Energy Profiling Analysis Based on Energy Assessments for Small Rural Businesses in West Virginia

Monick Kumar Mahareddy

Problem Report submitted to the

Benjamin M. Statler College of Engineering and Mineral Resources

at West Virginia University

in the partial fulfillment of the requirements

for the degree of

Master of Science

in

Industrial Engineering

Bhaskaran Gopalakrishnan, Ph.D., P.E.,Chair

Edward R. Crowe, Ph.D, P.E

Majid Jaridi, Ph.D

Department of Industrial and Management Science Engineering

Morgantown, West Virginia

2012

Keywords: Energy Profiling; Energy Assessments; Small Rural Business

ABSTRACT

Energy Profiling Analysis Based on Energy Assessments for Small Rural Businesses in West Virginia

Monick Kumar Mahareddy

Energy plays a vital role in the nation's development. There are many forms of energy that are utilized in daily life. Our aim is to increase the efficiency of the consumption of non-renewable sources of energy. USDA conducts Rural Development Energy Program, completes energy audits and feasible studies, complete energy efficiency improvements, install renewable energy systems. This program helps convert older heating sources to cleaner technologies, produce advanced biofuels, install flexible fuel pumps, install solar panels, build bio refineries, and much more. Industrial Assessment Center of West Virginia University conducts West Virginia Agricultural and Rural Small Business Energy Audit Program helping the rural small scale businesses.

This report contains the work done to collect the energy assessments of rural, small scale businesses in West Virginia. The collected data are analyzed using two methods- the regression method and the graphical method. Results generated from the above methods are used to summarize key conclusions, which state that independent variables like the size, type and recommendations have no effect on the cost savings through regression. Further conclusions are derived from graphs stating that size, type and after-audit recommendations place a key factor in energy savings. Besides this local community and support from the people play a major role in helping the small businesses for assessments. These findings can be useful for the stakeholders in decision making.

Table of Contents

List of Figures

List of Tables

List of Graphs

List of Pie-Charts

1 Introduction

1.1 Energy

In physics energy is termed as the indirectly observed quantity which is capable of performing an activity or operation. It is also defined as the work done on other system. In the content of physical science, which can be seen from Fig 1-1 there are different forms of energy like thermal, chemical, electrical, radiant, nuclear, magnetic, elastic, sound, mechanical, and luminous energy [1]. These energies are divided into two types' kinetic Energy and potential energy.

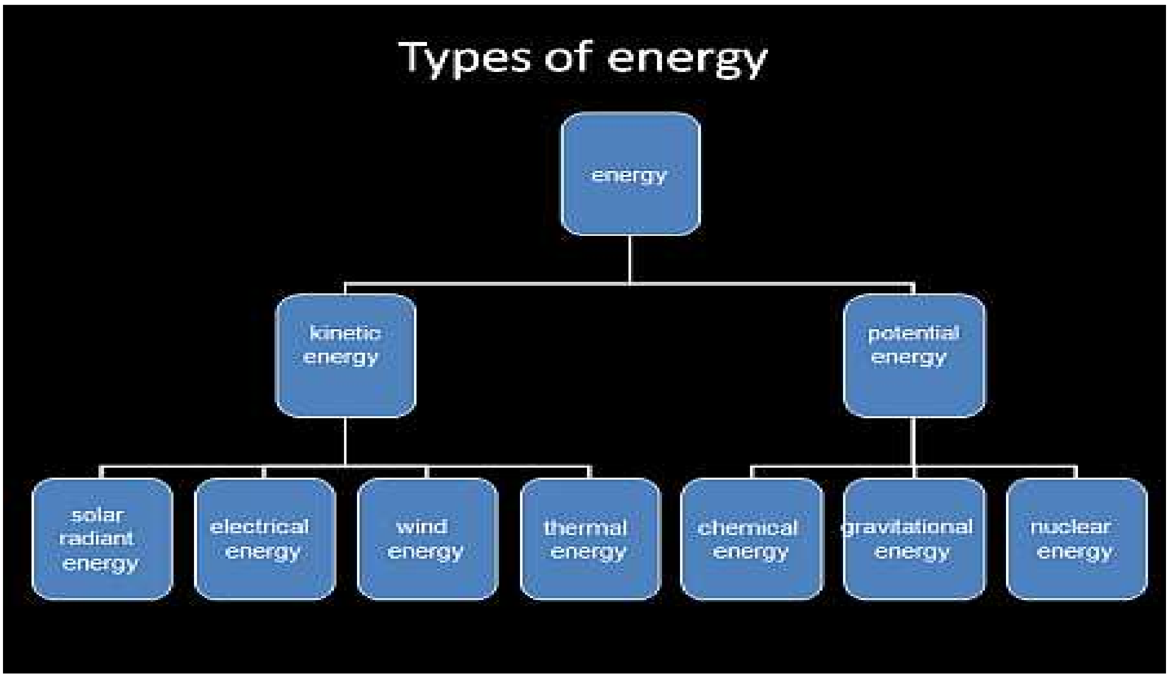


Fig 1-1 Types of Energy [2]

Energy is present throughout the universe and plays a vital role in life sustainability. Simply put, energy is the basic source that keeps the universe moving. The most interesting fact about energy is, "energy is neither consumed nor destroyed, but changes from one form to another" [3]. There are different ways in which different forms of energy are used. For example, solar energy is used to produce electricity, which can be further used to operate the machines/tools used in the daily life. What we see here is the conversion of energy from solar/radiant energy to electrical energy. Electrical energy is later converted to light or heat depending upon the machine used. Even the food we eat contains energy. Every object requires energy, and energy is closely linked with the economic growth of a country [3].

1.2 Source of Energy

Energy sources are divided into two groups:

- **Renewable Energy:** Energy which can be easily replenished.
  e.g.: Solar energy from the sun, which can be converted into electricity and heat; geothermal energy from heat inside the earth; wind energy from the atmosphere; biomass energy from plants, which includes firewood from trees, ethanol from corn, and biodiesel from vegetable oil; hydropower from hydro turbines at a dam.
- **Non-Renewable Energy:** Energy which cannot be recreated.

e.g. Most of this energy is produced from fossil fuels- oil, natural gas, coal, and uranium, which is used in a nuclear fission reaction to generate heat, and then electricity.

Non-renewable energy sources account for 92% of all energy consumption, with the remaining 8% making up renewable energy in United States [4, 5]. As shown in Figure 1-2, petroleum makes up 37% of the resources consumed by the human race, followed by natural gas and coal. Nuclear energy has a small role in energy utilization. When compared to fossil and nuclear energy, renewable energy is a recent development.

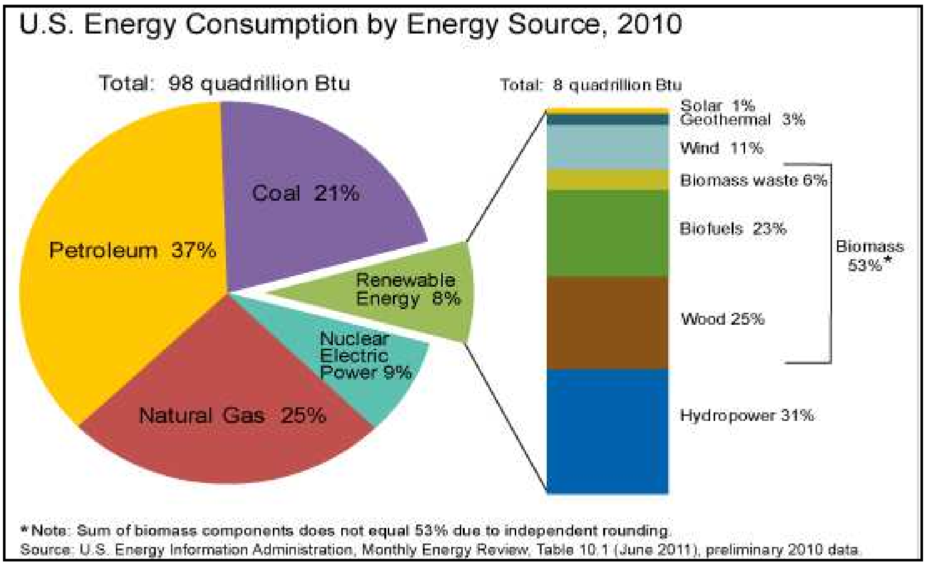


Fig 1-2 Sources of Energy [6]

1.3 Energy Consumption by Sector

As discussed earlier, there are many forms of energy that are inter-convertible. Energy consumption increased by 2.5 times as hunter-gatherer communities evolved into agricultural ones, making further use of energy. Around 1400 AD, energy consumption doubled again with inventions that generated energy from wind, water and coal. Then, the dawn of the Industrial Revolution increased energy consumption further with mass production of coal, gas, and oil. During the 1870's, energy consumption increased three-fold. By the year 1970, humans were making use of energy that is 115 times that of their primitive ancestors [7].

Accordingly, the Department of Energy has designated four sectors of the economy that consume energy: residential, commercial, industrial, and transportation [8].

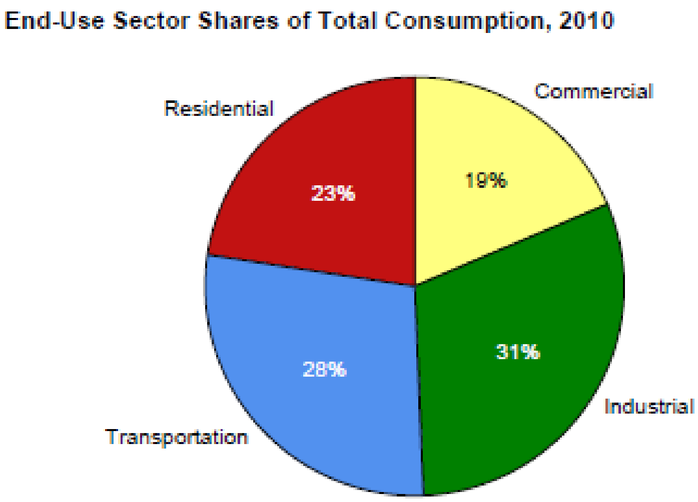


Fig 1-3 Energy Consumption by Sector [9]

Fig. 1-3 shows that the industry and transportation sectors consume more than half of the energy produced, followed by the residential and commercial sectors. Table 1-1 provides the energy breakdown by various sectors. Energy consumption by sector and source is given in Table 1-2, explaining the sector and the source of energy supply and the consumption percentage. All three are a deciding factor for further analysis of energy usage, thus leading to energy savings.

Table 1-1: Breakdown of Energy Consumption by Source [10]

Sector Name	Description	Major uses
Industrial	Facilities and equipment used for producing and processing goods.	22% chemical production 16% petroleum refining 14% metal smelting/refining
Transportation	Vehicles which transport people/goods on ground, air or water.	61% gasoline fuel 21% diesel fuel 12% aviation
Residential	Living quarters for private households.	32% space heating 13% water heating 12% lighting 11% air conditioning 8% refrigeration 5% electronics 5% wet-clean (mostly clothes dryers)
Commercial	Service-providing facilities and equipment (businesses, government, other institutions).	25% lighting 13% heating 11% cooling 6% refrigeration 6% water heating 6% ventilation 6% electronics

Table 1-1 and Table 1-2, gives the information about the major energy consumption sector wise and also based on its individual category. This data is surveyed in the year 2011-2012 and being formulated. The various energy consumption sectors are discussed below.

Residential and Commercial Sectors: The places where people live are considered to be the residential sector. All buildings used as offices, stores, hospitals, restaurants, and schools are termed as the commercial sector. Though they are categorized into two different sectors, both use the same kind of energy for heating and cooling, lighting, heating water, and operating appliances. Together, homes and commercial buildings consume more than a third of the energy in the world. The main energy consumers in these sectors are heating and cooling, lighting, and appliances [8]. This sector also includes the service industries.

Industrial Sector: Manufacturing and production companies fall under the industrial sector. These companies make use of core energy directly from the earth. Industries that consume the majority of energy are petroleum, steel, aluminum, paper, chemical and cement manufacturing industries. They utilize coal, oil and gas from the Earth’s core, then burn and convert them to heat for further production of materials. Combined, they consume 31% of the world's energy [8].

Transportation Sector: This sector creates 29% of the national energy consumption to transport people from one place to another. Energy in this sector is utilized mainly by the automobile industry, followed by commercial transportation like trucks, trains, airplanes, mass transits [8].

Table 1-2: Energy Consumption Summary [10]

Supply Sources	Percent of Source	Demand Sectors	Percent of Sector
Petroleum **37.1%**	71% Transportation 23% Industrial 5% Residential and Commercial 1% Electric Power	**Transportation** **27.8%**	95% Petroleum 2% Natural Gas 3% Renewable Energy
Natural Gas **23.8%**	3% Transportation 34% Industrial 34% Residential and Commercial 29% Electric Power	**Industrial** **20.6%**	42% Petroleum 40% Natural Gas 9% Coal 10% Renewable Energy
Coal **22.5%**	8% Industrial <1% Residential and Commercial 91% Electric Power	**Residential and Commercial** **10.8%**	16% Petroleum 76% Natural Gas 1% Coal 1% Renewable Energy
Renewable Energy **7.3%**	11% Transportation 28% Industrial 10% Residential and Commercial 51% Electric Power	**Electric Power** **40.1%**	1% Petroleum 17% Natural Gas 51% Coal 9% Renewable Energy 21% Nuclear Electric Power
Nuclear Electric Power **8.5% (30%))**	100% Electric Power		

Fig. 1-4 summarizes energy consumption in each sector into a single figure that explains the energy usage of USA in every field and energy source as a whole.

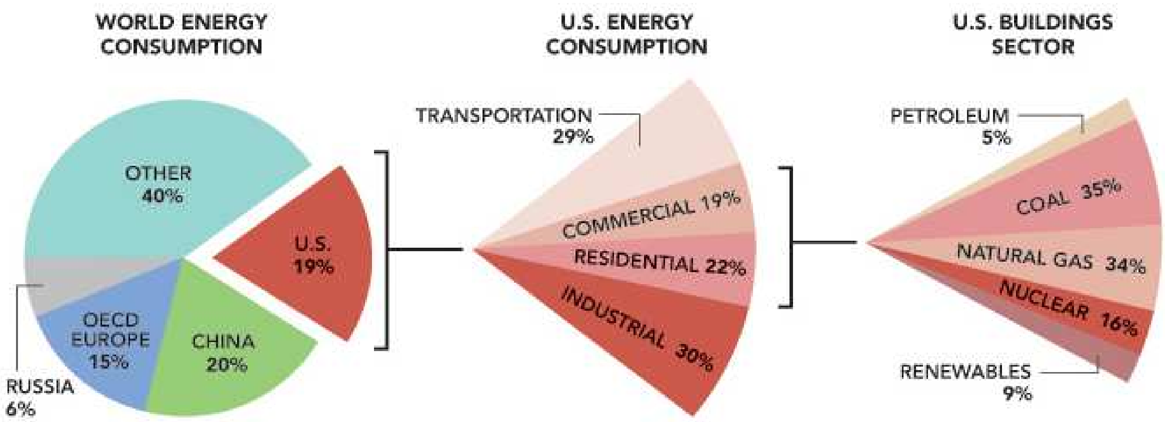


Fig 1-4: Energy Consumption According to Country [11]

1.4 Energy Consumption by Commercial Buildings

Energy consumption in the commercial sector depends on the services demanded by the buildings, such as lighting, heating in the winter, cooling in the summer, water heating, electronic entertainment, computing, refrigeration, and cooking. It accounts for 40 quadrillion BTU (quads) per year, and this number has been increasing over years. In 2008, nearly 40% of U.S. energy is created for residential and commercial buildings, where the former includes up to 114 million buildings and the latter includes 4.7 million. Requirements for energy are driven by:

- Population, where due to increase in population the number of buildings are growing.
- Economic growth, which is a major driver of new offices and commercial buildings.
- Service demands like lighting and air conditioning, increasing the human comforts.
- The real energy prices.
- The efficiency with which energy service demands are met.

The commercial sector is considerably more varied than residential buildings, covering hospitals, schools, offices, houses of worship, lodging, and the retail sector with its big box stores, enclosed malls, strip malls, grocery stores, and fast food and sit-down restaurants. Each of these commercial sub-sectors is unique in its market structure, energy use, and energy intensity, and in the set of decision makers involved in design and construction projects. The two largest energy-using areas within the commercial sector are office and retail buildings. The energy performance of a building is given by the ENERGY STAR label, introduced by the Environmental Protection Agency (EPA) in 1999. Buildings that have a score of 75 or above are eligible for the ENERGY STAR label [12]. Commercial buildings can be classified by the number of buildings, total floor space, and energy use. Figure 1-5: Commercial Building Types: Floor space, Number, and Primary Energy Consumption [14], shows the percentage energy consumption by each type of commercial building. As we can see, offices, retail and malls place highest in all three categories [13].

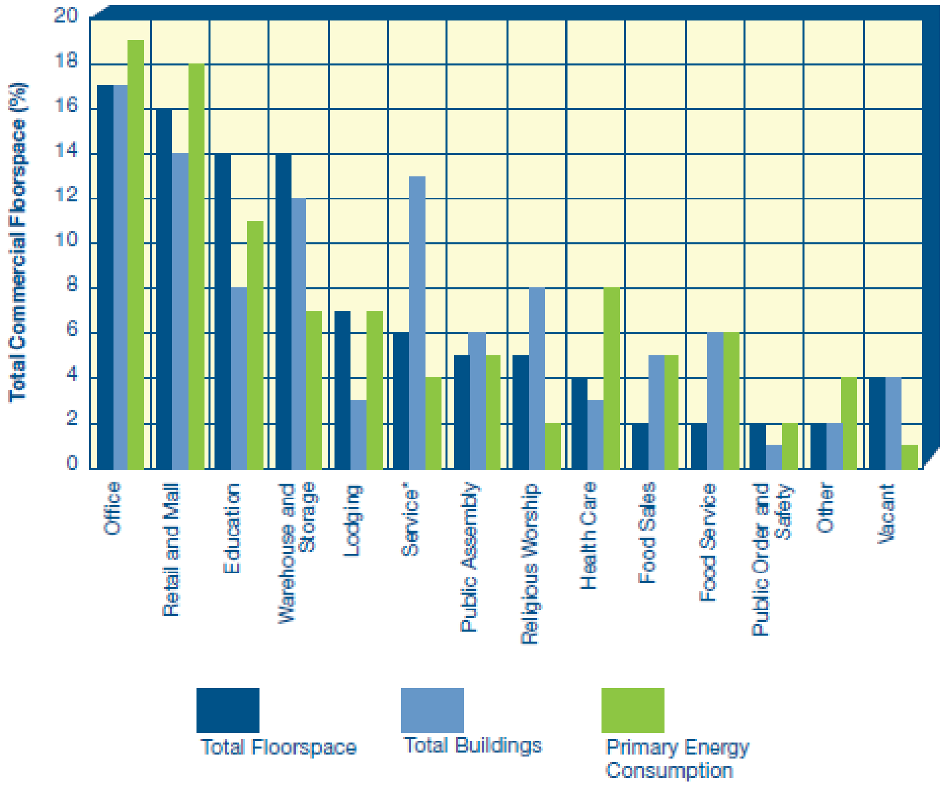


Fig 1-5: Commercial Building Types: Floor Space, Number, and Primary Energy Consumption [14].

These commercial buildings have a varied range in ownership and occupancy. Here, the private sector occupies 77% of the floor space, which is divided into owner and non-owner occupied. The government owns the remaining 23% this is shown in Fig 1-6.

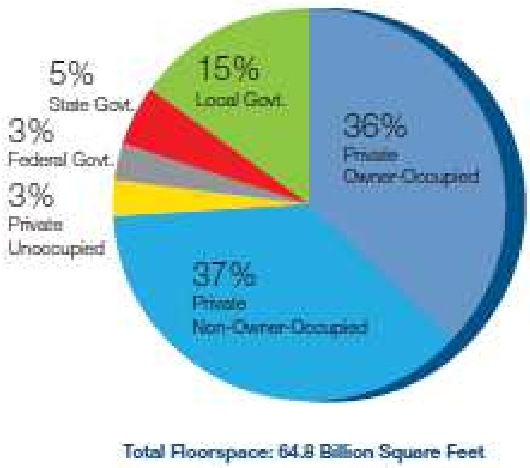


Fig 1-6: Commercial Building Ownership and Occupancy 2003 (Non-Mall Building) [15].

Since we know how commercial buildings are owned and what the building types are, and which buildings consume most of the energy, we also need to know how energy is consumed by each of the devices/appliances. How the energy is used has an effect on energy efficiency strategies

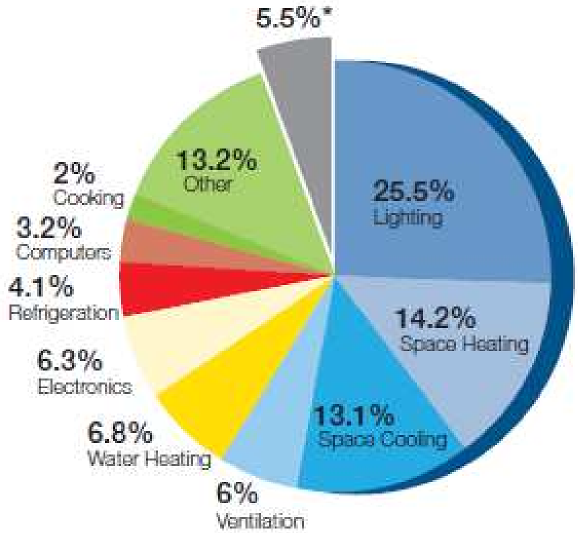


Fig 1-7: Commercial Primary Energy End-Use Splits, 2005 [16].

Lighting takes up a quarter of energy consumption in commercial buildings. Heating and cooling comes next, each of which is one-seventh. Fig 1-7 is analyzed and categorized by the Energy Information Administration. There are other end users which add up for small amounts from 6-7 percent [13].

1.5 Small Rural Business

It is agreed that energy plays a vital role in national development. There is a high degree of correlation between energy use, economic growth, and level of development. In rural developments, energy is mostly used for agricultural and commercial use only. Motors used for grinding grains, operating tools, supplying water to farm lands, and facilitating many commercial activities are all examples of the ways in which energy is used for commercial and agricultural purposes. Before going into further detail, it is important to define what “rural” means. It is stated that all of the non-metropolitan counties in the United States constitute rural America [17]. With respect to the agricultural and commercial sectors, the main source of energy consumption is electricity. This electricity is used to run motors to irrigate fields, for fodder choppers, and to run other machinery. In the case of commercial buildings, energy is used for lightning and air conditioning rooms [18].

There has been a slight decrease in the economics activities of rural America. Small businesses are finding it hard to get loans, and bank failures are running at a post-depression high. Besides this, the country's economic viability is in question and the government is experiencing a strong eroded tax base. In short, the rural economy is under pronounced stress and this stress is accelerating at a very rapid pace [17]. To overcome this stress, the US governments have created an organization especially for rural development and to safe guard its economy.

1.6 United States Department of Agriculture (USDA)

Informally known as the Agricultural Department, the United States Department of Agriculture (USDA) is a U.S. Federal office responsible for developing and executing federal policies on farming, agriculture, and food. The USDA was formed on May 15, 1862 by President Abraham Lincoln to safe-guard the nation’s agricultural resources [20]. “This agency works for the needs of the farmers and ranchers to promote agricultural trade and production, assure food safety, protect natural resources, foster rural communities, and end hunger in the United States [19].”

The different programs/services associated with USDA are:

- ❖ **Assisting Rural Communities:** grants loans, disaster assistance, and insurance programs.
- ❖ **Conservations:** deals with restoration and conservation, environmental markets, water resources, and wildfire prevention.
- ❖ **Food and Nutrition:** SNAP, WIC, food security, child nutrition programs, and national organic programs.
- ❖ **Marketing and Trade:** importing and exporting of goods.
- ❖ **Education and Research:** economic research, agricultural research, and agricultural statistics.

The USDA states, “We want to be recognized as a dynamic organization that is able to efficiently provide the integrated program delivery needed to lead a rapidly evolving food and agriculture system.”[21] Keeping this in mind, it has developed a framework on a few key activities, such as expanding the agricultural market, supporting international economic development, developing alternative agricultural markets, proving the financial need to expand job opportunities and housing, enhancing food assistance by giving nutrition education and providing support, and assisting in conducting surveys for energy reduction.

1.7 West Virginia Agricultural and Rural Small Business Energy Audit Programs

The objective of the audit program is, "to develop and implement a state-wide energy audit program that delivers cost-effective audits to assist agricultural producers and rural small businesses reduce energy cost" [22]. Let us first define what is a small rural business, a small business which has less than 500 employees and does not qualify for the IAC assessments and which is a part of USDA associated rural area of West Virginia is termed as a small rural business.

Fig 1-8: USDA Defined Rural Business Area of West Virginia [48]

Figure 1-8 shows the rural areas in the state of West Virginia. This rural area has been defined by USDA on the following basis," All persons living in UA's (Urban Area) and in places (cities, towns, villages, etc.) with a population of 2,500 or more outside of UA's are considered the urban population. All others are considered rural" [47] Based on this definition the USDA has categorized the rural areas of West Virginia. In Fig 1-8, except for Charleston, Huntington and a small stretch of I-64, the remaining area comes under rural business and any industry having less than 500 employees and which doesn't qualify for the IAC assessments comes under this program.

This program is conducted under the partnership of West Virginia University, Industries of the Future-West Virginia (IOF-WV), the West Virginia University Industrial Assessment Center, West Virginia Manufacturing Extension Partnership, West Virginia Agricultural and Natural Resources Extension Service, West Virginia Division of Energy, West Virginia Department of Agriculture, and West Virginia Manufacturers Association. The audits conducted help small businesses save energy in the areas of lightning and HVAC, and building envelop thermo graphic analysis by 5 to 10 percent by following the recommendations**.** An analysis that shows high consumption yields a higher energy cost saving recommendation.

Fig 1-9: Small Rural Business Locations of West Virginia

Fig 1-8 shows the locations of all the small scale rural businesses where assessments were done in the state of West Virginia. The audits are free to rural, small businesses. In general, there are three kinds of audits conducted: on-site audits, off-site energy audits, and agricultural producer audits. Financial assistance is provided by the National Capital Investment Fund, The USDA Financial Assistance Program, West Virginia Incentive for Renewable and Energy Efficiency, and West Virginia Incentives. These funds are provided to Industrial Assessment Center in doing the assessments [23].

1.8 Research Objectives

The objective of this research is to collect and analyze energy assessment data conducted at 98 small, rural businesses and agricultural producers in West Virginia. This analysis involves processing and segregating data to profile energy consumption and energy saving opportunities for different rural businesses at different locations in West Virginia. This work would help energy consumption among various businesses located across varied topography of West Virginia, and also recommend energy savings opportunities with expected payback and implementation cost. The key findings from the output would help the stakeholders in making effective decisions. A stakeholder is defined as the person, group, organization, or member that affects or is affected by an organization’s actions. In our research, government, industrial assessment service and the owner of the business are considered to be stakeholders because their actions lead to the improvement or downfall of the company. The objectives of this research are to:

- Help the government allocates proper funds and budget for development of the company depending on the size, location, and usage.
- Help the owner to enhance their profits while saving energy.
- Help the Industrial Assessment team to make proper use of resources without excessive investment.

1.9 Methodology

- Collect the U.S Department of Agriculture assessment data.
- Segregation of the data into various columns using Microsoft Excel^R.
- Develop an equation for one of the variables considering the other factors, using indicator variables.
- Draw various graphs and pie-chart, correlating with each other.

- Obtain results from the above two methodologies.
- Infer key points and conclusions from the results.

1.10 Conclusion

This chapter helps in understanding energy consumption across United States in the residential, commercial, industrial, and transportation sectors, followed with a brief study of energy consumption in rural, small scale industries and energy audit programs conducted by West Virginia Agricultural and Rural Small Business Energy Audit Programs to assist businesses by lowering energy costs.

2 Literature Review

2.1 Energy Assessment

There is currently renewed interest in many countries in analyzing energy use in the industrial sector, with a view to improving energy efficiency. Energy is a key production factor in many industries and, with the growing pace of globalization, international competitiveness issues are placing greater emphasis on reducing production cost, including those related to energy [40]. The United Stated Department of Energy (DOE) energy assessment standards are built on a foundation of research conducted over the past 10 years. Energy assessment standards establish procedures for assessing a facility's complete system, from the energy input to the work performed. Energy assessments not only deal with the sectors where energy is involved, but they also address the topics and requirements for organizations and conducting assessments, analyzing the data collected, and reporting and documentation. An assessment may also include recommendations for energy resource improvisation, reducing the unit production cost, and improving environmental performance [24].

United States DOE has developed an Industrial Technologies Program which is now named as Advanced Manufacturing Office (AMO), which helps in identifying and recording the energy waste in industrial energy systems. The purpose of this program is to examine plant utility and process operation and to identify the opportunities for improving their energy efficiency [31]. This program has developed software, tools, training, and publications on how to identify and take advantage of industrial energy efficiency opportunities. There are few set of standards which are intended to assist U.S. industry in meeting the energy efficiency of the industry [24]. These standards have been developed to assist plant personnel in identifying cost-effective projects that often have limited capital requirements. Improving the efficiency of industrial system increases profits and reliability, and makes better use of the resources [25]. The energy assessment process in a large-sized manufacturing facility containing a plethora of interacting energy consuming systems and equipments may be complicated if pursued in a non-structured manner. The plant wide energy assessment process is an important step in the assessment process. To assess a plant, two things have to be followed, plant-wide energy assessment followed by proposed systematic approach [26]. The energy consumption and assessment follows four-step procedure: (a) collect a set of energy and output data for a country/place which is to be studied; (b) select or develop a decomposition method; (c) apply the method to the data to give the required decomposition results; and (d) use these results to explain the observed changes in energy consumption or aggregate energy intensity [39].

2.2 Industrial Energy Assessment

The need for energy efficiency has captured all the sectors of our society in 1970's when the energy supply has fallen and when there was an increase in the price. Then the energy efficiency was continued till 1980's due to the environmental issues and also because of economic and industrial competitiveness. Energy supply disruptions due to natural calamities like hurricane Katrina and Rita, and recent hike in energy prices, have once again evolved interest in the energy efficiency [27].

Given the importance of the global environmental agenda, it has been important to understand the determinants of industrial energy demand in the developed world [32]. In the past, the industrial sector has responded to energy shortages and price increases with varying effectiveness, but the small and the mid-sized plants generally lacked the resource to meet the problem. In many cases companies do not know the exact quantitative saving effect of conservation measures, due to insufficient monitoring and measurement [35]. In the study of the factors that influence a firm's decision to invest in energy efficiency, energy audit programs conducted were cost effective and that the implementation rates were high. About five out of every six suggestions from the energy audit were implemented, with the aid of government subsidies. Analysis, however, indicate that the energy audits would have been worthwhile for the firms in any case [36].

The U.S government has proposed a program to help the small and mid-sized plants with technical assistance, known as the Industrial Assessment Center (IAC) program. The IAC program has been successfully over the past three decades, but the IAC does not include Large Energy Users (LEU's). The recent program launched by U.S. Department of Energy (DOE) is Save Energy Now (SEN), which helps businesses, factories, plants and manufacturing facilities save energy and continue to work during a draught and cost increase in energy. The programs were successful mainly because of the software tools that made the assessment easy for the analysis. The two tools prescribed by the Department of Energy (DOE) are the Steam System Assessment Tool (SSAT) and the Process Heating Assessment and Survey Tool PHAST [27].

There are other tools for assessing for example, Motor Master + for motors, Air Master + for air compressors, PSAT for pumps and ePEP for plant energy profiler.

Numerous studies of energy efficiency potential state that cost-effective energy efficiency technology in industry is not always implemented for various reason, such as lack of information, procedural implementation, and routines not favoring energy efficiency. Hence, few companies have established their own tacit knowledge, perceived truths, and routines concerning energy efficiency measures [38]. Thermodynamic methods of (energy and exergy) analysis are employed to illustrate energy use in industry [42] [43] [44].

2.3 Small Business Energy Audits

Energy monitoring is one way to get information for making efficiency plans and comparisons between factories. Such bench marking activities may be important to identify investment opportunities and promote knowledge transfer. Energy audits are also a way to identify opportunities for energy related investment [33]. It is found from the paper written by Tonn, B., Martin, M., Industrial Energy Efficiency Decision-Making, that energy saving opportunities frequently went from 17% before the Industrial Assessment Center energy assessment to 77% afterwards. The corresponding figures for implementation of energy saving measures were 8% before and 6% after the assessment, there was reduction in the implementation after assessment because undesired recommendations were removed and efficient recommendations were only suggested during the assessment [34].

When energy audits are done, we should be able to understand how energy is used by the facility to make sure that the energy efficiency recommendations are accurate and appropriate. We must know what equipment uses energy, how much energy it uses and how much energy it consumes in proportion to the total energy use of the facility [28]. Energy audits play an important role in analyzing a small business because of the recommendations that are made to make the facility “green”. Green represents green energy (i.e. not only saving energy but also the money through local utility rebates and government incentives). “Reducing energy consumption saves money,” said Edmund Kohlberg, principal of Einhorn Yaffee Prescott in Albany, New York. "An energy audit may also increase the comfort level in a building," Kohlberg explains. The different aspects taken into consideration are heating, ventilation, lighting, cooling, and miscellaneous. Simulating research and development (R & D) of innovation energy-efficient technologies for industry is an attractive option for reducing greenhouse gas emissions [37]. Each of this are analyzed and appropriate recommendations are implemented to help small scale industries to go green [28]. The usage of an energy store in an industrial system may minimize the system cost primarily by keeping the level of power demand for the whole system equal to or less than the maximum value of the level of the power demand for the whole system according to electricity or natural gas contact [41].

2.4 Conclusion

In this chapter, literature review gives an idea about the work carried out in making a framework for energy assessments and energy audits in small and medium sized facilities. They help reduce energy consumption and increase the efficiency of the system. Research has been carried out in this area by the U.S government under many organizations and multiple programs to help preserve resources for the future generations. Besides these topics, this chapter talks about the help provided by different organizations to help the small and medium sized companies. This research provides us with the appropriate data for further analysis of energy usage in facilities, and what can be done to reduce energy consumption and increase energy efficiency.

3 Methodology

3.1 Generation of Data

Databases with large amounts of information are common in many fields, like business, medicine, etc. Databases are analyzed to present conclusions in such a way that the information can be used to increase revenue and reduce the cost with reduction of energy. The data found in the USDA assessments contains a wealth of information. To convert the existing data into useful data, we need to identify the required fields so that we can avoid the unwanted resources. Thus, the data is analyzed from different dimensions and angles to extract information and create a table using Microsoft Excel [29].

3.2 Data Collection

The Industrial Assessment Center (IAC) of WVU has ample amount of data related to USDA assessments of West Virginia. The required data was collected from each of the assessments/audits, and then segregated accordingly in a table (Table 3-1) using Microsoft Excel. Table 3-1 provides information on the audit report, including the name of the company, the location, recommendations made for energy efficiency and energy cost reductions. Energy recommendations also include data for implementation cost, savings per year, corresponding cost savings per year, and the simple pay-back period. Additional data such as the county, address, the NACIS code, the kind of business, the square-footage, and the annual sales were collected from various Internet sources.

Table 3-1: USDA Segregation Table (EXCEL^{R})

S.No	Name of the Business	State	County
Address	Size of Business	NAICS Code	Type of Business
Energy Savings(Natural Gas) MMBtu	Energy Savings (Electricity) Kwh	Total Energy Savings (Natural Gas) MMBtu	Total Energy Savings (Electricity) Kwh
Suggested Recommendations	Implementation Cost (Individually) ($)	Total Implementation Cost ($)	Cost Savings/year (individually)
Total Cost Savings/year	Pay Back Period		

3.3 Regression Analysis

The regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables varies, while the other independent variables are held fixed [45]. Regression models involve the following components: the unknown parameter (β), the independent variable (X) and the dependent variable (Y). The general equation is given as $Y \approx f(X, \beta)$.

An Excel table can have many variables. Independent and dependent variables must be identified to produce an equation. The regression equation is developed by considering indicator variables. Table 3-1 shows cost savings (in U.S. dollars) as the dependent variable, the independent variables are divided into three categories;

Size of industry this section is segregated by considering energy savings in natural gas and electricity. The industry that saves the least energy is considered to be a small industry; the industry that saves the most is considered a large industry. Accordingly, the medium scale industry is classified.

- **Type of industry**: By NAICS (North American Industry Classification System) code standards, there are 11 types of industry, which can create difficulty while running the regression equation. Hence, industry can be combined into 3 types, namely Service Type, Trade Type and Finance Type.
    1. Service Type: Accommodation & Food Service, Health Care & Social Assistance, Art, Entertainment & Recreation and Other Service (except public administration).
    2. Trade Type: Retail Trade, Wholesale Trade, Agriculture, Forestry, Fishing & Hunting and Manufacturing.
    3. Finance Type: Finance & Insurance, Professional, Scientific & Technical and Real Estate Rental & Leasing.

Types of Recommendation: There are 12 different kinds of recommendations. It is difficult to do the regression equation with so many independent variables. Listed below is a set of identical recommendations subdivided into four different categories,

1. Lighting System: Lighting System, Replace the existing T12 fluorescent bulbs with magnetic ballast with T8 fluorescent bulbs.
2. Comfort System: Add economizer on the rooftop air conditioning system units, Install setbacks for air conditioning, Replace the existing heating system with infrared space heaters and Recommendations according to the operation.
3. Efficiency Improvement System: Adjust air to fuel ratio for boilers, Reduce heating load due to infiltration in the doors, Insulation System and System enhancement recommendation.
4. Replacement Process Improvement System: Replace single paned glass with double paned glass and Replacement Process Improvements.

3.3.1 Procedure

- Collect the data and put into Excel spread sheet.
- Use indicator variables for each of the variables. Take it as 1 if that particular variable exists and 0 if not.
- Run the table using Mini-Tab or SAS for the results and write down the equation with independent variables and dependent variables.

3.3.2 Definition of Variables

Let Y be the estimator or calculated energy savings in dollars if the recommendations are implemented. We make use of indicator variables in defining the independent variables. The corresponding independent variables defined are as follows:

Size of Industry: 3 sizes (small, medium, large)

$$\begin{cases} X_1 = 1 \text{ if small sized industry.} \\ \quad = 0 \text{ if not.} \\ X_2 = 1 \text{ if medium sized industry.} \\ \quad = 0 \text{ if not.} \end{cases}$$

Type of Industry: 3 types (Service, trade, finance)	X_3=1 if service type industry. =0 if not. X_4=1 if trade type industry. =0 if not.

Type of Recommendation: 10 types (lighting, comfort, efficiency improvement, replacement process improvement with combinations)	X_5=1 if only lighting system. =0 if not. X_6=1 if only comfort system. =0 if not. X_7=1 if only efficiency improvement =0 if not. X_8=1 if only Replacement Process =0 if not X_9=1 if both lighting and comfort =0 if not X_{10}=1 if both lighting & efficiency =0 if not

X_{11}=1 if lighting & replacement

=0 if not

X_{12}=1 if comfort & efficiency

=0 if not

X_{13}=1 if comfort & replacement

=0 if not

X_{14}=1 if efficiency & replacement

=0 if not.

By considering the above variables a first order regression model is developed;

$$E(Y) = \beta_0+X_1\beta_1+X_2\beta_2+X_3\beta_3+X_4\beta_4+X_5\beta_5+X_6\beta_6+X_7\beta_7 +X_8\beta_8+ X_9 \beta_9+ X_{10} \beta_{10}+ X_{11} \beta_{11}+ X_{12} \beta_{12}+ X_{13} \beta_{13}+ X_{14} \beta_{14}.$$

E(Y) - estimated energy savings in dollars.

There are 98 data set points for the dependent variable (i.e. cost savings in dollars). The mean of which gives the estimated value.

3.3.3 Coding Scheme:

We make use of indicator variables to run the regression model. Consider 1 if the variable exists as 0 for something else. For example, consider 1 if the industry is large or else 0, in the same way if the industry is labeled as retail trade and if it exists take it as 1 or else take it as 0. Listed below is the Excel spread sheet,

Table 3-2: Assigning the Indicators Variables

	size		type		recommendation									
	small	medium	service	trade	lighting	comfort	efficiency improvement	Replacement	Lighting & comfort	Lighting & Efficiency	Lighting & Replacement	Comfort & Efficiency	Comfort & Replacment	Efficiency & Replacement
savings	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
24818	0	0	1	0	0	0	0	0	0	0	0	1	0	0
1199	0	1	1	0	0	0	0	1	0	0	0	0	0	0
183	1	0	1	0	0	0	0	1	0	0	0	0	0	0
496	0	1	1	0	0	0	0	0	0	1	0	0	0	0
36619	0	0	0	1	0	0	0	0	1	0	0	0	0	0
400	1	0	1	0	0	0	1	0	0	0	0	0	0	0
5807	0	0	0	1	0	0	0	0	0	1	0	0	0	0
1997	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1190	0	0	0	0	0	0	0	0	0	0	1	0	0	0
828	0	1	0	0	0	0	0	1	0	0	0	0	0	0
793	1	0	0	0	0	0	0	1	0	0	0	0	0	0
184	1	0	1	0	0	0	0	0	0	0	1	0	0	0
873	0	1	0	0	0	0	0	1	0	0	0	0	0	0
3313	0	0	0	0	0	0	0	0	0	0	1	0	0	0
6294	0	0	0	1	0	0	0	0	1	0	0	0	0	0
1864	0	1	1	0	0	0	0	0	1	0	0	0	0	0
1014	0	1	0	1	0	0	0	0	1	0	0	0	0	0
242	1	0	0	0	0	0	0	0	0	0	1	0	0	0
186	1	0	0	0	0	0	0	0	0	0	1	0	0	0
145	1	0	0	1	0	0	0	0	0	0	1	0	0	0
288	0	1	0	0	0	0	0	0	0	0	1	0	0	0
1380	0	1	0	0	0	0	0	0	0	0	1	0	0	0

3.4 Graphs and Plots

Graphs are an abstract representation of a set of objects where they are connected with some kind of links [46]. Here, we have many variables listed in the Excel table, from which we can draw various kinds of pie-charts and bar graphs. We can clearly see the distribution of industries according to the county, according to the NAICS (North American Industry Classification System) code, etc. With the help of bar graphs we can clearly mark out the trends for a particular category.

The different variable using which we can plot pie-charts and bar graphs are:

- County
- Kind of business
- Government Code (NAICS Code)
- Energy Saving (Natural Gas in MMBtu)
- Energy Saving (Electricity in Kwh)
- Recommendation/ Recommendation Code
- Implementation/Recommendation Cost
- Energy Cost Savings (per year)
- Payback period (in month)

3.4.1 Data Profile

Our objective is to collect the data from all of the USDA Assessments, put them into an Excel table, and analyze the corresponding data, and then create various profiles with the defined set of variables. These profiles can later be used to draw a conclusion. Before we start drawing the histograms we need to classify each of the NAICS codes to a particular department type, then group the recommendations into a single category. This grouping is done because the data are unique and difficult to plot. We make use of these data and plot pie-charts and histograms.

The various pie-charts drawn are:

- Industries according to county.
- Industries according to NAICS code.
- Industries according to the business type.

- Energy Consumption between Natural Gas and Electricity.
- Suggested Recommendations List

The various bar graphs drawn are:

1. Estimated Cost savings according to the county.
2. Estimated Natural gas savings according to the county.
3. Estimated Electricity savings according to the county.
4. Estimated Energy savings according to the area.
5. Estimated Implementation Cost for various recommendations.
6. Estimated Implementation cost according to the type of industry.
7. Top 10 natural gas savings industries.
8. Top 10 electricity saving industries.
9. Estimated Implementation cost for the top 10 natural gas saving industries.
10. Estimated Implementation cost for the top 10 electricity saving industries.
11. Estimated Cost savings for the top 10 natural gas saving industries.
12. Estimated Cost savings for the top 10 electricity saving industries.
13. Present Worth Savings (Natural Gas) Vs The Estimated Implementation Cost
14. Present Worth Savings (Electricity) Vs The Estimated Implementation Cost
15. Estimated average payback period for the suggested recommendation

3.5 Conclusion

This chapter defines the variables and gives a clear view of the two methods (i.e. Regression Method and Graphical Method), and provides a step-by-step procedure to find the results and these results are used to deduce further conclusions.

4 Results

4.1 Regressions Analysis

The regression equation is given as,

$E(Y) = \beta_0+X_1\beta_1+X_2\beta_2+X_3\beta_3+X_4\beta_4+X_5\beta_5+X_6\beta_6+X_7\beta_7 +X_8\beta_8+ X_9 \beta_9+ X_{10} \beta_{10}+ X_{11} \beta_{11}+ X_{12} \beta_{12}+ X_{13} \beta_{13}+ X_{14} \beta_{14}$.

We need to find out the β values in the above equation to get an estimator of the savings ($) as a function of all independent variables. I have chosen **Mini-Tab v16.1** to analyze the input data and get the regression equation. Here are the steps followed,

Step 1: Select the Excel data with independent variables (as shown in Table 3-2: Assigning The Indicators Variables) and enter them into Mini-Tab labeling each of the columns accordingly.

Step 2: To run the regression, initially we need to go to the Stat > Regression > General Regression from the tool bar as shown in Fig 4-1 .

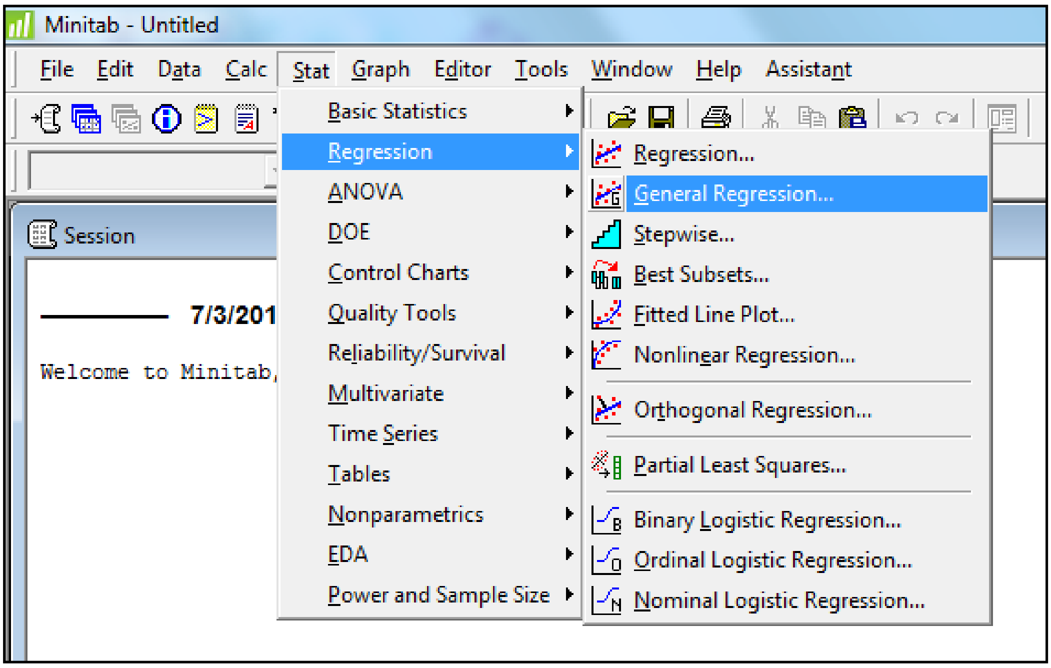


Fig 4-1: Procedure for Running Regression in Mini-Tab Output

Step 3: Select the response variable i.e. savings, and model i.e. independent variables and press OK from the Mini-Tab screen.

4.1.1 Mini-Tab Output

```
Regression Equation

savings  =  5547.6 - 3452.85 small - 3508.24 medium - 174.148 service - 159.215
            trade - 1851.6 lighting - 1595.61 comfort - 1601.03 efficiency
            improvement - 1216.66 Replacement - 948.111 Lighting & comfort -
            660.759 Lighting & Efficiency - 1974.09 Lighting & Replacement +
            2559.39 Comfort & Efficiency
```

Coefficients

Term	Coef	SE Coef	T	P
Constant	5547.60	2598.68	2.13478	0.036
small	-3452.85	1840.17	-1.87637	0.064
medium	-3508.24	1102.35	-3.18251	0.002
service	-174.15	1786.11	-0.09750	0.923
trade	-159.22	1726.66	-0.09221	0.927
lighting	-1851.60	2393.04	-0.77374	0.441
comfort	-1595.61	4150.87	-0.38440	0.702
efficiency improvement	-1601.03	3872.58	-0.41343	0.680
Replacement	-1216.66	3169.31	-0.38389	0.702
Lighting & comfort	-948.11	2173.84	-0.43614	0.664
Lighting & Efficiency	-660.76	2596.18	-0.25451	0.800
Lighting & Replacement	-1974.09	2517.63	-0.78411	0.435
Comfort & Efficiency	2559.39	2991.14	0.85566	0.395

Summary of Model

```
S = 4425.47          R-Sq = 21.39%        R-Sq(adj) = 10.02%
PRESS = 2130990724   R-Sq(pred) = -3.06%
```

Analysis of Variance

Source	DF	Seq SS	Adj SS	Adj MS	F
Regression	12	442265889	442265889	36855491	1.8818
small	1	54600871	68953739	68953739	3.5208
medium	1	313684711	198362491	198362491	10.1284
service	1	1314130	186182	186182	0.0095
trade	1	71989	166524	166524	0.0085
lighting	1	10231108	11725022	11725022	0.5987
comfort	1	228759	2893950	2893950	0.1478
efficiency improvement	1	1161688	3347474	3347474	0.1709
Replacement	1	54494	2886220	2886220	0.1474
Lighting & comfort	1	3734214	3725468	3725468	0.1902
Lighting & Efficiency	1	57119	1268638	1268638	0.0648
Lighting & Replacement	1	42787798	12041181	12041181	0.6148
Comfort & Efficiency	1	14339008	14339008	14339008	0.7321
Error	83	1625539964	1625539964	19584819	
Lack-of-Fit	22	440059318	440059318	20002696	1.0293
Pure Error	61	1185480646	1185480646	19434109	
Total	95	2067805853			

Fig 4-2: Mini-Tab Output

Once the procedure is followed we get the output as shown in Fig 4-2, the output gives us the regression equation and ANOVA table from which we need to conclude the final solution. The first line gives us the regression equation with dependent variable on the left-hand side followed by all of the independent variables on the right-hand side.

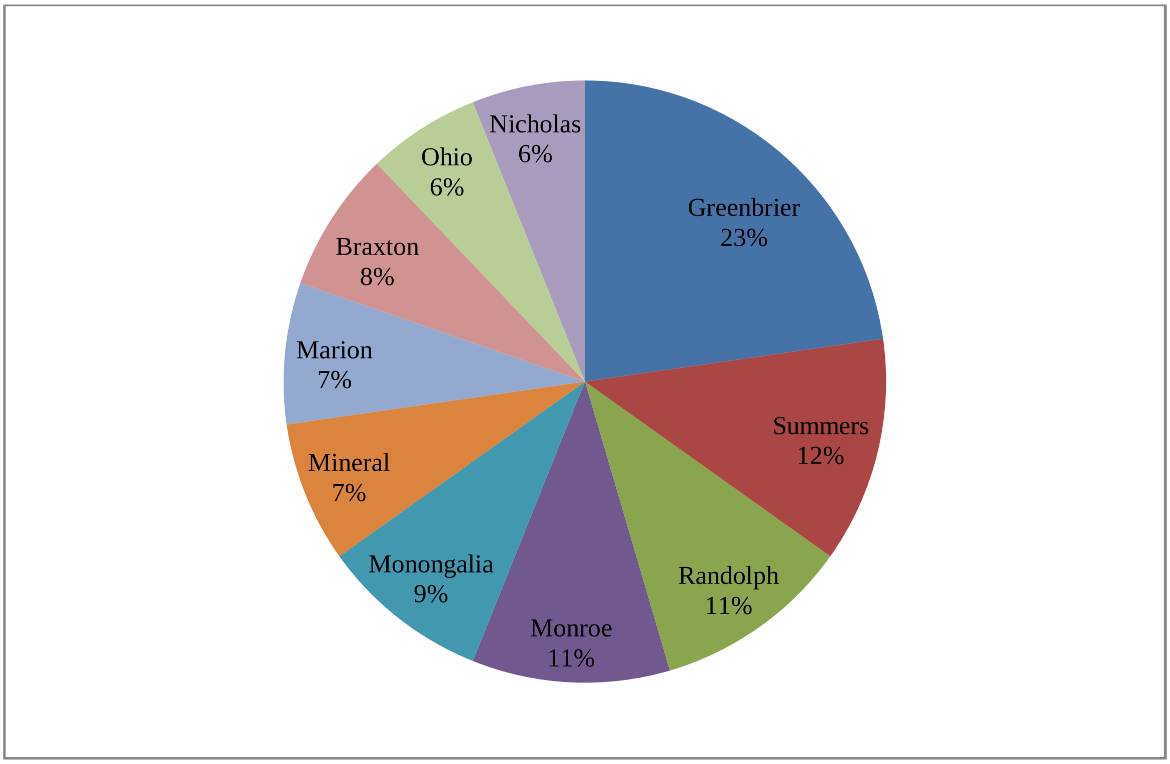
The next set of output has co-efficient for each of the independent variable. Depending upon the company size, type and suggested recommendation the co-efficient remain or becomes zero. Along with the coefficients, the T-value which is a result of *t*-test determining statistical hypothesis test and the P-value determining statistical significance testing of the developed regression equation. These values are useful in further conclusions. The Mini-Tab output provides ANOVA table having all the values of independent variables. The R-sq and R-sq (Adj) in the output also helps in finalizing the conclusion.

Mini-Tab gives us with all the results, looking into the results we need to deduce the final answer.

4.2 Graphs and Plots

The results of the pie-charts and bar graphs of various varying variables are shown in the following section.

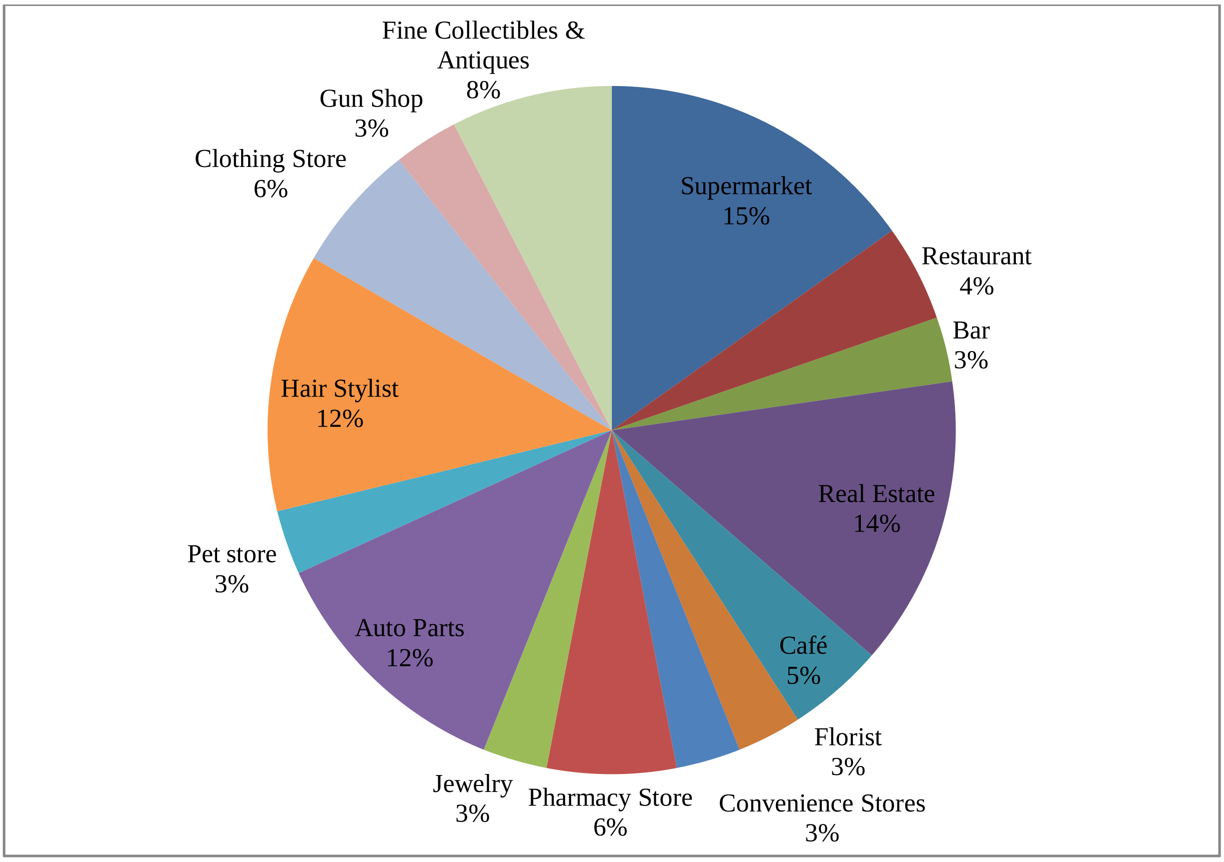
4.2.1 Percentage No. of Assessments According to the County (Top 10 Counties)



Pie-Chart 1: Percentage No. Of Industries According to County (Top 10 Counties)

Pie Chart 1 shows the distribution of USDA assessments done in different counties in the state of West Virginia. There are 23 different counties, from which we have chosen the top 10 counties where maximum assessments were performed. When looking at the chart, we see that Greenbrier County accounts for 23% of assessments performed. This is because the Greenbrier Valley Economic Development Corporation has been set up by local citizens and it promotes and supports the development of the local businesses. It covers Pocahontas, Monroe, and Greenbrier County, which have commissioned the study with outlines for an expanded local food system that would bring jobs to the region, enhancing health for its residents, and ensure an adequate food supply of fresh fruits, vegetables, meats, and other goods. Additionally, it helps small scale business to be sustainable. There are more than 11 different organizations in the region and the state ready to help support a local food system [30]. Hence, there are more USDA assessments in Greenbrier and Monroe County.

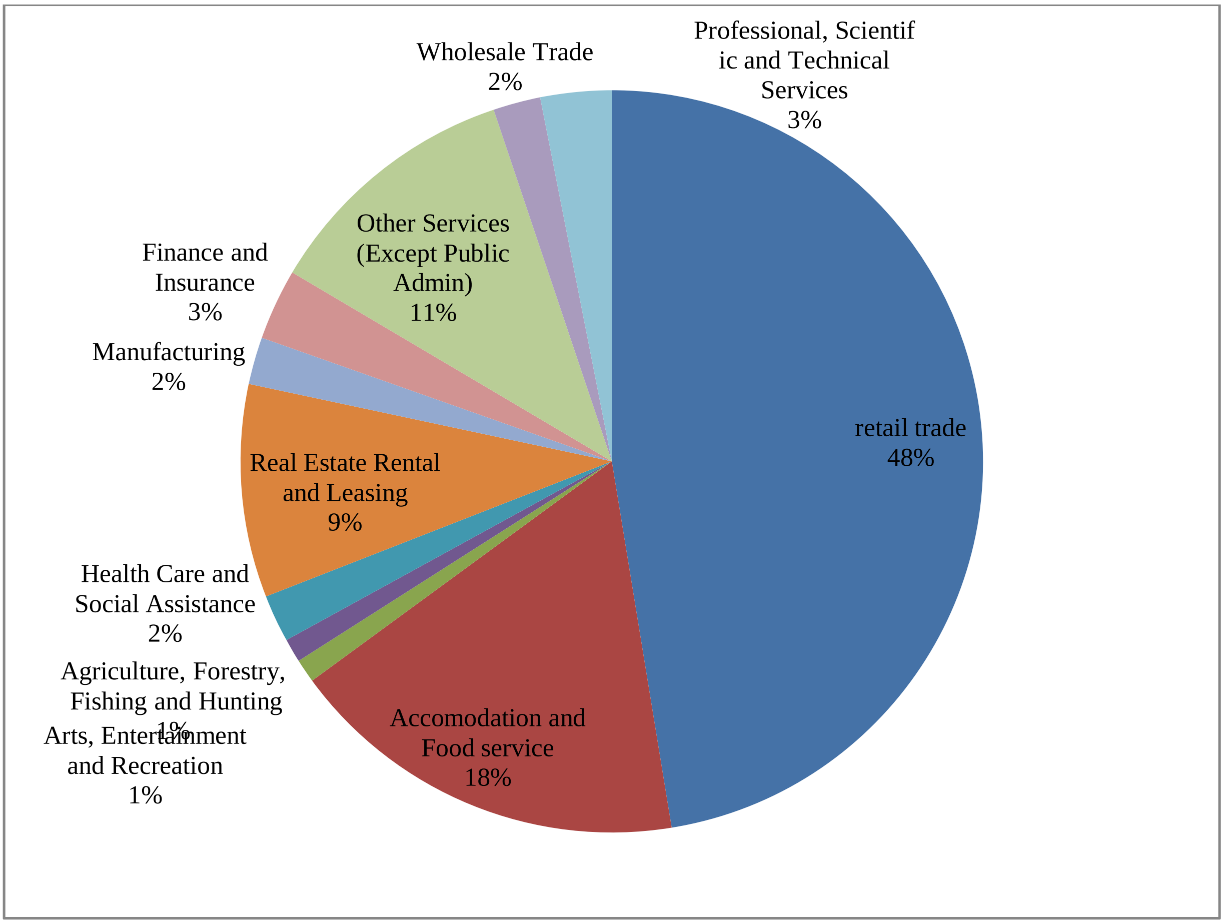
4.2.2 Percentage No. of Assessments Based on Type of Industry



Pie-Chart 2: Percentage No. of Assessments Based on Type of Industry

Pie Chart 2 gives us a clear indication of the different kinds of industries and their percentage distribution in West Virginia. The supermarket, real estate, auto parts and hair stylist industries create just over half of the energy usage; hence, most of the assessments are done in these industries. Of these four, supermarkets consume the most energy due to lighting systems and air conditioning needed to keep the food products fresh and clean. Real estate consumes the second highest amount of energy. In the auto parts industry, most of the energy is used for running air compressors, hydraulic presses, and other mechanical equipment that consume energy. Overall, energy consumption is higher because of the huge size of these three industries. Because of this, more assessments are performed in these areas to evaluate energy consumption.

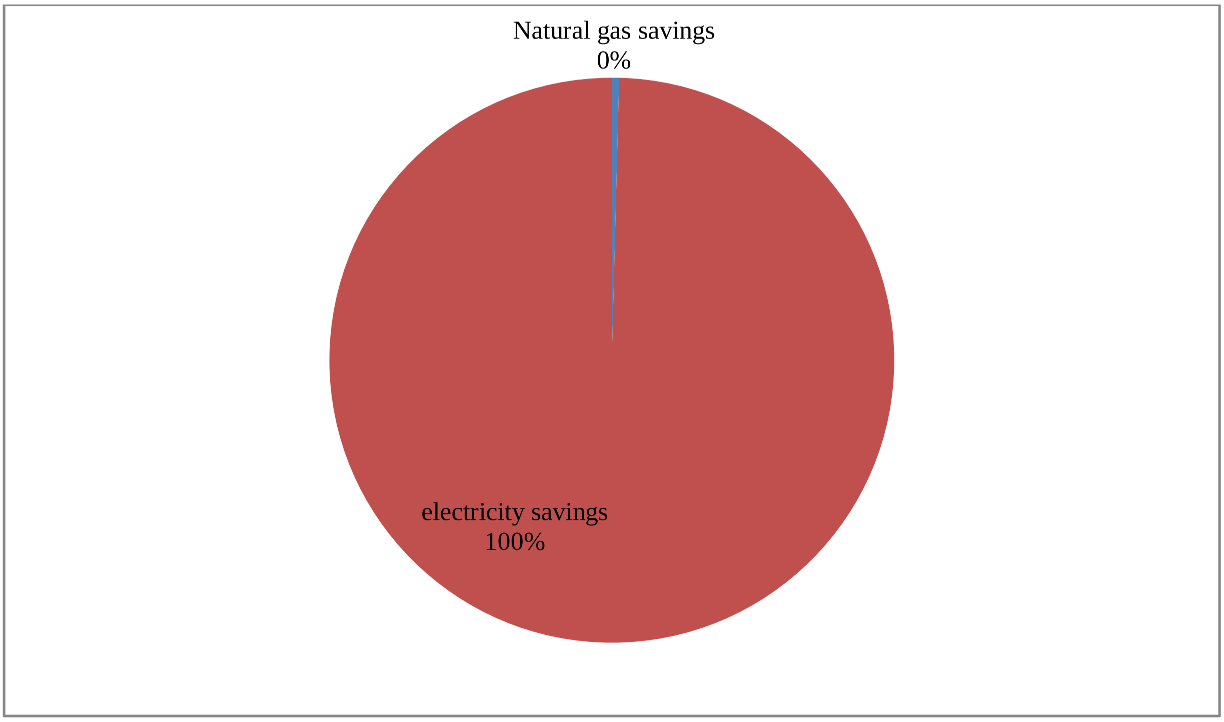
4.2.3 Percentage No. of Assessments Based on NAICS Code



Pie-Chart 3: Percentage No. of Assessments Based on NAICS Code

Pie Chart 3 gives us information about the assessments performed according to NAICS code. Retail trade comprised 48% of assessments. Retail trade consists of supermarkets, florists, jewelers, clothing stores, convenience stores, etc., which cover the major market. We have already seen from Pie-Chart 2 that more energy is consumed in the retail trade. We also know that due to the huge competition from large scale industries, small rural businesses see less profit. Due to this, more USDA assessments are conducted in rural locations to help reduce energy consumption and gain profit through energy savings.

4.2.4 Comparison of Energy Saving Between Natural Gas and Electricity



Pie-Chart 4: Natural Gas Savings Vs Electricity Savings

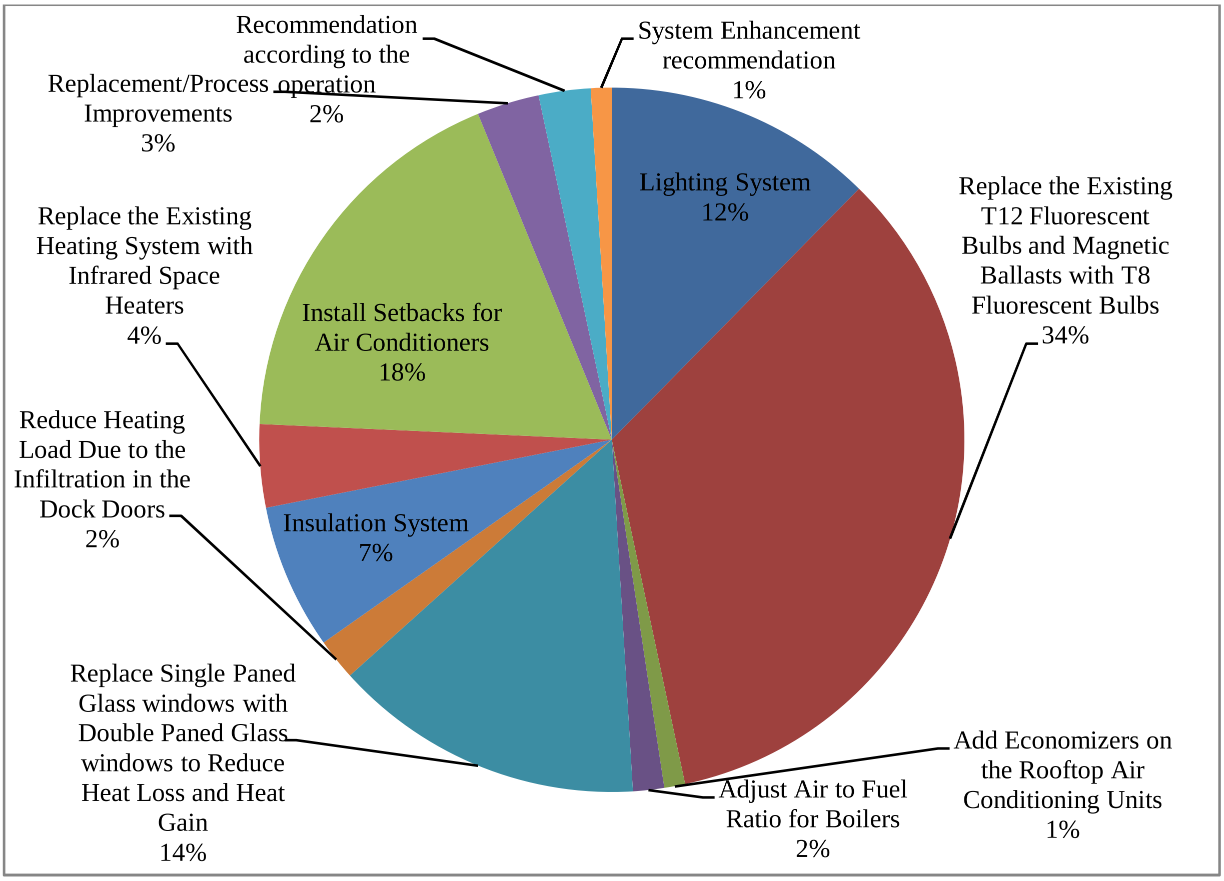
When we look the Pie Chart 4, electricity savings are far higher than natural gas savings. The individual values for each of the savings are,

Natural Gas: 7139.09 MMBtu

Electricity: 1710945 Kwh

This is a clear indication that most of the industries run their machinery and equipment on electricity. The only use of natural gas occurs in bakeries, where it is used for oven heating, and in some buildings and industries for heating. Since there is very little usage of natural gas, the energy savings are also less. Conversely, electricity is utilized in almost every sector of every industry, thus energy savings are higher.

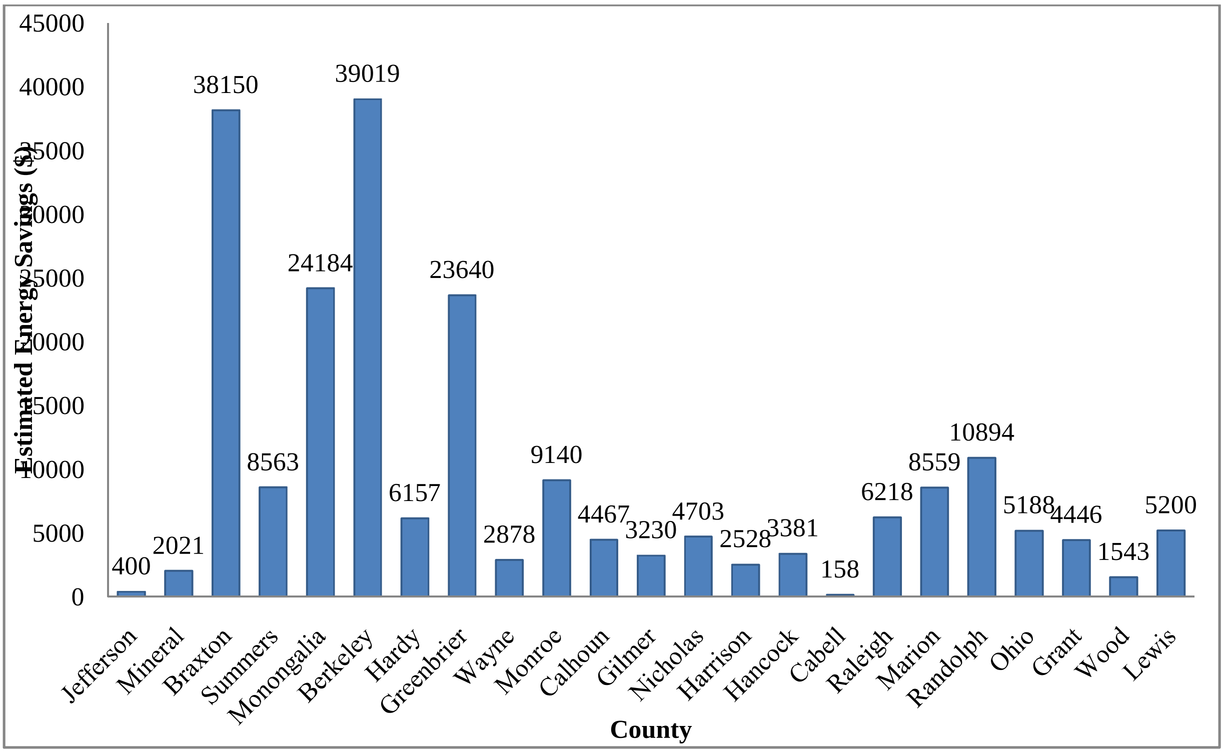
4.2.5 Percentage Number of Suggested Recommendations



Pie-Chart 5: Percentage No. of Suggested Recommendations

We have seen from Pie Chart 4 that energy is mostly saved in electricity. Hence, the recommendations suggested correspond entirely to electricity. If we look at Pie Chart 5, replacing the T12 with T8 fluorescent bulb is the most highly recommended. Recommendations related to other lighting system were around 12%. Combined, adjustments to lighting systems make up 46% of the total recommendations. This proves that most industries use older lighting systems that consume a lot of energy. T8 bulbs give the same intensity of light as that of T12 bulbs, but the energy saving is greater. The next highest recommendations are to install setbacks for air conditioning systems, accounting for 18% of the total recommendations. This recommendation helps in adjusting the room temperature according to working and non-working hours. The setback helps control any unnecessary heating or cooling of the building, thereby saving energy. Adding an economizer and replacing the existing heating systems with infrared space heaters will increase the energy efficiency of a system. Insulation was the next most recommended, accounting for 23%. Insulation helps avoid heat exchange with surroundings, retaining the set temperatures of the room. Infiltration and replacing single paned window with double paned window falls under the insulation system, of which replacing the single with double has the most with 14%.

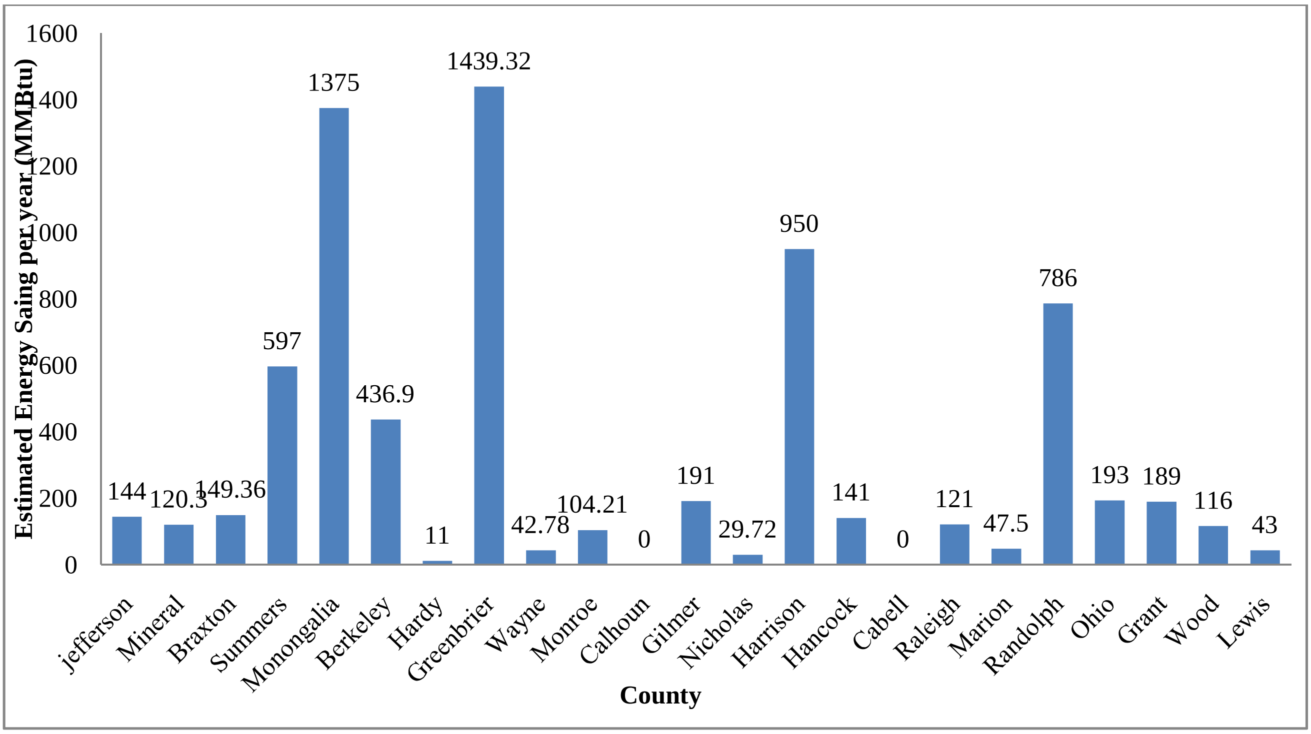
4.2.6 Estimated Cost Savings According to the County



Graph 1: Estimated Energy Savings in Each County

Graph 1 shows information about energy cost savings in each of the counties if the suggested recommendations are followed. Berkeley and Braxton County had maximum energy savings close to $40,000, though the number of assessments performed in the two counties only made up 8% of all assessments done (Pie Chart 1). The reason behind this is that, the industries are large-scale retail industries, and also a large number of recommendations were suggested. Cabell County had the least cost savings because there were only a couple of assessments done, where the firms were small and medium sized with less energy savings.

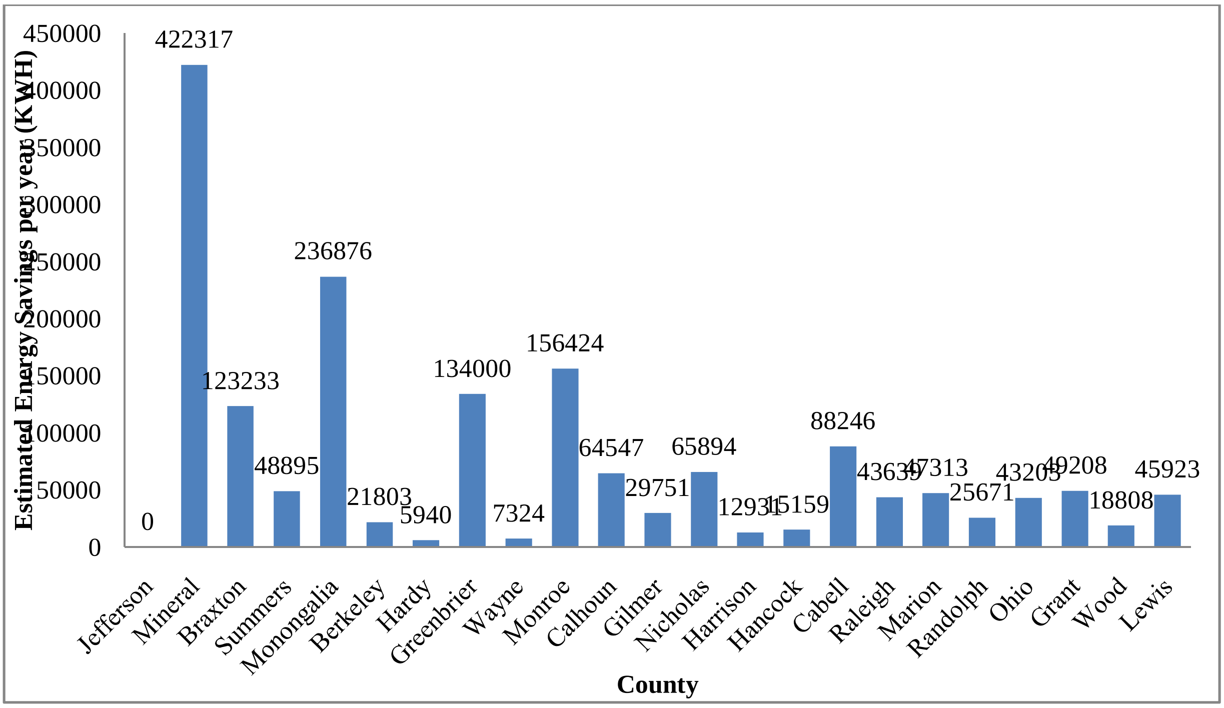
4.2.7 Estimated Natural Gas Savings According to the County



Graph 2: Estimated Natural Gas Saving (MMBtu) In Each County

Graph 2, shows the energy savings from natural gas. Greenbrier and Monongalia County saved the most in natural gas. This is because natural gas is used for the heating of buildings. There are few restaurants where natural gas is used for heating the grill and oven to cook the meat. Though the saving of natural gas is not significant when compared to electricity (Pie-Chart 4), the savings has an effect on the total cost savings when taken in total. Calhoun and Cabell County had zero savings because the firms assessed are small retail businesses that use hardly any natural gas.

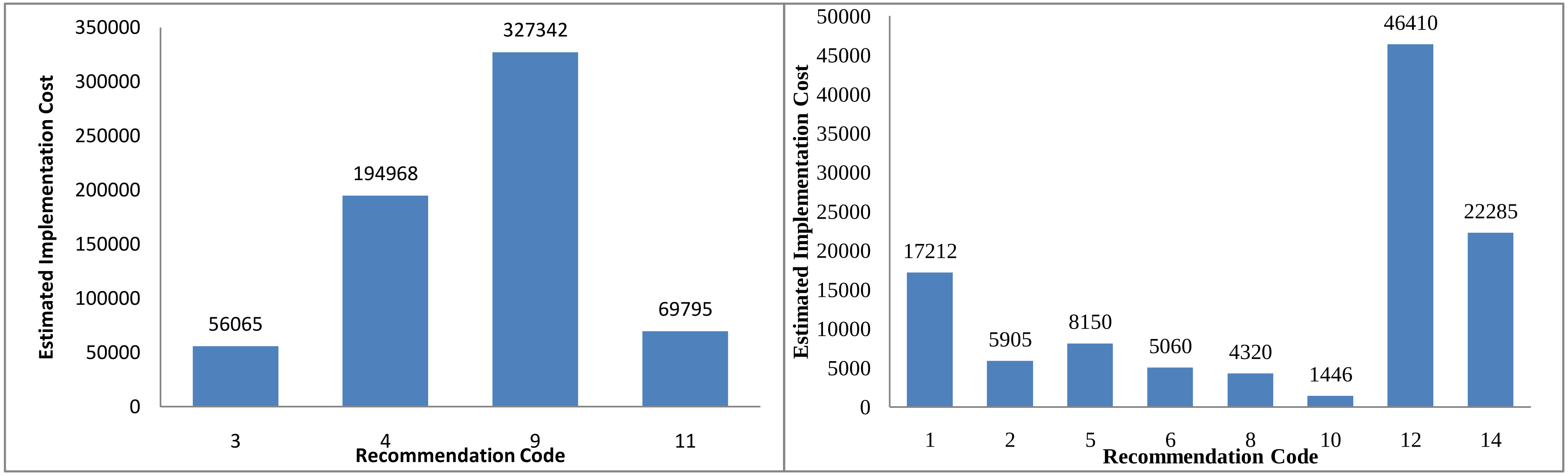
4.2.8 Estimated Electricity Savings According to the County



Graph 3: Estimated Electricity Savings According to the County

Graph 3 shows that Mineral County saved the most in electric energy with 422317 Kwh saved, followed by Monongalia County with 236876 Kwh saved. Because the fixed rate in Mineral County is 0.03910 $/Kwh, whereas in Braxton County it is almost twice that (0.06476 $/Kwh), cost savings in terms of dollars are higher. Due to the change in the fixed rate, the final output (i.e. dollar savings) varies. The average energy savings of the remaining counties are around 80,000 Kwh, but the cost savings may vary according to the fixed rate offered by each county utility board.

4.2.9 Estimated Implementation Cost for Suggested Recommendations



Graph 4: Estimated Implementation Cost for Various Suggested Recommendations

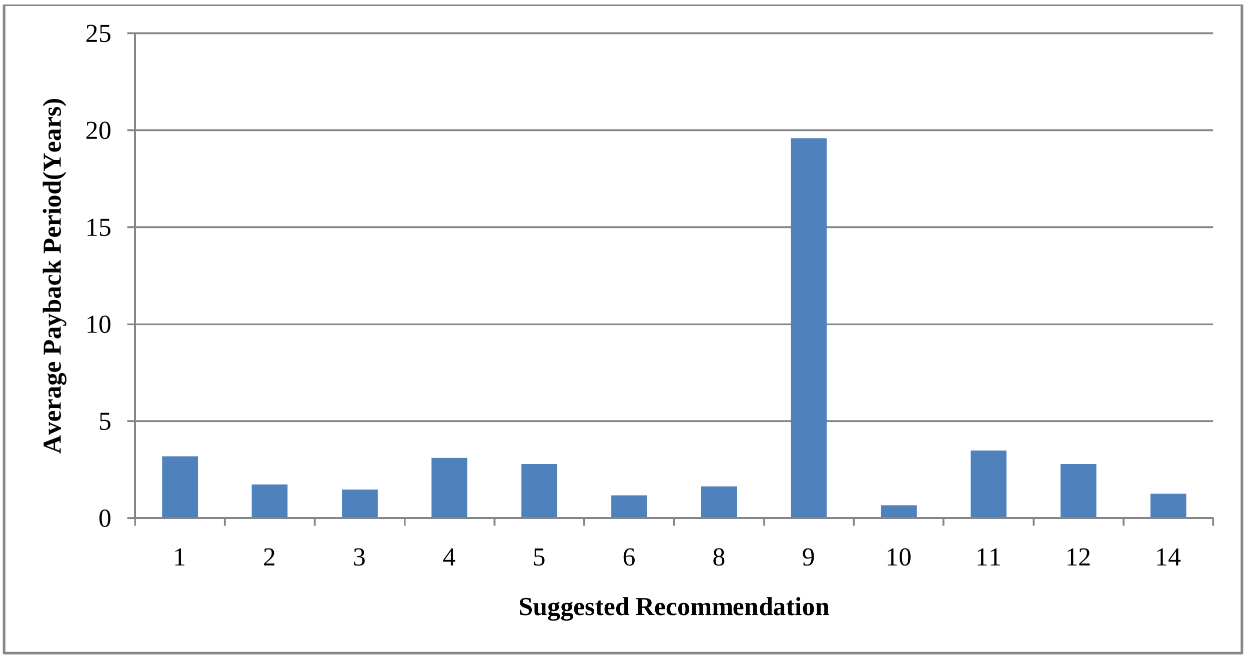
Graph 4 aids us in calculating the implementation cost for the various recommendations. Here, both graphs represent the same title, but with a difference in scale. The graph on the left shows the recommendations that cost above $50,000, whereas the graph on the right shows recommendations that have implementation costs less than $50,000. Table 3-2 provides information about the various recommendations. Replacing a single-paned glass window with a double-paned glass window (i.e. Recommendation Code 9) costs the most, followed by replacing T12 bulbs with T8 fluorescent bulbs (Recommendation Code 4). Implementation costs are higher in the graph on the left because most of the assessments done are in retail. The retail industry has more energy savings in lighting and air conditioning, two recommendations that are made the most often. Since there are many of these assessments and recommendations, the cost associated with them is also higher.

Table 4-1: Recommendation Table

code	Recommendations
1	Replacement/Process Improvements
2	Recommendation according to the operation
3	Lightning System
4	Replace the Existing T12 Fluorescent Bulbs and Magnetic Ballasts with T8 Fluorescent Bulbs
5	Add Economizers on the Rooftop Air Conditioning Units
6	System Enhancement recommendation
8	Adjust Air to Fuel Ratio for Boilers
9	Replace Single Paned Glass windows with Double Paned Glass windows to Reduce Heat Loss and Heat Gain
10	Reduce Heating Load Due to the Infiltration in the Dock Doors
11	Insulation System
12	Replace the Existing Heating System with Infrared Space Heaters
14	Install Setbacks for Air Conditioners

Recommendation Code 10 has the lowest implementation cost. We find this kind of recommendation in supermarkets and poultry farms. To avoid infiltration, we need to stop the air flow in and out of the dock. There is not much cost associated with this type of recommendation since most of the industries are small scale business where the docks and storage spaces are not common, reducing the overall cost.

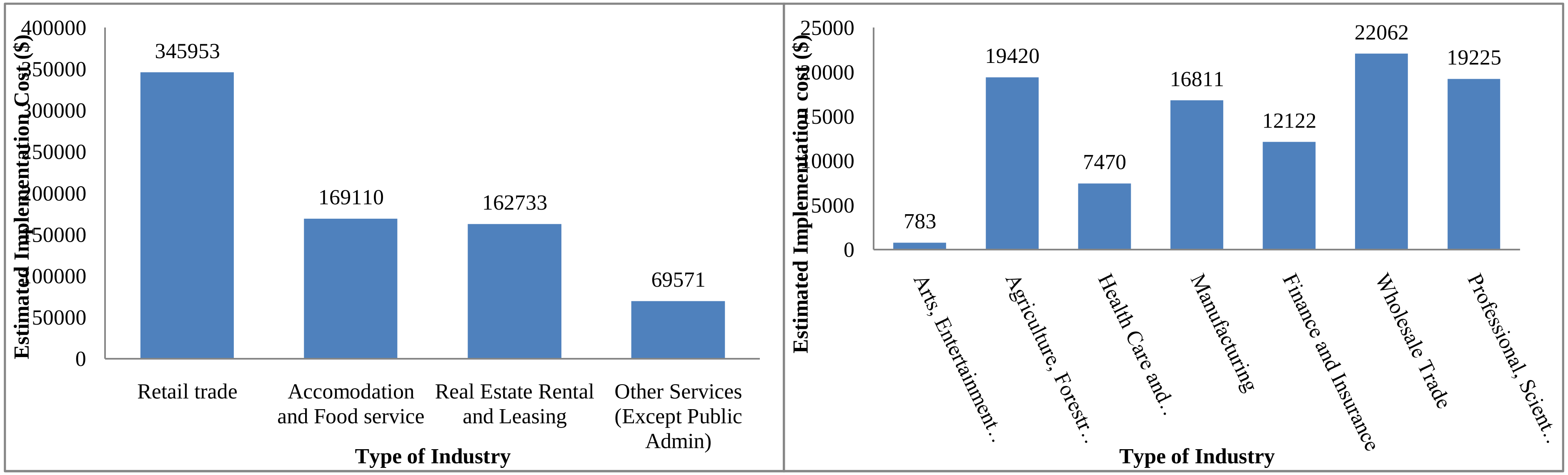
4.2.10 Estimated Average Payback Period for the Suggested Recommendations



Graph 5: Estimated Average Payback Period for the Suggested Recommendation

Graph 5 shows the average payback period for the suggested recommendation and the recommendations are labeled according to Table 4-1. Except for replacing the single paned glass window with double paned glass window the average payback period is 5 years. The reason behind high payback period is because of the high implementation cost associated with this recommendation. Since the total average payback period was 10 years, this number was used in calculating the present worth of the future amount.

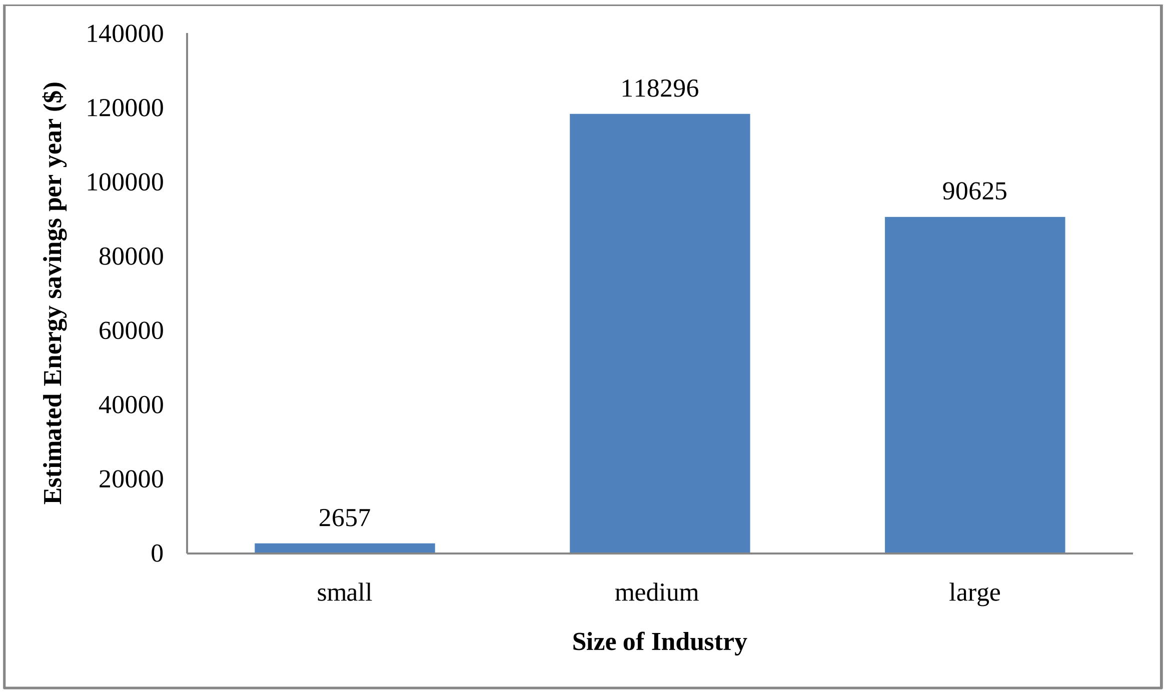
4.2.11 Estimated Implementation Cost According to the Type of Industry



Graph 6: Estimated Implementation Cost for Various Types of Industries

Graph 5 represents the cost for each type of industry when the suggested recommendations have to be implemented. The retail industry has to spend lot of money to become more energy efficient because of the costs associated with upgrading lighting and HVAC systems (Graph 4), two upgrades done mainly in the retail, accomodation, and food industries. These industries are also more highly populated, another reason for high implementation cost. The arts, enetertaiment, and recreation industries have the lowest implementation cost. Here there are two sets of graphs. The graph on the right represents the type of industries that have implmentation costs less than $25,000. The graph on the left gives us the type of industries that have implementation costs greater than $50,000.

4.2.12 Estimated Energy Saving According to the Size of Industry



Graph 7: Estimated Energy Saving with the Size of Industry

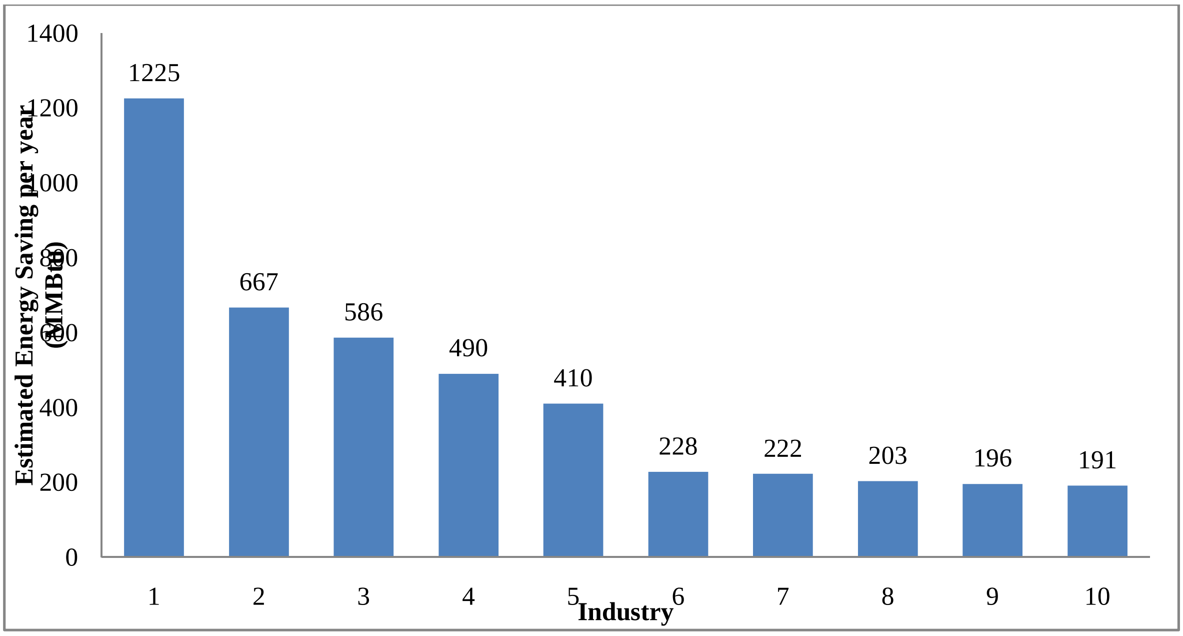
In the case of mid-sized industry, savings are higher, followed by large-scale industry, with the least amount of savings occurring in small-scale industry. In general, a large industry will save more energy than medium or small sized industries. Graph 6 displays the total savings in each category of the industries. Since there are more medium sized industries, the incurred savings are higher. Though there are fewer large industries, the cost savings are higher because the energy savings are more in large industries. This small rural businesses are segregated according to the area it occupies (sq-foot).

4.2.13 Top 10 Natural Gas Saving (MMBtu) Industries

There were 98 USDA assessments done in the state of West Virginia, of which the top 10 energy savings (MMBtu) industries in terms of natural gas are shown in Table 4-2:

Table 4-2: Top 10 Natural Gas Saving Industry Details

S.No	Size	Type
1	medium	Retail Trade
2	large	Manufacturing
3	medium	Real Estate Rental and Leasing
4	large	Accommodation and Food service
5	large	Agriculture, Forestry, Fishing and Hunting
6	medium	Accommodation and Food service
7	large	Manufacturing
8	large	Accommodation and Food service
9	large	Retail Trade
10	large	Retail Trade

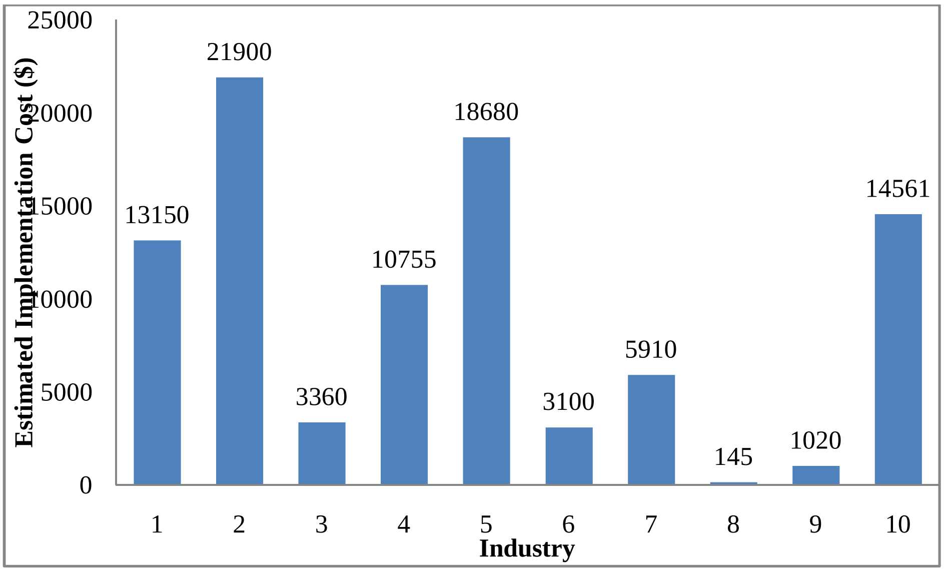


Graph 8: Top 10 Natural Gas Saving Industry

Graph 7 depicts the best energy saving industries in regards to natural gas. Table 4-2 elaborates on Graph 7 by showing the size and type of each industry. Most industries in the top 10 are the large-scale industries, mostly retail and accommodation. It is a hosiery manufacturing company that uses natural gas to heat materials and utilizes excess heat to warm the building. Hence, when a recommendation was suggested, the energy savings associated with natural gas was higher.

Implementation cost and the cost savings vary with the same set of industries. The above two quantities are measured with respect to the maximum energy savings (MMBtu). We consider the energy saving in MMBtu because the energy savings are constant, whereas the cost savings vary as the fixed rate varies from county to county.

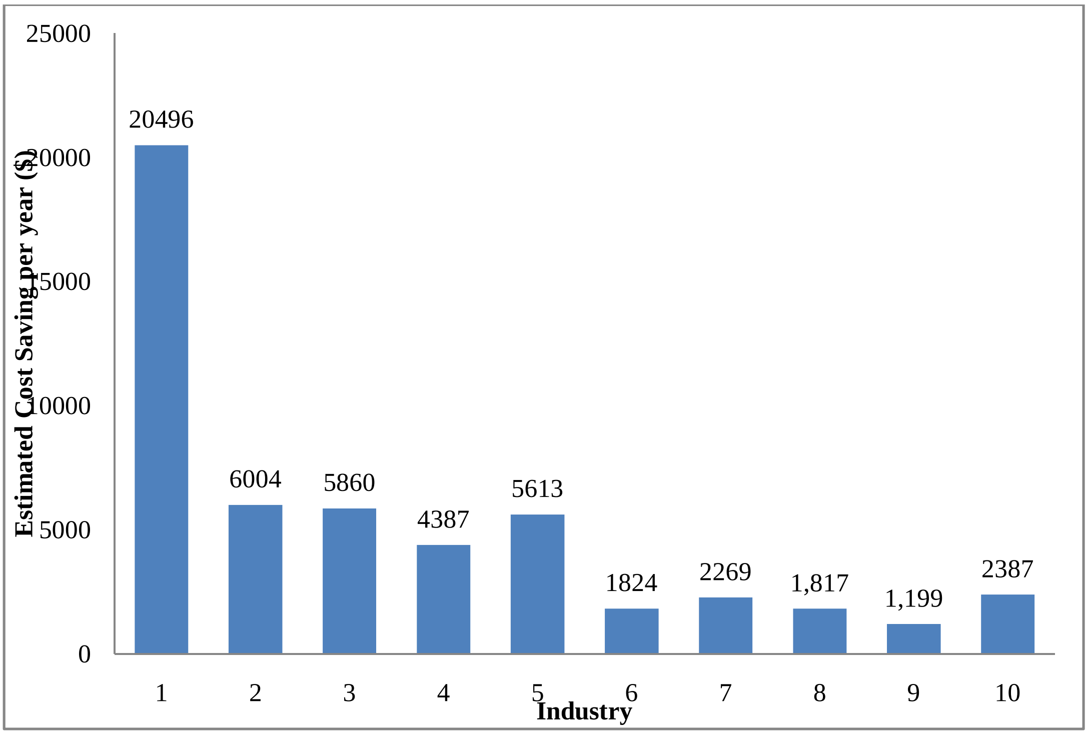
4.2.14 Estimated Implementation Cost of the Top 10 Natural Gas Saving Industries



Graph 9: Estimated Implementation Cost for the Top 10 Industries

From Graph 8, we can see that Industry 2 had to spend more to implement the suggested recommendations, as it is a manufacturing industry and the heating system associated with it is energy consuming. That heating system had to be replaced by infrared heating, which saves energy but has a high initial setup cost.

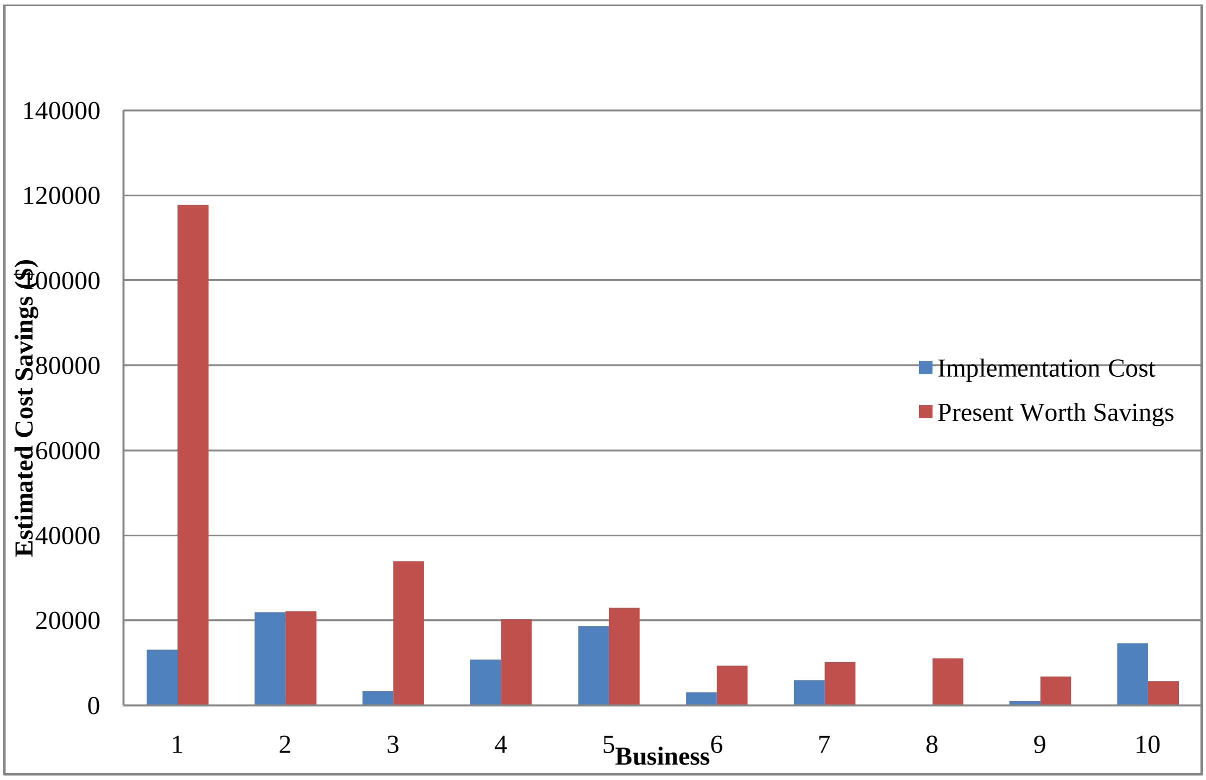
4.2.15 Estimated Cost Savings for the Top 10 Natural Gas Saving Industries



Graph 10: Estimated Cost Savings for the Top 10 Natural Gas Savings Industry

Graph 9 shows the money each industry saved at the end of each year. Industry 1 had the highest energy saving because it is located in a county which has got a very good fixed rate and gives high profits in terms of dollars. Therefore, Industry 1 saves more on cost savings ($) if the recommendations suggested are implemented. The remaining industries saved an average of $2,500 per year.

4.2.16 Present Worth Savings (Natural Gas) vs. the Estimated Implementation Cost



Graph 11: Estimated Present Worth Savings vs. Implementation Cost

Savings for 10 years have been assumed for calculating the present worth of the future savings and this has been graphed. The discounted rate of 5% has been assumed to calculate the present value. Industry 1 saved more and the suggested implementation cost is less. Most of the industries make profit except for the last one because the rate of return is not high. This business would end up with profits at the end of 10 years.

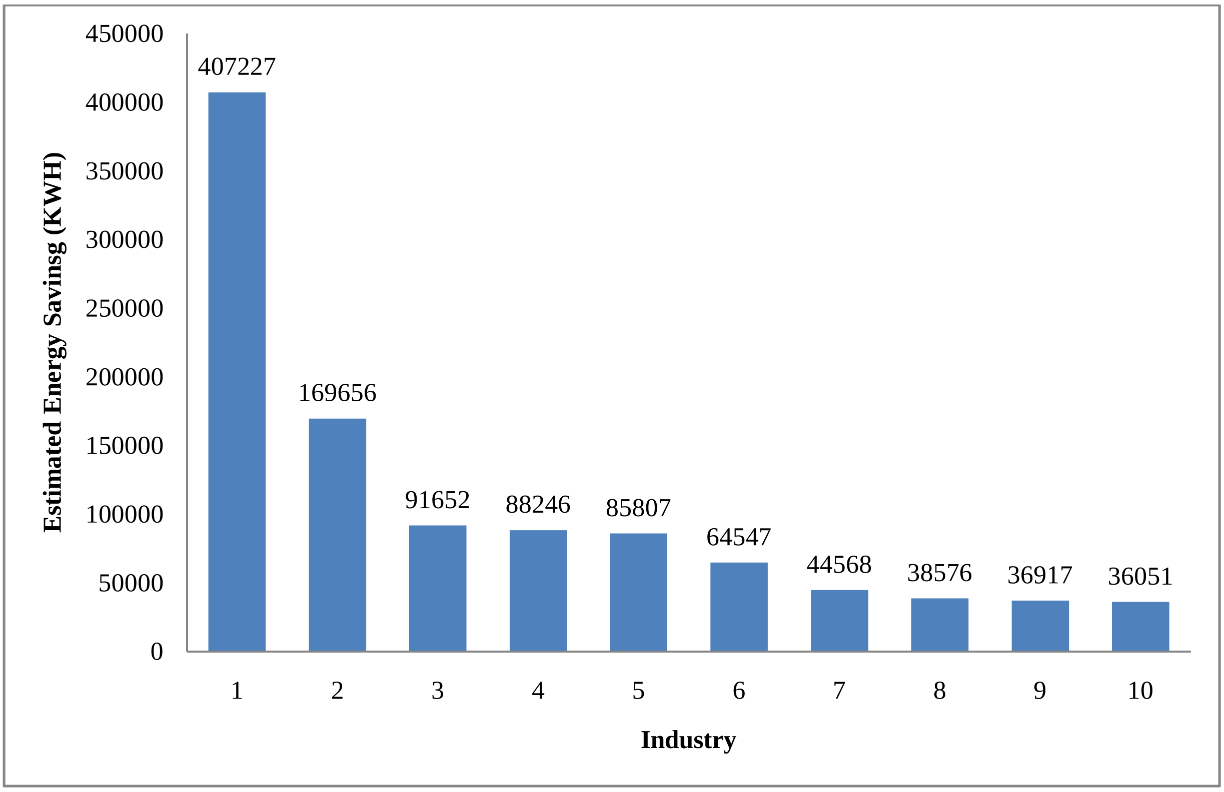
4.2.17 Top 10 Electricity Saving (Kwh) Industries

The top 10 industries which save electricity (Kwh) have been segregated from the 98 USDA assessments. The Table 4-12 below gives us the information about the size and type of industry which saves high on electricity. Here, most of the industries are retail or accommodations which are large or medium sized.

The implementation cost and the cost savings are varied with respect to the top 10 energy saving industries.

Table 4-3: Top 10 Electricity Saving Industry Details

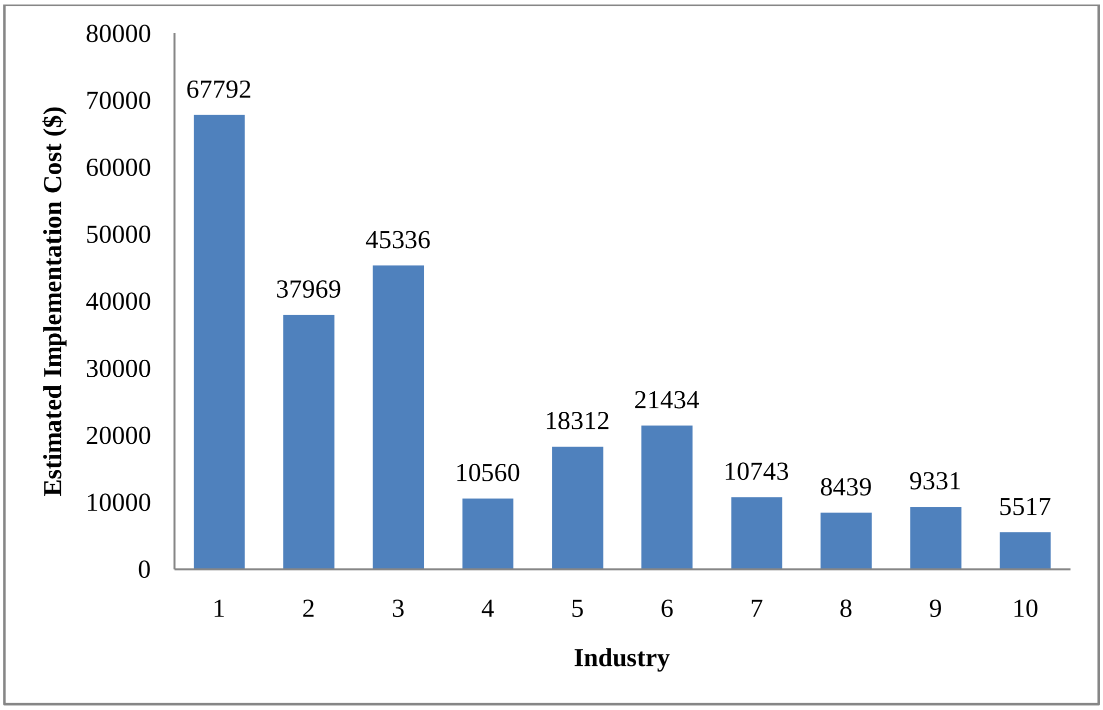
S.No	Size	Type
1	large	Accomodation and Food service
2	medium	Retail Trade
3	large	Retail Trade
4	large	Manufacturing
5	large	Retail Trade
6	large	Retail Trade
7	large	Manufacturing
8	large	Retail Trade
9	large	Accommodation and Food service
10	medium	Retail Trade



Graph 12: Top 10 Natural Gas Saving Industry

The information given by Graph 11 states that the Industry 1 would save around 407227 Kwh of electrical energy every year if the suggested recommendations were followed. This is a significant energy saving. When we look at Table 4-3, Industry 1 is large and in the accommodation sector. Since it is large in size, there were more recommendations to be applied to a large scale of equipment. Energy saving are higher when compared to the remaining set of industries in the list. The remaining energy saving are around 50,000 Kwh per year.

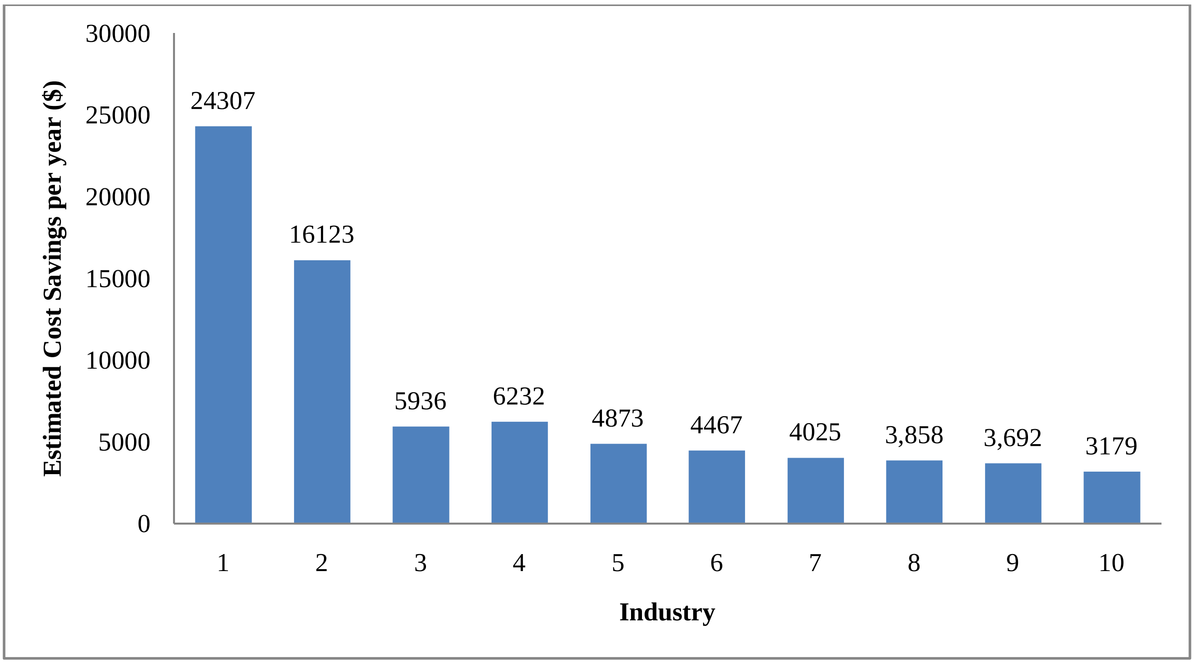
4.2.18 Estimated Implementation Cost for the Top 10 Electricity Saving Industries



Graph 13: Estimated Implementation Cost for the Top 10 Electricity Saving Industry

Graph 12 gives us information about the implementation cost. It states that the larger the industry is, the higher the energy consumption, hence a higher number of recommendations suggested and, eventually, higher implementation costs.

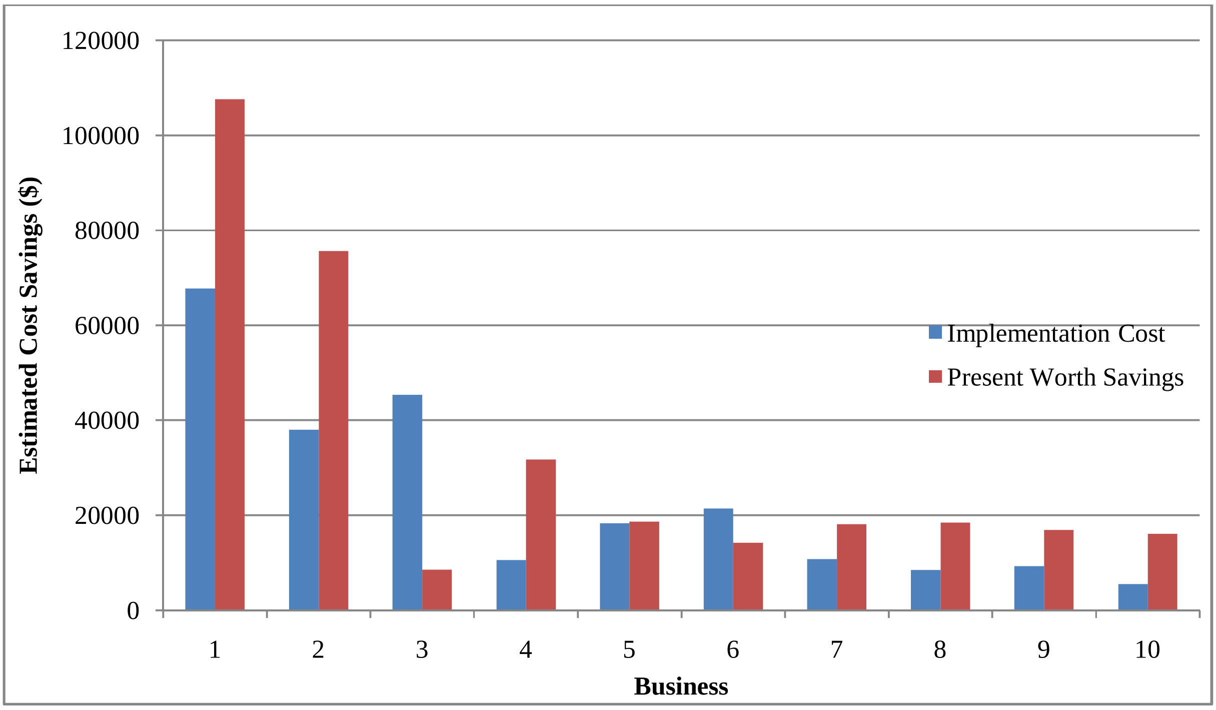
4.2.19 Estimated Cost Savings for the Top 10 Electricity Saving Industries



Graph 14: Estimated Cost Savings for the Top 10 Electricity Savings Industry

Industry 1 would save $24,307 per year followed by Industry 2, which would save around $16,123 per year. The remaining industries would save around $5,000 per year. From Graph 13, we can conclude that the size of the industry coincides with energy savings as long as the industry is located in a county that has a higher fixed for savings. These factors combined to create higher savings.

4.2.20 Present Worth Savings (Electricity) vs. the Estimated Implementation Cost



Graph 15: Estimated Present Worth Savings vs. Implementation Cost

Savings for 10 years have been assumed for calculation and the present worth of the future profit has been found and graphed. The discounted rate of 5% has been assumed to calculate the present value. Almost all of the companies would save energy, but when calculated to the present value savings of the industries 3 and 6 are low compared to the implementation cost. This is because the payback period is high. The profits they get for the energy savings go to replace the money spent in the implementation of the suggested recommendation until the payback period. If the payback period is high (i.e. when the cost savings are low), it will take some time to see the actual profits. Implementing the recommendation would create savings, however those savings would vary according to the implementation cost and recovery savings.

5 Conclusion

5.1 Regression Analysis

Independent variables X_1 to X_{14} have no effect on the dependent variable the Cost Saving ($). This can be concluded by analyzing the Mini-Tab (Fig 4-3) output, where the R-Sq and the Adjusted R-Sq values are 21.39 % and 10.02% respectively. For the variables to be significant, the P-Value of each variable should be less than 0.05. Using regression analysis, we can conclude that the variables chosen have no effect on cost savings ($) except for medium sized industry (i.e. variable X_2).

5.2 Graphs and Plots

This method gives us many key findings; many conclusions can be drawn from the various pie charts and bar graphs. The key conclusions are:

- Small scale industries are needed in each county. They are setup with the encouragement and support of the local citizens and communities, which plays a major role when the firms are being assessed. More assessments would benefit counties by producing higher energy savings, thus reducing the burden on the government.
- Consumption of energy depends on the size and type of industry. The larger the industry, the more energy savings an assessment can produce. Commercial industry (i.e. Retail Trade, Accommodation, and Food Service) consumes more energy because these companies have to satisfy customers to ensure profits. To provide good customer satisfaction, each company will want to provide sufficient lighting and HVAC systems, both of which are energy consumers. When a more energy efficient system is installed, energy is saved.
- In today's world, a large portion of energy consumption comes from the use of electricity. As newer electrical systems are invented, they can replace older, outdated systems and provide relief in the form of better efficiency.
- Lighting and HVAC systems have to be improved in most industries in order to save energy.
- Due to the change in the energy fixed rate from county to county, high energy savings are not always proportional to cost savings. Sometimes this has an adverse effect on the firm when accounting for profits.

- Implementation cost depends on the size of the industry and the number of recommendations suggested. Larger industries will generally have a higher number of recommendations, thus a higher implementation cost.
- If the suggested recommendations are implemented, there will be profits after the payback period. Until then, the energy savings are used to compensate the cost incurred from implementation.

Key conclusions shown in the graphs will help stakeholders to make decisions about implementation. The above key factors act as building blocks for further development. The government can allocate the funds to the Industrial Assessment Center in conducting more number of assessments. This helps more number of small business in doing assessments.

The owners of the firm will also benefit from this report. They can evaluate their own firm without an assessment and make proper recommendations to improve upon the company. In doing so, they can acquire profits and help the government reach its goal of creating a more energy efficient economy.

These reports will benefit the Industrial Assessment Center (IAC), as well. This paper will help the IAC to cut costs during assessment by giving a rough estimate of the energy savings, as well as providing a guideline for what recommendations can be suggested and how much cost will be incurred for implementation.

5.3 Future Works

Since the information in this report is limited, it would be useful to continue research. For further analysis, research can be extended by collecting more implemented data, which would help to formulate regression equation that would give a rough estimate of the energy cost savings in dollars.

Research can also be extended by making the process web based, for calculating the cost savings. This data can be a source for finding key features about small scale business in West Virginia. The same research can be extended to other states, as well.

6 Bibliography

[1] Bri-Mathias Scott Hodge, A Multi-Paradigm Modeling Approach For Energy Systems Analysis, Thesis Document for Doctor of Philosophy, Purdue University, West Lafayette, Indiana. August 2010.

[3] Zheng Liu, Sustainable Design of Complex Industrial and Energy System Under Uncertainty, Thesis Document in for Doctor of Philosophy, Wayne State University, Detroit, Michigan. 2012.

[4] Nicolas Lopez, Renewable Energy Integration: An Approach For Micro-Grid Optimization, Thesis Document for Master of Sciences, The University of Texas, El Paso, Texas. December 2010.

[6] U.S. Energy Information Administration, Annual Energy Review 2009, Primary Energy Consumption by Energy Source, 1949-2009, Table 1.3. August 2010.

[7] Gordon J. Aubrecht, Energy/ Edition 2, Prentice Hall, New Jersey, January 1995.

[8] National Energy Education Development, Intermediate Energy Info Book 2011-2012, The NEED Project, Virginia.2012.

[9] U.S. Energy Information Administration, Annual Energy Review 2010, End-Use Sector Shares of Total Consumption, Fig: 2.1a: Energy Consumption Estimates by Sector Overview. October 2011.

[11] Energy Efficiency and Renewable Energy, Building Energy Data Book, Chapter 1: Building Sector, U.S. Department of Energy. March 2012.

[12] Reed. J and Johnson. K, Who Plays And Who Decides, Innovologie LLC. March 2004.

[13] Energy Efficiency and Renewable Energy, Energy Efficiency Trends In Residential And Commercial Buildings, U.S. Department of Energy. October 2008.

[14] Energy Efficiency and Renewable Energy, Commercial Building Types: Floor space, Number, and Primary Energy Consumption, Building Energy Data Book, Table 2.2.2. October 2008.

[15] Energy Efficiency and Renewable Energy, Commercial Building Ownership and Occupancy, 2003 (Non-Mall Buildings), Building Energy Data Book, Table 2.2.3, October 2008.

[16] Energy Efficiency and Renewable Energy, Commercial Primary Energy End-Use Splits, 2005, Building Energy Data Book, Table 1.3.3, October 2008.

[17] Mark Henry, Mark Drabenstott and Lynn Gibson, A Changing Rural America,Economic Review. August 1986.

[18] Anil Cabraal. R, Douglas F. Barnes, and Sachin G. Agarwal, Productive Uses Of Energy For Rural Development, Energy and Water, Energy Sector Management Assistance Program, World Bank, Annual Reviews. 2005.

[19] Mlarc 0. Ribaudo, Lessons Learned About The Performance Of USDA Agricultural Nonpoint Source Pollution Programs, Journal of soil and water conservation. 1998

[20] Rodney C. Loehr, The Influence Of English Agriculture On American Agriculture, Agricultural History, Vol. 11, No. 1 (Jan., 1937) pp. 3-15. 1775-1825

[21] U.S. Department of Agriculture, Mission Statement. Electronic Source: http://www.usda.gov/wps/portal/usda/usdahome?navid=MISSION_STATEMENT

[22] West Virginia Agricultural and Rural Small Business Energy Audit Program, Electronic Source: http://www.iofwv.nrcce.wvu.edu/usda/index.cfm.

[23] U.S. Department of Agriculture - West Virginia Agricultural and Rural Small Business Energy Assessment Program, Brochure.

[24] Ryan Crane, Energy Assessment Guidance, American Society of Mechanical Engineers. 2011.

[25] Ryan Crane, New Energy Assessments Standards, American Society of Mechanical Engineers. 2011.

[26] Gopalakrishnan.B, Selvaraj.R , Turton.R , Plummer.R.W. , Sukumar.S, A Systems Approach To Plant-Wide Energy Assessment: A Peer Reviewed Publication, The Association of Energy Engineers, Pg: 49-80. 2005.

[27] Mehta, D. Paul, Impacts Of The Save Energy Now (Sen) Program, The Associate of Energy Engineers, Pg: 43-59. November 2010.

[28] Klaus-Dieter, Pawlik.E, Lynne C. Capehart , Barney L. Capehart, Analyzing Facility Energy Use: A Balancing Act, The Association of Energy Engineers, Pg: 8 to 33. 2011.

[29] Nithya Sundararajan, An Analysis Of The Trends In Energy Conservation Studies Of The Iac Program, M.S Problem Report, West Virginia University. 1999.

[30] Laura Hartz, Fritz Boettner, Jason Clingerman, Greenbrier Valley Local Foods:The Possibilities And Potential, Greenbrier Valley Economic Develeopment Corporation. Oct, 2011.

[31] Mitch Olszewski, Robert Leach & Karen McElhaney, DOE/OIT Plant-Wide energy Assessment Experience Summary, Engineering Energy, 99:2,56-71.July 2009.

[32] Olutomi I. Adeyemi. Lester C. Hunt, Modelling OECD Industrial Energy Demand: Asymmetric Price Responses and Energy- Saving Technical Change, Energy Economy, v 29, n 4, p 693-709. 2007.

[33] Peter Sandberg, Mats Soderstrom, Industrial Energy Efficiency: The Need For Investment Decision Support From A Manager Perspective, Energy Policy, v 31, n 15, p 1623-34. December 2003.

[34] Tonn, B., Martin, M., Industrial Energy Efficiency Decision-Making, Energy Policy 28(12), 831-843. 2000.

[35] Ramesohl, S., Clases,C., Prose, F., Duplicating The Success- From Positive Examples To Social-Economic Marketing Strategies For Greater Energy Efficiency In Industry, Proceedings

of the European Council for an Energy Efficient Economy (ECEEE) Summer Study 9-14 June, Spindleruv Mlyn, Czechia, Panel 3-ID 9, p 1-12. 1997.

[36] Harris, J., Anderson, J., Shafron, W., Investment In Energy Efficiency: A Survey Of Australian Firm, Energy Policy, 28(12), 867-876. 2000.

[37] EsterLuiten, Kornelis Blok, Stimulating R & D Of Industrial Energy-Efficient Technology. Policy Lessons-Impulse Technology, Energy Policy, v 32, n9, p1087-108. June 2004.

[38] Jenny Palm, Patrik Thollander, An Interdisciplinary Perspective On Industrial Energy Efficiency, Applied Energy, V87, n10, p 3255-61, October 2010.

[39] Ang B.W., Multilevel Decomposition Of Industrial Energy Consumption, Energy Economics, v 17, n 1, p 39-51. January 1995.

[40] Dolf Gielen, Peter Taylor, Indicators For Industrial Energy Efficiency In India, Energy, v 34, n 8, p 962-9. August 2009.

[41] Mehrdad Heidari Tari, Mats Soderstrom, Modeling Of Thermal Energy Storage In Industrial Energy System The Method Development On MIND, Applied Thermal Engineering v 22, n 11, p 1195-205. August, 2002.

[42] Geoffrey P. Hammond, Industrial Energy Analysis, Thermodynamics And Sustainability, Applied Energy, v 84, n 7-8, p 675-700. July/August 2007.

[43] Parkin S, Sustainable Development: The Concept And The Practical Challenge, Proc ICE: Civil Engineering, 138: 3-8. 2000.

[44] Van Gool W, Nieuwlaar E, Hoogendoorn A, Gaasbeck J, van Gool P, de Graaf E, et al. The Book On Energy Analysis And Energy Optimization Of Industrial Processes. Hilversum: ERBEKO BV. 1990

[47] Louise Reynnells, Patricia LaCaille John, USDA National Agricultural Library, Rural Information Center, Beltsville, MD. 2008.

Web Links

[2] Types of Energy, Figure 1-1, VCE Environmental Science by Edublogs.org, http://vceenviroscience.edublogs.org/2012/02/08/transformations-of-energy/.

[5] U.S. Energy Information Administration, Energy Kids, http://www.eia.gov/kids/energy.cfm?page=about_home-basics

[10] Wikipedia, Energy, http://en.wikipedia.org/wiki/Energy

[45] Wikipedia, REGRESSION ANALSIS, http://en.wikipedia.org/wiki/Regression_analysis

[46] Wikipedia, GRAPHS,http://en.wikipedia.org/wiki/Graph_%28mathematics%29

[48] http://eligibility.sc.egov.usda.gov/eligibility/welcomeAction.do