THE USE OF MULTIPLE REGRESSION ANALYSIS AND RESPONSE SURFACE TECHNIQUES IN THE DESIGN OF OPTIONAL NON-DEMAND ELECTRIC UTILITY RATES

By

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PREFACE

This study develops a systematic procedure whereby multiple regression analysis and response surface techniques can be used in the design of electric utility rates to determine revenue recovery involving migration for large non-demand rate classes. A Plackett-Burman design and a Central Composite design are used in the development of the three models included in this study. Correlation coefficients and residuals are calculated in the evaluation of these models.

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For her continual support and encouragement, I dedicate this study to my wife, Pamela.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE RESEARCH PROBLEM

The Ratemaking Process

The fundamental steps in the ratemaking process are load research, a cost of service study, and rate design. In the load research process, data are collected which indicate the electrical characteristics of sampled customers and groups of customers. In the cost of service study, data are collected from the load research process and from company books and records. Costs are then classified as demand, energy, or customer related, and allocated to the various rate classes. The cost of service study provides some essential information needed in the rate design process, primarily, the revenue requirement for each rate class and the overall revenue requirement for the utility as well as the costs associated with the different components of service for each of the rate classes. This work will address a specific problem which is encountered in the design of electric utility rates. In the design of electric utility rates, the analyst typically formulates a proposed rate based on load research and cost of service data. The rate is then tested using computer programs which run against a large data base of customer data to determine other factors instrumental in the evaluation of a rate, e.g., revenue recovery, revenue stability, customer impact, weather sensitivity, and accurate cost recovery. The objectives most often suggested for rates were stated by Bonbright (1961) as :

1. The related, practical attributes of simplicity, understandability, public acceptability, and feasibility of application.

2. Freedom from controversies as to proper interpretation.

3. Effectiveness in yielding total revenue requirements under the fair-return standard.

4. Revenue stability from year to year.

5. Stability of the rates themselves, with a minimum of unexpected changes seriously adverse to existing customers.

6. Fairness of the specific rates in the apportionment of total costs of service among the different consumers.

7. Avoidance of undue discrimination in rate relationships.

8. Efficiency of the rate classes and rate blocks in discouraging wasteful use of service while promoting all justified types and amounts of use:

    a. In the control of the total amounts of service supplied by the company, and

    b. In the control of the relative uses of alternative types of service (p. 291).

Many proposed rates must be analyzed to determine the most appropriate rate. An example of a commonly used rate type, frequently referred to as a blocked rate is as follows:

Customer Charge = $5.00

June-September	July-October
0 - 500 kWh @ 5.25 ¢/kWh	0 - 500 kWh @ 5.00 ¢/kWh
501 - 100 kWh @ 6.40 ¢/kWh	501 - 1000 kWh @ 4.45 ¢/kWh
over 1000 kWh @ 7.35 ¢/kWh	over 1000 kWh @ 4.10 ¢/kWh

Data, exhibits, and prefiled testimony concerning load research, cost of service, and rate design are then compiled and filed with the appropriate regulatory agency, e.g., the state corporation commission. Hearings are then held and the order regarding the filing is rendered. Frequently, rates must be redesigned pursuant to the findings of the proceedings. New rates become effective when ordered by the presiding regulatory body.

The Rate Design Process

In the design of rates a predominant limitation lies in the type of metering equipment which is installed for different types of customers, i.e., the metered data available for those customers. This study will be concerned with the design of rates for non-demand customers for which a single monthly kWh usage is available. This is typically the case for small commercial and residential customers due to the expense associated with more sophisticated metering. Given the load research and cost of service data, the objective of the rate design process is to design rates which most closely adhere to the previously stated criteria, i.e., Bonbright's principles. Prices are developed from cost of service and load research data for each rate class. This is typically done by the use of one of two computer programs. The first program uses a data base which includes twelve months of metered data for each individual customer in the rate class or a sample of customers in the rate class. For the purposes of this study, this method will be referred to as a customer-by-customer method. The program uses as input the present rate and the proposed rate and simulates the billing that would occur under each rate for each customer, determines the revenue difference between present and proposed rates for each customer, and determines the total revenue which would be collected under the proposed rate. The second program uses a data base which is essentially a grouped frequency distribution of kWh usages for customers in the rate class. This frequency distribution data base is built from a customer-by-customer data base, but only includes such information as the number of customers which used a specified number of kWh or less and the total number of kWh used by these customers. For the purposes of this study, this will be referred to as a bill frequency method. It is this reduced data file that the program uses. By using this method, any customer-specified information is lost, however, the total revenue difference between the present and proposed rates, and the total revenue which would be recovered under the new rate can still be determined. The bill frequency method is often used when designing rates for non-demand rate classes with large numbers of customers, for example, in the design of residential rates this may be hundreds of thousands of customers. Since many computer runs are required in the rate design process, computer cost savings is the primary benefit of using the bill frequency method. The cost of using the customer-by-customer method is a serious drawback to its use in the case of such a large rate class.

The Problem of Predicting Migration For Large Non-Demand Rate Classes

This study is concerned with the determination of revenue recovered under proposed rates. In some cases, the analyst must determine the change in revenue resulting from a group of customers which are currently being billed under the existing rate x_e being billed under proposed rate x_p (or the revenue recovered by each of the rates). This is the typical case where there is only one proposed rate and all customers will be billed according to that rate. In this case, the revenue that would be recovered can be determined by use of the bill frequency method. In many cases, however, each of the customers in the group may be offered optional proposed rates, i.e., each customer may have the option of being billed under proposed rate x_p or proposed rate y_p. For example:

<u>Rate x_e</u>

Customer Charge = $5.00

0 - 500 kWh @ 5.50 ¢/kWh

501 - 1000 kWh @ 5.00 ¢/kWh

over 1000 kWh @ 4.50 ¢/kWh

<u>Rate x_p</u>

Customer Charge = $5.00

0 - 500 kWh @ 6.00 ¢/kWh

501 - 1000 kWh @ 5.00 ¢/kWh

over 1000 kWh @ 4.00 ¢/kWh

<u>Rate y_p</u>

Customer Charge = $4.00

0 - 400 kWh @ 7.00 ¢/kWh

401 - 800 kWh @ 5.00 ¢/kWh

over 800 kWh @ 4.00 ¢/kWh

In this case, the computer model used in the determination of revenue recovery must analyze each customer's usage pattern and determine the rate which would result in the lowest annual billing for the customer. If the revenue recovered under rate x_p, $R(x_p)$, is lower that the revenue recovered under rate y_p, $R(y_p)$, then $R(x_p)$ is the revenue that the model will use in calculating the revenue recovery. Likewise, if $R(y_p)$ is lower than $R(x_p)$, then $R(y_p)$ will be used in the calculation of revenue recovery. In this case, the total revenue recovery calculated would be that which would occur if each customer actually chose to be billed on the rate which the model determined would result in the lowest annual billing. At this point, other assumptions may be made in the determination of revenue recovery, e.g., that only those customers who would save a specified amount or a specified percent would actually change rates. Whether rate x_p or rate y_p results in the lowest annual billing will be dependent upon each particular customer's usage pattern. Consider rate x_p to be a revision of rate x_e and consider rate y_p to be an optional alternative rate. For the purposes of this study, the selection of an optional alternative proposed rate (y_p) by a customer or group of customers will be called migration. In the case whereby a group of customers have a choice of multiple proposed rates, the bill frequency method cannot determine the revenue which would be recovered. The bill frequency method could only determine the revenue which would be recovered if all customers in the group were billed on proposed rate x_p and then the revenue which would be recovered if all customers in the group were billed on proposed rate y_p. This is due to the fact that the individual customer data needed to determine which rate is lower for a particular customer is not available in the frequency distribution used by the bill frequency method. To determine the revenue recovery for a group of customers with multiple proposed rates, the analyst must use the customer-by-customer method. As mentioned previously, the customer-by-customer method of determining revenue can have some serious shortcomings. One primary objective of any rate is that it recover the revenue requirement for that rate class. It is apparent from the discussion above that in the development process of proposed rates, a change in prices does not directly translate into a change in revenue recovered when dealing with optional rates due to the effects of migration. The revenue recovered from a particular proposed rate is dependent upon the other proposed rates. Therefore, the rate design process becomes an iterative process of changing prices in consideration of other prices. The analyst then must develop proposed rates which recover the revenue requirement without the knowledge of the effect of a price change on revenue recovery. This requires many computer runs, some of which will not fulfill a primary requirement of the rate design, i.e., recovering the revenue requirement. The iterative process of making many computer runs, some of which will yield unusable results is time consuming and impedes the regulatory process (for example, in the redesign of rates pursuant to the findings of the presiding regulatory agency, etc.). As mentioned previously, the shortcomings of this process are especially apparent in the design of rates for large classes of non-demand customers. In this case, the customer-by-customer method requires calculation of twelve months of bills of each of several rates for what may be hundreds of thousands of customers. One such computer run may take an excessive amount of processing time in a large mainframe computer. The computer costs associated with one such computer run may be thousands of dollars. Given the iterative nature of the process, computer costs can be extremely prohibitive. As stated in the direct testimony of James B. Long (1985), Manager of Rates for Public Service Company of Oklahoma, before the Oklahoma Corporation Commission in recent rate case hearings:

> The RS rate class is a very large class comprised of over 300,000 customers. The use of a customer-by customer data base is the best means of assessing the revenue impact of customer migration since the customer can be offered several alternative pricing schedules from which to select (p. 24).

Increasing demands in the area of rate design to meet the needs of society, e.g., economic development rates, distressed industry rates, energy efficiency rates, more precise defintion of customer groups, and end use rates, further compound the problem. The expense associated with this process inhibits experimentation. The analyst may be limited to performing only essential analysis. This expense may prohibit the analyst from considering alternative rates. The objective of this study is to develop and evaluate a mathematical model for predicting the revenue recovered from multiple proposed rates for large non-demand customer groups. A model of this type would reduce the time and the expense associated with the rate design process by allowing the analyst to perform the iterative process with the model and to use the customer-by-customer computer run for verification in the final stages of the rate design. The number of customer-by-customer computer runs would be reduced, whereby time required and expense would be reduced. As a result, the model would allow further research of alternative rates and better meet the increasing demands in the field of rate design. Such a model would expedite the rate design and the regulatory process, reduce associated expenses, and improve the quality of rate design.

CHAPTER II

METHOD AND PROCEDURE

The objective of this study is to develop a systematic procedure whereby multiple regression techniques can be used in the design of electric utility rates to determine revenue recovery involving migration for large non-demand rate classes. This objective was met in the following manner.

This study consists of the development and evaluation of three models. The first model consists of the development of a first degree prediction equation with $k = 7$ independent variables. It allows the prediction of revenue deviation due to migration for cases involving two proposed rates with a maximum of three rate blocks for each of two seasons for each rate. A response surface technique known as a Plackett-Burman design was used to reduce the number of required design points, i.e., computer runs to $n = k + 1 = 8$.

The second model consists of the development of a first degree prediction equation with $k = 15$ independent variables. This model allows for the prediction of revenue deviation due to migration for cases involving three proposed rates with a maximum of three rate blocks for each of two seasons for each rate. The Plackett-Burman design was again used to reduce the number of required design points to $n = k + 1 = 16$.

The third model consists of the development of a second degree prediction equation with $k = 7$ independent variables. This, like the first model allows for the prediction of revenue deviation due to migration for cases involving two proposed rates with a maximum of three rate blocks for each of two seasons for each rate. A response surface technique known as a Central Composite design was used to reduce the required number of design points to $n = 2^k + 2k + 1 =$ 143.

Sample Selection and Validation

A sample of 2,000 customers was selected from a database of 59,797 Public Service Company of Oklahoma residential customers. A systematic sample, with a random start, in which every twenty-ninth customer is chosen from the list of customer accounts, was employed. The data collected for this sample consisted of monthly kWh usages for each customer for a one-year period ending December 1984.

A t-test was performed to test the hypothesis that the sample mean monthly usage equals the population mean at a .05 level of significance for sample validation purposes. An F-test was also performed to test the hypothesis that the sample variance in mean monthly usage equals the population variance in mean monthly usage at a .05 level of significance for sample validation purposes.

To test the hypothesis $\mu = \bar{x}$

where μ = population mean = 875.18

$\bar{x}$ = sample mean = 875.46

σ = population standard deviation = 616.66

n = sample size = 2,000

the normal distribution test can be applied (Walpole & Myers, 1978).

$$Z = \frac{\bar{x} - \mu}{\sigma \ / \ n}$$

$$Z = \frac{875.46 - 875.18}{616.66 \ / \ 2000} = 0.203$$

Critical region: $Z < -z_{\alpha/2}$ and $Z > z_{\alpha/2}$

for $\alpha = .05$, $z_{\alpha/2} = 1.96$

Since $-1.96 < .0203 < 1.96$, the hypothesis that the population mean equals the sample mean is accepted.

To test the hypothesis $s_1 = s_2$

where s_1 = population standard deviation = 616.66

s_2 = sample standard deviation = 605.55

ν_1 = degrees of freedom = 59,797 - 1 = 59,796

ν_2 = degrees of freedom = 2,000 - 1 = 1,999

the F-test can be applied (Walpole & Myers, 1978).

$$F = \frac{s_1^{\ 2}}{s_1^{\ 2}} = \frac{616.66^2}{605.55^2} = 1.037$$

Critical region: $F < f_{1 - \alpha/2 \ (\nu_1, \nu_2)}$ and

$F > f_{\alpha/2} \ (\nu_1, \nu_2)$

for $\alpha = .05$, $f_{\alpha/2}(120, 120) = 1.53$

$f_{\alpha/2}(\infty, \infty) = 1.00$

This was accepted as sufficient evidence to accept the hypothesis, $s_1 = s_2$.

After the sample had been selected and validated, the data was downloaded from the mainframe to a microcomputer with mass storage capabilities using one of the many commercially available mainframe/PC interface software packages. In recognition of the expense of making computer runs on the mainframe, this procedure allowed the data collection for the study to be conducted at negligible cost.

Defintion of Independent Variables

In the determination of revenue recovery for a blocked kWh rate, the variables are customer charge, the kWh prices, and the breakpoints for the rate. For the purposes of this study, breakpoints are considered to be known beforehand and are not considered variables. If in the rate design process the breakpoints were changed, the data collection process described later in this chapter would need to be repeated using the new breakpoints. For example, in the case of two optional seasonal rates as shown below, there are fourteen variables.

Customer Charge = \$5.00	Customer Charge = \$6.00
On-Peak Rate x_p	On-Peak Rate y_p
0 - 400 kWh @ 5.00 ¢/kWh	0 - 400 kWh @ 4.50 ¢/kWh
401 - 800 kWh @ 6.00 ¢/kWh	401 - 800 kWh @ 6.00 ¢/kWh
over 800 kWh @ 7.00 ¢/kWh	over 800 kWh @ 6.50 ¢/kWh
Off-Peak Rate x_p	Off-Peak Rate y_p
0 - 400 kWh @ 5.00 ¢/kWh	0 - 400 kWh @ 5.50 ¢/kWh
401 - 800 kWh @ 4.50 ¢/kWh	401 - 800 kWh @ 5.00 ¢/kWh
over 800 kWh @ 4.00 ¢/kWh	over 800 kWh @ 4.00 ¢/kWh

The fourteen variables are as follows:

variable 1 = on-peak rate x_p first kWh price (5.00 ¢/kWh)

variable 2 = on-peak rate x_p second kWh price (6.00 ¢/kWh)

variable 3 = on-peak rate x_p third kWh price (7.00 ¢/kWh)

variable 4 = off-peak rate x_p first kWh price (5.00 ¢/kWh) variable 5 = off-peak rate x_p second kWh price (4.50 ¢/kWh)

variable 6 = off-peak rate x_p third kWh price (4.00 ¢/kWh)

variable 7 = rate x_p customer charge ($5.00)

variable 8 = on-peak rate y_p first kWh price (4.50 ¢/kWh)

variable 9 = on-peak rate y_p second kWh price (6.00 ¢/kWh)

variable 10 = on-peak rate y_p third kWh price (6.50 ¢/kWh)

variable 11 = off-peak rate y_p first kWh price (5.50 ¢/kWh)

variable 12 = off-peak rate y_p second kWh price (5.00 ¢/kWh)

variable 13 = off-peak rate y_p third kWh price (4.00 ¢/kWh)

variable 14 = rate y_p customer charge ($6.00)

Notice, however, that the revenue which would be recovered if all customers were billed on rate x_p can be determined from a bill frequency. Any deviation from this revenue due to the existence of an additional optional rate, i.e., rate y_p is a result of differences between the values of the independent variables defining rate x_p and the values of the independent variables defining rate y_p. Therefore, by initially assuming the revenue recovery to be that which would occur if all customers were billed on rate x_p, the independent variables can be defined as the difference in an independent variable in rate x_p and the corresponding variable in rate y_p. The dependent variable in this case would represent the deviation in revenue due to the difference in the two rates, i.e., due to migration.

For this example, the variables would be redefined as follows:

variable 1 = difference in on-peak first kWh price for rate x_p and rate y_p (5.00 - 4.50 = 0.50 ¢/kWh)

variable 2 = difference in on-peak second kWh price for rate x_p

and rate y_p (6.00 - 6.00 = 0.00 ¢/kWh)

variable 3 = difference in on-peak third kWh price for rate x_p and rate y_p (7.00 - 6.50 = 0.50 ¢/kWh)

variable 4 = difference in off-peak first kWh price for rate x_p and rate y_p (4.50 - 5.00 = -0.50 ¢/kWh)

variable 5 = difference in off-peak second kWh price for rate x_p and y_p (4.50 - 5.00 = -0.50 ¢/kWh)

variable 6 = difference in off-peak third kWh price for rate x_p and y_p (4.00 - 4.00 = 0.00 ¢/kWh)

variable 7 = difference in rate x_p customer charge and y_p customer charge (\$5.00 - \$6.00 = -\$1.00)

Experiment Design

For each model with k independent variables, n distinct design points will be selected. The coordinates of the design may be written as follows:

design point							
1	x_{11}	x_{12}	x_{13}	.	.	.	x_{1k}
2	x_{21}	x_{22}	x_{23}	.	.	.	x_{2k}
3	x_{31}	x_{32}	x_{33}	.	.	.	x_{3k}
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	x_{n1}	x_{n2}	x_{n3}	.	.	.	x_{nk}

Where in the u^{th} row, the values of x_{u1}, x_{u2}, x_{u3}, . . ., x_{uk} represent the coordinate settings of x_1, x_2, x_3, . . ., x_k at the

u^{th} design point. The above array will be referred to as the design array (Cornell, 1984).

In a 2^k factorial experiment, where k equals the number of variables, each variable is measured at only two values, v_{high} and v_{low}. To aid in the estimation of the coefficients of the models, if the same number of observations is collected at each level then the variables may be represented as coded variables in the form:

$$v_c = \frac{v - ((v_h + v_l)/2)}{((v_h - v_l)/2)}$$

Using this coding scheme, v_h will always be recoded to a value of +1 and v_l will always be recoded to a value of -1 (Cornell, 1984). For example, if there is a 1.5 ¢/kWh price difference for one level of measurement of variable 1, and a -.05 ¢/kWh price for the other level of measurement of variable 1 then the coded values for variable 1 would be as follows:

Price Difference	Coded Value
$1.5(v_h)$	$v_c = \frac{1.5 - ((1.5 + 0.5)/2)}{(1.5 - .05)/2} = +1$
$-0.5(v_l)$	$v_c = \frac{-0.5 - ((1.5 + (-.05))/2)}{(1.5 - (-.05))/2} = -1$

For the purposes of this study, however, the price differences will be defined such that they are to equal the coded value, i.e., the levels of measurement for variables 1 - 6 will be conducted at +1 ¢/kWh and -1 ¢/kWh and variable 7 will be conducted at +\$1 and -\$1. By considering all possible combinations of the coded values for the 7 variables, an experiment design consisting of $2^k = 2^7 = 128$ design points is obtained. Likewise, when considering three levels of measurement, as is required in the non-linear case, considering all possible combinations yields a 3^k factorial design consisting of 3^k design points. One problem associated with factorial designs is that as k, the number of variables, increases, the number of required design points becomes large rapidly.

At this point, a few comments regarding the nature of this model are in order. The first point is that this model is free of the multicollinearly problems, i.e., none of the predictor variables have any correlations with any of the other predictor variables. Therefore, this will not be a concern in this model. A second point is that each of the independent variables is measurable without error and each of the independent variables is directly controllable. Therefore, the study lends itself to a designed experiment. This study incorporates the use of a designed experiment in an effort to increase the effectiveness of the resulting prediction equations. The third point is that the problem at hand, in general, involves a large number of variables. Response Surface methodology is a set of techniques which is helpful in solving problems such as selecting a proper experimental design in cases involving a large number of variables. Two such Response Surface techniques have been used in this study.

The first of these Response Surface techniques, known as a Plackett-Burman design was used in determining the first-degree models of the form:

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \quad . \quad . \quad . \quad b_7x_7$$

This technique reduces the number of required design points to n = k + 1 where n is a multiple of four. The Plackett-Burman design array is constructed by selecting, from the 2^k factorial design array, one row which contains $(k + 1)/2$ +1's and $(k-1)/2$ -1's. This is defined to be the first row of the Plackett-Burman design array. Each successive row up to row k of the new array is created by rotating the previous row one place to the right with the last element of the previous row becoming the first element of the current row. The last row of the Plackett-Burman design array is defined to be a row of -1's. The resulting array is of dimension $(k + 1) \times k$ (Cornell, 1984). For use in this study, a computer program was written which constructs a Plackett-Burman design array for a given number of variables. This program is listed in Appendix A.

The second of these Response Surface techniques, known as a Central Composite design, was used in determining the second degree model of the form:

$$y = b_0 + \sum_{i=1}^{k} + b_i x_i + \sum_{i=1}^{k} b_{ii} x_i^2 + \sum \sum_{i<j}^{k} b_{ij} x_i x_j$$

This technique reduces the number of required design points to $n = 2^k + 2k + 1$. The Central Composite design array is defined to be 1) the 2^k rows defined by $(\pm 1, \pm 1, . . ., \pm 1)$ 2) the $2k$ rows defined by $(\pm a, 0, 0, . . ., 0)$, $(0, \pm a, 0, . . ., 0)$, . . ., $(0, 0, 0, . . ., \pm a)$

where

$$a = \sqrt[4]{2^k}$$

3) the last row consisting of $(0, 0, . . ., 0)$. The resulting array is of dimension $(2^k + 2k + 1) \times k$ (Cornell, 1984). A computer program was written which constructs a Central Composite design array for a

given number of variables. This program is listed in Appendix A.

The design arrays for the three models in this study are therefore defined as follows:

1. first degree model for:

   2 optional rates

   2 seasons per rate

   3 blocks per season

   variable 1 = difference in on-peak first kWh price for rate one and rate two

   variable 2 = difference in on-peak second kWh price for rate one and rate two

   variable 3 = difference in on-peak third kWh price for rate one and rate two

   variable 4 = difference in off-peak first kWh price for rate one and rate two

   variable 5 = difference in off-peak second kWh price for rate one and rate two

   variable 6 = difference in off-peak third kWh price for rate one and rate two

   variable 7 = difference in rate one customer charge and rate two customer charge

   The Plackett-Burman design array is of dimension (k + 1) X k = 8 X 7.

2. first degree model for:

   3 optional rates

   2 seasons per rate

   3 blocks per season

variable 1 = difference in on-peak first kWh price for rate one and rate two

variable 2 = difference in on-peak second kWh price for rate one and rate two

variable 3 = difference in on-peak third kWh price for rate one and rate two

variable 4 = difference in off-peak first kWh price for rate one and rate two

variable 5 = difference in off-peak second kWh price for rate one and rate two

variable 6 = difference in off-peak third kWh price for rate one and rate two

variable 7 = difference in rate one customer charge and rate two customer charge

variable 8 = difference in on-peak first kWh price for rate one and rate three

variable 9 = difference in on-peak second kWh price for rate one and rate three

variable 10 = difference in on-peak third kWh price for rate one and rate three

variable 11 = difference in off-peak first kWh price for rate one and rate three

variable 12 = difference in off-peak second kWh price for rate one and rate three

variable 13 = difference in off-peak third kWh price for rate one and rate three

variable 14 = difference in rate one customer charge and rate three customer charge

The Plackett-Burman design array is of dimension (k + 1) X k = 16 X 15.

3. the second degree model for:

   2 optional rates

   2 seasons per rate

   3 blocks per season

   The variables are defined the same as in number one. The Central Composite design array is of dimension (2^k + 2k + 1) X k = 143 X 7.

These arrays are contained in Appendix B.

Data Collection

Two special purpose computer programs were written for the data collection process. These special purpose programs were customer-by-customer billing programs, one for using two optional rates and the other for using three optional rates, with the enhancements needed for this particular data collection process, i.e., they used as input, the redefined independent variables (differences in customer charges, and differences in prices) and were capable of making several rate design runs in succession for efficiency purposes. Data for the models was collected by running this program against the database for various values of the independent variables defined by the design array and measuring the response in the dependent variable, i.e., revenue deviation due to migration. Listings of these programs are contained in Appendix C. The revenue change due to migration associated with each design point is shown in Appendix B along with the design point which generated this revenue difference. These programs use constant breakpoints (set at 400 kWh and 800 kWh for this study) for both of two seasons. If these criteria were to change in the rate design process, these programs would be changed to incorporate the new criteria and the data collection process would be repeated.

Development of the Models

The regression equation for each model was determined by the use of a commercially available statistical analysis software package. The multiple correlation coefficient was also calculated for each model as a test for lack of fit. These models will constitute a basis for the prediction of revenue deviation due to migration. The data collection program was then used to determine the observed response to an equal number of additional data points (i.e., the same number of design points as in the original design array) for each model. This was done by taking the original design array and changing all +1 values to +1.1 and all -1 values to -0.8. With the addition of these data points, a new regression equation and a new multiple correlation coefficient were determined. The combined observed responses were compared to the predicted responses for the same design points. The results are contained in the next chapter.

CHAPTER III

ANALYSIS OF THE MODELS

Linear: Two Rates, Two Seasons, Three Blocks Per Season

The data collection program was run for seven independent variables and eight design points as dictated by the Plackett-Burman design. The Plackett-Burman design matrix and the calculated value of the dependent variable, i.e., revenue decrease due to migration, for each of the design points are shown in Appendix B. The approximate run time for the data collection program for these design points was 17 minutes on a microcomputer with mass storage capabilities. In order to determine the contribution of each variable to the resulting prediction equation, regressions were performed for all possible subsets of the seven independent variables. The maximum obtainable multiple correlation coefficient for each number of independent variables is shown in Table I.

For seven independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + b_2x_2 + \ldots b_7x_7$$

where

$$b_0 = -39{,}661.39$$

$$b_1 = 32{,}477.93$$

$$b_2 = 27{,}905.85$$

$$b_3 = 30{,}570.63$$

$b_4 = 27,248.07$

$b_5 = 20,346.92$

$b_6 = 26,292.58$

$b_7 = 29,473.18$

TABLE I

R^2 FOR LINEAR & VARIABLE MODEL WITH 8 DESIGN POINTS

Number in Model	R^2
1	0.1909
2	0.6249
3	0.8148
4	0.8838
5	0.9484
6	0.9746
7	1.0000

In order to determine the accuracy of the regression equation and to evaluate the change in coefficients of the equation with the addition of more design points, the data collection program was run with an alternate design matrix. This alternate design matrix consisted of the original Plackett-Burman design matrix except that -1 was replaced with -.8 and +1 was replaced with +1.1. This alternate design matrix and the resulting value of the dependent variable for each design point are also shown in Appendix B. The regression analysis for seven independent variables was then performed using the combination of both matrices as data points. The results are shown in Table II.

TABLE II

R^2 FOR LINEAR 7 VARIABLE MODEL
WITH 16 DESIGN POINTS

Number in Model	R^2
1	.1825
2	.6109
3	.8058
4	.8678
5	.9324
6	.9570
7	.9828

For seven independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + b_2x_2 + . . . b_7x_7$$

where

$$b_0 = - 46,812.44$$

$$b_1 = 29,062.68$$

$$b_2 = 25,803.60$$

$b_3 = 27,387.66$

$b_4 = 24,217.28$

$b_5 = 19,306.08$

$b_6 = 24,994.10$

$b_7 = 27,276.02$

For each design point, the actual value of the dependent variable was compared to the value predicted by using the equation above and the residual computed. The results are shown in Appendix D.

For the design points, the mean actual value of the dependent variable was -33,458.88. The mean of the absolute value of the residuals was 8,549.28. This equates to a mean error of 25.55%. Note that in some cases, the model predicts a positive value for the dependent value. When this occurs, this should be interpreted as a prediction of zero revenue deviation. Using this interpretation of the prediction, the mean of the absolute value of the residuals was 6,417.27. This equates to a mean error of 19.18%.

Linear: Three Rates, Two Seasons, Three Blocks Per Season

The data collection program was run for fourteen independent variables and sixteen design points as dictated by the Plackett-Burman design. The design matrix and calculated responses are shown in Appendix B. The approximate run time of the data collection program for these design points was 34 minutes. Again, regressions were performed for all possible subsets of the 14 independent variables to observe the effect on the correlation coefficients of the resulting prediction equations. The maximum obtainable multiple correlation coefficient for each number of independent variables is shown in Table III.

TABLE III

R^2 FOR LINEAR 14 VARIABLE MODEL WITH 16 DESIGN POINTS

Number in Model	R^2
1	.2552
2	.6237
3	.7662
4	.8410
5	.8880
6	.9317
7	.9496
8	.9634
9	.9724
10	.9862
11	.9890
12	.9937
13	.9984
14	.9988

For the fourteen independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + b_2x_2 + \ldots b_{14}x_{14}$$

where

$$b_0 = -46,014.16$$

$$b_1 = 13,588.00$$

$b_2 = 9,465.33$

$b_3 = 12,130.11$

$b_4 = 9,497.42$

$b_5 = 2,612.72$

$b_6 = 10,672.10$

$b_7 = 17,836.07$

$b_8 = 21,763.02$

$b_9 = 19,780.80$

$b_{10} = 19,755.02$

$b_{11} = 12,896.01$

$b_{12} = 11,120.66$

$b_{13} = 13,465.68$

$b_{14} = 14,063.05$

An alternate design matrix was constructed as described previously. This alternate design matrix and the resulting value of the dependent variable for each design point of the alternate design matrix are shown in Appendix B. The regression analysis for 14 independent variables was then performed using the combination of both matrices as data points. The results are shown in Table IV.

For fourteen independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + b_2x_2 + \ldots + b_{14}x_{14}$$

where

$b_0 = -48,178.66$

$b_1 = 11,300.40$

$b_2 = 10,016.31$

$b_3 = 11,600.37$

$b_4 = 8,761.35$

$b_5 = 3,858.80$

$b_6 = 10,681.55$

$b_7 = 15,825.31$

$b_8 = 19,388.15$

$b_9 = 18,068.65$

$b_{10} = 18,052.57$

$b_{11} = 12,281.90$

$b_{12} = 11,036.04$

$b_{13} = 14,205.99$

$b_{14} = 12,858.69$

TABLE IV

R^2 FOR LINEAR 14 VARIABLE MODEL
WITH 32 DESIGN POINTS

Number in Model	R^2
1	.2070
2	.6142
3	.7686
4	.8434
5	.8833
6	.9156
7	.9386
8	.9525
9	.9625

TABLE IV (Continued)

10	.9732
11	.9766
12	.9821
13	.9857
14	.9866

As before, for each design point, the actual value of the dependent variable was compared to the value predicted by using the above equation and the residual computed. The results are shown in Appendix D.

For the design points, the mean actual value of the dependent variable was -34.836.82. The mean of the absolute value of the residuals was 4,559.32. This equates to a mean error of 13.09%. Interpreting positive predictions as zero predictions, the mean of the absolute value of the residuals was 3,895.65. This equates to a mean error of 11.18%.

Quadratic: Two Rates, Two Seasons,
Three Blocks Per Season

The data collection program was run for seven independent variables and the 143 design points dictated by the Central Composite design. The Central Composite design matrix and the calculated value of the dependent variable, i.e., revenue decrease due to migration for each of the design points is shown in Appendix B. The approximate run time of the data collection program for these design points was five hours.

A complete quadratic multiple regression for seven independent variables was performed for these design points. The contribution to the R^2 value for the linear, quadratic, adn crossproduct terms of the prediction equation is shown in Table V.

TABLE V

R^2 FOR QUADRATIC 7 VARIABLE MODEL
WITH 143 DESIGN POINTS

Terms	R^2
Linear	0.8280
Quadratic	0.0163
Crossproduct	0.1486
Total Regression	0.9930

For the seven independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + . . . + b_7x_7 + b_8x_1x_1 + b_9x_2x_1 + b_{10}x_2x_2 + b_{11}x_3x_1 +$$
$$b_{12}x_3x_2 + b_{13}x_3x_3 + . . . + b_{33}x_7x_5 + b_{34}x_7x_6 + b_{35}x_7x_7$$

where

b_0 = -21,819.87

b_1 = 17,823.91

b_2 = 13,287.25

b_3 = 23,041.53

$b_4 = 23,402.62$

$b_5 = 13,261.91$

$b_6 = 14,171.07$

$b_7 = 12,000.00$

$b_8 = -3,593.63$

$b_9 = -3,821.64$

$b_{10} = -2,245.04$

$b_{11} = -5,645.73$

$b_{12} = -4,988.43$

$b_{12} = -5,144.64$

$b_{13} = -5,144.64$

$b_{14} = -8,431.74$

$b_{15} = -5,292.50$

$b_{16} = -8,010.96$

$b_{17} = -5,251.98$

$b_{18} = -3,270.36$

$b_{19} = -2,634.30$

$b_{20} = -5,398.23$

$b_{21} = -4,791.62$

$b_{22} = -2,237.50$

$b_{23} = -2,273.16$

$b_{24} = -2,007.63$

$b_{25} = -6,720.23$

$b_{26} = -3,218.84$

$b_{27} = -2,859.47$

$b_{28} = -2,507.76$

$b_{29} = -3,578.45$

$$b_{30} = -2,568.52$$

$$b_{31} = -3,406.40$$

$$b_{32} = -5,220.23$$

$$b_{33} = -2,161.42$$

$$b_{34} = -1,443.46$$

$$b_{35} = -1,862.38$$

For each design point of the Central Composite design array, the actual value of the dependent variable, i.e., revenue deviation due to migration, was compared to the value predicted by using the equation above and the residual computed. The results are shown in Appendix D.

For the design points, the mean actual value of the dependent variable was -45,882.10. The mean of the absolute value of the residuals was 3,289.68. This equates to a mean error of 7.17%. Interpreting positive predictions as zero predictions, the mean of the absolute value of the residuals was 2, 803.10. This equates to a mean error of 6.11%

For the latter interpretation of the model, a summary of the residuals is shown in Table VI.

An alternate design matrix was constructed as described previously. This alternate design matrix and the resulting value of the dependent variable for each design point of the alternate design matrix is shown in Appendix B. The regression analysis for seven independent variables was then performed using the combination of both matrices as design points. The resulting contribution to the R^2 value for the linear, quadratic, and crossproduct terms of the prediction equation is shown in Table VII.

TABLE VI

RESIDUALS FOR QUADRATIC 7 VARIABLE MODEL WITH 143 DESIGN POINTS

Residual	Cumulative Percent of Design Points
0 - 1000	25.2
1001 - 2000	37.1
2001 - 3000	63.6
3001 - 4000	78.3
4001 - 5000	90.2
over 5000	100.0

TABLE VII

R^2 FOR QUADRATIC 7 VARIABLE MODEL WITH 286 DESIGN POINTS

Terms	R^2
Linear	0.7810
Quadratic	0.0289
Crossproduct	0.1795
Total Regression	0.9930

For the seven independent variables, the resulting prediction equation was:

$$y = b_0 + b_1x_1 + \ldots + b_7x_7 + b_8x_1x_1 + b_9x_2x_1 + b_{10}x_2x_2 + b_{11}x_3x_1 + b_{12}x_3x_2 + b_{13}x_3x_3 + \ldots + b_{33}x_7x_5 + b_{34}x_7x_6 + b_{35}x_7x_7$$

where

b_0 = -18,994.75

b_1 = 18,084.68

b_2 = 13,504.25

b_3 = 23,051.38

b_4 = 23,611.70

b_5 = 13,459.54

b_6 = 14,076.37

b_7 = 12,104.80

b_8 = -3,987.09

b_9 = -3,794.01

b_{10} = -2,566.72

b_{11} = -5,587.70

b_{12} = -4,927.90

b_{13} = -5,672.58

b_{14} = -8,324.42

b_{15} = -5,261.57

b_{16} = -7,869.89

b_{17} = -5,751.91

b_{18} = -3,237.11

b_{19} = -2,610.20

b_{20} = -5,327.29

b_{21} = -4,771.72

$$b_{22} = -2,562.08$$

$$b_{23} = -2,265.03$$

$$b_{24} = -2,005.70$$

$$b_{25} = -6,656.32$$

$$b_{26} = -3,215.85$$

$$b_{27} = -2,863.86$$

$$b_{28} = -2,898.60$$

$$b_{29} = -3,583.45$$

$$b_{30} = -2,466.17$$

$$b_{31} = -3,384.54$$

$$b_{32} = -5,187.30$$

$$b_{33} = -2,097.32$$

$$b_{34} = -1,448.53$$

$$b_{35} = -2,180.89$$

For each design point of the alternate design array, the actual value of the dependent variable was compared to the value predicted by using the equation above and the residual computed. The results are shown in Appendix D.

For the design points, the mean actual value of the dependent variable was -36,562.07. The mean of the absolute value of the residuals was 3,658. This equates to a mean error of 10.01%. Interpreting positive predictions as zero predictions, the mean of the absolute value of the residuals was 2,934.66. This equates to a mean error of 8.03%.

For the latter interpretation of the model, a summary of the residuals is shown in Table VIII.

TABLE VIII

RESIDUALS FOR QUADRATIC 7 VARIABLE MODEL WITH 286 DESIGN POINTS

Residual	Cumulative Percent of Design Points
0 - 1000	28.3
1001 - 2000	43.0
2001 - 3000	57.0
3001 - 4000	73.8
4001 - 5000	100.0

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Multiple regression analysis and Response Surface techniques can be used to predict revenue recovery involving migration in the design of optional non-demand electric utility rates. The accuracy of the prediction equation will be dependent upon the validity of the sample of customers, if a sample is used, and the number and appropriateness of the design points used in the regression. This study employed multiple linear regressions with a Plackett-Burman design and quadratic multiple regressions with a Central Composite design. By transferring a customer-by-customer data file to a microcomputer with mass storage capability, using a designed experiment to collect revenue deviation data, and performing a multiple regression on the experiment results, a model can be developed which will predict revenue deviation due to migration for rate design purposes.

The use of such a procedure provides the following benefits to the rate analyst:

1. reduced expense - Fewer rate design computer runs on the mainframe computer (costly for large rate classes) and fewer runs on the entire population would be necessary since an immediate prediction of the results of such a computer run would be available.

2. reduced time requirements - By reducing the number of computer runs for the entire population, and by having access to immediate predictions of such runs, the time requirements associated with the rate design process are reduced.

3. allows further analysis - Since expense and time requirements are factors in the amount of analysis which can be performed in rate design, the reduction of these factors allows more in-depth and cost effective analysis; analysis which might otherwise be infeasible.

4. feasibility of the model - The model can be developed at virtually no cost by using a microcomputer for data collection. To the analyst, the model represents valuable additional information which is available at virtually no cost. The model can be developed within hours or days depending on the user's requirements and can be developed well in advance of the need for it.

By performing the data transfer and data collection processes during those hours or days in which microcomputer equipment normally stands idle (e.g., overnight, weekends), and by using this procedure on several microcomputers simultaneously, greater efficiency can be made of existing computer resources. Such a model can be constructed for any type of non-demand rate structure. The specification of each model developed will depend upon the requirements defined by the analyst and the resources available, e.g., accuracy required, number of rates, number of variables, number of required design points, population or sample size, and available computer resources.

These models provide the analyst with a means of predicting revenue deviation due to migration for large non-demand rate classes. The use of such models would expedite the rate design process, allow more extensive analysis on large non-demand rate classes, and reduce the costs associated with rate design for those rate classes.

Recommendations

This study presents a systematic procedure whereby a model can be developed for the prediction of revenue deviation due to migration in the design of optional non-demand utility rates. For use in future research in this area, the following recommendations are provided:

1. Investigate the use of other types of equations in the regression, e.g., negative exponential.
2. Investigate the use of combinations of variables, e.g., weighted average price.
3. Investigate the extension of this procedure to optional demand rates.
4. Investigate the use of alternative experiment designs, particularly the use of a fractional replicate of the Central Composite design for use with models involving large numbers of variables, e.g., models for three optional rates.
5. Examine the effects on R^2 as the number of design points continues to increase.

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APPENDIXES

APPENDIX A

DESIGN ARRAY PROGRAM LISTINGS

Plackett-Burman Design Program

```
10 REM PLANKETT-BURMAN DESIGN PROGRAM
20 DIM VALUE(100,27)
30 CLS
40 OPEN "F:PBD001" FOR OUTPUT AS #1
50 LPRINT
60 INPUT "HOW MANY VARIABLES ";K
70 LPRINT "REQUESTED VARIABLES = K = ";K
80 FINDN=FIX((K+1)/4+.9999)
90 N=FINDN*4
100 K=N-1
110 LPRINT "ADJUSTED VARIABLES  = K = ";K
120 LPRINT "NUMBER OF DATA POINTS = N = ";N
130 LPRINT "PBD MATRIX IS ";N;" X ";K
140 VALUE(1,1)=-1
150 VALUE(1,2)=1
160 VALUE(1,3)=1
170 VALUE(1,4)=-1
180 VALUE(1,5)=1
190 VALUE(1,6)=-1
200 VALUE(1,7)=1
210 VALUE(1,8)=-1
220 VALUE(1,9)=1
230 VALUE(1,10)=-1
240 VALUE(1,11)=1
250 VALUE(1,12)=-1
260 VALUE(1,13)=1
270 VALUE(1,14)=-1
280 VALUE(1,15)=1
290 VALUE(1,16)=-1
300 VALUE(1,17)=1
310 VALUE(1,18)=-1
320 VALUE(1,19)=1
330 VALUE(1,20)=-1
340 VALUE(1,21)=1
350 VALUE(1,22)=-1
360 VALUE(1,23)=1
370 VALUE(1,24)=-1
380 VALUE(1,25)=1
390 VALUE(1,26)=-1
400 VALUE(1,27)=1
410 FOR I = 2 TO K
420    FOR J = 1 TO K-1
430    VALUE(I,J+1)=VALUE(I-1,J)
440    NEXT J
450    VALUE(I,1)=VALUE(I-1,K)
460 NEXT I
470 FOR J = 1 TO K
480    VALUE(K+1,J)=-1
490 NEXT J
500 LPRINT "THE PLANKETT-BURMAN DESIGN MATRIX IS "
510 FOR I = 1 TO K+1
520   FOR J = 1 TO K
530    PRINT #1, USING "##.### "; VALUE(I,J);
540    LPRINT USING "##.### "; VALUE(I,J);
550   NEXT J
560 PRINT #1, " "
570 LPRINT
580 NEXT I
590 LPRINT
600 END
```

Central Composite Design Program

```
10 REM CENTRAL COMPOSITE DESIGN PROGRAM
20 CLS
30 DIM VALUE(200,27)
40 OPEN "F:CCD001" FOR OUTPUT AS #1
50 LPRINT
60 INPUT "HOW MANY VARIABLES ";K
70 LPRINT "VARIABLES = K = ";K
80 N=(2^K)+(2*K)+1
90 LPRINT "NUMBER OF DATA POINTS = N =";N
100 LPRINT "THE CCD MATRIX IS ";N;" X ";K
110 FOR J = 1 TO K
120 COUNTER=0
130 SEQ=(2^J)/2
140 NUMBER=1
150 NUMBER=NUMBER/-1
160    FOR I = 1 TO SEQ
170    COUNTER= COUNTER+1
180    VALUE(COUNTER,J)=NUMBER
190    NEXT I
200    IF COUNTER <> 2^K THEN GOTO 150
210 NEXT J
220 M=2^K
230 ALPHA=M^.25
235 ALPHA=(CINT(ALPHA*1000))/1000
240 FOR I = (2^K)+1 TO N-1 STEP 2
250    FOR J = 1 TO K
260    VALUE(I,J)=0
270    VALUE(I+1,J)=0
280    NEXT J
290 NEXT I
300 JCOUNT=0
310 FOR I = (2^K)+1 TO N-1 STEP 2
320    JCOUNT=JCOUNT+1
330    VALUE(I,JCOUNT)=-ALPHA
340    VALUE(I+1,JCOUNT)=ALPHA
350 NEXT I
360 FOR J = 1 TO K
370 VALUE(N,J)=0
380 NEXT J
390 LPRINT "THE CENTRAL COMPOSITE DESIGN MATRIX IS "
400 FOR I = 1 TO N
410    FOR J = 1 TO K
420    PRINT #1, USING "##.### "; VALUE(I,J);
430    LPRINT USING "##.### "; VALUE(I,J);
440    NEXT J
450 PRINT #1, " "
460 LPRINT
470 NEXT I
480 END
```

APPENDIX B

DESIGN ARRAYS AND DEPENDENT VARIABLE VALUES

Design Array and Dependent Variable
Values for Plackett-Burman Design
With 7 Variables

-1	1	1	-1	1	-1	1	-17383.38
1	-1	1	1	-1	1	-1	-798.13
-1	1	-1	1	1	-1	1	-24028.51
1	-1	1	-1	1	1	-1	-14600.43
-1	1	-1	1	-1	1	1	-12137.19
1	-1	1	-1	1	-1	1	-8239.22
1	1	-1	1	-1	1	-1	-6127.69
-1	-1	-1	-1	-1	-1	-1	-233976.56

Design Array and Dependent Variable
Values for Plackett-Burman Design
With 14 Variables

-1	1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-57603.07
1	-1	1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	-8797.94
-1	1	-1	1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-62868.45
1	-1	1	-1	1	1	-1	1	-1	1	-1	1	-1	1	-1	-22567.34
-1	1	-1	1	-1	1	1	-1	1	-1	1	-1	1	-1	1	-46749.87
1	-1	1	-1	1	-1	1	1	-1	1	-1	1	-1	1	-1	-8239.22
-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	1	-1	1	-38895.98
1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	1	-1	-12203.65
-1	1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	1	-38947.54
1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	-25921.67
-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-42498.25
1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1	-21231.63
-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-46771.85
1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-54826.07
1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	-14127.50
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-233976.56

Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables

-1	-1	-1	-1	-1	-1	-1	-233976.56
1	-1	-1	-1	-1	-1	-1	-162680.94
-1	1	-1	-1	-1	-1	-1	-180827.56
1	1	-1	-1	-1	-1	-1	-109637.69
-1	-1	1	-1	-1	-1	-1	-142025.00
1	-1	1	-1	-1	-1	-1	-71797.75
-1	1	1	-1	-1	-1	-1	-89847.77
1	1	1	-1	-1	-1	-1	-28969.86
-1	-1	-1	1	-1	-1	-1	-140366.08
1	-1	-1	1	-1	-1	-1	-76701.81
-1	1	-1	1	-1	-1	-1	-87398.47
1	1	-1	1	-1	-1	-1	-42461.34
-1	-1	1	1	-1	-1	-1	-50572.83
1	-1	1	1	-1	-1	-1	-13441.17
-1	1	1	1	-1	-1	-1	-18102.95
1	1	1	1	-1	-1	-1	-7304.99
-1	-1	-1	-1	1	-1	-1	-180928.92
1	-1	-1	-1	1	-1	-1	-109633.30
-1	1	-1	-1	1	-1	-1	-127779.92
1	1	-1	-1	1	-1	-1	-57594.55
-1	-1	1	-1	1	-1	-1	-90296.44
1	-1	1	-1	1	-1	-1	-29604.37
-1	1	1	-1	1	-1	-1	-46347.49
1	1	1	-1	1	-1	-1	-11106.86
-1	-1	-1	1	1	-1	-1	-87594.20
1	-1	-1	1	1	-1	-1	-36120.47
-1	1	-1	1	1	-1	-1	-40780.43
1	1	-1	1	1	-1	-1	-19796.28
-1	-1	1	1	1	-1	-1	-18591.33
1	-1	1	1	1	-1	-1	-5071.13
-1	1	1	1	1	-1	-1	-6960.12
1	1	1	1	1	-1	-1	-2857.24
-1	-1	-1	-1	-1	1	-1	-178699.29
1	-1	-1	-1	-1	1	-1	-108957.68
-1	1	-1	-1	-1	1	-1	-126873.91
1	1	-1	-1	-1	1	-1	-58954.51
-1	-1	1	-1	-1	1	-1	-98979.58
1	-1	1	-1	-1	1	-1	-37859.07
-1	1	1	-1	-1	1	-1	-55443.90
1	1	1	-1	-1	1	-1	-9629.14
-1	-1	-1	1	-1	1	-1	-87862.10
1	-1	-1	1	-1	1	-1	-29769.58
-1	1	-1	1	-1	1	-1	-38772.04
1	1	-1	1	-1	1	-1	-6127.69
-1	-1	1	1	-1	1	-1	-21882.13
1	-1	1	1	-1	1	-1	-798.13
-1	1	1	1	-1	1	-1	-3661.96
1	1	1	1	-1	1	-1	-673.93
-1	-1	-1	-1	1	1	-1	-128243.63
1	-1	-1	-1	1	1	-1	-61335.18
-1	1	-1	-1	1	1	-1	-78693.91
1	1	-1	-1	1	1	-1	-18245.82
-1	-1	1	-1	1	1	-1	-60475.25
1	-1	1	-1	1	1	-1	-14600.43
-1	1	1	-1	1	1	-1	-29627.44
1	1	1	-1	1	1	-1	-3768.46
-1	-1	-1	1	1	1	-1	-42584.62
1	-1	-1	1	1	1	-1	-4975.12
-1	1	-1	1	1	1	-1	-8310.00
1	1	-1	1	1	1	-1	-1161.09

Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables
(Continued)

-1	-1	1	1	1	1	-1	-7953.72
1	-1	1	1	1	1	-1	-517.56
-1	1	1	1	1	1	-1	-1926.68
1	1	1	1	1	1	-1	-482.38
-1	-1	-1	-1	-1	-1	1	-186458.94
1	-1	-1	-1	-1	-1	1	-116607.62
-1	1	-1	-1	-1	-1	1	-133345.12
1	1	-1	-1	-1	-1	1	-69485.66
-1	-1	1	-1	-1	-1	1	-94971.53
1	-1	1	-1	-1	-1	1	-30824.82
-1	1	1	-1	-1	-1	1	-45636.56
1	1	1	-1	-1	-1	1	-11950.44
-1	-1	-1	1	-1	-1	1	-96134.54
1	-1	-1	1	-1	-1	1	-50697.90
-1	1	-1	1	-1	-1	1	-53817.51
1	1	-1	1	-1	-1	1	-28396.71
-1	-1	1	1	-1	-1	1	-18445.78
1	-1	1	1	-1	-1	1	-7598.25
-1	1	1	1	-1	-1	1	-8386.14
1	1	1	1	-1	-1	1	-3998.97
-1	-1	-1	-1	1	-1	1	-133602.85
1	-1	-1	-1	1	-1	1	-65295.26
-1	1	-1	-1	1	-1	1	-80578.05
1	1	-1	-1	1	-1	1	-30366.43
-1	-1	1	-1	1	-1	1	-46890.49
1	-1	1	-1	1	-1	1	-8239.22
-1	1	1	-1	1	-1	1	-17383.38
1	1	1	-1	1	-1	1	-4180.28
-1	-1	-1	1	1	-1	1	-48947.58
1	-1	-1	1	1	-1	1	-23466.72
-1	1	-1	1	1	-1	1	-24028.51
1	1	-1	1	1	-1	1	-13853.40
-1	-1	1	1	1	-1	1	-6106.83
1	-1	1	1	1	-1	1	-2730.61
-1	1	1	1	1	-1	1	-2961.00
1	1	1	1	1	-1	1	-1406.99
-1	-1	-1	-1	-1	1	1	-132149.54
1	-1	-1	-1	-1	1	1	-64956.80
-1	1	-1	-1	-1	1	1	-81214.43
1	1	-1	-1	-1	1	1	-23439.01
-1	-1	1	-1	-1	1	1	-56922.46
1	-1	1	-1	-1	1	1	-6610.99
-1	1	1	-1	-1	1	1	-20097.65
1	1	1	-1	-1	1	1	-275.76
-1	-1	-1	1	-1	1	1	-46788.68
1	-1	-1	1	-1	1	1	-10733.69
-1	1	-1	1	-1	1	1	-12137.19
1	1	-1	1	-1	1	1	-1533.64
-1	-1	1	1	-1	1	1	-1110.25
1	-1	1	1	-1	1	1	0.00
-1	1	1	1	-1	1	1	0.00
1	1	1	1	-1	1	1	0.00
-1	-1	-1	-1	1	1	1	-83549.65
1	-1	-1	-1	1	1	1	-23051.99
-1	1	-1	-1	1	1	1	-36536.83
1	1	-1	-1	1	1	1	-2372.87
-1	-1	1	-1	1	1	1	-26539.88
1	-1	1	-1	1	1	1	-181.39
-1	1	1	-1	1	1	1	-7631.35
1	1	1	-1	1	1	1	0.00

Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables
(Continued)

-1	-1	-1	1	1	1	1	-11604.04
1	-1	-1	1	1	1	1	-1186.33
-1	1	-1	1	1	1	1	-1282.93
1	1	-1	1	1	1	1	-214.56
-1	-1	1	1	1	1	1	-105.75
1	-1	1	1	1	1	1	0.00
-1	1	1	1	1	1	1	0.00
1	1	1	1	1	1	1	0.00
-3.364	0	0	0	0	0	0	-119919.23
3.364	0	0	0	0	0	0	0.00
0	-3.364	0	0	0	0	0	-89396.62
0	3.364	0	0	0	0	0	0.00
0	0	-3.364	0	0	0	0	-155023.42
0	0	3.364	0	0	0	0	0.00
0	0	0	-3.364	0	0	0	-157452.83
0	0	0	3.364	0	0	0	0.00
0	0	0	0	-3.364	0	0	-89226.13
0	0	0	0	3.364	0	0	0.00
0	0	0	0	0	-3.364	0	-95342.93
0	0	0	0	0	3.364	0	0.00
0	0	0	0	0	0	-3.364	-80735.99
0	0	0	0	0	0	3.364	0.00
0	0	0	0	0	0	0	0.00

Alternate Design Array and Dependent Variable
Values for Plackett-Burman Design
With 7 Variables

-.8	1.1	1.1	-.8	1.1	-.8	1.1	-6522.63
1.1	-.8	1.1	1.1	-.8	1.1	-.8	-396.36
-.8	1.1	-.8	1.1	1.1	-.8	1.1	-12225.96
1.1	-.8	1.1	-.8	1.1	1.1	-.8	-5538.26
-.8	1.1	-.8	1.1	-.8	1.1	1.1	-1961.10
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-3094.59
1.1	1.1	-.8	1.1	-.8	1.1	-.8	-1130.87
-.8	-.8	-.8	-.8	-.8	-.8	-.8	-187181.25

Alternate Design Array and Dependent Variables
Values for Plackett-Burman Design
With 14 Variables

-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-23479.65
1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	-3472.55
-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-29308.18
1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	-8614.46
-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-18948.17
1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	-3094.59
-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-12945.33
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-.8	-4206.44
-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	1.1	-12955.44
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-.8	-12879.49
-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	1.1	-14207.85
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-.8	-5119.90
-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	1.1	-15888.57
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-22042.76
1.1	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	1.1	-.8	-4207.07
-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-.8	-187181.25

Alternate Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables

-.8	-.8	-.8	-.8	-.8	-.8	-.8	-187181.25
1.1	-.8	-.8	-.8	-.8	-.8	-.8	-119455.41
-.8	1.1	-.8	-.8	-.8	-.8	-.8	-136689.70
1.1	1.1	-.8	-.8	-.8	-.8	-.8	-69889.30
-.8	-.8	1.1	-.8	-.8	-.8	-.8	-100803.13
1.1	-.8	1.1	-.8	-.8	-.8	-.8	-37668.99
-.8	1.1	1.1	-.8	-.8	-.8	-.8	-54128.63
1.1	1.1	1.1	-.8	-.8	-.8	-.8	-13060.30
-.8	-.8	-.8	1.1	-.8	-.8	-.8	-98287.13
1.1	-.8	-.8	1.1	-.8	-.8	-.8	-46164.87
-.8	1.1	-.8	1.1	-.8	-.8	-.8	-51349.00
1.1	1.1	-.8	1.1	-.8	-.8	-.8	-23216.49
-.8	-.8	1.1	1.1	-.8	-.8	-.8	-22358.17
1.1	-.8	1.1	1.1	-.8	-.8	-.8	-5903.05
-.8	1.1	1.1	1.1	-.8	-.8	-.8	-7710.84
1.1	1.1	1.1	1.1	-.8	-.8	-.8	-2946.38
-.8	-.8	-.8	-.8	1.1	-.8	-.8	-136785.99
1.1	-.8	-.8	-.8	1.1	-.8	-.8	-69107.16
-.8	1.1	-.8	-.8	1.1	-.8	-.8	-86294.44
1.1	1.1	-.8	-.8	1.1	-.8	-.8	-27213.98
-.8	-.8	1.1	-.8	1.1	-.8	-.8	-56111.60
1.1	-.8	1.1	-.8	1.1	-.8	-.8	-12012.03
-.8	1.1	1.1	-.8	1.1	-.8	-.8	-25396.54
1.1	1.1	1.1	-.8	1.1	-.8	-.8	-4275.60
-.8	-.8	-.8	1.1	1.1	-.8	-.8	-49931.71
1.1	-.8	-.8	1.1	1.1	-.8	-.8	-18623.26
-.8	1.1	-.8	1.1	1.1	-.8	-.8	-19904.83
1.1	1.1	-.8	1.1	1.1	-.8	-.8	-10130.64
-.8	-.8	1.1	1.1	1.1	-.8	-.8	-6999.69
1.1	-.8	1.1	1.1	1.1	-.8	-.8	-1829.37
-.8	1.1	1.1	1.1	1.1	-.8	-.8	-2529.69
1.1	1.1	1.1	1.1	1.1	-.8	-.8	-939.28
-.8	-.8	-.8	-.8	-.8	1.1	-.8	-136781.06
1.1	-.8	-.8	-.8	-.8	1.1	-.8	-72085.83
-.8	1.1	-.8	-.8	-.8	1.1	-.8	-88943.14
1.1	1.1	-.8	-.8	-.8	1.1	-.8	-27470.07
-.8	-.8	1.1	-.8	-.8	1.1	-.8	-68065.29
1.1	-.8	1.1	-.8	-.8	1.1	-.8	-16871.63
-.8	1.1	1.1	-.8	-.8	1.1	-.8	-32410.40
1.1	1.1	1.1	-.8	-.8	1.1	-.8	-3369.90
-.8	-.8	-.8	1.1	-.8	1.1	-.8	-52870.06
1.1	-.8	-.8	1.1	-.8	1.1	-.8	-9665.87
-.8	1.1	-.8	1.1	-.8	1.1	-.8	-12812.38
1.1	1.1	-.8	1.1	-.8	1.1	-.8	-1130.87
-.8	-.8	1.1	1.1	-.8	1.1	-.8	-7078.48
1.1	-.8	1.1	1.1	-.8	1.1	-.8	-396.36
-.8	1.1	1.1	1.1	-.8	1.1	-.8	-1093.61
1.1	1.1	1.1	1.1	-.8	1.1	-.8	-392.14
-.8	-.8	-.8	-.8	1.1	1.1	-.8	-90980.54
1.1	-.8	-.8	-.8	1.1	1.1	-.8	-30333.13
-.8	1.1	-.8	-.8	1.1	1.1	-.8	-46186.42
1.1	1.1	-.8	-.8	1.1	1.1	-.8	-3621.40
-.8	-.8	1.1	-.8	1.1	1.1	-.8	-38602.19
1.1	-.8	1.1	-.8	1.1	1.1	-.8	-5538.26
-.8	1.1	1.1	-.8	1.1	1.1	-.8	-17291.67
1.1	1.1	1.1	-.8	1.1	1.1	-.8	-1460.58
-.8	-.8	-.8	1.1	1.1	1.1	-.8	-16361.09
1.1	-.8	-.8	1.1	1.1	1.1	-.8	-1024.04
-.8	1.1	-.8	1.1	1.1	1.1	-.8	-1792.51
1.1	1.1	-.8	1.1	1.1	1.1	-.8	-340.81

Alternate Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables
(continued)

-.8	-.8	1.1	1.1	1.1	1.1	-.8	-2872.92
1.1	-.8	1.1	1.1	1.1	1.1	-.8	-310.97
-.8	1.1	1.1	1.1	1.1	1.1	-.8	-798.27
1.1	1.1	1.1	1.1	1.1	1.1	-.8	-306.75
-.8	-.8	-.8	-.8	-.8	-.8	1.1	-142237.11
1.1	-.8	-.8	-.8	-.8	-.8	1.1	-78273.38
-.8	1.1	-.8	-.8	-.8	-.8	1.1	-91892.72
1.1	1.1	-.8	-.8	-.8	-.8	1.1	-40050.24
-.8	-.8	1.1	-.8	-.8	-.8	1.1	-57530.70
1.1	-.8	1.1	-.8	-.8	-.8	1.1	-12382.57
-.8	1.1	1.1	-.8	-.8	-.8	1.1	-20837.46
1.1	1.1	1.1	-.8	-.8	-.8	1.1	-5172.23
-.8	-.8	-.8	1.1	-.8	-.8	1.1	-61091.45
1.1	-.8	-.8	1.1	-.8	-.8	1.1	-28727.81
-.8	1.1	-.8	1.1	-.8	-.8	1.1	-29842.14
1.1	1.1	-.8	1.1	-.8	-.8	1.1	-15077.87
-.8	-.8	1.1	1.1	-.8	-.8	1.1	-7872.97
1.1	-.8	1.1	1.1	-.8	-.8	1.1	-2931.24
-.8	1.1	1.1	1.1	-.8	-.8	1.1	-3344.32
1.1	1.1	1.1	1.1	-.8	-.8	1.1	-1305.30
-.8	-.8	-.8	-.8	1.1	-.8	1.1	-92181.38
1.1	-.8	-.8	-.8	1.1	-.8	1.1	-34032.00
-.8	1.1	-.8	-.8	1.1	-.8	1.1	-43129.51
1.1	1.1	-.8	-.8	1.1	-.8	1.1	-15495.88
-.8	-.8	1.1	-.8	1.1	-.8	1.1	-22608.56
1.1	-.8	1.1	-.8	1.1	-.8	1.1	-3094.59
-.8	1.1	1.1	-.8	1.1	-.8	1.1	-6522.63
1.1	1.1	1.1	-.8	1.1	-.8	1.1	-1392.53
-.8	-.8	-.8	1.1	1.1	-.8	1.1	-24741.74
1.1	-.8	-.8	1.1	1.1	-.8	1.1	-12104.64
-.8	1.1	-.8	1.1	1.1	-.8	1.1	-12225.96
1.1	1.1	-.8	1.1	1.1	-.8	1.1	-6860.84
-.8	-.8	1.1	1.1	1.1	-.8	1.1	-2059.63
1.1	-.8	1.1	1.1	1.1	-.8	1.1	-800.38
-.8	1.1	1.1	1.1	1.1	-.8	1.1	-847.10
1.1	1.1	1.1	1.1	1.1	-.8	1.1	-316.79
-.8	-.8	-.8	-.8	-.8	1.1	1.1	-93670.86
1.1	-.8	-.8	-.8	-.8	1.1	1.1	-34494.33
-.8	1.1	-.8	-.8	-.8	1.1	1.1	-47102.81
1.1	1.1	-.8	-.8	-.8	1.1	1.1	-5748.65
-.8	-.8	1.1	-.8	-.8	1.1	1.1	-31704.08
1.1	-.8	1.1	-.8	-.8	1.1	1.1	-723.19
-.8	1.1	1.1	-.8	-.8	1.1	1.1	-7463.02
1.1	1.1	1.1	-.8	-.8	1.1	1.1	-21.94
-.8	-.8	-.8	1.1	-.8	1.1	1.1	-20516.74
1.1	-.8	-.8	1.1	-.8	1.1	1.1	-1791.28
-.8	1.1	-.8	1.1	-.8	1.1	1.1	-1961.10
1.1	1.1	-.8	1.1	-.8	1.1	1.1	-153.56
-.8	-.8	1.1	1.1	-.8	1.1	1.1	-47.36
1.1	-.8	1.1	1.1	-.8	1.1	1.1	0.00
-.8	1.1	1.1	1.1	-.8	1.1	1.1	0.00
1.1	1.1	1.1	1.1	-.8	1.1	1.1	0.00
-.8	-.8	-.8	-.8	1.1	1.1	1.1	-50239.11
1.1	-.8	-.8	-.8	1.1	1.1	1.1	-5064.77
-.8	1.1	-.8	-.8	1.1	1.1	1.1	-12218.79
1.1	1.1	-.8	-.8	1.1	1.1	1.1	-209.72
-.8	-.8	1.1	-.8	1.1	1.1	1.1	-12832.77
1.1	-.8	1.1	-.8	1.1	1.1	1.1	0.00
-.8	1.1	1.1	-.8	1.1	1.1	1.1	-2640.94
1.1	1.1	1.1	-.8	1.1	1.1	1.1	0.00

Alternate Design Array and Dependent Variable
Values for Central Composite Design
With 7 Variables
(continued)

-.8	-.8	-.8	1.1	1.1	1.1	1.1	-2057.63
1.1	-.8	-.8	1.1	1.1	1.1	1.1	-114.92
-.8	1.1	-.8	1.1	1.1	1.1	1.1	-126.10
1.1	1.1	-.8	1.1	1.1	1.1	1.1	-2.83
-.8	-.8	1.1	1.1	1.1	1.1	1.1	-15.48
1.1	-.8	1.1	1.1	1.1	1.1	1.1	0.00
-.8	1.1	1.1	1.1	1.1	1.1	1.1	0.00
1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.00
-1.682	0	0	0	0	0	0	-59959.62
1.682	0	0	0	0	0	0	0.00
0	-1.682	0	0	0	0	0	-44698.31
0	1.682	0	0	0	0	0	0.00
0	0	-1.682	0	0	0	0	-77511.71
0	0	1.682	0	0	0	0	0.00
0	0	0	-1.682	0	0	0	-78726.41
0	0	0	1.682	0	0	0	0.00
0	0	0	0	-1.682	0	0	-44613.07
0	0	0	0	1.682	0	0	0.00
0	0	0	0	0	-1.682	0	-47671.46
0	0	0	0	0	1.682	0	0.00
0	0	0	0	0	0	-1.682	-40368.00
0	0	0	0	0	0	1.682	0.00
0	0	0	0	0	0	0	0.00

APPENDIX C

DATA COLLECTION PROGRAM LISTING

Data Collection Program for Two Optional Rates

```
10 REM **********************************************************************
20 REM DATA COLLECTION PROGRAM
30 REM **********************************************************************
40 OPEN "B:PBD007" FOR INPUT AS #1
50 OPEN "B:SAMPLE" FOR INPUT AS #2
60 OPEN "B:REVPBD07" FOR OUTPUT AS #3
70 SUMGTREV#=0
80 DIM CHARGE (14)
90 DIM KWH (12), AMONREVT (12), CCREV (12), ENGREV (12)
100    REM
110    REM DETERMINE TYPE OF RUN
120    REM
130 INPUT "NUMBER OF INDEPENDENT VARIABLES ";NFIELDS
140 REM
150 REM READ RATEFILE
160 REM
170 FOR I = 1 TO NFIELDS
180 IF EOF(1) GOTO 680
190 INPUT #1, CHARGE(I)
200 NEXT I
210 SUMGTREV#=0
220 REM
230 REM READ A CUSTOMER RECORD
240 REM
250 FOR I = 1 TO 12
260 IF EOF(2) THEN GOTO 610
270 INPUT #2, KWH(I)
280 NEXT I
290 REM***********************************************************************
300 REM CALCULATE KWH REVENUE
310 REM***********************************************************************
320 FOR I = 1 TO 12
330 IF (SEASONS = 2) AND ((I < 5) OR (I > 9)) THEN GOTO 380
340 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(I) * CHARGE(1)
350 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400* CHARGE(1)) + ((KWH(
I) - 400) * CHARGE(2))
360 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(1)) +(400 * CHARGE(2)) +((KWH(
I) - 800) * CHARGE(3))
370 GOTO 450
380 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(I) * CHARGE(4)
390 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400 * CHARGE(4)) + ((KWH
(I) - 400) * CHARGE(5))
400 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(4)) +(400* CHARGE(5)) +((KWH(I
) - 800) * CHARGE(6))
410 GOTO 450
420 REM***********************************************************************
430 REM CALCULATE CUSTOMER CHARGE
440 REM***********************************************************************
450 CCREV(I) = CHARGE(7)*100
460 REM***********************************************************************
470 REM CALCULATE TOTAL MONTHLY BILL
480 REM***********************************************************************
490 AMONREVT(I) = (CCREV(I) + ENGREV(I))/100
500 NEXT I
510 REM**********************************************************************
520 REM CALCULATE ANNUAL TOTALS
530 REM**********************************************************************
540 ENGREVTOT = 0
550 GTREV = 0
560 FOR I = 1 TO 12
```

Data Collection Program for Two Optional Rates
(continued)

```
570 GTREV = GTREV + AMONREVT(I)
580 NEXT I
590 IF GTREV < 0 THEN SUMGTREV# = SUMGTREV#+GTREV
600 GOTO 250
610 FOR I = 1 TO NFIELDS
620 PRINT #3,CHARGE(I);
630 NEXT I
640 PRINT #3,USING"#########.##";SUMGTREV#
650 CLOSE #2
660 OPEN "B:SAMPLE" FOR INPUT AS #2
670 GOTO 170
680 END
```

Data Collection Program for Three Optional Rates

```
10 REM ************************************************************************
20 REM DATA COLLECTION PROGRAM
30 REM ************************************************************************
40 OPEN "B:PBD014" FOR INPUT AS #1
50 OPEN "B:SAMPLE" FOR INPUT AS #2
60 OPEN "B:REVPBD14" FOR OUTPUT AS #3
70 SUMGTREV#=0
80 DIM CHARGE (14)
90 DIM KWH (12), AMONREVT (12), CCREV (12), ENGREV (12)
100    REM
110    REM DETERMINE TYPE OF RUN
120    REM
130 INPUT "NUMBER OF INDEPENDENT VARIABLES ";NFIELDS
140 REM
150 REM READ RATEFILE
160 REM
170 FOR I = 1 TO NFIELDS
180 IF EOF(1) GOTO 990
190 INPUT #1, CHARGE(I)
200 NEXT I
210 SUMGTREV#=0
220 REM
230 REM READ A CUSTOMER RECORD
240 REM
250 FOR I = 1 TO 12
260 IF EOF(2) THEN GOTO 920
270 INPUT #2, KWH(I)
280 NEXT I
290 REM*********************************************************************
300 REM CALCULATE KWH REVENUE
310 REM*********************************************************************
320 FOR I = 1 TO 12
330 IF (SEASONS = 2) AND ((I < 5) OR (I > 9)) THEN GOTO 380
340 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(I) * CHARGE(1)
350 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400* CHARGE(1)) + ((KWH(
I) - 400) * CHARGE(2))
360 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(1)) +(400 * CHARGE(2)) +((KWH(
I) - 800) * CHARGE(3))
370 GOTO 450
380 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(I) * CHARGE(4)
390 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400 * CHARGE(4)) + ((KWH
(I) - 400) * CHARGE(5))
400 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(4)) +(400* CHARGE(5)) +((KWH(I
) - 800) * CHARGE(6))
410 GOTO 450
420 REM*********************************************************************
430 REM CALCULATE CUSTOMER CHARGE
440 REM*********************************************************************
450 CCREV(I) = CHARGE(7)*100
460 REM*********************************************************************
470 REM CALCULATE TOTAL MONTHLY BILL
480 REM*********************************************************************
490 AMONREVT(I) = (CCREV(I) + ENGREV(I))/100
500 NEXT I
510 REM********************************************************************
520 REM CALCULATE ANNUAL TOTALS
530 REM********************************************************************
540 ENGREVTOT = 0
550 GTREV = 0
560 FOR I = 1 TO 12
```

Data Collection Program for Three Optional Rates
(continued)

```
570 GTREV = GTREV + AMONREVT(I)
580 NEXT I
590 REM**************************************************************************
600 REM CALCULATE KWH REVENUE
610 REM**************************************************************************
620 FOR I = 1 TO 12
630 IF (SEASONS = 2) AND ((I < 5) OR (I > 9)) THEN GOTO 680
640 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(I) * CHARGE(8)
650 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400* CHARGE(8)) + ((KWH(
I) - 400) * CHARGE(9))
660 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(8)) +(400 * CHARGE(9)) +((KWH(
I) - 800) * CHARGE(10))
670 GOTO 750
680 IF KWH(I) <= 400 THEN ENGREV(I) = KWH(X) * CHARGE(11)
690 IF KWH(I) > 400 AND KWH(I) <= 800 THEN ENGREV(I) = (400 * CHARGE(11)) + ((KW
H(I) - 400) * CHARGE(12))
700 IF KWH(I) > 800 THEN ENGREV(I) =(400 * CHARGE(11)) +(400* CHARGE(12)) +((KWH
(I) - 800) * CHARGE(13))
710 GOTO 750
720 REM**************************************************************************
730 REM CALCULATE CUSTOMER CHARGE
740 REM**************************************************************************
750 CCREV(I) = CHARGE(14)*100
760 REM**************************************************************************
770 REM CALCULATE TOTAL MONTHLY BILL
780 REM**************************************************************************
790 AMONREVT(I) = (CCREV(I) + ENGREV(I))/100
800 NEXT I
810 REM*************************************************************************
820 REM CALCULATE ANNUAL TOTALS
830 REM*************************************************************************
840 ENGREVTOT = 0
850 GTREVA = 0
860 FOR I = 1 TO 12
870 GTREVA = GTREVA + AMONREVT(I)
880 NEXT I
890 IF GTREVA < GTREV THEN GTREV = GTREVA
900 IF GTREV < 0 THEN SUMGTREV# = SUMGTREV#+GTREV
910 GOTO 250
920 FOR I = 1 TO NFIELDS
930 PRINT #3,CHARGE(I);
940 NEXT I
950 PRINT #3,USING"#########.##";SUMGTREV#
960 CLOSE #2
970 OPEN "B:SAMPLE" FOR INPUT AS #2
980 GOTO 170
990 END
```

APPENDIX D

RESIDUALS

Residuals for Linear 7 Variable Model

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	-17383.4	-25313.1	7929.8
2	-798.1	-13536.4	12738.3
3	-24028.5	-31653.9	7625.4
4	-14600.4	-23358.8	8758.4
5	-12137.2	-20277.9	8140.7
6	-8239.2	-18795.0	10555.8
7	-6127.7	-16704.5	10576.9
8	-233977	-224860	-9116.7
9	-6522.6	319.0	-6841.6
10	-396.4	11506.9	-11903.2
11	-12226.0	-5704.7	-6521.2
12	-5538.3	2175.6	-7713.9
13	-1961.1	5102.5	-7063.6
14	-3094.6	6511.3	-9605.8
15	-1130.9	8497.2	-9628.0
16	-187181	-189250	2069.1

Residuals for Linear 14 Variable Model

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	-23479.6	-27402.0	3922.3
2	-3472.5	6459.4	-9932.0
3	-29308.2	-32796.1	3487.9
4	-8614.5	-2855.4	-5759.0
5	-18948.2	-19832.9	884.7
6	-3094.6	6917.7	-10012.3
7	-12945.3	-13063.5	118.1
8	-4206.4	4410.7	-8617.1
9	-12955.4	-13094.0	138.6
10	-12879.5	-6553.6	-6325.9
11	-14207.8	-15461.2	1253.3
12	-5119.9	-530.7	-4589.2
13	-15888.6	-18021.0	2132.4
14	-22042.8	-24962.2	2919.5
15	-4207.1	3449.7	-7656.8
16	-187181	-190531	3349.6
17	-57603.1	-54403.4	-3199.6
18	-8797.9	-18759.9	9961.9
19	-62868.4	-60081.5	-2787.0
20	-22567.3	-28565.0	5997.6
21	-46749.9	-46436.0	-313.9
22	-8239.2	-18277.5	10038.2
23	-38896.0	-39310.3	414.3
24	-12203.6	-20916.5	8712.8
25	-38947.5	-39342.4	394.9
26	-25921.7	-32457.8	6536.1
27	-42498.3	-41834.2	-664.1
28	-21231.6	-26117.9	4886.3
29	-46771.8	-44528.8	-2243.1
30	-54826.1	-51835.3	-2990.8
31	-14127.5	-21928.0	7800.5
32	-233977	-226118	-7858.5

Residuals for Quadratic 7 Variable Model

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
1	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	RESIDUAL	-1867.4	-187181	1867.38
2	1.1	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	RESIDUAL	-6953.2	-119455	6953.21
3	-0.8	1.1	-0.8	-0.8	-0.8	-0.8	-0.8	RESIDUAL	-7590.4	-136690	7590.43
4	1.1	1.1	-0.8	-0.8	-0.8	-0.8	-0.8	RESIDUAL	94.7	-69889	94.68
5	-0.8	-0.8	1.1	-0.8	-0.8	-0.8	-0.8	RESIDUAL	-7359.0	-100803	7359.04
6	1.1	-0.8	1.1	-0.8	-0.8	-0.8	-0.8	RESIDUAL	3135.0	-37669	3135.03
7	-0.8	1.1	1.1	-0.8	-0.8	-0.8	-0.8	RESIDUAL	890.6	-54129	890.58
8	1.1	1.1	1.1	-0.8	-0.8	-0.8	-0.8	RESIDUAL	3015.2	-13060	3015.23
9	-0.8	-0.8	-0.8	1.1	-0.8	-0.8	-0.8	RESIDUAL	-7198.7	-98287	7198.68
10	1.1	-0.8	-0.8	1.1	-0.8	-0.8	-0.8	RESIDUAL	2163.0	-46165	2163.05
11	-0.8	1.1	-0.8	1.1	-0.8	-0.8	-0.8	RESIDUAL	2519.1	-51349	2519.11
12	1.1	1.1	-0.8	1.1	-0.8	-0.8	-0.8	RESIDUAL	1587.5	-23216	1587.47
13	-0.8	-0.8	1.1	1.1	-0.8	-0.8	-0.8	RESIDUAL	5270.8	-22358	5270.78
14	1.1	-0.8	1.1	1.1	-0.8	-0.8	-0.8	RESIDUAL	-863.0	-5903	863.02
15	-0.8	1.1	1.1	1.1	-0.8	-0.8	-0.8	RESIDUAL	487.5	-7711	487.50
16	1.1	1.1	1.1	1.1	-0.8	-0.8	-0.8	RESIDUAL	-3640.6	-2946	3640.57
17	-0.8	-0.8	-0.8	-0.8	1.1	-0.8	-0.8	RESIDUAL	-7364.3	-136786	7364.28
18	1.1	-0.8	-0.8	-0.8	1.1	-0.8	-0.8	RESIDUAL	-811.2	-69107	811.16
19	-0.8	1.1	-0.8	-0.8	1.1	-0.8	-0.8	RESIDUAL	-3664.5	-86294	3664.50
20	1.1	1.1	-0.8	-0.8	1.1	-0.8	-0.8	RESIDUAL	7986.6	-27214	7986.64
21	-0.8	-0.8	1.1	-0.8	1.1	-0.8	-0.8	RESIDUAL	671.8	-56112	671.84
22	1.1	-0.8	1.1	-0.8	1.1	-0.8	-0.8	RESIDUAL	3817.3	-12012	3817.32
23	-0.8	1.1	1.1	-0.8	1.1	-0.8	-0.8	RESIDUAL	2384.9	-25397	2384.86
24	1.1	1.1	1.1	-0.8	1.1	-0.8	-0.8	RESIDUAL	-3751.9	-4276	3751.91
25	-0.8	-0.8	-0.8	1.1	1.1	-0.8	-0.8	RESIDUAL	2490.5	-49932	2490.50
26	1.1	-0.8	-0.8	1.1	1.1	-0.8	-0.8	RESIDUAL	2724.4	-18623	2724.38
27	-0.8	1.1	-0.8	1.1	1.1	-0.8	-0.8	RESIDUAL	4719.9	-19905	4719.87
28	1.1	1.1	-0.8	1.1	1.1	-0.8	-0.8	RESIDUAL	-2884.1	-10131	2884.12
29	-0.8	-0.8	1.1	1.1	1.1	-0.8	-0.8	RESIDUAL	1194.5	-7000	1194.54
30	1.1	-0.8	1.1	1.1	1.1	-0.8	-0.8	RESIDUAL	-4538.1	-1829	4538.10
31	-0.8	1.1	1.1	1.1	1.1	-0.8	-0.8	RESIDUAL	-4343.2	-2530	4343.24
32	1.1	1.1	1.1	1.1	1.1	-0.8	-0.8	RESIDUAL	40.6	-939	40.60
33	-0.8	-0.8	-0.8	-0.8	-0.8	1.1	-0.8	RESIDUAL	-4615.2	-136781	4615.17
34	1.1	-0.8	-0.8	-0.8	-0.8	1.1	-0.8	RESIDUAL	-4554.9	-72086	4554.87
35	-0.8	1.1	-0.8	-0.8	-0.8	1.1	-0.8	RESIDUAL	-5751.3	-88943	5751.28
36	1.1	1.1	-0.8	-0.8	-0.8	1.1	-0.8	RESIDUAL	4783.3	-27470	4783.25
37	-0.8	-0.8	1.1	-0.8	-0.8	1.1	-0.8	RESIDUAL	-3739.9	-68065	3739.86
38	1.1	-0.8	1.1	-0.8	-0.8	1.1	-0.8	RESIDUAL	2990.5	-16872	2990.49
39	-0.8	1.1	1.1	-0.8	-0.8	1.1	-0.8	RESIDUAL	730.7	-32410	730.74
40	1.1	1.1	1.1	-0.8	-0.8	1.1	-0.8	RESIDUAL	-995.7	-3370	995.69
41	-0.8	-0.8	-0.8	1.1	-0.8	1.1	-0.8	RESIDUAL	-3313.1	-52870	3313.15
42	1.1	-0.8	-0.8	1.1	-0.8	1.1	-0.8	RESIDUAL	5307.3	-9666	5307.26
43	-0.8	1.1	-0.8	1.1	-0.8	1.1	-0.8	RESIDUAL	6764.8	-12812	6764.77
44	1.1	1.1	-0.8	1.1	-0.8	1.1	-0.8	RESIDUAL	-2441.1	-1131	2441.11
45	-0.8	-0.8	1.1	1.1	-0.8	1.1	-0.8	RESIDUAL	3048.3	-7078	3048.27
46	1.1	-0.8	1.1	1.1	-0.8	1.1	-0.8	RESIDUAL	-4681.8	-396	4681.78
47	-0.8	1.1	1.1	1.1	-0.8	1.1	-0.8	RESIDUAL	-3156.9	-1094	3156.89
48	1.1	1.1	1.1	1.1	-0.8	1.1	-0.8	RESIDUAL	-3171.2	-392	3171.20
49	-0.8	-0.8	-0.8	-0.8	1.1	1.1	-0.8	RESIDUAL	-4368.3	-90981	4368.29
50	1.1	-0.8	-0.8	-0.8	1.1	1.1	-0.8	RESIDUAL	3330.2	-30333	3330.16
51	-0.8	1.1	-0.8	-0.8	1.1	1.1	-0.8	RESIDUAL	874.6	-46186	874.64
52	1.1	1.1	-0.8	-0.8	1.1	1.1	-0.8	RESIDUAL	4187.1	-3621	4187.09
53	-0.8	-0.8	1.1	-0.8	1.1	1.1	-0.8	RESIDUAL	-598.9	-38602	598.88
54	1.1	-0.8	1.1	-0.8	1.1	1.1	-0.8	RESIDUAL	-312.3	-5538	312.29
55	-0.8	1.1	1.1	-0.8	1.1	1.1	-0.8	RESIDUAL	-1049.8	-17292	1049.82

Residuals for Quadratic 7 Variable Model
(continued)

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
56	1.1	1.1	1.1	-0.8	1.1	1.1	-0.8	RESIDUAL	-4299.7	-1461	4299.7
57	-0.8	-0.8	-0.8	1.1	1.1	1.1	-0.8	RESIDUAL	4868.1	-16361	4868.1
58	1.1	-0.8	-0.8	1.1	1.1	1.1	-0.8	RESIDUAL	-2692.7	-1024	2692.7
59	-0.8	1.1	-0.8	1.1	1.1	1.1	-0.8	RESIDUAL	-1120.2	-1793	1120.2
60	1.1	1.1	-0.8	1.1	1.1	1.1	-0.8	RESIDUAL	-8870.0	-341	8870.0
61	-0.8	-0.8	1.1	1.1	1.1	1.1	-0.8	RESIDUAL	-1842.4	-2873	1842.4
62	1.1	-0.8	1.1	1.1	1.1	1.1	-0.8	RESIDUAL	-2006.6	-311	2006.6
63	-0.8	1.1	1.1	1.1	1.1	1.1	-0.8	RESIDUAL	-2534.9	-798	2534.9
64	1.1	1.1	1.1	1.1	1.1	1.1	-0.8	RESIDUAL	8926.8	-307	8926.8
65	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	1.1	RESIDUAL	-6293.5	-142237	6293.5
66	1.1	-0.8	-0.8	-0.8	-0.8	-0.8	1.1	RESIDUAL	-2205.2	-78273	2205.2
67	-0.8	1.1	-0.8	-0.8	-0.8	-0.8	1.1	RESIDUAL	-3261.0	-91893	3261.0
68	1.1	1.1	-0.8	-0.8	-0.8	-0.8	1.1	RESIDUAL	2402.4	-40050	2402.4
69	-0.8	-0.8	1.1	-0.8	-0.8	-0.8	1.1	RESIDUAL	-1238.7	-57531	1238.7
70	1.1	-0.8	1.1	-0.8	-0.8	-0.8	1.1	RESIDUAL	4205.6	-12383	4205.6
71	-0.8	1.1	1.1	-0.8	-0.8	-0.8	1.1	RESIDUAL	5932.4	-20837	5932.4
72	1.1	1.1	1.1	-0.8	-0.8	-0.8	1.1	RESIDUAL	-4409.8	-5172	4409.8
73	-0.8	-0.8	-0.8	1.1	-0.8	-0.8	1.1	RESIDUAL	-647.1	-61091	647.1
74	1.1	-0.8	-0.8	1.1	-0.8	-0.8	1.1	RESIDUAL	1892.3	-28728	1892.3
75	-0.8	1.1	-0.8	1.1	-0.8	-0.8	1.1	RESIDUAL	2284.6	-29842	2284.6
76	1.1	1.1	-0.8	1.1	-0.8	-0.8	1.1	RESIDUAL	920.9	-15078	920.9
77	-0.8	-0.8	1.1	1.1	-0.8	-0.8	1.1	RESIDUAL	1330.1	-7873	1330.1
78	1.1	-0.8	1.1	1.1	-0.8	-0.8	1.1	RESIDUAL	-3380.9	-2931	3380.9
79	-0.8	1.1	1.1	1.1	-0.8	-0.8	1.1	RESIDUAL	-4669.2	-3344	4669.2
80	1.1	1.1	1.1	1.1	-0.8	-0.8	1.1	RESIDUAL	1413.5	-1305	1413.5
81	-0.8	-0.8	-0.8	-0.8	1.1	-0.8	1.1	RESIDUAL	-4558.6	-92181	4558.6
82	1.1	-0.8	-0.8	-0.8	1.1	-0.8	1.1	RESIDUAL	5401.4	-34032	5401.4
83	-0.8	1.1	-0.8	-0.8	1.1	-0.8	1.1	RESIDUAL	6604.2	-43130	6604.2
84	1.1	1.1	-0.8	-0.8	1.1	-0.8	1.1	RESIDUAL	-255.2	-15496	255.2
85	-0.8	-0.8	1.1	-0.8	1.1	-0.8	1.1	RESIDUAL	4594.2	-22609	4594.2
86	1.1	-0.8	1.1	-0.8	1.1	-0.8	1.1	RESIDUAL	-3909.7	-3095	3909.7
87	-0.8	1.1	1.1	-0.8	1.1	-0.8	1.1	RESIDUAL	580.7	-6523	580.7
88	1.1	1.1	1.1	-0.8	1.1	-0.8	1.1	RESIDUAL	-8610.6	-1393	8610.6
89	-0.8	-0.8	-0.8	1.1	1.1	-0.8	1.1	RESIDUAL	4607.7	-24742	4607.7
90	1.1	-0.8	-0.8	1.1	1.1	-0.8	1.1	RESIDUAL	-893.5	-12105	893.5
91	-0.8	1.1	-0.8	1.1	1.1	-0.8	1.1	RESIDUAL	-1771.3	-12226	1771.3
92	1.1	1.1	-0.8	1.1	1.1	-0.8	1.1	RESIDUAL	-848.1	-6861	848.1
93	-0.8	-0.8	1.1	1.1	1.1	-0.8	1.1	RESIDUAL	-4720.0	-2060	4720.0
94	1.1	-0.8	1.1	1.1	1.1	-0.8	1.1	RESIDUAL	-1427.4	-800	1427.4
95	-0.8	1.1	1.1	1.1	1.1	-0.8	1.1	RESIDUAL	-4612.5	-847	4612.5
96	1.1	1.1	1.1	1.1	1.1	-0.8	1.1	RESIDUAL	11647.5	-317	11647.5
97	-0.8	-0.8	-0.8	-0.8	-0.8	1.1	1.1	RESIDUAL	-5646.0	-93671	5646.0
98	1.1	-0.8	-0.8	-0.8	-0.8	1.1	1.1	RESIDUAL	1831.8	-34494	1831.8
99	-0.8	1.1	-0.8	-0.8	-0.8	1.1	1.1	RESIDUAL	850.7	-47103	850.7
100	1.1	1.1	-0.8	-0.8	-0.8	1.1	1.1	RESIDUAL	4202.6	-5749	4202.6
101	-0.8	-0.8	1.1	-0.8	-0.8	1.1	1.1	RESIDUAL	698.5	-31704	698.5
102	1.1	-0.8	1.1	-0.8	-0.8	1.1	1.1	RESIDUAL	152.3	-723	152.3
103	-0.8	1.1	1.1	-0.8	-0.8	1.1	1.1	RESIDUAL	2657.9	-7463	2657.9
104	1.1	1.1	1.1	-0.8	-0.8	1.1	1.1	RESIDUAL	-7731.7	-22	7731.7
105	-0.8	-0.8	-0.8	1.1	-0.8	1.1	1.1	RESIDUAL	3625.3	-20517	3625.3
106	1.1	-0.8	-0.8	1.1	-0.8	1.1	1.1	RESIDUAL	703.2	-1791	703.2
107	-0.8	1.1	-0.8	1.1	-0.8	1.1	1.1	RESIDUAL	1103.8	-1961	1103.8
108	1.1	1.1	-0.8	1.1	-0.8	1.1	1.1	RESIDUAL	-5039.7	-154	5039.7
109	-0.8	-0.8	1.1	1.1	-0.8	1.1	1.1	RESIDUAL	-3117.3	-47	3117.3
110	1.1	-0.8	1.1	1.1	-0.8	1.1	1.1	RESIDUAL	-4545.9	0	4545.9

Residuals for Quadratic 7 Variable Model
(continued)

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
111	-0.800	1.100	1.100	1.100	-0.800	1.100	1.100	RESIDUAL	-6357.3	0	6357.3
112	1.100	1.100	1.100	1.100	-0.800	1.100	1.100	RESIDUAL	5863.2	0	5863.2
113	-0.800	-0.800	-0.800	-0.800	1.100	1.100	1.100	RESIDUAL	-196.6	-50239	196.6
114	1.100	-0.800	-0.800	-0.800	1.100	1.100	1.100	RESIDUAL	4965.1	-5065	4965.1
115	-0.800	1.100	-0.800	-0.800	1.100	1.100	1.100	RESIDUAL	7175.2	-12219	7175.2
116	1.100	1.100	-0.800	-0.800	1.100	1.100	1.100	RESIDUAL	-7132.0	-210	7132.0
117	-0.800	-0.800	1.100	-0.800	1.100	1.100	1.100	RESIDUAL	819.0	-12833	819.0
118	1.100	-0.800	1.100	-0.800	1.100	1.100	1.100	RESIDUAL	-6189.3	0	6189.3
119	-0.800	1.100	1.100	-0.800	1.100	1.100	1.100	RESIDUAL	-1847.9	-2641	1847.9
120	1.100	1.100	1.100	-0.800	1.100	1.100	1.100	RESIDUAL	-5351.7	0	5351.7
121	-0.800	-0.800	-0.800	1.100	1.100	1.100	1.100	RESIDUAL	1328.0	-2058	1328.0
122	1.100	-0.800	-0.800	1.100	1.100	1.100	1.100	RESIDUAL	-6690.8	-115	6690.8
123	-0.800	1.100	-0.800	1.100	1.100	1.100	1.100	RESIDUAL	-8394.7	-126	8394.7
124	1.100	1.100	-0.800	1.100	1.100	1.100	1.100	RESIDUAL	-4536.6	-3	4536.6
125	-0.800	-0.800	1.100	1.100	1.100	1.100	1.100	RESIDUAL	-4610.3	-15	4610.3
126	1.100	-0.800	1.100	1.100	1.100	1.100	1.100	RESIDUAL	5615.2	0	5615.2
127	-0.800	1.100	1.100	1.100	1.100	1.100	1.100	RESIDUAL	1540.7	0	1540.7
128	1.100	1.100	1.100	1.100	1.100	1.100	1.100	RESIDUAL	25447.1	0	25447.1
129	-1.682	0.000	0.000	0.000	0.000	0.000	0.000	RESIDUAL	733.6	-59960	733.6
130	1.682	0.000	0.000	0.000	0.000	0.000	0.000	RESIDUAL	-143.7	0	143.7
131	0.000	-1.682	0.000	0.000	0.000	0.000	0.000	RESIDUAL	4272.2	-44698	4272.2
132	0.000	1.682	0.000	0.000	0.000	0.000	0.000	RESIDUAL	3542.2	0	3542.2
133	0.000	0.000	-1.682	0.000	0.000	0.000	0.000	RESIDUAL	-3696.1	-77512	3696.1
134	0.000	0.000	1.682	0.000	0.000	0.000	0.000	RESIDUAL	-3729.2	0	3729 2
135	0.000	0.000	0.000	-1.682	0.000	0.000	0.000	RESIDUAL	-3743.9	-78726	3743.9
136	0.000	0.000	0.000	1.682	0.000	0.000	0.000	RESIDUAL	-4447.3	0	4447.3
137	0.000	0.000	0.000	0.000	-1.682	0.000	0.000	RESIDUAL	4269.1	-44613	4269.1
138	0.000	0.000	0.000	0.000	1.682	0.000	0.000	RESIDUAL	3604.2	0	3604.2
139	0.000	0.000	0.000	0.000	0.000	-1.682	0.000	RESIDUAL	3200.3	-47671	3200.3
140	0.000	0.000	0.000	0.000	0.000	1.682	0.000	RESIDUAL	3518.8	0	3518.8
141	0.000	0.000	0.000	0.000	0.000	0.000	-1.682	RESIDUAL	5157.0	-40368	5157.0
142	0.000	0.000	0.000	0.000	0.000	0.000	1.682	RESIDUAL	4804.5	0	4804.5
143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	RESIDUAL	18994.8	0	18994.8
144	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	15418.6	-233977	15418.6
145	1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-3038.6	-162681	3038.6
146	-1.000	1.000	-1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-571.9	-180828	571.9
147	1.000	1.000	-1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-3958.8	-109638	3958.8
148	-1.000	-1.000	1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-6239.8	-142025	6239.8
149	1.000	-1.000	1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-3414.6	-71798	3414.6
150	-1.000	1.000	1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	-3490.5	-89848	3490 5
151	1.000	1.000	1.000	-1.000	-1.000	-1.000	-1.000	RESIDUAL	5161.4	-28970	5161.4
152	-1.000	-1.000	-1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	-7459.8	-140366	7459.8
153	1.000	-1.000	-1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	-250.7	-76702	250.7
154	-1.000	1.000	-1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	-2585.4	-87398	2585.4
155	1.000	1.000	-1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	1072.6	-42461	1072.6
156	-1.000	-1.000	1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	203.0	-50573	203.0
157	1.000	-1.000	1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	3230.3	-13441	3230.3
158	-1.000	1.000	1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	4291.2	-18103	4291.2
159	1.000	1.000	1.000	1.000	-1.000	-1.000	-1.000	RESIDUAL	-3839.1	-7305	3839.1
160	-1.000	-1.000	-1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	-267.8	-180929	267.8
161	1.000	-1.000	-1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	-5776.6	-109633	5776.6
162	-1.000	1.000	-1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	-5817.5	-127780	5817.5
163	1.000	1.000	-1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	2739.5	-57595	2739.5
164	-1.000	-1.000	1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	-1936.2	-90296	1936.2
165	1.000	-1.000	1.000	-1.000	1.000	-1.000	-1.000	RESIDUAL	4302.3	-29604	4302.3

Residuals for Quadratic 7 Variable Model (continued)

RSREG - COMPLETE QUADRATIC MODEL 7 INDEPENDENT VARIABLES

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
166	-1	1	1	-1	1	-1	-1	RESIDUAL	3025.6	-46347	3025.64
167	1	1	1	-1	1	-1	-1	RESIDUAL	-1011.2	-11107	1011.24
168	-1	-1	-1	1	1	-1	-1	RESIDUAL	-4335.1	-87594	4335.12
169	1	-1	-1	1	1	-1	-1	RESIDUAL	3631.9	-36120	3631.90
170	-1	1	-1	1	1	-1	-1	RESIDUAL	4826.2	-40780	4826.24
171	1	1	-1	1	1	-1	-1	RESIDUAL	-2520.3	-19796	2520.27
172	-1	-1	1	1	1	-1	-1	RESIDUAL	3846.4	-18591	3846.41
173	1	-1	1	1	1	-1	-1	RESIDUAL	-3789.3	-5071	3789.28
174	-1	1	1	1	1	-1	-1	RESIDUAL	-2463.2	-6960	2463.18
175	1	1	1	1	1	-1	-1	RESIDUAL	-4340.1	-2857	4340.14
176	-1	-1	-1	-1	-1	1	-1	RESIDUAL	5628.6	-178699	5628.58
177	1	-1	-1	-1	-1	1	-1	RESIDUAL	-5322.5	-108958	5322.51
178	-1	1	-1	-1	-1	1	-1	RESIDUAL	-3662.7	-126874	3662.74
179	1	1	-1	-1	-1	1	-1	RESIDUAL	-1260.0	-58955	1259.99
180	-1	-1	1	-1	-1	1	-1	RESIDUAL	-1636.5	-98980	1636.46
181	1	-1	1	-1	-1	1	-1	RESIDUAL	1142.2	-37859	1142.16
182	-1	1	1	-1	-1	1	-1	RESIDUAL	494.1	-55444	494.13
183	1	1	1	-1	-1	1	-1	RESIDUAL	3143.1	-9629	3143.05
184	-1	-1	-1	1	-1	1	-1	RESIDUAL	-7151.7	-87862	7151.72
185	1	-1	-1	1	-1	1	-1	RESIDUAL	3545.8	-29770	3545.76
186	-1	1	-1	1	-1	1	-1	RESIDUAL	1867.9	-38772	1867.92
187	1	1	-1	1	-1	1	-1	RESIDUAL	2293.3	-6128	2293.28
188	-1	-1	1	1	-1	1	-1	RESIDUAL	3323.0	-21882	3323.04
189	1	-1	1	1	-1	1	-1	RESIDUAL	-637.2	-798	637.18
190	-1	1	1	1	-1	1	-1	RESIDUAL	1184.4	-3662	1184.41
191	1	1	1	1	-1	1	-1	RESIDUAL	-5695.7	-674	5695.73
192	-1	-1	-1	-1	1	1	-1	RESIDUAL	-1194.4	-128244	1194.44
193	1	-1	-1	-1	1	1	-1	RESIDUAL	-2030.2	-61335	2030.25
194	-1	1	-1	-1	1	1	-1	RESIDUAL	-2320.6	-78694	2320.61
195	1	1	-1	-1	1	1	-1	RESIDUAL	5559.3	-18246	5559.27
196	-1	-1	1	-1	1	1	-1	RESIDUAL	898.4	-60475	898.35
197	1	-1	1	-1	1	1	-1	RESIDUAL	1379.7	-14600	1379.73
198	-1	1	1	-1	1	1	-1	RESIDUAL	781.9	-29627	781.89
199	1	1	1	-1	1	1	-1	RESIDUAL	-3576.5	-3768	3576.53
200	-1	-1	-1	1	1	1	-1	RESIDUAL	-66.0	-42585	66.03
201	1	-1	-1	1	1	1	-1	RESIDUAL	3096.9	-4975	3096.88
202	-1	1	-1	1	1	1	-1	RESIDUAL	4579.0	-8310	4578.98
203	1	1	-1	1	1	1	-1	RESIDUAL	-7542.6	-1161	7542.65
204	-1	-1	1	1	1	1	-1	RESIDUAL	368.8	-7954	368.83
205	1	-1	1	1	1	1	-1	RESIDUAL	-4290.8	-518	4290.79
206	-1	1	1	1	1	1	-1	RESIDUAL	-3522.1	-1927	3522.13
207	1	1	1	1	1	1	-1	RESIDUAL	1002.4	-482	1002.44
208	-1	-1	-1	-1	-1	-1	1	RESIDUAL	2392.1	-186459	2392.13
209	1	-1	-1	-1	-1	-1	1	RESIDUAL	-3175.6	-116608	3175.56
210	-1	1	-1	-1	-1	-1	1	RESIDUAL	-3769.1	-133345	3769.09
211	1	1	-1	-1	-1	-1	1	RESIDUAL	-152.6	-69486	152.59
212	-1	-1	1	-1	-1	-1	1	RESIDUAL	-6192.4	-94972	6192.36
213	1	-1	1	-1	-1	-1	1	RESIDUAL	4886.2	-30825	4886.16
214	-1	1	1	-1	-1	-1	1	RESIDUAL	3579.2	-45637	3579.19
215	1	1	1	-1	-1	-1	1	RESIDUAL	-626.8	-11950	626.83
216	-1	-1	-1	1	-1	-1	1	RESIDUAL	-3023.2	-96135	3023.17
217	1	-1	-1	1	-1	-1	1	RESIDUAL	292.1	-50698	292.14
218	-1	1	-1	1	-1	-1	1	RESIDUAL	1065.1	-53818	1065.11
219	1	1	-1	1	-1	-1	1	RESIDUAL	-459.4	-28397	459.38
220	-1	-1	1	1	-1	-1	1	RESIDUAL	6073.2	-18446	6073.25

Residuals for Quadratic 7 Variable Model
(continued)

RSREG - COMPLETE QUADRATIC MODEL 7 INDEPENDENT VARIABLES

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
221	1.000	-1.000	1	1	-1	-1	1	RESIDUAL	-2849.7	-7598	2849.7
222	-1.000	1.000	1	1	-1	-1	1	RESIDUAL	-2384.3	-8386	2384.3
223	1.000	1.000	1	1	-1	-1	1	RESIDUAL	-2591.6	-3999	2591.6
224	-1.000	-1.000	-1	-1	1	-1	1	RESIDUAL	-5096.6	-133603	5096.6
225	1.000	-1.000	-1	-1	1	-1	1	RESIDUAL	740.4	-65295	740.4
226	-1.000	1.000	-1	-1	1	-1	1	RESIDUAL	-906.0	-80578	906.0
227	1.000	1.000	-1	-1	1	-1	1	RESIDUAL	2011.1	-30366	2011.1
228	-1.000	-1.000	1	-1	1	-1	1	RESIDUAL	2853.0	-46890	2853.0
229	1.000	-1.000	1	-1	1	-1	1	RESIDUAL	1384.6	-8239	1384.6
230	-1.000	1.000	1	-1	1	-1	1	RESIDUAL	3237.5	-17383	3237.5
231	1.000	1.000	1	-1	1	-1	1	RESIDUAL	-8503.1	-4180	8503.1
232	-1.000	-1.000	-1	1	1	-1	1	RESIDUAL	2905.9	-48948	2905.9
233	1.000	-1.000	-1	1	1	-1	1	RESIDUAL	-786.2	-23467	786.2
234	-1.000	1.000	-1	1	1	-1	1	RESIDUAL	37.0	-24029	37.0
235	1.000	1.000	-1	1	1	-1	1	RESIDUAL	-3784.7	-13853	3784.7
236	-1.000	-1.000	1	1	1	-1	1	RESIDUAL	-1536.6	-6107	1536.6
237	1.000	-1.000	1	1	1	-1	1	RESIDUAL	-4982.4	-2731	4982.4
238	-1.000	1.000	1	1	1	-1	1	RESIDUAL	-6467.1	-2961	6467.1
239	1.000	1.000	1	1	1	-1	1	RESIDUAL	3440.9	-1407	3440.9
240	-1.000	-1.000	-1	-1	-1	1	1	RESIDUAL	-2571.7	-132150	2571.7
241	1.000	-1.000	-1	-1	-1	1	1	RESIDUAL	-1737.8	-64957	1737.8
242	-1.000	1.000	-1	-1	-1	1	1	RESIDUAL	-2888.8	-81214	2888.8
243	1.000	1.000	-1	-1	-1	1	1	RESIDUAL	3703.8	-23439	3703.8
244	-1.000	-1.000	1	-1	-1	1	1	RESIDUAL	-791.2	-56922	791.2
245	1.000	-1.000	1	-1	-1	1	1	RESIDUAL	5512.2	-6611	5512.2
246	-1.000	1.000	1	-1	-1	1	1	RESIDUAL	4493.0	-20098	4493.0
247	1.000	1.000	1	-1	-1	1	1	RESIDUAL	-4517.1	-278	4517.1
248	-1.000	-1.000	-1	1	-1	1	1	RESIDUAL	-79.1	-46789	79.1
249	1.000	-1.000	-1	1	-1	1	1	RESIDUAL	2914.7	-10734	2914.7
250	-1.000	1.000	-1	1	-1	1	1	RESIDUAL	4366.4	-12137	4366.4
251	1.000	1.000	-1	1	-1	1	1	RESIDUAL	-2915.2	-1534	2915.2
252	-1.000	-1.000	1	1	-1	1	1	RESIDUAL	3632.3	-1110	3632.3
253	1.000	-1.000	1	1	-1	1	1	RESIDUAL	-5967.9	0	5967.9
254	-1.000	1.000	1	1	-1	1	1	RESIDUAL	-5751.8	0	5751.8
255	1.000	1.000	1	1	-1	1	1	RESIDUAL	-1286.2	0	1286.2
256	-1.000	-1.000	-1	-1	1	1	1	RESIDUAL	-2861.2	-83550	2861.2
257	1.000	-1.000	-1	-1	1	1	1	RESIDUAL	4226.0	-23052	4226.0
258	-1.000	1.000	-1	-1	1	1	1	RESIDUAL	3340.2	-36537	3340.2
259	1.000	1.000	-1	-1	1	1	1	RESIDUAL	-730.2	-2373	730.2
260	-1.000	-1.000	1	-1	1	1	1	RESIDUAL	2011.2	-26540	2011.2
261	1.000	-1.000	1	-1	1	1	1	RESIDUAL	-2690.0	-181	2690.0
262	-1.000	1.000	1	-1	1	1	1	RESIDUAL	-180.1	-7631	180.1
263	1.000	1.000	1	-1	1	1	1	RESIDUAL	-8432.3	0	8432.3
264	-1.000	-1.000	-1	1	1	1	1	RESIDUAL	5303.1	-11604	5303.1
265	1.000	-1.000	-1	1	1	1	1	RESIDUAL	-4392.0	-1186	4392.0
266	-1.000	1.000	-1	1	1	1	1	RESIDUAL	-4141.0	-1283	4141.0
267	1.000	1.000	-1	1	1	1	1	RESIDUAL	-8009.3	-215	8009.3
268	-1.000	-1.000	1	1	1	1	1	RESIDUAL	-3856.5	-106	3856.5
269	1.000	-1.000	1	1	1	1	1	RESIDUAL	-1512.8	0	1512.8
270	-1.000	1.000	1	1	1	1	1	RESIDUAL	-3804.3	0	3804.3
271	1.000	1.000	1	1	1	1	1	RESIDUAL	13609.8	0	13609.8
272	-3.364	0.000	0	0	0	0	0	RESIDUAL	5032.3	-119919	5032.3
273	3.364	0.000	0	0	0	0	0	RESIDUAL	3277.8	0	3277.8
274	0.000	-3.364	0	0	0	0	0	RESIDUAL	4072.7	-89397	4072.7
275	0.000	3.364	0	0	0	0	0	RESIDUAL	2612.7	0	2612.7

Residuals for Quadratic 7 Variable Model
(continued)

OBS	CHG1	CHG2	CHG3	CHG4	CHG5	CHG6	CHG7	_TYPE_	REV	ACT	RESID
276	0	0	-3.364	0.000	0.000	0.000	0.000	RESIDUAL	5709.9	-155023	5709.9
277	0	0	3.364	0.000	0.000	0.000	0.000	RESIDUAL	5643.7	0	5643.7
278	0	0	0.000	-3.364	0.000	0.000	0.000	RESIDUAL	6063.1	-157453	6063.1
279	0	0	0.000	3.364	0.000	0.000	0.000	RESIDUAL	4656.5	0	4656.5
280	0	0	0.000	0.000	-3.364	0.000	0.000	RESIDUAL	4040.3	-89226	4040.3
281	0	0	0.000	0.000	3.364	0.000	0.000	RESIDUAL	2710.6	0	2710.6
282	0	0	0.000	0.000	0.000	-3.364	0.000	RESIDUAL	3806.8	-95343	3806.8
283	0	0	0.000	0.000	0.000	3.364	0.000	RESIDUAL	4443.9	0	4443.9
284	0	0	0.000	0.000	0.000	0.000	-3.364	RESIDUAL	3659.3	-80736	3659.3
285	0	0	0.000	0.000	0.000	0.000	3.364	RESIDUAL	2954.2	0	2954.2
286	0	0	0.000	0.000	0.000	0.000	0.000	RESIDUAL	18994.8	0	18994.8

VITA

Donald Wayne Fry

Candidate for the Degree of

Master of Science

Thesis: THE USE OF MULTIPLE REGRESSION ANALYSIS AND RESPONSE SURFACE TECHNIQUES IN THE DESIGN OF OPTIONAL NON-DEMAND ELECTRIC UTILITY RATES

Major Field: General Engineering

Biographical:

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