PROPANE DEMAND MODELING FOR RESIDENTIAL SECTORS: A REGRESSION
ANALYSIS

by

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ABSTRACT

This thesis presents a forecasting model for propane consumption within the residential sector. In this research we explore the dynamic behavior of different variables that affect the propane consumption and develop a forecasting model. The significant factors that had an impact on propane consumption in houses were heating degree days of that area, wind speed, precipitation and the size of the houses. However in the case of mobile homes, only the heating degree days had significance. The behavior of the customers was assumed to be static. This model is based on multiple regression methods. The data was collected from a local propane company in West Texas. Different combinations of months were used in this model to study propane consumption behavior for each month. These different studies were used to generate the final forecasting model. As propane consumption was low for the months from June to September, the best results were obtained when the data for the months from October through May was used for analysis. The results indicate that the forecasting model provides a potentially useful forecast.

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CHAPTER I

INTRODUCTION

1.1 Motivation

Forecasting is a method of estimation of future outcome of the variables we are interested in. It is an important tool in any business leading to successful managerial decisions. We use forecasts in making strategic decisions under uncertainty. This research is intended to help propane companies do a better job of anticipating, and hence a better job of managing uncertainty, by using effective forecasting and other predictive techniques.

Ideally, large organizations can afford to do forecasting usually by assigning the responsibilities to the people who are best qualified and have the resources at hand to make such estimations under complicated demand patterns. However, small firms do not have enough resources and the staff to carry out these forecasts. Also the smaller firms cannot afford miscalculations in new forecast levels. Hence we decided to forecast the propane demand for a local small firm. Also not many researchers have studied propane demand forecasting. It was this motivation that led us attempt to do the modeling.

This research presents a forecasting model for propane consumption within the residential sector. The forecasting of propane demand may be useful to propane suppliers and customers by providing information on maximum demand to be expected and the duration and timing of these demands.

Transporting propane is one of the most influential factors that affect propane prices. Propane first moves through underground pipelines to the distribution terminals, from where it is moved to the dealers either by rail or road. These dealers then serve customer demands. Predicting propane demand can help reduce transport costs by not overstocking the storage centers when propane demand is too low.

1.2 Propane as a Fuel

Propane is liquefied petroleum gas consumed for different applications in residential, commercial and industrial sectors. In the residential sector, it is primarily used as a space heating fuel. It is also used for water heating, cooking fuel, drying clothes, and sometimes as an alternative fuel for vehicles. Propane is also used as a fuel in many appliances for mobile homes. Portable propane heaters are used as a source of heat for construction and road workers in cold weather.

Propane is largely used to make petrochemicals that are then used for the production of plastics, alcohols, fibers, and cosmetics.

However, propane has not yet become a widely used fuel. Many consumers are not fully aware of the benefits of propane. It is currently the most inexpensive alternative fuel to natural gas. It is a relatively safe fuel to use and also emits fewer toxic chemicals as compared to other alternative fuels.

1.3 Propane Demand

If we look at figure 1.1, about 37 percent of all propane consumed in the United States is used by the petrochemical sector. According to the American Petroleum Institute, about 45 percent is used by the residential and commercial sector.

Figure 1.3 Propane Demand by Sector

Of the 107 million households in the U.S., 9.3 million depend on propane for one use or another, and 54 percent of these households rely on propane for their primary heating fuel.

Farmers contribute 8% of the total propane consumed. They use propane to dry crops. Propane is also used to heat barns, and also used as a fuel to operate farm equipments.

Propane is most commonly used to provide energy to areas not serviced by a natural gas distribution system. Thus, it competes mainly with heating oil for space heating purposes.

1.3.1 Realistic Residential Propane Usage

No one uses their appliances at 100% all day long and hence we can use a higher than average gas usage approach to find the summer and winter propane usage.

1.3.1.1 Summer Propane Usage

During summers, most of the residential propane is used by cooking appliances, water heaters and dryers. For example, if we consider a water heater (with appliance BTU rating of 220,000) used at the rate of 25% capacity for 2 hours a day, the total propane consumed will be:

$$220,000 \text{ BTU/hr} \div 91,547 = 2.4 \text{ gal/hr (Since one gallon of propane has 91,547 BTU's)}$$

Therefore total propane consumed per day will be:

$$2.4 \text{ gal/hr} \times 0.25 \times 2 \text{ hrs} = 1.2 \text{ gallons.}$$

Similarly, we can calculate the propane used by other appliances per day and thus the total propane used by a particular household in summers.

1.3.1.2 Winter Propane Usage

In winters, as the heating requirements increase, more usage of all energy sources is made. Hence, propane used by the household drastically increases. Similar calculations can be used to calculate the propane consumed.

Since it was not feasible for us to go to each house and calculate the propane consumed, we obtained the data on different households from a local propane distribution center.

Lubbock is located on the Texas South Plains and is at 3200 feet above sea level. It has a population of about 200,000. The city's propane demand arises primarily from residential units for cooking and space heating purposes in rural areas that are not served by natural gas distribution system.

1.4 Factors that Impact the Consumption of Propane

Propane supply and demand is subject to changes in domestic production, weather, and inventory levels, among other factors. Weather conditions have been recognized as being a significant factor in the consumption of propane. While propane production is not seasonal, residential demand is highly seasonal. This imbalance causes the buildup of inventories during the summer months when consumption is low and the drawdown of inventories during the winter months when consumption is much higher. When inventories of propane at the start of the winter heating season are low, chances increase that higher propane prices may occur during the winter season.

Colder-than-normal weather can put extra pressure on propane prices during the high demand winter season because there are no readily available sources of increased supply except for imports. Imports may take several weeks to arrive, during which time above normal withdrawals from inventories may occur, sending prices

upward. Cold weather early in the heating season can cause higher prices to occur earlier, since early inventory withdrawals affect supply availability of the propane.

1.5 Importance of Energy Demand Forecasting

As the future is uncertain energy demand forecasting is very important. Energy demand forecasting is nothing but to predict what will be the demand in future for a particular source of energy. For examples, forecasting propane demand helps to determine if there will be a shortage of propane in the storage or distribution center, and is there a need for new distribution station or a storage facility, or vice-versa that there is an overabundance of propane i.e. far more than the demand and if there is a need to shut down few facilities.

Cost is another reason for developing the energy demand model. Too low forecasts will result in a shortage of energy, which will lead to increase in the prices and as a result the consumers will have to pay more for the service. High forecasts will result in over abundant supply which might result in shutting down of few storage or distribution centers. The costs associated with this shutting down will be passed on to the consumers. Hence forecasting energy plays an important role in determining costs and thus might have an effect on the consumer behavior.

There should always be a timely and reliable availability of energy supplies and this is directly related to the economy. Also the investments in such energy systems are very high and can largely affect the economy of a country. Hence forecasting energy demand is very important for any country.

In any energy service market, the market will always decide price and price will determine demand. Therefore the importance of energy demand forecasting grows.

1.6 Types of Energy Forecasts

Many types of energy demand forecasting techniques exist. The energy consumption pattern varies over time. It also varies according to season.

More consumption of energy is used during the winter and summer months than in spring and fall. Because the temperatures during summers and winters are extreme while moderate during fall and spring.

Also energy consumption varies within a day. During day time less energy is used as people tend to go to work or are usually not present in their respective houses. The energy consumption increases during night till early morning. It also varies from day to day. During weekdays less amount of energy is used as compared to weekends when people stay at home. During evenings and weekend people tend to watch television, or play games, they cook food and also need light to see. As a result more energy is consumed.

As a result there are different types of forecasts, namely:

- 1) Seasonal forecast
- 2) Short run forecast
- 3) Long run forecast
- 4) Peak Demand forecast

5) Medium run forecast

These different types of forecasts are used to determine the energy level at different levels.

1.6.1 Peak Forecasts

During summers and winters there are some days when maximum amount of energy is required. Forecasting such days is called peak demand forecasting technique.

In winters sometimes temperature in North America goes bitterly cold. As a result there is more demand for energy to heat the space. Similarly, temperature during summers goes very high which demands for more air conditioning. Hence peak demand forecasting is necessary to ensure that there is enough energy to heat or cool a place.

1.6.2 Short-Run Forecasts

Shorts run forecasts are forecasting for a very small period of time. They are valid for a few hours in future. These forecasts are important for the energy service unit who have to schedule and dispatch units on time within a given day.

1.6.3 Medium-Run Forecasts

Medium run forecasts are valid from 3 months to several months.

1.6.4 Long-Run Forecasts

A long run forecasts are valid from five to twenty-five years into the future.

1.6.5 Seasonal Forecasts

Seasonal forecasts are valid for a particular season. They are used to predict the peak demand for a forthcoming season.

1.7 Types of Forecasting Methods

Different methods are used for forecasting energy demand. Those include time-series method, time-trend method, judgmental method, identity method, end use method and econometric method. Detailed explanation of these methods is given below.

1.7.1 Time-Series Method

The time-series method is used for data with a pattern or trend over time. It consists of either one variable i.e. univariate or many variables i.e. multivariate. Such forecasts are usually based upon historical data for the loads being forecast. Time-series is mainly used to project seasonal patterns and daily or seasonal loads.

Time-series methods are often accurate for short term and also less expensive compared to other methods. Only a small data set can be used to carry out this method.

However there are a few disadvantages of this method. Many a times, historical data patterns cannot be applied to long term forecasts. Also the error sources are difficult to interpret.

1.7.2 Time-Trend Method

Time-trend methods are considered when data follows a permanent deterministic pattern across time. It determines the overall trend in historical data and develops the forecast based upon that trend. Earlier this method consisted of plotting the data on graph paper and laying a ruler through the points. Time-trend method can be used for short-term modeling. This method is vulnerable to many errors.

The main advantage of this method is that it requires little skill and is inexpensive. It can be modeled as per requirements by changing data. The data set required for such analysis is very small.

The main disadvantage of this method is that it is vulnerable to many errors. It does not pay attention to any influences.

1.7.3 Judgmental Method

The judgmental method uses information obtained from experts in the field rather than numerical data. This relies on judgments, opinions and probabilistic estimates from experts. The knowledge of experts like managers, developers, etc. is used to develop the forecast. When other forecasting methods do not work, it is better to rely on judgmental method. It is sometimes the most effective of all methods.

Judgmental methods are usually low cost. It uses the expertise and knowledge available freely. It is helpful when there is no historical data available.

However, there are a few disadvantages for this method. The expert opinion can be wrong sometimes. Also experts are not always available for their opinion. This method is not accurate enough as it does not make use of any statistical techniques.

1.7.4 Identity Method

The identity method uses separate forecasts of two variables and then defines a relationship between them. It is a very basic form of forecasting energy demand. The data required for this method are always generated by other forecasting models. This model is usually used for forecasting electricity in a particular area of service. Underlying factors are not accountable in this method and so this method can sometimes be very uncertain.

It is a very simple method as no special skills are required and the forecast can be computed in a very short period of time. It is a much accurate method for forecast as it uses other independent forecasts.

However, it is a very difficult method and it sometimes can be subject to great uncertainty.

1.7.5 End Use Method

The end-use method is generally used to forecast electricity demand for a particular house. It forecasts using the data from all of the electrical appliances used in the home. It sums up all the end-use activities. End-use models must include all the energy consumed data by type of equipment or process. This method is usually applied to residential sectors.

The main advantage of this method is that it gives a detailed understanding of how equipment is used and how it changes over time. Errors in forecasting can be easily interpreted. The computer skills required for this method is intermediate. It can be used as a great tool for marketing. This method is easy to understand and explain it to others.

Data on end use may not be available all the time. This method takes a lot of time and also requires large amount of detailed data. It is a very difficult and a costlier method. Sometimes long term forecasts using this method can be tedious.

1.7.6 Econometric Method

The econometric method is the most complex technique used for forecasting energy demand. It considers the influence of independent variables on the demand variable. Econometric models usually use time-series data and usually include regression analysis. They can be used for all sectors namely residential, industrial, and commercial. A lot of data is required for forecasting using this method. It requires the data such as incomes, prices of the variables required to forecast, weather factors if applicable, etc.

Econometric methods provide a statistical interpretation of forecasting uncertainty. It measures the underlying causes of different trends. It is one of the most accurate methods of forecasting and it is very easy to re-estimate such models. The data required for developing such models can be easily available.

The disadvantages of econometric models are that it is very expensive and also the data required to carry out the analysis is large. The skill and experience required in computer programs is too high.

1.8 Problem Statement

Because the propane demand is seasonal there is a huge imbalance between inventories in the summer and winter months. Demand for propane is low in the summer months and as inventories build up and the prices go downward. As demand begins to increase in winters and the temperature drops prices go high. Household consumption of propane depends highly on weather conditions and hence is a major reason of increased demand in the winter.

The inventories that build up during the summer are used as a cushion during the winter months, but soon the demand starts to overtake supply. However sometimes there can be a shock demand when the winter or cold weather falls quite before expected. This can lead to an imbalance in the supply and demand of propane. So the problem of this research was to forecast propane demand so as to obtain a balance between the supply and demand during the winter months and thus not hike the propane prices.

Another problem was to estimate the number of in-call customers. Some propane supply companies have two types of customers; those served on regular (usually monthly) schedule and those who call in for service only when propane is needed. This second type of customers present the most difficult type to serve since

their need for delivery is unscheduled and often urgent. A predictive model such as one presented in this research can be used by a propane supply company to have a better estimation of the number of call in demands for service.

1.9 Objectives

The objective of this thesis is to develop a winter residential propane energy demand model for West Texas Gas, Inc. service area in Lubbock. Regression analysis was used to test the model. Therefore, the objectives of the thesis are:

- 1) Develop a winter residential propane energy demand model for West Texas Gas, Inc. service area in Lubbock
- 2) Use regression analysis to analyze the model.
- 3) And measure the forecasting performance by calculating a percentage of error between the actual and derived values.

1.10 Terminology

1.10.1 Regular Customers

Regular propane customers are those that are long term customers with the propane company. They are reliable in paying for propane service and also require propane on a monthly basis. These customers pay for the bill later as they are billed for service by on a monthly basis.

1.10.2 Call-in Customers

Call-in customers are customers who call for service when they are low on propane. They also may not have enough money to pay for the bill every month.

Some call-in customers call only when they have the cash to pay upon delivery.

Usually these call-in customers move frequently, hence the demand fluctuates and also the propane company has a risk a customer moving away with an unpaid bill.

1.10.3 Mobile Homes

Mobile homes are first built in factories and then taken to the site where it has to be installed. These homes are usually fixed at one location permanently and cannot be moved.

1.11 Assumptions

- 1) The customer behavior is assumed to be static. That is, the regular customer does not change their demand every year depending on the prices or other factors.
- 2) The propane price is not considered to be a significant factor in determining or predicting the propane consumption.
- 3) This research has been limited to forecasting for normal periods that is periods without irregularities in demand caused by holidays or festivals.
- 4) Data is obtained from West Texas Gas Inc. and the parameters are calculated as per their records.
- 5) Only data for 20 – 30 houses was collected and the rest of the houses were assumed to have the same demand.
- 6) The economic effect on the propane consumption is considered to be constant.

1.12 Expected Results

Different solutions for houses and mobile homes were developed. The models provided potentially useful forecasts. Evaluations of the solutions were also been made.

CHAPTER II

LITERATURE REVIEW

There are not many researches who have attempted to predict the propane demand as it is not a widely used fuel. However, similar predictions on the demand from other sources of energy have been made. The need for accurate energy forecasts began during the industrial revolution when there was a need for the efficient use of energy (Burns, 1984).

2.1 Supply-Demand Modeling

In 1987, a model for energy supply and demand in the state of Illinois was introduced. In developing countries, the major part of energy is consumed by households. In 1990, Kamal Rijal used a linear multiple regression demand forecasting model for presenting the energy requirements in Nepal [17]. A few years later, in 1993 an energy demand-supply model for developing countries was suggested by Vishwa B. Amatya [5]. His model was based on the demand for wood resources in Nepal. There model was capable of simulating different cases or scenarios. It was based on an end-use/process analysis approach. Also in the same year, Fang Zhen carried out a research to forecast energy supply-demand [26]. He developed, an optimized linear model for energy demand-supply forecasting for a village in north China. In 1997, a model called LEAP model (Long-range Energy Alternative Planning) was developed by Bala [8]. He developed a dynamic model of supply and demand forecasting for rural energies and also impacts it had on the

environment. The output of this model was employed in another similar model associated with energy and environmental concerns.

2.2 Electricity Demand Modeling

In 1966, researchers G. T. Heinemann and D. A. Nordman published a paper on relationship between summer weather and summer loads [13]. This demand modeling was done using regression techniques. Regression analysis showed that the combined effect of the weather variables can be expressed by one composite weather variable.

Houthakker and Taylor in 1970 developed a dynamic model for forecasting energy demand [14]. Their model determined the current level of the variable by the cumulative effects of past behavior. Later this approach was used to model predict the residential electricity demand and also the price at national and state level. In 2005, Bernstein and Griffin did an analysis to estimate the prices at national and regional levels [10]. They found out that there was a huge difference between the prices at various regional levels. Also there was a huge difference between national and regional levels.

In 1997, Baltagi and Griffin and suggested that homogeneous estimators were better at predicting demand [9]. This shows that a lot of research was carried out from the year 1966 till today on electricity demand and prices.

2.3 Forecasting Models

A modern technique of forecasting energy demand was developed by Al-Garni, Zubair, and Nizami in 1994 [6]. They developed this model for Saudi Arabia. They used statistical method for forecasting. The summers in Saudi Arabia are very hot as so they decided to forecast the energy during warm weathers.

Similar research was done by Leung and Miklius in 1994 on Hawaii [16]. They used different statistical methods of energy forecasting. Again Hawaii's warm climate may lead to excessive demand and so forecasting was necessary.

Many other researchers developed forecasting methods using statistical methods. Summer residential energy demand forecasting model was developed by S. V. Lee in the year 1983 [15]. He studied which factors influenced summer peak residential energy demand and then forecasted demand based on those factors. His model is very similar to our models.

Halvorsen suggested that residential electricity demand is a function of both economic and non-economic variables [12]. All these factors can be included while developing a forecasting model.

CHAPTER III

METHODOLOGY

Forecasting is to make statements about the events in future by using the variables from present and past. Although there is no way through which we can predict the future completely, but forecasting helps to make the necessary changes required now in order for avoiding uncertainties and risks in the future. This section describes the methodology used to forecast the residential propane demand.

3.1 Model Development

Residential propane demand is affected by many different factors. Initially, we observed that the residential propane demand is a function of propane price, size of the houses and mobile homes, economy, number of customers and weather variables.

Cold waves during winters can cause many problems when the temperature reaches very low levels. As the temperature decreases, the demand for propane increases due to increased demand for heating devices. A temperature variable like heating degree days measures the relationship between temperature and demand.

Size of the houses can also be very important factor in determining the demand for each house. The amount of propane consumed has a relationship with the size of the houses. Larger houses require more propane because the heating space is more.

Precipitation is another factor that has a relation with propane consumption. Precipitation can lead to cold weather, heavy snowfall and rainfall. This will bring the temperature down and as a result the need for propane to heat the space will increase.

Propane price is another factor that influences its consumption. As price goes up, the consumer tends to use less propane and when the prices are low they use more. Also, if the consumers have a cheaper option, they will always go for the inexpensive one. However, in a small town like Lubbock the price of propane did not affect much on the consumer's behavior. Hence, the data on the price of propane was rejected.

3.2 Description of Data

All the data on monthly propane consumed by different houses from the year 2004 through year 2009 was obtained from a company that serves Lubbock. Data on weather variables was obtained from the U.S. records on historical weather data. The data is shown in Appendix A in the tables 2-5.

The data obtained was at county level. County level was selected because the company West Texas Gas, Inc. mainly serves the county of Lubbock in West Texas.

3.3 Variables

The variables represent the factors that influence the propane consumption. Various variables were considered at the beginning. However, the model obtained was influenced only by a few of these factors.

3.3.1 Total Propane Consumed

The total propane consumed is the total energy demand consumed by the customers served by West Texas Gas, Inc.

3.3.2 Heating Degree Days

Demand for energy to heat is home is often calculated using the heating degree days. They are defined with respect to a base temperature above which the system needs no heating. Usually the base temperature is considered as 65⁰ F. One problem using heating degree days is that they do not consider all weather factors, like humidity, wind, etc. The data on heating degree days was obtained from U.S. records for weather.

3.3.3 Size of the Houses or Mobile Homes

Size of the houses or mobile homes is measured in square foot. One problem using the size of the house was that it did not consider the height of the room. Hence the heating space was considered as square foot and not cubic foot.

3.3.4 Precipitation

Precipitation is the condensation of water vapor that takes place in the atmosphere and falls under gravity.

3.3.5 Temperature

Temperature is a quantity that is used to measure the amount of hotness or coldness. Low temperatures are referred to as coldness and high temperatures as hotness.

3.3.6 Cooling Degree Days

Cooling degree day is a similar quantity to heating degree day, the difference being that it is the amount of energy required to cool a space.

3.3.7 Price

The price of the propane is a variable which might have an effect on the consumer behavior.

3.3.8 Wind Speed

Wind speed is the velocity at which wind travels. Sometimes during colder weather high wind speed can get lower wind chills which make us feel colder than what the actual measured temperature is.

3.4 Method of Analysis

At early stages of the research, it was decided to use only the readily available weather variables to forecast the propane demand. The U.S. maintains a record of historical data on weather which includes temperature, heating degree days, cooling degree days, wind speed, precipitation, snowfall and relative humidity. The data on size of the houses and the average monthly propane consumption was obtained from a local propane company that serves about 50% of the customer demand in Lubbock. It was necessary to examine the history of each variable affecting the propane consumption in order to establish trends.

Firstly, the software Minitab was used for developing scatter plots which helped to find the correlation between various factors. Later, regression analysis was

used to find a relationship between the total propane consumed and the correlated independent variables. SAS 9.1 was used as a tool to run the regression analysis.

3.4.1 Correlation Matrix

Scatter plots were produced to find the correlation between different variables. Scatter plot gives an idea of how does a dependent variable change with respect to the independent variables. A best fit line is always drawn in the plot to study the correlation. The scatter plots for different variables are shown in Appendix B.

Using excel toolbar a correlation matrix was also developed for all the variables that might have an influence on the propane demand. The variables considered were:

- 1) Propane Demand
- 2) Heating Degree Days
- 3) Temperature
- 4) Precipitation
- 5) Cooling Degree Days
- 6) Price
- 7) Wind Speed

Shown below is the correlation matrix for all the variables.

Table 3.4 Correlation Matrix of Variables

Matrix	Demand	Heating Degree Days	Tempera ture	Precipitation	Cooling Degree Days	Price	Wind Speed
Demand	1						
Heating Degree Days	0.875	1					
Temperature	-0.889	-0.991	1				
Precipitation	-0.436	-0.487	0.509	1			
Cooling Degree Days	-0.668	-0.718	0.787	-106	1		
Price	-0.269	-0.122	0.141	0.216	0.174	1	
Wind Speed	0.023	-0.217	0.211	-0.152	0.161	0.2	1

As seen from the above table the variables price and wind speed hardly have an effect on other variables. Hence the data on these was rejected from the model. Also you can see that the heating degree day had a positive correlation with the demand for propane. Temperature had a negative correlation with the demand.

3.4.2 Regression Analysis

Regression analysis is a technique used for modeling and analysis. It is used when we have to find a relationship between the dependent and independent

variables. It estimates the value of dependent variable given the independent variables.

Multiple linear regression analysis was used for the modeling. The regression equation was as follows:

$$X = A_0 + A_1Y_1 + \dots + A_nY_n$$

where; X = Average monthly consumption of propane (Demand)

Y_i = Independent variable

A_i = Coefficient of regression

The regression coefficient measures the amount of change that will occur in the dependent variable for every unit change in the independent variables.

Definitions of some regression statistics is given below.

1) Population

Samples are always obtained for a population. As the size of population is too large, hence samples are always taken from the population for analysis.

2) Mean

Mean is the average of the samples taken from the population. The mean is represented by the following equation:

$$\bar{X} = (X_1 + X_2 + X_3 + X_4 + X_5 + \dots) / n, \text{ where } n \text{ is the number of observations.}$$

3) Regression Coefficients

A constant coefficient is always considered as a base level for prediction. The rest of the coefficient defines the effect of the independent variables on the dependent variable. These coefficients are multiplied with the independent variables for predictions.

4) Least squares

Least squares are an estimation method used in regression analysis. It minimizes the sum of squared deviations.

5) Residuals

Residuals are the difference between estimated values and actual values for a given dependent variable.

6) Standard Errors

Standard errors gives an idea about how reliable are the regression coefficients. It determines the strength of the residuals.

7) Sample Variance

Sample variance tells us how far the set of values are from each other within a given sample. It is usually calculated with respect to the mean of the sample.

8) Standard Deviation

The square root of variance is called standard deviation.

9) Degree of Freedom

Degree of freedom is the number of observations minus the number of coefficients estimated. The prediction largely depends on the degree of freedom. Lower values of the degree of freedom will give us a poor estimate. Hence an estimate should always have a higher degree of freedom.

10) R^2

It gives us a degree of success in predicting the values of dependent variable. It ranges from 0-1 scale. More the value closer to 1 will suggest that the predicted values are highly reliable. If the value is closer to 0 then it suggests that the regression fit is worse and we need to make changes in our model.

11) Adjusted R^2

When R^2 is adjusted for the degrees of freedom it is called adjusted R^2 . Addition of new variables result in the loss of a degree of freedom and thus adjusted R^2 can suggest if the model has improved or gone worse than the previous one. If there is more than one variable then adjusted R^2 is always less than the value of R^2 .

12) F-Statistic

It determines whether the overall fit of the equation developed is significant or not. It can also be defined as a measure of correlation between the dependent and the independent variables.

3.4.3 Modeling

Demand forecasting models were developed separately for houses and mobile homes.

3.4.3.1 Modeling for Houses

The initial step before applying the regression model was to identify those variables that are associated with the changes in dependent variable. A large set of variables were identified as possibly having an impact on the dependent variable, but only a few of them actually had an impact.

Scatter plots were used to identify variables having an impact on the dependent variable with a reasonable level of confidence.

The weather variables precipitation (P), heating degree days (HDD) or temperature (T) and wind speed (S) showed a linear relationship with the dependent variable (Propane Demand) and hence these variables were used in the regression equation. However we chose to use HDD instead of temperature as heating requirements of a house were directly proportional to the number of HDD of that area. The absence of relative humidity in our equation is because of low relative humidity that prevails in Lubbock, thus having a low impact on the demand for propane.

Initially only one model was developed for all size of houses. Later we found that the model was differing greatly in terms of size. Hence, two models were generated for different size of the houses. Small houses being 2000 square feet &

below and those above 2000 square feet were considered large houses. This produced more significant forecasts. Histograms of monthly propane demand were established from December 2004 through December 2008. Figure 3.4 presents one of these histograms for a specific residence.

Figure 3.4 Propane Demand Graph

It is necessary to alter the data to account for the fact that all the variables vary throughout the year. Many similarities in the demand pattern were observed for the months from October through May. Demands for the months from June till September did not resemble the demands for the other months. Therefore, we decided to exclude the demands for the summer months from the data sets. We also assume that there is no significant effect of the price of propane upon consumer's use habit.

3.4.3.2 Modeling for Mobile Homes

The procedure to model propane demand in mobile homes was similar to that of the houses. Scatter plots were developed for different variables that were

considered to have an impact on the demand, but the graph results indicated that only HDD had significant impact. The graphs unlike those for the houses did not show the variables precipitation and the size having any effect on the propane consumed. Also histograms suggested that the propane demand was too low for the months from June till September and hence we had to reject those data.

CHAPTER IV

RESULTS

Regression analysis was carried out separately for houses and mobile homes.

The propane demand for house largely depended on the size

4.1 Regression Analysis Results for Houses

The stepwise regression procedure from the SAS software was used to perform the regression analysis. The independent variables used for the analysis of houses are as follows:

- 1) Heating Degree Days
- 2) Size of the houses as Large and Small
- 3) Precipitation
- 4) Wind Speed

Table 4.1 below shows demand models for small and large houses

Table 4.1 Demand Forecasting Models for Houses

Size of House	Demand Equation	R ²
Large	DMD = -63.345 + 4.064 (P) + 6.034 (HDD) + 7.018 (S)	0.85

Small	$\text{DMD} = -103.786 + 4.064 (P) + 6.034 (\text{HDD}) + 7.018 (S)$	0.85
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Different combinations of months were used in this analysis to study the propane consumption behavior for each month. However we finally decided to generate a single model for the months from October through May. Refer Appendix C.

The weather related variables had a positive coefficient as we expected. It means that the demand for propane increases with an increase in these weather variables. Size was used as a dummy variable in our analysis and hence we obtained a single model with different coefficients of regression. Another value which is of importance in the regression model is the coefficient of determination (R^2). The R^2 value of 0.85 in the above table provides acceptable demand forecasts for both sizes of houses. Any value above 0.75 is considered to have a fairly good model fit.

SAS 9.1 was used as a tool to carry out the analysis.

The SAS output obtained was as follows:

Dependent Variable: Propane consumption Houses		
Source	F Value	Pr > F
Model	90.56	<.0001
R-Square		0.85586
Coeff Var		24.40260
Root MSE		20.95677
Propane_consumption Mean		85.87924

Figure 4.1 SAS Output for Houses

The F test is used to measure the overall fit of the regression model. For 95 percent significance the F- statistic should always be greater or equal to +4. From the SAS output table we can clearly see that the F – statistic was computed as 90.56 which is significantly above 4 and hence suggests that the overall fit of the model is good. Also the P-value from the SAS output table is very small at .0001, which suggests that all the three variables in the model are accounting for a significant part of variation in demand.

4.2 Regression Analysis Results for Mobile Homes

Again the stepwise regression procedure from the SAS software was used to perform the regression analysis for mobile homes. The independent variables used for the analysis was:

- 1) Heating Degree Days

Table 3 gives the results obtained for mobile homes.

Table 4.2 Demand Forecasting Model for Mobile Homes

Demand Equation	R ²
DMD = 8.381 + 3.010 (HDD)	0.80

The R² value of 0.80 in the above table provides acceptable demand forecasts for mobile homes.

The SAS output obtained was as follows:

Dependent Variable: Propane consumption Mobile homes		
Source	F Value	Pr > F
Model	129.48	<.0001
R-Square		0.8068
Coeff Var		25.72142
Root MSE		12.34442
Propane_consumption Mean		47.99278

Figure 4.2 SAS output for Mobile Homes

From the SAS output table we can clearly see that the F– statistic was computed as 129.48 which suggest that the overall fit of the model is good. Also the P-value from the SAS output table is very small at .0001, which suggests that the variable HDD in the model is accounting for a significant part of variation in demand.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The models developed provided a pretty significant forecast for the propane demand. Regression results were compared to the actual values obtained from the West Texas Gas, Inc., Lubbock.

5.1 Measuring Forecasting Performance

This is one of the most important elements of the demand forecasting process. Once we obtain a model we need to check the performance of our model to determine its accuracy. Forecasting performance is measured as a percentage of error between the actual and derived values.

Error can be calculated as follows:

$$E_T = A_T - F_T$$

where;

E_T = error for time period T

A_T = actual demand

F_T = forecasted demand

However when we calculate the performance of the model we convert this error in to percentage.

The percentage error in forecast can be calculated using the following formula:

$$\text{Percent Error (\% E)} = (A_T - F_T) / A_T * 100$$

Tables 5.1 show one of such performance charts.

Table 5.1 Forecasting Performance Chart

Actual demand (A_T)	Forecasted demand (F_T)	Error (E_T)	% E (in %)
173.2117	154.5275	17.6842	10.20
144.6417	144.9751	-0.3334	-0.2
143.7033	127.7440	15.9593	11.10

The forecasting performance charts for large houses, small houses and mobile homes can be found in Appendix D.

In reality it is almost impossible to have a zero error model. From the above table we can clearly see that our models generate an error between 0 - 15 %. Anything in the range of 0 – 25 % is considered acceptable. Also the model developed for the winter propane consumption was applied to the months from May through September when the temperatures are too high. We found that the error was too high for those months. Hence, the demand forecasting models we obtained performed significantly well for the months from October through April.

5.2 Conclusion

Propane demand forecasting models were developed for both houses and mobile homes. Models were generated for the months from October through May and yielded equations having high R^2 values. Although different models for all the months were developed initially, we suggested a single model for all the months considered that provides an acceptable forecasting model. However we found that different number of variables had an impact on the demand for houses as compared to mobile homes. Price variable too can have an impact on the propane consumption to some extent. Inclusion of the price variable will change the forecasting equation. Also, if we consider the changes in the behavior of the consumers then we have to develop a different forecasting model.

Many improvements can be further implemented into this model. There were many limitations to our model. Price did show much significance and so was not considered in the model. However, many times price plays an important role in energy demand. Hence price is important factor that can change or effect consumer behavior. For example, when the electricity prices go up, people will always tend to use less electricity and also look for cheaper alternatives.

Also we can consider the impact of economy on the propane consumption. Economic imbalance can have a huge affect on the amount of propane consumed by a customer. Bad economy can lead to less propane demand. This might result into shutdown of various facilities that serve propane.

The amount of propane consumed over a period of a day can be considered to find short term forecasts. During day less propane might be consumed as people often go to work. Also during the weekends more propane will be consumed as people stay within their houses.

The number of people staying in the house was another factor that could affect the propane consumption. More people in the house means more propane required for the house.

All these factors will give us a better and a more reliable model. This model can serve as a basis to design any energy demand model.

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APPENDIX A

DATA ON PROPANE CONSUMPTION

1. Data on Propane Consumption by Houses (in gallons/month). Provided by West Texas Propane, Inc.

Size of House(Sq ft)	2000	1700	1900	1800
Month				
Nov-04	71.76	44.16	38.64	0
Dec-04	22.08	69	104.88	175
Jan-05	80.04	63.48	52.44	214
Feb-05	118.68	69	77.28	100
Mar-05	93.84	38.64	60.72	150
Apr-05	69	33.12	19.32	0
May-05	49.68	8.82	13.8	0
Jun-05	19.32	0	19.32	0
Jul-05	19.32	0	13.8	0
Aug-05	24.84	0	16.56	0
Sep-05	24.84	0	19.32	0
Oct-05	41.4	8.82	19.32	100
Nov-05	96.6	44.16	49.68	0
Dec-05	63.48	49.68	71.76	0
Jan-06	129.72	35.88	96.6	200
Feb-06	102.12	69	41.4	0
Mar-06	63.48	35.88	27.6	100
Apr-06	5.52	30.36	60.72	0
May-06	22.08	0	0	0
Jun-06	24.84	0	16.56	0
Jul-06	5.52	0	16.56	0
Aug-06	0	0	11.04	100
Sep-06	2.76	0	8.82	0
Oct-06	2.76	35.88	49.68	0
Nov-06	2.76	82.8	38.64	92
Dec-06	2.76	88.23	91.08	100

Jan-07	5.52	91.08	110.4	100
Feb-07	2.76	55.2	99.36	250
Mar-07	2.76	49.68	35.88	0
Apr-07	2.76	44.16	49.68	100
May-07	2.76	0	19.32	0
Jun-07	0	0	16.56	0
Jul-07	0	0	19.32	0
Aug-07	5.52	0	13.8	0
Sep-07	2.76	0	19.32	100
Oct-07	2.76	8.82	22.08	60
Nov-07	33.12	63.48	55.2	0
Dec-07	0	69	82.8	100
Jan-08	0	121.44	77.28	150
Feb-08	0	93.84	77.28	120
Mar-08	0	80.04	55.2	100
Apr-08	0	24.84	33.12	0
May-08	0	2.76	24.84	0
Jun-08	0	0	19.32	0
Jul-08	19.32	0	19.32	0
Aug-08	19.32	0	19.32	0
Sep-08	16.35	0	13.8	105
Oct-08	30.36	19.32	2.76	0
Nov-08	46.92	41.4	38.64	0
Dec-08	157.32	121.44	91.08	150
Jan-09	110.4	85.56	77.28	130
Feb-09	135.24	102.12	88.32	0
Mar-09	55.2	33.12	44.16	100

Size of House(Sq ft)	1800	3500	3100	2500
Month				
Nov-04	73	150	200	200
Dec-04	0	150	150	400
Jan-05	80	150	176	400
Feb-05	85	150	220	460
Mar-05	50	150	180	300
Apr-05	0	150	190	210
May-05	0	0	0	100
Jun-05	0	150	0	0

Jul-05	0	0	0	0
Aug-05	80	150	0	0
Sep-05	0	100	0	200
Oct-05	0	60	0	0
Nov-05	0	150	350	200
Dec-05	80	150	390	430
Jan-06	0	70	180	700
Feb-06	100	0	225	330
Mar-06	100	150	0	400
Apr-06	0	0	170	0
May-06	0	0	0	370
Jun-06	0	0	0	0
Jul-06	75	0	0	0
Aug-06	0	150	200	430
Sep-06	0	0	0	0
Oct-06	55	110	0	220
Nov-06	0	0	0	170
Dec-06	115	124	300	350
Jan-07	75	150	400	440
Feb-07	110	150	320	640
Mar-07	0	0	250	350
Apr-07	32	50	110	250
May-07	0	0	0	150
Jun-07	0	0	100	0
Jul-07	0	0	0	0
Aug-07	0	0	0	0
Sep-07	38	116	0	200
Oct-07	0	0	0	0
Nov-07	0	88	225	0
Dec-07	91	57	187	200
Jan-08	50	147	244	0
Feb-08	95	123	374	200
Mar-08	71	92	195	350
Apr-08	47	72	0	200
May-08	0	0	100	150
Jun-08	0	0	117	0
Jul-08	0	0	0	0
Aug-08	0	0	0	0
Sep-08	49	0	101	200
Oct-08	0	150	0	150

Nov-08	45	0	112	250
Dec-08	43	125	125	350
Jan-09	117	100	332	0
Feb-09	94	100	260	200
Mar-09	67	0	146	155

Size of House(Sq ft)	1900	1875	2900	1800
Month				
Nov-04	180	57.96	100	50
Dec-04	0	171.12	0	20
Jan-05	220	138	100	0
Feb-05	100	118.68	100	48
Mar-05	0	110.4	100	0
Apr-05	0	41.4	100	0
May-05	0	44.16	0	0
Jun-05	0	35.88	0	0
Jul-05	150	27.6	0	0
Aug-05	0	27.6	0	0
Sep-05	100	19.32	100	78
Oct-05	0	35.88	0	0
Nov-05	100	19.32	100	0
Dec-05	100	176.64	0	90
Jan-06	100	102.12	100	0
Feb-06	250	138	100	0
Mar-06	0	99.36	100	0
Apr-06	0	27.6	0	0
May-06	0	22.08	0	0
Jun-06	150	24.84	0	0
Jul-06	0	30.36	100	0
Aug-06	0	22.08	0	0
Sep-06	0	13.8	100	123
Oct-06	65	30.36	0	50
Nov-06	84	52.44	100	53
Dec-06	95	207	0	53
Jan-07	220	140.76	100	0
Feb-07	100	276	100	64
Mar-07	0	71.76	100	0
Apr-07	0	80.04	100	73
May-07	0	24.84	0	0

Jun-07	0	24.84	0	0
Jul-07	150	24.84	0	0
Aug-07	0	16.56	100	0
Sep-07	100	22.08	100	0
Oct-07	0	22.08	0	0
Nov-07	100	88.32	100	47
Dec-07	95	85.56	94	75
Jan-08	150	223.56	100	65
Feb-08	135	126.96	124.2	0
Mar-08	100	91.08	124	70
Apr-08	0	33.12	98	0
May-08	0	22.08	0	0
Jun-08	0	24.84	0	0
Jul-08	75	24.84	0	0
Aug-08	0	19.32	0	0
Sep-08	75	22.08	50	0
Oct-08	0	33.12	0	50
Nov-08	56	44.16	48	0
Dec-08	100	124.2	56	76
Jan-09	144	132.48	357	47
Feb-09	107	99.36	115	0
Mar-09	75	52.44	60	0

Size of House(Sq ft)	1400	2000	2100	2800
Month				
Nov-04	100	55.2	55	22.08
Dec-04	100	151.8	135	140.76
Jan-05	150	107.64	0	82.8
Feb-05	150	99.36	0	85.56
Mar-05	150	91.08	0	71.76
Apr-05	0	13.8	0	38.64
May-05	0	16.56	0	11.04
Jun-05	0	13.8	0	0
Jul-05	0	16.56	0	0
Aug-05	0	11.04	0	0
Sep-05	100	11.04	170	0
Oct-05	150	6.56	100	5.52
Nov-05	140	24.84	0	77.28
Dec-05	150	138	0	35.88

Jan-06	0	77.28	100	115.92
Feb-06	0	82.8	0	60.72
Mar-06	150	80.04	0	93.84
Apr-06	100	8.82	0	2.76
May-06	0	16.56	0	2.76
Jun-06	0	19.32	0	2.76
Jul-06	0	19.32	0	2.76
Aug-06	100	16.56	0	0
Sep-06	100	8.82	170	0
Oct-06	0	24.84	76	16.56
Nov-06	140	52.44	121	82.8
Dec-06	0	113.16	77	118.68
Jan-07	300	165.6	113	126.96
Feb-07	300	118.68	93	107.64
Mar-07	100	63.48	0	33.12
Apr-07	0	57.96	0	35.88
May-07	100	22.08	0	2.76
Jun-07	0	19.32	0	0
Jul-07	0	13.8	0	0
Aug-07	0	19.32	0	0
Sep-07	110	24.84	100	0
Oct-07	0	19.32	0	0
Nov-07	47	46.92	0	33.12
Dec-07	147	91.08	83	91.08
Jan-08	126	135.24	0	129.72
Feb-08	140	107.64	0	66.24
Mar-08	126	107.64	120	91.08
Apr-08	87	33.12	0	13.8
May-08	0	19.32	0	0
Jun-08	0	13.8	0	0
Jul-08	0	19.32	0	0
Aug-08	0	19.32	0	0
Sep-08	122	19.32	0	0
Oct-08	0	5.52	0	11.04
Nov-08	75	49.68	0	2.76
Dec-08	151	115.92	0	5.52
Jan-09	139	99.36	0	16.56
Feb-09	101	99.36	0	19.32
Mar-09	127	46.92	0	33.12

Size of House(Sq ft)	1450	1700	1950	2500
Month				
Nov-04	50	200	38.64	100
Dec-04	50	150	129.72	100
Jan-05	75	200	82.8	100
Feb-05	0	0	99.36	100
Mar-05	0	0	82.8	200
Apr-05	0	0	41.4	200
May-05	0	0	38.64	178
Jun-05	0	0	35.88	0
Jul-05	0	0	33.12	0
Aug-05	0	0	27.6	0
Sep-05	0	0	22.08	178
Oct-05	200	0	24.84	0
Nov-05	0	0	63.48	0
Dec-05	150	100	80.04	200
Jan-06	0	118.68	55.2	0
Feb-06	0	176.64	85.56	200
Mar-06	0	66.24	16.56	150
Apr-06	0	63.48	91.08	0
May-06	0	5.52	30.36	0
Jun-06	0	0	24.84	0
Jul-06	0	0	24.84	0
Aug-06	0	0	16.56	100
Sep-06	125	0	19.32	0
Oct-06	100	22.08	33.12	100
Nov-06	0	102.12	35.88	100
Dec-06	66	212.52	60.72	100
Jan-07	106	234.6	52.44	450
Feb-07	126	46.92	104.88	174
Mar-07	74	220.8	35.88	0
Apr-07	0	99.36	55.2	150
May-07	0	22.08	27.6	0
Jun-07	0	0	24.84	0
Jul-07	0	0	22.08	0
Aug-07	0	0	19.32	0
Sep-07	0	0	19.32	105
Oct-07	117	2.76	24.84	84

Nov-07	0	96.6	46.92	50
Dec-07	84	107.64	69	127
Jan-08	47	231.84	80.04	150
Feb-08	141	146.28	66.24	150
Mar-08	65	96.6	52.44	150
Apr-08	0	33.12	35.88	150
May-08	0	11.04	35.88	0
Jun-08	0	0	19.32	0
Jul-08	0	0	19.32	0
Aug-08	0	0	19.32	0
Sep-08	0	0	24.84	150
Oct-08	100	5.52	30.36	0
Nov-08	0	38.64	22.08	118
Dec-08	125	2.76	55.2	150
Jan-09	100	2.76	44.16	150
Feb-09	0	0	35.88	204
Mar-09	0	0	22.08	145

Size of House(Sq ft)	3500	2500	1200	1100
Month				
Nov-04	132.48			46.92
Dec-04	229.08	199.9	99.36	107.64
Jan-05	209.76	80.4	88.32	77.28
Feb-05	184.92	8.58	41.4	69
Mar-05	152.9	27.6	27.6	55.2
Apr-05	151.8	2.76	8.53	46.92
May-05	107.64	2.76	11.04	24.84
Jun-05	98.97	2.76	13.8	19.32
Jul-05	102.12	2.76	5.52	8.28
Aug-05	91.08	5.52	2.76	16.56
Sep-05	44.16	5.52	2.76	24.84
Oct-05	99.36	8.58	5.52	35.88
Nov-05	132.48	107.64	72.4	88.32
Dec-05	240.12	107.64	63.48	90
Jan-06	259.63	143.52	60.72	66.24
Feb-06	176.64	80.04	41.4	77.28
Mar-06	171.12	8.58	11.04	5.52
Apr-06	71.76	2.76	11.04	13.8
May-06	33.12	2.76	2.76	19.32

Jun-06	49.68	2.76	2.76	16.56
Jul-06	115.92	2.76	5.52	24.84
Aug-06	91.08	2.76	5.52	13.8
Sep-06	78.1	5.52	35.88	30.36
Oct-06	57.96	8.58	35.88	30.36
Nov-06	135.24	27.6	88.32	80.04
Dec-06	218.04	74.52	96.6	101.02
Jan-07	251.16	143.52	104.88	93.5
Feb-07	254.64	27.6	91.08	27.6
Mar-07	135.24	33.12	57.96	35.88
Apr-07	129.72	2.76	57.96	16.56
May-07	110.4	2.76	35.88	2.76
Jun-07	44.16	2.76	19.32	5.52
Jul-07	33.12	2.76	16.56	13.8
Aug-07	30.36	2.76	13.8	19.32
Sep-07	41.4	5.52	19.32	19.32
Oct-07	38.64	2.76	30.36	41.4
Nov-07	66.12	8.28	63.48	41.4
Dec-07	151.8	107.64	60.72	74.52
Jan-08	447.12	99.36	102.12	53.91
Feb-08	124.2	74.52	41.4	38.64
Mar-08	96.6	33.12	44.16	16.56
Apr-08	44.16	8.28	24.84	2.76
May-08	42.13	2.76	24.84	2.76
Jun-08	38.64	2.76	11.04	2.76
Jul-08	35.88	2.76	2.76	2.76
Aug-08	30.36	2.76	5.52	2.76
Sep-08	35.88	5.52	5.52	0
Oct-08	22.08	2.76	35.88	8.28
Nov-08	69	2.76	44.16	19.32
Dec-08	124.2	115.92	91.08	69
Jan-09	104.88	57.96	88.32	60.72

Size of House(Sq ft)	3200	3000	4215
Month			
Nov-04		69	
Dec-04	162.84	223.56	187.4
Jan-05	110.4	121.44	204.9
Feb-05	107.64	107.64	200.1
Mar-05	82.8	121.44	243.6
Apr-05	63.48	44.16	101.02
May-05	35.88	24.84	98.07
Jun-05	8.28	11.04	77.28
Jul-05	5.52	8.28	51.01
Aug-05	16.65	11.04	56.93
Sep-05	19.32	8.28	55.2
Oct-05	22.08	16.56	116.93
Nov-05	57.96	52.44	138.54
Dec-05	162.84	179.4	196.43
Jan-06	171.12	162.84	207.53
Feb-06	151.8	102.12	184.92
Mar-06	71.76	71.76	118.06
Apr-06	63.84	13.8	74.51
May-06	19.32	2.73	63.82
Jun-06	11.04	11.04	49.97
Jul-06	13.8	11.04	51.03
Aug-06	16.56	8.28	63.59
Sep-06	16.56	5.52	58.4
Oct-06	49.68	22.08	67.89
Nov-06	52.44	49.68	113.52
Dec-06	165.5	129.72	293.67
Jan-07	223.56	198.72	259.44
Feb-07	165.6	143.52	223.56
Mar-07	63.48	49.68	113.59
Apr-07	69	55.2	93.84
May-07	19.32	11.04	102.12
Jun-07	16.56	5.52	69
Jul-07	11.04	8.28	52.44
Aug-07	11.07	5.52	41.4
Sep-07	13.8	8.28	57.96
Oct-07	22.08	5.52	55.2
Nov-07	57.96	63.48	110.4
Dec-07	149.04	91.08	113.16

Jan-08	193.2	176.64	223.56
Feb-08	135.24	113.16	198.72
Mar-08	104.88	71.76	116.82
Apr-08	41.4	19.32	82.53
May-08	27.6	5.52	69
Jun-08	13.8	8.28	49.68
Jul-08	8.28	8.28	52.44
Aug-08	11.04	8.28	60.72
Sep-08	16.56	8.28	57.96
Oct-08	33.12	16.56	80.04
Nov-08	63.48	49.68	71.76
Dec-08	182.16	135.24	287.04
Jan-09	160.08	138	212.52

2. Data on Consumption of Propane by Mobile Homes (in gallons/month)

Size of Mobile Homes(Sq ft)	2000	1700	1900	1800	1900	1950
Month						
Dec-04	22.08	69	104.88	20	0	129.72
Jan-05	80.04	63.48	52.44	0	220	82.8
Feb-05	118.68	69	77.28	48	100	99.36
Mar-05	93.84	38.64	60.72	0	0	82.8
Oct-05	41.4	8.82	19.32	0	0	24.84
Nov-05	96.6	44.16	49.68	0	100	63.48
Dec-05	63.48	49.68	71.76	90	100	80.04
Jan-06	129.72	35.88	96.6	0	100	55.2
Feb-06	102.12	69	41.4	0	250	85.56
Mar-06	63.48	35.88	27.6	0	0	16.56
Oct-06	2.76	35.88	49.68	50	65	33.12
Nov-06	2.76	82.8	38.64	53	84	35.88
Dec-06	2.76	88.23	91.08	53	95	60.72
Jan-07	5.52	91.08	110.4	0	220	52.44
Feb-07	2.76	55.2	99.36	64	100	104.88
Mar-07	2.76	49.68	35.88	0	0	35.88
Oct-07	2.76	8.82	22.08	0	0	24.84
Nov-07	33.12	63.48	55.2	47	100	46.92

Dec-07	0	69	82.8	75	95	69
Jan-08	0	121.44	77.28	65	150	80.04
Feb-08	0	93.84	77.28	0	135	66.24
Mar-08	0	80.04	55.2	70	100	52.44
Oct-08	30.36	19.32	2.76	50	0	30.36
Nov-08	46.92	41.4	38.64	0	56	22.08
Dec-08	157.32	121.44	91.08	76	100	55.2

3. Data on Temperature(in F), Heating Degree days (in days), Cooling Degree days (in days).

Provided by National Climatic Data Center, U.S. Departmental of Commerce.

Month	Temperature	Heating degree days	Cooling degree days
Dec-04	42.3	697	0
Jan-05	43.5	661	0
Feb-05	46	525	0
Mar-05	50.5	444	0
Apr-05	59.4	190	28
May-05	69	80	210
Jun-05	79	0	427
Jul-05	79.4	0	457
Aug-05	77.1	0	382
Sep-05	76	6	343
Oct-05	61.9	161	72
Nov-05	52.2	384	6
Dec-05	41.4	726	0
Jan-06	47.3	542	0
Feb-06	45.1	553	0
Mar-06	53.9	347	11
Apr-06	66.2	72	114
May-06	73.7	21	297
Jun-06	80.5	0	471
Jul-06	82.9	0	561
Aug-06	80.6	0	493
Sep-06	68.6	22	137

Oct-06	61	181	61
Nov-06	51.9	389	4
Dec-06	41.5	720	0
Jan-07	36.4	879	0
Feb-07	43.6	593	0
Mar-07	55.7	286	11
Apr-07	55.8	280	12
May-07	66.8	47	110
Jun-07	74.6	1	295
Jul-07	77.5	0	395
Aug-07	79.7	0	463
Sep-07	74.2	0	285
Oct-07	65.1	105	116
Nov-07	50.7	422	0
Dec-07	41.9	713	0
Jan-08	40.5	752	0
Feb-08	47.4	506	0
Mar-08	52.8	382	11
Apr-08	60.7	175	53
May-08	70.2	50	222
Jun-08	80.9	0	485
Jul-08	79.3	0	448
Aug-08	77.6	0	396
Sep-08	68.7	5	121
Oct-08	61.3	144	37
Nov-08	51.1	410	2
Dec-08	42.6	687	0

4. Data on Precipitation (in inches) and Wind Speed (in m/sec).

Provided by National Climatic Data Center, U.S. Departmental of Commerce.

Month	Wind Speed	Precipitation
Nov-04	11.1	0.69
Dec-04	11.3	1.33
Jan-05	10.6	1.32
Feb-05	10.3	0.73
Mar-05	13.2	0.27
Apr-05	14.1	2.24
May-05	12.5	1.84
Jun-05	13.9	2.41
Jul-05	10.7	2.01
Aug-05	9.2	0.28
Sep-05	10.4	2.61
Oct-05	9.7	0
Nov-05	11.3	0
Dec-05	10.9	0
Jan-06	12.9	0.18
Feb-06	12.6	1.62
Mar-06	14.4	0.77
Apr-06	14.1	2.15
May-06	12.6	0.57
Jun-06	12.3	0.62
Jul-06	10.6	1.51
Aug-06	10.1	4.87
Sep-06	10.3	1.3
Oct-06	11.4	0.26
Nov-06	11.7	1.71
Dec-06	11.4	1.12
Jan-07	11	0.36
Feb-07	12.8	5.94
Mar-07	11.7	1.23
Apr-07	13	5.35
May-07	11	3.39
Jun-07	10.6	0.94
Jul-07	8.1	1.99

Aug-07	10.6	2.2
Sep-07	9.7	0.28
Oct-07	11.5	0.2
Nov-07	9.8	0.94
Dec-07	11.2	0.07
Jan-08	12.8	0.72
Feb-08	12.7	0.1
Mar-08	15	1.07
Apr-08	14.4	5.32
May-08	13	2.91
Jun-08	14.2	1.77
Jul-08	10.5	3.48
Aug-08	8.7	8.7
Sep-08	7.9	3.77
Oct-08	10.5	0.08
Nov-08	10.6	0.01

APPENDIX B

SCATTER PLOTS

1. Scatter plots for Demand versus Cooling Degree Days

2. Scatter plots for Demand versus Heating Degree Days

1. Scatter plots for Demand versus Temperature

2. Scatter plots for Demand versus Propane Price

APPENDIX C

MODELS

Different Models Developed on SAS software for Estimating Propane Demand.

1. Model 1

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	75
Number of Observations Used	74

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	249026.6986	83008.8995	84.98	<.0001
Error	70	68379.9586	976.8566		
Corrected Total	73	317406.6571			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.784567	39.19265	31.25470	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Heating_degree_days	1	140669.8913	140669.8913	144.00	<.0001
Cooling_degree_days	1	3.7200	3.7200	0.00	0.9510
Size	1	108353.0873	108353.0873	110.92	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Heating_degree_days	1	57181.6094	57181.6094	58.54	<.0001
Cooling_degree_days	1	3.7200	3.7200	0.00	0.9510
Size	1	108353.0873	108353.0873	110.92	<.0001

Standard

Parameter		Estimate	Error	t Value	Pr > t
Intercept		-1.94558435 B	11.10150242	-0.18	0.8614
Heating_degree_days		0.15883425	0.02076019	7.65	<.0001
Cooling_degree_days		0.00190573	0.03088211	0.06	0.9510
Size	Large	76.53054054 B	7.26657119	10.53	<.0001
Size	Small	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

2. Model 2

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read 188
Number of Observations Used 74

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	249081.3614	62270.3404	62.89	<.0001
Error	69	68325.2957	990.2217		
Corrected Total	73	317406.6571			

R-Square Coeff Var Root MSE Propane_Consumption_4215_sq_ft_ Mean
0.784739 39.45985 31.46779 79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Temperature	1	129976.7812	129976.7812	131.26	<.0001
Heating_degree_days	1	10694.0038	10694.0038	10.80	0.0016
Cooling_degree_days	1	57.4892	57.4892	0.06	0.8103
Size	1	108353.0873	108353.0873	109.42	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Temperature	1	54.6629	54.6629	0.06	0.8149
Heating_degree_days	1	193.9007	193.9007	0.20	0.6595

Cooling_degree_days	1	57.4892	57.4892	0.06	0.8103
Size	1	108353.0873	108353.0873	109.42	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > t
Intercept		106.6803614 B	462.4667610	0.23	0.8182
Temperature		-1.6805968	7.1529241	-0.23	0.8149
Heating_degree_days		0.1038917	0.2347779	0.44	0.6595
Cooling_degree_days		0.0572893	0.2377643	0.24	0.8103
Size	Large	76.5305405 B	7.3161121	10.46	<.0001
Size	Small	0.0000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

3. Model 3

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	188
Number of Observations Used	74

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	249023.8722	83007.9574	84.97	<.0001
Error	70	68382.7849	976.8969		
Corrected Total	73	317406.6571			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.784558	39.19346	31.25535	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Temperature	1	129976.7812	129976.7812	133.05	<.0001
Heating_degree_days	1	10694.0038	10694.0038	10.95	0.0015
Size	1	108353.0873	108353.0873	110.92	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Temperature	1	0.8936	0.8936	0.00	0.9760
Heating_degree_days	1	10694.0038	10694.0038	10.95	0.0015
Size	1	108353.0873	108353.0873	110.92	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	-3.47093396 B	69.42518651	-0.05	0.9603
Temperature	0.02809999	0.92907938	0.03	0.9760
Heating_degree_days	0.15924337	0.04812997	3.31	0.0015
Size Large	76.53054054 B	7.26672136	10.53	<.0001
Size Small	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

4. Model 4

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	188
Number of Observations Used	148

The SAS System 00:55 Tuesday, March 31,2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	498045.9572	249022.9786	264.01	<.0001
Error	145	136767.3571	943.2232		
Corrected Total	147	634813.3142			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.784555	38.51203	30.71194	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
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Heating_degree_days	1	281339.7827	281339.7827	298.27	<.0001
Size	1	216706.1745	216706.1745	229.75	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
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Heating_degree_days	1	281339.7827	281339.7827	298.27	<.0001
Size	1	216706.1745	216706.1745	229.75	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > t
Intercept		-1.37971808 B	4.34800741	-0.32	0.7515
Heating_degree_days		0.15784309	0.00913939	17.27	<.0001
Size	Large	76.53054054 B	5.04901155	15.16	<.0001
Size	Small	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

5. Model 5

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	188
Number of Observations Used	74

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	238329.8685	119164.9342	106.99	<.0001
Error	71	79076.7887	1113.7576		
Corrected Total	73	317406.6571			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.750866	41.84895	33.37301	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Temperature	1	129976.7812	129976.7812	116.70	<.0001
Size	1	108353.0873	108353.0873	97.29	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Temperature	1	129976.7812	129976.7812	116.70	<.0001
Size	1	108353.0873	108353.0873	97.29	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	219.8155762 B	17.39597134	12.64	<.0001
Temperature	-2.9288368	0.27111754	-10.80	<.0001
Size Large	76.5305405 B	7.75906649	9.86	<.0001
Size Small	0.0000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

6. Model 6

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	188
Number of Observations Used	148

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	383690.1782	191845.0891	110.77	<.0001
Error	145	251123.1360	1731.8837		
Corrected Total	147	634813.3142			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.604414	52.18534	41.61591	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Cooling_degree_days	1	166984.0037	166984.0037	96.42	<.0001
Size	1	216706.1745	216706.1745	125.13	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Cooling_degree_days	1	166984.0037	166984.0037	96.42	<.0001
Size	1	216706.1745	216706.1745	125.13	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > t
Intercept		69.64669006 B	5.62419806	12.38	<.0001
Cooling_degree_days		-0.18089351	0.01842235	-9.82	<.0001
Size	Large	76.53054054 B	6.84161293	11.19	<.0001
Size	Small	0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

7. Model 7

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	188
Number of Observations Used	74

The SAS System 00:55 Tuesday, March 31, 2009

The GLM Procedure

Dependent Variable: Propane_Consumption_4215_sq_ft_

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	248887.4607	82962.4869	84.76	<.0001
Error	70	68519.1964	978.8457		
Corrected Total	73	317406.6571			

R-Square	Coeff Var	Root MSE	Propane_Consumption_4215_sq_ft_ Mean
0.784128	39.23253	31.28651	79.74635

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Temperature	1	129976.7812	129976.7812	132.79	<.0001
Cooling_degree_days	1	10557.5922	10557.5922	10.79	0.0016
Size	1	108353.0873	108353.0873	110.69	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Temperature	1	57042.3716	57042.3716	58.28	<.0001
Cooling_degree_days	1	10557.5922	10557.5922	10.79	0.0016
Size	1	108353.0873	108353.0873	110.69	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	310.8257108 B	32.15440198	9.67	<.0001
Temperature	-4.8332715	0.63313965	-7.63	<.0001
Cooling_degree_days	0.1602371	0.04879078	3.28	0.0016
Size Large	76.5305405 B	7.27396566	10.52	<.0001
Size Small	0.0000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

8. Model 8

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	36
Number of Observations Used	36

The SAS System

The GLM Procedure

Dependent Variable: Average_Consumption

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	100486.5245	50243.2622	66.45	<.0001
Error	33	24950.7175	756.0823		
Corrected Total	35	125437.2420			

R-Square		Coeff Var	Root MSE	Average_Consumption Mean	
0.801090		28.99120	27.49695	94.84586	
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Heating_degree_days	1	51896.83343	51896.83343	68.64	<.0001
Size	1	48589.69105	48589.69105	64.27	<.0001
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Heating_degree_days	1	51896.83343	51896.83343	68.64	<.0001
Size	1	48589.69105	48589.69105	64.27	<.0001
Parameter		Estimate	Standard Error	t Value	Pr > t
Intercept		-28.37980095 B	12.28742689	-2.31	0.0273
Heating_degree_days		0.18036957	0.02177095	8.28	<.0001
Size Large		73.47689815 B	9.16565054	8.02	<.0001
Size Small		0.00000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

9. Model 9

The SAS System

The GLM Procedure

Class Level Information

Class	Levels	Values
Size	2	Large Small

Number of Observations Read	36
Number of Observations Used	36

The SAS System

The GLM Procedure

Dependent Variable: Average_Consumption

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	99425.3432	49712.6716	63.07	<.0001
Error	33	26011.8987	788.2394		
Corrected Total	35	125437.2420			

R-Square		Coeff Var	Root MSE	Average_Consumption Mean		
0.792630		29.60129	28.07560	94.84586		
Source	DF	Type I SS	Mean Square	F Value	Pr > F	
Temperature	1	50835.65216	50835.65216	64.49	<.0001	
Size	1	48589.69105	48589.69105	61.64	<.0001	
Source	DF	Type III SS	Mean Square	F Value	Pr > F	
Temperature	1	50835.65216	50835.65216	64.49	<.0001	
Size	1	48589.69105	48589.69105	61.64	<.0001	
Parameter	Estimate		Standard Error	t Value	Pr > t	
Intercept	299.1229523 B		30.73256210	9.73	<.0001	
Temperature	-4.8766635		0.60725017	-8.03	<.0001	
Size Large	73.4768981 B		9.35853357	7.85	<.0001	
Size Small	0.0000000 B		.	.	.	

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

10. Model for the Month of October- November

The SAS System					
The GLM Procedure					
Class Level Information					
Class	Levels	Values			
Size	2	Large	Small		
Number of Observations Read				16	
Number of Observations Used				16	
The SAS System				00	
The GLM Procedure					
Dependent Variable: Average_consumption					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	4197.891223	2098.945612	5.44	0.0192
Error	13	5014.570336	385.736180		
Corrected Total	15	9212.461560			

R-Square		Coeff Var	Root MSE	Average_consumption Mean	
0.455675		38.89934	19.64017	50.48972	
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Temperature	1	2813.472496	2813.472496	7.29	0.0182
Size	1	1384.418728	1384.418728	3.59	0.0806
Source	DF	Type III SS	Mean Square	F Value	Pr > F
Temperature	1	2813.472496	2813.472496	7.29	0.0182
Size	1	1384.418728	1384.418728	3.59	0.0806
Parameter	Estimate		Standard Error	t Value	Pr > t
Intercept	176.8193594 B		50.69869794	3.49	0.0040
Temperature	-2.3836833		0.88261725	-2.70	0.0182
Size Large	18.6038889 B		9.82008375	1.89	0.0806
Size Small	0.0000000 B		.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

11. Model for the Month of December-January

The SAS System		
The GLM Procedure		
Class Level Information		
Class	Levels	Values
Size	2	Large Small
Number of Observations Read		16
Number of Observations Used		16
The SAS System		00:21 Thursday, September 17
The GLM Procedure		
Dependent Variable: Average_consumption		

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	17886.67872	8943.33936	15.25	0.0004
Error	13	7625.26712	586.55901		
Corrected Total	15	25511.94585			

		R-Square	Coeff Var	Root MSE	Average_consumption Mean	
		0.701110	17.25101	24.21898	140.3917	
Source		DF	Type I SS	Mean Square	F Value	Pr > F
Temperature		1	4184.02532	4184.02532	7.13	0.0192
	Size	1	13702.65341	13702.65341	23.36	0.0003
Source		DF	Type III SS	Mean Square	F Value	Pr > F
Temperature		1	4184.02532	4184.02532	7.13	0.0192
	Size	1	13702.65341	13702.65341	23.36	0.0003
Parameter		Estimate	Standard Error	t Value	Pr > t	
Intercept		349.5044962 B	89.66300198	3.90	0.0018	
Temperature		-5.6959955	2.13269300	-2.67	0.0192	
Size	Large	58.5291667 B	12.10949018	4.83	0.0003	
Size	Small	0.0000000 B	.	.	.	

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

12. Model for the Month of February- March

The SAS System					
The GLM Procedure					
Class Level Information					
Class	Levels	Values			
Size	2	Large	Small		
Number of Observations Read				17	
Number of Observations Used				16	
The SAS System					
The GLM Procedure					
Dependent Variable: Average_consumption					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	16283.02767	8141.51383	16.98	0.0002
Error	13	6232.28086	479.40622		
Corrected Total	15	22515.30853			

R-Square		Coeff Var	Root MSE	Average_consumption Mean		
0.723198		19.75015	21.89535	110.8617		
Source		DF	Type I SS	Mean Square	F Value	Pr > F
Temperature		1	6161.75946	6161.75946	12.85	0.0033
Size		1	10121.26821	10121.26821	21.11	0.0005
Source		DF	Type III SS	Mean Square	F Value	Pr > F
Temperature		1	6161.75946	6161.75946	12.85	0.0033
Size		1	10121.26821	10121.26821	21.11	0.0005
Parameter		Estimate		Standard Error	t Value	Pr > t
Intercept		317.0068421 B		64.97886768	4.88	0.0003
Temperature		-4.6844818		1.30665524	-3.59	0.0033
Size Large		50.3022569 B		10.94767350	4.59	0.0005
Size Small		0.0000000 B		.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

APPENDIX D**FORECASTING PERFORMANCE CHARTS****1) Forecasting Performance Chart for Large Houses**

Month-Year	Actual Demand (A_T)(gallons/month)	Forecasted Demand (F_T)	Error (E_T)	% E (in %)
Dec-04	173.21	154.4302374	18.78143	10.84305
Jan-05	144.64	145.1113716	-0.4697	-0.32474
Feb-05	143.70	127.44238	16.26095	11.31564
Mar-05	135.84	118.6817716	17.1599	12.63228
Apr-05	104.32	69.08854667	35.23312	33.77354
May-05	46.52	108.2271019	-61.7079	-132.651
Jun-05	29.03	187.70576	-158.678	-546.648
Jul-05	14.14	127.0395174	-112.899	-798.388
Aug-05	27.60	117.0280142	-89.4263	-323.989
Sep-05	73.37	80.57338667	-7.20005	-9.8129
Oct-05	35.75	50.56741419	-14.8149	-41.4374
Nov-05	113.86	94.19926667	19.6624	17.26867
Dec-05	174.36	153.2957161	21.06345	12.0805
Jan-06	184.21	198.2802968	-14.067	-7.63624
Feb-06	134.27	153.60482	-19.3348	-14.4
Mar-06	111.26	99.96639613	11.2936	10.15064
Apr-06	33.29	59.85708	-26.5712	-79.8275
May-06	41.21	115.9596581	-74.7505	-181.393
Jun-06	10.60	168.7009467	-158.097	-1490.89
Jul-06	24.78	159.9386413	-135.163	-545.543
Aug-06	88.52	112.1638916	-23.6414	-26.7066
Sep-06	36.18	105.5650133	-69.39	-191.818
Oct-06	60.73	49.97230323	10.75686	17.71285
Nov-06	79.36	102.2869067	-22.9302	-28.8952
Dec-06	162.59	157.3308658	5.263301	3.237079
Jan-07	238.03	154.0723574	83.95764	35.27187
Feb-07	199.96	170.39394	29.56939	14.78741
Mar-07	94.02	145.0944697	-51.0753	-54.3244
Apr-07	87.20	122.19092	-34.9909	-40.1272

May-07	33.20	66.93327097	-33.7333	-101.606
Jun-07	19.83	102.05796	-82.2246	-414.578
Jul-07	8.97	138.6333471	-129.663	-1445.52
Aug-07	15.93	124.6308374	-108.705	-682.57
Sep-07	62.33	124.8971333	-62.5671	-100.38
Oct-07	17.35	86.04179097	-68.6918	-395.918
Nov-07	66.86	42.64933333	24.214	36.21417
Dec-07	120.98	94.79372774	26.18961	21.64728
Jan-08	159.22	166.9143961	-7.69773	-4.83475
Feb-08	140.27	218.13418	-77.8608	-55.5065
Mar-08	128.77	157.7559806	-28.9843	-22.5083
Apr-08	60.79	99.58681333	-38.796	-63.8188
May-08	33.08	69.94722194	-36.8631	-111.422
Jun-08	19.18	133.0151067	-113.835	-593.509
Jul-08	8.97	156.31928	-147.349	-1642.69
Aug-08	9.43	158.2274813	-148.797	-1577.92
Sep-08	52.10	129.2274667	-77.1275	-148.037
Oct-08	38.80	100.0197316	-61.2197	-157.783
Nov-08	65.62	40.33412	25.28588	38.5338
Dec-08	138.01	101.4179561	36.58871	26.51228

2) Forecasting Performance Chart for Small Houses (Dec-Oct)

Month-Year	Actual Demand (A_T)(gallons/month)	Forecasted Demand (F_T)	Error (E_T)	% E (in %)
Dec-04	90.52	113.9892374	-23.4723	-25.9314
Jan-05	110.87	104.6703716	6.200398	5.592455
Feb-05	73.67	87.00138	-13.3306	-18.0948
Mar-05	55.80	78.24077161	-22.4438	-40.2242
Oct-05	44.64	10.12641419	34.50897	77.31303
Nov-05	44.41	53.75826667	-9.34596	-21.0436
Dec-05	92.43	112.8547161	-20.4239	-22.0965
Jan-06	64.26	157.8392968	-93.5747	-145.608
Feb-06	75.33	113.16382	-37.8346	-50.2256
Mar-06	47.09	59.52539613	-12.4331	-26.4015
Oct-06	39.03	9.531303226	29.49639	75.5781
Nov-06	65.33	61.84590667	3.480247	5.327494

Dec-06	98.94	116.8898658	-17.9537	-18.1468
Jan-07	125.28	113.6313574	11.65018	9.2992
Feb-07	127.00	129.95294	-2.94986	-2.32267
Mar-07	52.45	104.6534697	-52.2042	-99.5329
Oct-07	25.33	45.60079097	-20.2669	-79.9995
Nov-07	49.95	2.208333333	47.74551	95.57925
Dec-07	87.79	54.35272774	33.43496	38.08616
Jan-08	113.71	126.4733961	-12.7665	-11.2275
Feb-08	93.97	177.69318	-83.7209	-89.091
Mar-08	74.47	117.3149806	-42.8473	-57.5381
Oct-08	21.94	59.57873161	-37.6372	-171.534
Nov-08	32.65	-0.10688	32.75303	100.3274
Dec-08	92.29	60.97695613	31.31227	33.92842

3) Forecasting Performance Chart for Mobile Homes (Dec-Oct)

Month-Year	Actual Demand (A_T)(gallons/month)	Forecasted Demand (F_T)	Error (E_T)	% E (in %)
Dec-04	57.61	76.05745161	-18.4441	-32.0136
Jan-05	83.13	72.56196774	10.5647	12.70916
Feb-05	85.39	64.8185	20.56817	24.08827
Mar-05	46.00	51.49196774	-5.49197	-11.9391
Oct-05	15.73	25.95551613	-10.2255	-65.0065
Nov-05	58.99	47.41066667	11.576	19.62477
Dec-05	75.83	78.29067742	-2.46401	-3.24953
Jan-06	69.57	93.72906452	-24.1624	-34.7327
Feb-06	91.35	72.1285	19.21817	21.03872
Mar-06	23.92	36.15067742	-12.2307	-51.1316
Oct-06	39.41	22.36293548	17.04373	43.25088
Nov-06	49.51	49.51766667	-0.00433	-0.00875
Dec-06	65.13	75.08648387	-9.95482	-15.2841
Jan-07	79.91	76.05745161	3.849215	4.817139
Feb-07	71.03	79.4385	-8.40517	-11.8327
Mar-07	20.70	59.35680645	-38.6568	-186.748
Oct-07	9.75	42.07358065	-32.3236	-331.524
Nov-07	57.62	26.54133333	31.07867	53.93729
Dec-07	65.13	46.15164516	18.98169	29.14282

Jan-08	82.29	78.29067742	4.002656	4.863888
Feb-08	62.06	102.8735	-40.8135	-65.7646
Mar-08	59.61	65.9593871	-6.34605	-10.6454
Oct-08	22.13	45.47196774	-23.3386	-105.446
Nov-08	34.17	22.829	11.34433	33.19645
Dec-08	100.17	48.19067742	51.98266	51.89271