000-60000	20.07	50%
51579234	1900-1909	1,377	Partial	Single Story	90000-100000	20.08	50%
51579235	1900-1909	1,560	Slab	1.5 story	60000-70000	20.14	50%
51579236	1900-1909	944	Full	Single Story	70000-80000	20.15	50%
51579237	1980-1989	1,344	Full	Single Story	140000-150000	20.15	50%
51579238	1910-1919	1,616	Partial	Two-story	80000-90000	20.18	50%
51579239	1950-1959	1,830	Full	1.5 story	120000-130000	20.19	50%
51579240	1900-1909	860	Slab	Single Story	40000-50000	20.29	50%
51579241	1970-1979	1,152	Full	Single Story	70000-80000	20.36	50%
51579242	1940-1949	936	Full	Single Story	60000-70000	20.38	50%
51579243	1900-1909	980	Partial	Single Story	50000-60000	20.42	50%
51579244	1980-1989	1,498	Full	Single Story	110000-120000	20.43	50%
51579245	1900-1909	1,487	Full	1.5 story	100000-110000	20.57	50%
51579246	1960-1969	1,232	Full	Single Story	80000-90000	20.60	50%
51579247	1900-1909	1,249	Partial	Single Story	40000-50000	20.65	50%
51579248	1960-1969	964	Full	Single Story	80000-90000	20.67	50%
51579249	1950-1959	1,029	Partial	Single Story	80000-90000	20.72	50%
51579250	1900-1909	1,056	Partial	Single Story	30000-40000	20.72	50%
51579251	1950-1959	1,486	Full	Single Story	100000-110000	20.74	50%
51579252	1900-1909	624	Full	Single Story	30000-40000	20.87	50%

51579253	1900-1909	1,296	Partial	Single Story	40000-50000	20.95	50%
51579254	1900-1909	1,418	Partial	Single Story	100000-110000	21.04	50%
51579255	1900-1909	1,438	Partial	1.5 story	70000-80000	21.10	50%
51579256	1900-1909	1,308	Partial	Single Story	50000-60000	21.11	50%
51579257	1960-1969	936	Full	Single Story	70000-80000	21.12	50%
51579258	1970-1979	1,336	Full	Single Story	90000-100000	21.25	50%
51579259	1900-1909	970	Slab	Single Story	50000-60000	21.27	50%
51579260	Pre 1900	960	Partial	Single Story	60000-70000	21.29	50%
51579261	1900-1909	1,992	Partial	Two-story	70000-80000	21.35	50%
51579262	1900-1909	888	Partial	Single Story	30000-40000	21.37	50%
51579263	1900-1909	1,230	Full	Single Story	40000-50000	21.39	50%
51579264	1970-1979	768	Slab	1.5 story	30000-40000	21.42	50%
51579265	1970-1979	1,352	Full	Split-Level	100000-110000	21.48	50%
51579266	1900-1909	1,994	Full	Single Story	130000-140000	21.53	50%
51579267	1990-1999	1,169	Full	Single Story	110000-120000	21.57	40%
51579268	1900-1909	1,630	Partial	Single Story	90000-100000	21.58	40%
51579269	1960-1969	936	Full	Single Story	80000-90000	21.60	40%
51579270	1900-1909	907	Partial	1.5 story	30000-40000	21.63	40%
51579271	1900-1909	1,182	Partial	Single Story	70000-80000	21.66	40%
51579272	1900-1909	1,414	Full	1.5 story	70000-80000	21.67	40%
51579273	1900-1909	1,232	Partial	Single Story	40000-50000	21.81	40%
51579274	1920-1929	1,140	Full	Single Story	80000-90000	21.83	40%
51579275	1900-1909	1,476	Partial	1.5 story	70000-80000	21.84	40%
51579276	1900-1909	1,020	Full	Single Story	60000-70000	21.85	40%
51579277	1900-1909	716	Partial	Single Story	30000-40000	21.88	40%
51579278	1910-1919	1,960	Partial	Single Story	80000-90000	21.99	40%
51579279	Pre 1900	820	Full	Single Story	50000-60000	22.05	40%
51579280	1900-1909	1,076	Full	Single Story	50000-60000	22.07	40%
51579281	1900-1909	1,355	Partial	Single Story	80000-90000	22.20	40%
51579282	1900-1909	1,356	Full	Single Story	80000-90000	22.20	40%
51579283	1910-1919	780	Full	Single Story	60000-70000	22.21	40%
51579284	1900-1909	1,621	Full	1.5 story	70000-80000	22.21	40%
51579285	1990-1999	1,362	Full	Single Story	160000-170000	22.24	40%
51579286	1990-1999	1,024	Full	Single Story	80000-90000	22.28	40%
51579287	1900-1909	1,578	Partial	1.5 story	60000-70000	22.29	40%
51579288	1970-1979	1,940	Full	Two-story	140000-150000	22.33	40%
51579289	1900-1909	829	Partial	Single Story	50000-60000	22.36	40%
51579290	1900-1909	976	Partial	Single Story	50000-60000	22.39	40%
51579291	1900-1909	1,605	Partial	Single Story	60000-70000	22.39	40%
51579292	1970-1979	1,750	Full	Single Story	150000-160000	22.39	40%
51579293	1970-1979	1,176	Slab	Single Story	50000-60000	22.40	40%
51579294	1900-1909	656	Partial	Single Story	30000-40000	22.40	40%
51579295	1950-1959	812	Partial	Single Story	50000-60000	22.53	40%

51579296	1900-1909	928	Partial	Single Story	30000-40000	22.53	40%
51579297	1900-1909	1,377	Full	1.5 story	60000-70000	22.54	40%
51579298	1900-1909	928	Full	Single Story	40000-50000	22.59	40%
51579299	1900-1909	676	Partial	Single Story	40000-50000	22.59	40%
51579300	1970-1979	1,040	Full	1.5 story	90000-100000	22.65	40%
51579301	1930-1939	876	Full	Single Story	70000-80000	22.74	40%
51579302	1900-1909	1,168	Partial	1.5 story	30000-40000	22.74	40%
51579303	1950-1959	1,287	Slab	Single Story	80000-90000	22.90	40%
51579304	1970-1979	1,248	Full	Single Story	100000-110000	22.98	40%
51579305	1900-1909	836	Partial	Single Story	40000-50000	23.06	40%
51579306	1900-1909	1,227	Partial	1.5 story	50000-60000	23.06	40%
51579307	1960-1969	1,452	Full	Single Story	130000-140000	23.12	40%
51579308	1900-1909	1,021	Partial	Single Story	60000-70000	23.20	40%
51579309	1900-1909	1,011	Full	1.5 story	40000-50000	23.45	40%
51579310	1900-1909	1,361	Partial	Single Story	70000-80000	23.49	40%
51579311	1900-1909	1,512	Partial	Single Story	90000-100000	23.49	40%
51579312	1900-1909	976	Slab	Single Story	50000-60000	23.52	40%
51579313	1970-1979	1,386	Full	Single Story	80000-90000	23.55	40%
51579314	1900-1909	728	Partial	Single Story	60000-70000	23.59	40%
51579315	1970-1979	1,144	Full	Single Story	110000-120000	23.68	40%
51579316	1900-1909	1,754	Slab	1.5 story	30000-40000	23.69	40%
51579317	1910-1919	1,456	Full	Single Story	100000-110000	23.70	40%
51579318	1900-1909	936	Partial	Single Story	40000-50000	23.78	40%
51579319	1900-1909	1,364	Slab	1.5 story	50000-60000	23.78	40%
51579320	1970-1979	1,236	Full	Split-Level	110000-120000	23.78	30%
51579321	1900-1909	1,624	Full	1.5 story	60000-70000	23.87	30%
51579322	1990-1999	1,485	Full	Single Story	110000-120000	23.89	30%
51579323	1990-1999	1,040	Full	Other	40000-50000	23.90	30%
51579324	1980-1989	1,092	Full	Single Story	90000-100000	23.96	30%
51579325	1900-1909	1,012	Partial	Single Story	70000-80000	24.01	30%
51579326	1960-1969	912	Slab	Other	30000-40000	24.04	30%
51579327	1900-1909	784	Slab	Single Story	30000-40000	24.08	30%
51579328	1900-1909	1,204	Full	Single Story	100000-110000	24.08	30%
51579329	1900-1909	1,716	Slab	Single Story	70000-80000	24.26	30%
51579330	1910-1919	963	Full	Single Story	60000-70000	24.28	30%
51579331	1990-1999	1,014	Full	Single Story	90000-100000	24.49	30%
51579332	1900-1909	1,464	Partial	Two-story	60000-70000	24.54	30%
51579333	1950-1959	1,144	Full	Single Story	80000-90000	24.58	30%
51579334	1900-1909	1,801	Partial	1.5 story	70000-80000	24.63	30%
51579335	2000-2010	1,857	Full	Single Story	180000-190000	24.68	30%
51579336	1900-1909	1,682	Full	1.5 story	70000-80000	24.75	30%
51579337	1970-1979	1,335	Full	Split-Level	110000-120000	24.79	30%
51579338	1900-1909	1,166	Partial	Single Story	50000-60000	24.79	30%

51579339	1990-1999	1,040	Full	Other	60000-70000	24.82	30%
51579340	1900-1909	1,022	Partial	Single Story	30000-40000	24.85	30%
51579341	1960-1969	1,008	Slab	Single Story	80000-90000	24.95	30%
51579342	1960-1969	1,176	Full	Single Story	100000-110000	24.97	30%
51579343	1900-1909	2,068	Partial	1.5 story	120000-130000	25.12	30%
51579344	1900-1909	868	Full	Single Story	30000-40000	25.13	30%
51579345	1900-1909	960	Slab	Single Story	40000-50000	25.16	30%
51579346	1990-1999	1,344	Full	Single Story	100000-110000	25.18	30%
51579347	1900-1909	1,317	Partial	1.5 story	40000-50000	25.25	30%
51579348	1900-1909	1,435	Partial	1.5 story	70000-80000	25.31	30%
51579349	1900-1909	1,224	Partial	Single Story	120000-130000	25.36	30%
51579350	1900-1909	1,558	Full	Single Story	100000-110000	25.47	30%
51579351	1900-1909	1,360	Full	1.5 story	50000-60000	25.62	30%
51579352	1910-1919	1,342	Partial	Single Story	70000-80000	25.71	30%
51579353	1900-1909	1,248	Full	1.5 story	50000-60000	25.73	30%
51579354	1900-1909	1,116	Full	Single Story	30000-40000	25.90	30%
51579355	1960-1969	960	Full	Single Story	80000-90000	25.93	30%
51579356	1900-1909	1,104	Partial	Single Story	40000-50000	26.08	30%
51579357	1920-1929	1,128	Partial	Single Story	60000-70000	26.10	30%
51579358	1900-1909	1,008	Slab	Single Story	70000-80000	26.10	30%
51579359	1990-1999	1,197	Full	Single Story	120000-130000	26.11	30%
51579360	1900-1909	858	Partial	Single Story	40000-50000	26.18	30%
51579361	1900-1909	1,204	Partial	Single Story	40000-50000	26.22	30%
51579362	Pre 1900	1,204	Partial	Single Story	40000-50000	26.22	30%
51579363	1900-1909	1,114	Partial	Single Story	40000-50000	26.29	30%
51579364	1900-1909	576	Partial	Single Story	30000-40000	26.30	30%
51579365	1900-1909	576	Full	Single Story	60000-70000	26.31	30%
51579366	1900-1909	1,196	Partial	1.5 story	40000-50000	26.35	30%
51579367	1900-1909	1,248	Partial	Single Story	80000-90000	26.47	30%
51579368	1900-1909	862	Full	1.5 story	30000-40000	26.54	30%
51579369	1900-1909	1,341	Full	Single Story	80000-90000	26.81	30%
51579370	1960-1969	1,472	Full	Single Story	120000-130000	26.86	30%
51579371	1900-1909	1,516	Partial	Single Story	120000-130000	26.88	30%
51579372	1900-1909	1,028	Partial	Single Story	50000-60000	26.94	20%
51579373	1900-1909	1,376	Slab	1.5 story	60000-70000	27.11	20%
51579374	1960-1969	1,352	Full	Single Story	110000-120000	27.12	20%
51579375	1900-1909	1,180	Slab	Single Story	40000-50000	27.16	20%
51579376	1900-1909	1,514	Full	1.5 story	90000-100000	27.28	20%
51579377	1900-1909	2,032	Full	Two-story	90000-100000	27.33	20%
51579378	1970-1979	864	Full	Single Story	80000-90000	27.45	20%
51579379	1900-1909	676	Partial	Single Story	50000-60000	27.48	20%
51579380	1900-1909	814	Partial	Single Story	30000-40000	27.49	20%
51579381	1950-1959	1,064	Full	Single Story	90000-100000	27.62	20%

51579382	1900-1909	704	Full	Single Story	40000-50000	27.69	20%
51579383	1900-1909	822	Partial	Single Story	60000-70000	27.73	20%
51579384	1950-1959	1,374	Full	Single Story	80000-90000	27.75	20%
51579385	1950-1959	858	Full	Single Story	70000-80000	27.92	20%
51579386	1970-1979	1,320	Full	Single Story	100000-110000	28.04	20%
51579387	1900-1909	624	Partial	Single Story	30000-40000	28.05	20%
51579388	1980-1989	1,578	Partial	Single Story	90000-100000	28.08	20%
51579389	1900-1909	1,184	Full	Single Story	70000-80000	28.20	20%
51579390	1940-1949	1,412	Slab	Single Story	60000-70000	28.24	20%
51579391	Pre 1900	904	Partial	Single Story	40000-50000	28.24	20%
51579392	1900-1909	1,056	Partial	Single Story	80000-90000	28.46	20%
51579393	1900-1909	784	Full	Single Story	60000-70000	28.53	20%
51579394	1970-1979	1,390	Full	Single Story	110000-120000	28.55	20%
51579395	1980-1989	1,120	Partial	Single Story	100000-110000	28.69	20%
51579396	1900-1909	833	Partial	Single Story	40000-50000	28.73	20%
51579397	1900-1909	1,238	Partial	1.5 story	40000-50000	29.18	20%
51579398	1970-1979	1,328	Full	Single Story	140000-150000	29.22	20%
51579399	1900-1909	1,200	Full	Single Story	70000-80000	29.30	20%
51579400	1970-1979	960	Full	Single Story	70000-80000	29.72	20%
51579401	1900-1909	1,200	Partial	Single Story	60000-70000	29.75	20%
51579402	1910-1919	532	Full	Single Story	40000-50000	29.85	20%
51579403	1970-1979	1,040	Full	Split-Level	80000-90000	29.90	20%
51579404	1960-1969	1,184	Full	Single Story	90000-100000	30.02	20%
51579405	1900-1909	722	Partial	Single Story	30000-40000	30.07	20%
51579406	1900-1909	1,198	Partial	1.5 story	70000-80000	30.14	20%
51579407	1900-1909	624	Partial	Single Story	40000-50000	30.20	20%
51579408	1970-1979	1,372	Full	Single Story	110000-120000	30.27	20%
51579409	1900-1909	1,232	Partial	Single Story	60000-70000	30.36	20%
51579410	1900-1909	906	Partial	1.5 story	40000-50000	30.37	20%
51579411	1900-1909	1,352	Partial	Single Story	110000-120000	30.95	20%
51579412	1900-1909	920	Partial	Single Story	90000-100000	30.98	20%
51579413	1900-1909	1,176	Full	Single Story	100000-110000	31.10	20%
51579414	1900-1909	954	Full	Single Story	70000-80000	31.15	20%
51579415	1900-1909	712	Slab	Single Story	30000-40000	31.51	20%
51579416	1900-1909	1,003	Full	Single Story	90000-100000	31.53	20%
51579417	1960-1969	1,169	Full	Single Story	80000-90000	31.73	20%
51579418	1900-1909	728	Full	Single Story	40000-50000	31.88	20%
51579419	1900-1909	1,306	Partial	Single Story	30000-40000	31.89	20%
51579420	1900-1909	864	Partial	Single Story	50000-60000	32.08	20%
51579421	1900-1909	748	Slab	Single Story	30000-40000	32.14	20%
51579422	1970-1979	960	Full	Single Story	70000-80000	32.57	20%
51579423	1970-1979	1,620	Full	Single Story	140000-150000	32.63	20%
51579424	Pre 1900	640	Full	Single Story	70000-80000	33.15	20%

51579425	1900-1909	576	Full	Single Story	60000-70000	33.25	20%
51579426	1900-1909	784	Partial	Single Story	30000-40000	33.26	20%
51579427	1970-1979	1,004	Slab	MblHome	50000-60000	33.28	10%
51579428	Pre 1900	907	Partial	1.5 story	30000-40000	33.33	10%
51579429	1970-1979	960	Slab	Single Story	50000-60000	33.42	10%
51579430	1900-1909	1,148	Full	1.5 story	40000-50000	33.59	10%
51579431	1900-1909	944	Partial	Single Story	30000-40000	33.60	10%
51579432	1990-1999	1,152	Full	Single Story	110000-120000	33.82	10%
51579433	1900-1909	1,164	Partial	Single Story	70000-80000	33.91	10%
51579434	1900-1909	834	Partial	Single Story	40000-50000	33.95	10%
51579435	1900-1909	1,030	Partial	Single Story	40000-50000	34.08	10%
51579436	1900-1909	1,122	Full	Single Story	110000-120000	34.18	10%
51579437	1900-1909	965	Partial	1.5 story	40000-50000	34.29	10%
51579438	1900-1909	812	Full	Single Story	60000-70000	34.37	10%
51579439	1900-1909	812	Partial	Single Story	30000-40000	34.39	10%
51579440	1900-1909	720	Partial	Single Story	40000-50000	34.56	10%
51579441	1900-1909	1,008	Partial	Single Story	70000-80000	34.72	10%
51579442	1950-1959	1,165	Full	Single Story	100000-110000	34.80	10%
51579443	Pre 1900	748	Partial	1.5 story	30000-40000	34.89	10%
51579444	1900-1909	1,568	Partial	1.5 story	50000-60000	35.02	10%
51579445	1900-1909	1,069	Partial	Single Story	50000-60000	35.26	10%
51579446	1970-1979	864	Full	Split-Level	80000-90000	35.31	10%
51579447	1960-1969	1,232	Full	Single Story	110000-120000	35.41	10%
51579448	1900-1909	1,300	Slab	Single Story	60000-70000	35.52	10%
51579449	1970-1979	1,080	Full	Split-Level	110000-120000	35.77	10%
51579450	1900-1909	988	Partial	Single Story	80000-90000	35.91	10%
51579451	1900-1909	871	Full	Single Story	30000-40000	35.95	10%
51579452	1900-1909	1,178	Partial	1.5 story	60000-70000	36.64	10%
51579453	1900-1909	1,256	Full	1.5 story	60000-70000	36.69	10%
51579454	1900-1909	810	Partial	Single Story	80000-90000	37.11	10%
51579455	1970-1979	992	Full	Single Story	70000-80000	37.12	10%
51579456	1900-1909	1,024	Partial	Single Story	30000-40000	37.54	10%
51579457	1900-1909	868	Partial	Single Story	70000-80000	38.46	10%
51579458	1950-1959	1,068	Partial	Single Story	50000-60000	38.56	10%
51579459	1900-1909	770	Partial	Single Story	30000-40000	39.32	10%
51579460	1970-1979	1,056	Full	Single Story	70000-80000	40.17	10%
51579461	1900-1909	898	Partial	Single Story	60000-70000	40.84	10%
51579462	1900-1909	1,354	Full	1.5 story	40000-50000	41.06	10%
51579463	1900-1909	1,032	Full	Single Story	60000-70000	42.68	10%
51579464	1900-1909	916	Full	Single Story	60000-70000	43.23	10%
51579465	1900-1909	616	Partial	Single Story	30000-40000	43.80	10%
51579466	1900-1909	784	Full	Single Story	40000-50000	43.83	10%
51579467	1900-1909	1,026	Partial	Single Story	70000-80000	45.59	10%

51579468	1980-1989	876	Full	Split-Level	100000-110000	45.92	10%
51579469	1900-1909	1,124	Partial	Single Story	40000-50000	47.28	10%
51579470	1900-1909	2,566	Full	Two-story	120000-130000	47.35	10%
51579471	1900-1909	1,018	Partial	Single Story	70000-80000	47.44	10%
51579472	1910-1919	932	Full	Single Story	90000-100000	47.69	10%
51579473	1900-1909	970	Full	Single Story	70000-80000	49.20	10%
51579474	1900-1909	1,063	Partial	Single Story	30000-40000	52.21	10%
51579475	1900-1909	900	Full	Single Story	80000-90000	52.54	10%
51579476	1900-1909	628	Partial	Single Story	30000-40000	52.86	10%
51579477	1960-1969	936	Full	Single Story	80000-90000	53.13	10%
51579478	1900-1909	794	Partial	Single Story	30000-40000	53.75	10%
51579479	1900-1909	856	Partial	Single Story	40000-50000	54.23	10%
51579480	1950-1959	891	Full	Single Story	100000-110000	56.16	10%
				Average BTU/Sqft/DD		**21.75**	

TABLE A.2: Year Built Correlation Table

Year Built	Code	BTU/SQFT/DD
1970-1979	8	4.55
1900-1909	1	5.09
1920-1929	3	5.64
1970-1979	8	6.48
1900-1909	1	6.66
1950-1959	6	7.48
1900-1909	1	7.77
1970-1979	8	7.99
1900-1909	1	8.07
1900-1909	1	8.20
1900-1909	1	8.20
1990-1999	10	8.24
1970-1979	8	8.79
1960-1969	7	8.82
1900-1909	1	8.87
1990-1999	10	8.89
1950-1959	6	9.29
1960-1969	7	9.29
1950-1959	6	9.50
1900-1909	1	9.61
1900-1909	1	9.85
1900-1909	1	9.94
1980-1989	9	10.06
Pre 1900	0	10.11
1900-1909	1	10.16
1990-1999	10	10.36
2000-2010	11	10.36
1970-1979	8	10.41
1960-1969	7	10.49
1910-1919	2	10.53
1990-1999	10	10.97
1900-1909	1	10.99
1900-1909	1	10.99
1900-1909	1	11.03
1970-1979	8	11.05
1920-1929	3	11.15
1900-1909	1	11.16
1900-1909	1	11.31
1900-1909	1	11.55
1900-1909	1	11.63

Coding Reference	
Pre 1900	0
1900-1909	1
1910-1919	2
1920-1929	3
1930-1939	4
1940-1949	5
1950-1959	6
1960-1969	7
1970-1979	8
1980-1989	9
1990-1999	10
2000-2010	11

1970-1979	8	11.64
1900-1909	1	11.67
1900-1909	1	11.73
Pre 1900	0	11.81
1980-1989	9	11.81
1900-1909	1	11.86
1900-1909	1	11.90
1900-1909	1	11.95
1900-1909	1	12.04
1900-1909	1	12.15
1990-1999	10	12.29
1980-1989	9	12.30
1900-1909	1	12.31
1900-1909	1	12.40
1900-1909	1	12.41
1970-1979	8	12.42
1900-1909	1	12.54
1990-1999	10	12.57
1990-1999	10	12.62
1900-1909	1	12.63
1900-1909	1	12.72
1990-1999	10	12.75
1900-1909	1	12.75
1900-1909	1	12.76
1900-1909	1	12.80
1900-1909	1	12.83
1900-1909	1	12.87
1900-1909	1	12.92
1900-1909	1	12.93
1920-1929	3	12.96
1900-1909	1	13.01
1970-1979	8	13.03
1960-1969	7	13.12
1970-1979	8	13.15
2000-2010	11	13.23
1970-1979	8	13.35
1990-1999	10	13.39
1950-1959	6	13.53
1900-1909	1	13.54
1970-1979	8	13.58
Pre 1900	0	13.64
1990-1999	10	13.71
2000-2010	11	13.79
1990-1999	10	13.96

1990-1999	10	14.00
1990-1999	10	14.01
1900-1909	1	14.06
1900-1909	1	14.11
1900-1909	1	14.15
1900-1909	1	14.17
1900-1909	1	14.20
Pre 1900	0	14.21
1900-1909	1	14.27
1900-1909	1	14.42
1960-1969	7	14.44
1910-1919	2	14.49
1990-1999	10	14.50
1900-1909	1	14.52
1900-1909	1	14.53
1980-1989	9	14.62
1970-1979	8	14.67
1990-1999	10	14.70
1920-1929	3	14.74
1900-1909	1	14.76
1900-1909	1	14.80
1900-1909	1	14.84
1960-1969	7	14.91
1950-1959	6	14.92
1970-1979	8	14.94
1930-1939	4	14.99
Pre 1900	0	15.00
1900-1909	1	15.06
1960-1969	7	15.08
1900-1909	1	15.11
2000-2010	11	15.12
1900-1909	1	15.16
1900-1909	1	15.21
1900-1909	1	15.21
1920-1929	3	15.21
1960-1969	7	15.33
1900-1909	1	15.39
Pre 1900	0	15.43
1900-1909	1	15.45
1970-1979	8	15.47
1990-1999	10	15.52
1990-1999	10	15.60
1990-1999	10	15.65
1900-1909	1	15.67

1900-1909	1	15.78
1900-1909	1	15.78
1900-1909	1	15.91
1980-1989	9	15.91
1970-1979	8	15.94
1900-1909	1	15.95
1900-1909	1	15.98
1900-1909	1	16.00
1900-1909	1	16.00
1950-1959	6	16.08
1950-1959	6	16.09
1940-1949	5	16.10
Pre 1900	0	16.11
1990-1999	10	16.13
1900-1909	1	16.15
1900-1909	1	16.17
1900-1909	1	16.19
1900-1909	1	16.20
1950-1959	6	16.25
1900-1909	1	16.29
1900-1909	1	16.45
1900-1909	1	16.49
1900-1909	1	16.52
1900-1909	1	16.58
1980-1989	9	16.58
1900-1909	1	16.64
1980-1989	9	16.64
1920-1929	3	16.65
1900-1909	1	16.67
1960-1969	7	16.68
1970-1979	8	16.86
1970-1979	8	16.87
1920-1929	3	16.94
1960-1969	7	16.96
1980-1989	9	17.01
1940-1949	5	17.06
1900-1909	1	17.07
1900-1909	1	17.10
1970-1979	8	17.13
Pre 1900	0	17.22
1900-1909	1	17.30
1970-1979	8	17.30
1900-1909	1	17.33
1900-1909	1	17.43

1900-1909	1	17.46
1970-1979	8	17.56
1960-1969	7	17.58
1960-1969	7	17.60
1900-1909	1	17.61
1970-1979	8	17.67
1960-1969	7	17.85
1900-1909	1	17.93
1960-1969	7	17.95
1960-1969	7	17.96
1960-1969	7	18.02
1900-1909	1	18.03
1970-1979	8	18.07
1900-1909	1	18.09
1900-1909	1	18.14
1920-1929	3	18.15
1900-1909	1	18.21
1950-1959	6	18.23
1900-1909	1	18.25
1900-1909	1	18.28
1900-1909	1	18.30
1970-1979	8	18.32
1970-1979	8	18.33
1950-1959	6	18.35
1990-1999	10	18.36
1970-1979	8	18.43
1950-1959	6	18.52
1980-1989	9	18.53
1900-1909	1	18.59
1900-1909	1	18.65
1970-1979	8	18.70
1960-1969	7	18.70
1970-1979	8	18.74
1970-1979	8	18.80
1900-1909	1	18.82
1970-1979	8	18.84
1900-1909	1	18.91
1900-1909	1	18.92
1970-1979	8	18.95
1970-1979	8	18.98
1900-1909	1	18.99
1900-1909	1	19.03
1930-1939	4	19.05
1990-1999	10	19.08

2000-2010	11	19.12
1980-1989	9	19.12
1900-1909	1	19.30
1990-1999	10	19.34
1900-1909	1	19.35
1900-1909	1	19.38
1980-1989	9	19.47
1910-1919	2	19.47
1960-1969	7	19.60
1900-1909	1	19.64
1900-1909	1	19.73
1960-1969	7	19.84
1900-1909	1	19.84
1900-1909	1	19.91
1900-1909	1	19.95
1910-1919	2	20.05
1900-1909	1	20.07
1900-1909	1	20.08
1900-1909	1	20.14
1900-1909	1	20.15
1980-1989	9	20.15
1910-1919	2	20.18
1950-1959	6	20.19
1900-1909	1	20.29
1970-1979	8	20.36
1940-1949	5	20.38
1900-1909	1	20.42
1980-1989	9	20.43
1900-1909	1	20.57
1960-1969	7	20.60
1900-1909	1	20.65
1960-1969	7	20.67
1950-1959	6	20.72
1900-1909	1	20.72
1950-1959	6	20.74
1900-1909	1	20.87
1900-1909	1	20.95
1900-1909	1	21.04
1900-1909	1	21.10
1900-1909	1	21.11
1960-1969	7	21.12
1970-1979	8	21.25
1900-1909	1	21.27
Pre 1900	0	21.29

1900-1909	1	21.35
1900-1909	1	21.37
1900-1909	1	21.39
1970-1979	8	21.42
1970-1979	8	21.48
1900-1909	1	21.53
1990-1999	10	21.57
1900-1909	1	21.58
1960-1969	7	21.60
1900-1909	1	21.63
1900-1909	1	21.66
1900-1909	1	21.67
1900-1909	1	21.81
1920-1929	3	21.83
1900-1909	1	21.84
1900-1909	1	21.85
1900-1909	1	21.88
1910-1919	2	21.99
Pre 1900	0	22.05
1900-1909	1	22.07
1900-1909	1	22.20
1900-1909	1	22.20
1910-1919	2	22.21
1900-1909	1	22.21
1990-1999	10	22.24
1990-1999	10	22.28
1900-1909	1	22.29
1970-1979	8	22.33
1900-1909	1	22.36
1900-1909	1	22.39
1900-1909	1	22.39
1970-1979	8	22.39
1970-1979	8	22.40
1900-1909	1	22.40
1950-1959	6	22.53
1900-1909	1	22.53
1900-1909	1	22.54
1900-1909	1	22.59
1900-1909	1	22.59
1970-1979	8	22.65
1930-1939	4	22.74
1900-1909	1	22.74
1950-1959	6	22.90
1970-1979	8	22.98

1900-1909	1	23.06
1900-1909	1	23.06
1960-1969	7	23.12
1900-1909	1	23.20
1900-1909	1	23.45
1900-1909	1	23.49
1900-1909	1	23.49
1900-1909	1	23.52
1970-1979	8	23.55
1900-1909	1	23.59
1970-1979	8	23.68
1900-1909	1	23.69
1910-1919	2	23.70
1900-1909	1	23.78
1900-1909	1	23.78
1970-1979	8	23.78
1900-1909	1	23.87
1990-1999	10	23.89
1990-1999	10	23.90
1980-1989	9	23.96
1900-1909	1	24.01
1960-1969	7	24.04
1900-1909	1	24.08
1900-1909	1	24.08
1900-1909	1	24.26
1910-1919	2	24.28
1990-1999	10	24.49
1900-1909	1	24.54
1950-1959	6	24.58
1900-1909	1	24.63
2000-2010	11	24.68
1900-1909	1	24.75
1970-1979	8	24.79
1900-1909	1	24.79
1990-1999	10	24.82
1900-1909	1	24.85
1960-1969	7	24.95
1960-1969	7	24.97
1900-1909	1	25.12
1900-1909	1	25.13
1900-1909	1	25.16
1990-1999	10	25.18
1900-1909	1	25.25
1900-1909	1	25.31

1900-1909	1	25.36
1900-1909	1	25.47
1900-1909	1	25.62
1910-1919	2	25.71
1900-1909	1	25.73
1900-1909	1	25.90
1960-1969	7	25.93
1900-1909	1	26.08
1920-1929	3	26.10
1900-1909	1	26.10
1990-1999	10	26.11
1900-1909	1	26.18
1900-1909	1	26.22
Pre 1900	0	26.22
1900-1909	1	26.29
1900-1909	1	26.30
1900-1909	1	26.31
1900-1909	1	26.35
1900-1909	1	26.47
1900-1909	1	26.54
1900-1909	1	26.81
1960-1969	7	26.86
1900-1909	1	26.88
1900-1909	1	26.94
1900-1909	1	27.11
1960-1969	7	27.12
1900-1909	1	27.16
1900-1909	1	27.28
1900-1909	1	27.33
1970-1979	8	27.45
1900-1909	1	27.48
1900-1909	1	27.49
1950-1959	6	27.62
1900-1909	1	27.69
1900-1909	1	27.73
1950-1959	6	27.75
1950-1959	6	27.92
1970-1979	8	28.04
1900-1909	1	28.05
1980-1989	9	28.08
1900-1909	1	28.20
1940-1949	5	28.24
Pre 1900	0	28.24
1900-1909	1	28.46

1900-1909	1	28.53
1970-1979	8	28.55
1980-1989	9	28.69
1900-1909	1	28.73
1900-1909	1	29.18
1970-1979	8	29.22
1900-1909	1	29.30
1970-1979	8	29.72
1900-1909	1	29.75
1910-1919	2	29.85
1970-1979	8	29.90
1960-1969	7	30.02
1900-1909	1	30.07
1900-1909	1	30.14
1900-1909	1	30.20
1970-1979	8	30.27
1900-1909	1	30.36
1900-1909	1	30.37
1900-1909	1	30.95
1900-1909	1	30.98
1900-1909	1	31.10
1900-1909	1	31.15
1900-1909	1	31.51
1900-1909	1	31.53
1960-1969	7	31.73
1900-1909	1	31.88
1900-1909	1	31.89
1900-1909	1	32.08
1900-1909	1	32.14
1970-1979	8	32.57
1970-1979	8	32.63
Pre 1900	0	33.15
1900-1909	1	33.25
1900-1909	1	33.26
1970-1979	8	33.28
Pre 1900	0	33.33
1970-1979	8	33.42
1900-1909	1	33.59
1900-1909	1	33.60
1990-1999	10	33.82
1900-1909	1	33.91
1900-1909	1	33.95
1900-1909	1	34.08
1900-1909	1	34.18

1900-1909	1	34.29
1900-1909	1	34.37
1900-1909	1	34.39
1900-1909	1	34.56
1900-1909	1	34.72
1950-1959	6	34.80
Pre 1900	0	34.89
1900-1909	1	35.02
1900-1909	1	35.26
1970-1979	8	35.31
1960-1969	7	35.41
1900-1909	1	35.52
1970-1979	8	35.77
1900-1909	1	35.91
1900-1909	1	35.95
1900-1909	1	36.64
1900-1909	1	36.69
1900-1909	1	37.11
1970-1979	8	37.12
1900-1909	1	37.54
1900-1909	1	38.46
1950-1959	6	38.56
1900-1909	1	39.32
1970-1979	8	40.17
1900-1909	1	40.84
1900-1909	1	41.06
1900-1909	1	42.68
1900-1909	1	43.23
1900-1909	1	43.80
1900-1909	1	43.83
1900-1909	1	45.59
1980-1989	9	45.92
1900-1909	1	47.28
1900-1909	1	47.35
1900-1909	1	47.44
1910-1919	2	47.69
1900-1909	1	49.20
1900-1909	1	52.21
1900-1909	1	52.54
1900-1909	1	52.86
1960-1969	7	53.13
1900-1909	1	53.75
1900-1909	1	54.23
1950-1959	6	56.16

TABLE A.3: House Style Correlation Table

Style	Code	BTU/SQFT/DD
Single Story	1	4.55
Two-story	3	5.09
Single Story	1	5.64
Single Story	1	6.48
Single Story	1	6.66
Single Story	1	7.48
1.5 story	2	7.77
Single Story	1	7.99
Single Story	1	8.07
Single Story	1	8.20
1.5 story	2	8.20
Single Story	1	8.24
Single Story	1	8.79
Single Story	1	8.82
1.5 story	2	8.87
Single Story	1	8.89
Single Story	1	9.29
Single Story	1	9.29
Single Story	1	9.50
Single Story	1	9.61
Single Story	1	9.85
1.5 story	2	9.94
Single Story	1	10.06
Single Story	1	10.11
Single Story	1	10.16
Single Story	1	10.36
Two-Story	3	10.36
Single Story	1	10.41
Single Story	1	10.49
Single Story	1	10.53
Single Story	1	10.97
Two-story	3	10.99
1.5 story	2	10.99
Single Story	1	11.03
Single Story	1	11.05
Single Story	1	11.15
1.5 story	2	11.16
Single Story	1	11.31
Single Story	1	11.55
Single Story	1	11.63

Code Reference

Single Story	1
1.5 story	2
Two-story	3
Split-Level	4
Mobile Home	5
Other	6

Single Story	1	11.64
Two-story	3	11.67
Two-story	3	11.73
Two-story	3	11.81
1.5 story	2	11.81
Single Story	1	11.86
Two-story	3	11.90
Single Story	1	11.95
Single Story	1	12.04
Single Story	1	12.15
Single Story	1	12.29
Single Story	1	12.30
Single Story	1	12.31
Single Story	1	12.40
1.5 story	2	12.41
Split-Level	4	12.42
1.5 story	2	12.54
Single Story	1	12.57
Single Story	1	12.62
1.5 story	2	12.63
Single Story	1	12.72
Mobile Home	5	12.75
1.5 story	2	12.75
1.5 story	2	12.76
Single Story	1	12.80
1.5 story	2	12.83
Single Story	1	12.87
1.5 story	2	12.92
Single Story	1	12.93
Single Story	1	12.96
Single Story	1	13.01
Single Story	1	13.03
Single Story	1	13.12
Single Story	1	13.15
Single Story	1	13.23
Two-story	3	13.35
Single Story	1	13.39
Single Story	1	13.53
1.5 story	2	13.54
Single Story	1	13.58
1.5 story	2	13.64
Single Story	1	13.71
1.5 story	2	13.79
Single Story	1	13.96

Two-story	3	14.00
1.5 story	2	14.01
Single Story	1	14.06
1.5 story	2	14.11
1.5 story	2	14.15
Single Story	1	14.17
1.5 story	2	14.20
1.5 story	2	14.21
1.5 story	2	14.27
Single Story	1	14.42
Single Story	1	14.44
Two-story	3	14.49
Single Story	1	14.50
Single Story	1	14.52
Single Story	1	14.53
Single Story	1	14.62
Single Story	1	14.67
Single Story	1	14.70
Two-story	3	14.74
1.5 story	2	14.76
Single Story	1	14.80
1.5 story	2	14.84
Single Story	1	14.91
Single Story	1	14.92
Single Story	1	14.94
Single Story	1	14.99
Single Story	1	15.00
Single Story	1	15.06
Single Story	1	15.08
1.5 story	2	15.11
Single Story	1	15.12
Single Story	1	15.16
Single Story	1	15.21
1.5 story	2	15.21
Single Story	1	15.21
Single Story	1	15.33
Single Story	1	15.39
Single Story	1	15.43
1.5 story	2	15.45
Single Story	1	15.47
Single Story	1	15.52
Single Story	1	15.60
Single Story	1	15.65
1.5 story	2	15.67

Single Story	1	15.78
Single Story	1	15.78
Single Story	1	15.91
Single Story	1	15.91
Two-story	3	15.94
Single Story	1	15.95
1.5 story	2	15.98
Single Story	1	16.00
Two-story	3	16.00
Single Story	1	16.08
Single Story	1	16.09
1.5 story	2	16.10
Two-story	3	16.11
Single Story	1	16.13
1.5 story	2	16.15
Single Story	1	16.17
Single Story	1	16.19
Single Story	1	16.20
Single Story	1	16.25
Single Story	1	16.29
1.5 story	2	16.45
Single Story	1	16.49
Single Story	1	16.52
1.5 story	2	16.58
Single Story	1	16.58
Two-story	3	16.64
Single Story	1	16.64
Single Story	1	16.65
1.5 story	2	16.67
Single Story	1	16.68
Two-story	3	16.86
Two-story	3	16.87
Single Story	1	16.94
Single Story	1	16.96
Single Story	1	17.01
Single Story	1	17.06
Single Story	1	17.07
Two-story	3	17.10
Single Story	1	17.13
Two-story	3	17.22
Single Story	1	17.30
Single Story	1	17.30
1.5 story	2	17.33
Single Story	1	17.43

Two-story	3	17.46
Single Story	1	17.56
Single Story	1	17.58
Single Story	1	17.60
1.5 story	2	17.61
Single Story	1	17.67
Single Story	1	17.85
Two-story	3	17.93
Single Story	1	17.95
Single Story	1	17.96
Single Story	1	18.02
1.5 story	2	18.03
Single Story	1	18.07
Two-story	3	18.09
Single Story	1	18.14
Two-story	3	18.15
1.5 story	2	18.21
Single Story	1	18.23
Single Story	1	18.25
Two-story	3	18.28
1.5 story	2	18.30
Single Story	1	18.32
Single Story	1	18.33
Single Story	1	18.35
Single Story	1	18.36
Two-story	3	18.43
Single Story	1	18.52
Single Story	1	18.53
Single Story	1	18.59
1.5 story	2	18.65
Single Story	1	18.70
Single Story	1	18.70
Single Story	1	18.74
Single Story	1	18.80
1.5 story	2	18.82
Single Story	1	18.84
Single Story	1	18.91
Single Story	1	18.92
Single Story	1	18.95
Single Story	1	18.98
1.5 story	2	18.99
Single Story	1	19.03
Single Story	1	19.05
Single Story	1	19.08

Single Story	1	19.12
Single Story	1	19.12
1.5 story	2	19.30
Single Story	1	19.34
Single Story	1	19.35
Single Story	1	19.38
Single Story	1	19.47
Single Story	1	19.47
Single Story	1	19.60
1.5 story	2	19.64
Single Story	1	19.73
Single Story	1	19.84
Single Story	1	19.84
Single Story	1	19.91
Single Story	1	19.95
Single Story	1	20.05
Single Story	1	20.07
Single Story	1	20.08
1.5 story	2	20.14
Single Story	1	20.15
Single Story	1	20.15
Two-story	3	20.18
1.5 story	2	20.19
Single Story	1	20.29
Single Story	1	20.36
Single Story	1	20.38
Single Story	1	20.42
Single Story	1	20.43
1.5 story	2	20.57
Single Story	1	20.60
Single Story	1	20.65
Single Story	1	20.67
Single Story	1	20.72
Single Story	1	20.72
Single Story	1	20.74
Single Story	1	20.87
Single Story	1	20.95
Single Story	1	21.04
1.5 story	2	21.10
Single Story	1	21.11
Single Story	1	21.12
Single Story	1	21.25
Single Story	1	21.27
Single Story	1	21.29

Two-story	3	21.35
Single Story	1	21.37
Single Story	1	21.39
1.5 story	2	21.42
Split-Level	4	21.48
Single Story	1	21.53
Single Story	1	21.57
Single Story	1	21.58
Single Story	1	21.60
1.5 story	2	21.63
Single Story	1	21.66
1.5 story	2	21.67
Single Story	1	21.81
Single Story	1	21.83
1.5 story	2	21.84
Single Story	1	21.85
Single Story	1	21.88
Single Story	1	21.99
Single Story	1	22.05
Single Story	1	22.07
Single Story	1	22.20
Single Story	1	22.20
Single Story	1	22.21
1.5 story	2	22.21
Single Story	1	22.24
Single Story	1	22.28
1.5 story	2	22.29
Two-story	3	22.33
Single Story	1	22.36
Single Story	1	22.39
Single Story	1	22.39
Single Story	1	22.39
Single Story	1	22.40
Single Story	1	22.40
Single Story	1	22.53
Single Story	1	22.53
1.5 story	2	22.54
Single Story	1	22.59
Single Story	1	22.59
1.5 story	2	22.65
Single Story	1	22.74
1.5 story	2	22.74
Single Story	1	22.90
Single Story	1	22.98

Single Story	1	23.06
1.5 story	2	23.06
Single Story	1	23.12
Single Story	1	23.20
1.5 story	2	23.45
Single Story	1	23.49
Single Story	1	23.49
Single Story	1	23.52
Single Story	1	23.55
Single Story	1	23.59
Single Story	1	23.68
1.5 story	2	23.69
Single Story	1	23.70
Single Story	1	23.78
1.5 story	2	23.78
Split-Level	4	23.78
1.5 story	2	23.87
Single Story	1	23.89
Other	6	23.90
Single Story	1	23.96
Single Story	1	24.01
Other	6	24.04
Single Story	1	24.08
Single Story	1	24.08
Single Story	1	24.26
Single Story	1	24.28
Single Story	1	24.49
Two-story	3	24.54
Single Story	1	24.58
1.5 story	2	24.63
Single Story	1	24.68
1.5 story	2	24.75
Split-Level	4	24.79
Single Story	1	24.79
Other	6	24.82
Single Story	1	24.85
Single Story	1	24.95
Single Story	1	24.97
1.5 story	2	25.12
Single Story	1	25.13
Single Story	1	25.16
Single Story	1	25.18
1.5 story	2	25.25
1.5 story	2	25.31

Single Story	1	25.36
Single Story	1	25.47
1.5 story	2	25.62
Single Story	1	25.71
1.5 story	2	25.73
Single Story	1	25.90
Single Story	1	25.93
Single Story	1	26.08
Single Story	1	26.10
Single Story	1	26.10
Single Story	1	26.11
Single Story	1	26.18
Single Story	1	26.22
Single Story	1	26.22
Single Story	1	26.29
Single Story	1	26.30
Single Story	1	26.31
1.5 story	2	26.35
Single Story	1	26.47
1.5 story	2	26.54
Single Story	1	26.81
Single Story	1	26.86
Single Story	1	26.88
Single Story	1	26.94
1.5 story	2	27.11
Single Story	1	27.12
Single Story	1	27.16
1.5 story	2	27.28
Two-story	3	27.33
Single Story	1	27.45
Single Story	1	27.48
Single Story	1	27.49
Single Story	1	27.62
Single Story	1	27.69
Single Story	1	27.73
Single Story	1	27.75
Single Story	1	27.92
Single Story	1	28.04
Single Story	1	28.05
Single Story	1	28.08
Single Story	1	28.20
Single Story	1	28.24
Single Story	1	28.24
Single Story	1	28.46

Single Story	1	28.53
Single Story	1	28.55
Single Story	1	28.69
Single Story	1	28.73
1.5 story	2	29.18
Single Story	1	29.22
Single Story	1	29.30
Single Story	1	29.72
Single Story	1	29.75
Single Story	1	29.85
Split-Level	4	29.90
Single Story	1	30.02
Single Story	1	30.07
1.5 story	2	30.14
Single Story	1	30.20
Single Story	1	30.27
Single Story	1	30.36
1.5 story	2	30.37
Single Story	1	30.95
Single Story	1	30.98
Single Story	1	31.10
Single Story	1	31.15
Single Story	1	31.51
Single Story	1	31.53
Single Story	1	31.73
Single Story	1	31.88
Single Story	1	31.89
Single Story	1	32.08
Single Story	1	32.14
Single Story	1	32.57
Single Story	1	32.63
Single Story	1	33.15
Single Story	1	33.25
Single Story	1	33.26
Mobile Home	5	33.28
1.5 story	2	33.33
Single Story	1	33.42
1.5 story	2	33.59
Single Story	1	33.60
Single Story	1	33.82
Single Story	1	33.91
Single Story	1	33.95
Single Story	1	34.08
Single Story	1	34.18

1.5 story	2	34.29
Single Story	1	34.37
Single Story	1	34.39
Single Story	1	34.56
Single Story	1	34.72
Single Story	1	34.80
1.5 story	2	34.89
1.5 story	2	35.02
Single Story	1	35.26
Split-Level	4	35.31
Single Story	1	35.41
Single Story	1	35.52
Split-Level	4	35.77
Single Story	1	35.91
Single Story	1	35.95
1.5 story	2	36.64
1.5 story	2	36.69
Single Story	1	37.11
Single Story	1	37.12
Single Story	1	37.54
Single Story	1	38.46
Single Story	1	38.56
Single Story	1	39.32
Single Story	1	40.17
Single Story	1	40.84
1.5 story	2	41.06
Single Story	1	42.68
Single Story	1	43.23
Single Story	1	43.80
Single Story	1	43.83
Single Story	1	45.59
Split-Level	4	45.92
Single Story	1	47.28
Two-story	3	47.35
Single Story	1	47.44
Single Story	1	47.69
Single Story	1	49.20
Single Story	1	52.21
Single Story	1	52.54
Single Story	1	52.86
Single Story	1	53.13
Single Story	1	53.75
Single Story	1	54.23
Single Story	1	56.16

TABLE A.4: House Condition Correlation Table

Condition	Code	BTU/SQFT/DD
Good	4	4.55
Average	3	5.09
Poor	2	5.64
Good	4	6.48
Average	3	6.66
Very Good	5	7.48
Average	3	7.77
Very Good	5	7.99
Good	4	8.07
Poor	2	8.20
Very Good	5	8.20
Very Good	5	8.24
Poor	2	8.79
Average	3	8.82
Poor	2	8.87
Excellent	6	8.89
Average	3	9.29
Good	4	9.29
Very Good	5	9.50
Very Good	5	9.61
Poor	2	9.85
Good	4	9.94
Poor	2	10.06
Good	4	10.11
Very Good	5	10.16
Excellent	6	10.36
Excellent	6	10.36
Average	3	10.41
Average	3	10.49
Very Good	5	10.53
Very Good	5	10.97
Good	4	10.99
Poor	2	10.99
Poor	2	11.03
Average	3	11.05
Very Good	5	11.15
Poor	2	11.16
Excellent	6	11.31
Good	4	11.55
Very Good	5	11.63

Code Reference	
Very Poor	1
Poor	2
Average	3
Good	4
Very Good	5
Excellent	6

Poor	2	11.64
Good	4	11.67
Average	3	11.73
Average	3	11.81
Excellent	6	11.81
Poor	2	11.86
Average	3	11.90
Poor	2	11.95
Very Good	5	12.04
Poor	2	12.15
Excellent	6	12.29
Very Good	5	12.30
Poor	2	12.31
Very Good	5	12.40
Good	4	12.41
Average	3	12.42
Poor	2	12.54
Excellent	6	12.57
Excellent	6	12.62
Good	4	12.63
Very Good	5	12.72
Average	3	12.75
Average	3	12.75
Average	3	12.76
Very Good	5	12.80
Poor	2	12.83
Very Good	5	12.87
Good	4	12.92
Average	3	12.93
Very Good	5	12.96
Good	4	13.01
Very Good	5	13.03
Good	4	13.12
Average	3	13.15
Excellent	6	13.23
Very Good	5	13.35
Average	3	13.39
Good	4	13.53
Average	3	13.54
Very Good	5	13.58
Poor	2	13.64
Good	4	13.71
Excellent	6	13.79
Excellent	6	13.96

Excellent	6	14.00
Excellent	6	14.01
Good	4	14.06
Good	4	14.11
Excellent	6	14.15
Poor	2	14.17
Poor	2	14.20
Poor	2	14.21
Good	4	14.27
Very Poor	1	14.42
Poor	2	14.44
Very Good	5	14.49
Excellent	6	14.50
Good	4	14.52
Average	3	14.53
Average	3	14.62
Average	3	14.67
Excellent	6	14.70
Average	3	14.74
Excellent	6	14.76
Good	4	14.80
Very Poor	1	14.84
Very Good	5	14.91
Poor	2	14.92
Average	3	14.94
Very Good	5	14.99
Poor	2	15.00
Excellent	6	15.06
Very Good	5	15.08
Very Good	5	15.11
Excellent	6	15.12
Good	4	15.16
Average	3	15.21
Poor	2	15.21
Very Good	5	15.21
Very Good	5	15.33
Average	3	15.39
Poor	2	15.43
Poor	2	15.45
Good	4	15.47
Excellent	6	15.52
Very Good	5	15.60
Excellent	6	15.65
Average	3	15.67

Good	4	15.78
Poor	2	15.78
Average	3	15.91
Very Good	5	15.91
Very Good	5	15.94
Average	3	15.95
Poor	2	15.98
Excellent	6	16.00
Good	4	16.00
Good	4	16.08
Average	3	16.09
Good	4	16.10
Average	3	16.11
Excellent	6	16.13
Poor	2	16.15
Very Good	5	16.17
Good	4	16.19
Very Good	5	16.20
Very Good	5	16.25
Average	3	16.29
Average	3	16.45
Excellent	6	16.49
Good	4	16.52
Average	3	16.58
Good	4	16.58
Poor	2	16.64
Very Good	5	16.64
Very Good	5	16.65
Poor	2	16.67
Good	4	16.68
Good	4	16.86
Good	4	16.87
Good	4	16.94
Average	3	16.96
Very Good	5	17.01
Good	4	17.06
Average	3	17.07
Good	4	17.10
Average	3	17.13
Average	3	17.22
Average	3	17.30
Poor	2	17.30
Poor	2	17.33
Good	4	17.43

Poor	2	17.46
Average	3	17.56
Average	3	17.58
Very Good	5	17.60
Good	4	17.61
Very Good	5	17.67
Good	4	17.85
Poor	2	17.93
Very Good	5	17.95
Average	3	17.96
Very Good	5	18.02
Very Good	5	18.03
Average	3	18.07
Poor	2	18.09
Very Good	5	18.14
Average	3	18.15
Average	3	18.21
Good	4	18.23
Average	3	18.25
Average	3	18.28
Average	3	18.30
Very Good	5	18.32
Very Good	5	18.33
Poor	2	18.35
Excellent	6	18.36
Average	3	18.43
Good	4	18.52
Very Good	5	18.53
Poor	2	18.59
Good	4	18.65
Average	3	18.70
Very Good	4	18.70
Poor	2	18.74
Average	3	18.80
Poor	2	18.82
Average	3	18.84
Poor	2	18.91
Average	3	18.92
Very Good	5	18.95
Good	4	18.98
Good	4	18.99
Very Good	5	19.03
Good	4	19.05
Excellent	6	19.08

Excellent	6	19.12
Excellent	6	19.12
Very Good	5	19.30
Poor	2	19.34
Poor	2	19.35
Good	4	19.38
Average	3	19.47
Average	3	19.47
Very Good	5	19.60
Very Poor	1	19.64
Average	3	19.73
Average	3	19.84
Poor	2	19.84
Poor	2	19.91
Poor	2	19.95
Average	3	20.05
Average	3	20.07
Very Good	5	20.08
Good	4	20.14
Average	3	20.15
Excellent	6	20.15
Average	3	20.18
Poor	2	20.19
Average	3	20.29
Poor	2	20.36
Average	3	20.38
Poor	2	20.42
Average	3	20.43
Good	4	20.57
Good	4	20.60
Poor	2	20.65
Very Good	5	20.67
Good	4	20.72
Poor	2	20.72
Good	4	20.74
Poor	2	20.87
Very Poor	1	20.95
Average	3	21.04
Average	3	21.10
Average	3	21.11
Average	3	21.12
Average	3	21.25
Good	4	21.27
Average	3	21.29

Poor	2	21.35
Poor	2	21.37
Poor	2	21.39
Poor	2	21.42
Average	3	21.48
Good	4	21.53
Good	4	21.57
Very Good	5	21.58
Very Good	5	21.60
Average	3	21.63
Excellent	6	21.66
Average	3	21.67
Poor	2	21.81
Very Good	5	21.83
Very Good	5	21.84
Good	4	21.85
Poor	2	21.88
Poor	2	21.99
Average	3	22.05
Poor	2	22.07
Average	3	22.20
Good	4	22.20
Average	3	22.21
Good	4	22.21
Excellent	6	22.24
Average	3	22.28
Very Good	5	22.29
Good	4	22.33
Very Good	5	22.36
Poor	2	22.39
Poor	2	22.39
Very Good	4	22.39
Poor	2	22.40
Very Poor	1	22.40
Average	3	22.53
Poor	2	22.53
Good	4	22.54
Average	3	22.59
Good	4	22.59
Average	3	22.65
Average	3	22.74
Poor	2	22.74
Very Good	5	22.90
Average	3	22.98

Poor	2	23.06
Poor	2	23.06
Average	3	23.12
Very Good	5	23.20
Average	3	23.45
Average	3	23.49
Very Good	5	23.49
Average	3	23.52
Poor	2	23.55
Very Good	5	23.59
Very Good	5	23.68
Poor	2	23.69
Average	3	23.70
Average	3	23.78
Average	3	23.78
Very Good	5	23.78
Average	3	23.87
Excellent	6	23.89
Average	3	23.90
Good	4	23.96
Good	4	24.01
Average	3	24.04
Poor	2	24.08
Very Good	5	24.08
Average	3	24.26
Poor	2	24.28
Very Good	5	24.49
Average	3	24.54
Average	3	24.58
Poor	2	24.63
Excellent	6	24.68
Average	3	24.75
Good	4	24.79
Poor	2	24.79
Average	3	24.82
Poor	2	24.85
Very Good	5	24.95
Very Good	5	24.97
Good	4	25.12
Average	3	25.13
Average	3	25.16
Excellent	6	25.18
Average	3	25.25
Poor	2	25.31

Very Good	5	25.36
Excellent	6	25.47
Average	3	25.62
Good	4	25.71
Average	3	25.73
Poor	2	25.90
Good	4	25.93
Poor	2	26.08
Average	3	26.10
Average	3	26.10
Excellent	6	26.11
Average	3	26.18
Good	4	26.22
Good	4	26.22
Poor	2	26.29
Average	3	26.30
Average	3	26.31
Good	4	26.35
Very Good	5	26.47
Poor	2	26.54
Very Good	5	26.81
Good	4	26.86
Average	3	26.88
Poor	2	26.94
Good	4	27.11
Good	4	27.12
Poor	2	27.16
Good	4	27.28
Average	3	27.33
Good	4	27.45
Good	4	27.48
Poor	2	27.49
Very Good	5	27.62
Poor	2	27.69
Average	3	27.73
Average	3	27.75
Good	4	27.92
Very Good	5	28.04
Poor	2	28.05
Average	3	28.08
Very Good	5	28.20
Average	3	28.24
Poor	2	28.24
Average	3	28.46

Average	3	28.53
Very Good	5	28.55
Average	3	28.69
Poor	2	28.73
Average	3	29.18
Very Good	5	29.22
Very Good	5	29.30
Average	3	29.72
Good	4	29.75
Average	3	29.85
Average	3	29.90
Very Good	5	30.02
Poor	2	30.07
Average	3	30.14
Poor	2	30.20
Average	3	30.27
Good	4	30.36
Poor	2	30.37
Very Good	5	30.95
Average	3	30.98
Excellent	6	31.10
Very Good	5	31.15
Good	4	31.51
Excellent	6	31.53
Good	4	31.73
Poor	2	31.88
Poor	2	31.89
Average	3	32.08
Poor	2	32.14
Very Good	5	32.57
Very Good	5	32.63
Good	4	33.15
Very Good	5	33.25
Poor	2	33.26
Average	3	33.28
Poor	2	33.33
Poor	2	33.42
Poor	2	33.59
Poor	2	33.60
Average	3	33.82
Good	4	33.91
Poor	2	33.95
Poor	2	34.08
Excellent	6	34.18

Poor	2	34.29
Average	3	34.37
Poor	2	34.39
Poor	2	34.56
Good	4	34.72
Good	4	34.80
Poor	2	34.89
Poor	2	35.02
Poor	2	35.26
Very Good	5	35.31
Good	4	35.41
Average	3	35.52
Good	4	35.77
Very Good	5	35.91
Poor	2	35.95
Average	3	36.64
Poor	2	36.69
Average	3	37.11
Average	3	37.12
Poor	2	37.54
Very Good	5	38.46
Average	3	38.56
Average	3	39.32
Average	3	40.17
Poor	2	40.84
Poor	2	41.06
Good	4	42.68
Very Good	5	43.23
Poor	2	43.80
Poor	2	43.83
Good	4	45.59
Very Good	5	45.92
Poor	2	47.28
Very Good	4	47.35
Average	3	47.44
Good	4	47.69
Very Good	5	49.20
Poor	2	52.21
Good	4	52.54
Average	3	52.86
Very Good	5	53.13
Very Poor	1	53.75
Average	3	54.23
Very Good	5	56.16

TABLE A.5: Assessed Value Correlation Table

Assessed Value	Code	BTU/SQFT/DD	Code Reference	
80000-90000	8	4.55	30000-40000	3
90000-100000	9	5.09	40000-50000	4
50000-60000	5	5.64	50000-60000	5
110000-120000	11	6.48	60000-70000	6
70000-80000	7	6.66	70000-80000	7
120000-130000	12	7.48	80000-90000	8
70000-80000	7	7.77	90000-100000	9
100000-110000	10	7.99	100000-110000	10
60000-70000	6	8.07	110000-120000	11
70000-80000	7	8.20	120000-130000	12
80000-90000	8	8.20	130000-140000	13
160000-170000	16	8.24	140000-150000	14
100000-110000	10	8.79	150000-160000	15
100000-110000	10	8.82	160000-170000	16
80000-90000	5	8.87	170000-180000	17
150000-160000	15	8.89	180000-190000	18
100000-110000	10	9.29	190000-200000	19
150000-160000	15	9.29	200000-210000	20
270000-280000	27	9.50	210000-220000	21
90000-100000	9	9.61	220000-230000	22
50000-60000	2	9.85	230000-240000	23
60000-70000	6	9.94	240000-250000	24
120000-130000	12	10.06	250000-260000	25
70000-80000	7	10.11	260000-270000	26
80000-90000	8	10.16	270000-280000	27
160000-170000	16	10.36	280000-290000	28
170000-180000	17	10.36	290000-300000	29
90000-100000	9	10.41	300000-350000	30
110000-120000	11	10.49	350000-400000	35
90000-100000	9	10.53	400000-450000	40
160000-170000	16	10.97	450000-500000	45
120000-130000	12	10.99	500000+	50
40000-50000	4	10.99		
40000-50000	4	11.03		
90000-100000	9	11.05		
60000-70000	6	11.15		
40000-50000	4	11.16		
80000-90000	8	11.31		
90000-100000	9	11.55		
90000-100000	9	11.63		

80000-90000	8	11.64
160000-170000	16	11.67
70000-80000	7	11.73
110000-120000	11	11.81
120000-130000	12	11.81
30000-40000	3	11.86
80000-90000	8	11.90
60000-70000	6	11.95
90000-100000	9	12.04
30000-40000	3	12.15
170000-180000	17	12.29
90000-100000	9	12.30
30000-40000	3	12.31
80000-90000	8	12.40
100000-110000	10	12.41
130000-140000	13	12.42
40000-50000	4	12.54
120000-130000	12	12.57
120000-130000	12	12.62
70000-80000	7	12.63
110000-120000	11	12.72
30000-40000	3	12.75
90000-100000	9	12.75
80000-90000	8	12.76
140000-150000	14	12.80
100000-110000	10	12.83
80000-90000	8	12.87
60000-70000	6	12.92
40000-50000	4	12.93
120000-130000	12	12.96
50000-60000	5	13.01
80000-90000	8	13.03
120000-130000	12	13.12
110000-120000	11	13.15
200000-210000	20	13.23
110000-120000	11	13.35
60000-70000	6	13.39
70000-80000	7	13.53
30000-40000	3	13.54
100000-110000	10	13.58
50000-60000	5	13.64
90000-100000	9	13.71
500000+	50	13.79
130000-140000	13	13.96

160000-170000	16	14.00
220000-230000	22	14.01
50000-60000	5	14.06
60000-70000	6	14.11
110000-120000	11	14.15
50000-60000	5	14.17
50000-60000	5	14.20
50000-60000	5	14.21
80000-90000	8	14.27
30000-40000	3	14.42
40000-50000	4	14.44
100000-110000	10	14.49
130000-140000	13	14.50
60000-70000	6	14.52
50000-60000	5	14.53
70000-80000	7	14.62
110000-120000	11	14.67
120000-130000	12	14.70
80000-90000	8	14.74
120000-130000	12	14.76
50000-60000	5	14.80
30000-40000	3	14.84
110000-120000	11	14.91
70000-80000	7	14.92
90000-100000	9	14.94
70000-80000	7	14.99
50000-60000	5	15.00
80000-90000	8	15.06
50000-60000	5	15.08
70000-80000	7	15.11
230000-240000	23	15.12
40000-50000	4	15.16
60000-70000	6	15.21
50000-60000	5	15.21
80000-90000	8	15.21
70000-80000	7	15.33
80000-90000	8	15.39
50000-60000	5	15.43
50000-60000	5	15.45
100000-110000	10	15.47
150000-160000	15	15.52
120000-130000	12	15.60
100000-110000	10	15.65
40000-50000	4	15.67

110000-120000	11	15.78
40000-50000	4	15.78
60000-70000	6	15.91
110000-120000	11	15.91
190000-200000	19	15.94
50000-60000	5	15.95
60000-70000	6	15.98
90000-100000	9	16.00
90000-100000	9	16.00
70000-80000	7	16.08
80000-90000	8	16.09
50000-60000	5	16.10
80000-90000	8	16.11
250000-260000	25	16.13
50000-60000	5	16.15
70000-80000	7	16.17
50000-60000	5	16.19
70000-80000	7	16.20
140000-150000	14	16.25
50000-60000	5	16.29
80000-90000	8	16.45
40000-50000	4	16.49
50000-60000	5	16.52
40000-50000	4	16.58
100000-110000	10	16.58
50000-60000	5	16.64
110000-120000	11	16.64
80000-90000	8	16.65
60000-70000	6	16.67
60000-70000	6	16.68
140000-150000	14	16.86
130000-140000	13	16.87
50000-60000	5	16.94
50000-60000	5	16.96
120000-130000	12	17.01
120000-130000	12	17.06
70000-80000	7	17.07
110000-120000	11	17.10
70000-80000	7	17.13
80000-90000	8	17.22
50000-60000	5	17.30
90000-100000	9	17.30
40000-50000	4	17.33
40000-50000	4	17.43

80000-90000	8	17.46
190000-200000	19	17.56
90000-100000	9	17.58
80000-90000	8	17.60
50000-60000	5	17.61
110000-120000	11	17.67
70000-80000	7	17.85
40000-50000	4	17.93
150000-160000	15	17.95
90000-100000	9	17.96
90000-100000	9	18.02
70000-80000	7	18.03
90000-100000	9	18.07
60000-70000	6	18.09
80000-90000	8	18.14
80000-90000	8	18.15
50000-60000	5	18.21
90000-100000	9	18.23
50000-60000	5	18.25
60000-70000	6	18.28
70000-80000	7	18.30
140000-150000	14	18.32
130000-140000	13	18.33
30000-40000	3	18.35
140000-150000	14	18.36
100000-110000	10	18.43
90000-100000	9	18.52
130000-140000	13	18.53
40000-50000	4	18.59
70000-80000	7	18.65
110000-120000	11	18.70
90000-100000	9	18.70
120000-130000	12	18.74
70000-80000	7	18.80
40000-50000	4	18.82
90000-100000	9	18.84
40000-50000	4	18.91
30000-40000	3	18.92
100000-110000	10	18.95
110000-120000	11	18.98
60000-70000	6	18.99
70000-80000	7	19.03
60000-70000	6	19.05
80000-90000	8	19.08

170000-180000	17	19.12
110000-120000	11	19.12
80000-90000	8	19.30
50000-60000	5	19.34
50000-60000	5	19.35
70000-80000	7	19.38
90000-100000	9	19.47
60000-70000	6	19.47
130000-140000	13	19.60
30000-40000	3	19.64
50000-60000	5	19.73
70000-80000	7	19.84
50000-60000	5	19.84
50000-60000	5	19.91
40000-50000	4	19.95
60000-70000	6	20.05
50000-60000	5	20.07
90000-100000	9	20.08
60000-70000	6	20.14
70000-80000	7	20.15
140000-150000	14	20.15
80000-90000	8	20.18
120000-130000	12	20.19
40000-50000	4	20.29
70000-80000	7	20.36
60000-70000	6	20.38
50000-60000	5	20.42
110000-120000	11	20.43
100000-110000	10	20.57
80000-90000	8	20.60
40000-50000	4	20.65
80000-90000	8	20.67
80000-90000	8	20.72
30000-40000	3	20.72
100000-110000	10	20.74
30000-40000	3	20.87
40000-50000	4	20.95
100000-110000	10	21.04
70000-80000	7	21.10
50000-60000	5	21.11
70000-80000	7	21.12
90000-100000	9	21.25
50000-60000	5	21.27
60000-70000	6	21.29

70000-80000	7	21.35
30000-40000	3	21.37
40000-50000	4	21.39
30000-40000	3	21.42
100000-110000	10	21.48
130000-140000	13	21.53
110000-120000	11	21.57
90000-100000	9	21.58
80000-90000	8	21.60
30000-40000	3	21.63
70000-80000	7	21.66
70000-80000	7	21.67
40000-50000	4	21.81
80000-90000	8	21.83
70000-80000	7	21.84
60000-70000	6	21.85
30000-40000	3	21.88
80000-90000	8	21.99
50000-60000	5	22.05
50000-60000	5	22.07
80000-90000	8	22.20
80000-90000	8	22.20
60000-70000	6	22.21
70000-80000	7	22.21
160000-170000	16	22.24
80000-90000	8	22.28
60000-70000	6	22.29
140000-150000	14	22.33
50000-60000	5	22.36
50000-60000	5	22.39
60000-70000	6	22.39
150000-160000	15	22.39
50000-60000	5	22.40
30000-40000	3	22.40
50000-60000	5	22.53
30000-40000	3	22.53
60000-70000	6	22.54
40000-50000	4	22.59
40000-50000	4	22.59
90000-100000	9	22.65
70000-80000	7	22.74
30000-40000	3	22.74
80000-90000	8	22.90
100000-110000	10	22.98

40000-50000	4	23.06
50000-60000	5	23.06
130000-140000	13	23.12
60000-70000	6	23.20
40000-50000	4	23.45
70000-80000	7	23.49
90000-100000	9	23.49
50000-60000	5	23.52
80000-90000	8	23.55
60000-70000	6	23.59
110000-120000	11	23.68
30000-40000	3	23.69
100000-110000	10	23.70
40000-50000	4	23.78
50000-60000	5	23.78
110000-120000	11	23.78
60000-70000	6	23.87
110000-120000	11	23.89
40000-50000	4	23.90
90000-100000	9	23.96
70000-80000	7	24.01
30000-40000	3	24.04
30000-40000	3	24.08
100000-110000	10	24.08
70000-80000	7	24.26
60000-70000	6	24.28
90000-100000	9	24.49
60000-70000	6	24.54
80000-90000	8	24.58
70000-80000	7	24.63
180000-190000	18	24.68
70000-80000	7	24.75
110000-120000	11	24.79
50000-60000	5	24.79
60000-70000	6	24.82
30000-40000	3	24.85
80000-90000	8	24.95
100000-110000	10	24.97
120000-130000	12	25.12
30000-40000	3	25.13
40000-50000	4	25.16
100000-110000	10	25.18
40000-50000	4	25.25
70000-80000	7	25.31

120000-130000	12	25.36
100000-110000	10	25.47
50000-60000	5	25.62
70000-80000	7	25.71
50000-60000	5	25.73
30000-40000	3	25.90
80000-90000	8	25.93
40000-50000	4	26.08
60000-70000	6	26.10
70000-80000	7	26.10
120000-130000	12	26.11
40000-50000	4	26.18
40000-50000	4	26.22
40000-50000	4	26.22
40000-50000	4	26.29
30000-40000	3	26.30
60000-70000	6	26.31
40000-50000	4	26.35
80000-90000	8	26.47
30000-40000	3	26.54
80000-90000	8	26.81
120000-130000	12	26.86
120000-130000	12	26.88
50000-60000	5	26.94
60000-70000	6	27.11
110000-120000	11	27.12
40000-50000	4	27.16
90000-100000	9	27.28
90000-100000	9	27.33
80000-90000	8	27.45
50000-60000	5	27.48
30000-40000	3	27.49
90000-100000	9	27.62
40000-50000	4	27.69
60000-70000	6	27.73
80000-90000	8	27.75
70000-80000	7	27.92
100000-110000	10	28.04
30000-40000	3	28.05
90000-100000	9	28.08
70000-80000	7	28.20
60000-70000	6	28.24
40000-50000	4	28.24
80000-90000	8	28.46

60000-70000	6	28.53
110000-120000	11	28.55
100000-110000	10	28.69
40000-50000	4	28.73
40000-50000	4	29.18
140000-150000	14	29.22
70000-80000	7	29.30
70000-80000	7	29.72
60000-70000	6	29.75
40000-50000	4	29.85
80000-90000	8	29.90
90000-100000	9	30.02
30000-40000	3	30.07
70000-80000	7	30.14
40000-50000	4	30.20
110000-120000	11	30.27
60000-70000	6	30.36
40000-50000	4	30.37
110000-120000	11	30.95
90000-100000	9	30.98
100000-110000	10	31.10
70000-80000	7	31.15
30000-40000	3	31.51
90000-100000	9	31.53
80000-90000	8	31.73
40000-50000	4	31.88
30000-40000	3	31.89
50000-60000	5	32.08
30000-40000	3	32.14
70000-80000	7	32.57
140000-150000	14	32.63
70000-80000	7	33.15
60000-70000	6	33.25
30000-40000	3	33.26
50000-60000	5	33.28
30000-40000	3	33.33
50000-60000	5	33.42
40000-50000	4	33.59
30000-40000	3	33.60
110000-120000	11	33.82
70000-80000	7	33.91
40000-50000	4	33.95
40000-50000	4	34.08
110000-120000	11	34.18

40000-50000	4	34.29
60000-70000	6	34.37
30000-40000	3	34.39
40000-50000	4	34.56
70000-80000	7	34.72
100000-110000	10	34.80
30000-40000	3	34.89
50000-60000	5	35.02
50000-60000	5	35.26
80000-90000	8	35.31
110000-120000	11	35.41
60000-70000	6	35.52
110000-120000	11	35.77
80000-90000	8	35.91
30000-40000	3	35.95
60000-70000	6	36.64
60000-70000	6	36.69
80000-90000	8	37.11
70000-80000	7	37.12
30000-40000	3	37.54
70000-80000	7	38.46
50000-60000	5	38.56
30000-40000	3	39.32
70000-80000	7	40.17
60000-70000	6	40.84
40000-50000	4	41.06
60000-70000	6	42.68
60000-70000	6	43.23
30000-40000	3	43.80
40000-50000	4	43.83
70000-80000	7	45.59
100000-110000	10	45.92
40000-50000	4	47.28
120000-130000	12	47.35
70000-80000	7	47.44
90000-100000	9	47.69
70000-80000	7	49.20
30000-40000	3	52.21
80000-90000	8	52.54
30000-40000	3	52.86
80000-90000	8	53.13
30000-40000	3	53.75
40000-50000	4	54.23
100000-110000	10	56.16

APPENDIX

B

Homeowner Perception Survey Data

FIGURE B.1: Notification of Upcoming Perceptions Survey

RESIDENTS OF WOODBINE

In your upcoming utility bill, you may receive a short survey. This is a research project being conducted by the University of Nebraska, School of Engineering. The research project is an attempt to better understand rural America's perceptions and feelings toward "green" or energy efficient homes. The project is being funded by the Department of Energy under the national program, "Build America." Please take a few minutes to complete the survey, and return it with your utility bill or in person at Woodbine Municipal Utility Office. I would like to thank the Woodbine Municipal Utility Office for their assistance and to all of you for taking the time out of your busy lives to complete the survey.

Sincerely,

Nathan A. Barry
Principal Investigator
University of Nebraska
School of Engineering
308.865.8733
barryna@unk.edu

FIGURE B.2: Informed Consent Form

University of Nebraska Lincoln

THE DURHAM SCHOOL
College of Engineering
Charles W. Durham School of Architectural Engineering and Construction
Construction Management

April 25, 2011

INFORMED CONSENT FORM

Title of Project: Energy Use Perceptions in Rural America

Dear Community of Woodbine Resident,

My name is Nathan Barry; I am a former resident of Woodbine (class of 2000) and currently a Ph.D. candidate at the University of Nebraska - Lincoln. With the assistance of your local utility company I am gathering information in regards to residential energy usage and homeowner perceptions toward "green" or sustainable building. This project and the data collected are going to be used for research. This letter is being sent to all residents within the city limits of Woodbine, Iowa. It is our hope at the University of Nebraska that we will be able to identify better energy consumption patterns and thus be able to provide a sustainable business model to make every home across the country more energy efficient. This model will allow homeowners to save money on their monthly utility bills and reduce this country's dependence on fossil fuels. While great strides are being made toward renewable sources of energy, the quickest and least expensive approach to energy savings remains conservation. You must be 19 years of age or older to participate.

Along with this letter you will find a short survey. We are extremely interested in your feedback and opinions. Your contributions will assist the University of Nebraska in identifying homeowners' priorities and energy usage patterns. **It is important that you do write your address on the form** so that we may use it as we analyze the historical energy usage of residential properties. Information obtained in this study may be published in scientific journals or presented at scientific meetings but the data will be reported as aggregated data. A data coding system has been developed to keep utility usage and property address identification secure, maximizing all confidentiality efforts. Please return the completed survey with your utility payment, or you may drop it off at the Woodbine Municipal Utility Office located at 517 Walker St. Your survey data will be collected by one designated person and stored in a lock box until collected by the research team.

You may ask any questions concerning this research and have those questions answered prior to completing the survey. Nathan Barry, investigator can be reached at (308) 440-8457. Please only contact the University of Nebraska-Lincoln Institutional Review Board at (402) 472-6965 for the following reasons.

- you wish to talk to someone other than the research staff to obtain answers to questions about your rights as a research participant
- to voice concerns or complaints about the research
- to provide input concerning the research process
- in the event the study staff could not be reached,

The survey should take less than 10 minutes to complete. Participation in this study is voluntary and there are no known risks for completing the survey. There are no direct benefits to you as a research participant. You can refuse to participate or withdraw at any time without harming your relationship with the Woodbine Municipal Power, the researchers, or the University of Nebraska-Lincoln. I thank you in advance for your assistance in this project and look forward to providing the residents of Woodbine valuable information regarding residential energy usage.

Sincerely,

Nathan Barry

Nathan A. Barry, MBA, Principal Investigator — *Office (308) 440-8457*
Charles W. Berryman, PhD, Secondary Investigator — *Office (402) 472-0098*

W145 Nebraska Hall   Lincoln, NE 68588-0500
(402) 472-3742

FIGURE B.3: Homeowner Perceptions Survey

Energy Use Perceptions in Rural America

Thank you for taking the time to complete this short survey regarding homeowner energy usage and opinions of energy conservation. The survey will take less than 10 minutes to complete and your input will be used to assist the University of Nebraska in identifying homeowners' priorities and energy use patterns. If you have any questions regarding the usage of the survey please contact Nathan Barry at (308) 440-8457 or barryna@unk.edu.

ADDRESS: ____

Demographic Information of Individual Completing Survey:

1. What is the sex of the individual completing the survey? O Male O Female

2. What is the age of the individual completing the survey? ____________________

3. Do you rent or own your home? O Rent O Own

4. How many years have you lived in your home? ____________________

5. How many people live in your house more than 50% of the time? ____________________

6. Not including yourself, what are the sex and age of the people living in your home more than 50% of the time?

1	Male	Female	Age:	______________
2	Male	Female	Age:	______________
3	Male	Female	Age:	______________
4	Male	Female	Age:	______________
5	Male	Female	Age:	______________
6	Male	Female	Age:	______________

7. Did the utility costs influence your decision to move into your current home?

O Yes O No O Not Sure

8. How would you describe your utility bills? Are they...

O very low O average O too high O not sure

9. How do you think your utility bills compare to your neighbor's utility bills?

O Mine are lower than my neighbors
O Mine are about the same as my neighbors
O Mine are higher than my neighbors
O I am not sure how my bills compare to my neighbors

10. How much do you feel your living habits contribute to your overall utility cost?

O A lot O Some O A little O None

11. Have you done anything to your home in the past 12 months to make it more energy efficient?

O No ⟶ Go to Question 12
O Yes ↓

11a. If yes, do you feel your utility costs have lowered because of these improvements?

O Yes O No O Not Sure

11b. Could you please describe the improvements?

____

____

12. Have you taken advantage of any tax rebates for energy efficient improvements to your home?

O Yes O No O Not Sure

Please continue the survey on the back of the form ⟶

13. Would you attend a community event to learn energy improvement techniques to your home?

- O Yes
- O No
- O Not Sure

14. Have you changed your habits (turning down the thermostat, using less water, opening windows, etc.) in the past 12 months to help lower your utility bills?

- O No → Go to Question 15
- O Yes ↓

14a. If yes, do you feel your utility costs have lowered because of these improvements?

- O Yes
- O No
- O Not Sure

14b. Could you please describe these changes?

____

____

15. How long is a reasonable time period for an energy efficient upgrade to pay for itself through energy savings?

- O 0-2 years
- O 2-5 years
- O 5-10 years
- O 10+ years

16. How important are the following improvements for making your home more energy efficient? Please rank them with 1 being the most important improvement, 2 being the next most important improvement and so on through 5 which would be the least important improvement.

_________ Adding more insulation to walls and ceiling
_________ Replacing light bulbs with more efficient bulbs
_________ Replacing windows
_________ Replacing appliances with more efficient appliances
_________ Replacing air conditioning or heating systems

17. How important are the following reasons to make your home more energy efficient? Please rank them with 1 being the most important improvement, 2 being the next most important improvement and so on through 5 which would be the least important improvement.

_________ Improve the environment
_________ Save on monthly operating costs
_________ Reduce the U.S. dependence on foreign oil
_________ Add value to the home
_________ Reduce climate change and greenhouse gases

18. Do you think your utility company should use a renewable energy such as wind or solar power?

- O Yes
- O No
- O Not Sure

19. How much more would you be willing to pay on your monthly utility bill to use a renewable energy?

- O 0%, I don't want my rates increased at all
- O 0% - 5%
- O 5% - 10%
- O 10% - 20%
- O More than 20% increase would be okay to know I am using a renewable energy

20. How important is it to you that your daily purchases consist of renewable or recycled material?

- O Really
- O Somewhat
- O Not important

THANK YOU, for completing the survey. Please return the completed survey with your utility payment or directly to the Woodbine Light and Power office located at 517 Walker St. Woodbine, IA 51579.

For questions regarding the survey please contact Nathan Barry at (308) 440-8457 or barryna@unk.edu

TABLE B.1: Individual Survey Results Questions 1-10

Survey	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Male	72	Own	1	2	F74	No	Average	I am not sure how my bills compare to my neighbors	Some
2	Male	35	Own	5	3	F33M2	No	Very Low	Mine are lower than my neighbors	A lot
3	Female	60	Own	35	2	M60	No	Too High	Mine are about the same as my neighbors	Some
4	Male	45	Own	1	1		No	Too High	Mine are about the same as my neighbors	A lot
5	Male	41	Own	10	5	f41f12m7m4	No	Average	I am not sure how my bills compare to my neighbors	A lot
6	Male	55	Own	27	2	f54	No	Average	Mine are about the same as my neighbors	A lot
7	Male	25	Rent	3	1		No	Average	Mine are lower than my neighbors	A little
8	Female	41	Own	4	3	m43f15	No	Not Sure	Mine are higher than my neighbors	A lot
9	Female	71	Own	10	1		No	Average	I am not sure how my bills compare to my neighbors	A lot
10	Female	53	Rent	2	1		Yes	Very Low	I am not sure how my bills compare to my neighbors	Some
11	Male	46	Own	20	5	f45m16f14m10	No	Average	Mine are about the same as my neighbors	A lot
12	Female	58	Rent	5	1			Average	Mine are lower than my neighbors	A little
13	Female	88	Own	65	1		No	Too High	Mine are higher than my neighbors	A little
14	Female	72	Own	24	1		No	Average	I am not sure how my bills compare to my neighbors	Some
15	Female	63	Own	11	2	m65	No	Average	I am not sure how my bills compare to my	None

								neighbors	
16	Female	80	Own	25	1		No	Average	I am not sure how my bills compare to my neighbors	Some
17	Male	66	Own	6	2	f66	No	Average		Some
18	Male	75	Own	25	1		No	Too High	Mine are about the same as my neighbors	Some
19	Male	77	Own	15	2	f79	Yes	Very Low	I am not sure how my bills compare to my neighbors	Some
20	Female	55	Rent	1	2	m58	Not Sure	Average	I am not sure how my bills compare to my neighbors	A lot
21	Female	53	Rent	22	2	m53	No	Average	I am not sure how my bills compare to my neighbors	Some
22	Female	56	Own	12	3	m56m30	No	Average	Mine are about the same as my neighbors	Some
23	Female	92	Own	46	1		No	Average	I am not sure how my bills compare to my neighbors	None
24	Female	77	Own	16	1		Not Sure	Average	I am not sure how my bills compare to my neighbors	None
25	Female	92	Rent	20	1		Yes	Not Sure	I am not sure how my bills compare to my neighbors	Some
26	Female	32	Own	6	5	m38f12m17m15	No	Average	I am not sure how my bills compare to my neighbors	A lot
27	Female	56	Own	26	2	m61	Yes	Very Low	I am not sure how my bills compare to my neighbors	A lot
28	Female	45	Own	16	2	m41	No	Too High	I am not sure how my bills compare to my neighbors	A lot
29	Female	39	Own	5	4	m40f12m8	No	Too High	I am not sure how my bills compare to my neighbors	Some
30	Female	57	Own	4	2	m54	No	Not Sure	I am not sure how my bills compare to my neighbors	Some
31	Female	61	Own	11	4	m58m26f23	No	Too High	Mine are about the same as my neighbors	A little

32	Female	32	Own	4	4	m30m5m1	No	Average	I am not sure how my bills compare to my neighbors	Some
33	Male	31	Own	3	4	f32f17m8	No	Too High	Mine are higher than my neighbors	A little
34	Male	76	Own	6	2	f68	No	Not Sure	I am not sure how my bills compare to my neighbors	Some
35	Female	73	Own	12	1		No	Average	Mine are about the same as my neighbors	A lot
36	Female	34	Own	6	2	m30	Yes	Average	I am not sure how my bills compare to my neighbors	Some
37	Male	29	Own	7	5	f29f4m3m1	No	Average	Mine are higher than my neighbors	Some
38	Male	45	Own	5	4	f49f14f8	No	Too High	I am not sure how my bills compare to my neighbors	A little
39	Female	48	Own	23	2	m50	No	Average	I am not sure how my bills compare to my neighbors	A little
40	Male	48	Own	12	3	f51m19	No	Too High	Mine are higher than my neighbors	A little
41	Male	68	Own	10	2	f68	No	Too High	I am not sure how my bills compare to my neighbors	A lot
42	Female	61	Own	2	1		No	Average	I am not sure how my bills compare to my neighbors	A lot
43	Female	86	Own	20	1		No	Average	I am not sure how my bills compare to my neighbors	Some
44	Female	45	Own	26	5	m52m18m11f20	Yes	Not Sure	Mine are higher than my neighbors	Some
45	Female	81	Own	22	2	m83	No	Too High	I am not sure how my bills compare to my neighbors	None
46	Male	66	Own	9	1		No	Too High	Mine are about the same as my neighbors	A lot
47	Female	53	Own	5	4	m54m24f20	Not	Not	I am not sure how my bills compare to my	A lot

							Sure	Sure	neighbors	
48	Female	47	Own	21	5	m47f19f17m14	No	Average	Mine are about the same as my neighbors	Some
49	Female	26	Own	3	5	m27f26f3f2m1	No	Average	I am not sure how my bills compare to my neighbors	None
50	Female	69	Own	22	2	m69	No	Average	I am not sure how my bills compare to my neighbors	Some
51	Female	38	Own	12	1		No	Average	I am not sure how my bills compare to my neighbors	A lot
52	Female	39	Own	12	7	m41f12f11m7f4m1	No	Too High	Mine are higher than my neighbors	Some
53	Female	42	Own	14	5	m42f15m9f6	No	Average	Mine are higher than my neighbors	Some
54	Female	22	Own	1	1		No	Not Sure	Mine are about the same as my neighbors	A little
55	Male	80	Own	45	2	f80	No	Average	I am not sure how my bills compare to my neighbors	Some
56	Female	77	Own	45	2	m79	No	Average	Mine are lower than my neighbors	Some
57	Female	55	Own	31	2	m57	No	Average	Mine are higher than my neighbors	A lot
58	Female	64	Rent	5	2	m16	No	Too High	I am not sure how my bills compare to my neighbors	
59	Female	75	Own	12	2	m80	No	Average	Mine are about the same as my neighbors	A lot
60	Female	34	Own	1	4	m34f3m2	No	Average	Mine are lower than my neighbors	Some
61	Female	57	Own	14	1		No	Too High	I am not sure how my bills compare to my neighbors	A little
62	Female	40	Own	6	3	m15f11	No	Average	Mine are higher than my neighbors	Some
63	Female	73	Own	12	2	m73	No	Average	I am not sure how my bills compare to my neighbors	Some
64	Male	61	Own	8	2	f61	No	Average	Mine are about the same as my neighbors	Some
65	Male	38	Own	6	4	f35m12m6	No	Average	Mine are about the same as my neighbors	A lot
66	Female	64	Own	20	3	m60m19	No	Average	Mine are about the same as my neighbors	A lot
67	Female	76	Own	11	2	m78	No	Average	I am not sure how my bills compare to my	Some

									neighbors	
68	Female	76	Rent	6	1		No	Very Low	Mine are lower than my neighbors	Some
69	Female	88	Own	39	1		No	Average	I am not sure how my bills compare to my neighbors	A little
70	Female	79	Own	7	3	m77f104	No	Average	Mine are about the same as my neighbors	None
71	Female	71	Own	1	1		No	Too High	I am not sure how my bills compare to my neighbors	A little
72	Female	91	Own	15	1		No	Not Sure	I am not sure how my bills compare to my neighbors	None
73	Male	49	Own	8	3	f38m18	Not Sure	Average	I am not sure how my bills compare to my neighbors	A little
74	Male	50	Own	18	2	f46	No	Average	Mine are about the same as my neighbors	A lot
75	Male	64	Own	31	2	f60	No	Average	I am not sure how my bills compare to my neighbors	A lot
76	Female	52	Own	15	2	m57	Yes	Too High	Mine are higher than my neighbors	A little
77	Female	55	Own	24	2	m61	No	Average	Mine are lower than my neighbors	Some
78	Female	84	Own	29	1		No	Too High	Mine are higher than my neighbors	None
79	Male	86	Own	11	1		No		I am not sure how my bills compare to my neighbors	Some
80	Male	11	Own	15	2	m80	No	Average	Mine are higher than my neighbors	Some
81	Female	75	Own	49	1		No	Too High	Mine are higher than my neighbors	Some
82	Female	41	Own	10	3	m42f2	No	Average	Mine are about the same as my neighbors	Some
83	Male	62	Own	27	2	f61	No	Too High	Mine are about the same as my neighbors	Some
84	Female	77	Own	29	1		No	Average	Mine are about the same as my neighbors	Some
85	Male	89	Own	3	1		No	Average	I am not sure how my bills compare to my	A lot

									neighbors	
86	Male	51	Own	3	2	f51	Yes	Too High	Mine are higher than my neighbors	A lot
87	Male	70	Own	33	2	F69	No	Not Sure	I am not sure how my bills compare to my neighbors	A lot
88	Male	80	Own	36	2	f67	No	Average	Mine are higher than my neighbors	A little
89	Female	38	Own	6	2	m42	Not Sure	Average	I am not sure how my bills compare to my neighbors	A little
90	Female	62	Own	21	1		No	Very Low	Mine are lower than my neighbors	A little
91	Female	55	Own	14	3	m56f17	No	Too High	Mine are about the same as my neighbors	Some
92	Male	41	Own	2	1		No	Average	Mine are lower than my neighbors	Some

TABLE B.2: Individual Survey Results Questions 11-13

Survey	Q11	Q11A	Q11B	Q12	Q13
1	Yes	Yes		Yes	Yes
2	Yes	No	insulated basement walls, replaced old storm door	No	Not Sure
3	Yes	Yes	Insulation	Yes	Yes
4	Yes	Not Sure	Installed 95% efficient furnace, more comfortable in the house, but bill about the same.	Yes	Not Sure
5	No			No	Not Sure
6	No			No	Yes
7	No			No	No
8	Yes	Not Sure	new windows	Yes	Not Sure
9	No			No	No
10	No			No	Not Sure
11	Yes	Yes	heat pump, windows	Yes	Not Sure
12	No			No	No
13	No			No	No
14	No			No	Yes
15	No			No	Yes
16	No			No	Yes
17	Yes	Not Sure	new windows and door	No	Not Sure
18	No			No	No
19	Yes	Yes	new electric furnace back up to heat pump	No	Yes

20	Yes	Yes	Installed insulation covers around switches and outlets. Installed new filter on faucets	No	Not Sure
21	No			No	Not Sure
22	Yes	Yes	new storm windows	Yes	Yes
23	Yes	Not Sure	new furnace, new microwave, new clothes dryer	No	No
24	No			Yes	Not Sure
25	No			No	Not Sure
26	Yes	Yes	we put in a new front screen door and inside front door, also put on new garage doors	Yes	Yes
27	No			No	Yes
28	Yes	Yes	outdoor wood stove for heat	Yes	Yes
29	Yes	No	Replaced an old refrigerator with an energy efficient refrigerator	No	Not Sure
30	No			Yes	Not Sure
31	No			Yes	Not Sure
32	Yes	Not Sure	new front door, 2 new basement windows	Yes	Yes
33	Yes	Yes	added crawlspace insulation, added/replaced storm door, added caulking and weather-stripping	Yes	Not Sure
34	No			No	Not Sure
35	No			Yes	Not Sure
36	Yes	Yes	new heating/cooling 2009; energy efficient washer/dryer 2009	No	Yes

37	Yes	Yes	new windows/one new door	Yes	No
38	Yes	Yes	insulation and bought used furnace newer than the old one we had. We received a grant for $7000 to install a new roof and insulate the attic and 2nd floor. We also installed a used furnace that is 90% efficient and ducted the 2nd floor which had no ducts ran to it.	No	Not Sure
39	Yes	Yes	Midwest RetroFoam installed November 2010. Natural gas reduction in usage; electric costs rise gave no relief overall in utility bill.	Yes	Yes
40	Yes	Yes	geothermal	Yes	Yes
41	No			No	Yes
42	No			No	Not Sure
43	Yes	Yes	new furnace	No	Yes
44	No			No	Not Sure
45	Yes	Yes	light bulbs, unplug lamps, etc. that we no longer use, seal basement windows, do not heat upstairs.	No	Yes
46	No			No	Not Sure
47	Yes	Not Sure	use the new cfl bulbs	No	Yes
48	No			No	No
49	Yes	Yes	spray foamed the basement	No	Not Sure
50	No			No	Not Sure
51	No			No	Not Sure
52	Yes	Yes	insulated walls w/RetroFoam and added insulation to attic. Replaced oven and dishwasher.	Yes	Not Sure

53	Yes	Yes	installed new geothermal heat and a/c	Yes	Not Sure
54	No			No	Not Sure
55	No			No	Not Sure
56	Yes	Not Sure	energy efficient refrigerator - washer and dryer	Yes	Not Sure
57	Yes	Yes	new storm door, doors and windows	Yes	Not Sure
58	No			No	Not Sure
59	No			No	Yes
60	Yes	Yes	heat pump, insulation - new construction	Yes	No
61	No			No	Not Sure
62	Yes	Yes	tank less water heater, added 10" of insulation to attic	Yes	Not Sure
63	Yes	Yes	new high efficiency washer and dryer. Replace bulbs with energy efficient light bulbs	No	Yes
64	Yes	Yes	new energy efficient water heater, new energy efficient air/heat pump	Yes	No
65	Yes	Not Sure		Yes	Yes
66	No			No	Yes
67	Yes	Not Sure	changed light bulbs and plan on getting new furnace	No	Not Sure
68	No			No	No
69	Yes	Not Sure	southwest Iowa sent a group of men to insulate and replace light bulbs last summer	Not Sure	Not Sure
70	No			No	Not Sure

71	No			No	No
72	No			Not Sure	No
73	Yes	No	insulation	Yes	Not Sure
74	No			No	No
75	No			Yes	No
76	Yes	Yes	window and door replacement	Yes	Not Sure
77	Yes	Yes	insulation, siding, new doors, new roof, new heat pump, new furnace	Yes	Yes
78	Yes	Yes	rebuilt sunroom - energy efficient windows	Yes	Not Sure
79	No			Not Sure	Not Sure
80	No			No	Yes
81	No			Yes	Yes
82	No			No	Yes
83	No				Yes
84	Yes	Yes	all new windows, patio door, garage door, putting on siding	Yes	Yes
85	No			No	Yes
86	No			No	Yes
87	Yes	Not Sure	new windows, reinsulated parts of the house	Yes	Not Sure
88	No			No	Yes
89	No			No	Yes
90	No			Yes	Yes
91	No			Yes	No
92	No			No	Yes

TABLE B.3: Individual Survey Results Questions 14-15

Survey	Q14	Q14A	Q14B	Q15
1	Yes	Yes		0-2 Years
2	Yes	Yes	lower thermostat; less lights on; dry clothes on the line	2-5 Years
3	Yes	Yes	lights off; thermostat adjusted	5-10 Years
4	Yes	No	My consumption of energy is lower, but the price of energy has been raised so bill is same, I am less comfortable	2-5 Years
5	Yes	No	We have our winter temp set at 68, use the windows to cool house when temp less than 85, set the temp to 78. This has been our habit all our years in the house	5-10 Years
6	Yes	Not Sure	turn down thermostat, turn down water heater	2-5 Years
7	No			2-5 Years
8	Yes	Not Sure	thermostat change, keeping shades closed	2-5 Years
9	No			5-10 Years
10	Yes	Yes	I keep the thermostat turned down in the winter and up in the summer. Hang clothes on the line in good weather. Fill sinks with water to do the dishes and rinse them instead of keeping the water running.	2-5 Years
11	No			2-5 Years
12	Yes			5-10 Years
13	Yes	No		2-5 Years
14	Yes	Yes	turn down thermostat	2-5 Years
15	No			10+ Years
16	Yes	Yes	unplug appliances when not in use, don't turn up furnace, put on sweater; make sure unused lights are off	
17	No			5-10 Years
18	No			5-10 Years
19	Yes	Yes		2-5 Years
20	Yes	Not Sure		2-5 Years

21	Yes	No		0-2 Years
22	No			5-10 Years
23	No			
24	No			
25	Yes	No		
26	Yes	Not Sure	we turn down the thermostat when we are not here or go to bed, keep windows open as much as possible	2-5 Years
27	No			2-5 Years
28	Yes	Yes	Thermostat turned to 63 in winter, 78 in summer. Run less water by filling sink 1/3 with water to rinse dishes.	2-5 Years
29	Yes	No	we shut off lights when not in use, we lowered our thermostat this winter by 4 degrees. We unplug items when gone for weekends	0-2 Years
30	Yes	No		2-5 Years
31	Yes	No	lowered thermostat wash larger loads, bought thermal drapes	0-2 Years
32	No			2-5 Years
33	No			2-5 Years
34	Yes	Yes	lower night time temp; utilize shade trees in lieu of A.C. open windows for ventilation and cooling; conserve water	2-5 Years
35	No			10+ Years
36	Yes	Yes		2-5 Years
37	Yes	Not Sure	focus in turning lights off; opening windows; keeping storm doors shut; run dehumidifier	2-5 Years
38	Yes	Not Sure	turned down the thermostat but I don't call that an improvement	0-2 Years
39	Yes	Yes	weather cooperating in not having to run A.C. Opening windows, spending time outdoors in evenings. No electric usage for lighting when outside.	2-5 Years
40	Yes	Not Sure		5-10 Years

41	Yes	Not Sure	we lowered the thermostat and used an elect heater for heat. However with the increased cost of fuel, we still pay about the same.	2-5 Years
42	No			2-5 Years
43	No			5-10 Years
44	Yes	Yes	open windows, lower thermostat	2-5 Years
45	Yes	Not Sure	turned down thermostat and we freeze all winter as we can't afford any more rises in utilities.	5-10 Years
46	Yes	Yes		2-5 Years
47	Yes	Yes	turning down the thermostat, using less water, using fans	2-5 Years
48	Yes	Not Sure	lowered thermostat, wash only 4 days clothes	5-10 Years
49	Yes	Not Sure	lights	2-5 Years
50	No			5-10 Years
51	Yes	Yes		2-5 Years
52	Yes	Yes	programmable thermostats for day/night usage	2-5 Years
53	Yes	Not Sure	keep thermostat lower in winter, higher in summer. Open windows last summer when not as hot	2-5 Years
54	Yes	Yes	I purchased a space heater to help reduce using the heat as much	2-5 Years
55	No			10+ Years
56	No			2-5 Years
57	Yes	Yes	lower thermostat in winter	5-10 Years
58	Yes		turn down thermostat, less water	0-2 Years
59	No			2-5 Years
60	No			2-5 Years
61	Yes	Yes	plastic on the windows in winter, closing blinds on sunny days, replacing light bulbs.	5-10 Years
62	No			2-5 Years
63	No			2-5 Years
64	Yes	Yes	lower thermostat, ceiling fans	2-5 Years
65	Yes	Yes		2-5 Years
66	No			5-10 Years
67	Yes	Yes	lowered the thermostat, closed the drapes	0-2 Years
68	No			

69	No			
70	No			5-10 Years
71	Yes	Not Sure		2-5 Years
72	Yes	Not Sure		2-5 Years
73	Yes	Not Sure	lowering thermostat	2-5 Years
74	No			5-10 Years
75	No			2-5 Years
76	Yes	No	I lowered my thermostat and installed a programmable one only to receive a rate increase in utilities	0-2 Years
77	No			5-10 Years
78	Yes	No	lowered thermostat	2-5 Years
79	Yes	Yes		
80	No			5-10 Years
81	Yes	Not Sure		0-2 Years
82	Yes	Yes		5-10 Years
83	Yes		lower thermostat, using less water, opening windows	2-5 Years
84	No			2-5 Years
85	Yes	Yes	lower thermostat, new water heater, window well covers	5-10 Years
86	Yes	Yes	new well field for geo thermal	2-5 Years
87	Yes	Yes	lowered thermostat in winter	2-5 Years
88	Yes	Yes	lowered thermostat, turned off lights	2-5 Years
89	No			0-2 Years
90	Yes	Yes		2-5 Years
91	Yes	Yes		2-5 Years
92	No			0-2 Years

TABLE B.4: Individual Survey Results Questions 16-20

Survey	Q16A	Q16B	Q16C	Q16D	Q16E	Q17A	Q17B	Q17C	Q17D	Q17E	Q18	Q19	Q20
1	1	1	1	4	4	2	2	1	3	2	Yes	0% I don't want my rates to increase at all	Somewhat
2	3	5	2	4	1	1	4	2	3	5	Yes	0% - 5%	Really
3	1	3	2	5	4	3	1	4	2	5	Yes	0% - 5%	Somewhat
4	3	5	1	4	2	4	1	3	2	5	Not Sure	0% I don't want my rates to increase at all	Not Important
5	3	4	2	5	1	3	2	5	1	4	Yes	5% - 10%	Somewhat
6	1	5	2	4	3	3	2	4	1	5	Yes	5% - 10%	Somewhat
7	4	5	2	1	3	1	2	4	3	5	Yes	0% - 5%	Somewhat
8	2	5	4	1	3	2	3	4	5	1	Yes	0% - 5%	Really
9	4	1	2	3	5	4	1	3	2	5	Yes	0% - 5%	Somewhat
10	1	4	2	5	3	1	2	3	5	4	Yes	5% - 10%	Somewhat
11	3	5	2	4	1	4	1	3	2	5	No	0% I don't want my rates to increase at all	Somewhat
12	5	5	5	5	5	5	5	5	5	1	Not Sure		Not Important
13	5	5	5	5	1	4	1	3	2	5	No	0% I don't want my rates to increase at all	Really
14	1	5	1	3	3	3	1	3	1	3	Yes	0% - 5%	Somewhat
15	2	5	1	3	4	1	2	3	4	5	Yes	0% I don't want my rates to increase at all	Somewhat
16	2	3	5	4	1	3	1	4	2	5	Not Sure	0% - 5%	Somewhat
17	1	5	2	4	3	3	1	5	2	5	Not Sure	0% I don't want my rates to increase at all	Not Important

18	2	4	1	5	3	1	3	5	2	4	Yes	0% I don't want my rates to increase at all	Somewhat
19	4	3	5	2	1	4	1	3	2	5	Not Sure	0% - 5%	Really
20	3	5	1	4	2	4	2	1	3	5	Yes	5% - 10%	Somewhat
21	4	5	1	3	2	2	1	4	3	5	Yes	0% - 5%	Somewhat
22	1	2	1	2	1	1	1	1	2	2	Yes	5% - 10%	Really
23	5	5	5	2	1	5	2	5	1	5	Not Sure	0% - 5%	Somewhat
24	4	3	1	5	2	3	1	4	2	5	Not Sure	0% I don't want my rates to increase at all	Really
25	5	5	5	5	5	5	5	5	5	5	Not Sure	0% I don't want my rates to increase at all	
26	3	4	1	5	2	3	1	4	2	5	Yes	0% I don't want my rates to increase at all	Not Important
27	4	5	2	1	3	5	2	1	3	4	Yes	0% - 5%	Really
28	1	5	2	4	3	1	2	4	5	3	Yes	0% I don't want my rates to increase at all	Somewhat
29	1	5	2	4	3	2	3	5	4	1	Yes	0% I don't want my rates to increase at all	Really
30	1	3	1	1	1	1	1	1	1	1	Yes	5% - 10%	Really
31	2	5	1	4	3	3	1	5	2	4	Yes	0% I don't want my rates to increase at all	Somewhat
32	2	5	3	4	1	4	2	3	1	5	Yes	0% - 5%	Not Important
33	2	5	1	3	4	2	1	4	3	5	Not Sure	0% - 5%	Not Important
34	5	1	1	1	1	4	1	3	2	5	Not Sure	0% I don't want my rates to increase at all	Somewhat

35	3	2	4	1	5	4	2	1	3	5	Yes	0% - 5%	Really
36	3	2	1	4	5	3	1	5	2	4	Yes	0% I don't want my rates to increase at all	Somewhat
37	1	4	5	2	3	5	1	3	2	4	Not Sure	0% - 5%	Not Important
38	2	5	3	4	2	5	1	5	2	5	Not Sure	0% I don't want my rates to increase at all	Not Important
39	1	5	2	4	3	3	2	1	4	5	Yes	0% - 5%	Somewhat
40	2	3	5	4	1	4	1	5	2	3	Yes	0% - 5%	Somewhat
41	2	5	1	4	3	4	1	3	2	5	Yes	0% - 5%	Really
42	1	1	1	5	1	3	1	2	4	5	Not Sure	0% I don't want my rates to increase at all	Somewhat
43	1	5	4	2	3	4	1	2	5	3	Not Sure	0% - 5%	Somewhat
44	1	5	2	4	3	3	1	4	2	5	Not Sure	0% - 5%	Not Important
45	5	5	2	5	1	3	2	1	4	5	Not Sure	0% I don't want my rates to increase at all	Really
46	1	5	3	4	2	5	1	2	3	4	Yes	0% - 5%	Somewhat
47	1	3	2	4	5	5	2	3	1	4	Yes	0% I don't want my rates to increase at all	Really
48	2	5	1	4	3	4	1	5	2	3	Not Sure	0% I don't want my rates to increase at all	Somewhat
49	1	2	5	4	3	3	1	5	2	4	Yes	0% - 5%	Somewhat
50	4	5	3	1	2	5	2	1	3	4	Not Sure	0% - 5%	Somewhat

51	2	1	3	5	4	4	2	3	1	5	Not Sure	0% - 5%	Somewhat
52	1	3	4	2	5	3	1	4	2	5	Yes	0% - 5%	Somewhat
53	1	4	5	3	2	4	1	3	5	2	Yes	5% - 10%	Somewhat
54	4	5	2	3	1	2	1	4	3	5	Yes	5% - 10%	Somewhat
55	5	3	2	4	1	3	4	1	5	2	Yes	0% - 5%	Really
56	1	5	2	4	3	5	1	5	2	5	Yes	0% I don't want my rates to increase at all	Somewhat
57	3	2	1	1	1	3	2	1	5	4	Yes	5% - 10%	Somewhat
58	1	5	2	4	3	3	1	2	5	4	Yes	0% I don't want my rates to increase at all	Somewhat
59	2	3	5	4	1	2	1	3	4	5	Yes	0% - 5%	Really
60	2	5	3	4	1	3	1	5	2	4	Yes	5% - 10%	Somewhat
61	2	5	1	4	3	3	1	5	2	4	Yes	0% I don't want my rates to increase at all	Somewhat
62	1	5	2	4	3	3	1	5	2	4	Yes	0% - 5%	Somewhat
63	2	5	3	4	1	2	1	3	5	4	Yes	0% - 5%	Somewhat
64	3	5	2	4	1	4	1	3	2	5	Yes	0% I don't want my rates to increase at all	Somewhat
65	1	5	2	4	3	4	2	3	1	5	Not Sure	0% - 5%	Somewhat
66	4	5	1	3	2	4	1	3	2	5	Yes	0% - 5%	Really
67	5	1	4	3	2	3	1	2	4	5	Yes	0% - 5%	Really
68	5	5	5	5	1	5	1	5	5	5	Not Sure		Somewhat
69	5	5	5	5	5	5	5	5	5	5	No	0% I don't want my rates to increase at all	
70	5	3	1	3	1	2	2	1	4	2	No	0% I don't want my rates to increase at all	Not Important
71	5	5	5	2	1	1	2	5	5	5	Yes	0% - 5%	Really

72	1	2	1	4	3	1	1	1	2	1	Not Sure	0% I don't want my rates to increase at all	Really
73	1	5	3	4	2	2	1	3	4	5	Yes	5% - 10%	Really
74	4	5	3	2	1	2	1	3	4	5	Yes	5% - 10%	Somewhat
75	2	5	1	3	4	5	1	2	3	4	Yes	0% - 5%	Somewhat
76	1	4	5	3	2	2	1	3	4	5	Yes	0% I don't want my rates to increase at all	Really
77	1	5	2	4	3	3	1	2	4	5	Yes	0% - 5%	Somewhat
78	1	5	4	5	5	5	1	2	5	5	Yes	0% I don't want my rates to increase at all	Really
79	5	1	5	5	5	5	1	5	5	5	Not Sure	0% - 5%	Somewhat
80	3	2	1	4	5	4	1	2	3	5	Not Sure	0% - 5%	Somewhat
81	1	2	1	1	1	1	1	5	1	5	Not Sure	0% - 5%	Somewhat
82	2	5	1	3	4	2	3	4	1	5	Yes	0% I don't want my rates to increase at all	Somewhat
83	1	5	2	4	3	3	1	4	5	2	Not Sure	0% I don't want my rates to increase at all	Not Important
84	4	5	1	3	2	3	1	4	2	5	Not Sure	0% I don't want my rates to increase at all	Really
85	5	3	5	1	2	4	1	3	2	5	Yes	0% - 5%	Really
86	1	2	5	4	3	3	2	1	4	5	Yes	10% - 20%	Somewhat
87	1	5	2	4	3	5	2	1	3	4	Not Sure	0% I don't want my rates to increase at all	Somewhat
88	3	4	5	2	1	4	1	2	5	3	Not Sure	0% - 5%	Somewhat
89	2	5	3	1	4	5	1	3	4	2	Yes	0% I don't want my rates to increase at all	Somewhat

90	3	4	5	2	1	3	2	1	5	4	Yes	0% - 5%	Somewhat
91	2	4	1	3	5	1	3	2	4	5	Not Sure	0% - 5%	Somewhat
92	5	4	3	1	2	2	1	3	4	5	Yes	0% I don't want my rates to increase at all	Not Important
	2.51	4.02	2.59	3.40	2.57	3.18	1.57	3.17	3.00	4.21			

TABLE B.5: Individual Survey Question Breakdown

Question	Respondent Choices	Percentage	Respondents
7	Yes	9%	8
	No	86%	75
	Not Sure	5%	4
8	Very Low	6%	5
	Average	59%	51
	Too High	25%	22
	Not Sure	10%	9
9	Mine are lower than my neighbors	8%	7
	Mine are about the same as my neighbors	23%	20
	Mine are higher than my neighbors	18%	16
	I am not sure how my bills compare to my neighbors	51%	44
10	A lot	30%	26
	Some	43%	38
	A little	17%	15
	None	10%	9
11	Yes	48%	42
	No	52%	46
11a	Yes	67%	28
	No	7%	3
	Not Sure	26%	11
12	Yes	38%	33
	No	59%	51
	Not Sure	3%	3
13	Yes	36%	32
	No	17%	15
	Not Sure	47%	41
14	No	35%	31
	Yes	65%	57
14a	Yes	54%	31
	No	18%	10
	Not Sure	28%	16

15	0-2 Years	11%	9
	2-5 Years	68%	55
	5-10 Years	26%	21
	10+ Years	4%	3
16	Adding more insulation to walls and ceiling	31%	33
	Replacing light bulbs with more efficient bulbs	7%	7
	Replacing windows	27%	28
	Replacing appliances with more efficient appliances	10%	10
	Replacing air conditioning or heating systems	26%	27
17	Improve the environment	11%	11
	Save on monthly operating costs	57%	56
	Reduce the U.S. dependence on foreign oil	15%	15
	Add value to the home	11%	11
	Reduce climate change and greenhouse gases	5%	5
18	Yes	63%	55
	No	5%	4
	Not Sure	33%	29
19	0%, I don't want my rates increased at all	38%	33
	0% - 5%	45%	39
	5% - 10%	14%	12
	10% - 20%	1%	1
	More than 20%	0%	0
20	Really	28%	24
	Somewhat	59%	51
	Not Important	13%	11

TABLE B.6: Question 10 and 14 Survey Result Calculations

Survey	Q10	Q14	BTU/SqFt/DD	Ranking
1	Some	Yes	28.04	20%
2	A lot	Yes	18.84	60%
3	Some	Yes	15.91	70%
4	A lot	Yes	16.67	70%
5	A lot	Yes	40.17	10%
6	A lot	Yes	21.58	40%
7	A little	No	12.75	80%
8	A lot	Yes	12.72	80%
9	A lot	No	14.94	70%
10	Some	Yes	12.31	90%
11	A lot	No	33.82	10%
12	A little	Yes	19.03	50%
13	A little	Yes	23.49	40%
14	Some	Yes	17.96	60%
15	None	No	29.18	20%
16	Some	Yes	30.02	20%
17	Some	No	22.24	40%
18	Some	No	18.91	60%
19	Some	Yes	16.11	70%
20	A lot	Yes	18.53	60%
21	Some	Yes	22.54	40%
22	Some	No	25.12	30%
23	None	No	22.74	40%
24	None	No	24.58	30%
25	Some	Yes	15.78	70%
26	A lot	Yes	16.87	60%
27	A lot	No	35.77	10%
28	A lot	Yes	29.75	20%
29	Some	Yes	35.91	10%
30	Some	Yes	28.55	20%
31	A little	Yes	17.06	60%
32	Some	No	24.97	30%
33	A little	No	12.92	80%
34	Some	Yes	17.07	60%
35	A lot	No	21.81	40%
36	Some	Yes	33.15	20%
37	Some	Yes	18.33	60%
38	A little	Yes	41.06	10%
39	A little	Yes	16.86	70%
40	A little	Yes	15.11	70%

41	A lot	Yes	18.02	60%
42	A lot	No	15.39	70%
43	Some	No	18.98	60%
44	Some	Yes	27.28	20%
45	None	Yes	23.89	30%
46	A lot	Yes	5.64	90%
47	A lot	Yes	27.45	20%
48	Some	Yes	42.68	10%
49	None	Yes	14.76	80%
50	Some	No	16.52	70%
51	A lot	Yes	16.08	70%
52	Some	Yes	17.96	60%
53	Some	Yes	14.01	80%
54	A little	Yes	22.05	40%
55	Some	No	14.91	70%
56	Some	No	17.95	60%
57	A lot	Yes	10.11	90%
58	Some	Yes	14.74	80%
59	A lot	No	12.62	80%
60	Some	No	18.15	60%
61	A little	Yes	26.1	30%
62	Some	No	18.36	60%
63	Some	No	19.6	50%
64	Some	Yes	15.06	70%
65	A lot	Yes	15.98	70%
66	A lot	No	17.22	60%
67	Some	Yes	18.43	60%
68	Some	No	13.53	80%
69	A little	No	23.2	40%
70	None	No	29.18	20%
71	A little	Yes	16.65	70%
72	None	Yes	24.82	30%
73	A little	Yes	16.25	70%
74	A lot	No	11.03	90%
75	A lot	No	14.52	80%
76	A little	Yes	17.22	60%
77	Some	No	18.35	60%
78	None	Yes	15.12	70%
79	Some	Yes	16.64	70%
80	Some	No	18.43	60%
81	Some	Yes	8.82	90%
82	Some	Yes	10.06	90%
83	Some	Yes	13.12	80%

84	Some	No	17.96	60%
85	A lot	Yes	16.09	70%
86	A lot	Yes	7.99	90%
87	A lot	Yes	15.67	70%
88	A little	Yes	14.53	80%
89	A little	No	20.72	50%
90	A little	No	22.39	40%
91	None	No	23.78	30%
92	A little	No	27.12	20%

Combined Results

Question	**Response**	**Total**	**Top 50%**	**Results**
10	A lot/Some	64	48	75%
14	Yes	57	41	72%
	Both	40	28	70%

APPENDIX

C

ON-SITE ANALYSIS DATA

FIGURE C.1: Selected Residents Invitation Letter

University of Nebraska Lincoln

THE DURHAM SCHOOL
College of Engineering
Charles W. Durham School of Architectural Engineering and Construction
Construction Management

May 14, 2011

Dear Woodbine Resident,

Congratulations, you have been randomly chosen for a brief energy analysis of your home.

My name is Nathan Barry, and I am the Principal Investigator of a national research project being funded by the Department of Energy and the University of Nebraska Lincoln. As a portion of the research project, I am working with the Woodbine Municipal Utility on gathering information from Woodbine residents. The first part of the project involved analyzing Woodbine's overall energy consumption. The second part involves surveying residents on their feelings or thoughts toward "green" or energy efficient homes. The third part involves me visiting 20-30 homes in the community and analyzing how they are performing.

The energy analysis takes approximately an hour and will involve taking measurements and gathering data in regards to air leakage, insulation, mechanical systems, etc. The analysis is completely free of charge, all I ask is that you open your home for approximately one hour. The data collected will NOT be shared with the general public, and NO personal information of any kind will be collected.

This energy analysis can provide you with valuable information on how your home is performing and what things you may be able to do to reduce your energy costs. You were randomly selected from more than 500 homes to participate in the research project.

The energy analysis will be taking place between May 31st and June 10th. Please call to schedule your analysis as soon as possible.

For questions or to schedule, I can be reached via cell at (308) 440-8457 or email at barryna@unk.edu

Again, thank you for assisting in this national research project,

Sincerely,

Nathan Barry
Principal Investigator
University of Nebraska Lincoln
School of Engineering

W145 Nebraska Hall Lincoln, NE 68588-0500
(402) 472-3742

Property Summary Reports

<u>Figure C.2 Property #1</u>

Date of Analysis: 6/7/11 **Time:** 0800

Temperature: 80F **Climate:** Warm, Humid

Current B.S.D.: 16.00 **CFM @ 50P:** 3200

Air Exchanges per Hour: 10.04

<u>Overall Analysis:</u>

The home analyzed is outperforming a majority of the homes in Woodbine in regards to energy consumption. This high performance is due to the positive homeowner habits and above average mechanical systems. CFL's were found throughout the home and the high efficiency furnace is in excellent condition. The building envelope is showing significant leakage in the attic and exterior walls. The homeowner should be commended on the basement rim joists sealant as it is performing very well. The recessed lights in the back room are leaking as well as the exterior wall outlets. It is recommended that a thermal picture be taken of the exterior when the temperature differential reaches 30 degrees to further analyze the possibility of exterior envelope improvements.

<u>Figure C.3 Property #2</u>

Date of Analysis: 5/31/11 **Time:** 1400

Temperature: 78F **Climate:** Warm, Dry

Current B.S.D.: 14.76 **CFM @ 50P:** 2200

Air Exchanges per Hour: 7.08

<u>Overall Analysis:</u>

The home is outperforming a majority of the homes in Woodbine, Iowa in regards to energy consumption. The building envelope is above average and the mechanical systems are all in excellent condition. It is recommended that the homeowner look into using more energy efficient light bulbs, specifically in the basement. CFL technology has advanced significantly in the past few years and many bulbs offer the same light output with much less energy usage. The homeowner has recently completed renovation of a “3 seasons” room between the home and garage. The blower door indicated that this room is currently not sealed properly, so it is recommended that the doors to the room remain closed to separate the conditioned space to the unconditioned space. Overall, the homeowner habits and recent investments in mechanical systems and appliances have had a definite benefit towards lowering the home’s energy consumption.

<u>Figure C.4 Property #3</u>

Date of Analysis: 6/2/11 **Time:** 1200

Temperature: 82F **Climate:** Warm, Humid

Current B.S.D.: 9.29 **CFM @ 50P:** 1200

Air Exchanges per Hour: 5.05

<u>Overall Analysis:</u>

The home analyzed performs better than a majority of homes in the Woodbine community. A visual inspection of the property showed an R50 in the attic and sufficient insulation in the exterior walls. The mechanical systems are of superior quality and are performing normally. The blower door performed verifies the home's performance with an air exchanges per hour rate of just over 5. This home meets and exceeds the performance measures of many new construction homes built today. The homeowners should be commended by their use of high efficiency appliances and programmable thermostats. These homeowner habits are in no doubt assisting in the low energy use of the home. The home would be a possible candidate for radiant barrier placed in the attic rafters. The position and style of the home is absorbing an above average amount of solar heat.

Figure C.5 Property #4

Date of Analysis: 6/1/11 **Time:** 1200

Temperature: 74F **Climate:** Cool, Dry

Current B.S.D.: 16.11 **CFM @ 50P:** 3100

Air Exchanges per Hour: 14.51

Overall Analysis:

The home is performing better than the average home in Woodbine, IA. The furnace has recently been replaced by a high efficiency heat pump which will assist in lowering the current B.S.D. The building envelope has multiple leaks around the basement rim joists and exterior walls. This is common with the period of home. The home would be a good candidate for exterior insulation as well as sealant of the rim joists. This improvement would not only assist in the energy costs but also the comfort level of the homeowner. There was no attic access to inspect the unconditioned space of the home.

<u>Figure C.6 Property #5</u>

Date of Analysis: 6/9/11 **Time:** 15:00

Temperature: 80F **Climate:** Cool, Breezy

Current B.S.D.: 14.01 **CFM @ 50P:** 2500

Air Exchanges per Hour: 3.45

<u>Overall Analysis:</u>

The home is performing exceptionally well in regards to energy usage. The air exchanges per hour in the home meet the standards of an energy efficient home. The building envelope shows opportunity for improvements in living areas above the crawl space as well as the 2^{nd} floor storage closet. Properly sealing the attic access and the storage closet door will not only improve the CFM, but will likely improve the comfort level of the rooms immediately adjacent to the area. The homeowners should be commended for being a leader in the community in regards to energy efficiency as can be noted by the closed loop geothermal mechanical system that was installed in 2010 and the compact fluorescent bulbs being used throughout the home. Noted during the energy analysis were the multiple electronic devices in the home. The homeowner is encouraged to invest in “smart strip” surge protectors. A growing number of electronic devices continue to draw wattage while they are not in use. Things such as computer monitors, DVD players, stereo software, etc., use electricity 24 hours a day. Smart strips cause these accessory devices only to turn on when the computer is on or the television is turned on. These can be purchased for as low as $20 and have been found to have a great return on investment.

<u>Figure C.7 Property #6</u>

Date of Analysis: 6/2/11 **Time:** 1300

Temperature: 84F **Climate:** Warm, Humid

Current B.S.D.: 18.95 **CFM @ 50P:** 1700

Air Exchanges per Hour: 7.26

<u>Overall Analysis:</u>

The building envelope of the home is performing very well. During the blower door tests, leakage was found around the exterior outlets, basement windows, and basement penetrations, specifically the plumbing vent pipe extending through the roof. While the B.S.D. is below the average of Woodbine residence, there is opportunity for improvement. The attic is currently R19 insulation. It is recommended that homes in this climate zone have a minimum R36 in the attic space. The gas water heater is approximately 20 years old. Investment in a new high efficient or on demand system will reduce the monthly expense of the system.

<u>Figure C.8 Property #7</u>

Date of Analysis: 5/31/11 **Time:** 8:30 am

Temperature: 62F **Climate:** Cool, Dry

Current B.S.D.: 21.58 **CFM @ 50P:** 3,300

Air Exchanges per Hour: 9.56

<u>Overall Analysis:</u>

The home is using energy consistent with the age and condition. The mechanical systems and appliances are all in excellent shape and are assisting in lowering the BSD. The building envelope is well insulated and the windows are sealed and of above average condition. The main cause of the building envelope leakage is taking place along the basement rim boards, the crawl space, and, most significantly, the attic space. Air leakage was also found in the second floor closets. It is suggested that the homeowner may look into improving the attic access and condition in the future.

<u>Figure C.9 Property #8</u>

Date of Analysis: 6/2/11 **Time:** 1000

Temperature: 74F **Climate:** Warm, Breezy

Current B.S.D.: 28.04 **CFM @ 50P:** 2350

Air Exchanges per Hour: 8.03

<u>Overall Analysis:</u>

The B.S.D. on this home takes into account 3 years of utility information. It is recognized that the current homeowner has not occupied the residence for the 3 years, so homeowner habits of the previous and current occupant cannot be determined in effecting the B.S.D. The building envelope of the property is performing well and is close to meeting new home standards. There was minimal leakage identified through multiple attic penetrations, the back slider door, basement rim joists, and exterior outlets. The windows of the property are in average condition and are not hurting or helping the B.S.D. The property could benefit from the usage of compact fluorescent lighting. The mechanical systems and appliances are all working properly.

<u>Figure C.10 Property #9</u>

Date of Analysis: 6/2/11 **Time:** 1100

Temperature: 76F **Climate:** Warm, Breezy

Current B.S.D.: 31.73 **CFM @ 50P:** 1100

Air Exchanges per Hour: 5.14

<u>Overall Analysis:</u>

The building envelope of the home is performing at new construction housing standards. The windows are sealed properly and the storm windows are assisting in the energy efficiency of the home. The homeowners should be commended on their positive energy habits including the use of compact fluorescent lighting and adjusting the thermostat while the home is unoccupied. While a more in-depth inspection by a certified HVAC technician is needed, the high B.S.D. seems to be the result of an undersized A/C unit. Since the installation of the A/C unit, the occupant number has increased and the basement is now being conditioned. While there is some thermal gain through the large front home windows, it is the recommendation that any energy efficient upgrades be focused on the mechanical system.

Figure C.11 Property #10

Date of Analysis: 5/31/11 **Time:** 1000

Temperature: 68F **Climate:** Cool, Dry

Current B.S.D.: 27.28 **CFM @ 50P:** 3000

Air Exchanges per Hour: 9.85

Overall Analysis:

The air exchange per hour for this period of home is above average. The building envelope is performing well, with minimal air leakage around the windows and doors. The basement is completely finished, so inspection of the rim joists was not completed. All mechanical systems and appliances are of superior condition. The homeowner should be commended for their use of a high efficiency furnace and on-demand water heater. After closer inspection of the exterior A/C unit, there is visible damage which may be deteriorating its performance. The home has an abundance of lighting in the basement. It is recommended that all light bulbs used more than 1 hour a day be replaced with compact fluorescent lighting. The higher than usual B.S.D. is most likely simply a result of an active household.

<u>Figure C.12 Property #11</u>

Date of Analysis: 6/6/11 **Time:** 1100

Temperature: 85F **Climate:** Warm, Humid

Current B.S.D.: 18.98 **CFM @ 50P:** 2100

Air Exchanges per Hour: 9.05

<u>Overall Analysis:</u>

The home is performing above average for the community of Woodbine, IA. The blower door detected air leakage from the exterior heat registers, basement penetrations, and patio door. The rim joists are insulated well and the mechanical systems are in great condition. It is recommended that the homeowner invest in a programmable thermostat that adjusts while the home is unoccupied. It is also recommended that all lighting used more than 1 hour a day be replaced to a more high efficiency bulb. The attic and walls of the home are sufficiently insulated. The homeowner indicated a temperature difference in the master bedroom. The blower door indicted that this was perhaps an HVAC balance issue and not a building envelope issue. A licensed HVAC technician can inspect the ducting and mechanical systems to insure and modify as needed.

<u>Figure C.13 Property #12</u>

Date of Analysis: 6/7/11 **Time:** 1000

Temperature: 84F **Climate:** Warm, Humid

Current B.S.D.: 24.79 **CFM @ 50P:** 3500

Air Exchanges per Hour: 13.08

<u>Overall Analysis:</u>

The home analyzed is using more energy per square foot than the average home in Woodbine, IA. This seems to be attributed by the building envelope as well as possible mechanical issues. The blower door indicated air leakage around the lower level windows, the exterior outlets, and multiple basement penetrations. Many of these basement penetrations can be sealed with expandable foam or caulking, which will help improve the comfort level of the space. While the furnace is in excellent condition, there is concern that the A/C unit may be undersized for the specific occupants and home. It is recommended that a certified HVAC technician examine the unit for sizing issues. While the water heater is currently working sufficiently, a water heater blanket can be purchased for less than $10 and can improve the efficiency of the unit immediately. As with all homes, using a programmable thermostat and compact fluorescent bulbs offer immediate return on their investment and can assist in reducing monthly energy costs.

Figure C.14 Property #13

Date of Analysis: 6/1/11 **Time:** 0915

Temperature: 68F **Climate:** Cool, Dry

Current B.S.D.: 22.05 **CFM @ 50P:** 2300

Air Exchanges per Hour: 16.83

Overall Analysis:

The home is using energy consistent with the period in which it was built. The building envelope on this specific home offers opportunity to reduce the monthly energy costs. The basement of the property is easily accessible and a majority of the leakage is coming from this area. It is recommended that the rim joists be sealed and insulated properly, along with the basement windows. The ductwork in the basement area is in an unconditioned space and should be insulated and sealed to prevent wear and overuse on the mechanical systems. A programmable thermostat will allow the mechanical system to shut down while the occupant is away, which will also cut energy costs immediately. As with all properties, compact fluorescent bulbs should be used wherever possible.

Figure C.15 Property #14

Date of Analysis: 6/1/11 **Time:** 1400

Temperature: 78F **Climate:** Warm, Dry

Current B.S.D.: 30.02 **CFM @ 50P:** 1400

Air Exchanges per Hour: 8.87

Overall Analysis:

The building envelope is performing exceptionally well and the homeowner's habits are in line which what should be a low B.S.D. All of the mechanical systems and appliances are less than 10 years of age and, while the thermostat is not programmable, the homeowner is manually doing setbacks as the home is unoccupied. The attic and wall insulation are sufficient for the climate narrowing the high B.S.D. number to a possible mechanical concern. It is the recommendation of the inspector that the homeowner have the mechanical system inspected to insure proper performance. While the units are less than 10 years old, there is a possibility of electrical issues causing the system to work improperly.

<u>Figure C.16 Property #15</u>

Date of Analysis: 6/2/11 **Time:** 1600

Temperature: 86F **Climate:** Warm, Humid

Current B.S.D.: 19.03 **CFM @ 50P:** 1700

Air Exchanges per Hour: 12.58

<u>Overall Analysis:</u>

The home is performing above average and the building envelope shows minor leakage around the windows and doors. The home is currently undergoing a basement construction project and when completed will help lower the amount of leakage and energy use on the property. The mechanical system is a high efficiency unit in excellent condition. The insulation in the attic and walls are sufficient for the climate region. It is recommended to insulate the hot water line leaving the water heater as it will help with efficiency at minimal cost. Using a properly installed programmable thermostat will also help in reducing the energy usage on the property while the home is unoccupied.

Figure C.17 Property #16

Date of Analysis: 6/6/11 **Time:** 1000

Temperature: 82F **Climate:** Warm, Humid

Current B.S.D.: 31.10 **CFM @ 50P:** 2600

Air Exchanges per Hour: 10.92

Overall Analysis:

The building envelopes leakage is typical for the period of home. Air leakage was found around the exterior outlets and windows indicating a possible candidate for exterior closed cell wall insulation. The mechanical systems are of superior quality and the addition of a programmable thermostat will only further enhance performance. It is always a good idea to replace burnt out light bulbs with more energy efficient compact fluorescents. The higher than average B.S.D. number can possibly be attributed to the additional appliances in the basement and the building envelope leakage. The upstairs of the home is currently unoccupied, so properly sealing the upstairs door will help improve the air exchanges per hour rating.

Figure C.18 Property #17

Date of Analysis: 6/1/11 **Time:** 1000

Temperature: 70F **Climate:** Cool, Dry

Current B.S.D.: 25.12 **CFM @ 50P:** 4860

Air Exchanges per Hour: 10.96

Overall Analysis:

For the period of the home, the building envelope is performing exceptionally well. The leakage found was coming through around the rim of the home and the attic space. The insulation in the exterior walls and attic are above average for the climate and in good condition. The home has numerous windows that are sealed properly, but are still attributing to the higher B.S.D. through thermal gain. Another attribute to the higher energy use is the amount of lighting in the home. It is recommended that the homeowner invest in higher efficiency fluorescent bulbs. Technology has advanced rapidly in the past few years to offer homeowners the same light output with much less energy use. A programmable thermostat would also help regulate the home when unoccupied to help further reduce the energy usage of the home.

Figure C.19 Property #18

Date of Analysis: 6/6/11 **Time:** 1600

Temperature: 89F **Climate:** Hot, Windy

Current B.S.D.: 24.97 **CFM @ 50P:** 1450

Air Exchanges per Hour: 9.25

Overall Analysis:

The home's energy use is higher than that of a typical Woodbine residence. The building envelope indicated air leakage around the rim joists in the basement. It is recommended that the rim joist be properly sealed and insulated prior to finishing the space. The attic insulation in the area should be a minimum R36. Currently the home has R19 insulation in the attic space. Adding additional insulation to the attic space will relieve some load on your mechanical systems. The mechanical systems are all working properly. To help maintain the lifespan a programmable thermostat could be installed to help regulate the air temperature while the occupant is away.

Figure C.20 Property #19

Date of Analysis: 5/31/11 **Time:** 1300

Temperature: 80F **Climate:** Warm, Dry

Current B.S.D.: 16.58 **CFM @ 50P:** 2300

Air Exchanges per Hour: 12.41

Overall Analysis:

The home has recently been completely renovated over the past year, which will only reduce the current B.S.D. The home received new wall and attic insulation, new energy efficient appliances, lighting, and a new mechanical system. The blower door indicated that the majority of the leakage is coming from the crawl space around the rim joists of the home. It is recommended that this area be sealed and insulated to help improve the comfort level of the home.

<u>Figure C.21 Property #20</u>

Date of Analysis: 6/9/11 **Time:** 15:45

Temperature: 80F **Climate:** Cool, Breezy

Current B.S.D.: 29.85 **CFM @ 50P:** 670

Air Exchanges per Hour: 5.98

<u>Overall Analysis:</u>

The building envelope of the home is performing exceptionally well, which is often the most critical component of the home's performance in regards to energy efficiency. The higher BSD is most likely a result of the electric baseboard heat and air conditioner being used. This heating and cooling method is more costly to operate than a central HVAC system. While there is opportunity to reduce your monthly bills by installing a whole-house mechanical system, the upfront installation cost is not economical for this particular home. It is estimated that a new HVAC system could take 15-20 years at today's utility rates to recover the investment. There may be an opportunity for newer, more efficient baseboard heaters. Today's electric baseboard heaters operate significantly more efficiently and provide a more comfortable source of heat. It should be noted that the style and design of the home, while built in the 1970s, is a design style that lends itself toward energy efficiency, especially passive solar.

Figure C.22 Property #21

Date of Analysis: 6/7/11 **Time:** 0900

Temperature: 82F **Climate:** Warm, Humid

Current B.S.D.: 21.85 **CFM @ 50P:** 950

Air Exchanges per Hour: 6.21

Overall Analysis:

The home's energy usage is average for the community of Woodbine, IA. The building envelope is performing extremely well with an air exchange rating near new construction standards. The homeowner has been actively remodeling the home and has done an exceptional job sealing the envelope. The rim insulation is professionally completed and the lighting is performing excellently. The mechanical systems are all in good quality and a programmable thermostat is being used properly. The home may be a good candidate for radiant barrier in the attic space. Radiant barrier will help reflect the solar heat in the attic space and improve the comfort level of the home. It is recommended that the mechanical systems get a yearly inspection from a certified HVAC technician to insure that the electrical board is sensing and working properly.

<u>Figure C.23 Property #22</u>

Date of Analysis: 6/6/11 **Time:** 1400

Temperature: 88F **Climate:** Warm, Humid

Current B.S.D.: 38.46 **CFM @ 50P:** 4000

Air Exchanges per Hour: 20.64

<u>Overall Analysis:</u>

The home is in excellent structural condition, but is running a BSD much higher than that of an average Woodbine residence. It should be noted that a daycare is being operated out of the home which will cause more energy usage than a typical home. The blower door did indicate significant leakage in the basement and attic penetrations. By caulking and sealing these penetrations, the mechanical systems will run much more efficiently. The home seems to be an excellent candidate for exterior closed cell insulation. The storm windows are working properly and by sealing the exterior walls, the air exchanges per hour will be greatly reduced. The window a/c unit on the second floor of the home is possibly too small. There is some possible efficiency to be gained by purchasing two smaller, higher efficiency units that are set to run less frequently.

TABLE C.1: Blower Door Reading to Air Exchange Calculations

Property	Blower Door Reading	CFM50 x 60	Building Volume	ACH50	BTU/SqFt/DD
1	3,300	198,000	20,710	9.56	21.58
2	670	40,200	6,720	5.98	29.85
3	2,500	150,000	43,518	3.45	14.01
4	950	57,000	9,180	6.21	21.85
5	3,200	192,000	19,116	10.04	16.00
6	3,500	210,000	16,056	13.08	24.79
7	2,300	138,000	8,200	16.83	22.05
8	4,860	291,600	26,612	10.96	25.12
9	3,100	186,000	12,816	14.51	16.11
10	1,400	84,000	9,472	8.87	30.02
11	3,000	180,000	18,266	9.85	27.28
12	2,300	138,000	11,124	12.41	16.58
13	2,200	132,000	18,656	7.08	14.76
14	2,350	141,000	17,560	8.03	28.04
15	1,100	66,000	12,852	5.14	31.73
16	1,200	72,000	14,264	5.05	9.29
17	1,700	102,000	14,052	7.26	18.95
18	1,700	102,000	8,109	12.58	19.03
19	2,600	156,000	14,292	10.92	31.10
20	2,100	126,000	13,920	9.05	18.98
21	4,000	240,000	11,628	20.64	38.46
22	1,450	87,000	9,408	9.25	24.97