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An Exploratory study on energy consumption of Energy Star and non-Energy Star homes

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AN EXPLORATORY STUDY ON ENERGY CONSUMPTION OF ENERGY STAR AND NON-ENERGY STAR HOMES

by

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ABSTRACT

An Exploratory Study on Energy Consumption of Energy Star and Non-Energy Star Homes

by

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The reduction of energy consumption is one of the economic necessities in the United States due to depleting energy sources in the world. The construction industry is stepping forward to reduce the energy consumption of buildings by efficient designs or by constructing buildings with energy efficient materials and features. In 1992, the U.S. Environmental Protection Agency (EPA) and Department of Energy (DOE) introduced the Energy Star Program to promote energy efficient products with the same or improved services. According to the EPA, Energy Star homes, which use these products, will consume 20 to 30 percent less energy than non-Energy Star homes.

This study compares the energy consumption of Energy Star and non-Energy Star homes. The data for similar types of 30 Energy Star and 30 non-Energy Star homes located in Henderson, Nevada were collected to perform statistical analysis. This study statistically compared annual, summer, and winter energy (electricity, natural gas, and water) consumption of these two types of homes. This study also identified the characteristics of buildings, appliances, and homeowners' behaviors that have a significant effect on the energy consumption.
Key words: - Energy Consumption, Energy Star Home, Construction Industry

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Energy conservation is one of the biggest issues today. The United States (U.S.) has many programs to conserve energy such as the Leadership in Energy and Environmental Design (LEED), the Energy Star Program, and the Clean Energy Supply Program. The construction industry is stepping forward to reduce the energy consumption of buildings by using efficient designs or by constructing buildings with energy efficient techniques, materials and features. The construction industry has numerous ways to reduce energy consumption during construction and the operation phase of a building's lifecycle. The LEED program encourages owners, architects, engineers, and contractors to construct the buildings through the use of energy efficient designs and construction materials and methods. The Energy Star Program recommends that homeowners install energy star certified home appliances and equipment, for example water heaters, air conditioners, stoves, and clothes washers and dryers in their homes to reduce energy consumption. The Energy Star Program offers various Energy Star label products that can be used in the residential, commercial, industrial and transportation sectors. This research focuses on the significance of the Energy Star Program in the residential sector.

Is energy conservation and environmental protection necessary? The simple answer to this question is "yes". There are major climate issues that need attention such as greenhouse gasses, global warming, and the melting of snow in the North and South Poles resulting in sea level rise. According to Council Adviser for Sustainable Development (CADS), these climatic issues are result of our dependence on fossil fuels. Even though fossil fuels are abundant, world is witnessing scarcity in the supply of these fuels (Capdevila, 2008). The Government and many research agencies have been working on ways to solve these problems. A short and brief answer to the problems is to reduce the energy consumption in the residential, commercial, industrial and transportation sectors. Reductions in energy consumption will hypothetically reduce carbon dioxide emissions which climate change is partially attributed to by many scientists. Energy consumption can be reduced with the proper education of end users of energy, creating awareness of the climate issues and understanding the alternatives to reduce the climatic change. One of the major steps taken towards saving energy is the introduction and implementation of the Energy Star Program. In 1992, the U.S. Environmental Protection Agency (EPA) introduced the Energy Star Program to promote energy efficient products. The Energy Star Program is a voluntary product-labeling program operated jointly by the EPA and the U.S. Department of Energy (DOE). Under this program, manufacturers promote energy savings while providing the same or improved services.

1.2 Energy Star Program

The EPA started the Energy Star program with the production of energy efficient computers, monitors and printers in 1993 to promote energy saving features. The program became popular when President Clinton issued Executive Order 12845 mandating that every computer, monitor and printer purchased by federal agencies be Energy Star (Webber et al., 1999). As a result, today 95 percent of monitors, 85 percent of computers and 99 percent of printers sold are Energy Star. Due to the tremendous success of the program, the list of Energy Star products was increased. In 1995, the Energy Star program was increased to include fax machines, copiers, residential heating and air conditioning equipment, thermostats and new homes. In 1996, the DOE joined the EPA giving a boost to the program by labeling refrigerators, room air conditioners, clothes washers and dishwashers as Energy Star. Later residential lightings, multifunction devices, and scanners were added to the list of Energy Star products. The list of products increased with addition of by TVs and VCRs in 1998 and fluorescent light bulbs in 1999. The EPA and the DOE continues with testing and planning to add products into the program.

According to the EPA, an Energy Star Home will consume 20 to 30 percent less energy than non-Energy Star Home. So what defines an Energy Star home? EPA uses the Home Energy Rating System (HERS) scoring method that uses a 1 – 100 rating scale with an A1 representing an open tent and an A100 representing a home that did not require any utility power or fossil fuel for heating, cooling and hot water. In addition to that, there was a more simplified five-star rating scale. A score of 80 (or four-star) was roughly equivalent to a national Model Energy Code (MEC) home, and each point above 80 represented a 5 percent incremental improvement above an MEC (Rashkin, 2000). A detailed description for the HERS rating system is discussed in Chapter 2. Energy Star labels are popular with the public in the marketplace; more than 35 product categories in the marketplace have Energy Star logos on them. More than 550 million Energy Star qualified products including appliances, heating and cooling equipment and lighting were purchased by the end of 2008. The EPA estimates that a home can save, on average, more than 20 percent of its total energy use and between $400 and $500 a year with Energy Star program (U.S. EPA 2007)

1.3 Purpose and Objectives

This study was conducted to determine the energy consumption of Energy Star and non Energy Star homes and the factors affecting the energy consumption of the homes. Data was collected to perform statistical analysis. The main objectives of this study were:

- Benchmark the energy consumption of Energy Star and non-Energy Star homes
- Perform an empirical comparison of annual, summer and winter energy consumption between these two types of homes analyzing the use of the electricity, natural gas and water
- Determine the correlations among certain characteristics of homes, appliances used in the home and the homeowners' behaviors and the energy consumption of the home

1.4 Research Hypotheses

There are two research hypotheses for this study. Research hypotheses with their null hypotheses are described below.

- Research Hypothesis 1: - The mean energy consumption (electricity, natural gas and water) of an Energy Star home is less than that of a non-Energy Star home

- Null hypothesis 2: - The mean energy consumption of an Energy Star Home (ESH) is not statistically different from that of a non–Energy Star Home (NESH)

  $\mu_{Electricity\ consumption\ of\ ESH} = \mu_{Electricity\ consumpiton\ of\ NESH}$

  $\mu_{Water\ consumptiom\ of\ ESH} = \mu_{Water\ consumption\ of\ NESH}$

  $\mu_{Natural\ Gas\ consumpiton\ of\ ESH} = \mu_{Natural\ Gas\ consumption\ of\ NESH}$

- Research Hypothesis 2: - Building characteristics, homeowner's behavior and appliances characteristics affect the electricity, natural gas and water consumption of a home
  - Null hypothesis: - The correlation coefficients between the electricity, natural gas and water consumption and the above mentioned factors are not significantly different from zero.

$$\beta = 0$$

CHAPTER 2

LITERATURE REVIEW

2.1 Energy Consumption

Global energy consumption has doubled in the last three decades. (Beretta, 2007) The rapid increased in population and economic development was thought to be the main reasons for an increase in the world's energy consumption. However, as per Kadoshin et al. (2000) both of these factors have different effects on the energy consumption as they differed in each country. Per their research, four factors were identified that affect the energy consumption of a country: (1) increasing population, (2) improvement in living standards, (3) development of advanced technology, and (4) unique conditions in each individual country such as energy savings, industrial structure, and lifestyle. The second factor would be shown by per capita GDP (Gross Domestic Product) (GDP/population) and factors three and four would be collectively shown by GDP energy consumption (energy consumption/GDP). Based on these Kadoshin et al. (2000) proposed Equation 2.1 and Equation 2.2 as follows:

$$energy\ consumption = \frac{energy\ consumption}{population} \times population \quad \ldots\ldots\ldots\ldots (2.1)$$

$$energy\ consumption = \frac{energy\ consumption}{GDP} \times \frac{GDP}{population} \times\ population .. (2.2)$$

The International Energy Agency's World Energy Outlook 2000 report projected that developing economies would have significantly better economic growth prospects (Priddle, 2000). Per the report, the economic growth was the most important driver of the energy trends. Figure 2.1 shows the share of various countries for world GDP in the year of 1997 and predicted the share for 2010 and 2020. Figure 2.1 shows that the non–OECD (Organization for Economic Cooperation and Development) share of world GDP raised from 46 to 58 percent. Most of this increase reflects growth in East Asia and India.

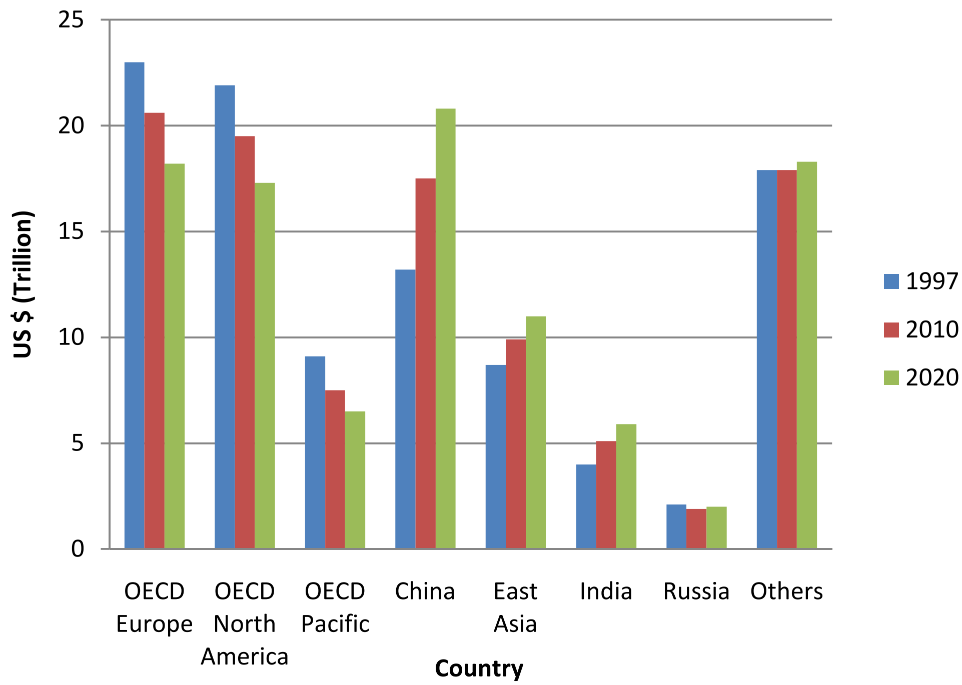


Figure 2.1: Regional shares in world GDP (Priddle, 2000)

Hayward (2009) research showed that primary energy consumption growth slowed in 2008. He also showed that the total natural gas consumption of the world for 2008 was 293.1 billion cubic foot per day. The U.S. natural gas consumption was 63.4 billion cubic foot per day, the highest among all countries. Hydroelectricity consumption in 2008 for the world was 3170.9 Terawatt hour, and for the U.S. it was 250.6 Terawatt hour. Table 2.1 shows the natural gas and hydroelectricity consumption for some of the countries in the world.

Table 2.1: Natural Gas and Hydroelectricity Consumption (Hayward, 2009)

Country	Natural Gas (Billion Cubic Foot per Day)	Hydroelectricity (Terawatt Hour)
Canada	9.7	369.5
China	7.8	585.2
France	4.3	63.4
Germany	7.9	19.6
India	4	116
Russia	40.5	167
United Kingdom	9.1	5
U.S.	63.4	250.6
World Total	293.1	3170.9

The U.S. residential sector consumes 22 percent of the total energy. and has 25 to 30 percent potential to save energy (EIA, 2009). Figure 3.2 shows the total energy consumption of the U.S. in 2008. The residential sector is comprised of single family homes, multiple family homes, townhomes, apartments, and condominium.

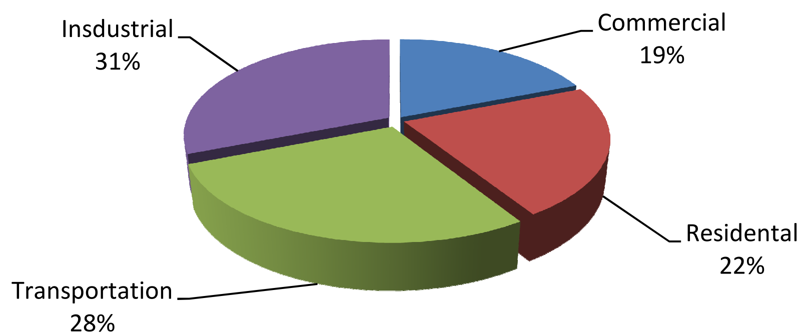


Figure 2.2: Total energy consumption breakdown by sector for 2008 (EIA, 2009)

2.2 History of the Energy Star Program

In 1992, the EPA created the Energy Star program with the help of John S. Hoffman. The goal of the program was to reduce energy consumption and the greenhouse gas emissions from power plants. John S. Hoffman designed, launch and managed EPA's Energy Star program. John S. Hoffman was the Director of the EPA when he designed, managed and launched the Energy Star program. He was the President of the WorkSmart Energy Enterprises, Inc. and the winner of the 1996 American Council for an Energy Efficient Economy (ACEEE) Champion of Energy efficiency award (Hoffman, et, al., 1998). The Energy Star program, which was intended to be a part of a voluntary program, demonstrated potential to reduce greenhouse gases and global warming gases. In 1995, the program expanded with an introduction of Energy Star labels for residential heating and cooling system for new homes. Since then, 15,000 Energy Star partners with a diverse range of public and private organizations have partnered with the EPA and DOE to protect the environment. The collective effort of the partners resulted in the growth of consumer awareness of the Energy Star label. Figure 2.3 shows that Americans purchased about 550 million Energy Star qualified products in 2008. This includes appliances, heating and cooling equipment, consumer electronics, office equipments, lightings and more.

Energy Star labeled products assure a similar or an improved performance. According to one of the EPA reports, even though the additional first cost for some of the appliances might be significant, the use of these products showed monthly saving. As a result, Americans saved more than $19 billion in the utility bills and prevented 43 million metric tons of the greenhouse gas emission in 2008 as shown in Figure 2.4. (U.S. EPA, 2008)

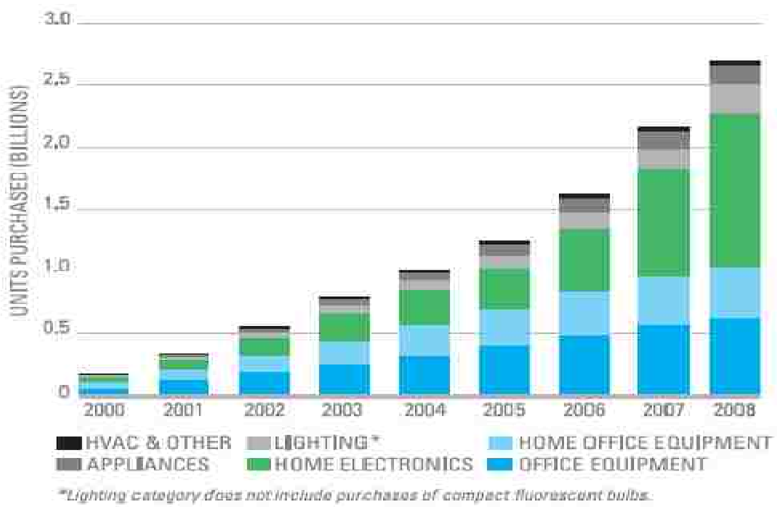


Figure 2.3: Energy Star qualified products purchased since 2000 (U.S. EPA, 2008)

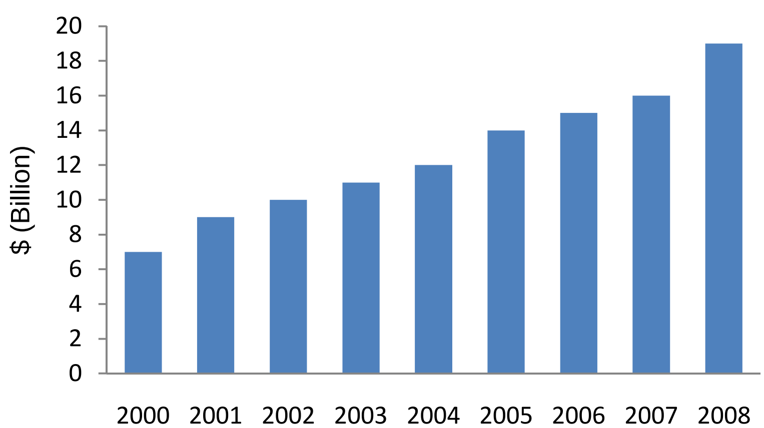


Figure 2.4: Saving in the utility bills by the use of Energy Star Products (U.S. EPA 2008)

2.3 Home Energy Rating System (HERS)

When the Energy Star Program was developed in 1994, there were no guidelines to build or define the Energy Star homes. The DOE assembled a national industry group, The Home Energy Rating System (HERS) Council. However, the HERS was operational in only six states with only a decade of experience. The primary activity of the HERS Council was to formulate national guidelines for DOE approval that would effectively establish national metrics for housing. Rashkin (2000) study showed that the HERS scoring method used A1–A100 rating scale with a A1 essentially representing an open tent and a A100 representing a home that did not requires any utility power or fossil fuel for heating, cooling and hot water. Even though the DOE was never able to approve the final HERS guideline, the EPA analysis indicated that the performance level could be cost effectively achieved throughout the country (Rashkin 2000). Homes rated before July 1 2006 followed the HERS Score, but after that the rating system changed and now uses the HERS Index as a guideline.

The HERS Index system was established by the Residential Energy Services Network (RESNET) (U.S. EPA, 2009). The standard procedure for the HERS Index involves two main steps

- Analysis of a home's construction plan – the HERS raters use a software package to perform an energy efficiency analysis. This analysis indicates the HERS index. Based on the index, raters work with builders to identify energy improvements that are required to meet the Energy Star performance.
- Onsite inspection – this includes a blower door test to determine leaks of the home and a duct test to determine leaks of the ducts.

A home built to the specifications of the HERS scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. The lower a home's HERS Index, the more energy efficient it is in comparison to the HERS Reference Home. Table 2.2 shows the comparison between the HERS Score and the HERS Index (U.S. EPA, 2009).

Table 2.2: Difference between HERS Score and HERS Index (U.S. EPA, 2009)

	HERS Score	HERS Index
Reference Home Score	Reference home is assigned a HERS score of 80	Reference home is assigned a HERS index of 100, while a net zero energy home is assigned a HERS index of 0
Reference Home Basis	1993 Model Energy Code (MEC)	2006 International Energy Conservation Code (IECC)
Scale	Each 5 % increase in energy efficiency corresponds to a 1-point increase in HERS score	Each 1 % increase in energy efficiency corresponds to a 1-point decrease in HERS index
Energy use considered	Heating, cooling and water heating	Heating, cooling, water heating, lighting, appliances, and on site power generation*
Energy Star requirement	HERS score 86	HERS index of 85 in climate zone 1-5, and 80 in climate zone 6-8
Status	Phasing out	Approved by the RESNET Board of Directors

Note: - * Although onsite power generation is included in the RESNET HERS Index, it cannot be used to decrease a HERS Index to qualify for Energy Star.

2.4 Drawbacks of Home Energy Rating System (HERS)

Success of the Energy Star Home Program depends on the coordination from important team participants such as builders, and designers. When the HERS Energy Star program was introduced as a guideline for building an Energy Star home, the HERS imposed a technical verification process that had a new concept and a new set of procedures for the home building industry. As a result, Rashkin (2000) observed five problems during his study with hundreds of builders in the Energy Star program:

- Scoring for each home: According to some builders, emotions play an important role when buying a home. Location, architectural look, layout, kitchen and master bedroom are some of the primary and important things that drive home buyer decsions. The Energy Star Rating and Energy Efficiency were not the driving factors. Builders wanted exteriors different from their competitors; however, variation in interiors was not good for their business. Builders did not want to explain the energy efficiency variations between two models. Another thing builders opposed was the HERS rating system. Instead, some builders suggested a “yes/no” approach to show their homes met the energy efficiency criteria.

- Increased cost: Builders did not want to spend additional money that cannot be recovered when selling a home, as the expense will be deducted from their profit. The HERS rating, required builders to spend an average of $250 - $450 per home.
- Increased risk: Builders took risks by buying land, securing regulatory approvals, sustaining qualified subcontractors and labor, timing their projects, etc. In addition to this, they did not want to burden themselves with an unknown rating system that increased their cost and time.
- Unwilling to work with an unknown partner: Builders did not like to work with unknown people. Small entrepreneurs who were unknown to most of the builders delivered the HERS rating system. Large number of builders thought that this rating system would affect project quality and schedule.
- Quality control procedure: Many builders had problems with the HERS procedure for quality control. Builders thought that they had an effective way to achieve a higher level of quality and energy efficiency without the HERS rating.

2.5 Effect of Home Appliances on Energy Consumption of Home

Energy consumption of appliances has a remarkable effect on the overall energy consumption of a home. The demand for appliances has increased over the years. In 2008, an average household spent $330 on energy of appliances with expenditure growing at an annual rate of 2 percent (Granade et al. 2009). Figure 2.5 shows the energy consumption of various appliances (all the percentage were rounded so the total might not be equal to 100). TVs consume 22 percent of the maximum amount of energy compared to all the other appliances.

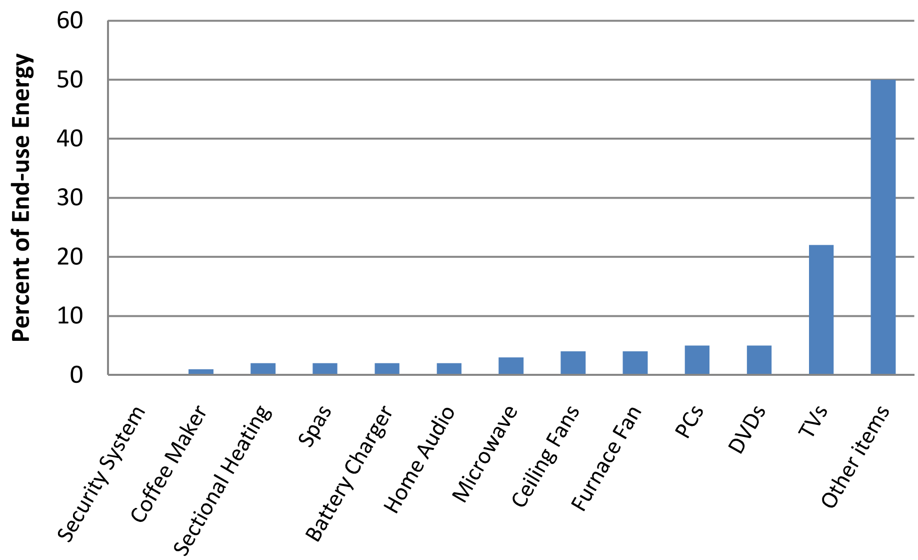


Figure 2.5: Energy consumption of electrical and small appliances (Granade et al., 2009)

Energy consumption has a complex relationship with efficiency of appliances used in a home. For example, the energy consumption for an air conditioning system depends on time of the year, insulation of the home, usage of the system, and number of people in the home. Ugursal and Fung (1996) studied this relationship between energy consumption and insulation of buildings, usage of air conditioning systems and occupancy rate of the buildings using data for 937 Expanded STAR homes from different regions of Canada. Expanded STAR database uses an hour-by-hour building energy simulation program to collect detailed descriptions of homes from different regions of Canada. Ugursal and Fung (1996) used a building simulation model to estimate the total household energy consumption with different scenarios for appliance, furnace, higher insulation and heat recovery ventilator efficiency. These simulations studied the effect of various appliance efficiencies and fuel substitution for the appliances. The findings indicated that appliance efficiency was not a key factor to reduce energy consumption. To reduce significant energy consumption, building envelopes and mechanical systems should be improved.

According to EPA's 2007 Energy Star Overview, Energy Star products can save consumer up to 30 percent in household energy bills (U.S. EPA 2007). Table 2.3 shows the list of Energy Star products and potential savings from these products. Savings by use of these products ranged from 10 to 45 percent.

Table 2.3: Savings with Energy Star appliances (U.S. EPA, 2009)

Energy Star Product Category	Average Energy Saving Above a Standard Product * (%)
Room Air Conditioners	10
Dehumidifiers	15
Ceiling Fans	45
Dishwasher	20
Refrigerators	15
Clothes Washers	30

* Actual saving will vary by climate regions and home characteristics

2.5.1 Effect of Ceiling Fans on Energy Consumption of Home

James et al. (1996) conducted a computer simulation to show the relationship of residential cooling energy use to interior thermostat set points and ceiling fan use for three Florida cities – Jacksonville, Orlando and Miami. The simulation studies demonstrated that use of ceiling fans combined with raising a home's temperature by 2℉ w ould generate about 14 percent net saving in an annual cooling energy and 2.6 percent net savings with raising a home's temperature by 1℉. The study also showed that when the thermostat was not adjusted at all for ceiling fan use, the cooling energy consumption might increase by 15 percent.

Ho et al. (2000) conducted a thermal comfort analysis for a person standing in a room with an air conditioning system and a ceiling fan. Different cases were studied to investigate the effect of using a ceiling fan in an air-conditioned room. The cases investigated included a ceiling fan not in use or used with different air speeds. Figure 2.6 shows results of the simulations of two-dimensional airflow and heat transfer in a room. From the figure it can be seen that the temperature of the room and body increases with the use of a ceiling fan in an air conditioned room. Also, it showed that as the speed of ceiling fans increases, the mean temperature of room and body increases. However, the thermal comfort factor was not considered in these simulations. Even though the use of a ceiling fan increases temperature in the room, the thermal comfort in the room significantly shifts toward the cooler scale. Thermal comfort is dependent on temperature, relative humidity and air speed. The increase in mean air speed, around the person will have significant impact on thermal comfort level. This can be calculated by a Predicted Mean Vote (PMV), a parameter for assessing thermal comfort in an occupied zone based on the conditions of metabolic rate, clothing, air speed besides temperature and humidity. “PMV values refer to the ASHRAE thermal sensation scale that ranges from -3 to +3 as follows: -3 = cold, -2 = cool, -1 = slightly cool, 0 = neutral, 1 = slightly warm, 2 = warm, and 3 = hot.

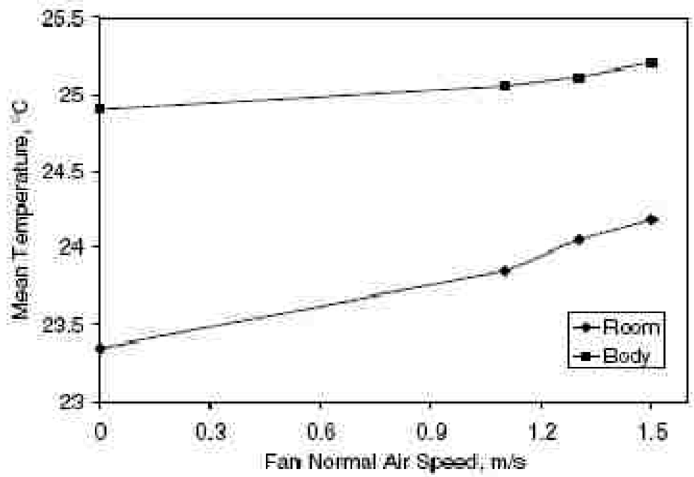


Figure 2.6: Effect of ceiling fan normal air speed on mean temperature (Ho et al., 2000)

Figure 2.7: Effect of ceiling fan normal air speed on predicted mean vote (PMV) (Ho et al., 2000)

Figure 2.7 shows that the PMV for the room was lower than the PMV calculated for the body and as the air speed increases, the PMV value decreases for both the room and body. Thus, the temperature setting for the air conditioner can be raised several degrees while maintaining the same comfort level.

2.5.2 Effect of Clothes Washers on Energy Consumption of Home

According to the Clothes Washer Consumer Brochure (U.S. EPA, 2007), an average household does nearly 400 loads of laundry each year. Figure 2.8 show that non-Energy Star clothes washer requires $630 and $680 of water and energy over its lifespan. Use of an Energy Star washer can save 75,000 gallons of water with $290 and $470 of saving in water and energy bills over 11 years of its lifespan.

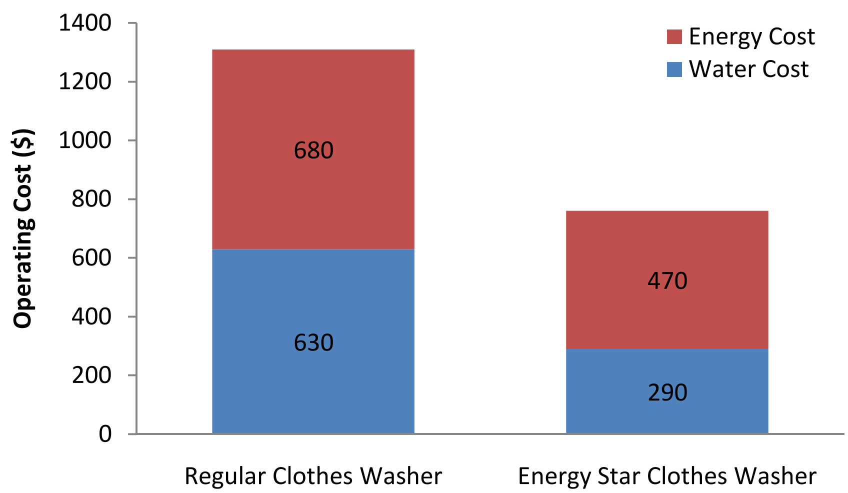


Figure 2.8: Savings with Energy Star Clothes Washer (U.S. EPA, 2007)

2.5.3 Effect of Solar Water Heater on Energy Consumption of Home

According to Hoffman et al, (1998) the Solar Weatherization Assistance Program (SWAP) in Florida is working on solar water heating to get the Energy Star label. Most of the energy in Florida homes is utilized in space and water heating. A solar water heater is an alternative method to the traditional electric or natural gas water heater. In the past, this method tended to provide 80 to 90 percent of household's hot water needs. Even though the solar method of water heating saved energy, it failed to provide the performance required in two major ways – the first problem was of overheating and the second problem was higher repair costs that increased the average cost of the heating compared to non-energy saving methods. SWH can easily be incorporated in the HERS rating, as the new models are smaller, cost half of the original's price, use a passive design with no moving parts, and removal is not required for repair. The SWAP in Florida demonstrated a 52 percent annual energy savings with the new modified model of solar heating.

2.5.4 Effect of a Ventilation System on the Energy Consumption of Home

Using efficient heating and cooling equipment and minimizing air infiltration improve the thermal quality of a home. The Environmental Energy Technologies Division (EETD) compared the cost and effectiveness of residential ventilation strategies in four different climates - cold, mixed (cold and hot), hot humid, and hot arid (Roberson et al. 1998). The EETD performs analysis, research and development leading to better energy technologies to reduce adverse energy-related environmental impacts. The five major criteria EETD considered for this analysis were capital cost, operating cost, distribution of ventilation air within a home, the potential for depressurization, and the potential for condensation in exterior walls. Results clearly showed that multi-port supply ventilation was very effective in all climates except in the cold climate. In a cold climate, a multi-port supply should be balanced by a single-port exhaust and builders should offer balanced heat recovery as an additional option. In hot and humid climates, builders should offer dehumidifying supply ventilation units as an additional option (Roberson et al. 1998). In a multi port supply system, ventilation ductwork are located within conditioned spaces, grills are located near the ceiling of bedrooms and living spaces, a fan operates continuously on low speed, and there are spot fans that exhaust air from kitchen and bathrooms for more efficiency. These features help to boost the ventilation rate.

2.6 Effect of Building Materials and Components on Energy Consumption of Home

Building materials and components play an important role in the energy consumption of a home. Material used in building a home defines its physical characteristics and performance over the time. Effects of some of these materials and components are discussed below.

2.6.1 Effect of Types of Wall Framing on the Energy Consumption of Home

The presence of wood and steel framing members reduces the R-value of a wall system. R-value is the ratio of the temperature difference across an insulator and the heat flow per unit area through it. A higher R-value indicates better insulation effectiveness. In the building and construction industry, it is a measure of thermal resistance (Desjarlais, 2008). Table 2.4 shows the R-value of some common building materials.

Kosny et al. (2008) tested wood and steel studs with three types of wall configuration. Three wall configurations were walls with empty air gaps, walls with partly filled insulation in spacing between studs, and walls with all cavities insulated. The result showed that the R-value depends not only on the wall materials but also on the types of insulation provided in the walls. Figure 2.9 shows the R-values for five simulations of wood and steel as wood and steel studs with empty air gaps, wood and steel studs with partly filled insulation and steel stud with all cavities insulated. The results showed that wood frame walls were very sensitive to installation imperfections of the cavity insulation. In case of the wood stud wall containing air gaps between studs, the R-value was 5.65 h·ft 2·℉/BTU. However, when this gap was filled with insu lation, the R-value increased to 9.24 h·ft 2·℉/BTU The insulation of walls should be installed perfectly in wood framing because small air gaps between wood studs degrade wall insulation performance.

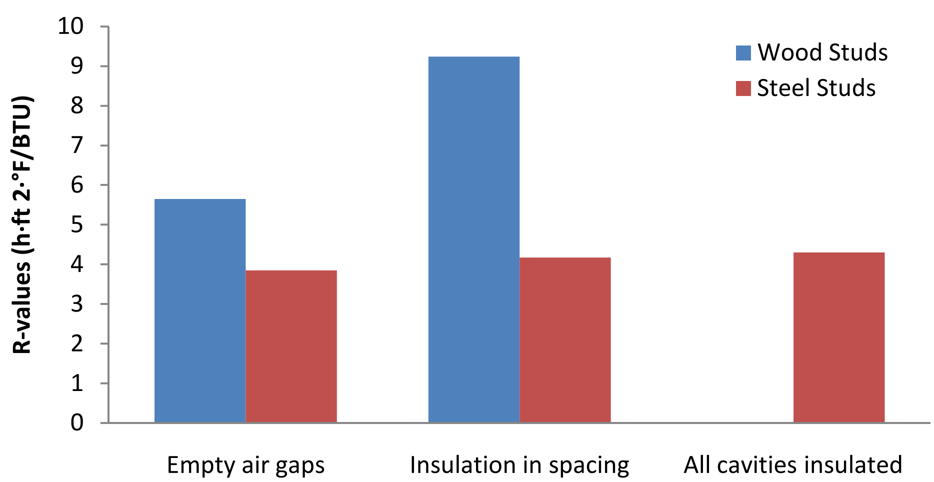


Figure 2.9: Calculated clear-wall R-value for wood and steel framing (Kosny et al., 2008)

Table 2.4: R-values of Building Material (Grassroots, 2007)

Material	R-Value Per Inch	R-Value Per Unit
Drywall	0.90	--
Particle Board - Low Density	1.41	--
Particle Board - Medium Density	1.06	--
Particle Board - Low Density	0.85	--
Hardwood	0.90	--
Cement Mortar	0.20	--
Sand & Gravel	0.09	--
Stucco	0.20	--
Masonry Systems	R-Value Per Inch	R-V Per Unit
Brick - 90 lb/cu.ft.	0.20	--
Brick - 120 lb/cu.ft.	0.11	--
Concrete Block - Normal wt. 8" empty core	--	1.11 - 0.97
Concrete Block - Normal wt. 12" empty core	--	1.23
Concrete Block - Medium wt. 8" empty core	--	1.71 - 1.28
Concrete Block - Light wt. 8" empty core	--	3.20 - 1.90
Concrete Block - Light wt. 12" empty core	--	2.60 - 2.30
Insulation	R-Value Per Inch	R-V Per Unit
Blankets/Batts – Fibreglass	3.0 - 3.8	--
Blankets/Batts - Rock Wool	3.0 - 3.8	--
Loose Fill – Cellulose	2.8 - 3.7	--
Loose Fill - Fibreglass 0.7 lb/cu.ft.	2.2	--
Loose Fill - Fibreglass 2.0 lb/cu.ft.	4.0	--
Loose Fill - Rock Wool	3.1	--
Loose Fill – Vermiculite	2.2	--
Rigid Board - Molded Polystyrene 0.9 lb/cu.ft.	3.6	--
Rigid Board - Molded Polystyrene 1.6 lb/cu.ft.	3.6	--
Rigid Board - Extruded Polystyrene 1.9 lb/cu.ft.	5.0	--
Rigid Board - Extruded Polystyrene – Urethanes	5.6 - 6.3	--
Rigid Board - Extruded Polystyrene – Isocyanurate	5.6 - 6.3	--
Sprayed – Cellulose	3.0 - 4.0	--
Foam Filled – Urethane	5.6 - 6.2	--

2.6.2 Effects of Wall Insulations on Energy Consumption of Home

Heating and cooling loads associated with the wall area are highest among all the building envelope systems. Figure 2.10 shows that energy load distribution for windows, floor, walls and roof. Among all the components shown in the Figure 2.10, walls have 35 percent of the total energy load distribution in a home (Kosny, 2008). Thus, a well insulated wall can produce significant savings in a home's energy consumption.

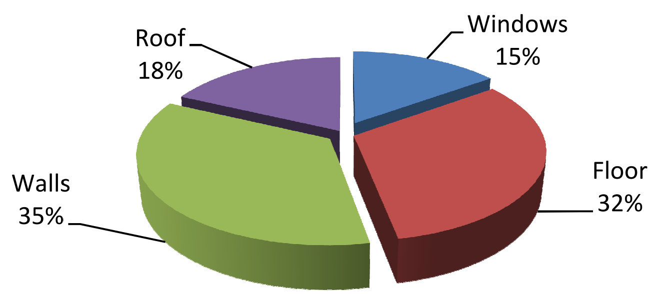


Figure 2.10: Energy load distribution in a residential building (Kosny, 2008)

The U.S. DOE works closely with the building industry, state and local regulatory agencies to improve building codes, appliance standards, and guidelines for efficient energy use. A Technology Fact Sheet prepared by the DOE provides the following guidelines to construct energy efficient walls in a building (U.S. DOE, 2000).

- "Airtight construction – all air leaks should be sealed in the wall during construction and prior to insulation installation
- Moisture control – external rain drainage system, continuous air barrier and vapor barrier located on the appropriate side of the wall
- Complete insulation coverage – advanced framing to maximize insulation coverage and reduce thermal bridging, no gaps or compressed insulation and continuous insulated sheathing"

<u>2.6.3 Effect of Thermal Insulation on Energy Consumption of Home</u>

Air conditioning and space heating are major components of the energy consumption of a home. Controlling the heat flow and the temperature in a room helps to reduce the need for air conditioning requirements for a home (Saleh, 1989). Aste et al. (2009) showed that a well-insulated building saves energy, provides more uniform temperatures throughout the space, produces a more comfortable occupant environment and minimizes recurring expenses. Insulation is also one of the major factors in low-energy buildings and in planning home using passive heating and cooling. The highest possible performing wall system has a proper combination of dynamic thermal transmittance and thermal admittance values. A set of six wall system types, namely C, H, I, L, O and S, with different construction characteristics was compared on the basis of heating and cooling demands. Table 2.5 shows the thermal properties of the selected construction systems.

Thermal transmittance, also known as the U-value, is the tendency of an assembly to conduct heat. It is mathematically the reciprocal of R-value. Thermal capacity, also known as heat capacity, is the product of masses and specific heats of the materials making up the assembly (Janis and Tao, 2005). The thermal admittance of a material is the ability to exchange heat with the environment when the material is subjected to cyclic variations in temperature. Thermal admittance, also known as a heat transfer coefficient, is used in calculating the heat transfer. (www.wikepedia.com). Thicker and more resistive the material, the longer it will take for heat waves to pass through. The time delay due to the thermal mass is known as a time lag. The reduction in cyclical temperature on the inside surface compared to the outside surface is known as the decrement. Thus, a material with a decrement value of 0.5, which experiences a 20-degree diurnal variation in external surface temperature, would experience only a 10-degree variation in internal surface temperature (www.learn.londonmet.ac.uk, 2009).

Table 2.5: Thermal properties of the selected six construction systems (Aste et al., 2009)

	Construction Systems					
	C	H	I	L	O	S
Thermal Transmittance	0.34	0.34	0.34	0.34	0.34	0.34
Thermal Capacity	275	135	175	389	417	59
Mass per unit area	282	146	193	449	482	53
Decrement Factor	0.10	0.46	0.28	0.03	0.11	0.70
Time lag for decrement factor	16.8	6.7	8.9	20.0	11.0	5.2
Thermal admittance	3.11	3.35	3.17	3.13	3.96	1.93
Time lag for thermal admittance	2.7	2.3	2.2	2.2	1.3	3.7

Figure 2.11 shows the heating and cooling demands for the six types of wall systems. The maximum difference among the heating and cooling energy demands results were around 10 percent and 1 percent respectively. It shows that there was no significant difference in the cooling demands. The lowest energy demand was found for wall system type O and highest for the S type. The wall system type O had thermal transmittance of 0.34W, thermal capacity of 417 kJ, 480 kg of mass per unit area, decrement factor of 0.11, time lag for decrement of 11 hours, thermal admittance of 3.96 W and time lag for thermal admittance of 1.3 hours (Aste et al., 2009).

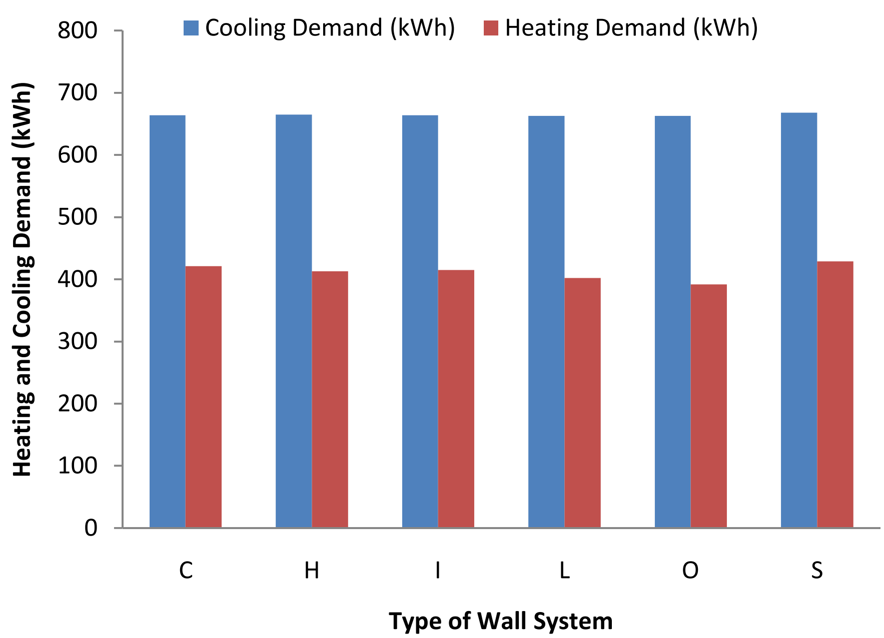


Figure 2.11: Heating and Cooling demands (Aste et al., 2009)

2.6.4 Effect of Types of Windows on Energy Consumption of Home

The energy consumption of homes can be reduced with an efficient window design. The transmission loss per unit surface area through a window is ten times higher than the neighboring wall. It is easier to renovate or replace windows than most of the other parts of a building envelope. Adding a low refractive index anti-reflective (AR) coating on both sides of a low-emittance (Low-E) coated pane in a double-glazed window makes it possible to achieve high light and solar transmittance, while the U-value remains unaffected. A Low-E coating is a microscopically thin, virtually invisible, metal or metallic oxide layers deposited on a window or skylight glazing surface primarily to reduce the U-factor by suppressing a radioactive heat flow (www.efficientwindows.org, 2009).

Rosencrantz et al (2005) performed simulations that showed the monthly average solar factor (g-value) and daylight factor increased by 7 and 21 percent respectively compared to the Low-e double-glazed window without AR-coatings. Light transmittance for a double-glazed window increased by 15 percent without affecting the emissivity, when the window had one Low-e hard coating and AR coating on both panes. The study also showed that the annual heating demand of a home could decreased by 4 percent with use of the Low-e double-glazed windows with AR coating due to higher solar transmittance.

A similar result could be achieved with windows of low Solar Heat Gain Coefficients (SHGC). These windows are double-glazed with the exterior pane tinted that helps reduce the solar heat gain in a hot season and when installed in reversed position, i.e. turned by 180° about the horizontal axis, has a significantly higher SHGC. The Jacob Blaustein Institute for Desert Research investigated the energy saving by turning windows 180° about the horizontal axis during the winter and summer seasons. The result showed that significant energy saving could be achieved with reversible windows (Feuermann, Novoplansky, 1997). Guliermetti and Bisegna (2005) studied positions of the reversible window and concluded that the yearly savings obtained with reversible windows were strictly linked to the method used to control indoor air temperature to avoid intolerance overheating. Their study also revealed that reversible windows facing west and east increased yearly energy savings from 10 to 15 percent.

2.7 Effect of Human Characteristics on Energy Consumption of Home

People exhibit different behavioral characteristics that affect the energy consumption of a home. Many researchers have studied the relationship between human behavior and energy consumption. Some of these concepts are mentioned below.

2.7.1 Human Behavior and the Rebound Effect

In the early eighties, Raaij and Verhallen (1983) noted five behavioral patterns in humans:

- Conservers – has the lowest energy use level;
- Spenders – has the highest energy use level;
- Average user – moderate energy use level;
- Cool dwellers – maintain low temperature and high ventilation
- Warm dwellers – maintain high temperature and low ventilation

These patterns were linked to the rebound effect, which changes attitudes about using energy. According to Greening et al. (2000), the rebound effect to an increase in the supply of energy services with a corresponding decrease in the price. Greening et al. (2000) refined the rebound effect by considering a direct and indirect effect. Hens et al. (2009) discussed and also refined the term “rebound” in their study to show the importance of direct rebound behavior of home inhabitants on the energy consumption for heating. The study showed that the direct rebound was related to the cost benefit relationship and indirect rebound was related to the fact that direct rebound allows households to spend more energy for other activities which demand energy, such as travelling.

Kaiser et al. (1999) identified three situations in which even though a person has a positive attitude towards an ecological behavior, they are prevented from carrying out this behavior. Those three situations were:

- People may be economically constrained.
- People may have the intent to carry out an ecological behavior but family members or friends not to do so.
- People may be restricted by a lack of opportunity to carry out an ecological behavior.

According to Newborough and Augood (1999), the rate of energy use varies dramatically with time of day and time of year. Use of several appliances at the same time produced a peak demand of several kilowatts and the electric stoves and ranges caused the largest peak. Per Newborough and Augood (1999) studied, use of electric cooker and range could produce a peak of up to 10 kW while kettles, ovens and tumble dryers create individual peak demands of only 2 to 2.5 kW. Various ways could influence the energy consumption of a cooking process; for example, use of a microwave oven instead of a conventional oven or use of a toaster instead of a grill. Energy consumption could also be reduced by planning the cooking time more effectively; for example, switching off the oven 5 to 15 min and switching off a electric stove by 2 to 3 min before the end of the cooking period. Based on this study Wood and Newborough (2002) conducted a field investigation to study the ability of consumers to carry out proven four energy saving techniques. Their study of human behavior showed that households who followed the energy saving techniques achieved an energy savings in the range of 10 to 39 percent.

2.7.2 Effect of Systems on Energy Consumption of Home

Hitchcock (1993) showed that over last 20 to 30 years, energy consumption was viewed and studied separately from engineering and social science perspectives. However, for further development in both of these perspectives, a single and coherent view was necessary. To understand energy consumption he divided a household into two systems as a physical system and a human system. Third important factor that affects the household system was environment. The physical and human system were affected by technical and social changes respectively.

Figure 2.12 shows the basic model for a household system. This model was further expanded to show elements of the physical system, human system and environment. The physical system consisted of parameters such as size, material, heating systems, and appliances in homes. The physical system also includes variables such as internal temperature, amount of hot water consumed, and use of appliances. The human system consisted of three variables: biophysical, demographic and psychological. A biophysical variable could be defined as physical characteristics of the body such as respiration and clothing. The second variable, the demographic variable, referred to household income, social status, and number of occupants. The third variable, the psychological variable, referred to beliefs, attitudes and knowledge.

The environment of the household system consists of three systems: a climatic system, an economic system and a cultural system. A climatic system consists of external temperature, insulation, wind, and shelter. An economic system consists of prices, tax structures and other economic regulators that affect an occupant's energy decisions. A cultural system describes general beliefs held by society on environmental issues, comfort, and consumption habits. Figure 2.13 shows the expanded household system model.

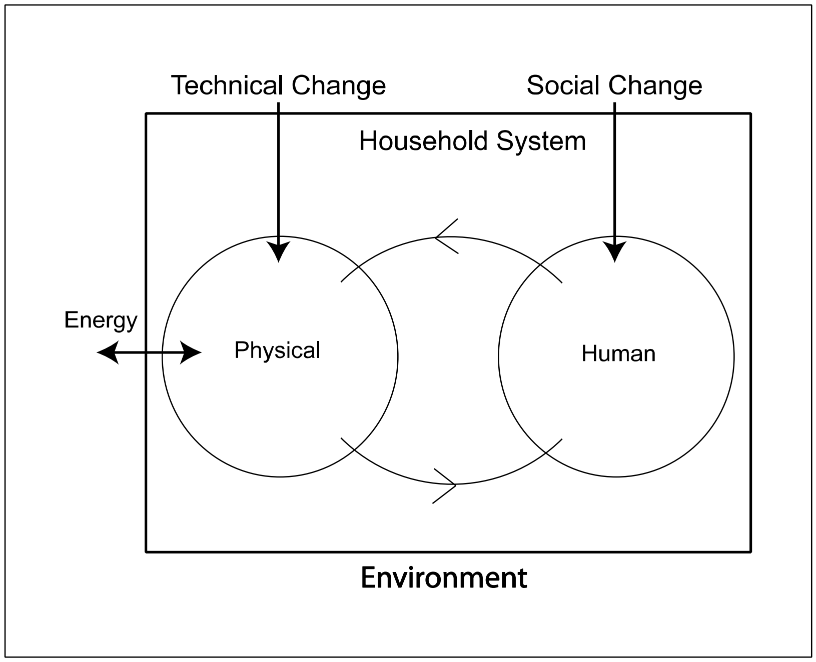


Figure 2.12: Basic household system (Hitchcock, 1993)

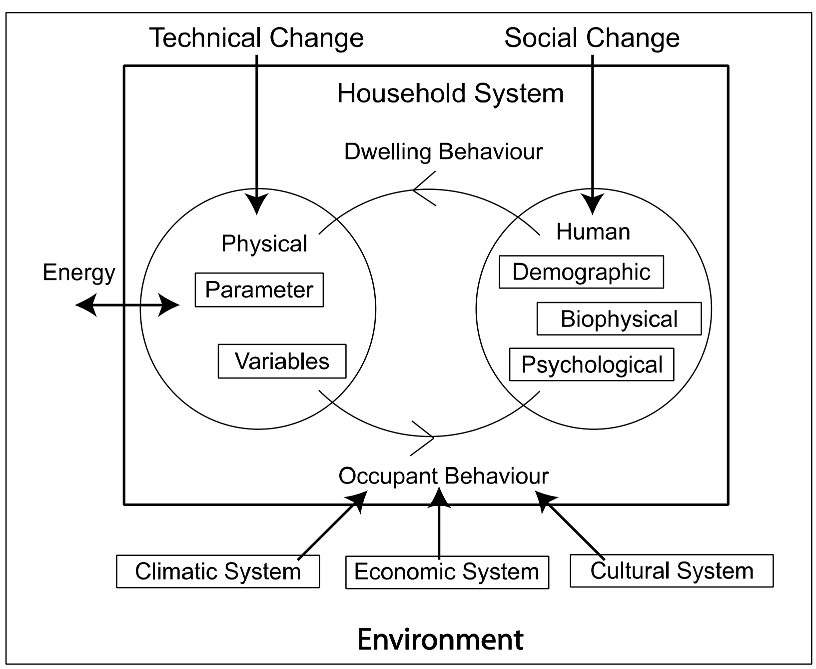


Figure 2.13: Expanded household system (Hitchcock, 1993)

2.7.3 Effect of Behavior Model on Energy Consumption of the Homes

Three types of the many types of methods to model residential energy consumption are the engineering method, conditional demand analysis method and the neural network (NN) method. In the area of residential energy modeling, the NN method had been used for utility load forecasting as it showed superior capability over the conventional methods. Aydinalp et al. (2002) proposed the NN method to model appliances, lighting, and space-cooling components of residential end use energy consumption in Canada. The NN model determined causal relationships between energy consumption of homes and different factors. Some of the factors were household income, dwelling type, ownership, size of the homes, and number of adults and children living in the homes. The following are five findings from Aydinalp et al. (2002) study:

- Electricity consumption of a home increases with increase in income level of the household (Figure 2.14).
- Electricity consumption of a single detached home was higher than a single attached home.
- Electricity consumption of an owner occupied home was higher than a rented occupied home (Figure 2.15).
- Electricity consumption of a home increased as number of children and adults in the home increased (Figures 2.16 and 2.17).
- Electricity consumption of a home decreased as population in the area increased.

Figure 2.14: Appliance, lighting and space cooling electricity consumption versus income (Aydinalp et al. 2002)

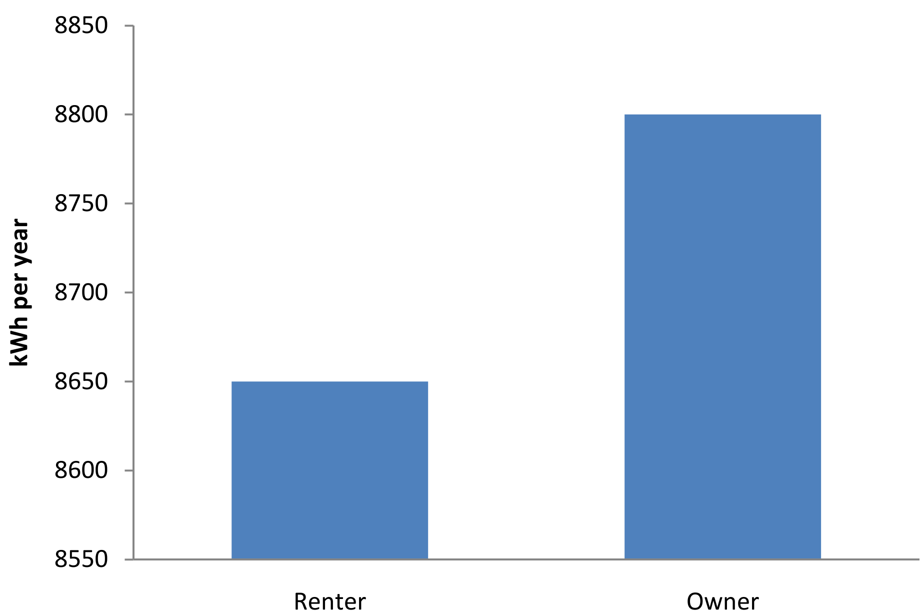


Figure 2.15: Appliance, lighting and space cooling consumption versus ownership status (Aydinalp et al. 2002)

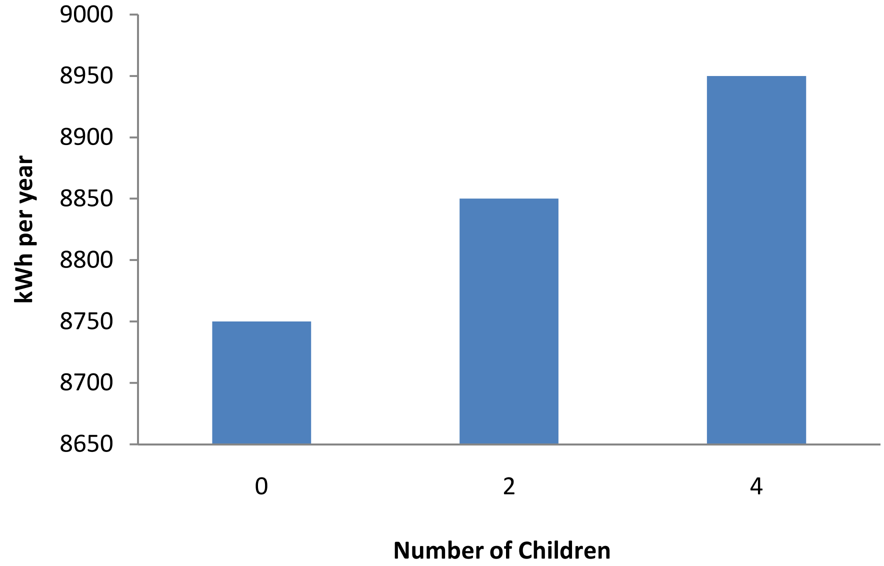


Figure 2.16: Appliance, lighting and space cooling consumption verses number of children (Aydinalp et al. 2002)

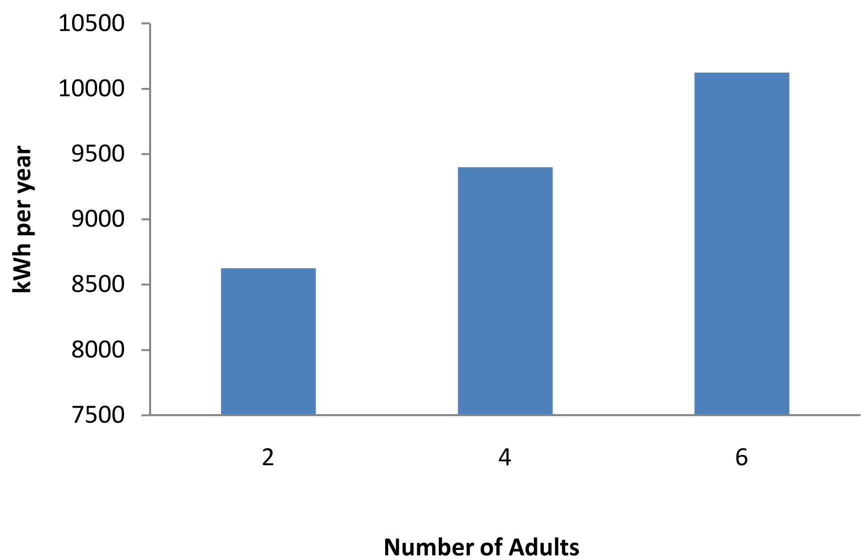


Figure 2.17: Appliance, lighting and space cooling consumption versus number of adults (Aydinalp et al. 2002)

CHAPTER 3

METHODOLOGY

3.1 Research Methodology

This research statistically compared the energy consumption of a small sample of Energy Star and non-Energy Star Homes located in Henderson, Nevada. Figure 3.1 shows the flow chart of the research methodology used for this study. The first two steps of setting an objective and reviewing the literature were covered in Chapter 1 and Chapter 2 of this thesis. This chapter will focus on the following steps: develop survey questions, identify target population and collect and process data. Chapter 4, 5 and 6 will cover data description, analyze data, and develop conclusion and recommendations respectively.

Figure 3.1: Research methodology flowchart

3.2 Develop Survey Questionnaires

In 2005, the U.S. DOE conducted the national “2005 Residential Energy Consumption Survey.” The survey had a total of 14 sections that include questions related to monthly income, and repairs made in the home. The survey questions from the DOE were used as guidelines to develop a questionnaire for this study (Appendix A). There were seven sections in the survey of this study as follows:

- Section 1: Housing unit characteristics – This section consisted of questions related to ownership, number of people who stayed in the home during the year 2008, area of the home in square feet, and garage heating and cooling.
- Section 2: Kitchen appliances – This section collected information about stoves, ovens, microwave ovens, dishwashers, refrigerators, clothes dryers, clothes washers, dehumidifiers and humidifiers. It consisted of questions related to the fuel used for the appliances, age of the appliances, frequency of use of the appliances, and whether the appliances were an Energy Star product.
- Section 3: Space heating – This section consisted of questions related to fuel used for space heating system, age of the system, frequency of use of the system, whether the system was an Energy Star product and average temperature setting of the home during winter.
- Section 4: Water heating – This section consisted of questions related to type of fuel used for water heater, and age of the water heater.
- Section 5: Air conditioning - This section consisted of questions related to the fuel used for the air conditioning system, age of the system, frequency of use of the system, whether the system was an Energy Star product and average temperature setting in the home during summer.
- Section 6: Miscellaneous – This section consisted of miscellaneous questions such as type of windows glass, number of ceiling fans in the home, frequency of use of the ceiling fans and type of the ceiling fans, whether the home was an Energy Star home and whether the homeowner had an Energy Star certificate.

- Section 7: Energy consumption data –This section collected data related to electricity, water, and natural gas bills for one year.

3.3 Selecting Target Population

A pilot study was conducted to determine what to expect in responses received from individuals living in different types of residences. About 10 surveys were distributed to apartment, townhome, and single-family homes. Apartment renters did not provide water and natural gas bills data in the survey. Townhomes and single-family homeowners provided all the data in the survey. Townhomes shared common walls, which might affect the energy consumption of the home. Therefore, data from townhomes were not included in this study. Only the data from single-family homes was analyzed. To conduct "apples to apples" comparisons, surveys were distributed to single-family homes in four subdivisions with similar physical characteristics located in Henderson, Nevada. The selected homes had the following characteristics: - located in Henderson Nevada, single family homes, desert landscape, two stories, air-conditioning unit on the ground, no pool or spa on the property. Refer to Appendix B for floor plans and sample homes photos.

3.4 Data Collection

One hundred and ten (110) surveys were distributed to single-family homes and 79 responses were received for a response rate of 86.9 percent. Out of 79 responses received, 32 responses were from single-family homes with an Energy Star Certificate, 33 responses were from single-family homes without an Energy Star certificate and 14 responses were incomplete. The data received from the survey was entered in an Excel spreadsheet. The survey responses were divided into five categories: 1) Unreturned surveys, 2) Responses from single-family homes with Energy Star certificates, 3) Responses from single-family homes without Energy Star certificates, 4) Incomplete responses from single-family homes with Energy Star certificates, and 5) Incomplete responses from single-family homes without Energy Star certificates. Figure 3.2 shows data received in these five categories.

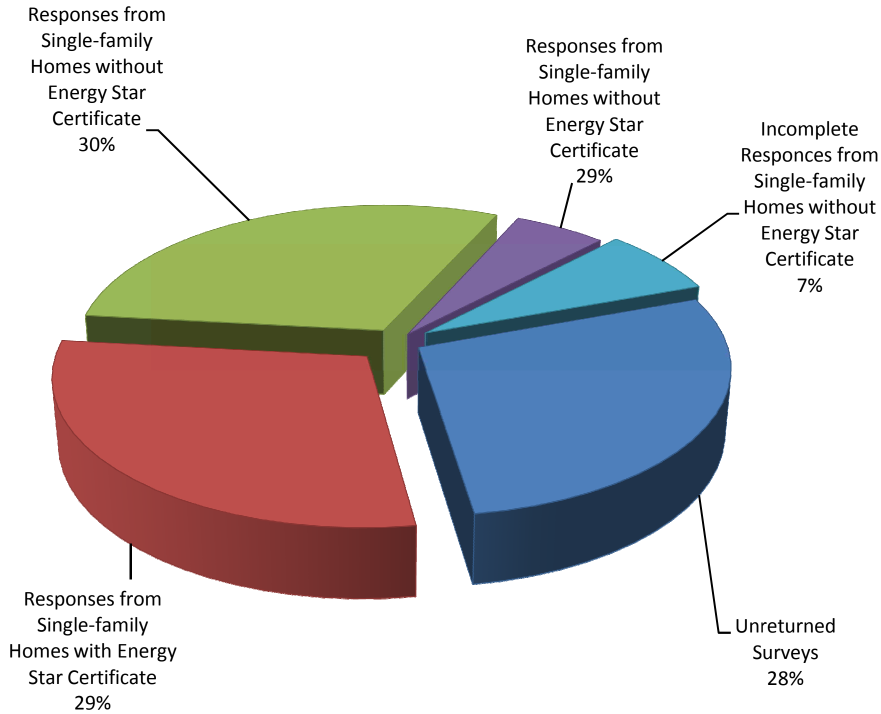


Figure 3.2: Percentage of responses by category (N=79)

3.5 Data Processing

The survey had two types of variables: numerical and categorical variables. Numerical variables have values that represent quantities. Categorical variables have values that can be placed only into categories such as yes and no. Categorical variables can be further divided as a nominal, ordinal, and interval scale categories. To conduct statistics analysis, all the nominal or ordinal data was converted into numeric codes, and entered in Excel spreadsheet.

In Section 7 of the survey, homeowners had an option to enter their electricity, natural gas and water bills in either dollar value or in kWh for the electricity consumption, gallons for the water consumption and therms for the natural gas consumption. Most of the homeowners entered the dollar values. Dollar values received for electricity bill were converted into kWh using a formula from the NV Energy. Dollar values received for natural gas bills were converted into therms using a formula from the Southwest Gas. Dollar values received for water bills were converted into gallons using a formula from the Southern Nevada Water Authority.

3.6 Statistical Analysis

The data was analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS). The Analysis of Variance (ANOVA) and the Pearson correlation tests were performed to reach the conclusions of this study.

3.6.1. Analysis of Variance Test

The ANOVA test was used to compare the means of electricity, natural gas and water consumption of the Energy Star and non–Energy Star homes. There are two types of hypothesis null and research hypothesis. A null hypothesis is always one of status quo, identified by the symbol H_0. A research hypothesis is the opposite of the null hypothesis, identified by symbol H_1. To obtain significant findings, null hypothesis should be rejected (Levine et al. 2007). The research and null hypothesis of ANOVA test for this study are as follows:

H_1 = The mean of the energy consumption (electricity, natural gas and water) of the Energy Star homes is less than the mean of the energy consumption (electricity, natural gas and water) of the non-Energy Star homes.

H_0 = The mean of the energy consumption (electricity, natural gas and water) of the Energy Star homes is not significantly different from the mean of the energy consumption (electricity, natural gas and water) of the non-Energy Star homes. It can be written as

$$\mu_{\text{Electricity of ESH}} = \mu_{\text{Electricity of NESH}}$$

$$\mu_{\text{Natural Gas of ESH}} = \mu_{\text{Natural Gas of NESH}}$$

$$\mu_{\text{Water of ESH}} = \mu_{\text{Water of NESH}}$$

As per Levine et al. (2007) the following four assumptions must be satisfied to conduct the ANOVA test

- The dependent variable should be an interval scale. In this study, all the energy consumption data was interval scales.
- Randomness and independence – The sample data for this study was collected randomly.

- Normal distribution – The histograms for the electricity, natural gas and water consumption were plotted to check whether the data was normally distributed.
- Homogeneity of variance – This assumption was verified by the Levene's test of homogeneity of variance. If the significance value in the test was greater than the *a priori* level of significance, in this case, it is 0.05, then the homogeneity of variance was justified. Levene's test showed that the electricity, natural gas and water consumption data had equal variances.

The ANOVA test determined whether the means of two groups were statistically different. In this study, the test was used to determine whether the mean of the electricity, natural gas and water consumption for the Energy Star Homes was statistically different from the mean of the electricity, natural gas and water consumption for the non–Energy Star Homes. This was done by analyzing variation among and within the groups. In the ANOVA test, the total variation is represented by the sum of squares total (SST). The SST is divided into among–group variation and within-group variation. An among-group variation is due to differences from group to group and within-group variation is considered as random error. The total variation is calculated by using Equation 3.1 or by using Equation 3.2 (Levine et al. 2007).

$$SST = SSA + SSW \qquad \text{(3.1)}$$

Where, $SSA = Square\ among\ group$;

$SSW = Square\ within\ group$

$$SST = \sum_{j=1}^{c} \sum_{i=1}^{n_j} (X_{ij} - \bar{\bar{X}})^2 \qquad \text{(3.2)}$$

Where, $\bar{\bar{X}} = \frac{\sum_{j=1}^{c} \sum_{i=1}^{n_j} X_{ij}}{n} = Grand\ mean$

$X_{ij} = ith\ value\ in\ group\ j$

$n_j = number\ of\ values$ in $group\ j$

$n = total\ number\ of\ values\ in\ all\ groups\ combined$

$c = number\ of\ groups$

The among-group variation, also called as sum of square among groups (SSA), is calculated by summing the squared difference between the sample mean of each group, and the grand mean, weighted by the sample size in each group. Equation 3.3 shows the formula for SSA (Levine et al. 2007).

$$SSA = \sum_{j=1}^{c} n_j(\bar{X}_j - \bar{\bar{X}})^2 \text{ ………………… (3.3)}$$

Where, $c = number\ of\ groups$

$n_j = number\ of\ values$ in $group\ j$

$\bar{X}_j = sample\ mean\ of\ group\ j$

$\bar{\bar{X}} = grand\ mean$

The within group variation, also called as the sum of squares within group (SSW), is calculated by using Equation 3.4 (Levine et al. 2007).

$$SSW = \sum_{j=1}^{c} \sum_{i=1}^{n_j} (X_{ij} - \bar{X}_j)^2 \text{ …………… (3.4)}$$

Where, $X_{ij} = ith\ value\ in\ group\ j$

$\bar{X}_j = sample\ mean\ of\ group\ j$

Once variations are calculated, the mean square can be determined for among and within group variables. There are three types of mean squares – mean square among (MSA), mean square within (MSW) and mean square total (MST). Equations 3.5, 3.6, and 3.7 shows formulas for calculating the mean square among, mean square within and mean square total respectively.

$$MSA = \frac{SSA}{c-1} \text{ ……………………………… (3.5)}$$

Where, $SSA = sum\ of\ square\ among\ groups;$

$c = number\ of\ groups$

$$MSW = \frac{SSW}{n-c} \text{ ……………………………… (3.6)}$$

Where, $SSW = sum\ of\ square\ within\ groups;$

$c = number\ of\ groups$

$n = total\ number\ of\ values\ on\ all\ groups\ combined$

$$MST = \frac{SST}{n-1} \text{ ……………………………… (3.7)}$$

Where, $SST = total\ variation\ in\ one-way\ ANOVA$

$n = total\ number\ of\ values\ on\ all\ groups\ combined$

If the null hypothesis is true and there are no real differences in the “*c*” group means, all three means squares provide estimates of the overall variance in the data. Thus, to test the null hypothesis against the alternatives hypothesis, the ratio of MSA and MSW is important. This ratio is called a one way ANOVA F test statistics and is calculated by using Equation 3.8 (Levine et al. 2007).

$$F = \frac{MSA}{MSW} \text{ ………………………………….. (3.8)}$$

Where, $MSA = mean\ square\ among$

$MSW = mean\ square\ within$

The F test statistics follows the F distribution, with (c-1) degrees of freedom in numerator and (n-c) degrees of freedom in denominator. Thus, for a given level of significance, reject the null hypothesis if the F test statistic is greater than the upper-tail critical value. That is - $Reject\ H_0\ if\ F > F_U$; otherwise do not reject H_0 (Levine et al., 2007).

If the null hypothesis is true, the computed F statistic is expected to be approximately equal to 1 otherwise the F statistic is expected to be substantially larger than 1. The results are usually displayed in an ANOVA summary table. This table includes the sources of variation, the degree of freedom, the sums of squares, the mean squares, p-value and the computed F statistics. The p-value allows the direct conclusions about the null hypothesis. The p-value is the probability of getting a test statistic equal to or more than the sample, given that the null hypothesis H_0 is ture. If the p-value is less than the chosen level of significance, reject the null hypothesis. Findings of these tests are discussed in Chapter 5.

3.6.2. The Pearson Correlation Coefficient between Energy Consumption and Factors Affecting Consumption

The Pearson correlation coefficient calculates the linear relationship between two variables. The value of the coefficient of correlation ranges from -1 for a perfect negative correlation to +1 for a perfect positive correlation. When the value of coefficient of correlation gets closer to –1 or +1, it suggests that the linear relationship between the variables is stronger. When the value of coefficient of correlation is near to 0, it suggests little or no relationship exists between the variables. The positive sign of correlation indicates that the larger values of *X* (variable 1) are paired with the larger values of *Y* (variable 2). The negative sign of correlation indicates that the larger values of *X* (variable 1) are paired with the smaller values of *Y* (variable 2). The following three assumptions for correlation should be valid (Levine et al., 2007).

- Normal distribution - histograms for the electricity, natural gas and water consumption were plotted to check whether the data was normally distributed. Histograms for age of appliance, frequency of use of appliance and type of appliance were also plotted to check whether the data was normally distributed. (see Appendix E for the plots)
- Dependent variable should be of interval scale – this assumption holds true in this study because the data collected for the energy consumption was interval scale.
- Independent variables should be of nominal, ordinal or interval scale – independent variables used in this study were nominal and ordinal scale.

Equation 3.9 shows the formula for calculating the coefficient of correlation (Levine et al., 2007)

$$r = \frac{cov(X,Y)}{S_X S_Y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.9)}$$

Where, $cov(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{n-1}$

$$S_X = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n-1}}$$

$$S_Y = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}{n-1}}$$

To conduct a statistical analysis, it was necessary to normalize the energy consumption data. Homeowners were asked about the area of their homes and number of people living in the home during 2008 year. The average area of homes was found to be 2108 square feet and average number of people in the home was 2.55 per home during 2008. Three different options were considered to normalize the energy consumption data: to convert all the data in unit per square foot per person, to convert the data in unit per square foot and to keep the data in unit consumption per month. Table 3.1 shows the result of the Pearson correlation coefficient test conducted between the annual electricity, natural gas and water consumption of homes and the area of homes and number of people living in the home. The correlation of the annual electricity, natural gas and water consumption with the area of homes was found to be significant at alpha level 0.01. Table 3.1 also shows that the correlation of the annual electricity, and water with number of people living in the home was weak. The correlation of the annual natural gas consumption with number of people living in the home was found to be significant at an alpha level 0.05.

Table 3.1: Correlation between the Energy Consumption and the Area of Home and Number of People (N=60)

Type of Energy	Area of home (ft^2)	No. of People
Annual Electricity Consumption	0.595**	0.118
Annual Natural Gas Consumption	0.499**	0.321*
Annual Water Consumption	0.405**	0.043

*Note: * significant at alpha level 0.05; ** significant at alpha level 0.01*

Based on the results of the Pearson correlation coefficient, the electricity consumption data was converted in to kWh/ft^2, the natural gas consumption data was converted in to $therms/ft^2$, and the water consumption data was converted in to gal/ft^2.

CHAPTER 4

DATA DESCRIPTION

Most of the homeowners provided the energy consumption data in terms of dollar value. Therefore, it was necessary to convert the electricity, natural gas and water bill into kWh, therms and gallons respectively. The following procedures were followed to convert these values.

4.1 Conversion of Electricity bill

The NV Energy electricity bill was used to convert the electric bill dollar values into kWh of electricity consumption. Table 4.1 shows charges included in NV Energy bill for calculating electricity consumption in dollar values. A sample of the NV Energy electricity bill is shown in Appendix D.

Table 4.1: Charges included in Electricity bill

Basic service charge (a)	\$8.00
Utility Fees (b)	\$2.35
Total Fixed Charges, TFC = (a + b)	\$10.35
Electric consumption (c)	\$0.11181
Temporary green power financing (d)	\$0.0041
Renewable Energy Program (e)	\$0.0071
Universal Energy Charge(f)	\$0.00039
Rate (c + d + e + f) (\$/kWh)	\$0.11971

Using values from Table 3.1, the equation for calculating electricity consumption in kWh was determined and is shown in Equation 4.1.

$$\frac{Electric\ Bill - TFC}{Electric\ Bill\ Rate} = Electricity\ consumption\ in\ kWh \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (4.1)$$

Example: If the electric bill was \$50 then using Equation 4.1, electricity consumption can be calculated as

$$\frac{\$50 - \ \$10.35}{\$0.11971/kWh} = 331.21\ kWh$$

4.2 Conversion of Natural Gas Bill

Natural gas rates change according to the season. May through Oct is the summer season and November through April is the winter season. Table 4.2 shows charges included in the natural gas consumption. A sample of Southwest Gas natural gas bill is provided in Appendix D.

Table 4.2: Charges included in Natural Gas bill (Statements of rates)

	May – Oct	Nov – April
Service Charges (a)	\$8.50	\$8.50
Local Tax (b)	\$1.36	\$5.1
Universal Energy Charge (c)	\$0.05	\$0.05
Total Fixed Charges, TFC = (a + b + c)	\$9.91	\$13.65
Gas Charges	\$0.741090/Therms	\$0.78342/Therms
Tier 1 Range	0 – 15 Therms	0 – 45 Therms
Rate for Tier 1	\$0.35419/Therms	\$0.35419/Therms
Tier 2 Range	15 Therms - above	45 Therms – above
Rate for Tier 2	\$0.16050/Therms	\$0.16050/Therms

Using values from Table 4.2, an equation for calculating natural gas consumption in therms for the months of May through October for Tier 1 in therms was determined and is shown in Equation 4.2

$$\frac{Natural\ Gas\ Bill - TFC\ during\ Summer}{Rate\ for\ Tier\ 1 + Gas\ Charges} = Natural\ gas\ consumption\ in\ therms \quad \text{............ (4.2)}$$

Example: If a natural gas bill was \$20.00 in June, using Equation 4.2, natural gas consumption for June will be

$$\frac{\$20.00 - \$9.91}{\$0.35419/therms\ + \$0.741090/therms} = 9.28\ therms$$

If a natural gas bill is more than \$26.30 during summer, it enters Tier 2. Using values from Table 4.2, an equation for natural gas consumption in therms for the months of May through October for Tier 2 was determined and is shown in Equation 4.3.

$$\frac{Natural\ Gas\ Bill - (\$16.3874 + TFC\ during\ Summer)}{Rates\ for\ Tier\ 2 + Gas\ Charges} = Natural\ Gas\ Consumption\ in\ therms\ \ldots\ldots(4.3)$$

Example: If a natural gas bill was \$30.00 in July, using Equation 4.3, natural gas consumption for July will be

$$\frac{\$30.00 - (\$16.3874 + \$\,9.91)}{\$0.1605/therms + \$0.741090/therms} = 19.1072\ therms$$

Using values from Table 4.2, an equation for calculating natural gas consumption in therms for the months of November through April for Tier 1 was determined and is shown in Equation 4.4.

$$\frac{Natural\ Gas\ Bill - TFC\ during\ Winter}{Rate\ for\ Tier\ 1 + Gas\ Charges} = Natural\ gas\ consumption\ in\ therms\ \ldots\ldots\ldots\ldots\ldots\ (4.4)$$

Example: If a natural gas bill was \$20.00 in November, then by using Equation 4.4, natural gas consumption for November will be

$$\frac{\$20.00 - \$13.65}{\$0.35419/therms + \$0.78342/therms} = 5.63\ therms$$

If natural gas bill was more than \$64.721 during winter, it enters Tier 2. Using values from Table 4.2, equation for calculating natural gas consumption in therms for the months of November through April was determined and is shown in Equation 4.5.

$$\frac{Natural\ Gas\ Bill - (TFC + \$51.071)}{Rate\ for\ Tier\ 2 + Gas\ Charges} = Natural\ gas\ consumption\ in\ therms\ \ldots\ldots\ldots\ldots\ (4.5)$$

Example: If a natural gas bill was \$70.00 in December, then by using Equation 4.5, natural gas consumption for December will be

$$\frac{\$70.00 - (\$13.65 + \$51.071)}{\$0.1605/therms + \$0.78342/therms} = 50.59\ therms$$

4.3 Conversion of Water Bill

Table 4.3 shows charges included for calculating water consumption in gallons for Henderson, NV. A sample of water bill is provided in Appendix D. Using values from Table 4.3, an equation for calculating water consumption in gallons for Tier 1 was determined and is given in Equation 4.6.

$$\frac{Water\ Bill - TFC}{\frac{Rate\ for\ Tier\ 1 + Commodity\ Charges}{1000 gal}} = \text{Water consumption in gal}\ \ldots\ldots\ldots\ldots\ (4.6)$$

Example: If a water and sewer bill was \$30.00, then using Equation 4.6, the water consumption will be

$$\frac{\$30.00-\$27.67}{\frac{\$1.46+\$0.10}{1000\ gal}}=1493.6\ gal$$

If a water and sewer bill is more than $36.94, then it enters Tier 2. Using values from Table 4.3, an equation for water consumption in gallons for Tier 2 was determined and is shown in Equation 4.7.

$$\frac{Water\ Bill-\$36.94}{\frac{Rate\ for\ Tier\ 2+Commodity\ Charges}{1000\ gal}}+\ 6000\ gal=Water\ Consumption\ in\ gal\ \ldots\ldots\ldots\ (4.7)$$

Table 4.3: Charges included in Water and Sewer bill (http://www.cityofhenderson.com)

Basic Service Charge	\$8.20
Surcharge (a)	\$0.09
Sewer Charges (b)	\$19.38
Total fixed charges, TFC = (a + b)	\$27.67
Commodity Charge	\$0.10/gal
Tier 1 (0 gal – 6000 gal)	\$1.46/1000 gal
Tier 2 (6000 gal – 16000 gal)	\$1.90/1000 gal
Tier 3 (16000 gal – 30000 gal)	\$ 2.47/1000 gal
Tier 4 (30000 gal – above)	\$3.56/1000 gal

Example: If a water and sewer bill was $40.00, then using Equation 4.7, the water consumption will be

$$\frac{\$40.00-\$36.94}{\frac{\$1.90+\$0.10}{1000\ gal}}+\ 6000\ gal=7530\ gal$$

If a water and sewer bill is more than $56.94, it enters Tier 3. Using values from Table 4.3 an equation for water consumption in gallons for Tier 3 was determined and shown in Equation 4.8.

$$\frac{Water\ Bill-\$56.94}{\frac{Rate\ for\ Tier\ 3+Coomodity\ Charges}{1000\ gal}}+\ 16000\ gal\ =Water\ Consumption\ in\ gal\ldots\ldots\ldots\ldots\ (4.8)$$

Example: If a water and sewer bill was $60.00, then using Equation 4.8, the water consumption will be

$$\frac{\$60.00-\$56.94}{\frac{\$2.47+\$0.10}{1000\ gal}}+\ 16000\ gal=17191\ gal$$

If a water and sewer bill is more than \$92.92, it enters Tier 4. Using values from Table 4.3, an equation for water consumption in gallons for Tier 4 was determined and is shown in Equation 4.9.

$$\frac{Water\ Bill - \$92.92}{\frac{Rate\ for\ Tier\ 4 + Commodity\ Charges}{1000\ gal}} + 30000\ gal = Water\ Consumption\ in\ gal \text{............ (4.9)}$$

Example: If a water and sewer bill was \$100.00, then using Equation 4.9, the water consumption in gallons will be

$$\frac{\$100.00 - \$92.92}{\frac{\$3.56 + \$0.10}{1000\ gal}} + 30000\ gal = 31934\ gal$$

4.4 Data Description

The nominal and ordinal scale data was coded to conduct the statistical analysis in Excel and SPSS. All homes used two types of fuels for appliances – electricity and natural gas. Figure 4.1 shows the number of homes that used electricity and natural gas for the appliances. Sixty homes used electricity for the air conditioning system, refrigerator, and microwave oven. Fifty homes used natural gas for their space heating system. Fifty-six homes used natural gas for their water heaters. Fifty-eight homes used electricity for clothes washer. Forty-eight homes used natural gas for their clothes dryer. Fifty-seven homes used electricity for dishwasher. Fifty-three homes used natural gas for their stove and 44 for their oven. Table 4.4 shows acronyms for home appliances for which data was explained in Figures 4.1 and 4.2

Table 4.4: Acronyms for Home Appliance

Appliance	Acronym	Appliance	Acronym
Air Conditioning System	AC	Space Heating System	SH
Water Heater	WH	Clothes washer	CW
Clothes Dryer	CD	Refrigerator	R
Dishwasher	DW	Stove	S
Oven	O	Microwave	M

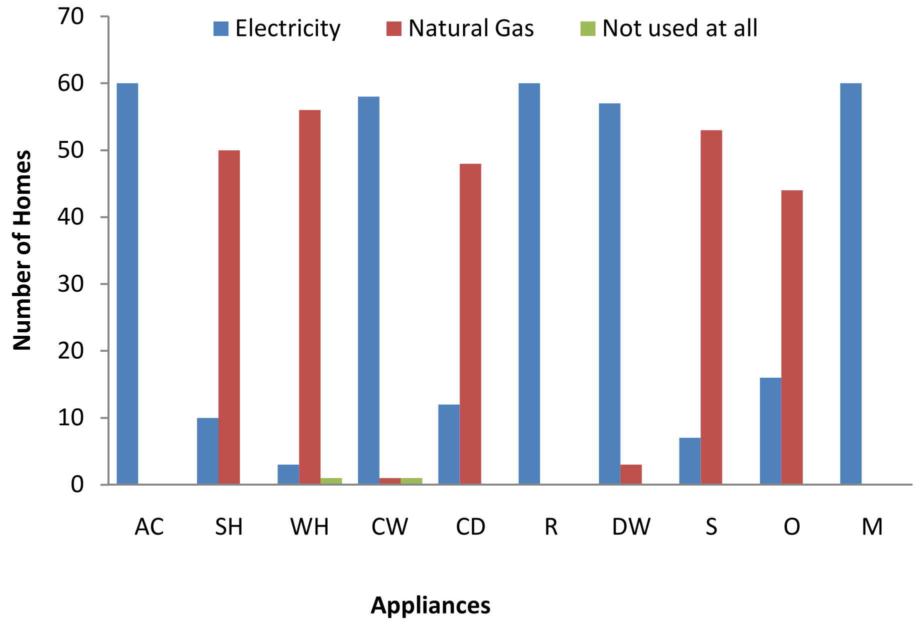


Figure 4.1: Type of fuel used for appliances

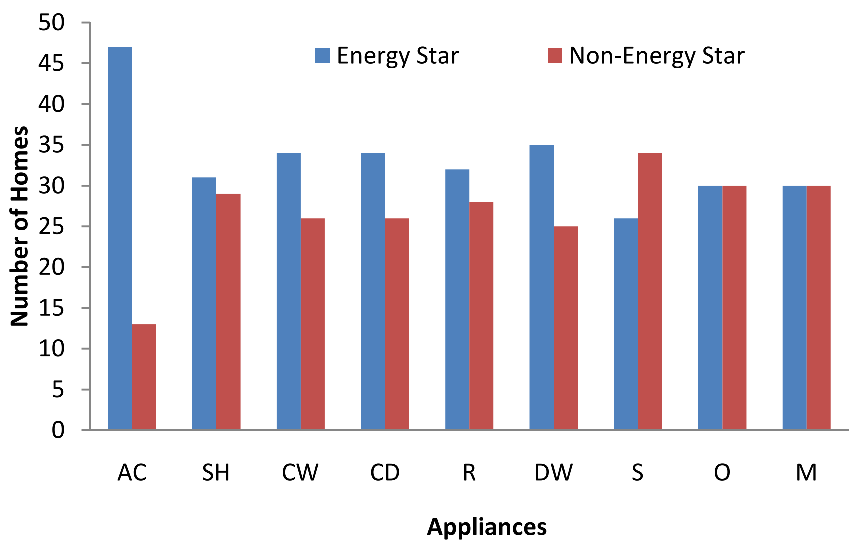


Figure 4.2: Number of Energy Star and non–Energy Star appliances by appliance type

Figure 4.2 shows number of homes and their appliances broken down by whether they have Energy Star or non–Energy Star appliances. Most of the air conditioning systems were Energy Star products.

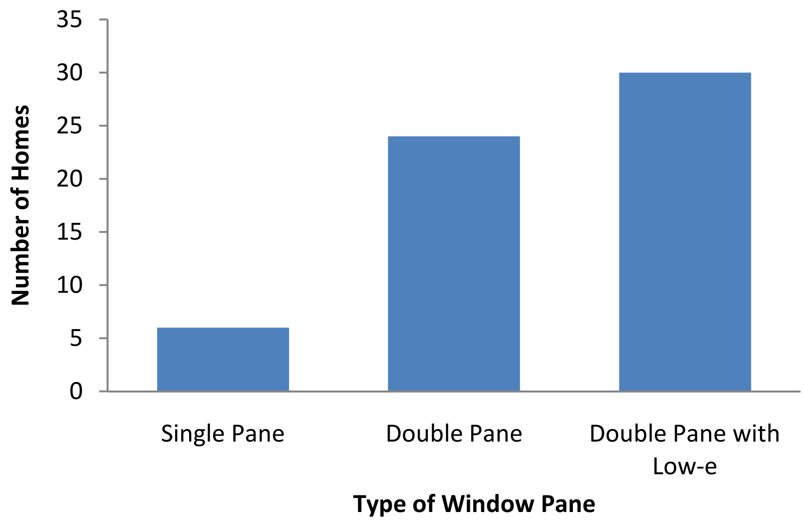


Figure 4.3: Breakdown of homes by windowpane type

Figure 4.3 shows number of homes that had single pane, double pane, and double pane windows with low-e glass for windows. There were 6, 24 and 30 homes that had single, double and double pane with low-e glass for windows respectively.

Figure 4.4 shows number of homes that had ceiling fans and number of ceiling fans. Twenty-eight homes did not have ceiling fans. Eleven homes had on average two ceiling fans, and one home had eight ceiling fans.

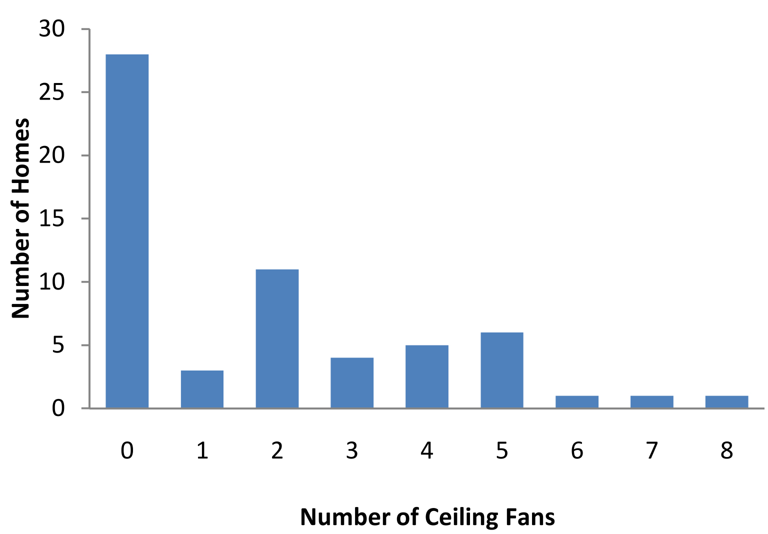


Figure 4.4: Number of ceiling fans per home

4.5 Assumptions for ANOVA test

As explained in Chapter 3, there are four assumptions for the ANOVA test. The second assumption of normal distribution was checked by plotting histograms of the energy consumption data using SPSS. The distribution is left skewed when the left tail is longer or the mass of the distribution is concentrated on the right of the figure. When the right tail is longer or the mass of the distribution is concentrated on left side of the figure, the data is right skewed and when the data is symmetrical, then the data is normally distributed (Levine et al., 2007).

4.5.1 Histograms for the Electricity Consumption per Square Foot

Figures 4.5, 4.6 and 4.7 shows histograms and their normal distribution curve for the electricity consumption with kWh per square foot data.

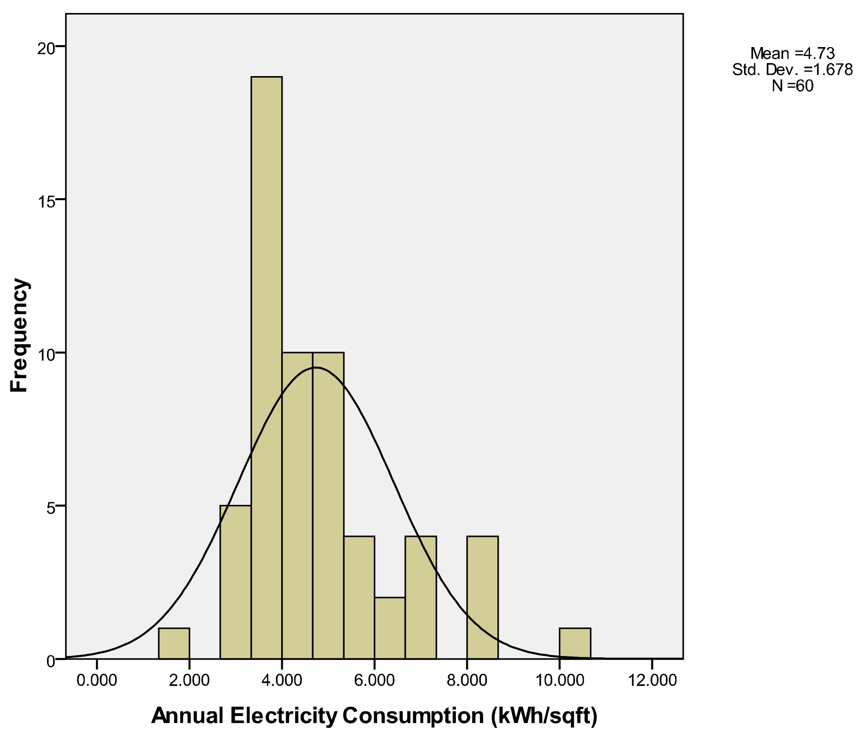


Figure 4.5: Histogram for the annual electricity consumption (kWh/ft^2)

Figure 4.5 shows the annual electricity consumption of homes followed a normal distribution curve with a mean of 4.73 kWh/ft^2. It also shows that the distribution was slightly right skewed.

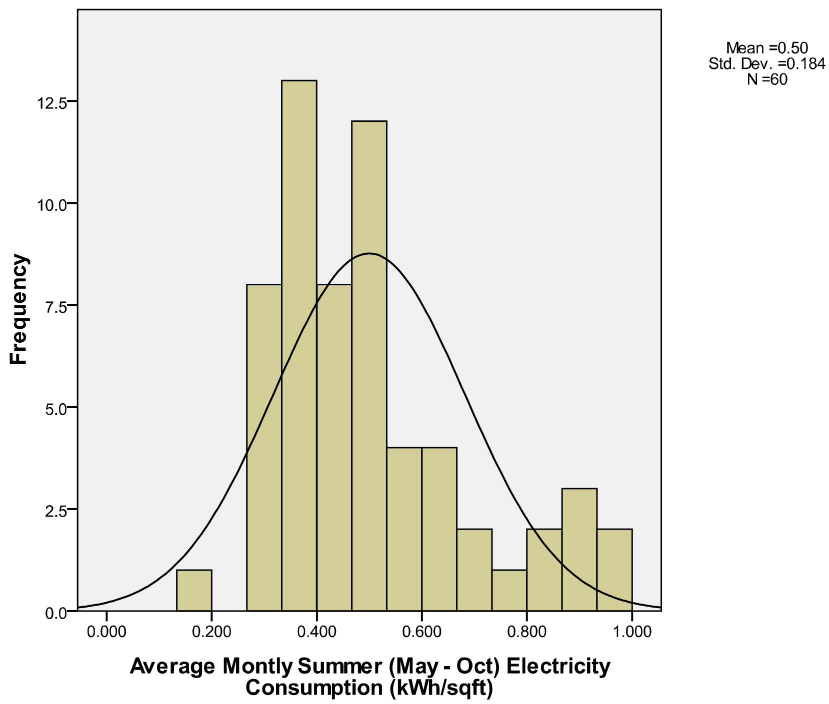


Figure 4.6: Histogram for the average monthly summer electricity consumption (kWh/ft^2)

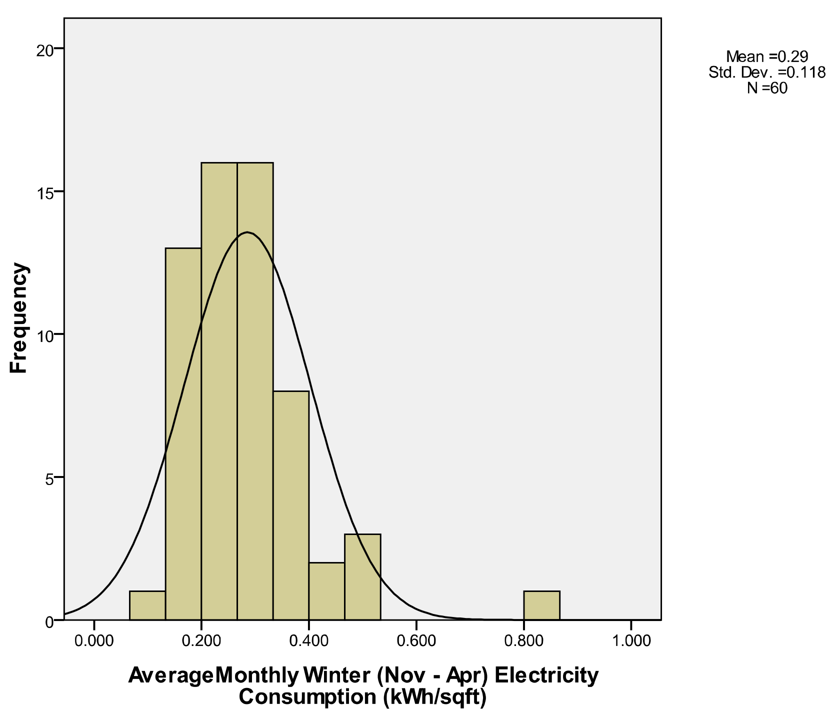


Figure 4.7: Histogram for the average monthly winter electricity consumption (kWh/ft^2)

Figure 4.6 show that the average monthly summer electricity consumption of homes followed a normal distribution curve with a mean of 0.50 kWh/ft^2. It also shows that the distribution was somewhat right skewed.

Figure 4.7 shows that the average monthly winter electricity consumption of homes followed a normal distribution curve with a mean of 0.29 kWh/ft^2. It also shows that the distribution was right skewed.

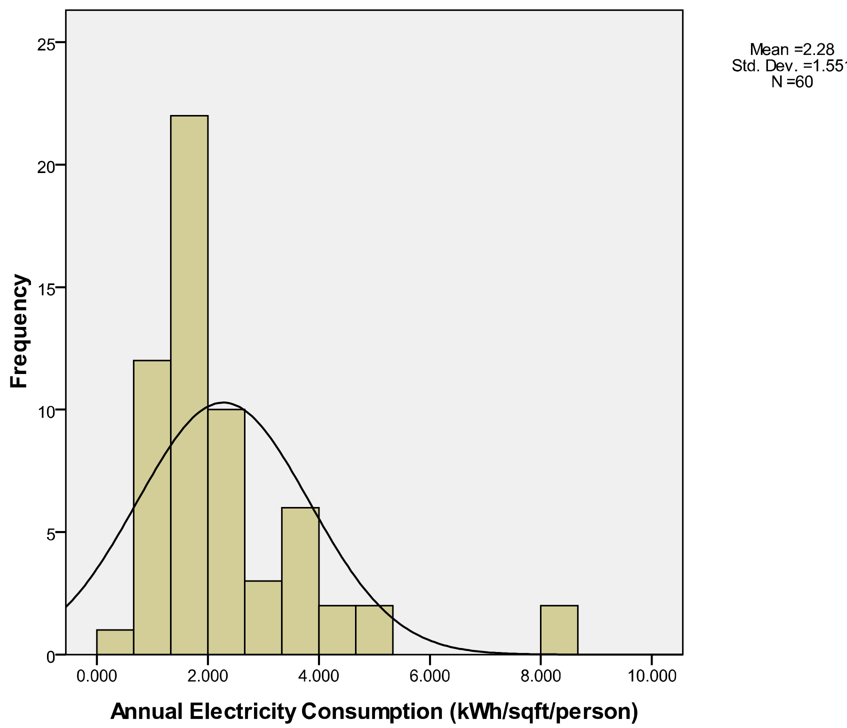


Figure 4.8: Histogram for the annual electricity consumption (kWh/ft^2/person)

Figures 4.8, 4.9 and 4.10 show histograms and normal distribution curves for the electricity consumption with kWh per square foot per person data. Figures showed the data was rightly skewed.

Figure 4.8 shows that the annual electricity consumption of homes followed a normal distribution curve with a mean of 2.28 kWh/ft^2/person. It also shows that the distribution was right skewed.

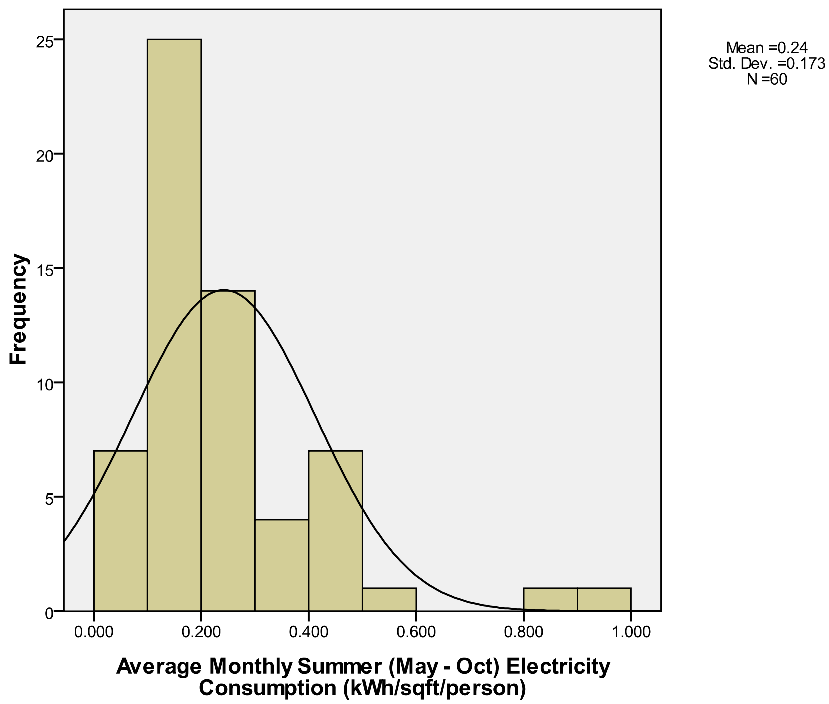


Figure 4.9: Histogram for the average monthly summer electricity consumption (kWh/ft^2/person)

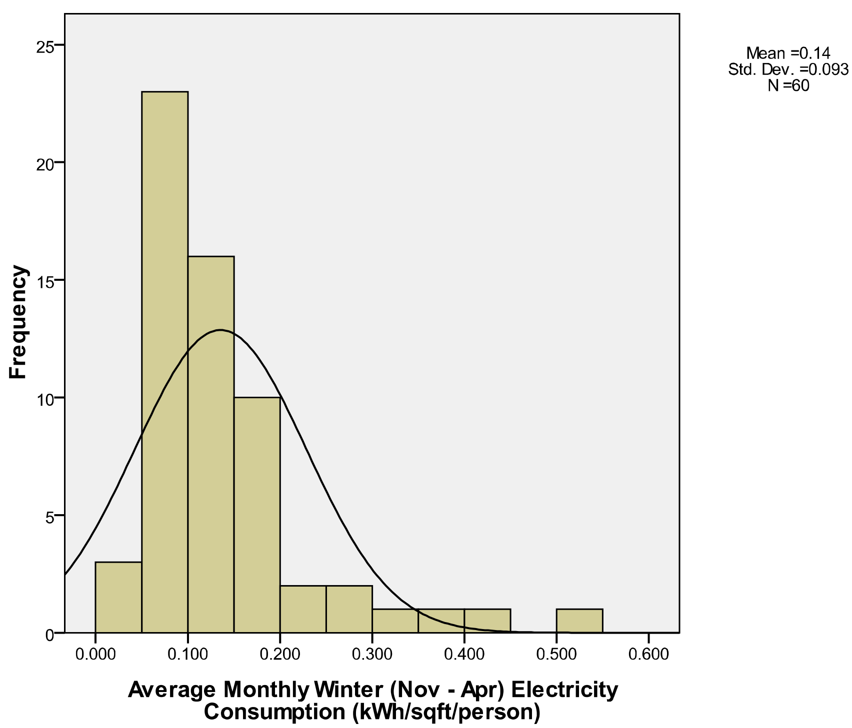


Figure 4.10: Histogram for the average monthly winter electricity consumption (kWh/ft^2/person)

Figure 4.9 shows that the average monthly summer electricity consumption of homes followed a normal distribution curve with a mean of 0.24 kWh/ft^2/person. It also shows that the distribution was right skewed. Figure 4.10 shows that the average monthly winter electricity consumption of homes followed a normal distribution curve with a mean of 0.14 kWh/ft^2/person. It also shows that the distribution was right skewed.

4.5.2 Histograms for the Natural Gas Consumption

Figures 4.11, 4.12 and 4.13 shows histograms and normal distribution curves for the natural gas consumption with therms per square foot data.

Figure 4.11 shows that the annual natural gas consumption of homes followed a normal distribution curve with a mean of 0.25 therms/ft^2. It also shows that the distribution was slightly right skewed.

Figure 4.12 shows that the annual monthly summer natural gas consumption of homes followed a normal distribution curve with a mean of 0.01 therms/ft^2. It also shows that the distribution was right skewed.

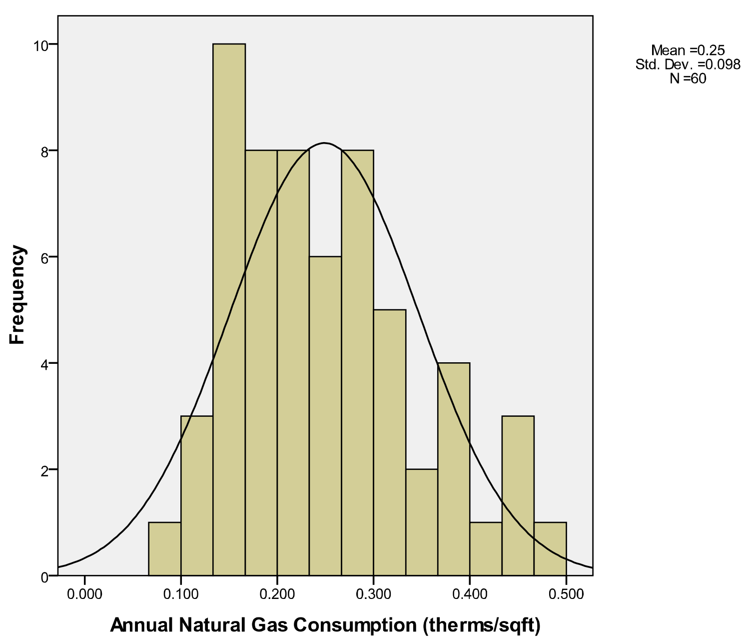


Figure 4.11: Histogram for the average annual natural gas consumption (therms/ft^2)

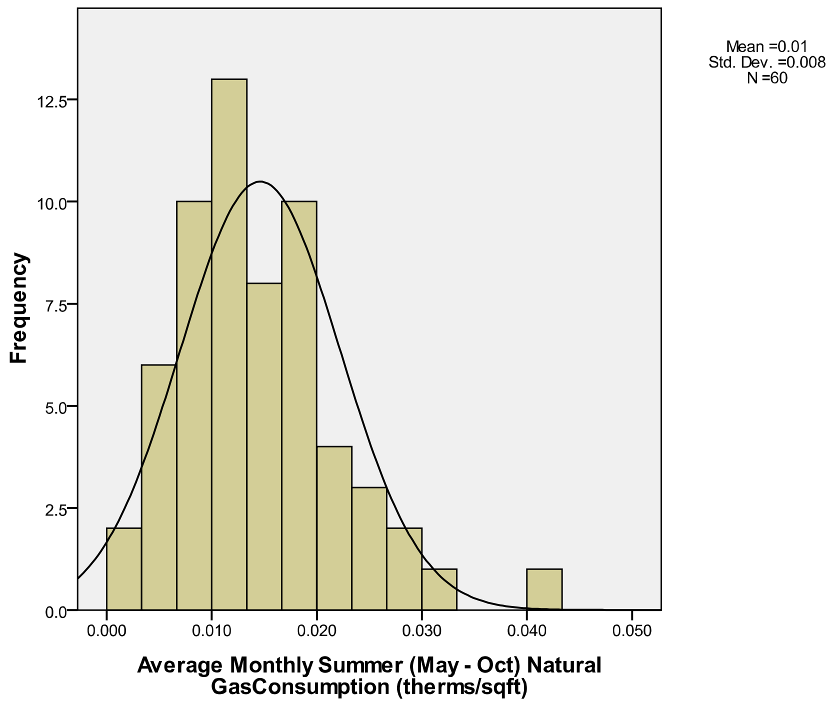


Figure 4.12: Histogram for the average monthly summer natural gas consumption (therms/ft^2)

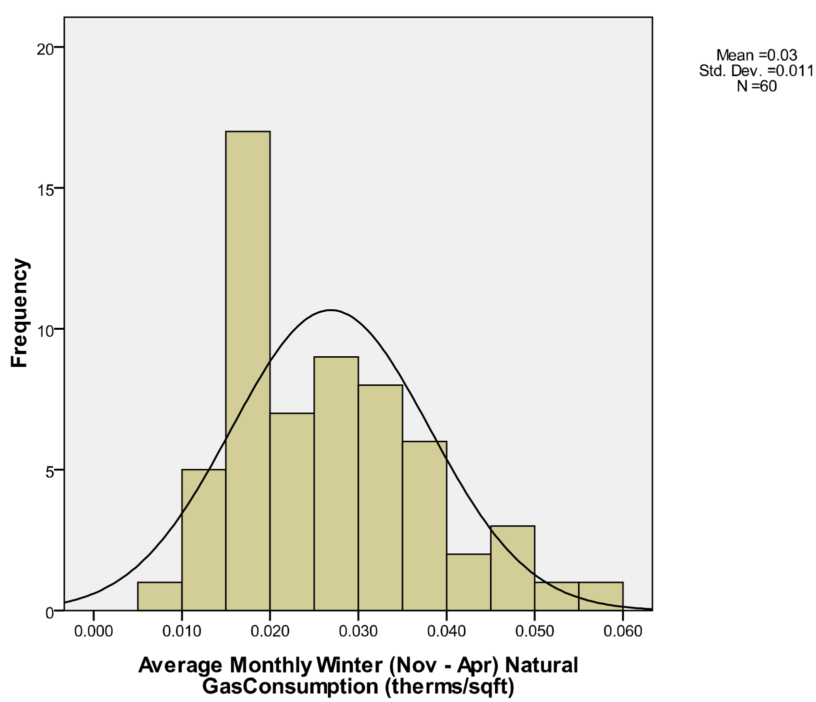


Figure 4.13: Histogram for the average monthly winter natural gas consumption (therms/ft^2)

Figure 4.13 shows that the monthly winter natural gas consumption of homes followed a normal distribution curve with a mean of 0.03 therms/ft^2. It also shows that the distribution was slightly right skewed.

Figures 4.14, 4.15 and 4.16 show histograms and normal distribution curves for the natural gas consumption with therms per square foot per person data for both the types of homes.

Figure 4.14 shows that the annual natural gas consumption of homes followed a normal distribution curve with a mean of 0.11 therms/ft^2/person. It also shows that the distribution was right skewed.

Figure 4.15 shows that the average monthly summer natural gas consumption of homes followed a normal distribution curve with a mean of 0.01 therms/ft^2/person. It also shows that the distribution was right skewed.

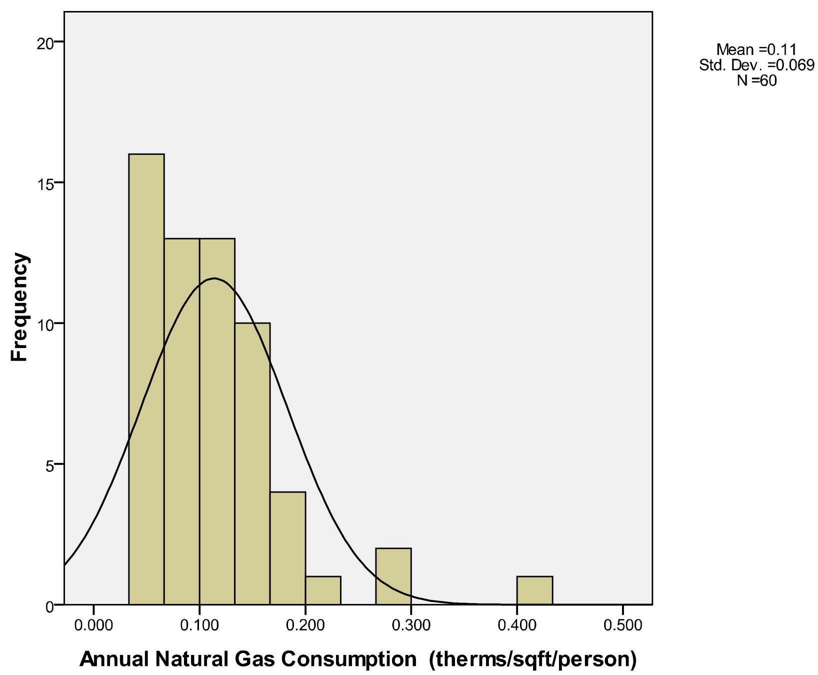


Figure 4.14: Histogram for the average annual natural gas consumption (therms/ft^2/person)

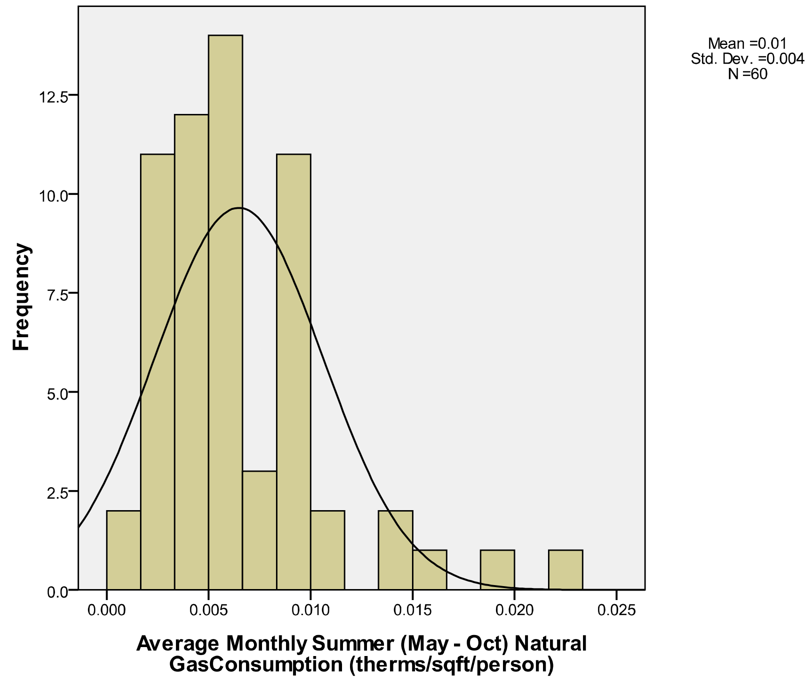


Figure 4.15: Histogram for the average monthly summer natural gas consumption (therms/ft^2/person)

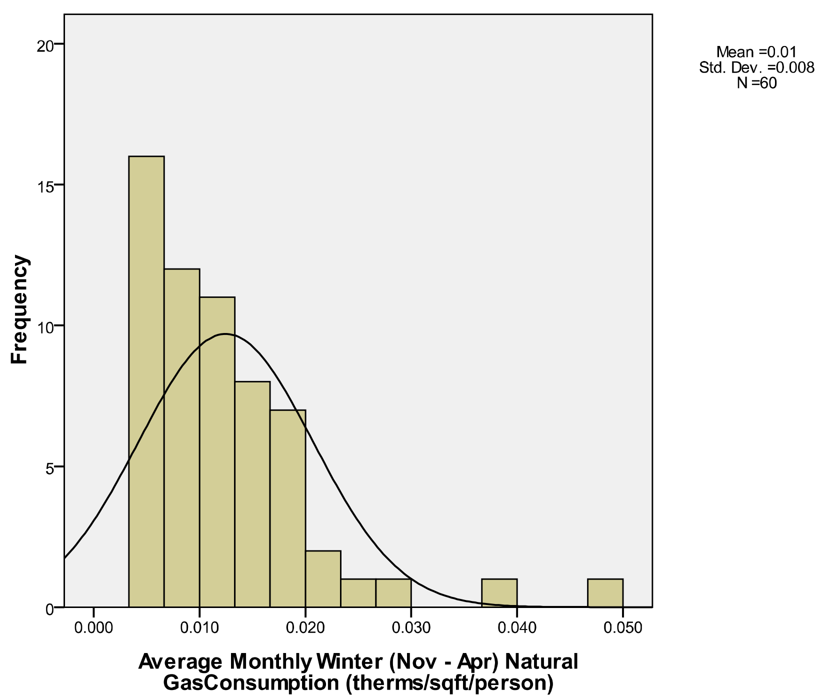


Figure 4.16: Histogram for the average monthly winter natural gas consumption (therms/ft^2/person)

Figure 4.16 shows that the average monthly summer natural gas consumption of homes followed a normal distribution curve with a mean of 0.01 therms/ft^2/person. It also shows that the distribution was right skewed.

4.5.3 Histograms for the Water Consumption per Square Foot

Figures 4.17. 4.18, and 4.19 show the histograms and normal distribution curves for the water consumption in gallons per square foot data.

Figure 4.17 shows that the annual water consumption of homes followed a normal distribution curve with a mean of 59.07 gal/ft^2. It also shows that the distribution was slightly right skewed.

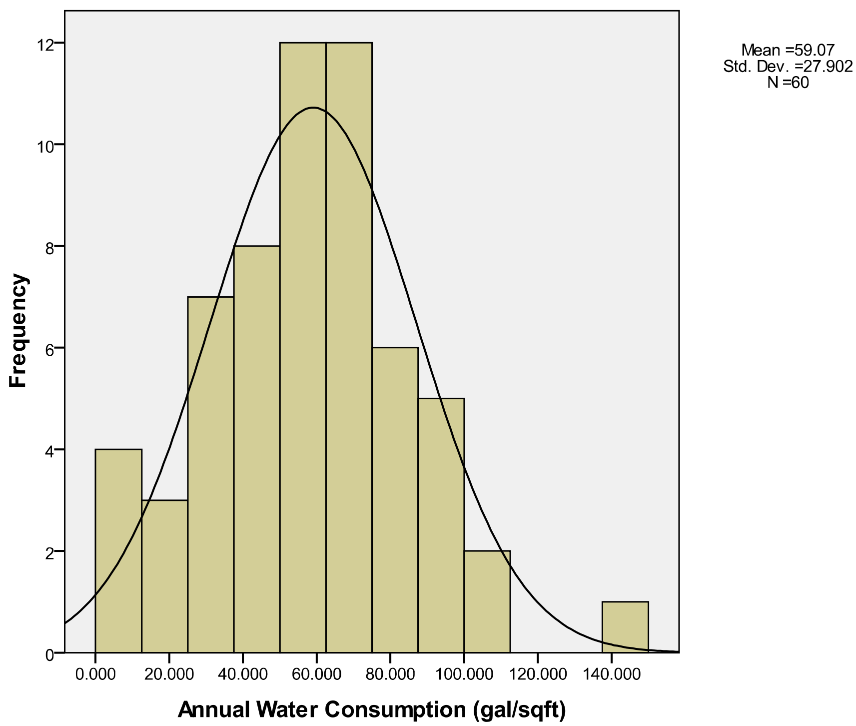


Figure 4.17: Histogram for the annual water consumption (gal/ft^2)

Figure 4.18 shows that the average monthly summer water consumption of homes followed a normal distribution curve with a mean of 5.78 gal/ft^2. It also shows that the distribution was slightly right skewed.

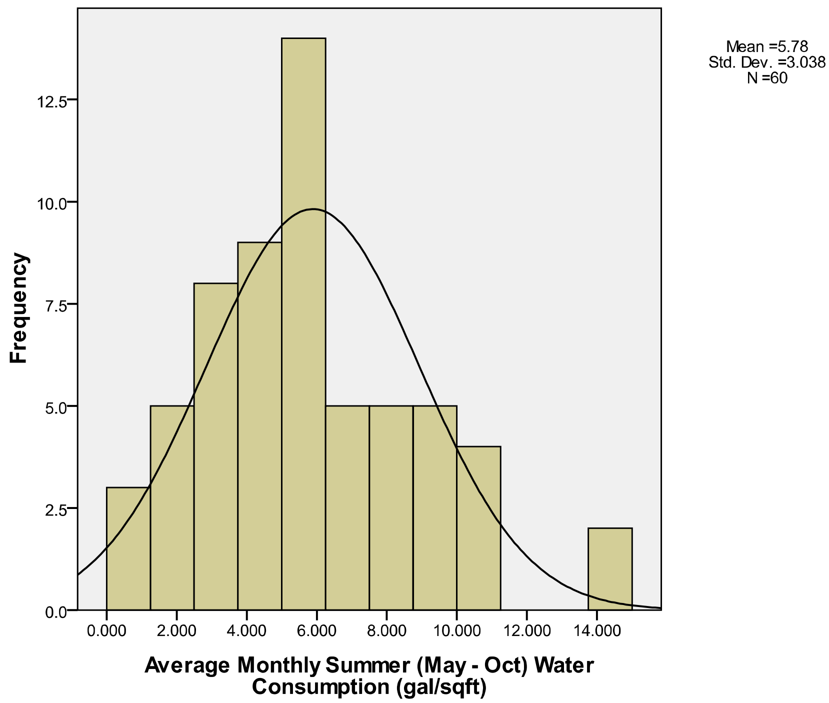


Figure 4.18: Histogram for the average monthly summer water consumption (gal/ft^2)

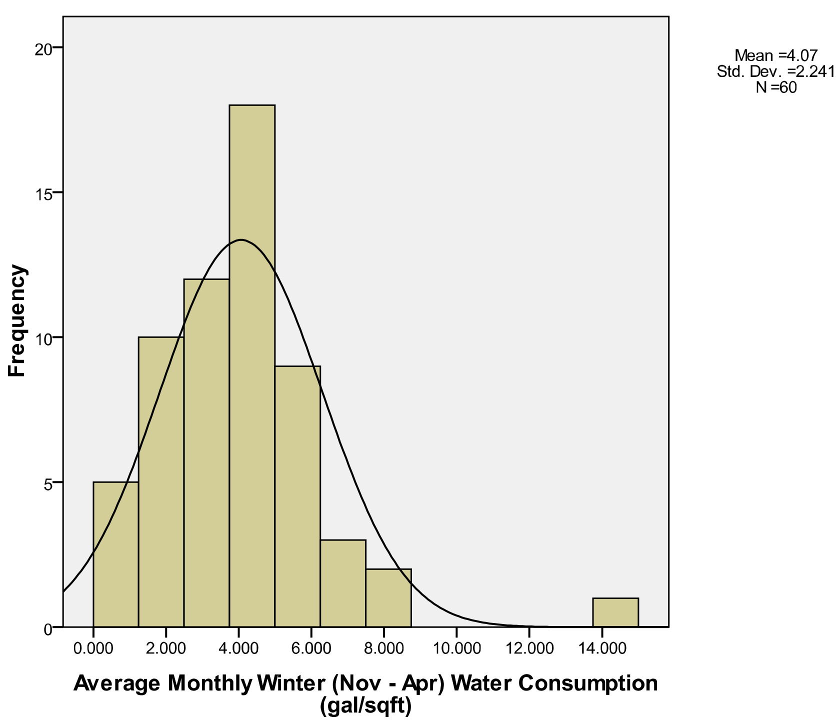


Figure 4.19: Histogram for the average monthly winter water consumption (gal/ft^2)

Figure 4.19 shows that the average monthly winter water consumption of homes followed a normal distribution curve with a mean of 4.07 gal/ft^2. It also shows that the distribution was right skewed.

Figures 4.20, 4.21 and 4.22 show histograms and normal distribution curves for the water consumption in gallons per square foot per person data for both the types of homes.

Figure 4.20 show that the annual water consumption of homes followed a normal distribution curve with a mean of 27.93 gal/ft^2/person. It also shows that the distribution was right skewed.

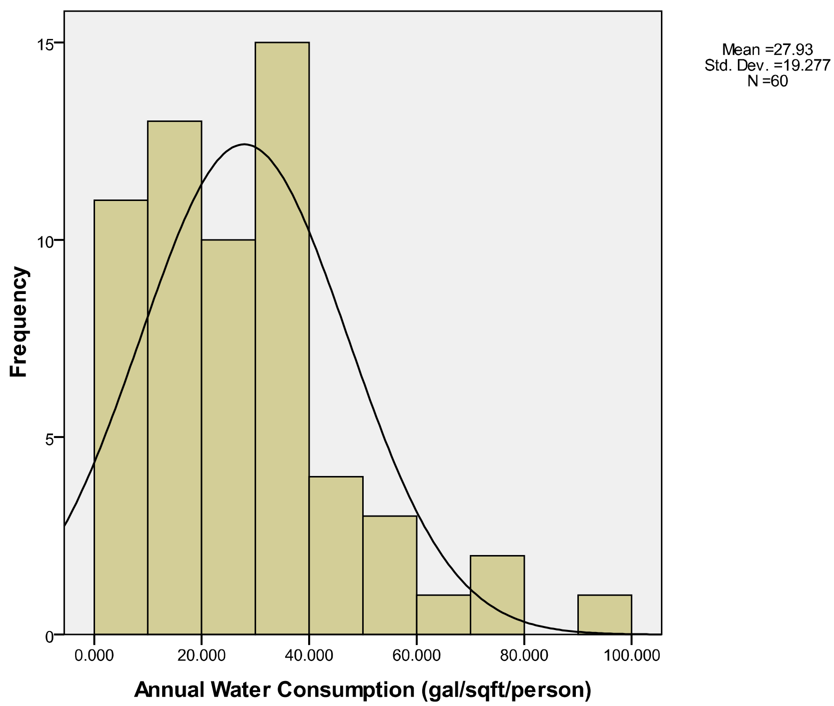


Figure 4.20: Histogram for the annual water consumption (gal/ft^2/person)

Figure 4.21 shows that the average monthly summer water consumption of homes followed a normal distribution curve with a mean of 2.74 gal/ft^2/person. It also shows that the distribution was right skewed.

Figure 4.22 shows that the average monthly winter water consumption of homes followed a normal distribution curve with a mean of 1.91 gal/ft^2/person. It also shows that the distribution was right skewed.

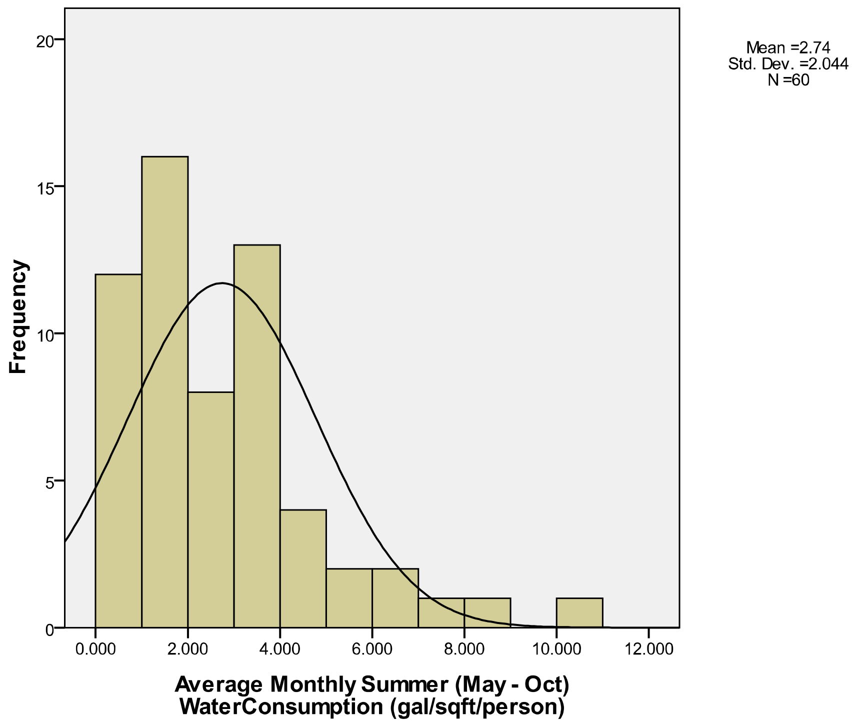


Figure 4.21: Histogram for the average monthly summer water consumption (gal/ft^2/person)

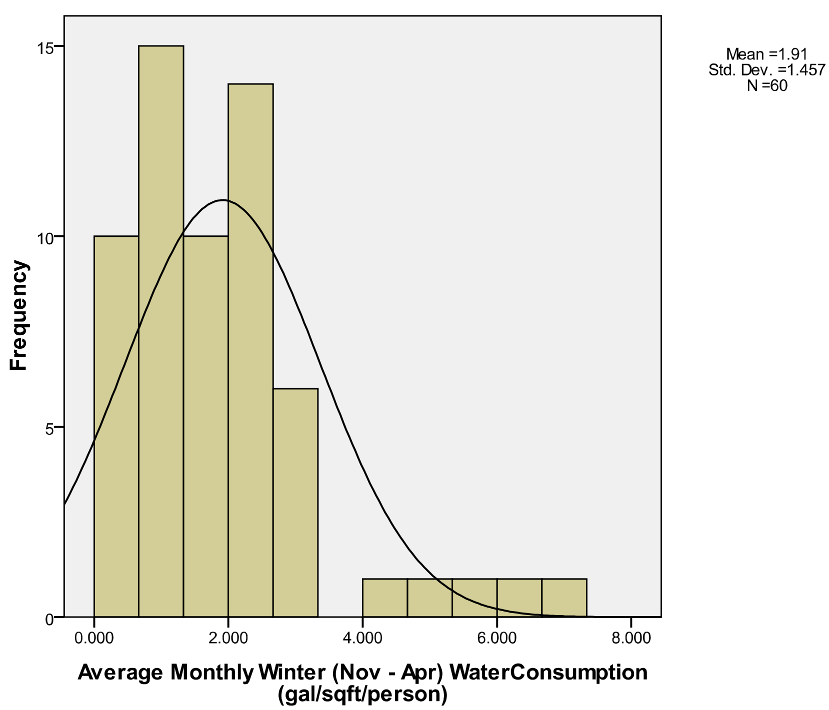


Figure 4.22: Histogram for the average monthly winter water consumption (gal/ft^2/person)

4.5.4 Test for Homogeneity of Variance

The third assumption, homogeneity of variance was verified by Levene's test. The null hypothesis for this test was that the variances of electricity consumption, natural gas consumption, and water consumption data were equal in non-Energy Star and Energy Star homes. If the significance value in the test is greater than level of significance (in this case, it is 0.05), then homogeneity of variance is proved. Table 4.4 shows the results for test for homogeneity of variance. All the values in the table are greater than the significance value of alpha that justifies the third assumption of equal variance.

Table 4.5: Test for Homogeneity of Variance

Metrics	Levene's Statistics	Significance
Electricity Consumption		
Summer	2.471	0.121
Winter	0.990	0.324
Annual	1.411	0.240
Natural Gas Consumption		
Summer	0.143	0.707
Winter	0.205	0.653
Annual	0.206	0.652
Water Consumption		
Summer	2.581	0.114
Winter	1.030	0.314
Annual	0.833	0.365

CHAPTER 5

FINDINGS OF THE STUDY

5.1 Analysis of Data

The energy consumption data for 60 homes was collected using a survey questionnaire, provided in Appendix A. The data consisted of 30 Energy Star homes and 30 non-Energy Star homes. The energy consumption data was normalized using the square foot area of the homes and occupancy. The assumptions of the statistical tests used in this study were checked and found valid. The detail of the validation of assumptions was presented in Chapter 4. This chapter focuses on the findings based on the descriptive statistics, the ANOVA and the Pearson correlation coefficient tests were used to draw the conclusions.

5.2 Limitations of the Study

This study has following limitations:

- A small sample size was used in this study. Data for sixty homes was gathered to conduct the statistical analysis of Energy Star and non-Energy Star homes.
- Energy consumption data was collected for one year cycle only.
- All the results were based upon the response received from homeowner in the form of survey (See Appendix A for survey questions). The validity of the responses received from the homeowner was not tested.
- This study does not include detail information of energy consumption of every appliance used in the home. For example, there were no questions regarding the fireplace, television, computer and there usages.

5.3 Descriptive Statistics

The result of descriptive statistics for monthly electricity consumption per square foot of Energy Star and non-Energy Star homes is shown in Table 5.1. The annual, summer, and winter electricity consumption was also calculated. The average summer electricity consumption was calculated by taking average of the electricity consumption between April to September and the average winter electricity consumption was calculated by taking average electricity consumption between October to March. Table 5.1 showed that the mean, median and standard deviation of the electricity consumption for the Energy Star homes were less than those of the non-Energy Star homes except for November and December. The annual electricity consumption was 81.71 and 54.92 kWh/ft^2 for non-Energy Star homes and Energy Star homes respectively. The annual mean, median and standard deviation values for non-Energy Star homes were found to be higher than that of Energy Star homes.

Table 5.1: Descriptive Statistics of the Electricity Consumption for Non-Energy Star and Energy Star Homes (kWh/ft^2)

Electricity Consumption	Non-Energy Star			Energy Star		
	Mean	Median	SD	Mean	Median	SD
January	0.293	0.284	0.132	0.251	0.237	0.122
February	0.294	0.264	0.153	0.263	0.249	0.146
March	0.276	0.269	0.109	0.271	0.241	0.158
April	0.300	0.269	0.118	0.264	0.266	0.099
May	0.358	0.314	0.137	0.326	0.302	0.130
June	0.552	0.535	0.235	0.461	0.422	0.191
July	0.743	0.698	0.458	0.526	0.498	0.197
August	0.648	0.589	0.232	0.574	0.541	0.208
September	0.573	0.560	0.238	0.502	0.495	0.212
October	0.417	0.347	0.216	0.362	0.330	0.165
November	0.303	0.267	0.149	0.317	0.278	0.165
December	0.293	0.256	0.131	0.301	0.281	0.128
Annual	5.049	4.703	1.725	4.419	4.082	1.597
Average monthly summer	0.549	0.493	0.199	0.459	0.444	0.158
Average monthly winter	0.293	0.289	0.110	0.278	0.263	0.126

Table 5.2 shows the descriptive statistics of the natural gas consumption per square foot for the Energy Star and non-Energy Star homes. Table 5.2 shows that some of the mean, median and standard deviation values of natural gas consumption for the Energy Star homes are almost the same as those of the non-Energy Star homes. The annual mean and standard deviation values of natural gas consumption for the non-Energy Star homes almost the same as those of the Energy Star homes. The annual mean, median and standard deviation values for non-Energy Star homes were found to be 0.246, 0.249, and 0.096 therms/ft^2 per person; and for Energy Star homes these values were 0.252, 0.226 and 0.102 therms/ft^2/person respectively.

Table 5.2: Descriptive Statistics of the Natural Gas Consumption for Non-Energy Star and Energy Star Homes (therms/ft^2)

Natural Gas Consumption	Non-Energy Star			Energy Star		
	Mean	Median	SD	Mean	Median	SD
January	0.039	0.033	0.019	0.036	0.029	0.018
February	0.032	0.028	0.014	0.032	0.027	0.017
March	0.023	0.023	0.012	0.023	0.018	0.016
April	0.016	0.013	0.010	0.017	0.013	0.012
May	0.016	0.013	0.010	0.015	0.013	0.009
June	0.015	0.014	0.009	0.016	0.013	0.008
July	0.015	0.014	0.009	0.014	0.012	0.008
August	0.013	0.012	0.009	0.013	0.011	0.008
September	0.013	0.010	0.009	0.015	0.012	0.009
October	0.014	0.011	0.009	0.017	0.015	0.010
November	0.016	0.012	0.010	0.022	0.021	0.012
December	0.034	0.029	0.019	0.031	0.029	0.016
Annual	0.246	0.249	0.096	0.252	0.226	0.102
Average monthly summer	0.014	0.013	0.008	0.015	0.012	0.007
Average monthly winter	0.027	0.026	0.011	0.027	0.024	0.012

Table 5.3: Descriptive Statistics of the Water Consumption for Non-Energy Star and Energy Star Homes (gal/ft^2)

Water Consumption	Non-Energy Star			Energy Star		
	Mean	Median	SD	Mean	Median	SD
January	4.603	4.182	3.521	3.129	2.729	1.940
February	3.980	3.091	4.111	3.214	2.916	1.871
March	4.075	3.440	3.195	3.296	3.067	1.951
April	4.417	4.160	3.150	3.372	3.650	1.877
May	5.664	5.137	3.470	3.909	3.869	2.085
June	6.900	6.133	4.500	4.818	4.332	2.757
July	7.337	6.284	4.916	4.871	4.934	2.663
August	7.270	6.809	4.139	5.319	4.839	3.050
September	6.778	6.196	4.053	5.829	5.252	3.886
October	5.360	5.044	2.809	5.284	5.020	2.857
November	5.245	4.623	3.836	4.518	3.750	2.775
December	4.442	4.265	2.744	4.505	3.802	2.966
Annual	66.072	68.259	30.041	52.063	52.635	24.082
Average monthly summer	6.552	6.290	3.367	5.005	4.834	2.492
Average monthly winter	4.460	4.284	2.576	3.672	3.792	1.807

Table 5.3 shows the descriptive statistics of water consumption per square foot for the Energy Star and non-Energy Star homes. Analysis of the data showed that the mean, median and standard deviation of water consumption per square foot for the Energy Star homes were less than those of non-Energy Star homes, except for October and December. The annual mean,

median and standard deviation values of water consumption per square foot for the non-Energy Star homes were found to be higher than that of Energy Star homes.

5.4 Analysis of Variance by Using Single Factor ANOVA

The ANOVA test was performed to determine whether the mean annual, summer and winter electricity consumption of the non-Energy Star homes were statistically different from that of the Energy Star homes.

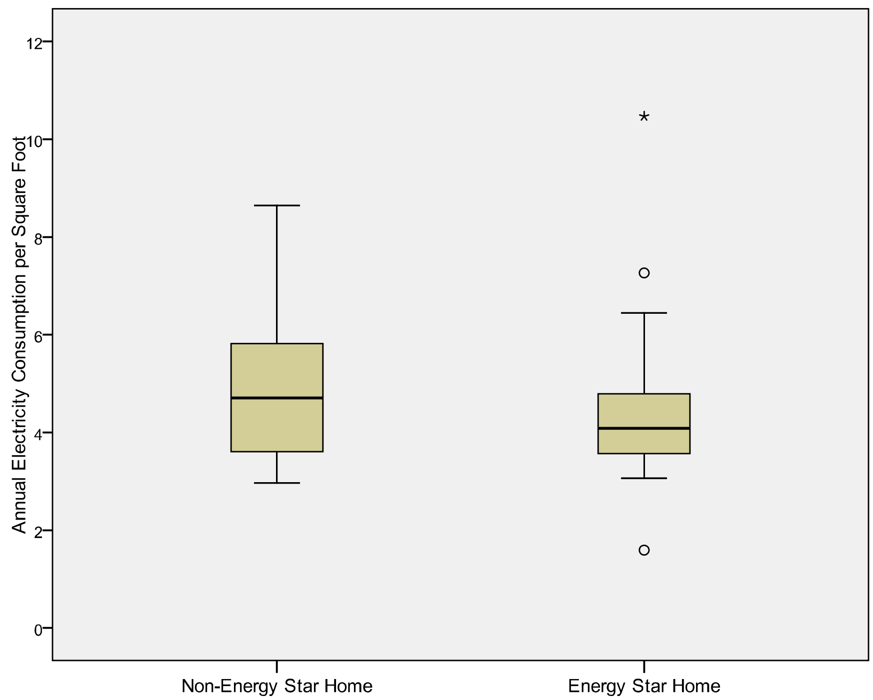


Figure 5.1: Box plot for the annual electricity consumption (kWh/ft^2)

Figure 5.1 shows the box plots for the annual electricity consumption per square foot of the non–Energy Star and Energy Star homes. It shows the variation of annual electricity consumption per square foot within each sample. The outlier's data point can be seen in this plot. In the non–Energy Star home sample, there was no outlier; however in the Energy Star home sample there were three outliers. "An outlier is characterized as being more than 1.5 times the inter quartile range above the third quartile or below the first quartile" (Weisstein 2009). The figure also shows that the annual electricity consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

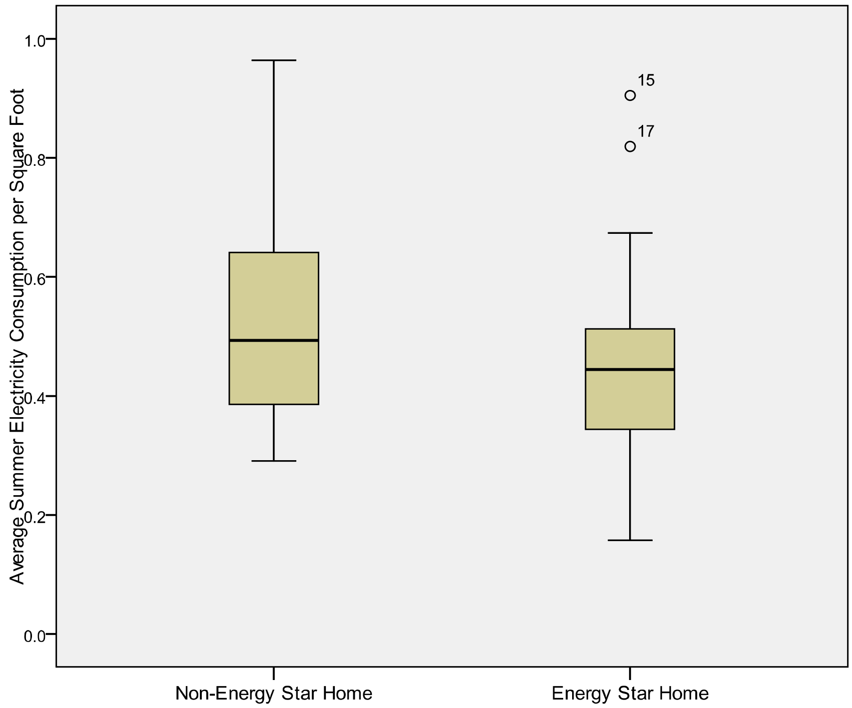


Figure 5.2: Box plot for the average monthly summer electricity consumption (kWh/ft^2)

Figure 5.2 shows box plot for the average monthly summer electricity consumption per square foot of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample, there was no outlier, whereas in the Energy Star home sample there were two outliers. The figure also shows that the average monthly summer electricity consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

Figure 5.3 shows box plots for the average monthly winter electricity consumption per square foot of the non–Energy Star and Energy Star homes. In non–Energy Star home sample there was no outlier, whereas in the Energy Star home sample there were two outliers. The figure also shows that the average monthly winter electricity consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

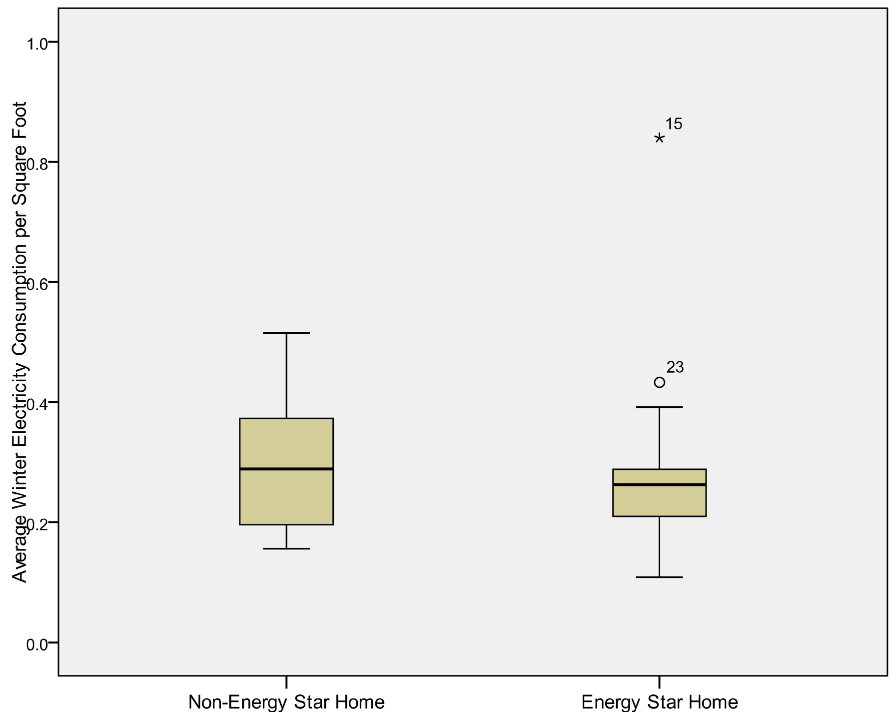


Figure 5.3: Box plot for the average monthly winter electricity consumption (kWh/ft^2)

Table 5.4 shows results of the ANOVA test for the electricity consumption per square foot of the non–Energy Star and Energy Star homes. The result showed that p-values for the annual and average monthly summer, winter electricity consumption per square foot were greater than the alpha level of 0.05.

Table 5.4: Single Factor ANOVA for the Electricity Consumption (kWh/ft^2)

Electricity Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	5.05	4.42	2.157	0.147	4.007
Average monthly summer	0.55	0.46	3.761	0.057	4.007
Average monthly winter	0.29	0.28	0.243	0.624	4.007

Figure 5.4 shows box plots for the annual natural gas consumption per square foot of non–Energy Star and Energy Star homes. In both non–Energy Star and Energy Star home samples there was no outlier. The figure also shows that the annual natural gas consumption per square foot of Energy Star homes was higher than that of the non-Energy Star homes.

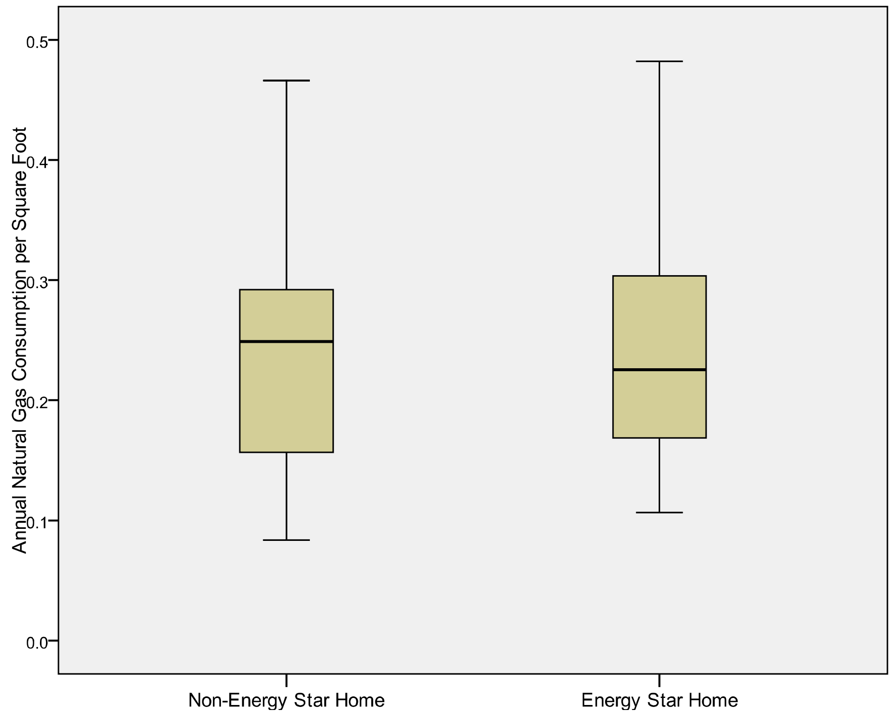


Figure 5.4: Box plot for the annual natural gas consumption (therms/ft^2)

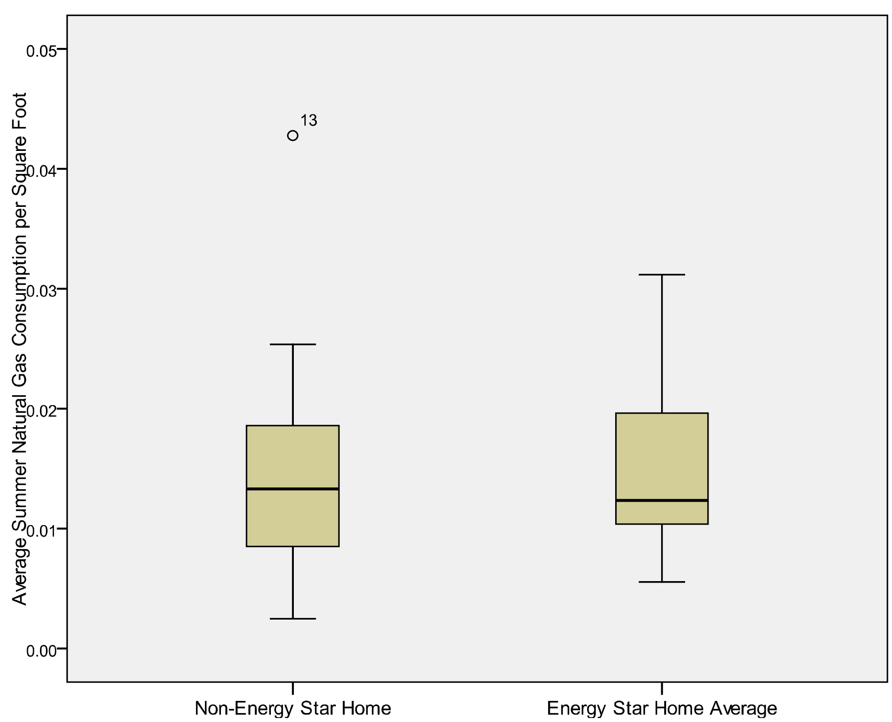


Figure 5.5: Box plot for the average monthly summer natural gas consumption (therms/ft^2)

Figure 5.5 shows box plots for the average monthly summer natural gas consumption per square foot of non–Energy Star and Energy Star homes. In the non–Energy, Star home sample there was one outlier; whereas in the Energy Star home sample there was no outlier. The figure also shows that the average monthly summer natural gas consumption per square foot of the Energy Star homes was higher than that of the non-Energy Star homes.

Figure 5.6 shows box plots for the average monthly winter natural gas consumption per square foot of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample there was no outlier; whereas in the Energy Star home sample there was one outlier. The figure also shows that the average monthly winter natural gas consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

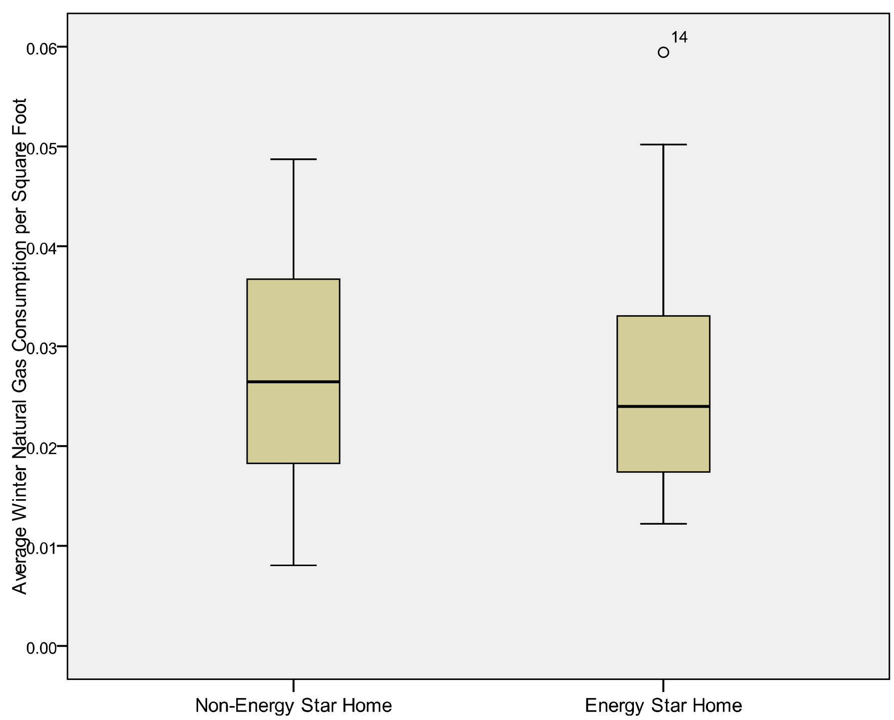


Figure 5.6: Box plot for the average monthly winter natural gas consumption (therms/ft^2)

Table 5.5 shows the result of the ANOVA test for the natural gas consumption per square foot of non–Energy Star and Energy Star homes. The result showed that p-values for the average monthly summer, winter and annual natural gas consumption per square foot were greater than the alpha level 0.05.

Table 5.5: Single Factor ANOVA for the Natural Gas Consumption (therms/ft^2)

Natural Gas Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	0.25	0.25	0.070	0.793	4.007
Average monthly summer	0.01	0.02	0.248	0.620	4.007
Average monthly winter	0.03	0.03	0.002	0.962	4.007

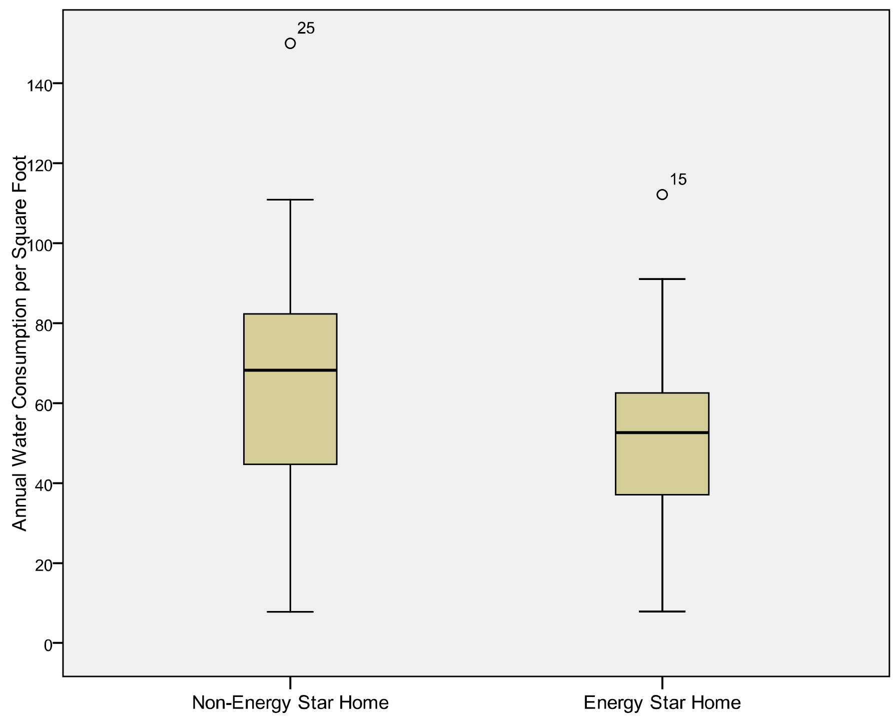


Figure 5.7: Box plot for the annual water consumption (gal/ft^2)

Figure 5.7 shows box plots for the annual water consumption per square foot of the non–Energy Star and Energy Star homes. It shows the variation of annual water consumption per square foot within each sample. In the non–Energy Star and Energy Star home samples, there were one outlier. The figure also shows that the annual water consumption per square foot of Energy Star homes was less than that of the non-Energy Star homes.

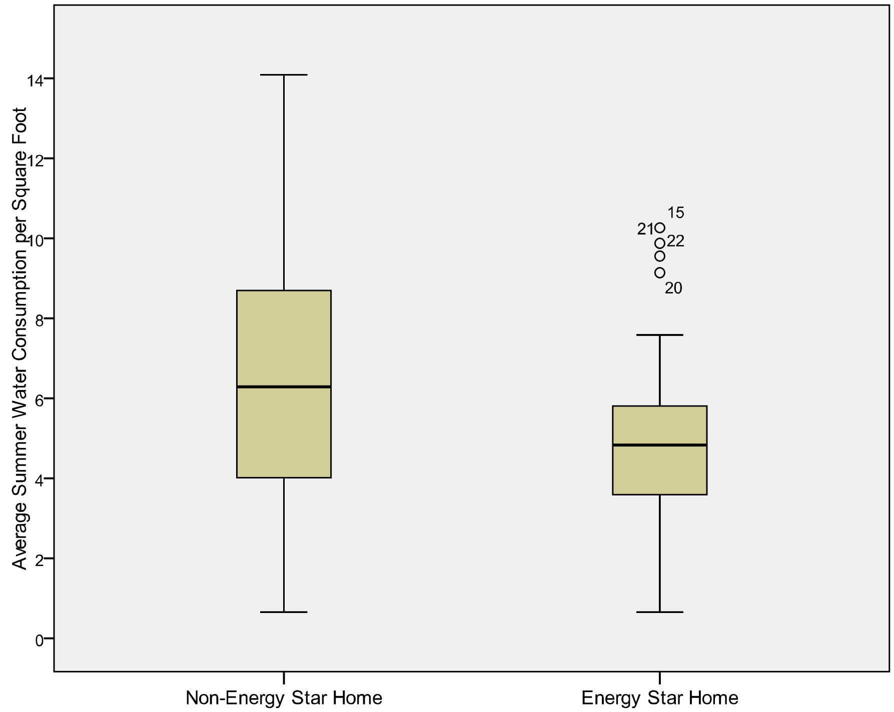


Figure 5.8: Box plot for the average monthly summer water consumption (gal/ft^2)

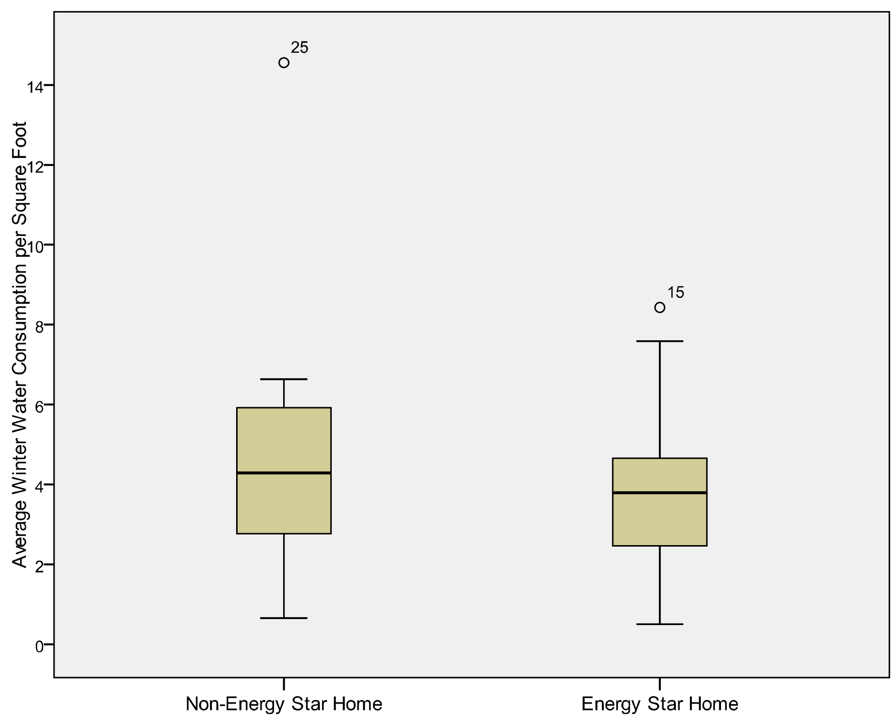


Figure 5.9: Box plot for the average monthly winter water consumption (gal/ft^2)

Figure 5.8 shows the box plots for the average monthly summer water consumption per square foot of the non–Energy Star and Energy Star homes. In the non-Energy Star home sample there was no outlier whereas in the Energy Star home sample there were four outliers. The figure also shows that the annual water consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

Figure 5.9 shows box plots for the average monthly winter water consumption per square foot of non–Energy Star and Energy Star homes. In both the non–Energy Star and Energy Star home samples, there was one outlier. The figure also shows that the annual water consumption per square foot of the Energy Star homes was less than that of the non-Energy Star homes.

Table 5.6 shows the result of the ANOVA test for water consumption per square foot of non–Energy Star and Energy Star homes. The result showed that p-values for the annual and average monthly winter water consumption per square foot were greater than the alpha level 0.05. The p-value for the average monthly summer water consumption per square foot was smaller than the alpha level 0.05.

Table 5.6: Single Factor ANOVA for the Water Consumption (gal/ft^2)

Water Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	66.07	52.06	3.971	0.051	4.007
Average monthly summer	6.55	5.01	4.090	0.048*	4.007
Average monthly winter	4.46	3.67	1.883	0.175	4.007

*Note: - * significant at alpha level 0.05*

The result of the ANOVA tests for the energy consumption per square foot did not validate the research hypothesis. Another ANOVA test was performed by using the energy consumption per square foot per person data.

Figure 5.10 shows box plots for the annual electricity consumption per square foot per person of the non–Energy Star and Energy Star homes. It shows the variation of annual electricity consumption per square foot within each sample. In both the non–Energy Star and Energy Star home samples, there were two outliers. The figure also shows that the annual electricity consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

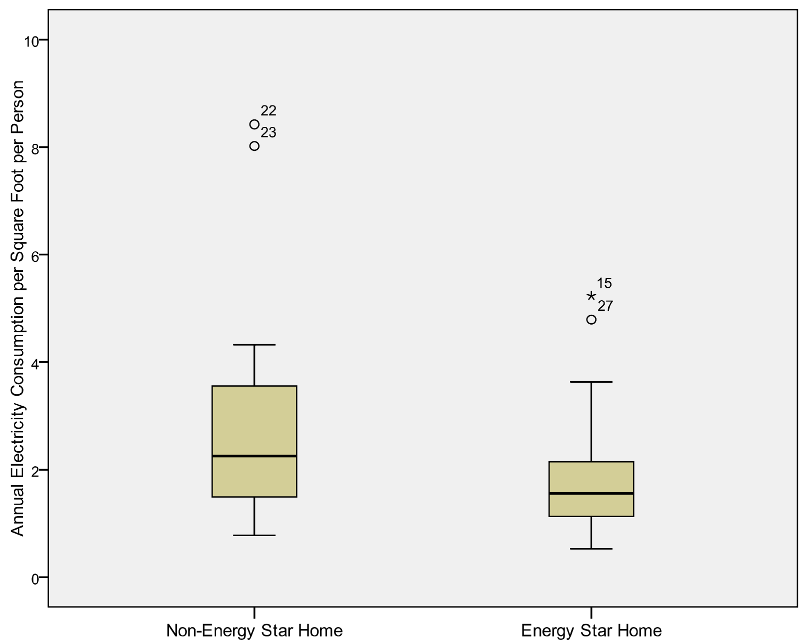


Figure 5.10: Box plot for the annual electricity consumption (kWh/ft^2/person)

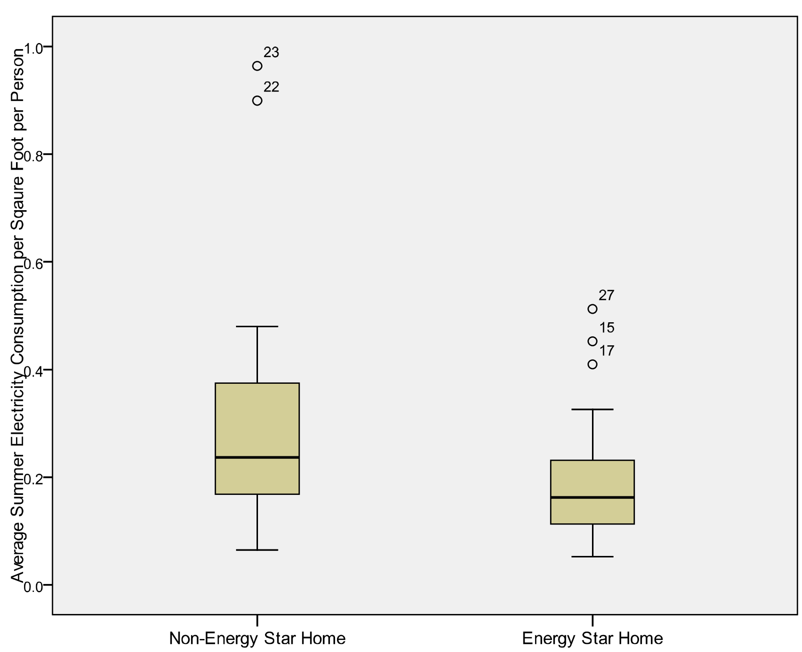


Figure 5.11: Box plot for the average monthly summer electricity consumption (kWh/ft^2/person)

Figure 5.11 shows box plots for the average monthly summer electricity consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample, there were two outliers and in the Energy Star home sample, there were three outliers. The figure also shows that the average monthly summer electricity consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

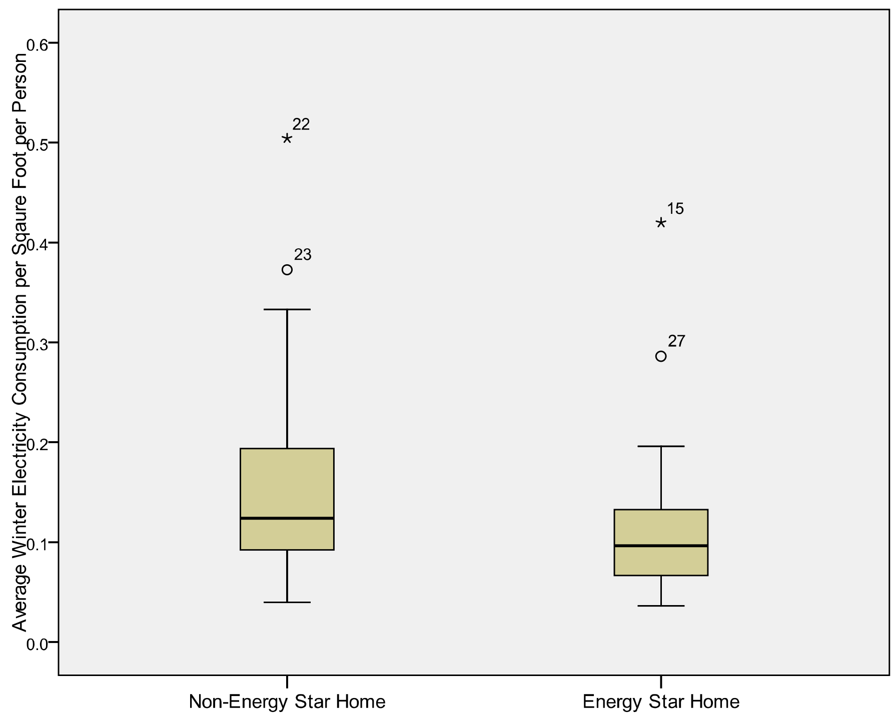


Figure 5.12: Box plot for the average monthly winter electricity consumption (kWh/ft^2/person)

Figure 5.12 shows box plots for the average monthly winter electricity consumption per square foot per person of the non–Energy Star and Energy Star homes. In both the non–Energy Star and Energy Star home samples, there were two outliers. The figure also shows that the average monthly winter electricity consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

Table 5.7 shows the result of the ANOVA test for the electricity consumption of non–Energy Star and Energy Star homes. The results showed that p-values for the annual and average monthly summer electricity consumption were smaller than the alpha level 0.05. However, the p-value for the average monthly winter electricity consumption was greater than the alpha level 0.05.

Table 5.7: Single Factor ANOVA for the Electricity Consumption (kWh/ft^2/person)

Electricity Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	2.72	1.83	5.333	0.025*	4.007
Average monthly summer	0.30	0.19	6.281	0.015*	4.007
Average monthly winter	0.16	0.12	3.093	0.084	4.007

*Note: * significant at alpha level0 .05*

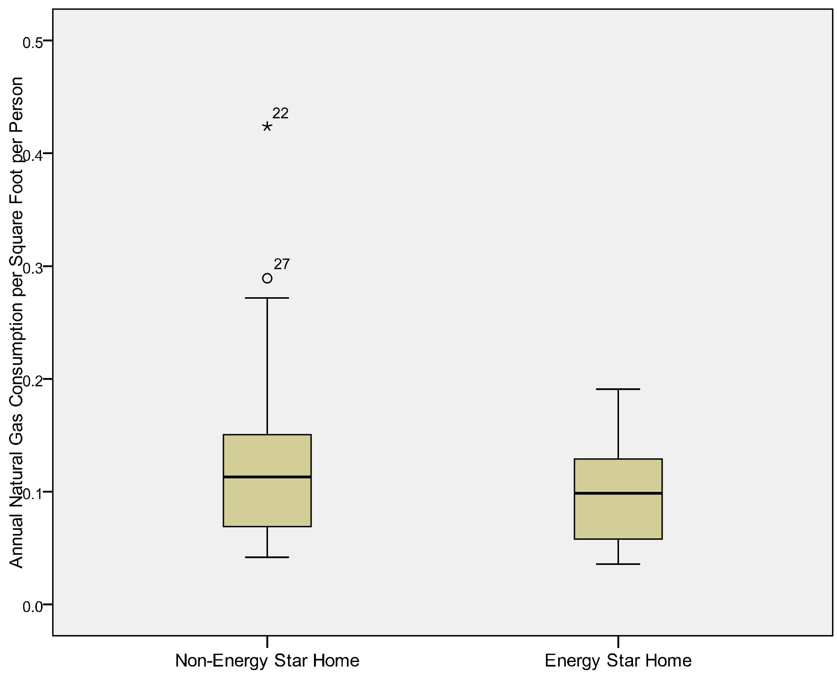


Figure 5.13: Box plot for the annual natural gas consumption (therms/ft^2/person)

Figure 5.13 shows box plots for the annual natural gas consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample there were two outliers; whereas in the Energy Star home sample there was no outlier. The figure also shows that the annual natural gas consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

Figure 5.14 shows the box plots for the average monthly summer natural gas consumption per square foot per person of the non–Energy Star and Energy Star homes. In both the non–Energy Star and Energy home samples, there were two outliers. The figure also shows that the average monthly summer natural gas consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

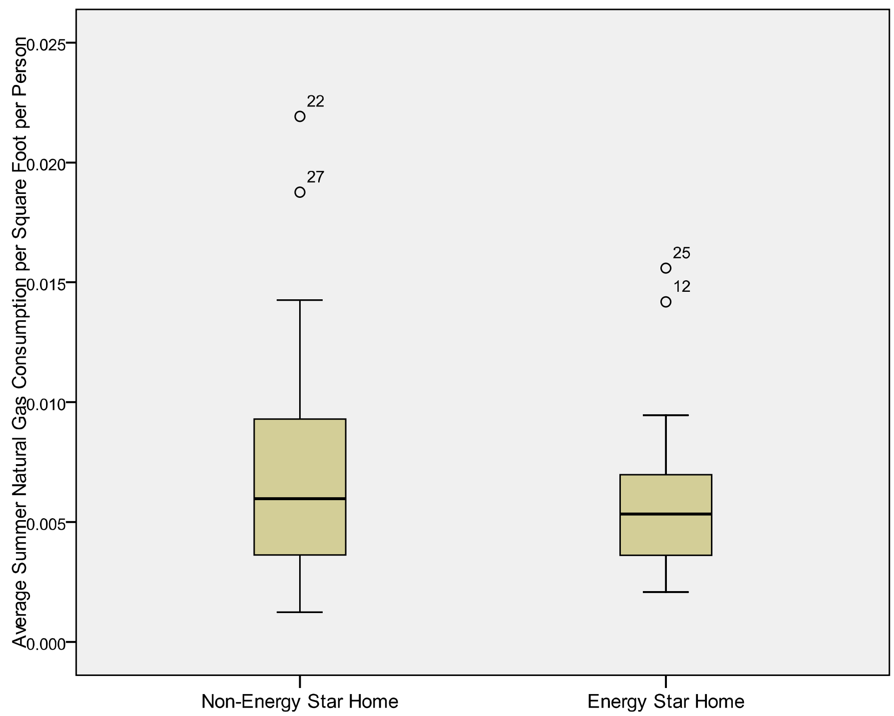


Figure 5.14: Box plot for the average monthly summer natural gas consumption ($therms/ft^2/person$)

Figure 5.15 shows box plots for the average monthly winter natural gas consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample, there were two outliers; whereas in the Energy Star home sample there was no outlier. The figure also shows that the average monthly winter natural gas consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

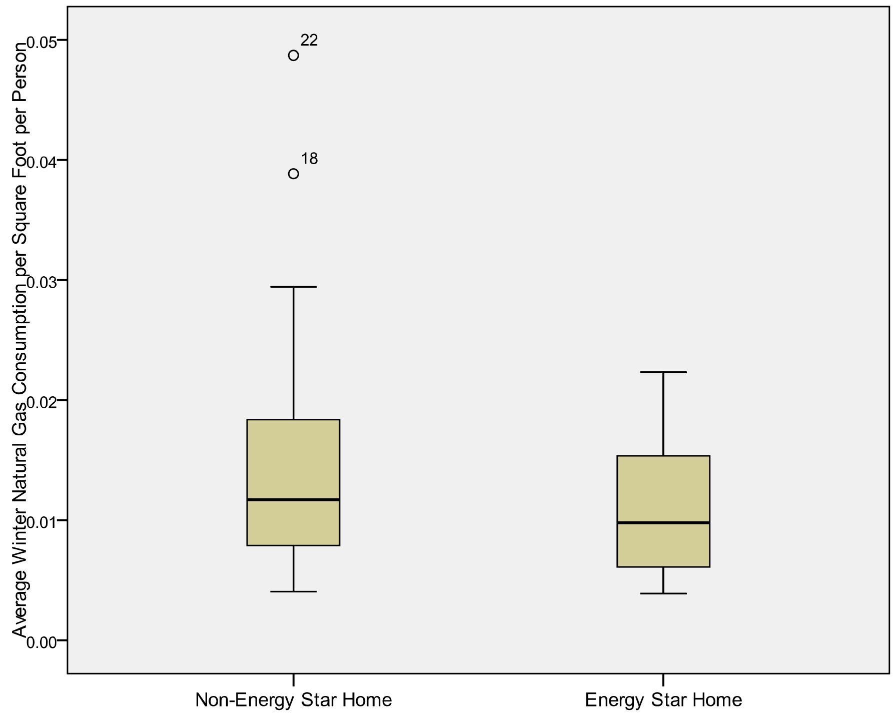


Figure 5.15: Box plot for the average monthly winter natural gas consumption (therms/ft^2/person)

Table 5.8 shows the result of the ANOVA test for the natural gas consumption per square foot per person of non–Energy Star and Energy Star homes. The result showed that p-values for the average monthly summer, winter and annual natural gas consumption were greater than the alpha level 0.05.

Table 5.8: Single Factor ANOVA for the Natural Gas Consumption (therms/ft^2/person)

Natural Gas Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	0.011	0.008	2.824	0.098	4.007
Average monthly summer	0.007	0.005	1.372	0.254	4.007
Average monthly winter	0.014	0.010	3.106	0.083	4.007

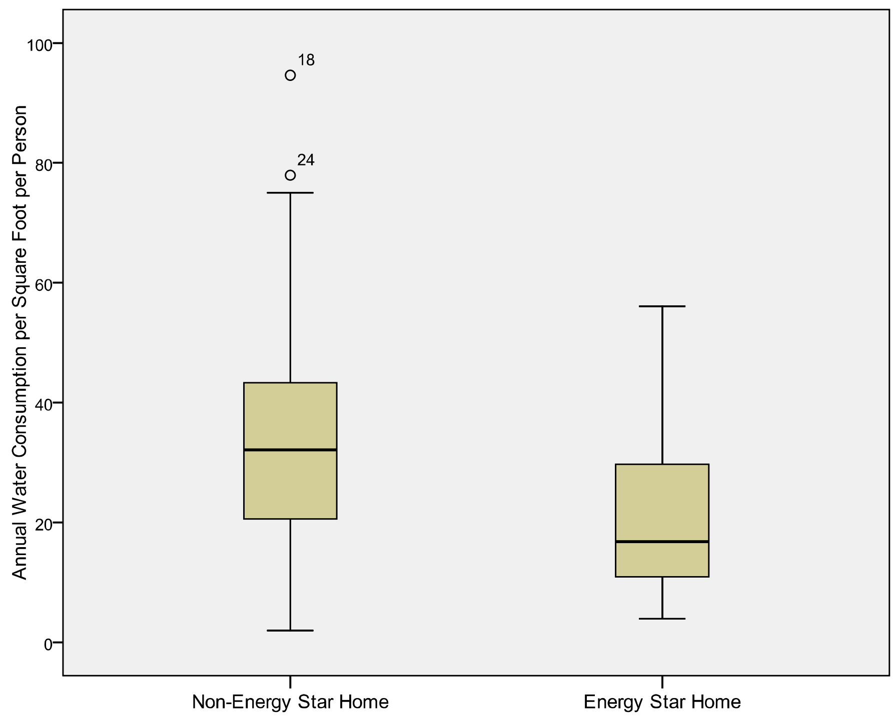


Figure 5.16: Box plot for the annual water consumption (gal/ft^2/person)

Figure 5.16 shows box plots for the annual water consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample, there were two outliers, whereas in the Energy Star home sample there was no outlier. The figure also shows that the annual water consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

Figure 5.17 shows box plots for the average monthly summer water consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample, there were two outliers, whereas in the Energy Star home sample there was no outlier. The figure also shows that the average monthly summer water consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

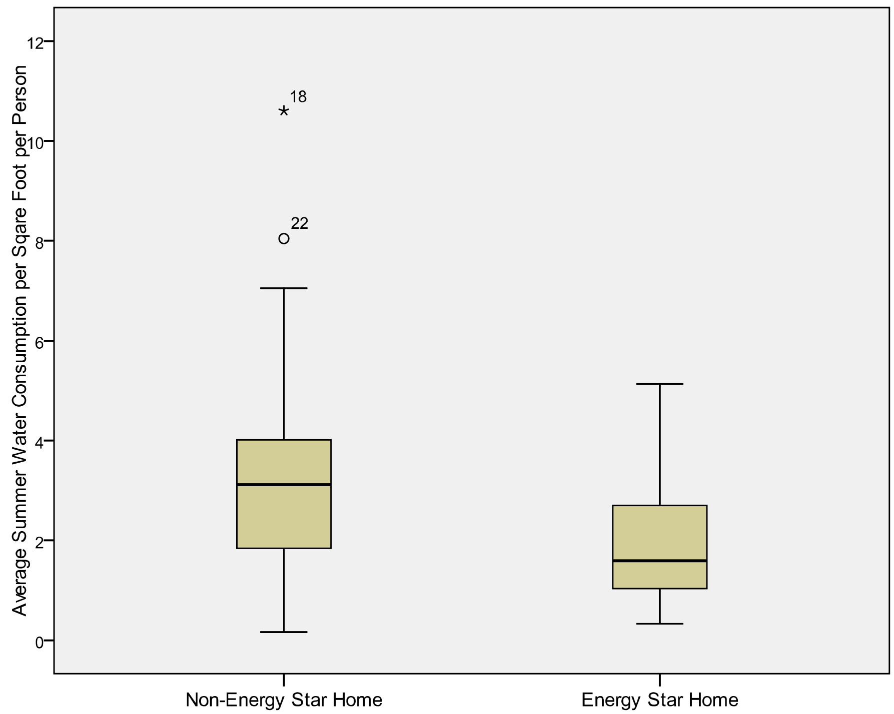


Figure 5.17: Box plot for the average monthly summer water consumption (gal/ft^2/person)

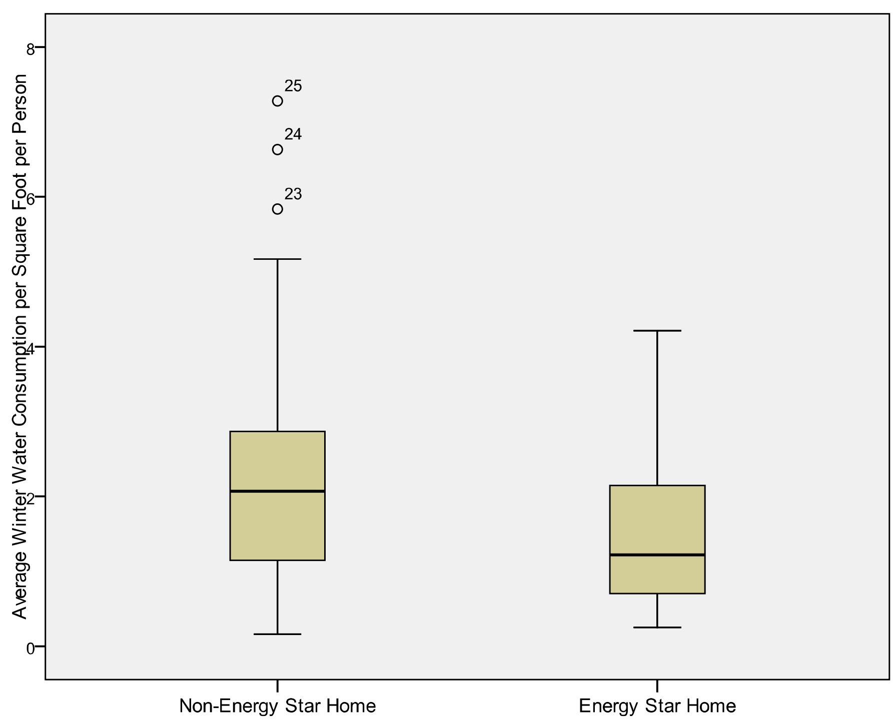


Figure 5.18: Box plot for the average monthly winter water consumption (gal/ft^2/person)

Figure 5.18 shows box plots for the average monthly winter water consumption per square foot per person of the non–Energy Star and Energy Star homes. In the non–Energy Star home sample there were three outliers; whereas in the Energy Star home sample there was no outlier. The figure also shows that the average monthly winter water consumption per square foot per person of the Energy Star homes was less than that of the non-Energy Star homes.

Table 5.9 shows the result of the ANOVA test for the water consumption per square foot per person of non–Energy Star and Energy Star homes. The result showed that p-values for the average monthly summer, winter and annual water consumption were smaller than the alpha level.

Table 5.9: Single Factor ANOVA for the Water Consumption (gal/ft^2/person)

Water Consumption	Mean		F-Value	p-value	F-Critical
	NES	ES			
Annual	35.36	20.49	10.339	0.002*	4.007
Average monthly summer	3.50	1.98	9.501	0.003*	4.007
Average monthly winter	2.32	1.43	7.146	0.010*	4.007

*Note: - * significant at alpha level 0.05*

5.5 The Pearson Correlation Coefficients

The independent variables collected for this analysis were mainly nominal or ordinal scale. Therefore, codes were used to convert the data in order to conduct correlation tests. The Pearson correlation coefficient was conducted between the age of appliances, frequency of use of the appliance, whether the appliance was an Energy Star product and the energy consumption of the homes. The results of these tests are explained below.

5.5.1. Correlation between the Electricity Consumption and Appliance

While conducting the Pearson correlation coefficient test for the electricity consumption of the homes air conditioning system, ceiling fans, clothes washer, refrigerator, microwave oven and dishwasher were considered.

Table 5.10 shows result of the correlation analysis between the electricity consumption per square foot and age of air conditioning system, frequency of use of the air conditioning system, room temperature setting during summer months and whether the air conditioning system was an Energy Star product.

Table 5.10: Correlation between the Electricity Consumption (kWh/ft^2) and Air Conditioning System (N=60)

Electricity Consumption	Characteristics of Air Conditioning System			
	Age of Appliance	Frequency of use	Energy Star Product	Temperature
Annual	0.190	0.350**	0.208	-0.141
Average monthly summer	0.179	0.401**	0.174	-0.128
Average monthly winter	0.171	0.206	-0.223*	-0.134

*Note: * significant at alpha level 0.05; ** significant at alpha level 0.01*

Electricity consumption per square foot had a weak correlation with the age of air conditioning system. The correlations were not statistically significant at alpha level 0.05. As the frequency of use of the air conditioning system increased, the electricity consumption of homes also increased. The Pearson correlation coefficients for the annual, summer and winter electricity consumption per square foot were found to be 0.350, 0.401 and 0.206 respectively. The correlation coefficients for annual and summer electricity consumption per square foot were statistically significant at alpha level 0.05. However, the coefficient for winter electricity consumption per square foot was not statistically significant at alpha level 0.05

The homes with the Energy Star air conditioning system had lower electricity consumption in summer than homes with a non–Energy Star air conditioning system. The Pearson correlation coefficients for the annual, summer, and winter electricity consumption were found to be 0.208, 0.174, and -0.223 respectively. Thus, there was a weak correlation between the electricity consumption and type of the air conditioning system. The correlation coefficient for winter electricity consumption per square foot was statistically significant at alpha level 0.05.

The correlation test showed that the temperature setting in the home during summer had a negative correlation with the electricity consumption per square foot. These correlations were weak and were not statistically significant at alpha level 0.05.

Table 5.11 shows results of the correlation analysis between the electricity consumption per square foot and number of ceiling fans in the home, frequency of use of ceiling fans and whether ceiling fans were Energy Star products.

Table 5.11: Correlation between the Electricity Consumption (kWh/ft^2) and Ceiling Fans (N=60)

Electricity Consumption	Characteristics of Ceiling Fan		
	No. of Fans	Frequency of use	Energy Star Product
Annual	-0.149	-0.232	0.036
Average monthly summer	-0.086	-0.124	0.009
Average monthly winter	-0.209	-0.340*	0.066

*Note: * significant at alpha level 0.05*

Electricity consumption per square foot had a negative correlation with number of ceiling fans. That means, as number of ceiling fans in home increased electricity consumption of the home decreased. The correlations were weak and were not statistically significant at alpha level 0.05.

The test results showed that as the frequency of use of the ceiling fans increased, the electricity consumption of the home decreased. The Pearson correlation coefficients for the annual, summer and winter electricity consumption per square foot were found to be -0.232, -0.124, and -0.340 respectively. The correlation coefficient for winter electricity consumption per square foot was statistically significant at alpha level 0.05.

The test result showed that homes with Energy Star ceiling fans had lower electricity consumption than homes with a non–Energy Star ceiling fans. There was a weak correlation between the electricity consumption and the type of the ceiling fans.

Table 5.12 shows results of the correlation analysis between electricity consumption per square foot and the age of clothes washer, frequency of use of the clothes washer, and whether the clothes washer was an Energy Star product.

Electricity consumption per square foot had a weak correlation with characteristics of clothes washers. The correlations were not statistically significant at alpha level 0.05.

Table 5.12: Correlation between the Electricity Consumption (kWh/ft^2) and Clothes Washer (N=60)

Electricity Consumption	Characteristics of Clothes Washer		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.169	0.124	0.053
Average monthly summer	0.138	0.148	0.010
Average monthly winter	0.185	0.063	0.110

Table 5.13 shows results of the correlation analysis between the electricity consumption per square foot and the age of refrigerator and whether the refrigerator was an Energy Star product.

Table 5.13: Correlation between the Electricity Consumption (kWh/ft^2) and Refrigerator (N=60)

Electricity Consumption	Characteristics of Refrigerator	
	Age of Appliance	Energy Star Product
Annual	0.154	0.076
Average monthly summer	0.087	0.042
Average monthly winter	0.230*	0.115

*Note: * significant at alpha level 0.05*

The test results indicated that the electricity consumption per square foot had a weak correlation with the age of refrigerator. The Pearson correlation coefficients were found to be 0.154, 0.087, and 0.230 for annual, summer, and winter electricity consumption per square foot respectively. The correlation coefficient for winter electricity consumption per square foot was statistically significant at alpha level 0.05. However, the coefficient for annual and summer electricity consumption per square foot was not statistically significant at alpha level 0.05

The homes with Energy Star refrigerator had lower electricity consumption than homes with non-Energy Star refrigerator. The correlations were weak and were not statistically significant at alpha level 0.05.

Table 5.14 shows results of the correlation analysis between the electricity consumption per square foot and the age of microwave oven, frequency of use of the microwave oven, and whether microwave oven was an Energy Star product.

Table 5.14: Correlation between the Electricity Consumption (kWh/ft^2) and Microwave Oven (N=60)

Electricity Consumption	Characteristics of Microwave Oven		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.217*	-0.062	0.114
Average monthly summer	0.176	-0.016	0.086
Average monthly winter	0.242*	-0.121	0.136

*Note: * significant at alpha level 0.05*

Electricity consumption per square foot had a weak correlation with the age of microwave oven. The Pearson correlation coefficients were found to be 0.217, 0.176, and 0.242 for annual, summer, and winter electricity consumption per square foot respectively. The correlation coefficients for annual and winter electricity consumption per square foot were statistically significant at alpha level 0.05. However, the coefficient for summer electricity consumption per square foot was not statistically significant at alpha level 0.05.

The test results showed that as the frequency of use of microwave oven increased the electricity consumption decreased. Thus, there was negative correlation between the frequency of use of microwave and the electricity consumption. The correlations were weak and were not statistically significant at alpha level 0.05.

The homes with Energy Star microwave oven had lower electricity consumption than homes with non-Energy Star microwave oven. There was a weak correlation between the electricity consumption and type of microwave oven. In addition, correlations were not statistically significant at alpha level 0.05.

Table 5.15 shows results of the correlation analysis between the electricity consumption per square foot and the age of dishwasher, frequency of use of dishwasher, and whether the dishwasher was an Energy Star product. The test results indicated that the electricity consumption per square foot had a weak correlation with the age of dishwasher. The correlations were not statistically significant at alpha level 0.05.

Table 5.15: Correlation between the Electricity Consumption (kWh/ft^2) and Dishwasher (N=60)

Electricity Consumption	Characteristics of Dishwasher		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.169	-0.124	0.053
Average monthly summer	0.138	-0.148	0.010
Average monthly winter	0.185	-0.063	0.110

Electricity consumption per square foot has negative correlation with the frequency of use of dishwasher. That means, as frequency of use of dishwasher increased electricity consumption of homes decreased. However, these correlations were weak and were not statistically significant at alpha level 0.05.

The test results also showed that homes with Energy Star dishwasher had lower electricity consumption than homes with a non-Energy Star dishwasher. These correlations were weak and were not statistically significant at alpha level 0.05.

5.5.2 Correlation between the Natural Gas Consumption and Appliance

While conducting the Pearson correlation coefficient test for the natural gas consumption of the homes the space heating system, water heater, stove, oven, and clothes dryer were considered.

Table 5.16 shows results of the correlation analysis between the natural gas consumption per square foot and age of space heating system, frequency of use of the system, whether the system was Energy Star appliance and temperature setting during winter months.

Table 5.16: Correlation between the Natural Gas Consumption (therms/ft^2) and Space Heating System (N= 50)

Natural Gas Consumption	Characteristics of Space Heating System			
	Age of Appliance	Frequency of use	Energy Star Product	Temperature
Annual	0.023	0.129	0.082	0.359**
Average monthly summer	-0.168	-0.122	0.058	0.221
Average monthly winter	0.145	-0.108	0.082	0.380**

*Note: ** significant at alpha level 0.01*

Natural gas consumption per square foot had a weak correlation with age of the space heating system. As age of the system increased, the annual and winter natural gas consumption per square foot also increased. It is obvious that there will not be any correlation between summer natural gas consumption and characteristics of space heating system because, space heating system will not be in operation during summer. The Pearson correlation coefficients were found to be 0.023, -0.168 and 0.145 for annual, summer, and winter natural gas consumption per square foot respectively. The correlations were not statistically significant at alpha level 0.05.

The test results showed that the frequency of use of the space heating system had a negative correlation with summer and winter natural gas consumption per square foot. However, frequency of use of the system had positive correlation with annual natural gas consumption per square foot. The Pearson correlation coefficients for the annual, summer and winter electricity consumption per square foot were found to be 0.129, -0.122 and -0.108 respectively. Thus, correlations were weak and were not statistically significant at alpha level 0.05.

The homes with the Energy Star space heating system had lower natural gas consumption than the homes with a non-Energy Star space heating system. There was a weak correlation between the natural gas consumption and type of the space heating system. These correlations were not statically significant at alpha level 0.05.

The correlation test showed that the temperature setting in the home during winter had a medium correlation with the annual and winter natural gas consumption per square foot. The Pearson correlation coefficients for the annual, summer, and winter natural gas consumption were found to be 0.359, 0.221, and 0.380 respectively. The correlation coefficient for the annual and winter natural gas consumption were statistically significant at alpha level 0.01. However, the correlation coefficient for natural gas consumption in summer was not statistically significant at alpha level 0.05.

Table 5.17 shows results of the correlation analysis between the natural gas consumption per square foot and age of the water heater. The test results indicated that the natural gas consumption per square foot had a weak correlation with the age of the water heater. As the age of water heater increased, the annual and summer natural gas consumption per square foot decreased. However, as the age of water heater increased, the winter natural gas consumption per square foot also increased. The Pearson correlation coefficients were found to be -0.003, -0.040 and 0.023 for annual, summer, and winter electricity consumption per square foot respectively. The correlations were not statistically significant at alpha level 0.05.

Table 5.17: Correlation between the Natural Gas Consumption (therms/ft^2) and Water Heater (N=60)

Natural Gas Consumption	Age of Appliance
Annual	-0.003
Average monthly summer	-0.040
Average monthly winter	0.023

Table 5.18 shows results of correlation analysis between the natural gas consumption per square foot and the age of stove, frequency of use of the stove, and whether the stove was an Energy Star appliance.

Table 5.18: Correlation between the Natural Gas Consumption (therms/ft^2) and Stove (N=53)

Natural Gas Consumption	Characteristics of Stove		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.065	-0.387**	0.013
Average monthly summer	0.050	-0.327**	0.029
Average monthly winter	0.126	-0.347**	0.001

*Note: ** significant at alpha level 0.01*

Natural gas consumption per square foot had a weak correlation with the age of stove. The correlations were not statistically significant at alpha level 0.05. The test results showed that the frequency of use of stove had a negative correlation with the natural gas consumption. That means, as the frequency of use of stove increased, the natural gas consumption decreased. The Pearson correlation coefficients for the annual, summer and winter natural gas consumption per square foot were found to be -0.387, -0.327 and -0.347 respectively. The correlation coefficients were statistically significant at alpha level 0.01. The negative correlation shows that there were factors other than frequency of use of stove that affects the natural gas consumption of the homes.

The homes with an Energy Star stove had lower natural gas consumption than the homes with a non-Energy Star stove. The correlations were weak and were not statistically significant at alpha level 0.05.

Table 5.19 shows results of the correlation analysis between the natural gas consumption per square foot and the age of oven, frequency of use of the oven, and whether the oven was an Energy Star product.

Table 5.19: Correlation between the Natural Gas Consumption (therms/ft^2) and Oven (N=44)

Natural Gas Consumption	Characteristics of Oven		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.013	0.054	0.051
Average monthly summer	-0.076	-0.019	0.046
Average monthly winter	0.078	0.096	0.044

Natural gas consumption per square foot had a weak correlation with the age of oven. As the age of oven increased the annual and winter natural gas consumption per square foot increased. However, as the age of oven increased, the natural gas consumption decreased in summer. The Pearson correlation coefficients were found to be 0.013, -0.076, and 0.078 for annual, summer, and winter natural gas consumption per square foot respectively. The correlations were not statistically significant at alpha level 0.05.

The test results showed that as the frequency of use of the oven increased, the annual and winter natural gas consumption of the also increased. However, the natural gas consumption in summer decreased with an increased in frequency of use of the oven. The reason might be homeowners were cooking outside or avoiding the use of oven due to heat during summer. The Pearson correlation coefficients for the annual, summer and winter electricity consumption per square foot were found to be 0.054, -0.019 and 0.096 respectively. The correlation coefficients were statistically significant at alpha level 0.01.

The homes with the Energy Star ovens had lower natural gas consumption than the homes with the non-Energy Star ovens. The correlations were weak and were not statistically significant at alpha level 0.05.

Table 5.20 shows results of the correlation analysis between the natural gas consumption per square foot and the age of clothes dryer, frequency of use of the clothes dryer, and whether the clothes dryer was an Energy Star product.

Table 5.20: Correlation between the Natural Gas Consumption (therms/ft^2) and Clothes Dryer (N=48)

Natural Gas Consumption	Characteristics of Clothes Dryer		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.075	-0.115	0.036
Average monthly summer	-0.129	-0.017	0.025
Average monthly winter	0.181	-0.154	0.037

Natural gas consumption per square foot had a weak correlation with the age of clothes dryer. As the age of clothes dryer increased, the annual and winter natural gas consumption per square foot also increased. However, as the age of clothes dryer increased, the natural gas consumption decreased in summer. The negative correlation shows that there were factors other than age of clothes dryer that affects the natural gas consumption of the homes in summer. The Pearson correlation coefficients were found to be 0.075, -0.129, and 0.181 for the annual, summer, and winter natural gas consumption per square foot respectively. The correlations were not statistically significant at alpha level 0.05.

The test results showed that the frequency of use of clothes dryer had a negative correlation with the natural gas consumption. That means, as the frequency of use of clothes dryer increased, the natural gas consumption decreased. The negative correlation shows that there were factors other than the frequency of use of clothes dryer that affects the natural gas consumption of the homes. The correlations were weak and were not statistically significant at alpha level 0.05.

The homes with an Energy Star clothes dryer had less natural gas consumption than the homes with non-Energy Star clothes dryer. The correlations were weak and were not statistically significant at alpha level 0.05.

5.5.3 Correlation between the Water Consumption and Appliance

While conducting the Pearson correlation coefficient test for the water consumption of the homes the dishwasher and clothes washer were considered.

Table 5.21 shows results of the correlation analysis between the water consumption per square foot and the age of dishwasher, frequency of use of the dishwasher, and whether the dishwasher was an Energy Star product. Water consumption per square foot had a negative correlation with the age of dishwasher. That means, as the age of dishwasher increases, the water consumption of a home decreases. The correlations were weak and were not statistically significant at alpha level 0.05.

Table 5.21: Correlation between Water Consumption (gal/ft^2) and Dishwasher (N= 60)

Water Consumption	Characteristics of Dishwasher		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	-0.076	0.041	0.079
Average monthly summer	-0.125	0.102	0.044
Average monthly winter	-0.013	-0.054	0.104

The test results showed that as the frequency of use of dishwasher increased the annual and summer water consumption also increased. However, the water consumption decreased when the frequency of the dishwasher increased in winter. The correlation coefficients were not statistically significant at alpha level 0.05. The homes with an Energy Star dishwasher had lower water consumption than the homes with a non-Energy Star dishwasher. The correlations were weak and were not statistically significant at alpha level .05.

Table 5.22 shows results of the correlation analysis between the water consumption per square foot and the age of clothes washer, the frequency of use of clothes washer, and whether the clothes washer was an Energy Star product. Water consumption per square foot had a weak correlation with the age of clothes washer. The correlations were not statistically significant at alpha level 0.05.

Table 5.22: Correlation between the Water Consumption (gal/ft^2) and Clothes Washer (N=60)

Water Consumption	Characteristics of Clothes Washer		
	Age of Appliance	Frequency of use	Energy Star Product
Annual	0.009	-0.275**	0.016
Average monthly summer	0.003	-0.285*	0.044
Average monthly winter	0.015	-0.183	-0.026

*Note: * significant at alpha level 0.05; ** significant at alpha level 0.01*

The test results showed that as the frequency of use of clothes washer increased the water consumption of the dishwasher decreased. The negative correlation shows that there were factors other than the frequency of use of clothes washer that affects the water consumption of the homes. The Pearson correlation coefficients for the annual, summer and winter water consumption per square foot were found to be -0.275, -0.285 and –0.183 respectively. The correlation coefficients for the annual and summer water consumption were statistically significant at alpha level 0.01 and 0.05 respectively.

The homes with an Energy Star clothes washer had lower annual and summer water consumption than the homes with a non-Energy Star dishwasher. However, the homes with the Energy Star clothes washer had higher water consumption in winter. These correlations were weak and were not statistically significant at alpha level 0.05

5.5.4 Correlation between the Electricity and Natural Gas Consumption and Type of Window Glass used in the Homes

The Pearson correlation coefficient test between the electricity and natural gas consumption of the homes and the type of window glass was conducted. Table 5.23 shows results of the correlation analysis between the electricity and natural gas consumption per square foot and type of window glass used in the homes.

The type of window glass had a negative correlation with the electricity consumption. That means, the homes with the double-glazed with low-e panes had lower electricity consumption. The correlations were weak and were not statistically significant at alpha level 0.05.

The test results indicated that the type of window glass had a weak correlation with the natural gas consumption. The correlations were not statistically significant at alpha level 0.05.

Table 5.23 Correlation between Type of Window Panes and the Electricity and Natural Gas Consumption (unit/ft^2) (N=60)

	Electricity Consumption (kWh/ft^2)	Natural Gas Consumption (therms/ft^2)
Annual energy consumption	‘0.155’	0.151
Average monthly summer energy consumption	‘0.175’	0.038
Average Winter energy consumption	‘0.095’	0.194

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1. Review of Research Hypotheses

The goals of this study were to compare the energy consumption of Energy Star and non–Energy Star homes and to determine the correlations between factors that affect the energy consumption of homes. The research consisted testing of two hypotheses.

- Research Hypothesis 1: - The mean energy consumption (electricity, natural gas and water consumption) of the Energy Star home is less than the mean energy consumption (electricity, natural gas and water) of the non-Energy Star home.
    - Null hypothesis: - The mean energy consumption (electricity, natural gas and water) of the Energy Star home is not significantly different from the mean energy consumption (electricity, natural gas and water) of the non-Energy Star home.
- Research Hypothesis 2: - The electricity, natural gas and water consumption of a home are significantly correlated to a number of factors.
    - Null hypothesis: - The correlation coefficients of the electricity, natural gas and water consumption and various factors are not significantly different from zero.

6.2 Conclusions

The estimated housing units in 2007 for Nevada were 1,102.377 (U.S. Census Bureau, 2009). The total electricity and natural gas consumption for state of Nevada in 2007 was around 12396.91 million kWh and 398.73 million therms respectively (EIA, 2009). The average electricity consumption for Nevada was about 11246 kWh per household in 2007. For this study, the average electricity consumption was about 14000 kWh per household. The average natural gas consumption for Nevada was about 362 therms per household in 2007. For this study, the average natural gas consumption was about 501 therms per household.

The test results showed that the mean electricity and water consumption per square foot of the Energy Star homes was lower than that of the non-Energy Star homes. However, the mean natural gas consumption per square foot of the Energy Star homes was higher than that of the non-Energy Star homes. The ANOVA test results showed that was no significant difference in the mean of the energy consumption of both the types of homes. Table 6.1 shows the potential saving in energy consumption per square foot with an Energy Star home compare to a non-Energy Star home in Henderson.

Table 6.1: Saving with Energy Star Home (Energy Consumption/ft^2)

Energy Consumption/ft^2	Average Energy Saving Above non–Energy Star Home (%)
Annual electricity consumption	12.48
Summer electricity consumption	16.36
Winter electricity consumption	10.34
Annual natural gas consumption	-2.38
Summer natural gas consumption	-6.66
Winter natural gas consumption	0
Annual water consumption	21.12
Summer water consumption	23.51
Winter water consumption	17.71

When the ANOVA test was performed with the energy consumption per square foot per person, the results showed that the mean electricity and water consumption for the Energy Star homes was significantly lower than the mean of the non-Energy Star homes except for the average monthly winter electricity consumption per person per square foot. The test results also showed that that the mean natural gas consumption per square foot per person of the Energy Star homes was not significantly different from the mean of the non–Energy Star homes. Table 6.2 shows potential saving in the energy consumption per square foot per person with an Energy Star home compare to a non-Energy Star home in Henderson, Nevada.

Table 6.2: Savings with Energy Star Home (Energy Consumption/ft^2/Person)

Energy Consumption/ft^2/Person	Average Energy Saving Above non–Energy Star Home (%)
Annual electricity consumption	32.72
Summer electricity consumption	36.66
Winter electricity consumption	25
Annual natural gas consumption	27.27
Summer natural gas consumption	28.57
Winter natural gas consumption	28.57
Annual water consumption	42.05
Summer water consumption	43.43
Winter water consumption	38.36

The Pearson correlation coefficient test was performed to find the correlations between the energy consumption of the home and the characteristics of appliances, human behavior and the type of the appliance. The results showed that there was medium to low level of correlation between the electricity consumption of the homes and age, frequency of use, and type of the air conditioning system, ceiling fans, clothes washer, refrigerator, microwave oven and dishwasher. The results showed that there was medium to low level of correlation between the natural gas consumption of the space heating system, water heater, stove, oven and clothes dryer. The results also showed that there was weak correlation between the water consumption and the age, frequency and the type of the dishwasher and clothes. Table 6.3 shows the list of correlated variables with their coefficient and p-values. From the table, it was clear that reducing the frequency of use of air conditioning systems, ceiling fans, microwave ovens, clothes washers, and stoves could reduce the energy consumption of a home. It was also seen that Energy Star air conditioning systems, temperature setting in winter and age of refrigerators, and microwave ovens impact the energy consumption of a home. The frequency of use of air conditioning system has the strongest positive correlation with the average monthly summer electricity consumption per square foot. The frequency of use of the stove had the strongest negative correlation with the annual natural gas consumption per square foot. The negative correlation showed that there were factors other than frequency of use of stove that affects the natural gas consumption of the homes.

Table 6.3: List of Correlated Variables

Name of Correlated Variables	R- Value	p- value
Annual electricity consumption per square foot and frequency of use of air conditioning system	0.350	0.01
Average monthly summer electricity consumption per square foot and frequency of use of air conditioning system	0.401	0.01
Average monthly winter electricity consumption per square foot and energy star air conditioning system	-0.223	0.05
Average monthly winter electricity consumption per square foot and frequency of use of ceiling fans	-0.340	0.05
Average monthly winter electricity consumption per square foot and age of refrigerator	0.230	0.05
Annual electricity consumption per square foot and frequency of use of microwave oven	0.217	0.05
Average winter electricity consumption per square foot and age of microwave oven	0.242	0.05
Annual natural gas consumption per square foot and temperature setting in winter	0.359	0.01
Average monthly winter natural gas consumption per square foot and temperature setting in winter	0.380	0.05
Annual natural gas Consumption per square foot and frequency of use of stove	-0.387	0.01
Average monthly summer natural gas consumption per square foot and frequency of use of stove	-0.327	0.01
Average monthly winter natural gas consumption per square foot and frequency of use of stove	-0.347	0.01
Annual water consumption per square foot and frequency of use of clothes washer	-0.275	0.01
Average monthly summer water consumption per square foot and frequency of use of clothes washer	-0.285	0.05

6.3 Recommendation for Further Study

Following future works are recommended:

- The data was gathered for thirty samples each for Energy Star and non-Energy star homes. Future study with more samples is recommended to validate the findings of this exploratory research.
- The variables included in the survey did not include several factors that could play important role in the energy consumption of the home. For example, use of fire place, computer usage, television usage, any special kitchen appliances, etc were not part of the survey.

- The energy consumption data gathered was for the span of one year only. Therefore, it is recommended that the energy consumption trend of the homes over longer period of time may yield more valid results.

APPENDIX A

SURVEY QUESTIONS

Survey title – Benchmarking Energy Consumption of Energy Star and non-Energy Star Homes

We would like to thank you in advance for the time and effort involved in your participation in this study. This study is conducted to fulfill the requirement of Master of Science in Construction Management in UNLV. This questionnaire has seven parts

1. Housing Unit Characteristics
2. Kitchen Appliances
3. Space Heating
4. Water Heating
5. Air Conditioning
6. Miscellaneous
7. Energy Consumption Data

In the questionnaire, we ask for detailed information on energy consumption bill. Please fill the information as fully and accurately as possible. Your detailed responses will allow us to understand trend of energy consumption in Energy Star and non-Energy Star homes in Las Vegas. This survey will take approximately 15 minutes.

The confidentiality of this questionnaire will be maintained. There will not be any permanent record of this data and will be destroyed when no longer needed by the researchers. The identity of person who provides all this information will remain anonymous. The data obtained from this questionnaire will not be linked in any way to participant's names.

Thanking you for your time

Prajakta A Kulkarni

Master Student, Construction Management Program

Howard R. Hughes College of Engineering

University of Nevada Las Vegas

Part 1: Housing Unit Characteristics

1. Write down the total area of your home _____(Square Footage)
2. On average, how many people stayed in this home in 2008?
   Enter the number of people _____
3. Is the garage heated during winter months?
   a. Yes b. No
4. Is the garage air conditioned during summer months?
   a. Yes b. No
5. Do you or members of your household own this home or do you rent?
   a. Own / buying b. Rent

Part 2: Kitchen Appliances and Other Appliances

Appliance	Stove	Oven	Dishwasher	Microwave	Refrigerator	Clothes Washer	Clothes Dryer	
Electricity				Electricity	Electricity			
Natural Gas								
Propane								
Some Other Fuel								
Is your appliance a								
Energy Star								
How old is the appliance?								
Less than 1 years								
1 to 5 years								
6 to 10 years								
11 to 20 years								
21 years or older								
How often you use it ?								
More than once a day (no.)								1 Load or less each week
Once a day								2 to 4 loads
Between once a day and once a week								5 to 9 loads
Once a week								10 to 15 loads
Less than once a week								more than 15 loads

	Dehumidifier	Humidifier
Yes		
No		
How many months of a typical year do you use?		
1 to 3 months each year		
4 to 6 months each year		
7 to 9 months each year		
10 to 11 months, but not all year		
turned on all year long		

Part 3: Space Heating

1. What is the main fuel used for heating your home?
   a. Electricity d. Solar
   b. Natural gas e. Don't heat home
   c. Wood f. Some other fuel _____
2. How old is your heating equipment?
   a. Less than 1 years d. 11 to 20
   b. 1 to 5 e. 21 years or older
   c. 6 to 10
3. Does the main heating system also heat any other building or unit?
   a. Yes b. No
4. How often do you use the heating system in winter?

a. Not used at all
b. Turned on only a few days or nights when really needed
c. Turned on quite a bit
d. Turned on just about all winter
5. At what temperature does your household usually keep your home in the winter?
   Enter the number _____

6. Is the space heating unit an Energy Star appliance?
a. Yes b. No
7. Do you use any other equipment/way for heating your home? (If No, go to Part 4 Water Heating) Enter here _____
8. What fuel does it use?
a. Electricity
b. Natural gas
c. Wood
d. Solar
e. Some other fuel _____
9. How often do you use it?
a. Turned on only a few days or nights when really needed
b. Turned on quite a bit
c. Turned on just about all winter
10. How old is it?
a. Less than 1 years
b. 1 to 5
c. 6 to 10
d. 11 to 20
e. 21 years or older
11. Is this space heating an Energy Star appliance?
a. Yes b. No

<u>Part 4: Water Heating</u>

1. Which fuel do you use to heat water?
c. Electricity
d. Natural gas
e. Wood
f. Solar
g. Don’t heat water
h. Some other fuel
2. How old is the water heater?
a. Less than 1 years
b. 1 to 5
c. 6 to 10
d. 10 to 20
e. 21 years or older

<u>Part 5: Air Conditioning</u>

1. Do you have any air conditioning unit in home?
a. Yes b. No
2. What kind of air conditioning equipment does your home have?
a. A central system *(Go to 7)*
b. Individual units in the windows
c. Both central and individual units
3. How many window or wall air conditioning units do you have?
a. Enter the number ___________
4. How often do you use window or wall air conditioning unit?
a. Not used at all
b. Turned on only a few days or nights when really needed
c. Turned on quite a bit

d. Turned on just about all summer
5. How old is/are windows or wall air-conditioning unit/units?
a. Less than 1 years d. 11 to 20
b. 1 to 5 e. 21 years or older
c. 6 to 10
6. Is/are window/windows or wall unit/units Energy Star appliance?
a. Yes b. No
7. How often do you use the air conditioning system?
a. Not used at all
b. Turned on only a few days or nights when really needed
c. Turned on quite a bit
d. Turned on just about all summer
8. How old is the air conditioning system?
a. Less than 1 years d. 11 to 20
b. 1 to 5 e. 21 years or older
c. 6 to 10
9. Is the air conditioning an Energy Star appliance?
a. Yes b. No
10. Do you have adjustable thermostat?
a. Yes b. No
11. At what temperature does your household usually keep your home in the summer?
a. Enter the number ________

Part 6: Miscellaneous

1. What is the type of glass in the windows of your home?
a. Single panel glass
b. Double panel glass
c. Double panel glass with Low-e coating
d. Triple panel glass
e. Triple panel glass with Low-e coating
2. Do you have ceiling fan?
a. Yes b. No (Go to No. 6)
3. How many ceiling fans do you have?
Enter the number ________

4. How often do you use ceiling fan?
a. Not used at all
b. Turned on only a few days or nights when really needed
c. Turned on quite a bit
d. Turned on just about all time
5. Are these ceiling fans Energy Star?
a. Yes b. No
6. Do you have any special equipment to save energy?
a. Name of equipment ____
7. Is your home an Energy Star Home?
a. Yes b. No
8. Do you have Energy Star Certificate
a. Yes b. No

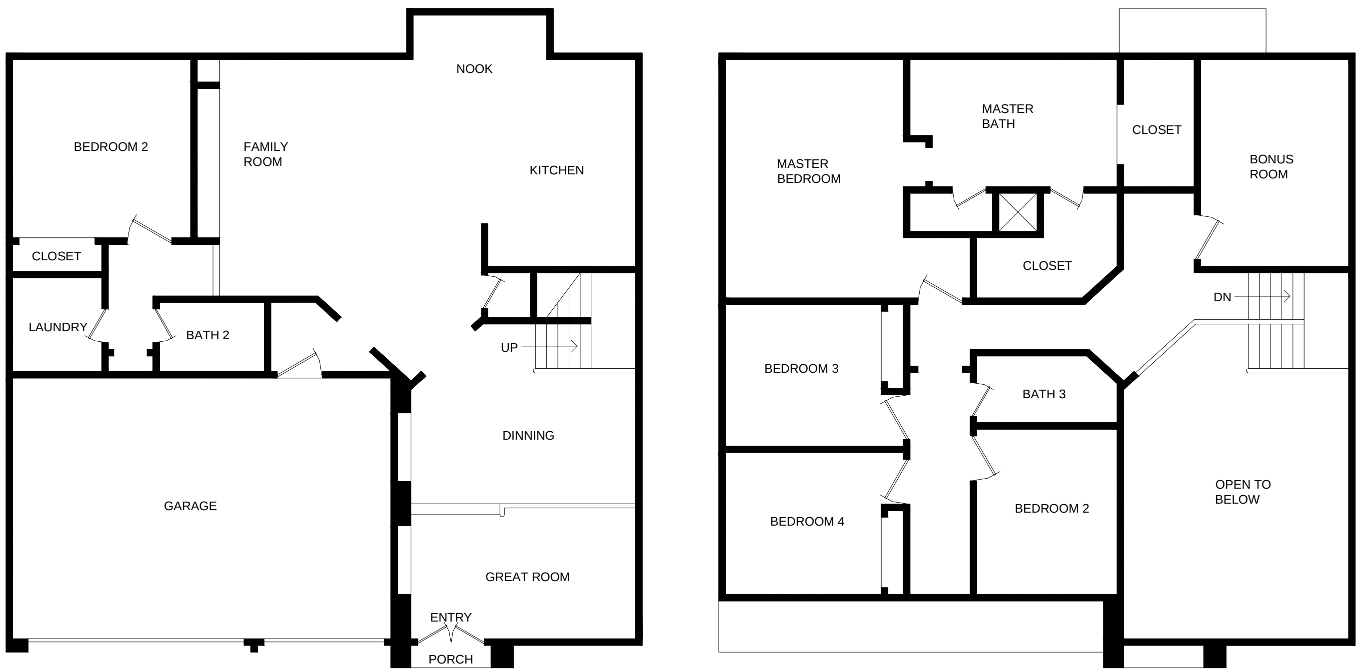
Part 7: Energy Consumption Data

Please provide following information

Month	Electric bill	Water bill	Natural Gas bill
January 2008			
February 2008			
March 2008			
April 2008			
May 2008			
June 2008			
July 2008			
August 2008			
September 2008			
October 2008			
November 2008			
December 2008			
January 2009			
February 2009			
March 2009			
April 2009			

APPENDIX B

SURVEYED HOMES' SAMPLE FLOOR PLANS AND PHOTOS



FIRST FLOOR PLAN

SECOND FLOOR PLAN

Figure B.1: Sample floor plan of 3400 sqft home (Plans not to scale)

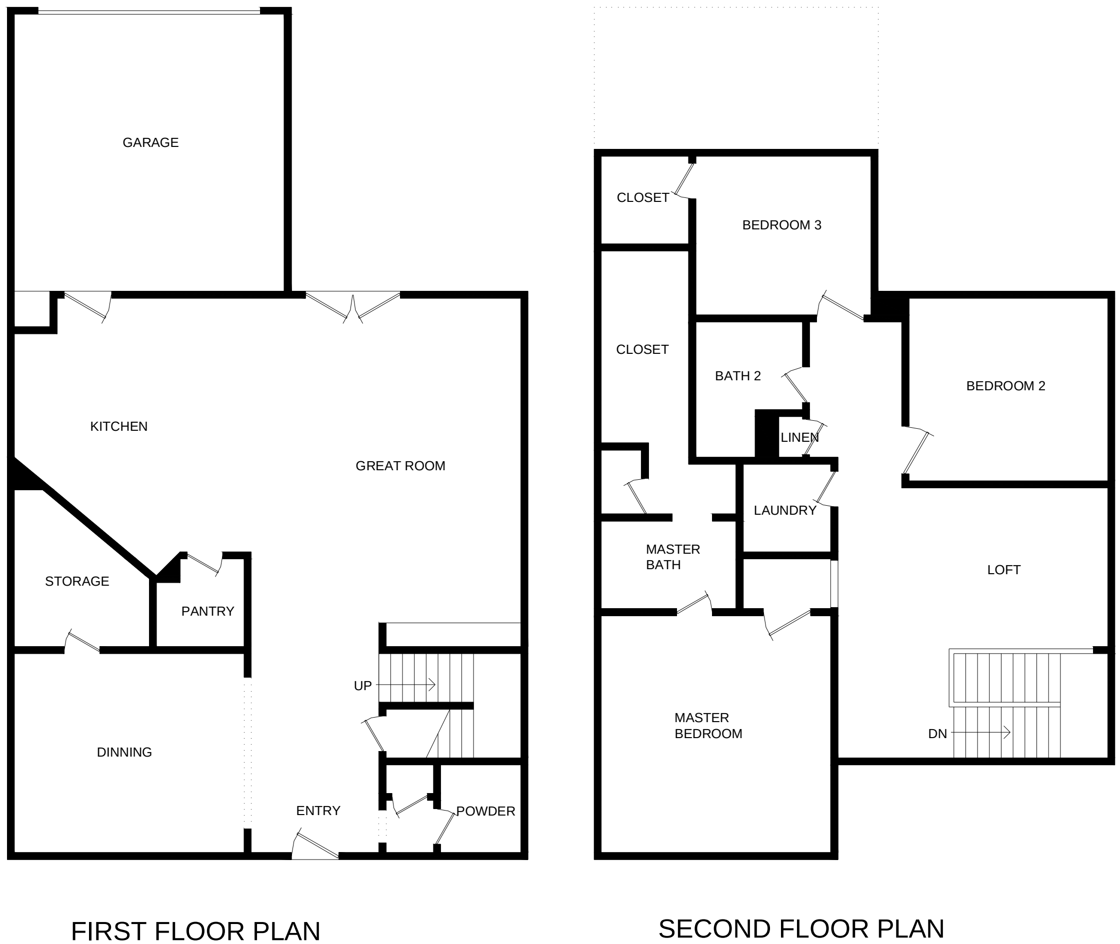
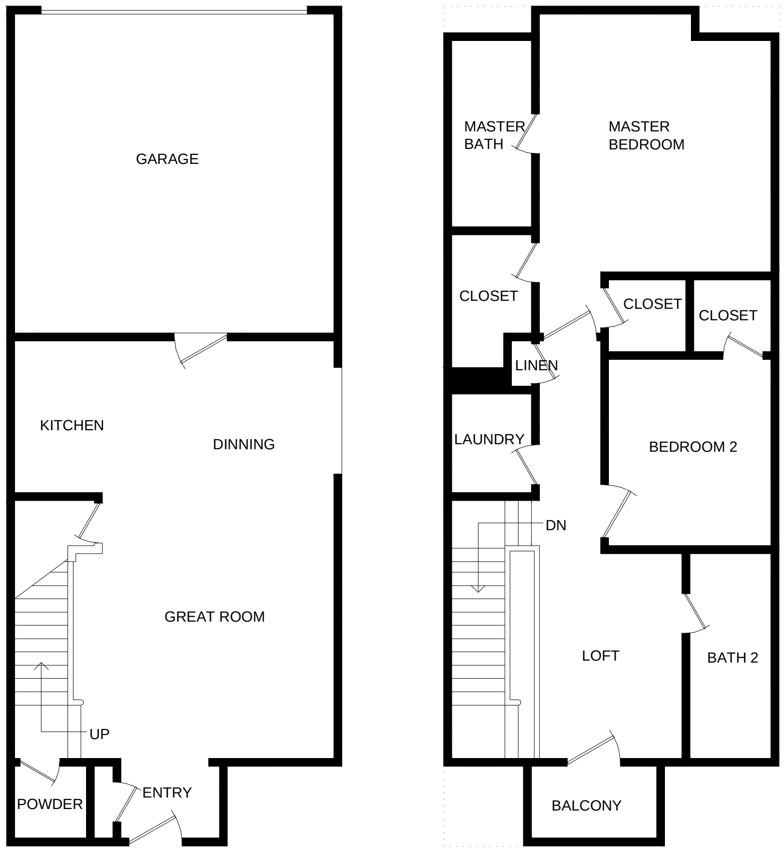


Figure B.2: Sample home 1 floor plan - Area 2847 sqft (Plans not to scale)

Figure B.3: Sample home 2 floor plan - Area 2300 sqft (Plans not to scale)

Figure B.4: Sample home 3 floor plan - Area 2040 sqft (Plans not to scale)

Figure B.5: Sample home 4 floor plan - Area 1812 sqft (Plans not to scale)



FIRST FLOOR PLAN SECOND FLOOR PLAN

Figure B.6: Sample home 5 floor plan - Area 1524 sqft (Plans not to scale)

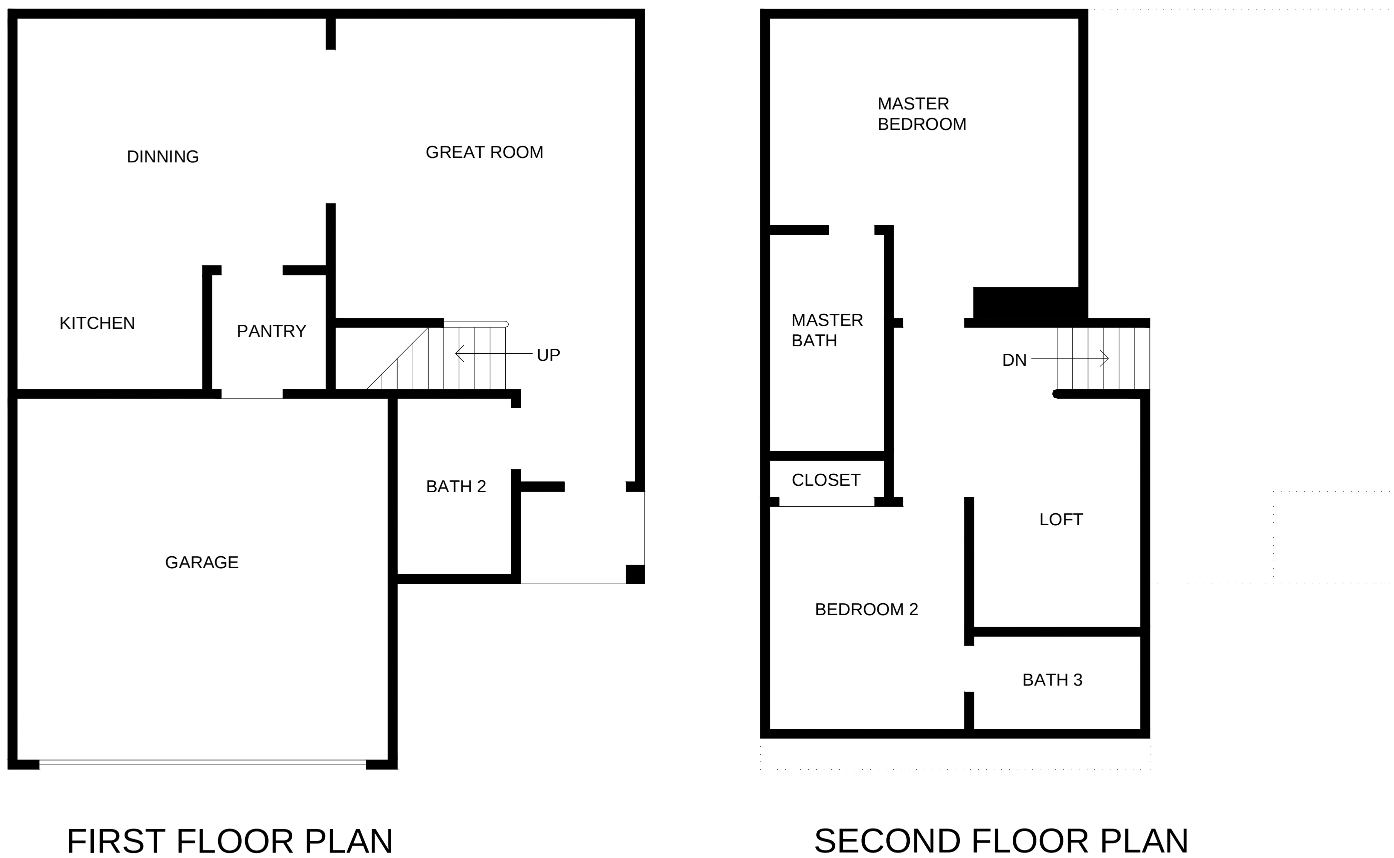


Figure B.7: Sample floor plan of 1224 sqft home (Plans not to scale)

Figure B.8: Sample home 1

Figure B.9: Sample home 2

Figure B.10: Sample home 3

Figure B.11: Sample home 4

Figure B.12: Sample home 5

Figure B.13: Sample home 6

Figure B.14: Sample home 7

Figure B.15: Sample home 8

Figure B.16: Sample home 9

Figure B.17: Sample home 10

Figure B.18: Sample home 11

Figure B.19: Sample home 12

APPENDIX C

ENERGY CONSUMPTION DATA

Electricity Consumption Data for non–Energy Star Homes

Non-Energy Star/Electricity Consumption (KWh/Sqft)														
Sr. No.	Area (sq)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	2849	2	0.1749	0.1749	0.2042	0.2629	0.3215	0.3508	0.3508	0.3362	0.2482	0.1896	0.1749	0.1749
2	4700	2	0.2873	0.2038	0.1824	0.1433	0.1700	0.2926	0.4402	0.3797	0.2678	0.1931	0.1540	0.2678
3	2120	2	0.3178	0.3257	0.2547	0.1917	0.2350	0.4912	0.6173	0.4715	0.5345	0.3296	0.1878	0.2350
4	3400	2	0.4709	0.3357	0.3063	0.4266	0.4660	0.6797	1.0482	1.0409	1.0138	0.6748	0.3603	0.2891
5	2316	4	0.3378	0.2873	0.2945	0.2729	0.4063	0.8427	0.7670	0.6768	0.5001	0.2729	0.3378	0.3955
6	1812	4	0.1597	0.1782	0.1644	0.1736	0.1597	0.1597	0.2335	0.4133	0.3027	0.8466	0.6392	0.3488
7	1387	4	0.1485	0.1485	0.1485	0.1485	0.2689	0.4797	0.4797	0.4797	0.4797	0.3291	0.1786	0.1786
8	2040	4	0.1419	0.1419	0.1828	0.1828	0.2647	0.7766	0.7766	0.7766	0.7766	0.3671	0.2033	0.1419
9	2041	3	0.3833	0.3178	0.3096	0.3178	0.3055	0.3342	0.3669	0.4570	0.6780	0.8908	0.2278	0.2523
10	1524	3	0.3818	0.4147	0.4750	0.5462	0.6065	0.6832	0.8203	0.7874	0.6997	0.5901	0.4256	0.4092
11	1812	2	0.1505	0.1551	0.1321	0.2012	0.2796	0.4963	0.6484	0.5055	0.1090	0.2519	0.2842	0.1828
12	2856	2	0.2388	0.1891	0.2066	0.1979	0.2330	0.4231	0.4670	0.4289	0.3851	0.3529	0.1832	0.2125
13	1387	6	0.4195	0.4255	0.4195	0.3894	0.3593	0.3954	0.4135	0.4195	0.4014	0.3412	0.3291	0.3593
14	1387	3	0.3800	0.2379	0.3129	0.4542	0.4694	0.4758	1.1175	0.9733	1.0058	0.6489	0.3800	0.2379
15	2040	2	0.2811	0.2443	0.2606	0.2524	0.2565	1.0182	1.0673	0.7356	0.5800	0.1869	0.1624	0.2647
16	1941	3	0.2653	0.2352	0.2094	0.2309	0.3041	0.5365	0.6914	0.6182	0.5365	0.4246	0.1836	0.2352
17	1524	2	0.2941	0.2831	0.3544	0.3982	0.5188	0.5736	0.7052	0.6832	0.6010	0.3818	0.3379	0.3215
18	1950	1	0.1784	0.1313	0.1227	0.2684	0.3798	0.7567	0.8081	0.5126	0.2727	0.1484	0.1270	0.1784
19	1229	2	0.1336	0.1336	0.1336	0.2695	0.2695	0.5414	0.5414	0.5414	0.5414	0.2695	0.1336	0.1336
20	2100	2	0.2134	0.2094	0.1856	0.1895	0.1697	0.2253	0.4083	0.5595	0.6152	0.3367	0.1776	0.2015
21	1560	2	0.6139	0.4265	0.4479	0.4961	0.5283	0.6782	1.2458	1.1869	0.9031	0.7853	0.5175	0.5872
22	1057	1	0.5504	0.4714	0.4714	0.5109	0.5900	0.9456	1.1037	1.1037	0.9456	0.7085	0.5109	0.5109
23	1180	1	0.1816	0.8753	0.3656	0.3161	0.5143	0.9107	2.5815	0.7692	0.6842	0.3232	0.2382	0.2595
24	1814	1	0.1457	0.1550	0.1504	0.1550	0.5049	0.5326	0.5464	0.5372	0.3760	0.1734	0.1550	0.1734
25	1200	2	0.1577	0.4083	0.3665	0.2621	0.2134	0.5266	0.7285	0.7076	0.4988	0.2134	0.5475	0.6032
26	1380	1	0.3190	0.3652	0.3639	0.3913	0.2920	0.0652	0.0562	0.4783	0.6200	0.3804	0.3594	0.2000
27	2500	1	0.2160	0.2160	0.1993	0.1993	0.2494	0.3664	0.5000	0.4666	0.3998	0.2661	0.2494	0.1993
28	1800	2	0.3232	0.3000	0.2768	0.3000	0.3464	0.5553	0.7177	0.6481	0.5785	0.4161	0.3000	0.3000
29	2000	2	0.4162	0.3703	0.3619	0.3953	0.4580	0.5499	0.7295	0.6710	0.6042	0.4789	0.4162	0.3661
30	1057	2	0.4951	0.4556	0.4082	0.4477	0.6137	0.9061	1.3170	1.0720	1.0167	0.7322	0.6216	0.5584

Non-Energy Star/Electricity Consumption (KWh/Sqft)								
Sr. No.	Area (sqft)	People stayed in 2008	Annual Electricity Consumption	Average Annual Electricity Consumption	Summer (May - Oct) Electricity Consumption	Average Summer (May - Oct) Electricity Consumption	Winter (Nov - Apr) Electricity Consumption	AverageWinter (Nov - Apr) Electricity Consumption
1	2849	2	2.9638	0.2470	1.7971	0.2995	1.1667	0.1944
2	4700	2	2.9820	0.2485	1.7434	0.2906	1.2386	0.2064
3	2120	2	4.1917	0.3493	2.6790	0.4465	1.5127	0.2521
4	3400	2	7.1123	0.5927	4.9234	0.8206	2.1889	0.3648
5	2316	4	5.3916	0.4493	3.4658	0.5776	1.9257	0.3210
6	1812	4	3.7794	0.3149	2.1156	0.3526	1.6638	0.2773
7	1387	4	3.4679	0.2890	2.5169	0.4195	0.9510	0.1585
8	2040	4	4.7328	0.3944	3.7382	0.6230	0.9946	0.1658
9	2041	3	4.8410	0.4034	3.0324	0.5054	1.8086	0.3014
10	1524	3	6.8396	0.5700	4.1872	0.6979	2.6524	0.4421
11	1812	2	3.3967	0.2831	2.2908	0.3818	1.1060	0.1843
12	2856	2	3.5181	0.2932	2.2899	0.3817	1.2282	0.2047
13	1387	6	4.6724	0.3894	2.3302	0.3884	2.3422	0.3904
14	1387	3	6.6936	0.5578	4.6907	0.7818	2.0029	0.3338
15	2040	2	5.3102	0.4425	3.8447	0.6408	1.4656	0.2443
16	1941	3	4.4707	0.3726	3.1112	0.5185	1.3595	0.2266
17	1524	2	5.4528	0.4544	3.4636	0.5773	1.9892	0.3315
18	1950	1	3.8846	0.3237	2.8783	0.4797	1.0063	0.1677
19	1229	2	3.6418	0.3035	2.7045	0.4508	0.9373	0.1562
20	2100	2	3.4918	0.2910	2.3147	0.3858	1.1771	0.1962
21	1560	2	8.4167	0.7014	5.3275	0.8879	3.0892	0.5149
22	1057	1	8.4231	0.7019	5.3970	0.8995	3.0261	0.5043
23	1180	1	8.0194	0.6683	5.7830	0.9638	2.2363	0.3727
24	1814	1	3.6048	0.3004	2.6705	0.4451	0.9344	0.1557
25	1200	2	5.2335	0.4361	2.8882	0.4814	2.3453	0.3909
26	1380	1	3.8909	0.3242	1.8921	0.3154	1.9988	0.3331
27	2500	1	3.5279	0.2940	2.2484	0.3747	1.2794	0.2132
28	1800	2	5.0622	0.4219	3.2620	0.5437	1.8002	0.3000
29	2000	2	5.8174	0.4848	3.4914	0.5819	2.3260	0.3877
30	1057	2	8.6444	0.7204	5.6578	0.9430	2.9866	0.4978

Electricity Consumption Data for Energy Star Homes

Energy Star/Electricity Consumption (KWh/Sqft)														
Sr. No.	Area (sqft)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	1387	2	0.2087	0.2147	0.1485	0.0943	0.2087	0.3412	0.4195	0.4496	0.4195	0.2388	0.2749	0.3171
2	2262	4	0.2424	0.2461	0.2757	0.2498	0.3126	0.4086	0.4973	0.5342	0.4714	0.3311	0.2978	0.3015
3	2316	2	0.1971	0.1971	0.2332	0.1791	0.2152	0.2332	0.4857	0.4676	0.3234	0.1791	0.1791	0.1791
4	2350	2	0.2405	0.2511	0.3009	0.2831	0.3116	0.5462	0.5675	0.6350	0.5071	0.3222	0.2796	0.2369
5	4200	4	0.2559	0.2698	0.1982	0.1982	0.2678	0.3752	0.3971	0.3971	0.3474	0.2778	0.2678	0.3533
6	3500	3	0.2975	0.2975	0.3094	0.2307	0.2474	0.4359	0.4145	0.4073	0.4049	0.2903	0.2856	0.4001
7	4200	5	0.2658	0.2797	0.3136	0.3215	0.3374	0.3732	0.3991	0.3692	0.3692	0.3076	0.3056	0.2439
8	1652	3	0.1499	0.1499	0.2005	0.2005	0.2511	0.3016	0.3775	0.3775	0.3522	0.3016	0.2511	0.1499
9	2800	4	0.2346	0.1929	0.2645	0.2406	0.2794	0.3957	0.4315	0.4465	0.4047	0.3301	0.2973	0.2645
10	3400	3	0.1711	0.1932	0.2080	0.2375	0.2448	0.2915	0.3898	0.4094	0.3701	0.3308	0.2669	0.2817
11	2316	4	0.2224	0.2512	0.2332	0.2837	0.3125	0.3558	0.3161	0.3089	0.3414	0.3306	0.2873	0.3234
12	1650	2	0.2007	0.2007	0.2261	0.2514	0.2514	0.3020	0.3020	0.3526	0.3526	0.3020	0.2767	0.2261
13	3700	3	0.0895	0.1121	0.1121	0.1121	0.1347	0.1572	0.1798	0.1798	0.1572	0.1347	0.1347	0.0895
14	2037	3	0.1216	0.1216	0.1626	0.1626	0.2036	0.4087	0.6547	0.8598	0.6547	0.4087	0.2036	0.1626
15	1180	2	0.7762	0.9107	0.9886	0.5780	0.6559	0.6771	0.8046	1.1160	1.1231	1.0523	1.0594	0.7267
16	3500	3	0.3142	0.3214	0.3047	0.3381	0.2665	0.5123	0.4980	0.5075	0.5481	0.4526	0.3214	0.3405
17	1521	2	0.3551	0.4429	0.4210	0.3770	0.4649	1.0361	1.0361	1.0196	0.8988	0.4594	0.3770	0.3770
18	2500	3	0.2394	0.2561	0.2762	0.2561	0.2929	0.3831	0.4599	0.5301	0.4833	0.3330	0.2695	0.2595
19	1812	2	0.2058	0.1874	0.1459	0.2197	0.2796	0.4963	0.6484	0.5055	0.1090	0.2519	0.2473	0.2796
20	2041	2	0.3178	0.3055	0.3178	0.3055	0.3342	0.3669	0.4570	0.6780	0.8908	0.2278	0.2523	0.3833
21	2133	2	0.1161	0.1161	0.1161	0.1161	0.1161	0.1161	0.1161	0.5469	0.5469	0.5469	0.5469	0.5469
22	1224	3	0.1546	0.1682	0.1682	0.3388	0.3457	0.5641	0.5982	0.5777	0.5504	0.3661	0.1955	0.1546
23	1521	3	0.4045	0.4374	0.4539	0.3880	0.4649	0.6626	0.7395	0.7835	0.7011	0.4979	0.4594	0.4539
24	1980	4	0.2559	0.2517	0.2390	0.3149	0.3656	0.5217	0.6018	0.6651	0.5639	0.4668	0.3360	0.3276
25	1812	2	0.3303	0.3165	0.3441	0.3488	0.5516	0.6069	0.7314	0.7452	0.7130	0.5608	0.4686	0.4317
26	2040	2	0.2033	0.2033	0.1624	0.1214	0.2443	0.5514	0.5923	0.6128	0.5309	0.2443	0.2238	0.2033
27	1980	1	0.2263	0.2306	0.2896	0.3149	0.3740	0.5428	0.5765	0.6103	0.5512	0.4204	0.3740	0.2812
28	1643	3	0.2931	0.2982	0.2423	0.2829	0.6592	0.8676	0.8931	0.8168	0.5067	0.2982	0.2982	0.3084
29	1812	3	0.2058	0.2058	0.1828	0.2750	0.4133	0.5055	0.6438	0.7130	0.3441	0.2519	0.2058	0.1828
30	2040	2	0.2443	0.2606	0.3057	0.2893	0.3876	0.4981	0.5432	0.5923	0.5227	0.3466	0.2729	0.2402

Energy Star/Electricity Consumption (KWh/Sqft)								
Sr. No.	Area (sqft)	People stayed in 2008	Annual Electricity Consumption	Average Annual Electricity Consumption	Summer (May - Oct) Electricity Consumption	Average Summer (May - Oct) Electricity Consumption	Winter (Nov - April) Electricity Consumption	Average Winter (Nov - April) Electricity Consumption
1	1387	2	3.3354	0.2779	2.0772	0.3462	1.2581	0.2097
2	2262	4	4.1686	0.3474	2.5552	0.4259	1.6135	0.2689
3	2316	2	3.0687	0.2557	1.9041	0.3173	1.1647	0.1941
4	2350	2	4.4818	0.3735	2.8896	0.4816	1.5921	0.2654
5	4200	4	3.6055	0.3005	2.0623	0.3437	1.5432	0.2572
6	3500	3	4.0211	0.3351	2.2003	0.3667	1.8208	0.3035
7	4200	5	3.8860	0.3238	2.1558	0.3593	1.7302	0.2884
8	1652	3	3.0633	0.2553	1.9615	0.3269	1.1018	0.1836
9	2800	4	3.7824	0.3152	2.2880	0.3813	1.4944	0.2491
10	3400	3	3.3950	0.2829	2.0365	0.3394	1.3584	0.2264
11	2316	4	3.5665	0.2972	1.9654	0.3276	1.6011	0.2668
12	1650	2	3.2442	0.2704	1.8626	0.3104	1.3816	0.2303
13	3700	3	1.5935	0.1328	0.9435	0.1572	0.6500	0.1083
14	2037	3	4.1247	0.3437	3.1901	0.5317	0.9346	0.1558
15	1180	2	10.4688	0.8724	5.4291	0.9048	5.0397	0.8400
16	3500	3	4.7252	0.3938	2.7851	0.4642	1.9402	0.3234
17	1521	2	7.2650	0.6054	4.9149	0.8192	2.3501	0.3917
18	2500	3	4.0391	0.3366	2.4823	0.4137	1.5568	0.2595
19	1812	2	3.5765	0.2980	2.2908	0.3818	1.2858	0.2143
20	2041	2	4.8369	0.4031	2.9546	0.4924	1.8823	0.3137
21	2133	2	3.5474	0.2956	1.9891	0.3315	1.5583	0.2597
22	1224	3	4.1822	0.3485	3.0022	0.5004	1.1800	0.1967
23	1521	3	6.4467	0.5372	3.8494	0.6416	2.5972	0.4329
24	1980	4	4.9100	0.4092	3.1849	0.5308	1.7251	0.2875
25	1812	2	6.1490	0.5124	3.9089	0.6515	2.2401	0.3733
26	2040	2	3.8934	0.3244	2.7759	0.4627	1.1175	0.1862
27	1980	1	4.7919	0.3993	3.0752	0.5125	1.7167	0.2861
28	1643	3	5.7646	0.4804	4.0415	0.6736	1.7231	0.2872
29	1812	3	4.1297	0.3441	2.8716	0.4786	1.2581	0.2097
30	2040	2	4.5035	0.3753	2.8906	0.4818	1.6130	0.2688

Water Consumption Data for non–Energy Star Homes

Non-Energy Star/Water Consumption (Gals/Sqft)														
Sr. No.	Area (sq)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	2849	2	3.1695	3.1695	2.6430	2.6430	2.6430	2.6430	3.5205	3.5205	3.5205	3.5205	3.1695	3.1695
2	4700	2	1.6021	1.7085	0.4634	0.3279	1.1411	1.7085	2.3468	2.3468	1.6021	1.9213	1.7085	1.1411
3	2120	2	5.2028	7.0896	7.3255	5.6745	5.4387	5.6745	5.4387	5.6745	5.4387	5.6745	5.4387	5.4387
4	3400	2	2.8029	1.2026	1.7735	3.9794	12.3812	18.2468	14.1985	19.0729	15.8509	3.5382	1.9206	2.0676
5	2316	4	6.2737	7.5907	6.2737	4.9784	4.1149	4.5466	12.7988	6.9184	7.3700	8.4305	7.5907	5.4102
6	1812	4	1.9051	2.2566	2.2566	3.3278	4.1556	6.0872	6.0872	6.0872	4.7075	2.6082	2.6082	2.6082
7	1387	4	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521	0.6521
8	2040	4	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167	2.3167
9	2041	3	2.9544	3.2518	2.6276	4.4243	3.9343	6.1391	6.1391	14.1421	20.0745	4.4243	0.7552	2.9544
10	1524	3	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252	5.9252
11	1812	2	3.3278	3.6038	3.6038	4.4316	5.2594	8.2947	8.5706	8.5706	8.8427	7.4669	7.4669	5.2594
12	2856	2	6.0193	5.7465	5.2626	5.7465	6.4279	7.2454	6.7003	6.7003	4.9125	2.8116	2.2864	2.1113
13	1387	6	3.8666	3.8666	3.8666	4.3475	3.8666	4.3475	3.8666	3.8666	4.3475	4.3475	4.3475	4.3475
14	1387	3	2.9481	2.9481	4.3475	5.4290	7.9524	11.5523	11.1968	12.3944	10.4758	9.3944	9.0339	5.0685
15	2040	2	4.1814	2.9559	5.1618	3.9363	14.9897	20.7725	25.4544	13.0044	5.4069	4.9167	4.9167	5.1618
16	1941	3	4.3946	1.4503	3.3642	4.1370	5.6826	10.2597	10.4606	11.0618	9.8588	7.2282	11.2622	15.0711
17	1524	2	4.2848	1.8473	1.8473	3.1011	4.2848	8.2218	10.1903	10.5138	7.5656	5.2690	4.9409	4.9409
18	1950	1	9.2149	1.1169	2.4236	7.1949	10.4123	11.0108	13.2056	11.2103	9.8133	7.9641	6.1692	4.8872
19	1229	2	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269	6.1269
20	2100	2	2.2505	1.6439	2.2505	1.9471	2.2505	1.9471	1.3406	1.3406	2.2505	1.9471	2.2505	1.9471
21	1560	2	5.7885	4.8269	3.8654	4.5064	4.8269	4.5064	6.4295	8.3526	8.9936	8.9936	10.2712	8.0321
22	1057	1	4.4712	2.0608	3.2660	2.0608	6.1779	9.0161	10.4352	9.9622	7.5970	5.0739	3.2660	1.4583
23	1180	1	4.0052	3.4653	2.3858	1.3063	2.9256	2.9256	3.4653	3.4653	4.0052	3.4653	19.8441	4.0052
24	1814	1	6.6318	6.6318	6.6318	6.6318	6.6318	6.6318	4.9779	6.6318	6.3561	6.9074	6.6318	6.6318
25	1200	2	20.4867	23.0800	17.5683	17.8925	13.3525	10.0250	9.1917	7.5250	9.1917	13.3525	2.8767	5.4417
26	1380	1	1.1167	0.1942	0.1942	1.1167	2.9630	2.9630	2.9630	2.9630	3.4246	3.4246	4.7319	3.8862
27	2500	1	3.0120	3.0120	3.0120	3.0120	3.0120	4.0120	5.0120	5.0120	4.0120	3.0120	3.0120	1.8904
28	1800	2	4.1833	4.1833	4.1833	4.1833	5.5722	6.9611	6.9611	8.3500	6.9611	5.5722	4.1833	4.1833
29	2000	2	4.5150	4.0150	3.5150	4.0150	5.0150	6.7650	7.0150	7.2650	6.2650	5.0150	4.5150	4.0150
30	1057	2	4.4711	1.4579	7.1239	7.1239	9.4891	9.4891	7.1239	7.1239	9.4891	9.4891	7.1239	7.1239

Non-Energy Star/Water Consumption (Gals/Sqft)								
Sr. No.	Area (sq)	People stayed in 2008	Annual Water Consumption	Average Annual Water Consupmtion	Summer (May - Oct) Water Consumption	Average Summer (May - Oct) Water Consumption	Winter Water (Nov - Apr) Consumption	Average Winter (Nov - Apr) Water Consumption
1	2849	2	37.3324	3.1110	19.3682	3.2280	17.9642	2.9940
2	4700	2	18.0181	1.5015	11.0666	1.8444	6.9515	1.1586
3	2120	2	69.5094	5.7925	33.3396	5.5566	36.1698	6.0283
4	3400	2	97.0353	8.0863	83.2885	13.8814	13.7468	2.2911
5	2316	4	82.2966	6.8581	44.1792	7.3632	38.1174	6.3529
6	1812	4	44.6954	3.7246	29.7329	4.9555	14.9625	2.4937
7	1387	4	7.8252	0.6521	3.9126	0.6521	3.9126	0.6521
8	2040	4	27.8006	2.3167	13.9003	2.3167	13.9003	2.3167
9	2041	3	71.8214	5.9851	54.8535	9.1423	16.9679	2.8280
10	1524	3	71.1024	5.9252	35.5512	5.9252	35.5512	5.9252
11	1812	2	74.6981	6.2248	47.0050	7.8342	27.6932	4.6155
12	2856	2	61.9706	5.1642	34.7980	5.7997	27.1726	4.5288
13	1387	6	49.2848	4.1071	24.6424	4.1071	24.6424	4.1071
14	1387	3	92.7412	7.7284	62.9661	10.4944	29.7751	4.9625
15	2040	2	110.8583	9.2382	84.5446	14.0908	26.3137	4.3856
16	1941	3	94.2313	7.8526	54.5518	9.0920	39.6795	6.6133
17	1524	2	67.0077	5.5840	46.0453	7.6742	20.9624	3.4937
18	1950	1	94.6231	7.8853	63.6164	10.6027	31.0067	5.1678
19	1229	2	73.5232	6.1269	36.7616	6.1269	36.7616	6.1269
20	2100	2	23.3663	1.9472	11.0766	1.8461	12.2898	2.0483
21	1560	2	79.3929	6.6161	42.1026	7.0171	37.2904	6.2151
22	1057	1	64.8454	5.4038	48.2622	8.0437	16.5833	2.7639
23	1180	1	55.2639	4.6053	20.2521	3.3754	35.0118	5.8353
24	1814	1	77.9272	6.4939	38.1367	6.3561	39.7905	6.6318
25	1200	2	149.9842	12.4987	62.6383	10.4397	87.3458	14.5576
26	1380	1	29.9413	2.4951	18.7014	3.1169	11.2399	1.8733
27	2500	1	41.0224	3.4185	24.0720	4.0120	16.9504	2.8251
28	1800	2	65.4778	5.4565	40.3778	6.7296	25.1000	4.1833
29	2000	2	61.9300	5.1608	37.3400	6.2233	24.5900	4.0983
30	1057	2	86.6291	7.2191	52.2044	8.7007	34.4248	5.7375

Water Consumption Data for Energy Star Homes

Energy Star/Water Consumption (Gals/Sqft)														
Sr. No.	Area (sq)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	1387	2	0.193	0.193	0.193	1.111	1.571	2.489	2.489	2.030	0.652	0.193	1.111	0.193
2	2262	4	2.089	2.371	2.089	2.089	2.887	3.329	4.655	4.655	7.428	4.876	3.550	3.550
3	2316	2	4.115	5.194	6.274	6.274	6.274	6.274	6.274	6.274	5.194	3.035	3.035	3.035
4	2350	2	0.656	0.656	0.656	0.656	0.656	0.656	0.656	0.656	0.656	0.656	0.656	0.656
5	4200	4	2.150	2.269	2.626	2.983	2.983	3.221	3.579	4.000	4.000	3.340	3.102	2.864
6	3500	3	2.437	2.580	3.151	2.437	2.437	2.866	5.467	5.023	4.801	3.151	2.437	1.723
7	4200	5	2.507	2.507	2.983	4.186	4.371	4.371	4.556	4.093	4.093	4.186	3.908	3.908
8	1652	3	7.585	7.585	7.585	7.585	7.585	7.585	7.585	7.585	7.585	7.585	7.585	7.585
9	2800	4	1.915	1.915	2.154	1.915	2.332	3.046	3.046	3.046	4.654	3.761	2.868	2.511
10	3400	3	2.950	3.685	3.685	5.628	6.086	6.201	6.429	6.315	5.628	5.056	3.685	3.685
11	2316	4	3.467	4.115	4.978	5.194	5.842	6.921	4.978	3.899	5.842	6.058	5.194	6.058
12	1650	2	2.478	2.478	2.478	4.261	4.261	5.776	5.776	5.776	5.776	7.291	7.291	5.776
13	3700	3	1.105	1.900	1.900	3.251	3.251	3.251	3.927	3.927	3.927	3.251	2.576	1.900
14	2037	3	3.697	3.697	3.697	3.697	3.697	3.697	3.697	3.697	3.697	3.697	3.697	3.697
15	1180	2	6.381	4.545	7.229	5.958	7.653	11.042	9.771	10.619	10.619	11.890	11.890	14.569
16	3500	3	5.245	5.245	5.245	5.245	5.245	5.245	5.245	5.245	5.245	5.245	5.245	5.245
17	1521	2	6.266	5.937	5.279	1.013	6.923	7.252	7.252	6.266	7.252	7.581	6.266	4.951
18	2500	3	4.012	3.012	1.890	1.890	2.612	3.012	3.812	3.812	6.721	6.876	5.812	4.812
19	1812	2	4.708	4.983	4.983	4.983	4.708	3.880	5.811	5.535	5.259	4.983	5.259	4.983
20	2041	2	3.199	3.199	2.316	4.424	3.934	6.139	6.139	14.142	20.074	4.424	0.755	2.954
21	2133	2	0.723	0.723	0.723	0.723	0.723	11.708	11.708	11.708	11.708	11.708	11.708	11.708
22	1224	3	1.259	2.820	4.382	4.382	7.377	9.420	9.420	10.237	11.462	9.420	7.786	6.560
23	1521	3	1.851	1.851	2.270	2.270	3.526	4.293	4.951	5.937	7.581	8.567	5.937	3.526
24	1980	4	3.803	6.328	3.803	3.803	3.803	6.328	0.778	3.803	3.803	6.328	3.803	6.328
25	1812	2	4.983	4.156	4.983	3.604	4.708	4.708	4.432	4.156	2.608	4.432	3.604	4.432
26	2040	2	0.756	0.756	0.756	0.756	0.756	0.756	0.756	3.691	3.691	6.142	3.691	3.691
27	1980	1	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778	0.778
28	1643	3	2.101	1.713	1.713	1.713	1.713	1.713	1.713	1.713	1.713	2.101	2.101	3.264
29	1812	3	5.535	5.535	4.156	4.156	4.156	4.156	5.535	5.535	5.535	5.535	5.535	5.535
30	2040	2	4.917	3.691	3.936	4.181	4.426	4.426	4.917	5.407	6.877	6.375	4.672	4.672

Energy Star/Water Consumption (Gals/Sqft)								
Sr. No.	Area (sq)	People stayed in 2008	Annual Water Consumption	Average Annual Water Consumption	Summer (May - Oct) Water Consumption	Average Summer (May - Oct) Water Consumption	Winter (Nov - Apr) Water Consumption	Average Winter (Nov - Apr) Water Consumption
1	1387	2	12.4173	1.0348	9.4232	1.5705	2.9941	0.4990
2	2262	4	43.5690	3.6307	27.8302	4.6384	15.7387	2.6231
3	2316	2	61.2522	5.1043	33.3247	5.5541	27.9275	4.6546
4	2350	2	7.8710	0.6559	3.9355	0.6559	3.9355	0.6559
5	4200	4	37.1200	3.0933	21.1248	3.5208	15.9952	2.6659
6	3500	3	38.5109	3.2092	23.7451	3.9575	14.7657	2.4610
7	4200	5	45.6686	3.8057	25.6700	4.2783	19.9986	3.3331
8	1652	3	91.0169	7.5847	45.5085	7.5847	45.5085	7.5847
9	2800	4	33.1639	2.7637	19.8857	3.3143	13.2782	2.2130
10	3400	3	59.0350	4.9196	35.7156	5.9526	23.3194	3.8866
11	2316	4	62.5475	5.2123	33.5406	5.5901	29.0069	4.8345
12	1650	2	59.4164	4.9514	34.6545	5.7758	24.7618	4.1270
13	3700	3	34.1673	2.8473	21.5351	3.5892	12.6322	2.1054
14	2037	3	44.3594	3.6966	22.1797	3.6966	22.1797	3.6966
15	1180	2	112.1644	9.3470	61.5932	10.2655	50.5712	8.4285
16	3500	3	62.9417	5.2451	31.4709	5.2451	31.4709	5.2451
17	1521	2	72.2360	6.0197	42.5247	7.0874	29.7114	4.9519
18	2500	3	48.2740	4.0228	26.8452	4.4742	21.4288	3.5715
19	1812	2	60.0773	5.0064	30.1766	5.0294	29.9007	4.9834
20	2041	2	71.7016	5.9751	54.8535	9.1423	16.8481	2.8080
21	2133	2	85.5687	7.1307	59.2623	9.8770	26.3064	4.3844
22	1224	3	84.5258	7.0438	57.3366	9.5561	27.1892	4.5315
23	1521	3	52.5578	4.3798	34.8540	5.8090	17.7037	2.9506
24	1980	4	52.7126	4.3927	24.8439	4.1407	27.8687	4.6448
25	1812	2	50.8035	4.2336	25.0419	4.1737	25.7616	4.2936
26	2040	2	26.1960	2.1830	15.7913	2.6319	10.4047	1.7341
27	1980	1	9.3418	0.7785	4.6709	0.7785	4.6709	0.7785
28	1643	3	23.2743	1.9395	10.6678	1.7780	12.6065	2.1011
29	1812	3	60.9051	5.0754	30.4525	5.0754	30.4525	5.0754
30	2040	2	58.4980	4.8748	32.4294	5.4049	26.0686	4.3448

Natural Gas Consumption Data for non-Energy Star Homes

Non-Energy Star/Natural Gas Consumption (Therms/Sqft)														
Sr. No.	Area (sq)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	2849	2	0.0215	0.0215	0.0082	0.0082	0.0106	0.0106	0.0145	0.0145	0.0301	0.0301	0.0252	0.0271
2	4700	2	0.0342	0.0234	0.0112	0.0031	0.0031	0.0038	0.0020	0.0010	0.0016	0.0034	0.0044	0.0218
3	2120	2	0.0354	0.0254	0.0106	0.0060	0.0070	0.0057	0.0039	0.0048	0.0070	0.0070	0.0085	0.0349
4	3400	2	0.0020	0.0068	0.0189	0.0081	0.0076	0.0089	0.0050	0.0056	0.0041	0.0041	0.0035	0.0089
5	2316	4	0.0589	0.0511	0.0237	0.0131	0.0111	0.0092	0.0073	0.0060	0.0092	0.0111	0.0260	0.0653
6	1812	4	0.0280	0.0274	0.0268	0.0192	0.0216	0.0198	0.0185	0.0149	0.0240	0.0112	0.0119	0.0461
7	1387	4	0.0295	0.0295	0.0231	0.0295	0.0138	0.0138	0.0138	0.0138	0.0138	0.0138	0.0295	0.0295
8	2040	4	0.0248	0.0248	0.0136	0.0136	0.0148	0.0148	0.0148	0.0148	0.0148	0.0175	0.0248	0.0248
9	2041	3	0.0622	0.0534	0.0477	0.0404	0.0404	0.0371	0.0311	0.0295	0.0068	0.0072	0.0062	0.0280
10	1524	3	0.0164	0.0164	0.0144	0.0125	0.0118	0.0112	0.0105	0.0112	0.0105	0.0118	0.0125	0.0144
11	1812	2	0.0467	0.0256	0.0153	0.0160	0.0171	0.0166	0.0066	0.0051	0.0082	0.0082	0.0192	0.0601
12	2856	2	0.0300	0.0270	0.0244	0.0106	0.0083	0.0102	0.0087	0.0090	0.0083	0.0083	0.0066	0.0103
13	1387	6	0.0327	0.0263	0.0365	0.0335	0.0442	0.0418	0.0442	0.0427	0.0410	0.0427	0.0365	0.0442
14	1387	3	0.0288	0.0238	0.0058	0.0050	0.0036	0.0101	0.0123	0.0108	0.0101	0.0094	0.0123	0.0187
15	2040	2	0.0804	0.0612	0.0326	0.0093	0.0118	0.0132	0.0137	0.0032	0.0050	0.0041	0.0074	0.0295
16	1941	3	0.0714	0.0556	0.0414	0.0288	0.0270	0.0248	0.0196	0.0127	0.0093	0.0062	0.0065	0.0430
17	1524	2	0.0645	0.0395	0.0298	0.0199	0.0162	0.0243	0.0256	0.0210	0.0111	0.0118	0.0164	0.0527
18	1950	1	0.0629	0.0368	0.0178	0.0061	0.0081	0.0057	0.0057	0.0052	0.0052	0.0087	0.0298	0.0798
19	1229	2	0.0296	0.0296	0.0296	0.0118	0.0156	0.0156	0.0156	0.0156	0.0156	0.0336	0.0296	0.0296
20	2100	2	0.0488	0.0483	0.0387	0.0111	0.0044	0.0040	0.0022	0.0022	0.0022	0.0027	0.0027	0.0086
21	1560	2	0.0234	0.0234	0.0234	0.0127	0.0166	0.0166	0.0258	0.0258	0.0258	0.0258	0.0200	0.0200
22	1057	1	0.0728	0.0587	0.0435	0.0265	0.0237	0.0246	0.0237	0.0180	0.0208	0.0208	0.0227	0.0681
23	1180	1	0.0484	0.0302	0.0093	0.0063	0.0086	0.0086	0.0055	0.0048	0.0071	0.0079	0.0100	0.0100
24	1814	1	0.0172	0.0167	0.0099	0.0065	0.0130	0.0130	0.0173	0.0061	0.0081	0.0093	0.0099	0.0235
25	1200	2	0.0303	0.0289	0.0297	0.0165	0.0187	0.0197	0.0187	0.0187	0.0206	0.0215	0.0304	0.0396
26	1380	1	0.0362	0.0304	0.0174	0.0174	0.0145	0.0145	0.0145	0.0116	0.0145	0.0159	0.0065	0.0333
27	2500	1	0.0414	0.0330	0.0245	0.0181	0.0232	0.0165	0.0165	0.0165	0.0188	0.0210	0.0203	0.0393
28	1800	2	0.0202	0.0154	0.0153	0.0104	0.0077	0.0077	0.0077	0.0052	0.0077	0.0077	0.0104	0.0227
29	2000	2	0.0269	0.0209	0.0178	0.0130	0.0129	0.0129	0.0118	0.0157	0.0118	0.0118	0.0116	0.0196
30	1057	2	0.0588	0.0559	0.0387	0.0345	0.0296	0.0244	0.0234	0.0149	0.0105	0.0160	0.0328	0.0579

Non-Energy Star/Natural Gas Consumption (Therms/Sqft)								
Sr. No.	Area (sq)	People stayed in 2008	Annual Natural Gas Consumption	Average Annual Natural Gas Consumption	Summer (May - Oct) Natural GasConsumption	Average Summer (May - Oct) Natural GasConsumption	Winter (Nov - Apr) Natural GasConsumption	Average Winter (Nov - Apr) Natural GasConsumption
1	2849	2	0.222	0.019	0.110	0.018	0.112	0.019
2	4700	2	0.113	0.009	0.015	0.002	0.098	0.016
3	2120	2	0.156	0.013	0.035	0.006	0.121	0.020
4	3400	2	0.084	0.007	0.035	0.006	0.048	0.008
5	2316	4	0.292	0.024	0.054	0.009	0.238	0.040
6	1812	4	0.269	0.022	0.110	0.018	0.159	0.027
7	1387	4	0.253	0.021	0.083	0.014	0.170	0.028
8	2040	4	0.218	0.018	0.092	0.015	0.126	0.021
9	2041	3	0.390	0.032	0.152	0.025	0.238	0.040
10	1524	3	0.154	0.013	0.067	0.011	0.087	0.014
11	1812	2	0.245	0.020	0.062	0.010	0.183	0.030
12	2856	2	0.162	0.013	0.053	0.009	0.109	0.018
13	1387	6	0.466	0.039	0.257	0.043	0.210	0.035
14	1387	3	0.151	0.013	0.056	0.009	0.094	0.016
15	2040	2	0.271	0.023	0.051	0.009	0.220	0.037
16	1941	3	0.346	0.029	0.100	0.017	0.247	0.041
17	1524	2	0.333	0.028	0.110	0.018	0.223	0.037
18	1950	1	0.272	0.023	0.039	0.006	0.233	0.039
19	1229	2	0.271	0.023	0.112	0.019	0.160	0.027
20	2100	2	0.176	0.015	0.018	0.003	0.158	0.026
21	1560	2	0.259	0.022	0.136	0.023	0.123	0.020
22	1057	1	0.424	0.035	0.132	0.022	0.292	0.049
23	1180	1	0.157	0.013	0.043	0.007	0.114	0.019
24	1814	1	0.151	0.013	0.067	0.011	0.084	0.014
25	1200	2	0.293	0.024	0.118	0.020	0.175	0.029
26	1380	1	0.227	0.019	0.086	0.014	0.141	0.024
27	2500	1	0.289	0.024	0.113	0.019	0.177	0.029
28	1800	2	0.138	0.011	0.043	0.007	0.094	0.016
29	2000	2	0.186	0.016	0.077	0.013	0.110	0.018
30	1057	2	0.398	0.033	0.119	0.020	0.279	0.046

Natural Gas Consumption Data for Energy Star

Energy Star/Natural Gas Consumption (Therms/Sqft)														
Sr. No.	Area (sq)	People stayed in 2008	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
1	1387	2	0.0155	0.0180	0.0079	0.0079	0.0034	0.0054	0.0079	0.0058	0.0050	0.0058	0.0079	0.0161
2	2262	4	0.0364	0.0341	0.0247	0.0161	0.0142	0.0158	0.0134	0.0134	0.0158	0.0183	0.0256	0.0364
3	2316	2	0.0242	0.0219	0.0043	0.0024	0.0024	0.0040	0.0040	0.0040	0.0083	0.0274	0.0274	0.0242
4	2350	2	0.0328	0.0342	0.0170	0.0114	0.0084	0.0072	0.0082	0.0096	0.0162	0.0176	0.0237	0.0328
5	4200	4	0.0267	0.0184	0.0118	0.0085	0.0072	0.0075	0.0061	0.0093	0.0128	0.0162	0.0196	0.0247
6	3500	3	0.0235	0.0190	0.0087	0.0117	0.0097	0.0121	0.0102	0.0102	0.0112	0.0115	0.0172	0.0381
7	4200	5	0.0247	0.0194	0.0133	0.0104	0.0091	0.0117	0.0093	0.0101	0.0099	0.0122	0.0154	0.0335
8	1652	3	0.0371	0.0371	0.0307	0.0307	0.0194	0.0183	0.0183	0.0183	0.0183	0.0250	0.0317	0.0307
9	2800	4	0.0268	0.0298	0.0222	0.0137	0.0118	0.0124	0.0108	0.0108	0.0128	0.0160	0.0203	0.0294
10	3400	3	0.0125	0.0165	0.0107	0.0123	0.0149	0.0105	0.0112	0.0131	0.0118	0.0112	0.0164	0.0155
11	2316	4	0.0209	0.0219	0.0154	0.0165	0.0142	0.0255	0.0212	0.0246	0.0222	0.0212	0.0135	0.0149
12	1650	2	0.0339	0.0339	0.0307	0.0275	0.0248	0.0318	0.0251	0.0284	0.0318	0.0284	0.0351	0.0371
13	3700	3	0.0251	0.0180	0.0137	0.0180	0.0194	0.0232	0.0247	0.0247	0.0292	0.0352	0.0397	0.0309
14	2037	3	0.0857	0.0873	0.0665	0.0613	0.0405	0.0257	0.0149	0.0149	0.0149	0.0149	0.0257	0.0301
15	1180	2	0.0663	0.0672	0.0546	0.0234	0.0107	0.0125	0.0063	0.0024	0.0032	0.0040	0.0040	0.0033
16	3500	3	0.0538	0.0562	0.0532	0.0079	0.0122	0.0207	0.0181	0.0210	0.0337	0.0448	0.0587	0.0674
17	1521	2	0.0211	0.0205	0.0153	0.0025	0.0072	0.0126	0.0111	0.0091	0.0111	0.0141	0.0155	0.0286
18	2500	3	0.0198	0.0203	0.0139	0.0125	0.0128	0.0161	0.0134	0.0134	0.0156	0.0196	0.0223	0.0211
19	1812	2	0.0513	0.0226	0.0153	0.0104	0.0177	0.0076	0.0051	0.0051	0.0082	0.0082	0.0247	0.0601
20	2041	2	0.0508	0.0466	0.0404	0.0336	0.0305	0.0311	0.0295	0.0068	0.0072	0.0083	0.0344	0.0622
21	2133	2	0.0287	0.0287	0.0287	0.0287	0.0287	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0068
22	1224	3	0.0647	0.0578	0.0363	0.0312	0.0262	0.0274	0.0247	0.0256	0.0292	0.0311	0.0446	0.0665
23	1521	3	0.0563	0.0507	0.0458	0.0199	0.0118	0.0192	0.0162	0.0170	0.0155	0.0155	0.0162	0.0193
24	1980	4	0.0253	0.0242	0.0131	0.0101	0.0101	0.0101	0.0101	0.0101	0.0111	0.0111	0.0162	0.0293
25	1812	2	0.0297	0.0274	0.0196	0.0245	0.0302	0.0277	0.0363	0.0338	0.0320	0.0271	0.0262	0.0285
26	2040	2	0.0300	0.0274	0.0200	0.0071	0.0094	0.0147	0.0147	0.0147	0.0045	0.0094	0.0071	0.0092
27	1980	1	0.0202	0.0141	0.0061	0.0061	0.0071	0.0056	0.0051	0.0040	0.0056	0.0071	0.0081	0.0263
28	1643	3	0.0244	0.0206	0.0088	0.0077	0.0084	0.0096	0.0096	0.0096	0.0084	0.0084	0.0099	0.0276
29	1812	3	0.0513	0.0426	0.0226	0.0226	0.0228	0.0198	0.0167	0.0106	0.0106	0.0136	0.0226	0.0338
30	2040	2	0.0534	0.0347	0.0269	0.0187	0.0175	0.0137	0.0154	0.0148	0.0192	0.0208	0.0213	0.0466

Energy Star/Natural Gas Consumption (Therms/Sqft)								
Sr. No.	Area (sq)	People stayed in 2008	Annual Natural Gas Consumption	Average Annual Natural Gas Consumption	Summer (May - Oct) Natural Gas Consumption	Average Summer (May - Oct) Natural Gas Consumption	Winter (Nov - April) Natural Gas Consumption	Average Winter (Nov - April) Natural Gas Consumption
1	1387	2	0.1067	0.0089	0.0333	0.0056	0.0734	0.0122
2	2262	4	0.2643	0.0220	0.0909	0.0151	0.1734	0.0289
3	2316	2	0.1545	0.0129	0.0502	0.0084	0.1044	0.0174
4	2350	2	0.2191	0.0183	0.0671	0.0112	0.1520	0.0253
5	4200	4	0.1687	0.0141	0.0591	0.0098	0.1096	0.0183
6	3500	3	0.1831	0.0153	0.0649	0.0108	0.1182	0.0197
7	4200	5	0.1789	0.0149	0.0623	0.0104	0.1166	0.0194
8	1652	3	0.3156	0.0263	0.1177	0.0196	0.1978	0.0330
9	2800	4	0.2168	0.0181	0.0745	0.0124	0.1423	0.0237
10	3400	3	0.1567	0.0131	0.0728	0.0121	0.0839	0.0140
11	2316	4	0.2320	0.0193	0.1289	0.0215	0.1031	0.0172
12	1650	2	0.3685	0.0307	0.1703	0.0284	0.1982	0.0330
13	3700	3	0.3015	0.0251	0.1562	0.0260	0.1453	0.0242
14	2037	3	0.4821	0.0402	0.1256	0.0209	0.3565	0.0594
15	1180	2	0.2579	0.0215	0.0392	0.0065	0.2187	0.0365
16	3500	3	0.4478	0.0373	0.1504	0.0251	0.2973	0.0496
17	1521	2	0.1688	0.0141	0.0652	0.0109	0.1036	0.0173
18	2500	3	0.2009	0.0167	0.0911	0.0152	0.1099	0.0183
19	1812	2	0.2362	0.0197	0.0518	0.0086	0.1843	0.0307
20	2041	2	0.3814	0.0318	0.1135	0.0189	0.2680	0.0447
21	2133	2	0.2042	0.0170	0.0736	0.0123	0.1306	0.0218
22	1224	3	0.4655	0.0388	0.1643	0.0274	0.3012	0.0502
23	1521	3	0.3036	0.0253	0.0952	0.0159	0.2083	0.0347
24	1980	4	0.1808	0.0151	0.0626	0.0104	0.1182	0.0197
25	1812	2	0.3430	0.0286	0.1871	0.0312	0.1559	0.0260
26	2040	2	0.1683	0.0140	0.0675	0.0112	0.1009	0.0168
27	1980	1	0.1152	0.0096	0.0343	0.0057	0.0808	0.0135
28	1643	3	0.1531	0.0128	0.0542	0.0090	0.0989	0.0165
29	1812	3	0.2894	0.0241	0.0940	0.0157	0.1954	0.0326
30	2040	2	0.3032	0.0253	0.1015	0.0169	0.2017	0.0336

APPENDIX D

ENERGY BILLS SAMPLES

Electricity Bill – February

NVEnergy Online Pay paperless billing

ACCOUNT NUMBER: [redacted]

Service Address: [redacted]

Customer: [redacted]
Premises: [redacted]

2/11/2009
[redacted]

Next Meter Read Date	Due Date	TOTAL AMOUNT DUE
Mar 10,2009	Feb 27,2009	$49.56

PREVIOUS BALANCE	PAYMENTS	ADJUSTMENTS	BALANCE FORWARD	CURRENT CHARGES
$71.42	$71.42 CR	$.00	$.00	$49.56

News **Bill Inserts**

Nevada Energy Connection may help pay your bill; call to see if you qualify. Local (702) 486-1404 or toll-free (866) 846-2009.
Thank you for maintaining an excellent payment record. We look forward to serving you in the future.

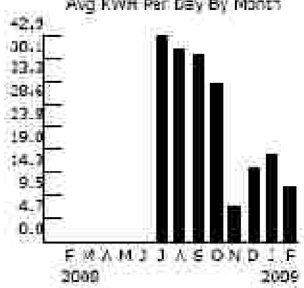
Summary | Electric Service | Contact Information | View Back of Bill

ELECTRIC - RESIDENTIAL SERVICE

Meter Number	Service Period From	Service Period To	Bill Days	Meter Readings Previous	Meter Readings Current	Meter Multiplier	Billing Usage
[redacted]	Jan 7	Feb 6	30	6982	7328	1	346

ELECTRIC CONSUMPTION	346.00 KWH x .1118100	38.69
TEMP. GREEN POWER FINANCING (TRED)	346.00 KWH x .0004100	.14
RENEWABLE ENERGY PROGRAM (REPR)	346.00 KWH x .0007100	.25
BASIC SERVICE CHARGE		8.00
CITY OF HENDERSON FRANCHISE TAX	5%	2.35
UNIVERSAL ENERGY CHARGE	346.00 KWH x .0003900	.13
TOTAL ELECTRIC SERVICE AMOUNT		**$49.56**

USAGE HISTORY	NO. DAYS	KWH	AVG KWH PER DAY	AVG COST PER DAY
THIS MONTH	30	346	11.5	1.65
LAST MONTH	30	548	18.3	



Water Bill – December

City of Henderson Utility Services • www.cityofhenderson.com/utilities • (702) 267-5900
City Hall Office: 240 Water Street

This is your Water and Sewer Service Bill

This bill is a summary of services provided to your service address and is due on the date indicated at right. Failure to pay current and/or past charges will result in a 10% late fee and could cause loss of service.

Detail of Current Charges

Your Previous Bill	$43.04		
Payment Received	$43.04 CR		
Balance Forward			$0.00
Sewer - Residential			
Sewer Base Svc Charge-Residential	$3.50		
Sewer Usage Charge Residential	$15.13		
Clean Water Coalition Surcharge	$0.75		
Sewer Services Non Metered Total		$19.38	
WTR service with Fire Protection Line			
6,600 Gallons at 1.46 per 1000 Gallons	$9.64		
3,124 Gallons at 1.90 per 1000 Gallons	$5.94		
WTR service with Fire Protection	$8.20		
SNWA Commodity Charge: 9,724 gal. at $0.10 per 1000	$0.97		
SNWA Reliability Surcharge - Residential	$0.06		
Wtr with a Fire Protection Line Total		$24.81	
Charges for this period			$44.19
Total Amount Due			$44.19

Look on the back of your bill to see your consumption history and learn valuable customer information!

Your Account Summary

Your [redacted] **ber**

Service Address

[redacted]

Service Period

33 Days in Service Period

Charges for this Period

$44.19

Unpaid Balance

$0.00

Thank you for your prompt payment

Other Credits & Charges

$0.00

Direct Pay Information

You can set up your account to be paid automatically each month! Contact us to learn how!

Your Bill is Due

01/20/09

Please allow 5 days for mailing

Total Amount Due

$44.19

Please pay this amount

Natural Gas Bill – January

SOUTHWEST GAS CORPORATION

Customer Assistance:
1-877-860-6020
Hearing Impaired:
Dial 711

Customer: [redacted]

Service Address: [redacted]

Rate Schedule: 510/SG-1 RESIDENTIAL GAS SERVICE

ACCOUNT NUMBER	CYCLE	DATE MAILED	DUE DATE	PLEASE PAY AMOUNT DUE
[redacted]	19	02/03/09	02/23/09	$101.77

Due on or before: 02/23/09 **Amount due: $101.77**

```
PREVIOUS BILLING:
  Previous Balance                                          124.69
  Payment(s) Since Last Bill - Thank You                    124.69CR
    Balance Forward                                                 $0.00
---------------------------------------------------------------------------
CURRENT BILLING:     30 Days
  Meter Reading: Current   Previous          Billing   Total
                 Jan. 30   Dec. 31           Factor    Therms
                   9148 -    9061 =     87 X   .9665 =     84
  Delivery Charge
           First Tier        45 Therms X   .351490
           Next  Tier        39 Therms X   .160500
  Total Delivery Charge                              =            22.08
  Gas Cost               Total Therms X   .783420   =            65.81
  Basic Service Charge                                             8.50
  Local Taxes                                                      5.10
  Universal Energy Charge                                          0.28
  Current Bill                                                          $101.77
---------------------------------------------------------------------------
To pay by Western Union Speedpay
call (866) 263-5188 toll free.
```

ACCOUNT NUMBER: [redacted]

Previous Balance	Payments & Adjustments	Balance Forward	Current Bill	Current Balance	AMOUNT DUE
124.69	- 124.69	= 0.00	+ 101.77	= 101.77	$101.77

Important Messages:
Your next meter read date is: Mar. 03, 2009

Natural Gas Bill – June

SOUTHWEST GAS CORPORATION

Customer Assistance:
1-877-860-6020
Hearing Impaired:
Dial 711

Customer: [redacted]

Service Address: [redacted]

Rate Schedule: 510/SG-1 RESIDENTIAL GAS SERVICE

ACCOUNT NUMBER	CYCLE	DATE MAILED	DUE DATE	PLEASE PAY AMOUNT DUE
[redacted]	19	07/02/09	07/21/09	$27.20

Due on or before: 07/21/09 **Amount due: $27.20**

```
PREVIOUS BILLING:
  Previous Balance                                                    30.05
  Payment(s) Since Last Bill - Thank You                              30.05CR
    Balance Forward                                                           $0.00
---------------------------------------------------------------------------------
CURRENT BILLING:     29 Days
  Meter Reading: Current   Previous         Billing   Total
                 June 30   June 01          Factor    Therms
                   9290 -    9273 =    17 X   .9591 =     16
  Delivery Charge
           First Tier        15 Therms X   .351490
           Next  Tier         1 Therms X   .160500
  Total Delivery Charge                              =               5.43
  Gas Cost                Total Therms X   .741890   =              11.86
  Basic Service Charge                                               8.50
  Local Taxes                                                        1.36
  Universal Energy Charge                                            0.05
  Current Bill                                                             $27.20
---------------------------------------------------------------------------------
To pay by Western Union Speedpay
call (866) 263-5188 toll free.
```

ACCOUNT NUMBER: [redacted]

Previous Balance	Payments & Adjustments	Balance Forward	Current Bill	Current Balance	AMOUNT DUE
30.05	- 30.05	= 0.00	+ 27.20	= 27.20	$27.20

Important Messages:
Your next meter read date is: July 30, 2009

APPENDIX E

HISTOGRAMS FOR THE PEARSON CORRELATION COEFFICIENT TEST

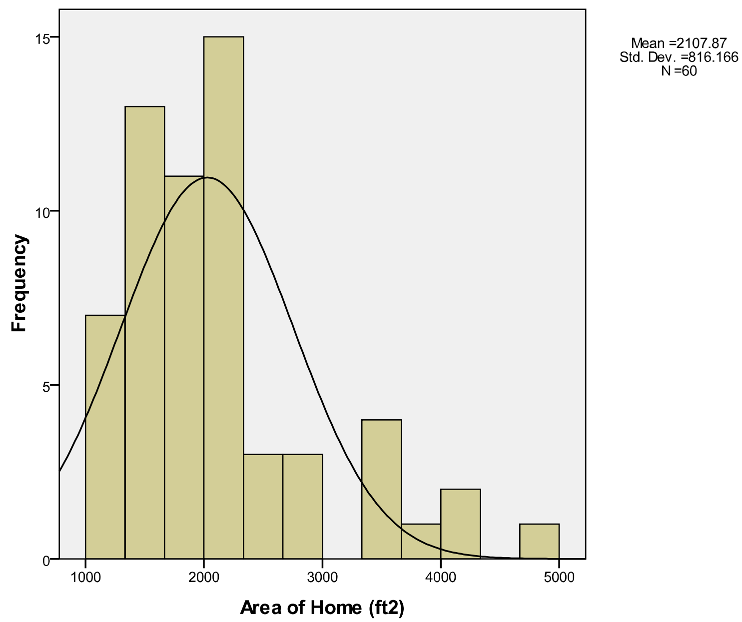


Figure E.1: Histogram for area of home (ft^2)

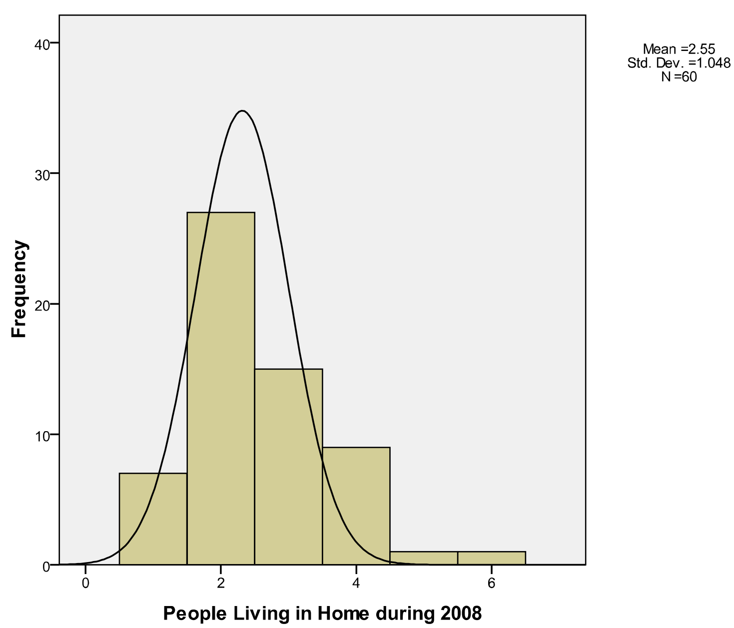


Figure E.2: Histogram for number of people living in home during 2008

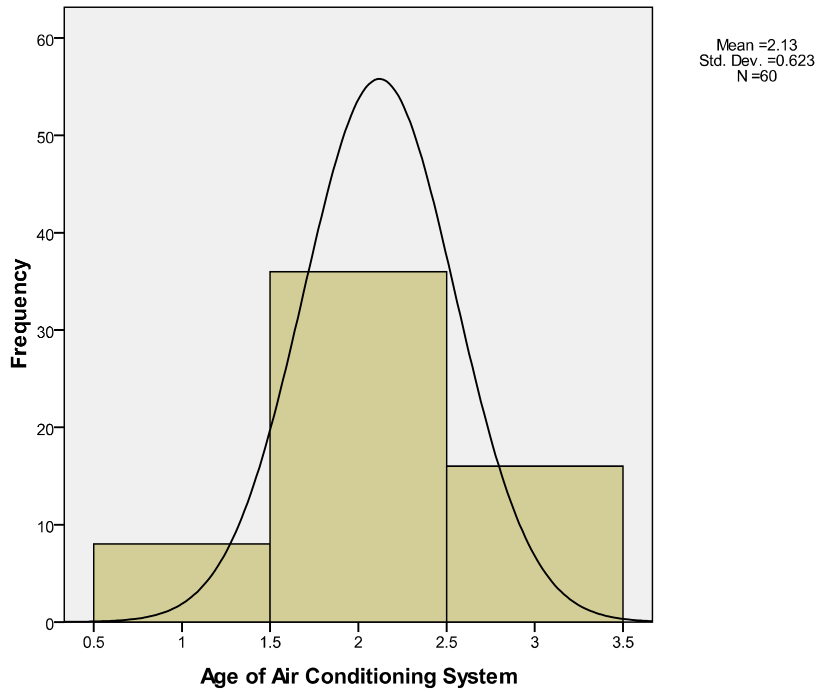


Figure E.3: Histogram for age of air conditioning system

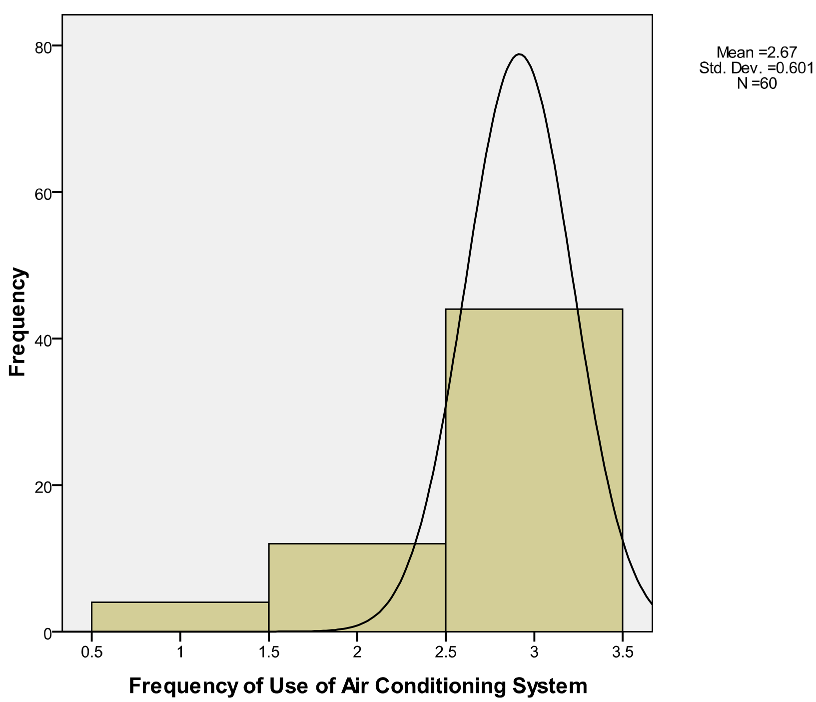


Figure E.4: Histogram for frequency of use of air conditioning system

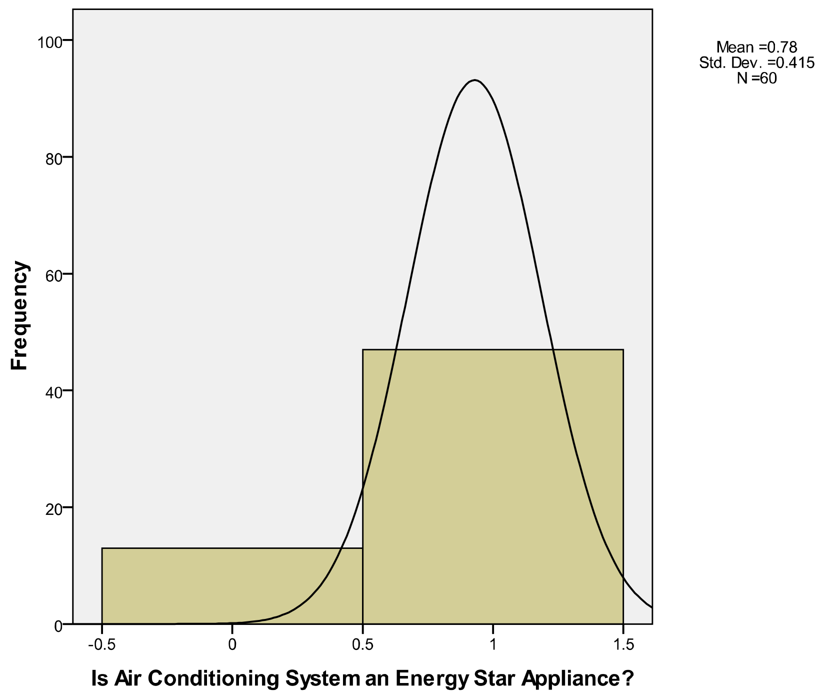


Figure E.5: Histogram for whether air conditioning system was an Energy Star appliance

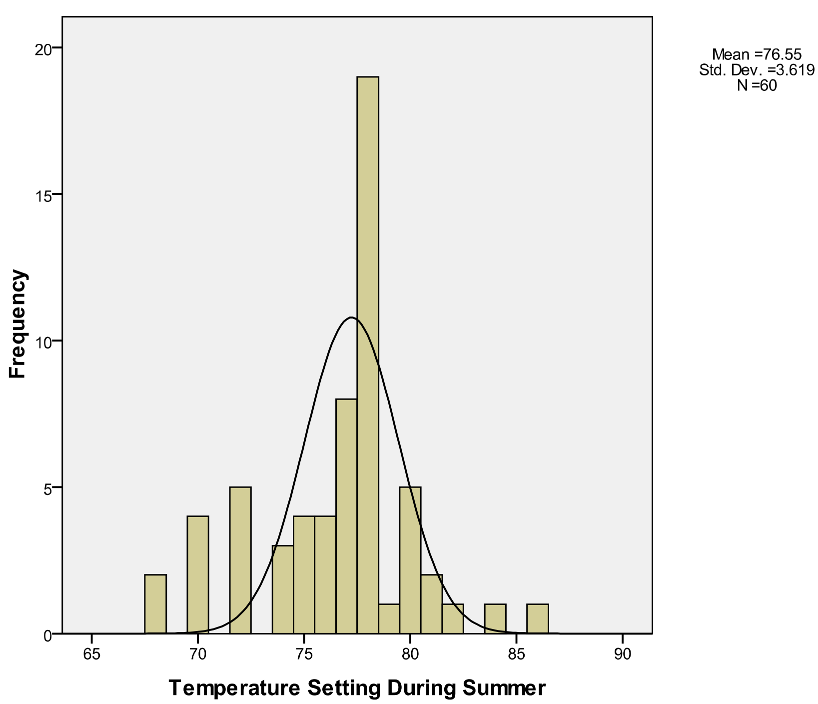


Figure E.6: Histogram for temperature setting during summer months

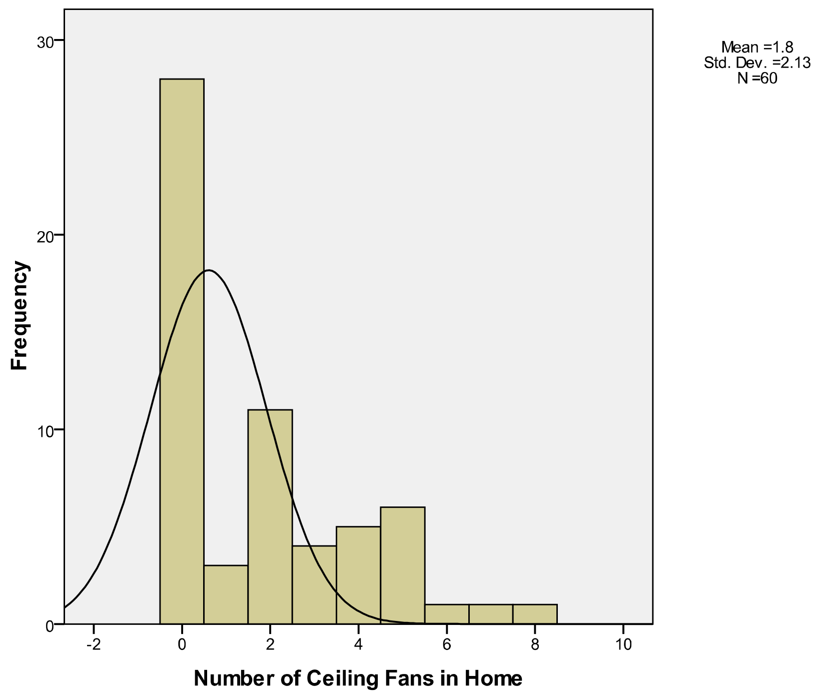


Figure E.7: Histogram for number of ceiling fans in home

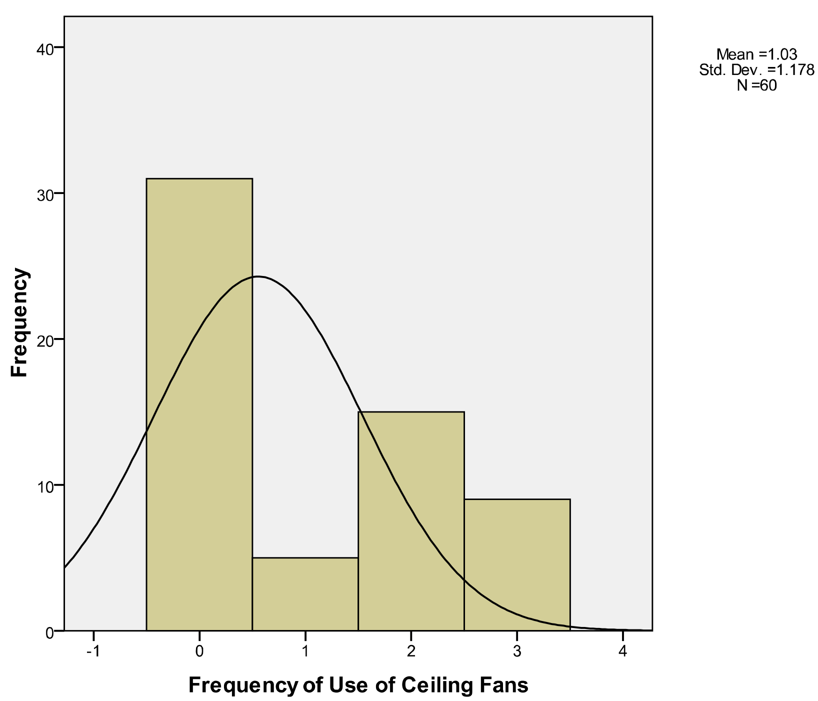


Figure E.8: Histogram for frequency of use of ceiling fans in home

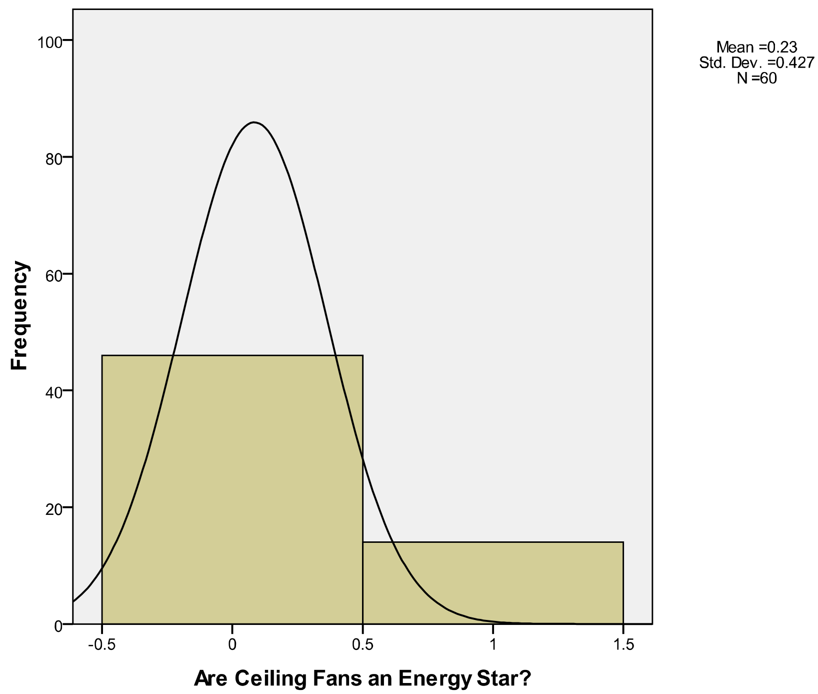


Figure E.9: Histogram for whether ceiling fans in home were Energy Star appliances

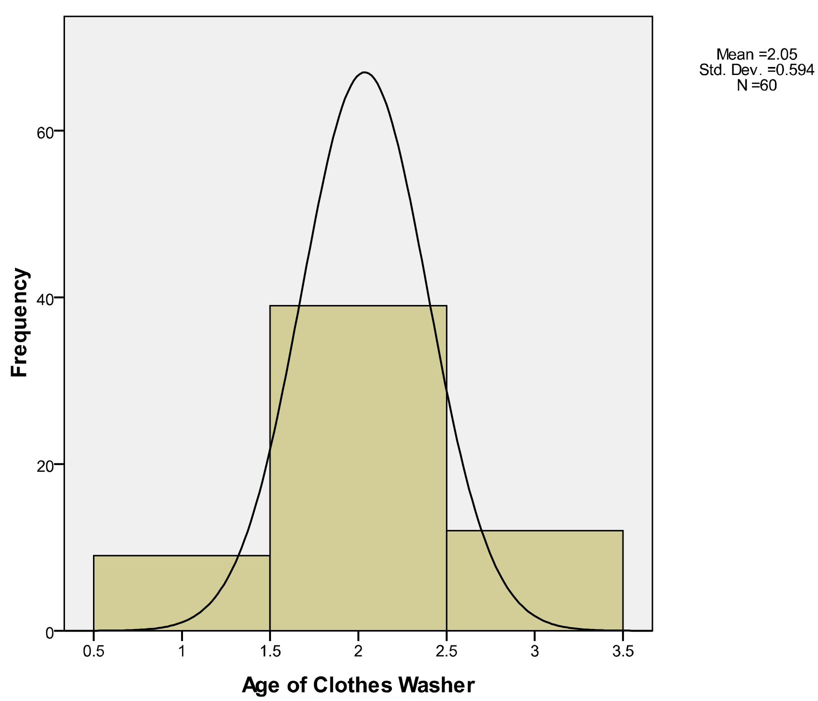


Figure E.10: Histogram for age of clothes washer

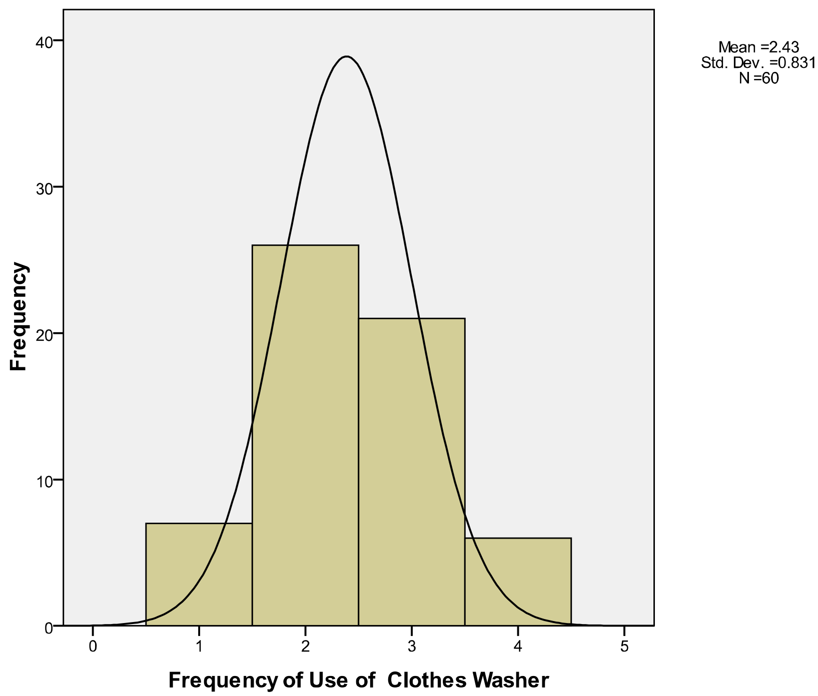


Figure E.11: Histogram for frequency of use of clothes washer

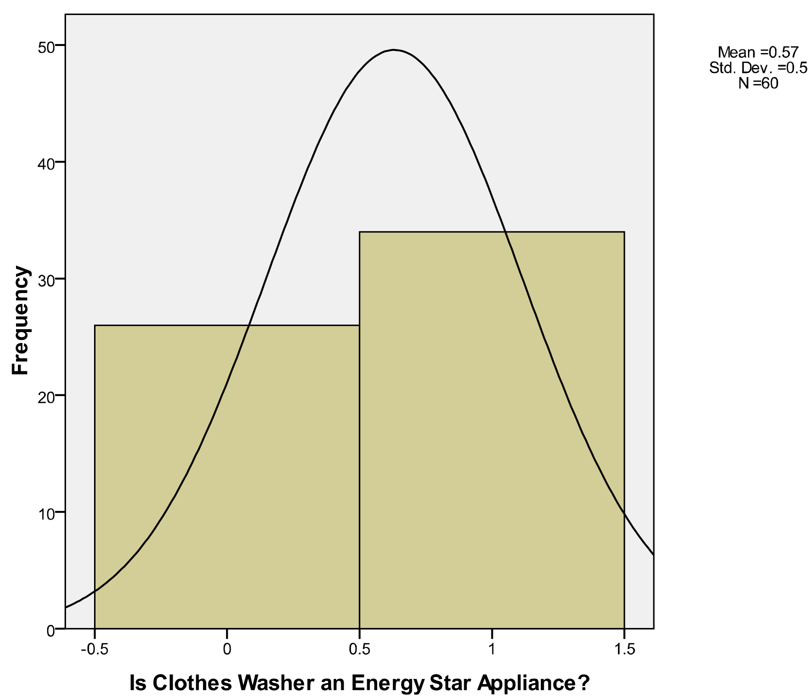


Figure E.12: Histogram for whether clothes washer was an Energy Star appliance

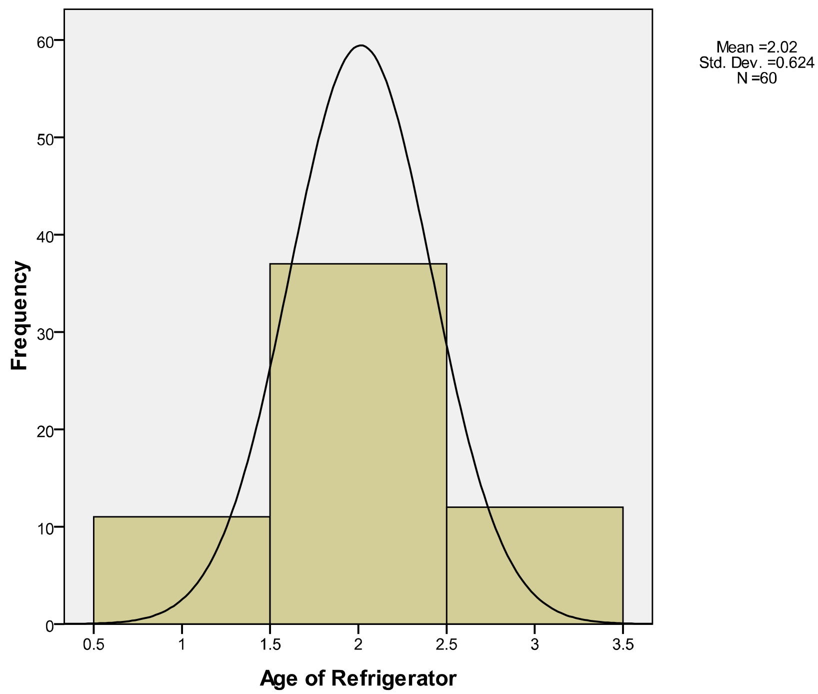


Figure E.13: Histogram for age of refrigerator

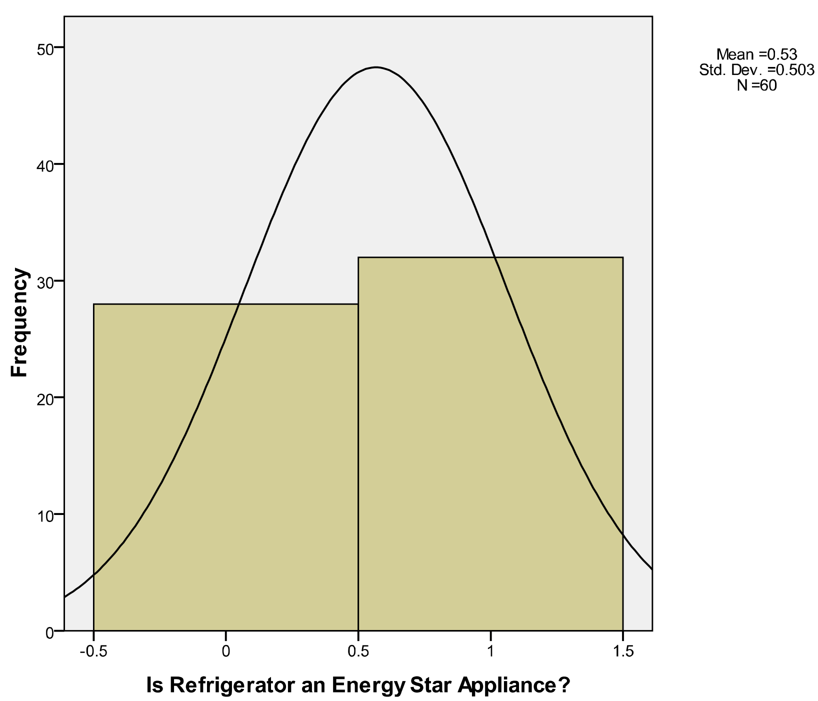


Figure E.14: Histogram for whether refrigerator was an Energy Star appliance

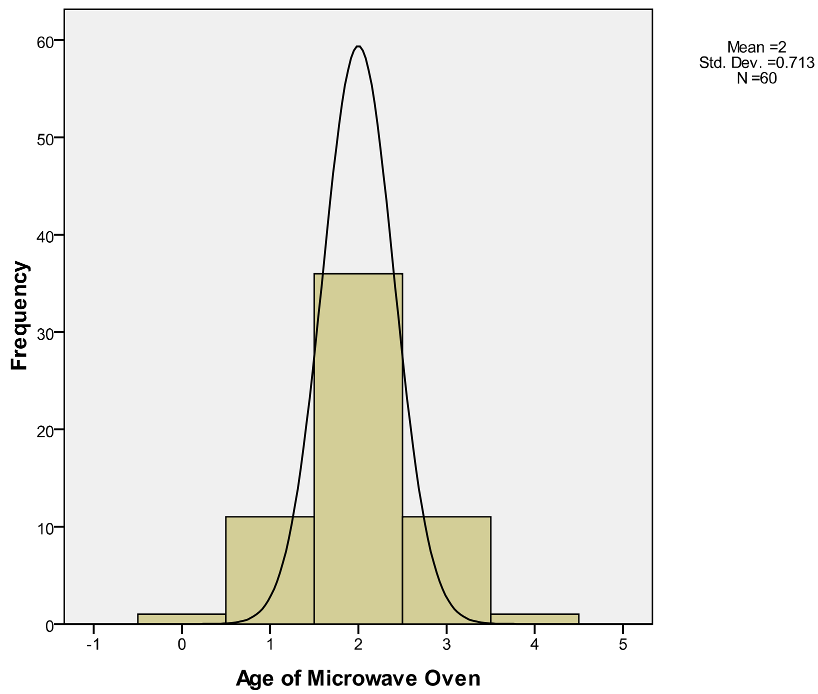


Figure E.15: Histogram for age of microwave oven

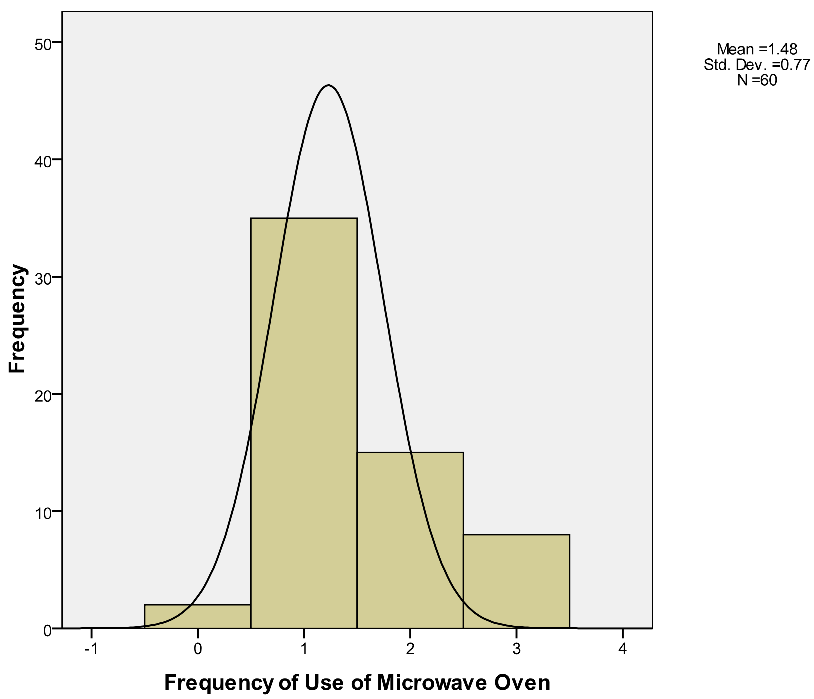


Figure E.16: Histogram for frequency of use of microwave oven

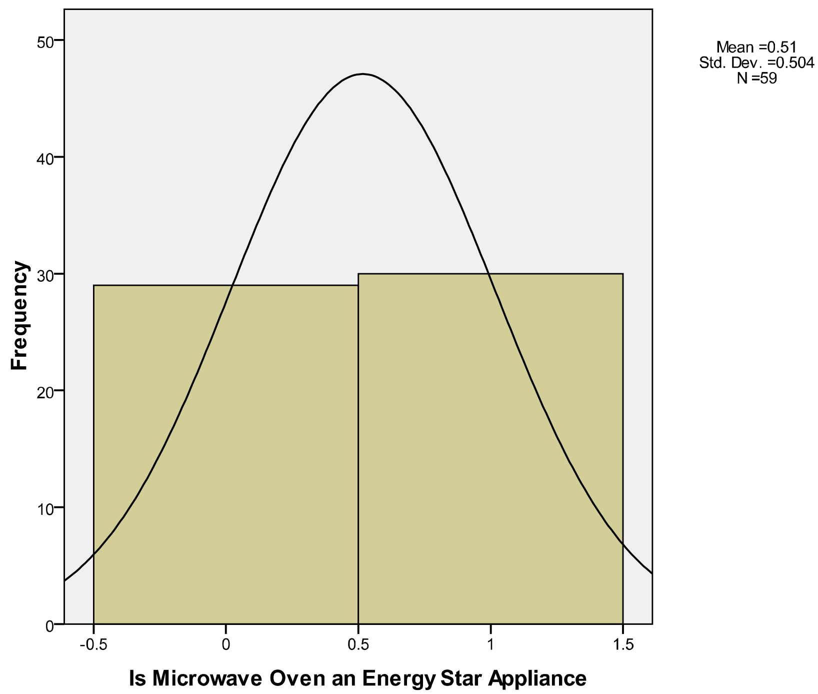


Figure E.17: Histogram for whether microwave oven was an Energy Star appliance

Figure E.18: Histogram for age of dishwasher

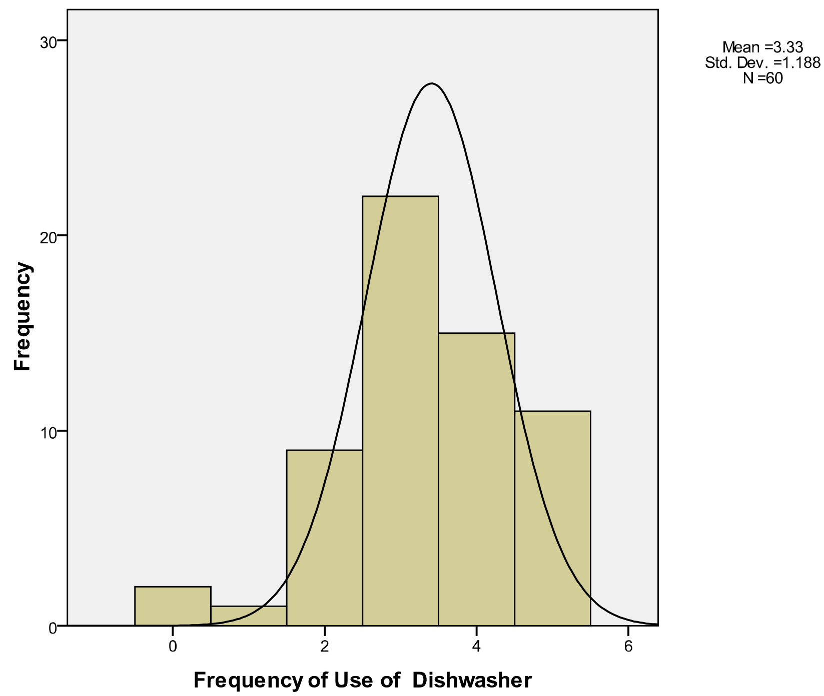


Figure E.19: Histogram for frequency of use of dishwasher

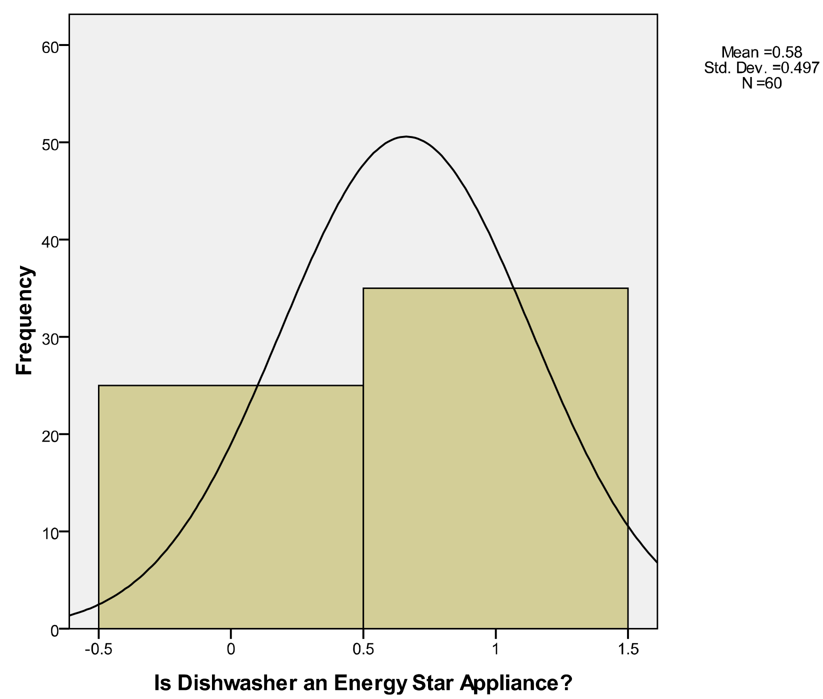


Figure E.20: Histogram for whether dishwasher was an Energy Star appliance

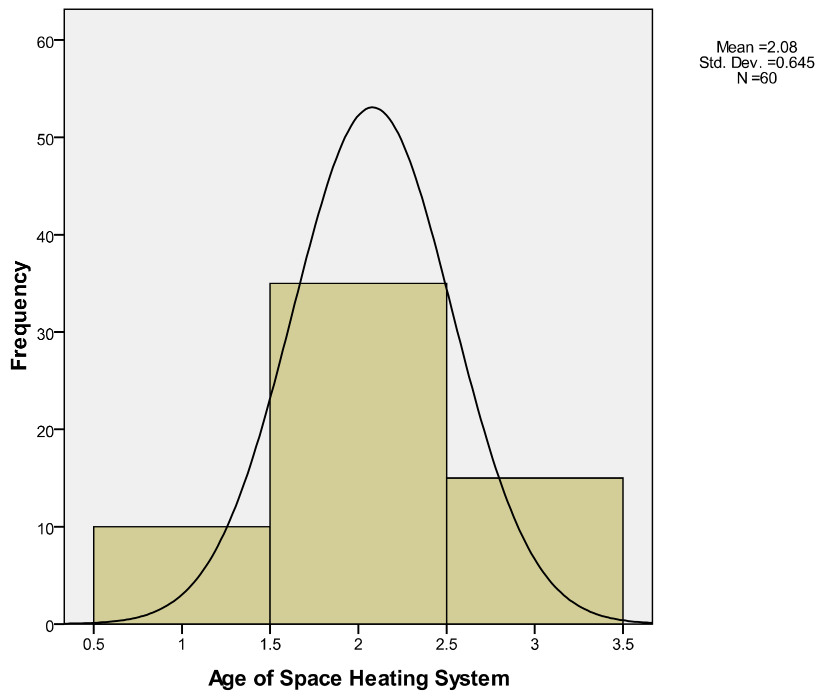


Figure E.21: Histogram for age of space heating system

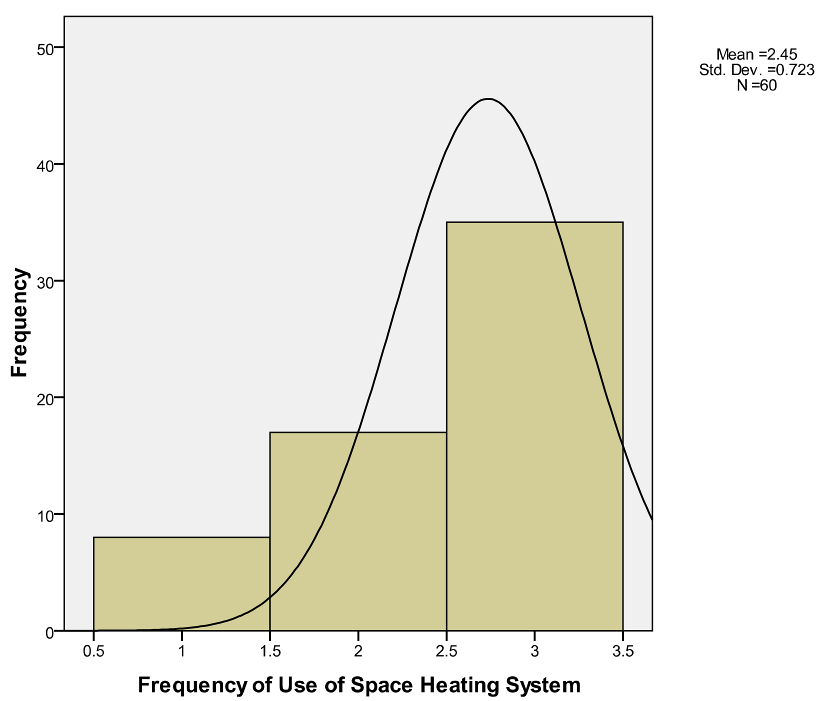


Figure E.22: Histogram for frequency of use of space heating system

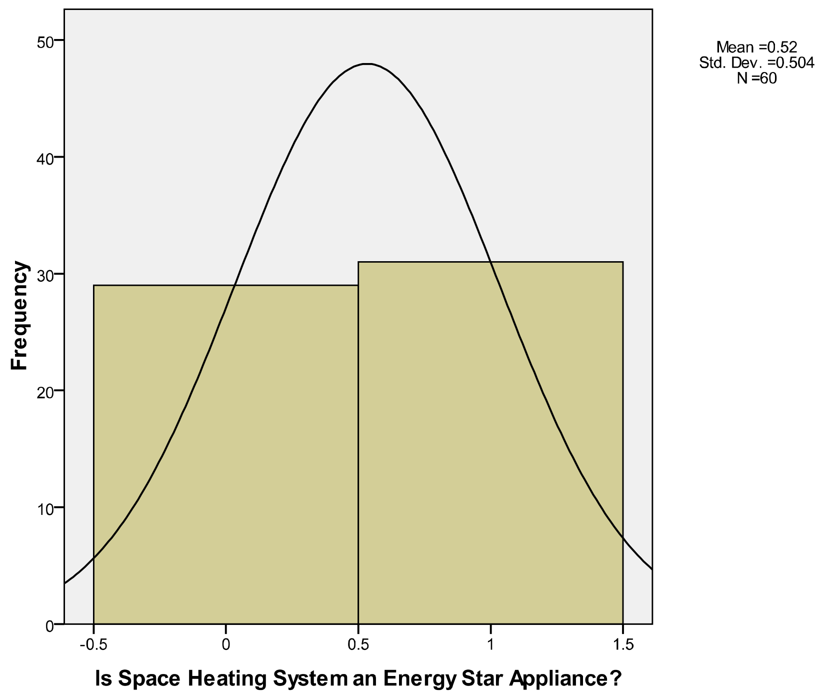


Figure E.23: Histogram for whether space heating system was an Energy Star appliance

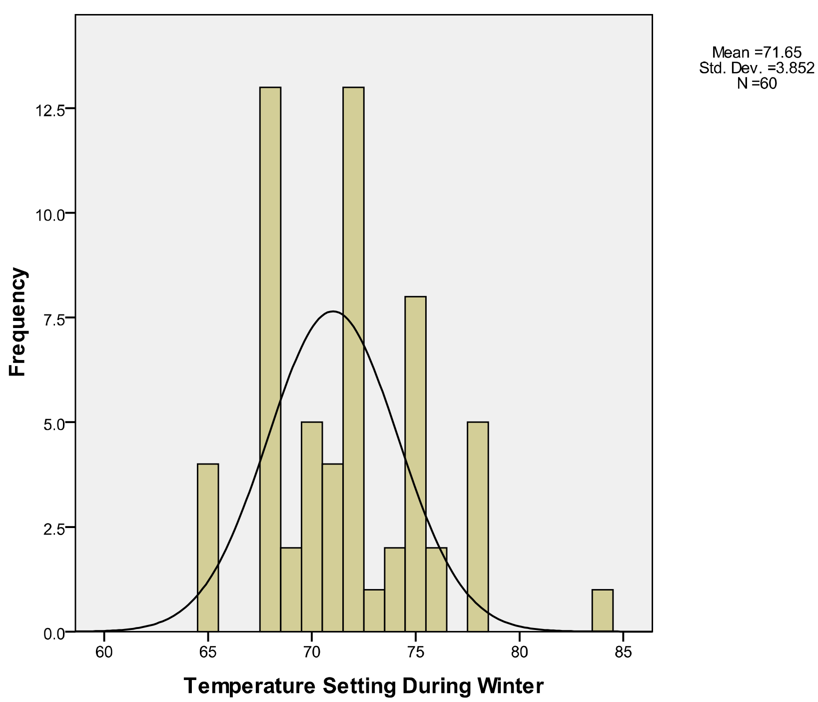


Figure E.24: Histogram for temperature setting during winter months

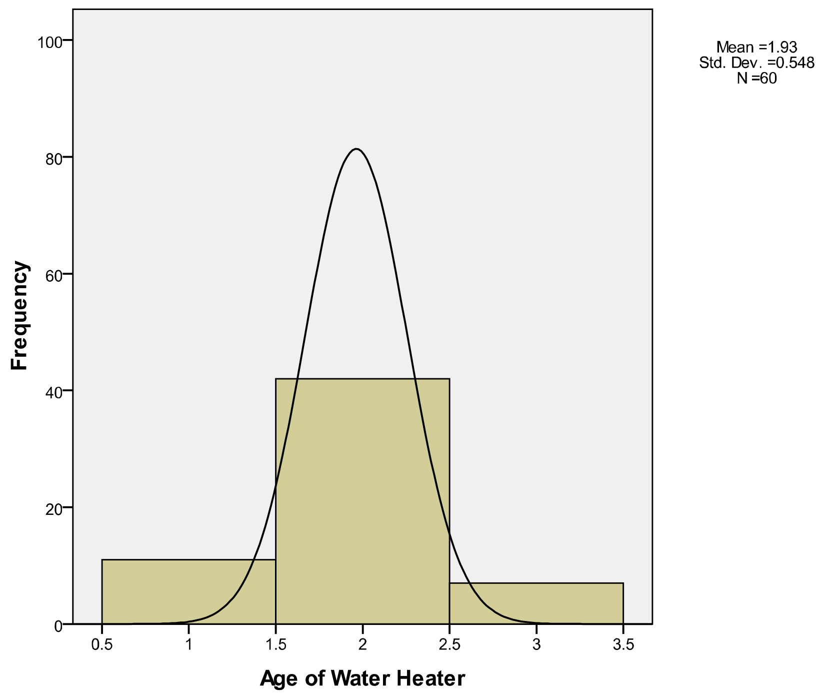


Figure E.25: Histogram for age of water heater

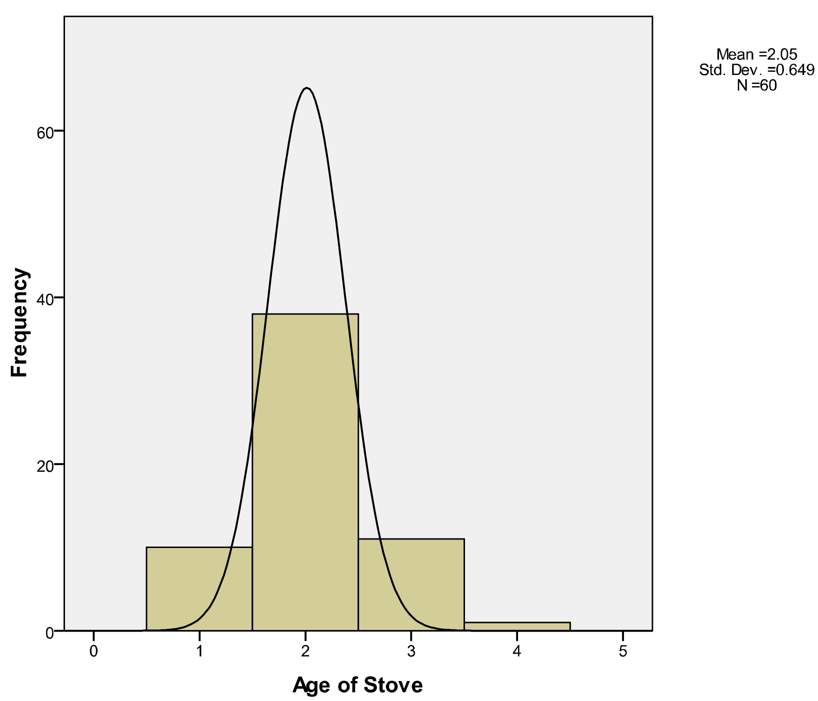


Figure E.26: Histogram for age of stove

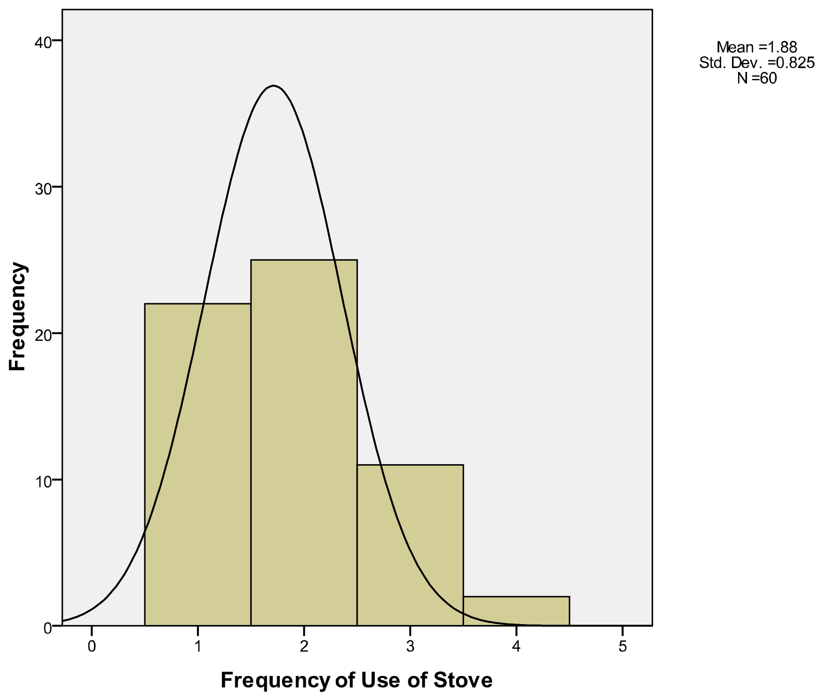


Figure E.27: Histogram for frequency of use of stove

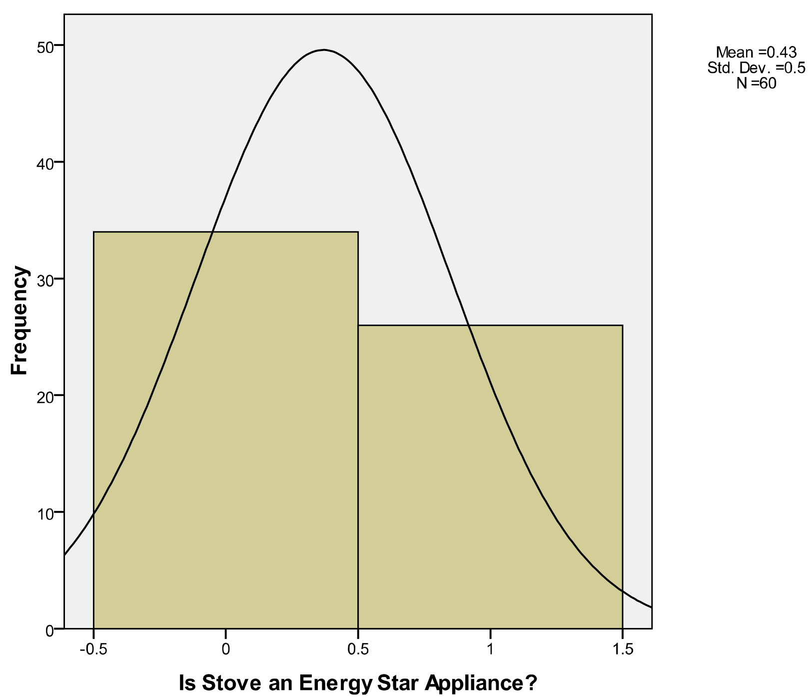


Figure E.28: Histogram for whether stove was an Energy Star appliance

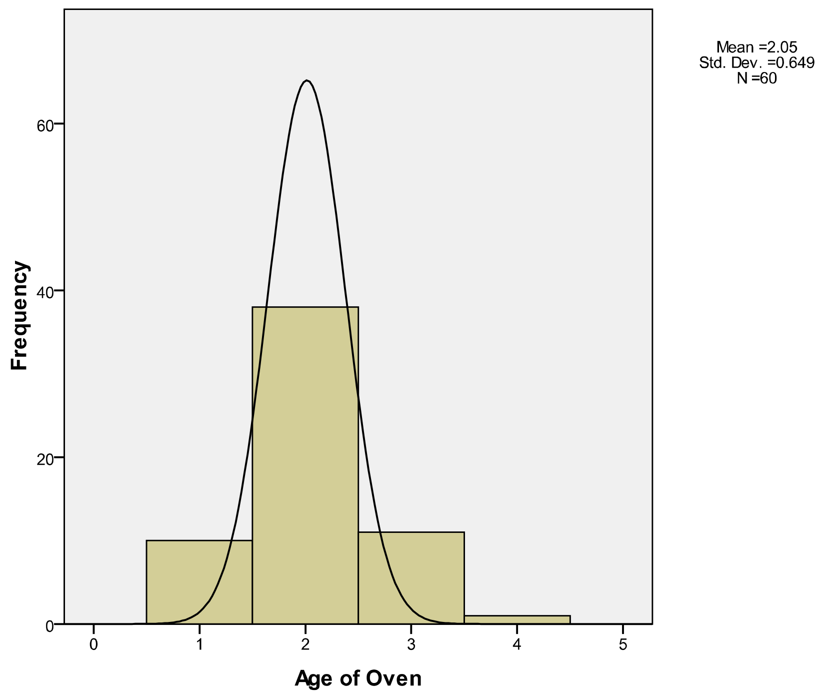


Figure E.29: Histogram for age of oven

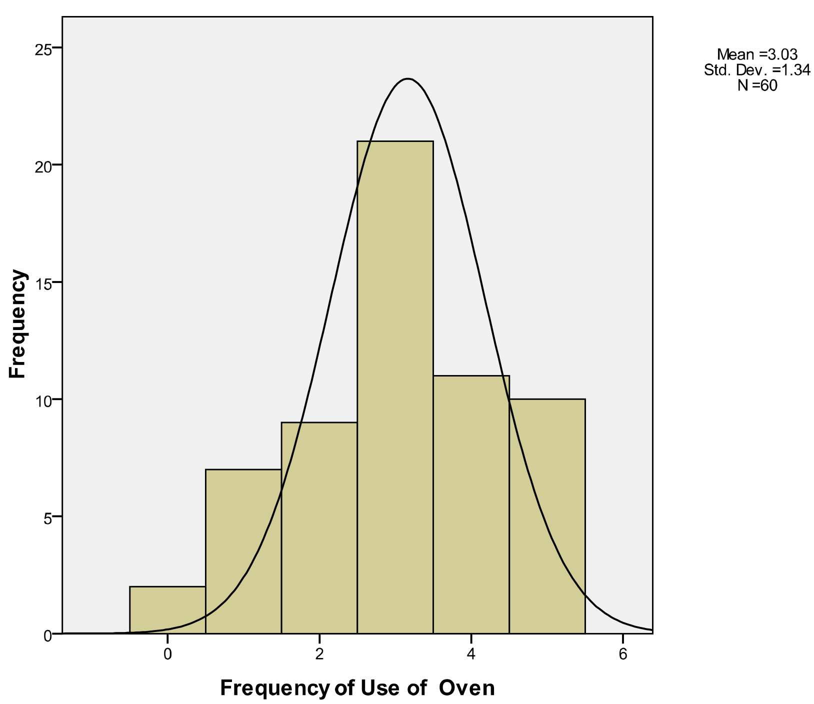


Figure E.30: Histogram for frequency of use of oven

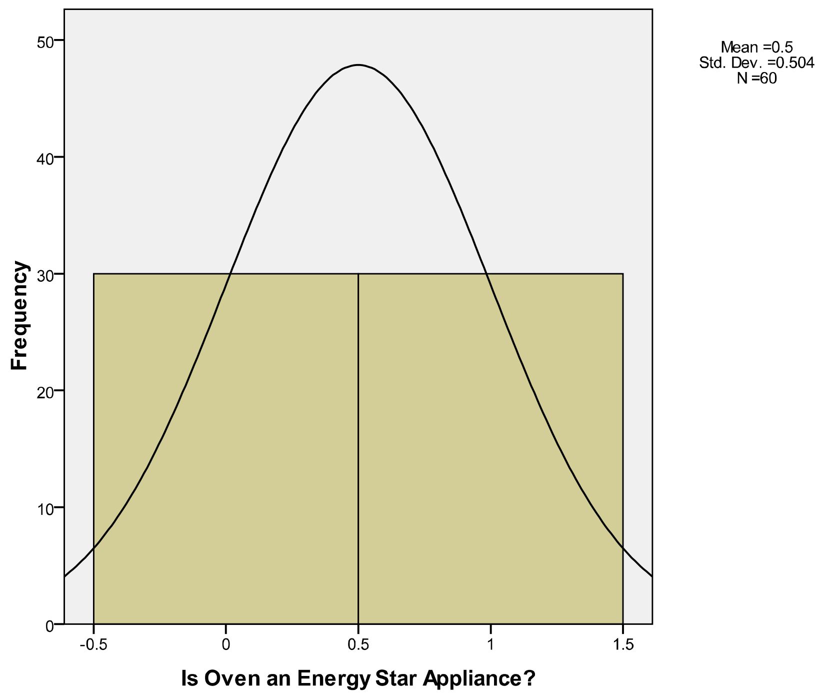


Figure E.31: Histogram for whether oven was an Energy Star appliance

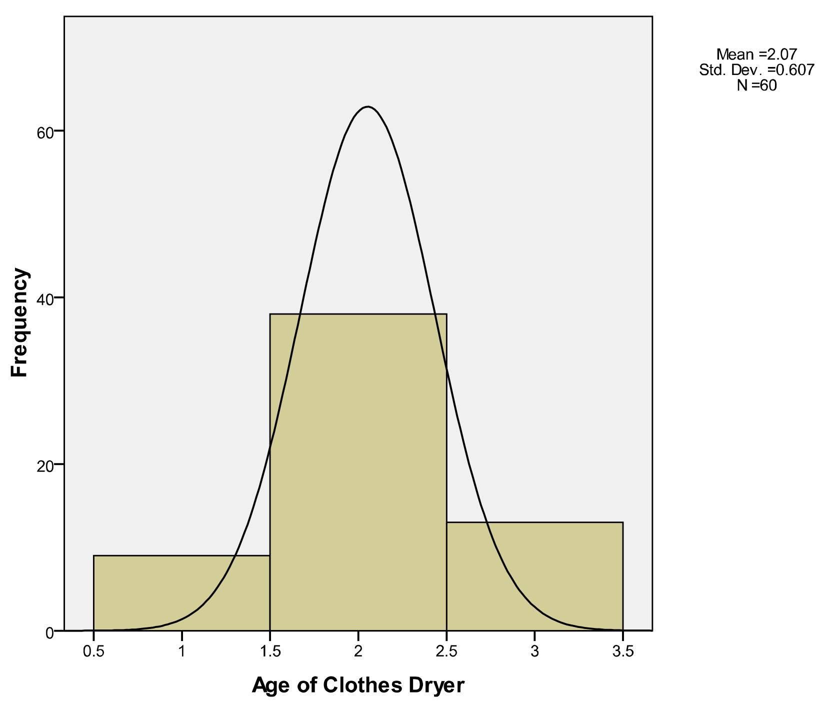


Figure E.32: Histogram for age of clothes dryer

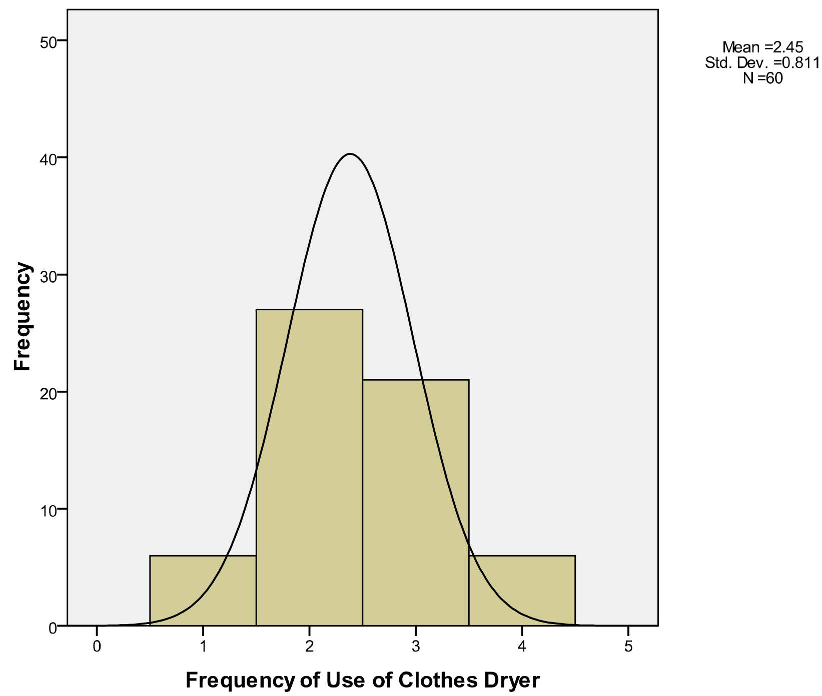


Figure E.33: Histogram for frequency of use of clothes dryer

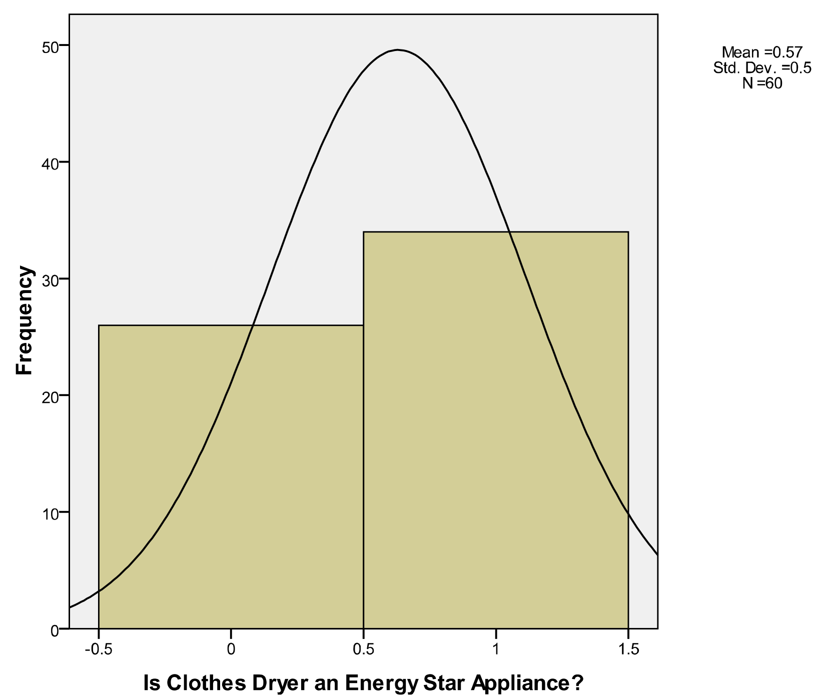


Figure E.34: Histogram for whether clothes dryer was an Energy Star appliance

REFERENCES

Aste, N., Angelotti, A., and Buzzetti, M. (2009). "The influence of the external walls thermal inertia on the energy performance of well insulated buildings." *Energy Build.,* 41(11), 1181-1187

Aydinalp, M.,Ugursal, I. V., and Fung, A. S. (2002). "Modeling of the appliance, lighting, and space-cooling energy consumptions in the residential sector using neural networks." *Appiled.Energy,* 71(2), 87-110

Autodesk Ecotect (2009). “Admittance” <http://ecotect.org>, (November 23, 2009)

Beretta, G.P. (2007). “World energy consumption and resources: an outlook for the rest of the century.” *Int. J. Environmental Technology and Management*., Vol 7, Nos. ½, 99-112

Capdevila, L., Gomez, A., Gomez D. (2008). “Climate change and energy crisis: common solutions.” *Council Adviser for Sustainable Development.,* 77-81

Desjarlais, A. O., (2008). “Insulation fact sheet” *Oak Ridge National Laboratory,* <http://www.ornl.gov> (November 23, 2009)

Effective Windows Collaborative (2009). “Window technology Low-e coating”, *Center for Sustainable Building Research, Alliance to Save Energy, Lawrence Berkeley Laboratory*, < http://www.efficientwindows.org> (October 16, 2009)

Energy Information Administration (2009). Department of Energy, Official Energy Statistics from the U.S. Government, <http//www.eia.doe.gov>, (October 13, 2009)

Energy Information Administration (2009), “State energy profiles”, <http://www.eia.doe.gov>, (November 23, 2009)

Feuermann, D., and Novoplansky, A. (1998). "Reversible low solar heat gain windows for energy savings." *Solar Energy,* 62(3), 169-175

Granade, H. C., Creyts, J., Derkach, A., Farese, P., Nyquist, S., Ostrowski, K., (2009). “Unlocking energy efficiency in U.S. economy.” *Mckinsey Global Energy and Materials*, 33 – 35

Grassroots (2007). “R-values of common building materials” *R-values of building material – Grassroots Home Inspection*, < http://www.grassroots.ca> (Sep 28, 2009)

Greening, L. A., Greene, D. L., Difiglio, C., (2000). “Energy efficiency and consumption – the rebound effect – a survey.” *Energy Policy,* 28, 389-401

Gugliermetti, F., Bisegna, F., (2005). “Saving energy in residential buildings: the use of fully reversible windows.” *Energy,* 32, 1235-1247

Hayward T., (2009). “BP statistical review of world energy” *British Petroleum Statistical Review,* London, UK, 22-39

Hens, H., Parijs, W., Deurinck M., (2009). “Energy consumption for heating and rebound effects” *Energy and Buildings*, 1-6

Hitchcock, G., (1993). “An integrated framework for energy use and behavior in the domestic sector” *Energy and Buildings,* 20*,* 151-157

Ho, S. H., Rosario, L., and Rahman, M. M. (2009). "Thermal comfort enhancement by using a ceiling fan." *Appl.Therm.Eng.,* 29(8-9), 1648-1656

Hoffman J. S., Wells J. B., Guiney W. T., (1998). “Transforming the market for solar water heaters: a new model to build a permanent sales force”. *Renewable Energy Policy Project,* 1-15

James, P. W., Sonne J. K., Vieira E. K., Parker D. S., Anello M. T., (1996). “Are energy saving due to ceiling fans just hot air?” *Florida Solar Energy Center,* 1-9

Janis R. R., Tao W. K. Y., (2005). “Mechanical and electrical systems in buildings.” *Pearson Prentice Hall,* Upper Saddle River, New Jersey, 41-62

Kadoshin S., Nishiyama T., Ito T., (2000). “The trend in current and near future energy consumption from a statistical perspective”. *Applied Energy,* 67*,* 407-417

Kaiser F. G., Wolfing S., Fuhrer, U., (1999). “Environmental attitude and ecological behavior”. *Journal of Environmental Psychology,* 19*,* 1-19

Kosny J., (2008). “R–value misconceptions: How the same wall can have several different R – values?” *Better Building by Design Conference,* Burlington, VT

Kosny, J., Yarbrough, D. W., Childs, P., Mohiuddin S. A., (2008). “Couple secrets about how framing is effecting the thermal performance of wood and steel framed walls”. 1-21

Levine, D. M., Stephan D. F., Krehbiel T. C., Berenson M. L., (2007). “Statistics for managers” *Pearson Prentice Hall,* Upper Saddle River, New Jersey, 8-10, 124-128, 422-432

Low Energy Architecture Research Unit, (2009). “Time lag and decrement factor”, < www.learn.londonmet.ac.uk> (October 16, 2009)

Newborough, M., Augood, P.,(1999). “Demand-side management opportunities for the UK domestic sector”. *IEE Proceedings of generation Transmission and Distribution,* 146, 283-293

Priddle R., (2000). “World energy outlook 2000.” *International Energy Agency,* Paris, France

Raaij W. F., Verhallen T. M. M., (1983). “Patterns of residential energy behavior”. *Journal of Economic Psychology,* 4*,* 85-106

Rashkin, S., R.A., (2000). "If home energy ratings are the solution for energy efficient new homes, what's the problem?". *Residential Buildings: Program Design, Implementation and Evaluation,* 2279-2285

Roberson, J. A., Brown, R. E., Koomey, J. G., Warner, J. L., Greenberg S. E., (1998). “Final report for the EPA Energy Star homes program” *Energy-Efficient Production Homes,* 9-50

Rosencrantz, T., Bulow-Hube, H., Karlsson, B., Roos, A., (2005). “Increased solar energy and daylight utilization using anti-reflective coatings in energy-efficient windows”. *Solar Energy Material and Solar Cells,* 89*,* 249-260

Saleh, M. A. E. (1990). "Impact of thermal insulation location on buildings in hot dry climates." *Solar & Wind Technology,* 7(4), 393-406

Ugursal, V. I., and Fung, A. S. (1996). "Impact of appliance efficiency and fuel substitution on residential end-use energy consumption in Canada." *Energy Build.,* 24(2), 137-146

U.S. Department of Energy (2000). “Wall insulation – Provide moisture control and insulation in wall systems” *Technology Fact Sheet*

U.S. Environmental Protection Agency (2007). “Clothes washer consumer brochure”

U.S. Environmental Protection Agency (2007). “Energy star and other climate protection partnership annual report 2007”

U.S. Environmental Protection Agency (2008). “Energy Star overview of 2008 achievements

U.S. Census Bureau; generated by Jane Smith; using American FactFinder; <http://factfinder.census.gov>; (October 22, 2009)

U.S. Census Bureau; “Geographic comparison table”, <http://factfinder.census.gov>; (November 23, 2009)

U.S. Department of Energy (2009), “What is a HERS rating?” www.energystar.gov, (November 20, 2009)

Webber, C. A., Brown, R. E., and Koomey, J. (2000). "Savings estimates for the Energy Star voluntary labeling program." *Energy Policy,* 28(15), 1137-1149

Weisstein, E. (2009). "Wolfram math world, the web's most extensive mathematics resource”, <http://mathworld.wolfram.com>, (October 21, 2009)

Wood, G., and Newborough, M. (2003). "Dynamic energy-consumption indicators for domestic appliances: Environment, behavior and design." *Energy Build.,* 35(8), 821-841

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