MASTER

Connecticut

Time-of-Use Electricity Price Effects

Prepared for the U.S. Department of Energy
Office of Utility Systems

S.B. White • C.A. Clayton
B.V. Alexander • D.P. Duncan

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ABSTRACT

The Connecticut Rate Demonstration Project was conducted to observe the effect of a time-of-use electrical rate on household electricity consumption. Under time-of-use rates higher prices are charged for electricity used during those parts of the day when demand and system costs are higher, and lower prices are charged during those parts of the day when demand and system costs are lower. In the Connecticut project 200 customers of the Connecticut Light and Power Company were placed on a seasonal time-of-use electricity rate from October 1975 to October 1976. The experimental rate schedule used three rating periods during weekdays and two on weekends. An equal number of customers on the existing rate served as a control group. All participation in the study was voluntary; customers on the experimental rate received a "lump sum" payment prior to the start of the experiment.

A comparative analysis of the electricity consumption patterns of the experimental customers on the time-of-use rate and the control group on the existing (declining block) rate showed that during the summer months the experimental group used less electricity during the peak and intermediate periods without any corresponding increase during the base period. Consequently, overall consumption during the summer months was reduced for the experimental group.

By contrast, during the winter months the experimental group used significantly more electricity than the control group during the base period and considerably less than the control group during the peak period. Usage was about the same for both groups during the intermediate period. The experimental group's shifts in usage from peak to base period offset each other, so that overall consumption during the winter months was about the same for both the experimental and the control group.

Other significant findings were that the diversified demand of the residential class at the time of system peak was, in almost every month, significantly lower for the experimental group. The residential class load factor based on that diversified demand was significantly higher for the experimental group. At the time of system peak, diversified demand was lower by 22 to 40 percent and the associated load factor was 118 to 149 percent of that under the control rate.

Projections to the population represented by the sample indicate that under the experimental rate schedule, savings of 12.7 megawatts would be realized for the winter hour of system peak and savings of 69.5 megawatts for the summer hour of system peak. However, the results of the analysis, it should be emphasized, are limited by the experimental and rate designs and are strictly applicable only to approximately 45 percent of the residential population within the Connecticut Light and Power Company service area.

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CHAPTER 1: INTRODUCTION

In 1975 the Federal Energy Administration (now part of the U.S. Department of Energy) initiated experiments in eight states to determine how household consumption of electricity is affected by time-of-use pricing.* Funding for the projects was provided by the Federal Energy Administration, participating utilities, and state governments. In the fall of 1977 the Department of Energy (DOE) contracted with the Research Triangle Institute (RTI) to perform a comprehensive, standardized analysis on the data from the residential components of these studies. This report on the Connecticut Rate Demonstration Project is one of a series of final reports which will be published under this contract. (For a listing of these reports and a summary of the standardized analytical approach, see the RTI Analytical Master Plan [RTI 1978].)

1.1 Objectives and Applications of Findings

The objective of the analyses reported here is to determine how electricity consumption by residential customers on a time-of-use (TOU) rate differs from electricity consumption under the existing rate. The findings of this study provide information which can be used by both regulators and utility system planners to: (1) project changes in total capacity and energy requirements if a TOU rate schedule were to be implemented, (2) project possible changes in the optimal mix of generating capacity, and (3) determine whether the potential benefits of altered load patterns under the TOU rate offset the potential additional metering costs of implementing such a rate.

*These eight projects were in Arizona, Arkansas, Connecticut, California (Los Angeles), Ohio, Wisconsin, Vermont, and New Jersey. Subsequently, six projects were added in California, North Carolina, Oklahoma (Edmond), Puerto Rico, Rhode Island, and Washington.

Table 1-1. Summary Features of the Connecticut Rate Demonstration Project

Participating Agencies/Utilities: U.S. Department of Energy, Connecticut Light and Power Company, Connecticut Public Utilities Control Authority, Connecticut Department of Planning and Energy Policy, and the Connecticut Office of Consumer Counsel.

Customer Participation: voluntary.

Study Period: one-year baseline period, beginning October 1974; one-year test period, beginning October 1975.

Metering: fifteen-minute kWh meters.

Rates: one time-of-use (TOU) rate with three daily rating periods on weekdays--peak (P), intermediate (I), base (B)--and two daily rating periods on weekends and holidays--I and B.

Number of Customers: 200 customers on TOU rates; 200 in control group.

Incentives/Revenue Neutralizers: variable lump sum payment (\$50-\$150, depending on prior usage) prior to start of study.

1.2 Summary Description of the Experimental Project

Initiated in October 1975, the Connecticut Rate Demonstration Project was a one-year controlled experiment in which 200 Connecticut Light and Power Company (CLP) residential customers were placed on a seasonal time-of-use rate. The rate used three rating periods during weekdays and two rating periods on weekends and holidays. An equal number of customers on conventional rates served as a control group. Table 1-1 summarizes characteristics of the Connecticut Project.

The population of customers from which the sample was drawn consisted of all 1973 CLP nonfarm residential customers who had a 12-month billing history and did not have estimated bills in 1973. This sampled population (numbering 296,776) was stratified into five groups according to 1973 annual consumption. Simple random sampling within each stratum produced the desired number of participants. For various reasons, including meter installation problems,

refusal to participate, and inability to contact customers, the sample was reduced during sample selection. Table 1-2 shows the number of customers involved by month.

All participation in the study was voluntary. Customers on the experimental rate were given a "lump sum" payment prior to the start of the experiment. The amount ranged from \$50 to \$150, depending on the level of prior consumption. Pre- and post-test survey questionnaires were given to both experimental and control customers to obtain and later update demographic information on the households in the project. At the pre-test interviews, the purpose of the study and the nature of the rates were explained to prospective participants. A market research and opinion survey firm was retained to design, administer, and analyze the information obtained.

This report covers analyses made on four winter months (December 1975-March 1976) and four summer months (June 1976-September 1976). These months were chosen from the test period data because they adequately represent the two peak seasons, winter and summer.

Table 1-2. Participant Allocation

Test Group	Number of Customers Providing Usage Data							
	1975				1976			
	Dec	Jan	Feb	Mar	Jun	Jul	Aug	Sep
Experimental	193	194	189	187	182	183	180	181
Control	162	166	176	181	147	141	136	160

For each month, 20 population parameters were estimated for the experimental and the control groups. Parameters included such quantities as usage during peak and base rating periods, noncoincident maximum demand, and

diversified demand at time of system peak. Table 3-1 in chapter 3 provides a complete list of all parameters used to characterize the load. Comparisons of these estimated population parameters were made between the control and experimental groups to see if statistically significant differences existed between the two groups. A series of average daily load curves which graphically depict changes in demand over time were also developed for each month. These load curves used various averaging periods such as all weekdays and all weekend days.

Finally, for the peak winter and summer months, estimates of five additional parameters were obtained for the control and experimental groups. These parameters were maximum diversified demand, class coincidence factor, class load factor, system peak, and system load factor. Tests for significant differences between the experimental and control groups were not conducted for these parameters, since standard errors for these estimates were not derived. The reason for this is that all of these variables depend upon maximum diversified demand which is a class oriented variable that cannot be computed on an individual customer basis. Consequently, the estimates for a given month represent single observations.

1.3 Summary of Findings

The findings summarized on the following pages are based on the comparative analysis method developed by the Research Triangle Institute. A discussion of the analytical methodology is given in Volume I of the Analytical Master Plan (RTI 1978) and in Appendixes A and B of this report. In this analysis the electricity consumption patterns of the sample were characterized by several parameters. Then differences in estimates of these parameters between the experimental and the control group were statistically compared. In addition to the comparative analyses, load curves were

constructed to provide visual comparisons of the differences in the electricity consumption patterns of the two groups. The graphs in figures 1-1 and 1-2 offer four examples of representative load curves.

The major results of the study are summarized below. They are considered applicable only to the population of residential customers actually represented by the sample.* The reasons for the limitations on application of these analytical results to a larger population are explained in the next section.

Peak Periods. The experimental group consumed significantly less electricity during the peak period than the control group. This result was evident for both the four summer months, June-September 1976, and for the four winter months, December, 1975, January-March, 1976.

Intermediate Period. During the summer months, the experimental customers used significantly less electricity during the intermediate period than the control customers. During the winter months, however, the two groups used about the same amount of electricity during the intermediate period.

Base Period. During the winter months, the experimental group used significantly more electricity in the base period than the control group. During the summer months, however, the two groups consumed about the same quantity of electricity during the base period.

Total Consumption. Total consumption refers to the total of all electricity consumed in the peak, intermediate, and base periods. During the summer months the experimental group used less electricity than the control in peak and intermediate periods but used about the same amount during the base

*This point cannot be overemphasized. The population of inference is estimated to contain only 45 percent of the sampled population or approximately 135,000 customers.

Figure 1-1. Summer and Winter Average Weekday Load Curves--June 1976 and January 1976

Figure 1-2. Day of Summer and Winter System Peak Load Curves--June 1976 and January 1976

period. Consequently, customers in the experimental group used significantly less electricity overall than their counterparts in the control group.

During the winter months the experimental and control groups used about the same amount of electricity. This was a result of offsetting shifts; the experimental customers used less electricity during the peak period than the control group but more during the base period. Usage during the intermediate period was about the same for both groups.

Diversified Demand. Diversified demand estimates the total demand for the portion of the residential class represented in the sample. At the time of system peak, diversified demand was significantly lower for the experimental group than for the control group.

System Peak. Peak demand is the maximum instantaneous demand on a system arising from the aggregation of the diversified demand of the various classes of users--residential, industrial, commercial, and so on--at a particular point in time. For the peak winter month (January 1976), the estimated impact of implementing the experimental rate on the population of inference was a reduction in the system peak of 8 to 13 megawatts. For the peak summer month (June 1976) a reduction of 70 to 83 megawatts was estimated.

1.4 Limitations of the Demonstration and Qualifications of Analytical Results

During the sampling process, some of the customers selected to participate in the study were not included for various reasons, such as meter installation problems, refusal to participate, seasonal consumption, and bad credit. Based on the combined rejections from the experimental and control groups, customers in the final sample represent about 135,000 residential customers. This group is defined as the effective population and constitutes

approximately 45 percent of the sampled population.* The effective population is the only population to which valid statistical inferences can be drawn from the sample results. Inferences to the sampled population or to any population larger than the effective population require the assumption that excluded customers will respond to the experimental rate in the same manner as those represented in the sample. Since this assumption was not made, all test results shown herein are applicable only to the effective population.

Even for the effective population a number of additional qualifications apply to the results. They may be summarized as follows:

- The results strictly apply only to the represented portion of the CLP residential class as of early 1974.
- The results strictly apply only to comparisons of the particular TOU and control rates incorporated in the experiment.
- Actual implementation of the TOU rate may not be accompanied by incentive payments of the type used in the Connecticut study. Therefore, to infer load patterns under such an implementation plan from this study requires an assumption that such lump sum payments do not affect electricity consumption patterns.
- During the experiment some customers were dropped because of meter malfunctions or because they moved. To extrapolate observed load patterns from the remaining sample to the initial effective population requires the assumption that such attrition does not introduce systematic bias, e.g., by representing an increasingly sedentary population in the later months of the test period.
- Participants knew that the experiment was limited to a single 12-month period after which they would return to the conventional rate. This may have discouraged them from investing in appliances and home improvements that are financially attractive under TOU rates. Consequently, the observed responses must be regarded as short-run rather than long-run responses that might occur under implementation.
- Actual implementation of a TOU rate would not involve the personal contact, that is, pre-test interviews, that customers on the experimental rate received prior to the start of the study. Any benefit or adverse effects that may accompany such a contact are ignored in estimating the observed responses.

*The sampled population was composed of all residential customers on the CLP system except those with new accounts (accounts less than one year old), those with estimated bills in 1973, and those identified as farm accounts.

- Finally, the results reported in this study are primarily short-term responses of a small portion of the Connecticut Light and Power Company customers living in the service area at the time the sample was drawn. The information provided by this experiment does not enable statistical inferences to be made about the long-term responses of some future customers to any TOU rate schedule. Furthermore, it does not enable such inferences about either short-or long-term responses to a TOU rate different from that used in this study; therefore, "real-world" application of these results require engineering assumptions or "best guesses" that are not statistically testable.

CHAPTER 2: PROJECT CHARACTERISTICS

This chapter describes design characteristics of the Connecticut Rate Demonstration Project. The first section summarizes major features of the experiment, including such items as the study period, and the number of customers involved. The second section describes the rate schedules used in the experiment and section three examines the terms of customer participation. Sections four and five summarize the design of the sample and describe sample rejections.

2.1 History and Major Features of the Project

The Connecticut time-of-use pricing experiment began in October 1975. It was a one-year controlled experiment in which 200 Connecticut Light and Power Company (CLP) residential customers were placed on a seasonal time-of-use rate. The rate utilized three rating periods during weekdays and two rating periods during weekends and holidays. An equal number of customers on the existing rate served as a control group. Personal interviews with the selected customers were conducted both before and after the experiment. The purpose of the first contact was to ask customers to participate in the experiment and to gather demographic data. The final interview at the conclusion of the project yielded further demographic data on each participant. One prior contact was made with these customers in the year preceding the study. At that time customers were asked to take part in a standard load research study.

Under the sponsorship of the Department of Energy, the study was conducted through the joint efforts of the Connecticut Public Utilities Control Authority, the Connecticut Department of Planning and Energy Policy, the Connecticut Office of Consumer Counsel, and the Connecticut Light and Power Company, part of Northeast Utilities.

2.2 Description of Rate Schedules

Two rates--control and experimental--were included in the Connecticut Project. The control group was billed under the existing rate (declining block) at the time the experiment began. The experimental rate schedule was a time-of-use rate with three daily rating periods during weekdays and two daily rating periods on weekends and holidays. The rating periods also differed by season. The hourly and seasonal variations as well as other specifications of the control and experimental rates are given in table 2-1.

Table 2-1. Specification of Rate Schedules Used in the Connecticut Rate Demonstration Project

Experimental Rate Time	Hours			Price (¢ per kWh)		
	P	I	B	P	I	B
Summer Weekday	10-12 13-15	08-10 12-13 15-21	21-08	16	3	1
Winter Weekday	09-11 17-19	08-09 11-17 19-21	21-08	16	3	1
Weekend (Summer and Winter)		08-21	21-08		3	1

Summer: May 16-October 15

Winter: October 16-May 15

P = peak period, I = intermediate period, B = base period

\$2.00 per month customer charge

The following six holidays are treated as weekend days: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.

Control Rate

First 12 kWh or less	- \$ 2.27
Next 88 kWh	- 6.25 cents per kWh
Next 200 kWh	- 5.05 cents per kWh
Next 300 kWh	- 3.54 cents per kWh
Additional kWh	- 3.24 cents per kWh

The peak-price rating periods were established after examining historical system hourly load patterns for the day of winter peak, the average January weekday, the day of summer peak and the average June weekday. Intermediate or shoulder periods included those hours other than the peak hours when the hourly system load was at least 90 percent of the daily system peak. The remaining hours constitute, by definition, the base or off-peak period. Prices to be charged during the various time periods were determined on the basis of the long-run incremental costs of electricity by time-of-use. The analyses that led to the rating periods and prices are given in Appendix D of the Connecticut Peak Load Pricing Test Final Report (1977). Figure 2-1 shows the daily rating periods of the experimental rate schedule as it was applied on weekdays and weekends during the summer and winter months of the experimental period.

2.3 Customer Interviews and Participation Payments

Customers on the experimental rate were interviewed personally on three occasions. The first contact was made in the summer of 1974. At that time all experimental participants in the Connecticut Project were contacted to solicit their participation in a standard CLP load research study to be conducted one year prior to the start of the experiment. Participation in the load research study required permission from the customer to install the test meter. Toward the end of the load research study, those customers who had volunteered were interviewed a second time. They were asked to remain members of the experimental group, participating in the rate demonstration project on the TOU rate. At that time attitudinal and updated demographic information was also obtained. Again, participation was optional and some customers refused the experimental rate. An experienced opinion survey and market research firm was retained to design and administer all survey questionnaires

*Holidays treated as weekend days.

Figure 2-1. Schematic of Connecticut Experimental Rate Schedule

and to analyze resulting data. At this pre-test interview all details of the study were described to potential participants. Customer education consisted of explanations of such factors as the background and purpose of the study, the rationale for TOU rate schedules, the specific rates to be used, potential savings likely to result from TOU rates and the billing format. Section 4 and Appendixes E and F of the Connecticut Final Report (1977) contain information about the post-test interview as well as copies of the customer information materials each household received.

Customers on the experimental rate were given a "lump sum" payment before the demonstration project began. The amount was computed on the basis of annual historical usage and was set at approximately 25 percent of the average annual bill per stratum under the existing rate. Payments ranged from \$50 (stratum 1) to \$150 (stratum 5).

At the conclusion of the rate demonstration project, a third interview was conducted with experimental customers to update existing data and to obtain additional information on actions and changes in lifestyle attributable to the TOU rate. Section 2 of the Connecticut Final Report (1977) provides a demographic description of experimental participants and households.

Similarly, participation in the demonstration project as members of the control group was limited to volunteers. In all cases customers were interviewed personally by CLP representatives on two occasions. The first contact was a personal interview to request permission to install the 15-minute recording meter and gather demographic data. After the demonstration project ended, control customers were contacted by telephone for updated demographic information. Further details about how the sample was drawn and rejections during sample selection are given in the following sections.

2.4 Sample for Load Research Study

In 1974, one year prior to the start of the project, a standard residential load research study was developed by Northeast Utilities and implemented within the CLP service area. The primary objective of this study was to obtain detailed information on electricity usage patterns of residential customers for use in developing a forecasting methodology, analyzing rate structures and designing distribution facilities. To accomplish this objective, 15-minute magnetic tape recording meters were installed on a sample of 250 residential dwellings.

Sample customers for the initial load research study were selected from the group of residential customers in the CLP service area that remained after all farm customers, customers with less than a 12-month billing history for 1973, and customers having any estimated bills during 1973 had been excluded. The group that was sampled numbered 296,776. A detailed accounting of the effects of criteria used to determine qualifications for participation in the rate demonstration project is given in table 2-2.

The sampled population was stratified into five groups or strata. Each stratum contained approximately 20 percent of the total electricity consumption of the sampled population during 1973. The characteristics of the five strata are shown in table 2-3. Under this stratification scheme, the number of customers varies widely from stratum to stratum, emphasizing the need for weighted analysis when a constant sample size is drawn from each stratum.

Within each of the five strata, simple random sampling was employed to obtain 50 customers to participate in the load research study. For convenience, 200 customers were actually selected within each stratum. The 150 additional customers or "alternates" served as replacements for the initial group of customers and also provided a means for selecting control customers.

Table 2-2. Criteria for Inclusion in the Demonstration

Inclusion Criterion	Percent Included	Number of Customers
(1) Estimated average number of residential customers in CLP service area - 1973	100%	471,000*
(2) Actual number of residential customers in sampled population (non-farm customers who have 12-month billing history and do not have estimated bill during prior year)	63% of (1)	296,776
(3) Estimated number of residential customers in population represented by sample (includes those customers not excluded during sample selection due to: metering problems, seasonal, moving, unable to contact, refusal, bad credit, chronic complainers and withdrawal)	45% of (2)	134,788

*Includes an unknown number of farm customers. Inferences to farm customers should not be made since this group is covered by a separate residential rate.

Table 2-3. Stratification of Sampled Population for Load Research Study

Stratum	Annual Consumption Per Customer (kWh)	Residential Customers	Initial Sample	Proportion of Total Residential Customers	Estimated Aggregate Annual Consumption* (MWH)	Proportion of Total Residential Consumption
1	0-6300	138,741	50	0.4675	479,624	0.182
2	6301-9400	66,653	50	0.2246	534,077	0.203
3	9401-13,500	46,584	50	0.1570	553,423	0.210
4	13,501-23,000	29,990	50	0.1011	507,360	0.193
5	Over 23,000	<u>14,808</u>	<u>50</u>	<u>0.0499</u>	<u>557,548</u>	<u>0.212</u>
Total		296,776	250	1.0000	2,632,032	1.000

*Estimated on the basis of number of residential customers and average annual consumption per customer in each stratum.

In order to obtain the initial sample size of 50 in each stratum for the load research study, it was necessary to screen a total of 390 customers.

Table 2-4 summarizes customer rejections from the load research study by reason and strata. There were six major reasons for excluding customers: (1) meter problems, (2) a seasonal customer or a change in home ownership, (3) refusal to participate, (4) poor credit, (5) chronic complaints, and (6) customer withdrawal. Almost half of all rejections were due to meter problems. The meter could not be installed without extensive rebuilding of the service facility or arrangements could not be made for accessing the meter to change the tape cartridge.

Table 2-4. Number and Type of Customer Rejections in Load Research Study

Stratum	Number of Customers Screened	Number of Customers Rejected	Percent Rejected	Number of Customer Rejections, By Reason*:					
				a	b	c	d	e	f
1	101	51	50.5	30	11	6	1	1	2
2	87	37	42.5	17	5	5	5	2	3
3	76	26	34.2	9	6	6	3	0	2
4	64	14	21.9	6	3	4	0	0	1
5	<u>62</u>	<u>12</u>	<u>19.4</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
TOTAL	390 [†]	140	35.9	65	26	23	11	5	10

*a = meter, b = seasonal, moving, unable to contact, c = refusal, d = credit, e = chronic complainers, and f = customer withdrawal.

[†]Note that after 390 customers were screened and 140 rejected, 250 remained. However, as shown in table 2-5, only 248 customers were screened for participation in the actual demonstration project. The Connecticut Final Report (1977) does not account for the loss of two customers.

2.5 Sample for Rate Demonstration Project

The load research study ended on October 15, 1975. For those customers who agreed to go on the experimental rate, the demonstration project began on the following day. There were 248 customers participating in the experiment at the time the load research study ended. An attempt was made to enroll all

of these customers on the TOU rate. Twenty-nine customers refused to participate and 20 could not be contacted. Hence, only 199 customers were actually placed on the experimental rate at the beginning of the demonstration project (October 16, 1975). During the experimental test period (scheduled for one year but subsequently extended to fourteen and one-half months) 17 of the 199 experimental customers relocated. New families that moved into the vacated residences were not included in the test. Fifteen-minute magnetic tape recording meters were utilized to collect electricity usage data.

Just prior to the termination of the load research study, other customers were asked to participate in the demonstration project as members of a control group. This sample was obtained from the list of "alternates" previously selected and the rate assigned to this group was the existing rate. A total of 200 control customers (40 per stratum) was established as the desired sample size. In order to obtain these 200 control customers, a total of 378 customers were screened. However, only 192 customers were actually included in the study. There were no substitutions made in the control group during the one-year study period prior to the demonstration project. However, the Connecticut Final Report (1977) indicates that three customers were added after the study began. A summary of total number of rejections by reason and strata for control and experimental groups is given in table 2-5.

The number of customers within each stratum in the sampled population was adjusted for rejections during sample selection to obtain an estimate of the population for which inferences can validly be made from the sample results. As shown in table 2-6, the size of this inferential population is estimated as 134,788. This represents approximately 45 percent of the residential customers in the population actually sampled. The last column of table 2-6 gives the weights (e.g., proportion of the inferential population within each

Table 2-5. Number and Type of Customer Rejections in Selection of Customers for Rate Demonstration Project

Stratum	Number of Customers Screened	Number of Customers Rejected	Initial Sample Size	Number of Customer Rejections, By Reason*:					
				a	b	c	d	e	f
<u>Experimental</u>									
1	50	14	36		8	6			
2	50	9	41		4	5			
3	49	5	44		1	4			
4	50	10	40		2	8			
5	49	11	38		5	6			
Total	248	49	199		20	29			
<u>Control</u>									
1	99	66	33	27	23	11	3	1	1
2	71	31	40	14	6	4	6	0	1
3	70	30	40	11	8	2	9	0	0
4	67	27	40	6	14	1	6	0	0
5	71	32	39	6	14	3	4	3	2
Total	378	186	192	64	65	21	28	4	4

*a = meter, b = seasonal, moving, unable to contact, c = refusal, d = credit, e = chronic complainers, and f = customer withdrawal.

Source: Connecticut Peak Load Pricing Test, Final Report, 1977.

stratum) for combining stratum means to obtain estimated means applicable to the population of inference. Readers may find it instructive to compare table 2-6 with table 2-3 which shows the stratification of the sample population for the preliminary load research study.

Table 2-6. Estimated Population Represented in Final Sample

Stratum	Number of Customers in Sampled Population	Estimated Inferential Population*	Estimated Proportion of Inferential Population
1	138,741	47,409	.3517
2	66,653	33,963	.2520
3	46,584	26,665	.1978
4	29,900	18,225	.1352
5	14,808	8,526	.0633
TOTAL	296,776	134,788	1.0000

*See Section B.3 of Appendix B for method of estimation.

Inferences to the sampled population (296,776 customers) require the assumptions that customers rejected during sample selection (a) would have similar consumption levels and patterns under the existing rate to those customers in the population actually represented in the sample, and (b) would have responded to the TOU experimental rate in the same manner as customers in this represented population. While there is no problem in deriving estimates of means or totals for this population, the application of these assumptions would invalidate statistical tests of hypotheses. Therefore, inferences have been confined to a population that is statistically defensible--in this case a group of approximately 135,000 customers.

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CHAPTER 3: COMPARATIVE ANALYSIS

Since only one experimental rate schedule was used in the Connecticut study, this chapter compares electricity consumption of customers on an experimental TOU rate with customers on a control rate. The results can be statistically projected only to those CLP non-farm customers who volunteered to participate in the experiment and would not have been excluded for the specific reasons described in section 2.3 and in section 2.4. The major results of the study are summarized in the following paragraphs.

Peak Periods. The experimental group consumed significantly less electricity during the peak period than the control group. This result was evident for each month.

Intermediate Period. During the summer months, the experimental customers used significantly less electricity during the intermediate period than the control customers. During the winter months, however, the two groups used about the same amount of electricity during the intermediate period.

Base Period. During the winter months, the experimental group used significantly more electricity in the base period than the control group. During the summer months, however, the two groups consumed about the same quantity of electricity during the base period.

Total Consumption. Customers in the experimental group used significantly less electricity than their counterparts in the control group during the summer months due to consumption patterns during the peak and intermediate periods described above. These patterns suggest that during the summer months, the experimental customers are conserving energy, whereas, during the winter months, these customers are shifting usage from the peak period to the base period. These same patterns were evident for weekdays and weekend days within a month.

Diversified Demand. Diversified demand at the time of system peak was significantly lower for the experimental group as compared to the control group. The associated load factor (the ratio of average hourly consumption to consumption at time of system peak) was significantly higher in each month for the experimental group.

System Peak. For the peak winter month (January), the estimated impact of implementing the experimental rate on the effective population was a reduction in the system peak of 8 to 13 megawatts. For the peak summer month (June) a reduction of 70 to 83 megawatts was estimated.

The sections which follow describe the analysis and these overall findings in detail. Section 3.1 outlines the estimation model for the comparative analysis. The next section identifies the population parameters pertinent to the evaluation of the TOU rate. This is followed by a description of the preparation of the data for the comparative analysis. Then in section 3.4, the results of tests of hypotheses on these parameters are reported. Section 3.5 identifies additional parameters that were estimated for the peak summer and peak winter months. Section 3.6 gives the results of these estimations. The next section describes the four types of load curves constructed for the study and provides representative plots of selected months. Finally, in section 3.8, comparisons of population estimates for different populations are made.

3.1 Analytical Approach

The comparative analysis involves a statistical comparison of responses observed under the experimental and control rate. The objective of the analysis is to determine whether for the experimental group the level of response to a particular parameter depends on the TOU rate applied. The analysis used to determine whether a response under one rate schedule differs significantly from the response under another rests on the assumption that

there exists a definable population about which inferences from samples can be drawn. Weights are used to expand the sample to a finite population. For example, assuming simple random sampling and proper randomization are employed within each stratum and that there are no exclusions during sample selection, the mean response for the sampled population under an experimental rate, $\hat{Y}_E$, and a control rate, $\hat{Y}_C$, can be estimated as

$$\hat{Y}_E = \sum_{i=1}^H W_i \hat{Y}_{Ei}$$

$$\hat{Y}_C = \sum_{i=1}^H W_i \hat{Y}_{Ci}$$

where H = number of strata,

W_i = weight for i^{th} stratum calculated as N_i/N where N_i is the number of customers in the sampled population in the i^{th} stratum and $N = \sum N_i$,

$\hat{Y}_{Ei}$ = mean response of customers on experimental rate in the i^{th} stratum,

$\hat{Y}_{Ci}$ = mean response of customers on the control rate in the i^{th} stratum.

When there are exclusions during sample selection, the population of inference becomes a subset of the sampled population and the weights, W_i , must be modified to reflect the estimated size of this reduced population. Procedures for constructing appropriate weights are given in Appendix B.

3.2 Selection of Parameters for Comparison

Four winter months, December 1975-March 1976, and four summer months, June 1976-September 1976, were selected for analysis. For each of these eight

months, the parameters of table 3-1 were estimated for the effective* population for the control and experimental rates (that is, assuming these rates were applied to the effective population). The twenty parameters shown in table 3-1 have been chosen for comparison of the control and experimental rates. For a more technical listing of these parameters, see table A-4. The objective was to determine, for the population of experimental customers, whether the level of response for a particular parameter was a result of the rate structure being used.

Several general comments may aid the reader in understanding the parameters. Parameters 1-6 of table 3-1 provide usage characteristics on a per customer basis for only one day of the month, the day of system peak. Parameters 1-6 of table 3-1 measure average usage per customer during certain hours of the peak day. For example, parameter 1 measures usage during the hours defined as the peak period on that day and parameter 6 measures total usage over all hours. Parameters 4 and 5 measure, respectively, usage on the peak day during the one-hour periods preceding and following the peak period(s). The purpose of these variables is to determine whether the TOU rates induce a surge in demand at those times, also sometimes called the "needle-peaking problem."

Parameters 7-12 are identical to parameters 1-6 except that they are averaged over all days of the month. It should be noted that usage for peak and intermediate periods includes usage during only those hours so defined by the TOU rate.

*As noted earlier, based on combined rejections from the experimental and control groups, customers in the final sample represent about 135,000 residential customers. This group is defined as the effective population and constitute approximately 45 percent of the sampled population.

Table 3-1. List of Parameters Estimated in Comparative Analysis
(Estimated per customer)

	Parameter Number	Description
Average for Day of Monthly System Peak	1	kWh - peak
	2	kWh - intermediate
	3	kWh - base
	4	kWh - during 1-hr. preceding peak period
	5	kWh - during 1-hr. following peak period
	6	Total kWh
Average for All Days of Month	7	kWh - peak
	8	kWh - intermediate
	9	kWh - base
	10	kWh - during 1-hr. preceding peak period
	11	kWh - during 1-hr. following peak period
	12	Total kWh
Average per Customer	13	Diversified demand at time of observed monthly system peak
	14	Noncoincident maximum demand
Average for Subset of Hours during Month	15	Average hourly kWh consumed during all hrs. of observed system load greater than 80% of <u>annual</u> system peak
	16	Average hourly kWh consumed during all hrs. of observed system load greater than 90% of <u>annual</u> system peak
	17	Average hourly kWh consumed during all hrs. of observed system load greater than 95% of <u>annual</u> system peak
Ratio	18	Proportion of total kWh used during peak period on peak day [#1/#6]
	19	Proportion of total kWh used during peak period on average day [#7/#12]
	20	Class load factor based on diversified demand at time of observed monthly system peak (#12/#13 ÷ 24)

The word "demand" is usually defined in electricity load research as the instantaneous load (in kilowatts) that a customer or customer group imposes on the utility system. The term "diversified demand" implies that two or more customers' "demands" are averaged together. The extent of diversity of their loads is reflected in that averaging process. For example, if all customers had identical load curves there would be no diversity and the average "maximum diversified demand" for the group would be the sum of their individual maximum demands, also called "noncoincident maximum demands," divided by the number of customers in the group. Given these definitions, it follows that parameter 13 is the average kWh usage per customer during the single hour in each month when the largest hourly demand was observed on the entire utility system. For example, the CLP system peaked during the hour ending at 11:00 a.m. on January 23, 1976, so, for the month of January, parameter 13 is the estimated average usage of all residential customers in the effective population. By contrast, parameter 14, noncoincident maximum demand, is the estimated average over all customers in the effective population of their individual maximum hourly kWh usages. This was computed as the weighted average of the maximum observed for each sample customer within each month.

Parameters 15-17 provide usage characteristics on a per customer basis averaged over subsets of hours identified by the magnitude of the observed load on the utility system. For example, parameter 16 averages hourly kWh consumption over those hours in the month when system load exceeds 90 percent of the annual system peak.

Parameters 18 and 19 are the proportion of total usage during the peak period on the peak day and on the average day, respectively, for each month. For example, during January the customers on the TOU rate used 16.1 percent of their total usage during the peak period on the peak day and 10.6

percent on the average day. These contrasted with corresponding estimates of 20.1 percent and 13.5 percent for the control group.

Load factor, the ratio of the average load to the peak load, can be measured for the entire system or by customer class. Class load factor, parameter 20, is the ratio of average hourly usage to average usage during the hour of system peak within each month. The numerator in this ratio is parameter 12 divided by 24 and the denominator is parameter 13. For example, during January 1976 the average hourly usage of the control group was 1.407 kWh and average usage during the hour of system peak was 1.593 so the class load factor based on the latter was .883 ($=1.407/1.593$).

For each of the eight months of the study, the parameters in table 3-1 were estimated for customers on the control and experimental rates. A test of the hypothesis that the true population parameters for the control and experimental rates do not differ was then conducted for each of the twenty parameters. A rejection of the hypothesis suggests evidence of a "real" difference between the two population parameters and that this difference is attributable to the rate structures.

3.3 Preparation of Data for Comparative Analysis

Prior to beginning the comparative analysis, an examination of system load data was made to identify time frames for this analysis and to formulate explicit parameter definitions. Observation of system load data under the control rate provided the following information for selected months: hourly system load, average hourly system load, maximum hourly system load, system load factor, and day and hour of maximum hourly system load. These results are given in table 3-2. Explicit definitions of the time frames for many of the parameters described in section 3.2 depend on such system load characteristics as the value of annual system peak (3710.4 megawatts) and the value and time of occurrence of the monthly system peak. For example,

parameter 15 requires an aggregation over those hours in the month in which system load exceeds 80 percent of the annual system peak. As table 3-2 indicates, over the eight months, the number of such hours ranged from 16 in September to 289 in January.

One main aspect of the data reduction was the aggregation of daily usage data to produce weekday and weekend averages. The first two rows of table 3-2 show the numbers of days involved in these aggregations. These values can be utilized to express certain parameter estimates in alternative forms. For example, although the peak period occurs only on weekdays, parameter 7, average kWh per customer per day during peak period in a selected calendar month, involves an average over all days in the month. Hence, an estimate of parameter 7 can be multiplied by the number of days in the given month and divided by the number of weekdays in the month in order to express the peak-period usage on an average weekday basis.

Following a preliminary analysis of system load data, the hourly consumption data was reduced (aggregated across various days and hours) and edited. These data handling procedures are described in Appendixes A and B. Editing of consumption data involves two steps (1) an automated edit, which excludes customers with large amounts of missing data and flags customers having unusual consumption values (e.g., a high hourly consumption value, or a large number of hours with zero consumption), and (2) a "manual" edit, which allows the user, after examining the consumption patterns of the flagged customers, to delete specific customers from the data base (on a month-by-month basis).

The consumption data for Connecticut had undergone extensive editing prior to its submission to the DOE data base (see Connecticut Final Report 1977). This editing involved deleting a customer's data from the data base for an entire calendar month whenever any missing or "invalid" data occurred

Table 3-2. Summary of Data Reduction

	Dec.	Jan.	Feb.	Mar.	June	July	Aug.	Sep.
No. Weekdays*	22	21	20	23	22	22	22	21
No. Weekend Days	9	10	9	8	8	9	9	9
No. Hours for:								
Parameter 15 [†]	182	289	140	124	136	42	67	16
Parameter 16 [¶]	15	65	24	---	8	---	8	---
Parameter 17 [§]	1	17	3	---	---	---	---	---
Observed System Load:								
Peak (MW)	3575.8	3710.4	3664.6	3308.1	3493.1	3155.3	3455.5	3044.0
Day/Hour	18/18	18/18	23/11	9/19	24/14	20/13	23/14	17/10
Load Factor	.702	.728	.728	.721	.663	.690	.654	.714

*Holidays are counted as weekend days.

[†]Average hourly kWh consumed during all hours of observed system load greater than 80 percent of annual system peak.

[¶]Average hourly kWh consumed during all hours of observed system load greater than 90 percent of annual system peak.

[§]Average hourly kWh consumed during all hours of observed system load greater than 95 percent of annual system peak.

within the month. Hence, customers either have complete (i.e., no missing values) data for a month or no data from the DOE data base. A number of customers were, however, flagged by this procedure. These are summarized in table 3-3 and are listed in Appendix C.

Table 3-3. Number of Customers Flagged by Month by Test Group

	Dec.	Jan.	Feb.	Mar.	June	July	Aug.	Sep.
Test Group	1975	1976	1976	1976	1976	1976	1976	1976
Control	2	3	8	4	4	2	3	7
Experimental	11	9	10	5	17	13	18	19

In a number of cases large blocks of zero hourly consumption values occurred. There were also cases with other unusual patterns. For example, zero usage values occurred day after day at the same time of day. Without additional information, it was impossible to know whether these zero values were legitimate. Because no rational method appears to exist for determining which of the flagged customer's data should be deleted and which retained, the decision was made to retain all data. This decision was made for two reasons. First, the data had been previously edited by the Connecticut Project team, for whom additional information was available. Second, if deletions of the flagged customers were made, then it would also be likely that some unflagged customers having zero consumption values should also be deleted. Thus, all available data were utilized in the analysis; the numbers of customers providing data, classified by stratum, treatment, and month, are given in table 3-4 on the next page.

Table 3-4 Customers Providing Usage Data for Analysis

Test Group	Stratum	1975	1976						
		Dec.	Jan.	Feb.	Mar.	June	July	Aug.	Sep.
Control	1	30	29	32	32	30	28	27	31
	2	29	32	32	34	26	29	24	32
	3	35	37	40	37	27	26	30	34
	4	36	34	34	39	34	29	26	30
	5	32	34	38	39	30	29	29	33
	Total	162	166	176	181	147	141	136	160
Experimental	1	33	35	32	30	29	28	28	30
	2	40	40	39	40	40	40	38	37
	3	44	42	42	41	38	39	40	39
	4	39	39	38	38	39	38	38	36
	5	37	38	38	38	36	38	36	37
	Total	193	194	189	187	182	183	180	179

3.4 Comparative Analysis Results

For each month selected for analysis, a set of summary statistics were developed which estimated those population parameters pertinent to the evaluation of the effects of a TOU rate. The estimates, coupled with distributional assumptions, were used to test whether significant differences existed between the true population parameters for the two groups. Results of tests of hypotheses concerning these parameters were also developed. The methodology for conducting these tests is described in Appendix B. Appendix D presents a detailed comparison of these data for experimental and control groups in tabular form for December 1975, January-March and June-September of 1976.

Table 3-5 summarizes tests of treatment differences for all months analyzed and identifies parameters for which the experimental TOU rate response differed significantly from the control group response. Entries on this table are shown as percentage changes for those parameters which were considered significant by tests of hypotheses. Blank spaces indicate that the associated differences were not statistically significant.

Several patterns are evident in table 3-5. For example, some parameters show significant differences only in the summer months, whereas significant

Table 3-5. Differences between Control and Experimental Groups for Values Deemed Significant*
(In estimated percentage changes)

Parameter†		Dec. 75	Jan. 76	Feb. 76	Mar. 76	June 76	July 76	Aug. 76	Sep. 76
Peak Day kWh									
	Peak - 1	-22.5	-14.4	-22.0	-20.9	-39.0	-28.8	-30.9	-22.1
	Intermediate - 2					-22.7	-21.5	-14.3	-15.3
	Base - 3	18.0	23.1	23.3	19.6				
	1-hr. before peak period - 4					-46.2	-41.1	-38.5	-26.0
	1-hr. after peak period - 5	-15.3				-28.5	-21.1	-24.4	-19.8
	Total - 6					-19.1	-18.1		-10.5
Average Day kWh									
	Peak - 7	-20.7	-18.7	-21.5	-25.4	-30.9	-27.0	-26.3	-23.4
	Intermediate - 8					-16.8	-14.8	-13.6	-12.4
	Base - 9	12.9	18.5	20.6	14.1				
	1-hr. before peak period - 10					-37.6	-34.2	-34.9	-31.7
	1-hr. after peak period - 11	-16.7	-12.3	-12.8	-13.8	-24.2	-19.9	-20.9	-17.7
	Total - 12					-12.6	-12.4	-11.3	-9.4
	Diversified Demand - 13	-22.0			-24.5	-39.0	-36.0	-40.3	-25.3
Noncoincident Maximum Demand - 14									
	Average Hourly kWh - 80% - 15	-12.2			-11.6	-28.1	-29.9	-23.7	-29.5
	Average Hourly kWh - 90% - 16	-20.7		-12.4	N/A‡	-37.4	N/A	-31.0	N/A
	Average Hourly kWh - 95% - 17	-22.0	-10.5	-15.8	N/A	N/A	N/A	N/A	N/A
	#1/#6 - 18	-22.9	-19.4	-22.5	-21.8	-24.5	-13.3	-22.5	-13.0
	#7/#12 - 19	-20.1	-21.5	-23.9	-23.8	-20.8	-16.5	-17.2	-15.0
Class Load Factor [#12/#13 - 24)] - 20		27.8	17.9	22.7	30.4	43.3	36.7	48.8	21.3

*Calculated as: $100(\bar{Y}_e - \bar{Y}_c) / \bar{Y}_c$ where $\bar{Y}_e$ and $\bar{Y}_c$ are means for experimental and control groups respectively. Values are shown only for those cases deemed significant at the .05 level.

†See table A-4 for more general parameter definitions.

‡N/A - not applicable, system load was not high enough to provide information on these parameters.

differences show up only in the winter months for others. These patterns may be summarized as follows:

Peak Period. In each of the eight months examined, the experimental group consumed less electricity during the peak period than the control group. This holds true for both the day of system peak (parameter 1) and for all days in the month (parameter 7). For the latter case, the reduction in consumption ranged from 19 to 25 percent for the four winter months and from 23 to 31 percent for the four summer months. The numerical reduction in usage during the peak period is shown in table 3-6 which gives, by month, the average hourly usage for the control and experimental groups. Average hourly values in table 3-6 for the peak period were developed by multiplying the average daily values shown as parameter 7 in tables D-2 through D-9 by the number of days in the month and dividing by the number of hours in the month in which the peak price was in effect. Average hourly usages were similarly developed for the intermediate, base and total periods. Usage during the peak period is also reflected through parameters 18 and 19 which measure, respectively, the proportion of total usage in the peak period for the day of system peak and for the month. In each of the eight months, these proportions were significantly lower for the experimental group.

Intermediate Period. During the four winter months (December-March), the levels of consumption during the intermediate period for the experimental and control groups did not differ statistically. This is evident in table 3-5 for the day of system peak (parameter 2) and for the average over all days (parameter 8). The four summer months (June-September) show an entirely different pattern. During each of these months, the experimental customers used significantly less electricity during the intermediate period than the control customers. For the day of system peak the reduction ranged from 14 to 23

Table 3-6. Average Hourly Usage in kWh per Customer by Month, Rating Period, and Treatment

Period	Treatment	Month							
		Dec. 75	Jan. 76	Feb. 76	Mar. 76	June 76	July 76	Aug. 76	Sep. 76
Peak	Control	1.617	1.679	1.501	1.408	1.084	1.068	1.049	0.920
	Experimental	1.282	1.366	1.178	1.050	0.749	0.780	0.773	0.705
	Difference	-0.335	-0.313	-0.323	-0.358	-0.335	-0.288	-0.276	-0.215
Intermediate	Control	1.503	1.588	1.373	1.286	1.262	1.204	1.267	1.203
	Experimental	1.434	1.559	1.336	1.199	1.050	1.026	1.094	1.054
	Difference	-0.069	-0.029	-0.037	-0.087	-0.212	-0.178	-0.173	-0.149
Base	Control	1.090	1.170	1.002	0.964	0.781	0.778	0.773	0.719
	Experimental	1.230	1.387	1.208	1.100	0.783	0.748	0.754	0.718
	Difference	0.140	0.217	0.206	0.136	0.002	-0.030	-0.019	-0.001
Total	Control	1.327	1.407	1.218	1.154	1.020	0.993	1.015	0.948
	Experimental	1.323	1.458	1.259	1.135	0.891	0.870	0.900	0.859
	Difference	-0.004	0.051	0.041	-0.019	-0.129	-0.123	-0.115	-0.089

percent, and for all days in the month the reduction ranged from 12 to 17 percent. Table 3-6 shows hourly consumption for the experimental and control groups during the intermediate rating period.

Base Period. Relative to the control group, the experimental group used significantly more electricity during the base period in each of the four winter months (parameters 3 and 9 of table 3-5). This was the case for both the day of system peak and for the average over all days. The magnitude of the increased usage ranged from 13 to 23 percent. However, the experimental group did not continue to use more electricity during the base period than the control in the summer months. From June through September, they used about the same amount of electricity as customers on the control rate. Base period consumption on an hourly basis is given in table 3-6.

Total Consumption. Customers in the experimental group used significantly less total electricity than their counterparts in the control group during the summer months (parameters 6 and 12 in table 3-5). During the four summer months the average reduction ranged from 9 to 13 percent. On an hourly basis, the reduction ranged from .089 (September) to .129 (June) kWh per customer (table 3-6). During the winter months, the daily consumption of electricity for the experimental and control groups did not differ significantly.

Seasonal Patterns. When comparisons of usage within the peak, intermediate, and base pricing periods and total consumption are jointly considered, two distinct seasonal patterns emerge. First, in the summer months customers on the experimental and control rates used about the same amount of electricity during the base period. During the peak and intermediate periods, the experimental group consumed less, thus causing the total consumption to be significantly reduced. The cause of this reduction is unknown. One possible explanation is that customers used their air conditioners less during the

daytime but did not attempt to make up this reduction by using them more at night.

Second, in the winter months total consumption did not differ significantly for the experimental and control customers. During the peak period the experimental customers used less electricity than the control group; however, this reduction was offset during the base period when the experimental group used more electricity than the control group. Thus, in the winter months, it appears that customers were shifting usage from the peak to the base period.

The seasonal patterns just described were based on electricity usage over all days in a month. Further examination of consumption data showed that these same patterns exist for both weekdays and weekend days within a month, which would indicate that conservation and shifting of usage are taking place within days rather than between days. These patterns are reflected in the average hourly consumption values given in table 3-7 for the four winter and four summer months.

Table 3-7. Average Hourly Consumption
(kWh)

	Weekdays				Weekend Days		
	Peak	I	Base	Total	I	Base	Total
Four Winter Months:							
Control	1.55	1.37	1.07	1.26	1.55	1.03	1.31
Experimental	1.22	1.30	1.25	1.26	1.51	1.18	1.36
Four Summer Months:							
Control	1.03	1.23	.77	.99	1.24	.75	1.01
Experimental	.75	1.03	.76	.86	1.11	.72	.93

Usage during Hour Preceding/Following Peak Period. The parameters involving the one-hour periods preceding and following the peak period(s) (parameters 4, 5, 10 and 11) were designed to detect needle peaking for rate structures having only two daily rating periods rather than three as used in Connecticut. For this study, these parameters involve subsets of hours within the intermediate period; hence, the results are similar to those given in section 3.4 for the intermediate period.

Diversified Demand at Time of System Peak and Associated Load Factor. In six of the eight months examined, the diversified demand at the time of system peak was significantly lower for the experimental group than for the control group (parameter 13 in table 3-5). These decreases ranged from 22 to 40 percent or from .21 to .54 kWh per customer. For the other two months, the estimates for the experimental group were lower but the differences were not statistically significant at the .05 level. In each of the eight months, the load factor based on diversified demand at the time of system peak (parameter 20) was significantly higher for the experimental group. The percentage increase ranged from 18 to 49 percent. Numerically, the increase in load factor for the four winter months ranged from .12 to .18 and from .24 to .37 for the four summer months.

Noncoincident Maximum Demand. Noncoincident maximum demand (the average of the individual customer's maximum demands over the month) was the only variable found to be non-significant for each of the eight months examined (parameter 14 of table 3-5).

3.5 Estimation of Additional Parameters

For the winter and summer peak months (January 1976 and June 1976), some additional population parameters were estimated for the effective population.

Listed in table 3-8, these are identified as parameters 21-27 to distinguish them from the twenty parameters utilized in the comparative analysis. Only the peak months within the summer and winter seasons have been examined for these variables since each hour in a month must be analyzed separately in order to determine the one-hour period in which the class peak occurs. Estimates of parameters 21-27 were obtained for the control and experimental rates. Tests of significance were not conducted, since standard errors for these estimates were not derived. All of these variables depend upon maximum diversified demand, a class-oriented variable which cannot be computed on an individual customer basis. Consequently, the estimates for a given month represent single observations.

System Peak and System Load Factor. Among the most important response measures in evaluating the effects of TOU pricing are measures of the impact on the system load curve. Two of these measures are of particular interest--system peak (parameters 23-24) and system load factor (parameters 25-26). For the peak winter and summer months (January and June), the hourly system peak and the associated load factor were estimated for both the control and experimental groups. Estimations of these parameters required development of average hourly load estimates for each hour of the month for the control and TOU rates. For purposes of this report, analysis was limited to the peak month of the summer and winter seasons.

The estimated system load curve for the experimental rate was obtained by adjusting the observed system load curve. This adjustment required estimating the difference between residential load curves for the experimental and control groups and inflating this difference to account for transmission/distribution losses. Since estimates are based on data observed at the customer's residence, inflation is necessary to reflect associated load impact on power generating facilities. These losses were estimated to be between 5

Table 3-8. List of Other Parameters Estimated for Winter and Summer Peak Months

Parameter Number	Description
21	Maximum diversified demand
22	Class coincidence factor
23	System peak--inflation factor of 1.05 to account for transmission/distribution losses
24	System peak--inflation factor of 1.25 to account for transmission/distribution losses
25	System load factor--inflation factor of 1.05 to account for transmission/distribution losses
26	System load factor--inflation factor of 1.25 to account for transmission/distribution losses
27	Class load factor--based on maximum diversified demand [$\#12/(\#21 \times 24)$]

and 25 percent of loads at residences, so the estimated differences were inflated by factors of 1.05 and 1.25. This range covers factors likely to be encountered under actual conditions for most utilities.

Estimation of Maximum Diversified Demand, Load Factor and Coincidence.

The availability of average hourly usage throughout the month enabled the estimation of three additional parameters--maximum diversified demand, class load factor and class coincidence factors. Maximum diversified demand for a class (parameter 21) represents the level of demand at the time of class peak. Class coincidence factor (parameter 22) shows the extent to which the average of the individual household's maximum demand (parameter 14) exceeds its demand at the time of residential class peak of the maximum diversified demand (parameter 21). Class load factor (parameter 27) based on maximum diversified

demand shows how the average household's demand at the time of the residential class peak compares to its average daily demand.

3.6 Results of Additional Parameter Estimates

Parameter estimates along with the day and hour of system peak and maximum diversified demand are shown in table 3-9. Note that the quantities shown in table 3-9 are estimates (except for the control group system-level quantities) and, as such, are subject to errors. Since estimates of these errors are not available, comparative inferential statements were not made. The comments that follow are not intended to imply that one estimate is better (worse) or higher (lower) than another.

System Peak and Load Factor. As shown in table 3-9, for January 1976, the hourly system load (parameter 23) under the control rate was actually observed to reach a peak of 3710.4 megawatts on January 23 at 11:00 A.M. (hour ending). Under the experimental rate, the estimated value of the system peak was 3697.7 megawatts. Its estimated time of occurrence was January 23 at 10:00 A.M. The difference in peak values is 12.7 megawatts. The corresponding values for the month of June indicate that under the experimental rate the system peak would be reduced by 69.5 megawatts. The associated system load factors (parameter 25) are slightly higher in both months under the experimental rate (.728 versus .732 for January and .663 versus .671 for June). The above quantities utilized an inflation factor of 1.05 to account for transmission/distribution losses. Corresponding quantities were calculated using an inflation factor of 1.25 (parameters 24 and 26). In this case, however, differences between the control and experimental rates remained relatively small.

Table 3-9. Additional Parameter Estimates for Winter and Summer Peak Months

Parameter Number	Description	January 1976		June 1976	
		Control	Experimental	Control	Experimental
21	Maximum Diversified Demand (kWh) Day/Hour	2.301 23/19	2.347 22/22	1.766 15/21	1.715 24/21
22	Class Coincidence Factor	.386	.397	.325	.344
23	System Peak--Inflation Factor of 1.05 Day/Hour (MW)	3710.4 23/11	3697.7 23/10	3493.1 24/14	3423.6 24/14
24	System Peak--Inflation Factor of 1.25 Day/Hour (MW)	3710.4 23/11	3702.1 23/09	3493.1 24/14	3410.3 24/14
25	System Load Factor-- Inflation Factor of 1.05	.728	.732	.663	.671
26	System Load Factor-- Inflation Factor of 1.25	.728	.732	.663	.673
27	Class Load Factor	.611	.621	.577	.520

The estimated difference in system peak values is assumed attributable to the experimental rate and its resulting influence on the effective population. Other components making up the total system usage (commercial and industrial, for example) are assumed to be unaffected by the TOU rate. For this study, the effective population is small--about 135,000 residential customers. At the hour of the winter or summer system peak, the total usage for this group represents only 5-6 percent of the total system usage. For this reason, only large shifts or reductions in usage by the experimental group are reflected in the system load curve. For example, during the peak hour of June the experimental group used 39 percent (or .491 kWh per customer) less than the control group (see parameter 13 in Appendix D, table D-6). At the system level, this 39 percent reduction is reflected as a reduction of 69.5 megawatts.

The number of customers in the population to which inferences are made plays a vital role in determining the impact on the system load. For example, if in the peak hour of June the sampled population, 296,776 customers, had been used as the population of inference, the results would have indicated a 37 percent (or .41 kWh per customer) reduction during the hour of system peak for the experimental group. This translates to a reduction in system peak of 127.8 megawatts. This reduction would be even greater if inferences were made to the target population consisting of all non-farm residential customers. The extent to which these reductions are meaningful is directly related to the validity of the assumptions required in making inferences beyond the effective population.

Group Peak Demand, Load Factor and Coincidence. The estimate of maximum diversified demand at the time of class peak (parameter 21 of table 3-9) for the experimental group relative to the control was slightly higher in January but lower for the month of June. In both months the peaks for the two groups occurred at different times.

Class load factor, derived by dividing the average demand by the maximum diversified demand, provides a measure of the utilization of system facilities. The higher the load factor the greater the utilization. As shown in table 3-9, the estimated load factor for the experimental group was slightly higher than for the control group for January but lower for June.

Class coincidence factor (parameter 22 of table 3-9) provides a measure of diversity. Small values are desirable since its maximum value of unity can be reached only when the maximum value for each member of the class occurs at the same time. Estimates for the control and experimental groups are, respectively, .386 and .397 for January and .325 and .344 for June.

3.7 Average Daily Load Curves

Another element in the comparative analysis is the examination of graphic displays of average daily residential load curves. A set of four daily curves were constructed for each of the eight calendar months used in the comparative analysis described earlier in this chapter. Table 3-10 describes the daily load curves constructed for each month.

Table 3-10. Average Daily Load Curves

Type	Averaging Period
1	Day of monthly system peak
2	Weekend days during the month
3	Weekdays during the month
4	All days during the month

The entire set of load curves for the winter and summer peak months have been selected for inclusion in this chapter. Figure 3-1 shows the set for January 1976 and figure 3-2 shows the set for June 1976. Figures 1-1 and 1-2 in chapter 1 show two of the load curves--average weekday and day of system peak—for these same months in greater detail. Appendix E provides corresponding load curves for December 1975, February, March and July-September, 1976 as well as June 1976 and January 1976.

In constructing the load curves, sample results were inflated to represent an average member of the effective population. A direct relationship exists between the parameters of table 3-1 and the load curves of table 3-10. For example, summation of usage under load curve 1 during the peak period on

Figure 3-1. Average Daily Load Curve for Control and Experimental
Rate Schedule, January 1976

DAY OF SYSTEM PEAK

WEEKEND DAYS

Figure 3-2. Average Daily Load Curve for Control and Experimental Rate Schedule, June 1976.

the day of system peak corresponds to parameter 1, peak period usage. Under a rate structure that does not vary from day to day, a similar summation of usage under load curve 4 corresponds to parameter 7. Extending the summation over all 24 hours under load curves 1 and 4 would produce parameters 6 and 12, respectively.

3.8 Comparison of Estimates for Effective and Sampled Populations

All population estimates shown herein apply to the effective population which is defined as the population of residential customers actually represented in the sample. The estimated size of the effective population is 134,788 as compared to 296,776 customers making up the sampled population.

It is of interest to determine how parameter estimates for the effective population differ from those for the sampled population. Inferences to the sampled population require, however, the assumption that customers represented by exclusions during the sampling process will respond in a manner similar to the actual participants. While this assumption is difficult to defend empirically, for illustrative purposes, it is considered valid. Table 3-11 provides information whereby direct comparisons can be made of parameter estimates for these two populations.

Table 3-11 indicates that consumption estimates for the sampled population are smaller than the corresponding estimates for the effective population. This holds for both the control group and the experimental group. This, however, is expected since the weights used to inflate sample results to the sampled population are smaller for the higher usage strata and larger for the lowest usage strata. The stratum weights for the two populations are found in table 3-12.

Table 3-11. Comparison of Estimates for Sampled Population and Effective Population for June 1976

Parameter [†] Number	Control Group		Experimental Group		Difference	
	Sampled Population	Effective Population	Sampled Population	Effective Population	Sampled Population	Effective Population
1	5.04	5.56	3.09	3.39	-1.95**	-2.17**
2	12.59	13.87	9.67	10.73	-2.92**	-3.15**
3	9.37	10.21	8.85	9.85	-0.53	-0.36
4	2.37	2.65	1.30	1.43	-1.07**	-1.23**
5	2.48	2.78	1.82	1.98	-0.66**	-0.79**
6	27.00	29.65	21.60	23.97	-5.40**	-5.68**
7	2.89	3.18	2.00	2.20	-0.89**	-0.98**
8	11.56	12.71	9.50	10.57	-2.06**	-2.14**
9	7.88	8.59	7.72	8.62	-0.16	0.03
10	1.38	1.53	0.87	0.95	-0.51**	-0.57**
11	1.54	1.69	1.16	1.28	-0.37**	-0.41**
12	22.32	24.47	19.22	21.38	-3.10**	-3.09**
13	1.12	1.26	0.71	0.77	-0.42**	-0.49**
14	5.13	5.44	4.53	4.98	-0.60*	-0.45
15	1.10	1.21	0.79	0.87	-0.31**	-0.34**
16	1.22	1.35	0.78	0.85	-0.45**	-0.51**
17	--	--	--	--	--	--
18	0.19	0.19	0.14	0.14	-0.04**	-0.05**
19	0.13	0.13	0.10	0.10	-0.03**	-0.03**
20	0.83	0.81	1.13	1.16	0.31**	0.35**

*Significant at $\alpha = .05$, based on t-statistics**Significant at $\alpha = .01$, based on t-statistics[†]See table 3-1 for parameter definitions.

Table 3-12. Stratum Weights for the Experimental and Control Groups

Stratum	Sampled Population	Effective Population
1	.4675	.3517
2	.2246	.2520
3	.1570	.1978
4	.1010	.1352
5	.0499	.0633

While the consumption parameters estimated for the sampled population are smaller for both the control and experimental groups, differences between the control and experimental group estimates are virtually the same for the two populations. This is evident by comparing the set of differences shown in table 3-11 and observing that tests of hypotheses give almost identical results. The procedures described in Appendix B were followed in conducting these tests.

Standard errors of estimates are in general smaller for the sampled population. The same holds true for standard errors of differences, although the discrepancies are not as pronounced.

For convenience, data covering the month of June 1976 are provided in table 3-11 for the comparison of estimates for the sampled population and the effective population. Examination of seven other months of data revealed patterns similar to those described.

In conclusion, consumption estimates for the sampled population, under the assumption that (potential) non-participants in the sampled population would have consumption patterns like those of the (potential) participants, tend to be smaller than corresponding estimates obtained for the effective population. This demonstrates that estimates of the effective population as

given herein should only be used for this population. On the other hand, differences between control and experimental group estimates are virtually the same for the two populations.

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APPENDIX A: DESCRIPTION OF DATA PROCESSING AND ANALYSIS METHOD

A.1 Analytical Objectives

The proposed data analyses* for the individual rate demonstration projects are described below. Not all of these objectives are relevant to every project.

- 1) Estimation, by treatment, of average daily load curves for the residential class of customers over several different time frames within each of several months (e.g., the day of system peak, weekdays, weekend days).
- 2) Estimation, by treatment, of the average daily residential-class load curve for that day in a month in which the class peak is estimated to occur.
- 3) Estimation of certain parameters characterizing the load curves indicated in (1) and (2).
- 4) Treatment-versus-control comparisons between certain parameters characterizing the load curves indicated in (1).
- 5) Estimation of response surface models which relate customer's usage patterns to electricity prices (perhaps adjusted for certain demographic characteristics).

This appendix provides a brief description of the computer programs which have been written to process, edit, and analyze the data in accordance with the above analytical objectives.

Section A.2 provides an overview of the analysis process, describing the steps involved, their interrelationships, and the purposes of individual programs. Programs and routines used in this analysis were developed at the Research Triangle Institute. For more detailed information see the User's Guide for Processing and Analyzing Data from the Electric Utility Demonstration Projects, revised June 1978. Details on the data editing procedures are provided in section A.3.

* See Analytical Master Plan for the Analysis of the Data from the Electric Utility Rate Demonstration Projects, Volume I, RTI Report No. 41U-1542/00-05F.

A.2. Overview of the Data Processing and Analysis System

As figure A-1 indicates, each analysis begins with an extraction of data for a particular project from the DOE data base. The programs are structured so that only one or two such extractions normally are necessary. For example, the extracted data may cover time periods longer than would be used in any particular analysis, or may include data on customers assigned to treatments which are not relevant to a particular analysis. Selections of treatments and months can be made at any stage in the analysis process. Figure A-1 indicates the structure of the analysis process, including the intermediate data files necessary for producing the final product. The five analytical objectives are satisfied as follows:

- 1) Plot of data from data file U-4,
- 2) Plot of (selected) data from data file U-6,
- 3) Output from the comparative analysis program and the daily load curve and system load curve estimation programs,
- 4) Output from the comparative analysis and/or the analysis of covariance program,
- 5) Output from the response surface analysis program.

It would be desirable to build these programs into an integrated system to minimize the user's input requirements and reduce the number of individual program runs. This does not appear to be feasible, however, because examination of the output of one program is generally necessary before execution of a subsequent program. In addition, the general system may have to be supplemented by other special-purpose programs (or enhancements to the general programs which can be implemented on an optional basis) on a project-specific basis. Three areas where such special programs are likely to be required are the following:

Figure A-1. Overview of Analysis System

NOTE: Dots indicate that a sorting of the data file may be required.

- 1) additional types of manual editing,
- 2) recoding of strata codes (e.g., in order to collapse certain strata into a single stratum), and
- 3) aggregation across monthly data records in order to perform analyses on a seasonal basis.

The remainder of this section briefly describes the individual programs and their inputs and outputs.*

A.2.1 System Load Analysis

This program extracts system load data for that day in each calendar month during which the hourly system peak for the month occurred. A data file (SL-1) containing this information is written. A second data file (SL-2) is also produced; this file simply represents a reformatting of the SL-0 file. The program output can be used to select those months for which subsequent analyses should be performed. In addition, if sufficient system load data are available, definition of the annual system peak is possible. The basic input to the program is the hourly system load data (SL-0), one record per day, in the form generated by a DAY BY HOUR extraction using the DOE extraction system.

The program writes a monthly record for each month having a "sufficient" number of valid hourly system load readings. "Sufficient" is defined by the program parameter SLIM, which gives the proportion of hours required in the month. The current value of SLIM is .95, indicating that 95 percent or more of the hourly system load readings must be positive, that is, non-missing.

* The response surface analysis and the (optional) analysis of covariance are handled by packaged routines and are not included in the discussion.

A.2.2 Linkage of Treatment, Stratum, and Weather Station Codes to U-0

This program augments treatment, stratum, and weather station codes from the DEMO-0 data file onto the usage data file U-0 by matching customer ID numbers from the two files. The resulting file, U-1, like U-0, contains one record per customer per day. Printed output consists of a list of customer ID numbers for which no match was achieved.

A.2.3 Automated Edit, Data Reduction

This program has four major purposes. It creates a reduced set of usage data, performs an automated editing of the hourly usage data, and provides outputs useful for performing additional editing. In addition, it provides counts of respondents, by treatment and stratum. The basic data reduction involves converting a data file (U-1) containing one record per customer per day to a data file containing from 3 to 7 records per customer per (calendar) month. Average hourly usage per customer is constructed over seven different time-frames (corresponding to the seven record types) which are as follows:

<u>Type</u>	<u>Time Frame</u>
1	day of monthly system peak
2	weekdays (excluding holidays) in calendar month
3	weekend days (including holidays) in calendar month
4	all days in calendar month in which system load exceeds $Q_1 \times P$
5	all days in calendar month in which system load exceeds $Q_2 \times P$
6	all days in calendar month in which system load exceeds $Q_3 \times P$
7	all days in calendar month

where P is a user-supplied value of the annual system peak and the Q_i are program parameters (currently set at $Q_1 = .80$; $Q_2 = .90$, $Q_3 = .95$).

The program writes usage records only for those customer-months with sufficient non-missing usage data in U-1. Thus U-2 represents an edited file. In addition, since some zero usage values may actually be miscoded missing values, the program performs a re-edit of the U-1 data. This involves performing the edit under the assumption that all zero kWh readings represent missing values. Records in U-2 which fail this re-editing procedure are flagged. Records derived from usage data in U-1 that contain one or more suspiciously-large hourly kWh readings during the month are also flagged.

The program requires four types of data (if all record types are to be built). A file of usage data (U-1) and the user's control data are always required, while the system load data files SL-1 and SL-2 may be required in some cases.

Output consists of two data files, in addition to printed output. One file is the index file I-1, which summarizes each customer's status with respect to the editing performed by the program. This file contains one record per customer per (selected) month -- for each customer having usage data on file U-1 in the particular month. The second output file is U-2, which contains the reduced, edited usage data. Tables A-1 and A-2 show, respectively, the information contained in each record of the I-1 and the U-2 data files.

Two major types of printed output occur. The first corresponds closely to the information contained in the index file I-1. For customers with a flag value of 2 in a particular month, the pattern of the hourly usage data during the month is displayed. This output can be used as an aid for determining whether or not the customer's usage data should be included in the analysis. The second major portion of the

TABLE A.1. Form of Records in File I-1

<u>Variable</u>	<u>Description</u>
JDCUST	Customer number
JMONTH	Year/Month
JTRT	Treatment code
JSTRAT	Stratum code
IFLAG	Flag indicating customer status (0 = no usage records written on U-2 due to edit failure 1 = some usage records written on U-2; all records written on U-2 pass both edit and re-edit 2 = some usage records written on U-2; at least one record failed to pass the re-edit)
Z2	Maximum hourly usage occurring on weekdays (excluding holidays) in month
Z3	Maximum hourly usage occurring on weekends (including holidays) in month
MB(I) (I=1,2,...,7)	No. of missing hourly values during time frame (record type) I
KB(I) (I=1,2,...,7)	No. of missing or zero hourly values during time frame (record type) I
IVEC(1)	Edit indicator for record type 1
IVEC(2)	Edit indicator for record type 2, 3, and 7
IVEC(3)	Edit indicator for record type 4
IVEC(4)	Edit indicator for record type 5
IVEC(5)	Edit indicator for record type 6
JVEC(1)	Re-edit indicator for record type 1
JVEC(2)	Re-edit indicator for record type 2, 3, and 7
JVEC(3)	Re-edit indicator for record type 4
JVEC(4)	Re-edit indicator for record type 5
JVEC(5)	Re-edit indicator for record type 6

NOTE: IVEC(I) (JVEC(I)) is equal to 1 if edit (re-edit) is passed, is equal to 0, otherwise.

TABLE A-2. Form of Records in File U-2

<u>Variable</u>	<u>Description</u>
JDCUST	Customer number
JW	Weather station code
JMONTH	Year/Month
JTRT	Treatment code
JSTRAT	Stratum code
J	Record type (Time Frame Indicator)
IFLAG	Flag indicating customer status (see Table A-1)
YM(J)	Vector of average hourly kWh values -- over time frame J
MM(J)	Vector of sample sizes (no. of non-missing values) used for computing YM(J) values
KM(J)	Vector containing the no. of positive values entering into YM(J) values
Z(J)	For J=1,2,3,7: maximum hourly kWh during time frame J; For J=4,5,6: average hourly kWh over all hours in month for which system load exceeds $Q_{J-3} \times P$
ND(J)	For J=1: the day of system peak; Otherwise: the number of potential* days in time frame J over which YM(J) values are computed
NH(J)	For J=1: the hour of system peak; Otherwise: the number of potential* hours over which Z(J) values are computed
MB(J)	No. of hours with non-missing kWh values involved in the computation of Z(J) values
KB(J)	No. of positive kWh values involved in the computation of Z(J) values

* That is, if no missing values are present.

output from this program is an array of sample sizes, by month, treatment, stratum, and record type. This can be used to determine where problems of estimability may arise in subsequent analysis programs.

A.2.4 Manual Edit

This program allows the user to perform additional editing of the U-2 data file. These edits simply involve flagging particular records (which are identified through the user's control data). Flagging of a record with record type equal to 2, 3, or 7 implies flagging of all existing record types for that customer and month. This rule is consistent with the rules employed in the automated edit. Since all subsequent programs utilizing U-3, the updated version of U-2, skip these flagged records, the update effectively corresponds to a deletion of the indicated records. The editing is documented in the index file I-2, which is the updated version of I-1.

A.2.5 Load Curve Estimation

This program estimates average daily load curves for the residential population (or a specified subpopulation thereof), where the time averaging corresponds to the seven time frames described in Section A.2.3. The program simply computes a weighted sum, by treatment and month, of the individual usage records in data file U-3. Within each stratum, the customers with data in U-3 are assumed to constitute a random sample from the effective population. Strata sizes are thus required as part of the user's input. Output can be restricted to particular months, treatments, and record types. A data file containing the estimated average daily load curve values is generated (file U-4 in Figure A.1). Printed output consists of a list of the strata and sample size information and (optionally) of the estimated load values.

A.2.6 Creation of Analysis Variables

This program creates a file of analysis variables for the comparative analyses (or certain dependent variables for the response surface analyses) from the data file U-3. The output file, U-5, contains one record per customer per (selected) month; each record contains values of 17 usage variables, as shown in Table A-3. Construction of many of these variables requires a definition of a pricing scheme that indicates those seasons, times-of-week, and hours within days during which peak-, intermediate-, and base-level prices are in effect. This pricing scheme is defined through the user's input; only a single pricing scheme is permitted.

Analysis variables Z1-Z6 and Z13 are constructed from input record type 1. The variables Z1-Z5 are constructed in accordance with the pricing scheme supplied by the user's control data.

Analysis variables Z15, Z16, Z17, and Z14 are extracted directly from the Z(J) variables appearing, respectively, in record types 4, 5, 6, and 7 of data file U-3 (see Table A-2).

Analysis variable Z12 is computed as the sum of the elements in the YM(7) vector (on record type 7 of data file U-3). Analysis variables Z7-Z11 are also derived from record type 7, if a single weekly rating period is indicated for the month. If two weekly rating periods are indicated, these variables are constructed from record types 2 and 3. The weekday pricing scheme is then associated with record type 2 and the weekend scheme, with record type 3.

A.2.7 Comparative Analysis

The purpose of this program is to estimate population parameters, by treatment and month, and to make selected comparisons of

TABLE A-3. Form of the U-5 Data File

<u>Variable</u>	<u>Description</u>
IDCUST	Customer number
IW	Weather station code
JMONTH	Year/Month
KTRT	Treatment code
KSTRAT	Stratum code
IFLAG	Editing flag
Z1	kWh during peak period on day of observed system peak in JMONTH
Z2	kWh during intermediate period on day of observed system peak in JMONTH
Z3	kWh during base period on day of observed system peak in JMONTH
Z4	kWh during one-hour periods preceding peak periods--on day of observed system peak in JMONTH
Z5	kWh during one-hour periods following peak periods--on day of observed system peak in JMONTH
Z6	kWh on day of observed system peak in JMONTH
Z7	Average daily peak-period usage in JMONTH
Z8	Average daily intermediate-period usage in JMONTH
Z9	Average daily base-period usage in JMONTH
Z10	Average daily usage for JMONTH during one-hour periods preceding peak periods
Z11	Average daily usage for JMONTH during one-hour periods following peak periods
Z12	Average daily usage for JMONTH
Z13	Usage during one-hour corresponding to hour of observed system peak in JMONTH
Z14	Maximum hourly usage during JMONTH
Z15	Average hourly usage during hours in which observed system load exceeded .80 times the (assumed) annual system peak
Z16	Same as Z15 with .90 replacing .80
Z17	Same as Z15 with .95 replacing .80

NOTE: Input records (file U-3) with IFLAG values other than 1 or 2 are skipped; hence, only values of 1 and 2 will occur for IFLAG on the output file U-5.

NOTE: Variables Z7, Z8, Z9, Z10 and Z11 are averaged over all days in the month even though peak, intermediate, and base prices may be present only during a subset of the days. Holidays are treated as defined by the user in the creation of the U-2 data file. It is assumed, however, that the monthly system peak does not occur on a weekday which is one of user-defined holidays, since input to this program does not allow it to identify that such a day should be treated like a weekend day in terms of the pricing scheme.

NOTE: Any of the variables Z1 through Z17 which cannot be constructed due to lack of the necessary input records are coded as -1.

the treatments with respect to these population parameters. The program assumes that customers with data in file U-5 constitute random samples from each stratum of the effective population. Strata and sample size information -- furnished by the user -- are used to compute the weighted estimates. The user's control data are used to restrict the estimates to particular months and treatments. Comparisons are made between treatment 1 and each of the other treatments, where the order of the treatments is specified by the user. Generally, treatment 1 would be a control group, although this is not required to be the case. The estimates involved in the comparisons are assumed to be approximately normally distributed; an approximate t-test is used for testing the equality of the various treatment population parameters.

The output consists of a series of (NTRT-1) tables for each month. The first table presents results for treatments 1 and 2; the second, for treatments 1 and 3, etc. For each of the two treatments involved in a particular table, the following are given for each parameter of interest:

- a) sample size upon which the parameter estimate is based,
- b) the value of the parameter estimate, and
- c) the estimated standard error of the estimate.

An estimate is not provided for the particular treatment and parameter if there is any stratum which contains no customers (who furnish data) assigned to that treatment. Similarly, item (c) is not given if any stratum contains no customers or a single customer on the particular treatment.

If all three of the above quantities can be determined for each of the two treatments, a test of significance is performed. The following output is presented:

- a) the estimated difference between the population parameters under treatment 1 and treatment k ($k = 2, 3, \dots, \text{NTRT}$), and an indication of the statistical significance of the true difference *
- b) the standard error of this difference
- c) approximate 99 percent confidence limits for the true difference.*

The above estimates and comparisons are made for the 20 parameters given in table A-4. The parameters are labeled numerically in the output as indicated in this table.

A.2.8 Daily Load Curve Estimation

This program provides average hourly usage estimates (per customer) for the specified (residential) population. These estimates are provided for each selected treatment at each hour of each day in each selected month. In addition, the estimated maximum monthly diversified demand (per customer) for this class of customers is determined for each treatment, as well as its time of occurrence. The monthly class load factor is also presented. Customers whose data are to be utilized in making the estimates are determined by the flag and IVEC values appearing on the index file I-2. The data file U-1 is the source file for the usage data. The estimated residential load curves are written onto data file U-6, which can subsequently be used for producing graphical output.

A.2.9 Daily System Load Curve Estimation

This program combines the existing daily system load curves (data file SL-2) with the daily residential load curves estimated for each treatment (data file U-6) to produce estimated system load

* The tests and confidence limits assume that degrees of freedom for the test statistic (computed as a t statistic) are sufficiently large so that comparisons to tabulated Normal (0,1) percentage points are justified.

curves for each treatment. The user must furnish control data in addition to these two data files. The estimation procedure assumes that all pertinent system characteristics (e.g., distribution and transmission losses) can be reduced to a single user-supplied constant which holds uniformly over both time and treatments. Output consists of a list of the estimated daily system load curves, by treatment. The following system-level quantities are also presented for each selected month and treatment.

- average hourly system load
- maximum hourly system load
- system load factor
- day and hour at which maximum hourly system load occurs

A.3 Data Editing Procedures

Let the system load data on file SL-2 be defined as

S_{hjm} = system load at hour h of j^{th} day in m^{th} calendar month.

Let $(h^*, j^*)_m$ denote the hour and day in the m^{th} month at which the maximum hourly load, S_m^* , occurs. Let A_m be the (user-supplied) value of the (assumed) annual system peak. Now define

$$G_{hjml} = \begin{cases} 1 & \text{if } S_{hjm} > C_l A_m \\ 0 & \text{otherwise,} \end{cases}$$

where C_l are program parameters with current values as follows:

l	C_l
1	.80
2	.90
3	.95

Note that the data $S_{hj^*_m}$ is contained on the data file SL-1. We also define the following quantities:

TABLE A-4. List of Parameters Estimated in the Comparative Analysis (By Treatment and Month)

1. Average kWh per customer during peak period on day of observed system peak in calendar month i
2. Average kWh per customer during intermediate period on day of observed system peak in calendar month i
3. Average kWh per customer during base period on day of observed system peak in calendar month i
4. Average kWh per customer during 1-hr. preceding peak period(s) on day of observed system peak in calendar month i
5. Average kWh per customer during 1-hr. following peak period(s) on day of observed system peak in calendar month i
6. Average kWh per customer on day of observed system peak in calendar month i
7. Average kWh per customer per day during peak period for i th calendar month
8. Average kWh per customer per day during intermediate period for i th calendar month
9. Average kWh per customer per day during base period for i th calendar month
10. Average kWh per customer per day during 1-hr. preceding peak period(s) for i th calendar month
11. Average kWh per customer per day during 1-hr. following peak period(s) for i th calendar month
12. Average kWh per customer per day during i th calendar month
13. Diversified demand (average per customer) at time of observed system peak in the i th calendar month
14. Noncoincident maximum demand (average per customer) for i th calendar month
15. kWh per customer averaged over all hours in the i th calendar month for which observed system load was greater than .80 of observed annual system peak
16. kWh per customer averaged over all hours in the i th calendar month for which observed system load was greater than .90 of observed annual system peak
17. kWh per customer averaged over all hours in the i th calendar month for which observed system load was greater than .95 of observed annual system peak
18. Proportion of total kWh in peak period on day of observed system peak in the i th calendar month ($\#1/\#6$)
19. Proportion of total kWh in peak period for i th calendar month ($\#7/\#12$)
20. Class load factor for i th calendar month based on diversified demand at time of observed system peak ($\#12/\#13 \div 24$)

$$X_{jm}^{(1)} = \begin{cases} 1 & \text{if day } j \text{ is the day of system peak in month } m \\ 0 & \text{otherwise} \end{cases}$$

$$X_{jm}^{(2)} = \begin{cases} 1 & \text{if day } j \text{ of month } m \text{ is a weekday (excluding holidays)} \\ 0 & \text{otherwise} \end{cases}$$

$$X_{jm}^{(3)} = 1 - X_{jm}^{(2)}$$

$$X_{jm}^{(4)} = \max_h [G_{hjm1}]$$

$$X_{jm}^{(5)} = \max_h [G_{hjm2}]$$

$$X_{jm}^{(6)} = \max_h [G_{hjm3}]$$

The above indicator variables define subsets of days in month m corresponding to the first six output record types. Let $Y_{hjm}(i)$ denote the usage for the i^{th} customer at hour h of day j in month m . Define

$$M_{hjm}(i) = \begin{cases} 1 & \text{if } Y_{hjm}(i) \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (\text{i.e., if } Y_{hjm}(i) \text{ has a non-missing value})$$

and

$$K_{hjm}(i) = \begin{cases} 1 & \text{if } Y_{hjm}(i) > 0 \\ 0 & \text{otherwise.} \end{cases}$$

The average usage vector for the i^{th} customer over time frame J in month m is then computed as

$$\bar{Y}_{h.m}^{(J)}(i) = \frac{\sum_{j=1}^{r_m} X_{jm}^{(J)} Y_{hjm}(i) K_{hjm}(i)}{\sum_{j=1}^{r_m} X_{jm}^{(J)} M_{hjm}(i)}$$

where r_m is the total number of days in month m . The vectors $YM(J)$, $MM(J)$, and $KM(J)$ of Table A-2 correspond, respectively, to

$$\bar{Y}_{h.m}^{(J)}(i) \quad h = 1, 2, \dots, 24;$$

$$\sum_{j=1}^{r_m} X_{jm}^{(J)} M_{hjm}(i) \quad h = 1, 2, \dots, 24;$$

and

$$\sum_{j=1}^{r_m} X_{jm}^{(J)} K_{hjm}(i) \quad h = 1, 2, \dots, 24.$$

The average vector for record type 7 is computed as a weighted average of the weekend and weekday usage vectors:

$$\bar{Y}_{h.m}^{(7)}(i) = \left(\bar{X}_{.m}^{(2)} \bar{Y}_{h.m}^{(2)} + \bar{X}_{.m}^{(3)} \bar{Y}_{h.m}^{(3)} \right) / r_m$$

where

$$\bar{X}_{.m}^{(J)} = \sum_{j=1}^{r_m} X_{jm}^{(J)}.$$

Note that this calculation involves an (implicit) imputation of the raw usage data if missing values occur.

The $Z(J)$ variables (see table A-3) are computed as follows:

$$Z_m^{(J)}(i) = \max_{h,j} \left[X_{jm}^{(J)} Y_{hjm}(i) \right] \quad \text{for } J=1,2,3;$$

$$Z_m^{(7)}(i) = \max \left[Z_m^{(2)}(i), Z_m^{(3)}(i) \right];$$

and

$$Z_m^{(J)}(i) = \sum_{j=1}^{r_m} \sum_{h=1}^{24} G_{hjm, J-3} Y_{hjm}(i) K_{hjm}(i) / R_m^{(J)}(i)$$

for $J=4,5,6$, where

$$R_m^{(J)}(i) = \sum_{j=1}^{r_m} \sum_{h=1}^{24} G_{hjm, J-3} M_{hjm}(i).$$

Output records are written only if "sufficient" non-missing data is available in the U-1 file. In order to make this determination, the program compares the number of non-missing values to the potential number of hourly values which are involved in the calculations of the $\bar{Y}_{h.m}^{(J)}(i)$ and the $Z_m^{(J)}(i)$ variables. In particular, three basic types of screening conditions are employed:

$(a) \min_h \left[M_{h.m}^{(J)}(i) / X_{.m}^{(J)} \right] < .75$	$J=1,2,\dots,6$	(i.e., data is available for at least 75% of the potential number of days -- at <u>each</u> hour of the day)
$(b) \sum_{h=1}^{24} M_{h.m}^{(J)}(i) / 24 X_{.m}^{(J)} < .90$	$J=1,2,\dots,6$	
$(c) R_m^{(J)}(i) / G_{..m, J-3} < .90$	$J=4,5,6$	

(i.e., data is available
for at least 90% of the
potential number of hours)

where

$$G_{..m, J-3} = \sum_{j=1}^{r_m} \sum_{h=1}^{24} G_{hjm, J-3}.$$

Note that $X_{.m}^{(J)}$ represents the potential number of hourly observations over which averages of the Y-type variables can be constructed for record type J in month m; $G_{..m, J-3}$ is the potential number of hours for averages of the Z-type variables.

The values appearing on the right-hand side of the inequalities are program parameters. The above screening criteria are logically ordered as follows:

1. No records for customer i in month m are retained if condition (a) holds when $J=2$ or 3 or condition (b) holds when $J=2$ or 3. Otherwise record types 2, 3, and 7 are retained and the editing continues.
2. For $J=1, 4, 5$, and 6, record type J is not retained if either (a) or (b) holds for the corresponding value of J .
3. Record type J , $J=4, 5, 6$, is not retained if condition (c) holds for the corresponding value of J .

It should be noted that all of the edit checks performed by the program are concerned with the amount of missing data. No checks involving the patterns of missing data are made.

Because zero-usage hourly data may actually represent miscoded missing values, and because extremely large usage values may represent invalid readings, additional checks are made and reported in the output. These involve performing a re-edit of the hourly usage data under the assumption that all zero-kWh readings actually represent missing values. If any (output) record type passed the editing procedure but fails to do so under this assumption, this customer's records are flagged with a value of 2. A flag value of 2 also is assigned when the maximum hourly usage value during the month exceeds 20 kWh. For any customer receiving a flag value 2, the printed output shows the customer's usage pattern. This output appears as a day-by-hour array employing the following symbolic notation:

<u>Symbol</u>	<u>Meaning</u>
*	Usage value missing
0	Usage value of zero kWh
(blank)	$0 < \text{usage value} \leq 10 \text{ kWh}$
1	$10 < \text{usage value} \leq 20 \text{ kWh}$
2	$20 < \text{usage value} \leq 30 \text{ kWh}$
:	:
8	$80 < \text{usage value} \leq 90 \text{ kWh}$
9	Usage value $> 90 \text{ kWh}$.

These printouts are useful for determining if additional records should be deleted prior to analysis via the manual edit. Both the manual and automated edits are aimed at including or excluding entire records, as opposed to specific data elements within records. This approach is advocated for two reasons. First, it facilitates the analysis by applying a common sampling weight to all variables within a record type. For instance, load curve estimates and estimates of parameters characterizing the load curve are based on a common set of sample customers. Secondly, it is likely to produce estimates with less bias in that the presence of large amounts of missing or invalid data suggests that the time intervals associated with the raw usage data may also be in error; hence, data which appears valid may, in fact, be invalid.

As the output records of the U-2 file are produced, a count is made. All counts are reported in the printed output in the form of a table of sample sizes broken down by month, treatment, stratum, and record type. Examination of this table will indicate whether problems of estimability will occur in the analysis due to sample size counts of zero or one. Any invalid (i.e., out of range) stratum codes which may have occurred will appear in this table in stratum number zero.

APPENDIX B: STATISTICAL ESTIMATION AND TESTING
PROCEDURES USED IN COMPARATIVE ANALYSIS

B.1 Population and Sampling Structures

The population of customers for which inferences are desired is either the entire class of residential customers in a utility's service area or some specific subgroup of this class. Valid statistical inferences to this population is, in a strict sense, impossible, because the population is constantly changing. Target populations for most of the demonstration projects have been defined (at least, initially) as all households with an active residential account as of a specific time (namely, when the sample was drawn). This appears to be a reasonable modification of the desired population of inference. To obtain valid estimates for this target population requires that a probability sample of the target population be exposed to each experimental rate.

In most of the demonstration projects, however, a number of customers in the target population have been systematically excluded from participation in the experiment. These exclusions are of two basic types.

Type I exclusions involve those customers in the target population who have a zero probability of inclusion in the experiment. Although this type of exclusion may reduce the meaningfulness of results, since the sampled population may be less relevant, it does not otherwise cause inferential problems as long as inferences are limited to this reduced population.

Typical exclusions of this type are the following:

- 1) customers with less than a 12-month billing history,
- 2) customers with an estimated bill in the past X months,

- 3) accounts associated with seasonal dwellings*,
- 4) customers with irregular monthly usage patterns,
- 5) customers with low annual usage or low usage in X out of the past Y months,
- 6) customers with credit problems,
- 7) multiple-family dwellings*, and
- 8) customers living in certain geographic areas within the service area*.

Type II exclusions differ from Type I in that the total number of eligible accounts in the resulting effective population is unknown when exclusions of the second type occur. Type II exclusions may be further subdivided according to whether they occur because of customers' behavior or because of other circumstances. The latter include:

- 1) wiring incompatibility or meter inaccessibility, and
- 2) failure to locate or contact the customer.

Customer behavior which may bias results includes:

- 1) failure to be included because of numerous customer complaints;
- 2) failure to participate in experiments (including, in some cases, failure to volunteer as a participant) or cooperate in interviews, and
- 3) failure to be included because of certain interview responses (e.g., an indication of an intent to move in the near future).

B.2 Notation

Let N^* denote the number of residential customers in the target population and N , the number in the sampled population. Assume that the sampled population is partitioned into H strata, with $N(h)$ customers in

* These are considered as Type I exclusions only if such information is available for all accounts. Otherwise, they are regarded as Type II exclusions. It should also be noted that these may be legitimate exclusions if, in practice, such customers would not be placed on a time-of-use rate.

the h^{th} stratum ($h = 1, 2, \dots, H$). Because of the type II exclusions, it is apparent that implementation of a time-of-use rate (under the same conditions as used in the experiment) would not expose the entire sampled population to such a rate. Under these conditions, then, one cannot make valid statistical inferences to the entire sampled population, but only to those customers who would have been experimental participants if given the opportunity. Assume that M customers are in this population of potential participants (i.e., in the effective population -- all customers not belonging to either of the exclusion categories); in the h^{th} stratum, assume that there are $M(h)$ customers in the effective population. This population structure is depicted in figure B.1.a.

As indicated in figure B.1.b, the sampling structure within each stratum generally involved the following steps:

- 1) drawing a random sample
- 2) screening a sufficient number of the selected customers so as to achieve a fixed sample size of participants
- 3) assigning these participants at random to each of several electricity rates.

Let K denote the number of rates (treatments) involved in the experiment (including, in general, a control group). Let $m(h)$ denote the number of sample participants in the h^{th} stratum and let $n(h)$ denote the number of customers screened in order to achieve this many participants. At a particular point in time, not all of the customers will provide valid consumption data; out of the $m_k(h)$ participants assigned (at random) to treatment k , assume that $r_k(h)$ do provide valid consumption data. In particular, let $Y(h,i)$ and $Z(h,i)$ denote the values of two unique functions of the consumption data for the i^{th} participant of the h^{th} stratum. Let $T_k(h,i)$ be equal to one if the i^{th} participant of the h^{th}

Figure B-1. Population and Sampling Structures

a. POPULATION
STRUCTURE:

b. SAMPLING STRUCTURE WITHIN
STRATUM (h) OF THE SAMPLED
POPULATION:

stratum is assigned to treatment k , and equal to zero, otherwise. Let $V_y(h,i)$ be equal to 1 if the i^{th} customer of h^{th} stratum provides a valid value of $Y(h,i)$, and equal to 0, otherwise. Note that

$$r_k(h) = \sum_{i=1}^{n(h)} V_y(h,i) T_k(h,i) \quad \text{and} \quad m_k(h) = \sum_{i=1}^{n(h)} T_k(h,i).$$

B.3. Estimation of Averages for the Effective Population

To estimate the average of a consumption variable Y for the effective population (if this population were exposed to the k^{th} treatment) requires that one estimate both the size of the effective population (M) and the total of the variable over the population (for the given treatment). It is assumed that a customer's participation or non-participation does not depend upon the particular treatment to which he has been assigned. The size of effective population can therefore be estimated as

$$\hat{M} = \sum_{h=1}^H \hat{M}(h)$$

where

$$\hat{M}(h) = N(h) \frac{m(h)-1}{n(h)-1}.$$

This estimate assumes that the number of rejections in the h^{th} stratum, $n(h)-m(h)$, represents an observation from a negative binomial distribution with parameters $m(h)$ and $p(h)$, where $p(h)$ is the probability that a customer (in this stratum) will be a participant in the experiment.

The total of the consumption variable Y --over the effective population exposed to treatment k --is estimated as

$$\hat{Y}_k = \sum_{h=1}^H \hat{M}(h) \hat{\bar{Y}}_k(h, \cdot)$$

where

$$\hat{\bar{Y}}_k(h, \cdot) = \sum_{i=1}^{n(h)} v_y(h, i) T_k(h, i) Y(h, i) / r_k(h)$$

is the estimated mean for stratum h when treatment k is in effect. In this formulation it is implicitly assumed that those customers providing valid data in the h^{th} stratum still constitute a random sample from the h^{th} stratum of the effective population.

The mean of Y for the effective population under treatment k is then estimated as the ratio

$$\hat{\bar{Y}}_k = \hat{\bar{Y}}_k / \hat{M}. \quad (\text{B-1})$$

The estimated variance of $\hat{\bar{Y}}_k$ is approximated as

$$\widehat{\text{Var}} \left[\frac{\hat{\bar{Y}}_k}{\hat{M}} \right] = \frac{1}{\hat{M}^2} \left[\widehat{\text{Var}}(\hat{\bar{Y}}_k) + \frac{\hat{\bar{Y}}_k^2}{\hat{M}^2} \widehat{\text{Var}}(\hat{M}) - 2 \frac{\hat{\bar{Y}}_k}{\hat{M}} \widehat{\text{Cov}}(\hat{\bar{Y}}_k, \hat{M}) \right]$$

This can be rewritten as

$$\widehat{\text{Var}} \left[\frac{\hat{\bar{Y}}_k}{\hat{M}} \right] = \frac{1}{\hat{M}^2} \sum_{h=1}^H \left\{ \left(\left[\hat{M}(h) \right]^2 + \hat{Q}(h) \right) \frac{s_k^2(h)}{r_k(h)} + \left(\frac{\hat{\bar{Y}}_k(h, \cdot) - \hat{\bar{Y}}_k}{\hat{M}} \right)^2 \hat{Q}(h) \right\} \quad (\text{B-2})$$

where

$$s_k^2(h) = \sum_{i=1}^{n(h)} v_y(h, i) T_k(h, i) \left[Y(h, i) - \hat{\bar{Y}}_k(h, \cdot) \right]^2 / [r_k(h) - 1]$$

and

$$\hat{Q}(h) = \widehat{\text{Var}} \left[\hat{M}(h) \right] = \hat{M}(h) \left[N(h) - \hat{M}(h) \right] / [n(h) - 2].$$

Note that if $\hat{M}(h) = N(h)$ for all h (i.e., a 100% participation rate), then equation (B-1) produces the estimated mean for the sampled population and, since $\hat{Q}(h) = 0$, equation (B-2) produces the appropriate variance for this estimate.

B.4 Estimation of Ratios of Averages for the Effective Population

Load factors and certain proportions are estimated for the effective population by combined ratio estimates of the form

$$\hat{R}_k = \frac{\hat{Y}_k}{\hat{Z}_k} = \frac{\sum_{h=1}^H \hat{M}(h) \hat{Y}_k(h, \cdot)}{\sum_{h=1}^H \hat{M}(h) \hat{Z}_k(h, \cdot)}.$$

The approximate variance of $\hat{R}_k$ is estimated as

$$\widehat{\text{Var}}(\hat{R}_k) = \frac{1}{\hat{Z}_k^2} \sum \left\{ \left(\left[\hat{M}(h) \right]^2 + \hat{Q}(h) \right) \hat{\Gamma}_k(h) + \left[\hat{\Delta}_k(h) \right]^2 \hat{Q}(h) \right\}$$

where

$$\hat{\Delta}_k(h) = \hat{Y}_k(h, \cdot) - \hat{R}_k \hat{Z}_k(h, \cdot),$$

$$\hat{\Gamma}_k(h) = \widehat{\text{Var}} \left[\hat{Y}_k(h, \cdot) \right] + \hat{R}_k^2 \widehat{\text{Var}} \left[\hat{Z}_k(h, \cdot) \right]$$

$$- 2\hat{\rho}_k(h) \hat{R}_k \sqrt{\widehat{\text{Var}} \left[\hat{Y}_k(h, \cdot) \right] \widehat{\text{Var}} \left[\hat{Z}_k(h, \cdot) \right]}$$

and $\hat{\rho}_k(h)$ = the estimated correlation between $Y(h,i)$ and $Z(h,i)$ for customers in stratum h and assigned to treatment k .

B.5 Interval Estimates for the Difference in Effective Population Parameters Under Two Different Treatments

Without loss of generality, assume that treatment k ($k=2,3,\dots,K$) is to be compared to treatment 1 with respect to a consumption variable

Y. More explicitly, assume that one wants a $(1-\alpha) \times 100\%$ confidence interval for the difference $\bar{Y}_k - \bar{Y}_1$. Approximate confidence limits are computed by

$$\hat{\bar{Y}}_k - \hat{\bar{Y}}_1 \pm C_\alpha \sqrt{\widehat{\text{Var}}\left[\hat{\bar{Y}}_k\right] + \widehat{\text{Var}}\left[\hat{\bar{Y}}_1\right] - 2\hat{\beta}_k} \quad (\text{B-3})$$

where C_α is the $(1 - \frac{\alpha}{2}) \times 100$ percentage point of the standard normal distribution, and

$$\hat{\beta}_k = \frac{1}{\hat{M}^2} \sum_{h=1}^H \hat{Q}(h) \left[\hat{\bar{Y}}_k(h, \cdot) - \hat{\bar{Y}}_k \right] \left[\hat{\bar{Y}}_1(h, \cdot) - \hat{\bar{Y}}_1 \right].$$

The null hypothesis that $\bar{Y}_1 = \bar{Y}_k$ is rejected at the α level of significance if the upper and lower confidence limits (B-3) are of the same sign.

Approximate $(1-\alpha) \times 100\%$ confidence limits for the difference $R_k - R_1$ are given by

$$\hat{R}_k - \hat{R}_1 \pm C_\alpha \sqrt{\widehat{\text{Var}}(\hat{R}_k) + \widehat{\text{Var}}(\hat{R}_1) - 2\hat{\gamma}_k}$$

where

$$\hat{\gamma}_k = \frac{1}{\hat{Z}_k \hat{Z}_1} \sum_{h=1}^H \hat{Q}(h) \hat{\Delta}_k(h) \hat{\Delta}_1(h).$$

APPENDIX C: LISTING OF CUSTOMERS FLAGGED BY AUTOMATED EDIT

The editing of the consumption data involved two steps (1) an automated edit, which excludes customers with large amounts of missing data and which flags customers having unusual consumption values (e.g., a high hourly consumption value, or a large number of hours with zero consumption), and (2) a "manual" edit, which allows the user, after examining the consumption patterns of the flagged customers, to delete specific customers from the data base (on a month-by-month basis). The consumption data for Connecticut had undergone extensive editing prior to its submission to the DOE data base. Data for an entire calendar month were deleted whenever any missing or "invalid" data occurred within the month. Hence, customers either had complete (i.e., no missing values) data for a month or no data for a month. As a result, there were no deletions made by the automated edit programs. A number of customers were flagged as having an unusually large number of hours of zero consumption. A listing of these customers is given in this appendix.

CUSTOMER ID	TREATMENT	STRATA	NUMBER OF ZERO KWH VALUES FOR RECORD TYPE *							MAXIMUM HOURLY USAGE IN MONTH	
			1	2	3	4	5	6	7	WEEKDAY	WEEKEND
			---	---	---	---	---	---	---	-----	-----

December - 1975

10	EXP	1	1	30	8	28	7	1	38	1.12	1.01
13	EXP	1	7	159	74	152	53	7	233	0.13	0.14
2012	EXP	3	2	30	10	29	9	2	40	10.30	12.65
2062	EXP	3	5	66	42	59	13	5	108	4.32	0.13
3006	EXP	4	1	14	0	14	2	1	14	8.14	5.20
3049	EXP	4	0	0	0	0	0	0	0	21.22	13.48
4006	EXP	5	0	0	0	0	0	0	0	22.75	20.09
4030	EXP	5	0	0	0	0	0	0	0	20.07	16.79
4035	EXP	5	0	0	0	0	0	0	0	25.63	16.16
4055	EXP	5	1	7	0	6	2	1	7	12.94	12.89
4058	EXP	5	0	0	0	0	0	0	0	24.75	23.36
5133	CNT	1	1	8	3	10	7	1	11	2.30	1.96
7154	CNT	3	0	0	0	0	0	0	0	29.36	28.58

January - 1976

10	EXP	1	1	36	10	39	27	9	46	0.76	1.12
13	EXP	1	18	178	76	220	131	50	254	0.14	0.14
93	EXP	1	1	1	0	1	1	1	1	1.19	1.30
3028	EXP	4	1	1	0	1	1	1	1	5.44	6.08
4006	EXP	5	0	0	0	0	0	0	0	21.56	21.28
4009	EXP	5	0	60	10	70	24	0	70	13.25	14.04
4010	EXP	5	0	1	0	1	1	0	1	21.80	16.90
4035	EXP	5	0	0	0	0	0	0	0	26.26	20.02
4058	EXP	5	0	2	0	2	0	0	2	29.84	26.12
5133	CNT	1	0	12	5	14	12	12	17	2.93	3.56
5170	CNT	1	1	15	10	15	2	2	25	1.21	2.03
7154	CNT	3	0	0	0	0	0	0	0	24.43	26.84

February - 1976

10	EXP	1	2	54	22	37	6	2	76	0.79	0.81
13	EXP	1	8	117	54	108	44	8	171	0.14	0.14
25	EXP	1	1	2	0	1	1	1	2	4.72	4.55
1039	EXP	2	1	1	0	1	1	1	1	4.03	5.33
1062	EXP	2	1	1	0	1	1	1	1	4.77	4.36
2006	EXP	3	2	2	0	2	2	2	2	4.21	4.19
4010	EXP	5	0	2	0	1	0	0	2	20.52	15.12
4028	EXP	5	2	2	0	2	2	2	2	10.39	9.36
4035	EXP	5	0	0	0	0	0	0	0	20.72	19.66
4058	EXP	5	0	0	0	0	0	0	0	26.55	21.58
5111	CNT	1	1	1	0	1	1	1	1	1.66	1.51
5118	CNT	1	1	1	0	1	1	1	1	5.36	4.72
5133	CNT	1	0	9	13	10	4	0	22	1.94	1.49
5137	CNT	1	0	129	58	47	0	0	187	1.80	2.21
5170	CNT	1	3	62	32	43	5	3	94	1.58	0.88
7154	CNT	3	0	0	0	0	0	0	0	28.62	18.70
7160	CNT	3	1	1	0	1	1	1	1	5.87	4.45
8120	CNT	4	1	1	0	1	1	1	1	4.55	4.43

CUSTOMER ID	TREATMENT	STRATA	NUMBER OF ZERO KWH VALUES FOR RECORD TYPE							MAXIMUM HOURLY USAGE IN MONTH	
			1	2	3	4	5	6	7	WEEKDAY	WEEKEND
			---	---	---	---	---	---	---		

March - 1976

10	EXP	1	3	88	35	55	0	0	123	0.79	0.76
13	EXP	1	13	170	37	124	0	0	207	0.16	0.14
4010	EXP	5	0	7	0	2	0	0	7	14.18	17.62
4030	EXP	5	0	0	0	0	0	0	0	20.30	16.76
4035	EXP	5	0	0	0	0	0	0	0	21.40	13.68
5117	CNT	1	1	3	0	3	0	0	3	4.41	2.95
5133	CNT	1	1	21	12	13	0	0	33	6.01	4.72
7154	CNT	3	0	0	0	0	0	0	0	27.94	2.79
9177	CNT	5	1	2	0	2	0	0	2	5.99	7.02

June - 1976

5	EXP	1	24	193	94	193	24	0	287	5.58	4.90
10	EXP	1	8	213	67	161	10	0	300	0.65	0.59
64	EXP	1	1	26	6	15	4	0	32	2.52	3.19
1017	EXP	2	0	1	1	1	1	0	2	4.09	4.45
1052	EXP	2	1	7	1	6	2	0	8	7.06	5.42
1063	EXP	2	4	80	9	58	8	0	89	4.63	5.29
2012	EXP	3	1	1	0	1	1	0	1	8.51	8.17
2018	EXP	3	1	23	7	20	2	0	30	5.58	5.99
2049	EXP	3	2	4	0	4	2	0	4	4.45	7.83
2051	EXP	3	1	6	0	6	1	0	6	6.05	8.69
3006	EXP	4	2	31	0	23	5	0	31	6.62	6.66
3019	EXP	4	1	17	14	13	3	0	31	7.63	6.35
3022	EXP	4	0	114	36	89	0	0	150	9.34	8.80
3038	EXP	4	0	27	0	22	0	0	27	3.15	3.33
4010	EXP	5	0	7	1	6	0	0	8	11.30	10.80
4047	EXP	5	4	41	0	41	10	0	41	8.48	9.65
4052	EXP	5	1	9	0	8	1	0	9	2.70	5.15
5136	CNT	1	0	64	19	64	0	0	83	5.49	5.33
5141	CNT	1	17	322	123	243	27	0	445	1.57	1.22
5161	CNT	1	0	35	16	25	2	0	51	4.77	3.89
9161	CNT	5	0	132	34	43	6	0	166	10.49	9.43

July - 1976

5	EXP	1	24	524	216	213	0	0	740	0.07	0.00
64	EXP	1	1	19	6	7	0	0	25	3.01	2.45
1052	EXP	2	0	6	0	4	0	0	6	5.72	2.92
1063	EXP	2	5	105	25	42	0	0	130	4.54	5.92
2018	EXP	3	1	23	10	10	0	0	33	6.23	5.47
2071	EXP	3	0	27	8	19	0	0	35	6.16	5.13
3001	EXP	4	24	361	164	98	0	0	525	8.73	4.70
3019	EXP	4	0	19	16	8	0	0	35	7.97	5.69
3030	EXP	4	17	247	106	89	0	0	353	5.62	5.00
3033	EXP	4	22	96	33	42	0	0	129	7.11	5.40
3038	EXP	4	4	55	0	24	0	0	55	3.83	2.99
4030	EXP	5	1	23	0	16	0	0	23	12.04	10.22
4047	EXP	5	2	43	13	28	0	0	56	9.13	8.60

CUSTOMER ID	TREATMENT	STRATA	NUMBER OF ZERO KWH VALUES FOR RECORD TYPE							MAXIMUM HOURLY USAGE IN MONTH	
			1	2	3	4	5	6	7	WEEKDAY	WEEKEND
			---	---	---	---	---	---	---	-----	-----
5141	CNT	1	19	360	150	134	0	0	516	2.09	0.70
8124	CNT	4	14	149	34	73	0	0	183	3.38	5.26

August - 1976

25	EXP	1	0	31	5	11	3	0	36	4.07	4.70
64	EXP	1	0	11	1	3	1	0	12	7.15	5.15
87	EXP	1	0	8	0	5	4	0	8	3.67	3.02
1052	EXP	2	1	1	0	1	1	0	1	7.72	5.56
1071	EXP	2	1	3	5	2	1	0	8	2.75	6.05
1084	EXP	2	0	65	0	17	0	0	65	4.70	3.56
2001	EXP	3	13	95	47	74	13	0	142	6.03	6.48
2018	EXP	3	0	17	5	2	0	0	22	6.25	3.20
3001	EXP	4	0	272	119	95	23	0	391	6.46	5.72
3006	EXP	4	1	23	0	8	2	0	23	7.33	7.33
3016	EXP	4	0	64	0	16	0	0	64	7.47	5.96
3019	EXP	4	0	25	14	10	1	0	39	7.58	7.92
3030	EXP	4	16	303	117	137	29	0	420	2.65	1.35
3033	EXP	4	24	337	165	174	27	0	502	4.39	2.93
4005	EXP	5	2	7	3	4	2	0	10	7.47	9.05
4019	EXP	5	1	1	0	1	1	0	1	8.77	9.29
4047	EXP	5	1	37	15	11	6	0	52	8.96	8.57
4052	EXP	5	1	5	1	4	2	0	6	4.03	4.82
5141	CNT	1	17	311	143	142	34	0	454	1.21	0.86
5185	CNT	1	1	7	7	3	1	0	14	1.19	1.30
5210	CNT	1	20	203	72	113	20	0	275	1.80	0.59

September - 1976

5	EXP	1	18	278	120	137	0	0	398	4.77	4.07
25	EXP	1	0	16	7	4	0	0	23	4.52	3.69
1052	EXP	2	0	8	0	3	0	0	8	5.63	5.33
1063	EXP	2	1	35	12	3	0	0	47	5.11	4.23
1071	EXP	2	2	30	6	8	0	0	36	4.86	2.20
2001	EXP	3	11	46	13	20	0	0	59	1.58	1.82
2012	EXP	3	0	2	0	2	0	0	2	8.66	5.85
2018	EXP	3	0	7	1	3	0	0	8	6.07	6.93
2030	EXP	3	0	2	0	2	0	0	2	5.36	4.21
3006	EXP	4	0	18	0	6	0	0	18	6.37	7.04
3019	EXP	4	2	13	15	7	0	0	28	6.05	5.62
3022	EXP	4	1	4	2	1	0	0	6	10.40	8.75
3030	EXP	4	14	282	126	80	0	0	408	1.75	1.31
3033	EXP	4	0	237	108	17	0	0	345	3.38	3.55
4009	EXP	5	1	13	0	4	0	0	13	9.29	9.83
4014	EXP	5	2	20	4	2	0	0	24	9.59	10.58
4030	EXP	5	1	10	0	3	0	0	10	18.43	17.05
4047	EXP	5	0	2	0	2	0	0	2	9.14	9.29
4052	EXP	5	0	7	0	3	0	0	7	6.95	10.55
5141	CNT	1	12	265	119	81	0	0	384	0.77	0.61
5161	CNT	1	1	44	18	6	0	0	62	4.34	3.51
5181	CNT	1	0	0	22	0	0	0	22	4.93	4.37
5185	CNT	1	1	6	6	3	0	0	12	1.58	1.64

CUSTOMER ID	TREATMENT	STRAIT	NUMBER OF ZERO KWH VALUES FOR RECORD TYPE							MAXIMUM HOURLY USAGE IN MONTH	
			1	2	3	4	5	6	7	WEEKDAY	WEEKEND
			---	---	---	---	---	---	---	-----	-----
6128	CNT	2	1	17	8	3	0	0	25	5.00	4.36
9114	CNT	5	0	134	71	29	0	0	205	8.32	7.96
9161	CNT	5	0	72	21	0	0	0	93	6.98	4.18

* Record Type Definitions

- 1...Day of monthly system peak
- 2...Weekdays, excluding holidays
- 3...Weekend days, including holidays
- 4...All days where system load exceeds 0.80 times the assumed annual system peak
- 5...All days where system load exceeds 0.90 times the assumed annual system peak
- 6...All days where system load exceeds 0.95 times the assumed annual system peak
- 7...All days

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APPENDIX D: COMPARISON OF EXPERIMENTAL AND CONTROL RATES

This appendix contains nine tables. Eight of these tables provide sets of summary statistics for the months of December 1975, and January-March and June-September of 1976. The 20 parameters identified in the first column of each table are described in Table D-1. A detailed description of each parameter was given in Section 3.1 of Chapter 3. Columns 2-4 of each table gives respectively, the sample size, parameter estimate and standard error of the estimate for the control group. Columns 5-7 give corresponding values for the experimental group. For both groups, sample results have been weighted to produce estimates and standard errors applicable to the effective population. Column 8 shows the difference in parameter estimates for the control and experimental groups. The standard error of this estimated difference is given in column 9. The hypothesis that the difference between the actual population parameters for the two groups is zero is tested and the result indicated by the standard notation of a single asterisk for statistical significance at the .05 level of significance or a double asterisk for significance at the .01 level. An approximate ninety-nine percent confidence interval for the true difference is given in the last two columns. This interval is constructed such that the chances are 99 times out of 100 that the interval will cover the true difference between the population parameters.

Table D-1. List of Parameters Estimated in Comparative Analysis
(Estimated per customer)

	Parameter Number	Description
Average for Day of Monthly System Peak	1	kWh - peak
	2	kWh - intermediate
	3	kWh - base
	4	kWh - during 1-hr. preceding peak period
	5	kWh - during 1-hr. following peak period
	6	Total kWh
Average for All Days of Month	7	kWh - peak
	8	kWh - intermediate
	9	kWh - base
	10	kWh - during 1-hr. preceding peak period
	11	kWh - during 1-hr. following peak period
	12	Total kWh
Average per Customer	13	Diversified demand at time of observed monthly system peak
	14	Noncoincident maximum demand
Average for Subset of Hours during Month	15	Average hourly kWh consumed during all hrs. of observed system load greater than 80% of <u>annual</u> system peak
	16	Average hourly kWh consumed during all hrs. of observed system load greater than 90% of <u>annual</u> system peak
	17	Average hourly kWh consumed during all hrs. of observed system load greater than 95% of <u>annual</u> system peak
Ratio	18	Proportion of total kWh used during peak period on peak day [#1/#6]
	19	Proportion of total kWh used during peak period on average day [#7/#12]
	20	Class load factor based on diversified demand at time of observed monthly system peak (#12/#13 ÷ 24)

Table D-2. Comparison of Experimental and Control Rates - December 1975

PARAMETER ESTIMATES FOR CNI				PARAMETER ESTIMATES FOR EXP				TEST FOR TREATMENT DIFFERENCES			
PARAMETER	N	ESTIMATE	STD.ERR.	PARAMETER	N	ESTIMATE	STD.ERR.	DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
1	162	6.655	0.292	1	193	5.160	0.264	-1.496**	0.343	-2.380	-0.611
2	162	12.557	0.541	2	193	12.139	0.591	-0.418	0.683	-2.176	1.341
3	162	11.847	0.548	3	193	13.983	0.643	2.135**	0.695	0.344	3.926
4	162	2.685	0.129	4	193	2.879	0.149	0.193	0.171	-0.247	0.634
5	162	3.258	0.168	5	193	2.758	0.147	-0.500*	0.198	-1.010	0.009
6	162	31.060	1.267	6	193	31.282	1.394	0.222	1.532	-3.723	4.167
7	162	4.590	0.167	7	193	3.640	0.153	-0.950**	0.186	-1.430	-0.470
8	162	15.275	0.554	8	193	14.567	0.556	-0.708	0.608	-2.273	0.857
9	162	11.991	0.509	9	193	13.535	0.585	1.544*	0.620	-0.053	3.142
10	162	1.978	0.080	10	193	2.042	0.086	0.064	0.094	-0.177	0.305
11	162	2.286	0.087	11	193	1.904	0.078	-0.382**	0.096	-0.629	-0.135
12	162	31.856	1.190	12	193	31.743	1.245	-0.113	1.331	-3.541	3.314
13	162	2.082	0.098	13	193	1.625	0.096	-0.457**	0.126	-0.783	-0.132
14	162	6.060	0.234	14	193	5.824	0.185	-0.236	0.259	-0.903	0.430
15	162	1.613	0.060	15	193	1.417	0.057	-0.196**	0.067	-0.368	-0.024
16	162	1.887	0.074	16	193	1.497	0.070	-0.391**	0.085	-0.610	-0.171
17	162	2.082	0.098	17	193	1.625	0.096	-0.457**	0.126	-0.783	-0.132
18	162	0.214	0.005	18	193	0.165	0.004	-0.049**	0.006	-0.065	-0.033
19	162	0.144	0.002	19	193	0.115	0.002	-0.029**	0.003	-0.036	-0.022
20	162	0.657	0.022	20	193	0.814	0.034	0.177**	0.041	0.072	0.281

Table D-3. Comparison of Experimental and Control Rates - January 1976

PARAMETER ESTIMATES FOR CNT				PARAMETER ESTIMATES FOR EXP				TEST FOR TREATMENT DIFFERENCES			
	N	ESTIMATE	STD.ERR.		N	ESTIMATE	STD.ERR.		DIFFERENCE	STD.ERR.	99% CONF. LIMITS
1	166	7.768	0.361	:	194	6.652	0.375	:	-1.116*	0.451	-2.276 0.045
2	166	15.418	0.769	:	194	15.431	0.804	:	0.013	0.934	-2.392 2.419
3	166	15.544	0.895	:	194	19.129	1.140	:	3.585**	1.244	0.381 6.790
4	166	3.499	0.185	:	194	3.754	0.206	:	0.255	0.233	-0.344 0.855
5	166	3.794	0.214	:	194	3.461	0.193	:	-0.334	0.255	-0.990 0.323
6	166	38.729	1.919	:	194	41.212	2.192	:	2.483	2.429	-3.774 8.741
7	166	4.550	0.177	:	194	3.701	0.167	:	-0.850**	0.203	-1.373 -0.326
8	166	16.339	0.636	:	194	16.040	0.644	:	-0.299	0.711	-2.131 1.533
9	166	12.869	0.613	:	194	15.252	0.729	:	2.383**	0.778	0.379 4.387
10	166	2.033	0.085	:	194	2.116	0.093	:	0.083	0.101	-0.177 0.343
11	166	2.273	0.097	:	194	1.994	0.085	:	-0.279**	0.108	-0.558 -0.000
12	166	33.758	1.381	:	194	34.992	1.483	:	1.234	1.599	-2.884 5.352
13	166	1.593	0.108	:	194	1.401	0.104	:	-0.192	0.137	-0.544 0.161
14	166	5.957	0.218	:	194	5.912	0.186	:	-0.045	0.247	-0.682 0.592
15	166	1.601	0.064	:	194	1.507	0.063	:	-0.095	0.072	-0.280 0.091
16	166	1.776	0.075	:	194	1.610	0.074	:	-0.166	0.086	-0.388 0.056
17	166	1.901	0.083	:	194	1.701	0.085	:	-0.200*	0.100	-0.457 0.057
18	166	0.201	0.004	:	194	0.161	0.004	:	-0.039**	0.006	-0.054 -0.025
19	166	0.155	0.002	:	194	0.106	0.002	:	-0.029**	0.003	-0.036 -0.022
20	166	0.583	0.041	:	194	1.041	0.052	:	0.158*	0.066	-0.013 0.328

Table D-4. Comparison of Experimental and Control Rates - February 1976

	PARAMETER ESTIMATES FOR CNT			PARAMETER ESTIMATES FOR EXP			TEST FOR TREATMENT DIFFERENCES			
	N	ESTIMATE	STD.ERR.	N	ESTIMATE	STD.ERR.	DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
D-5	176	7.965	0.499	189	6.213	0.324	-1.752**	0.540	-3.144	-0.360
	176	16.557	0.826	189	16.012	0.765	-0.545	0.950	-2.992	1.901
	176	11.536	0.505	189	13.975	0.668	2.639**	0.692	0.856	4.423
	176	3.405	0.200	189	3.384	0.180	-0.021	0.241	-0.641	0.599
	176	3.970	0.192	189	3.636	0.180	-0.333	0.222	-0.906	0.239
	176	35.857	1.693	189	36.200	1.608	0.342	1.922	-4.609	5.293
	176	4.141	0.159	189	3.249	0.132	-0.892**	0.171	-1.333	-0.451
	176	14.058	0.516	189	13.687	0.485	-0.371	0.547	-1.780	1.038
	176	11.022	0.474	189	13.288	0.581	2.267**	0.601	0.718	3.815
	176	1.804	0.071	189	1.846	0.074	0.043	0.082	-0.167	0.253
	176	2.066	0.083	189	1.802	0.070	-0.264**	0.089	-0.494	-0.034
	176	29.221	1.105	189	30.225	1.123	1.004	1.205	-2.100	4.108
	176	2.250	0.165	189	1.898	0.104	-0.352	0.182	-0.821	0.116
	176	5.731	0.215	189	5.721	0.177	-0.010	0.244	-0.639	0.620
	176	1.526	0.062	189	1.395	0.056	-0.131	0.067	-0.303	0.042
	176	1.790	0.083	189	1.568	0.072	-0.222*	0.091	-0.457	0.013
	176	2.299	0.138	189	1.935	0.095	-0.364*	0.150	-0.751	0.023
	176	0.222	0.006	189	0.172	0.004	-0.050**	0.008	-0.070	-0.031
	176	0.142	0.002	189	0.108	0.002	-0.034**	0.003	-0.042	-0.027
	176	0.541	0.030	189	0.660	0.024	0.123**	0.042	0.015	0.230

Table D-5. Comparison of Experimental and Control Rates - March 1976

PARAMETER ESTIMATES FOR CNT				PARAMETER ESTIMATES FOR EXP			TEST FOR TREATMENT DIFFERENCES					
	N	ESTIMATE	STD.ERR.		N	ESTIMATE	STD.ERR.		DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
1	181	6.353	0.275	:	187	5.027	0.245	:	-1.327**	0.311	-2.129	-0.524
2	181	13.450	0.592	:	187	12.796	0.556	:	-0.655	0.668	-2.374	1.065
3	181	12.419	0.576	:	187	14.853	0.690	:	2.434**	0.725	0.568	4.301
4	181	3.035	0.148	:	187	2.986	0.157	:	-0.049	0.186	-0.529	0.430
5	181	3.276	0.161	:	187	2.983	0.140	:	-0.293	0.186	-0.773	0.186
6	181	32.222	1.350	:	187	32.675	1.368	:	0.453	1.505	-3.424	4.329
7	181	4.178	0.152	:	187	3.117	0.127	:	-1.061**	0.167	-1.490	-0.631
8	181	12.906	0.446	:	187	12.024	0.413	:	-0.882	0.472	-2.099	0.334
9	181	10.601	0.410	:	187	12.097	0.481	:	1.496**	0.488	0.238	2.754
10	181	1.804	0.069	:	187	1.900	0.077	:	0.016	0.082	-0.195	0.228
11	181	2.109	0.083	:	187	1.818	0.068	:	-0.290**	0.089	-0.520	-0.060
12	181	27.685	0.959	:	187	27.258	0.946	:	-0.447	1.009	-3.046	2.152
13	181	1.978	0.092	:	187	1.493	0.081	:	-0.485**	0.107	-0.762	-0.208
14	181	5.650	0.211	:	187	5.452	0.164	:	-0.197	0.234	-0.800	0.405
15	181	1.457	0.056	:	187	1.288	0.051	:	-0.169**	0.060	-0.323	-0.015
16	0			:	0			:				
17	0			:	0			:				
18	181	0.197	0.003	:	187	0.154	0.004	:	-0.043**	0.005	-0.057	-0.030
19	181	0.151	0.002	:	187	0.114	0.003	:	-0.036**	0.003	-0.045	-0.028
20	181	0.583	0.018	:	187	0.760	0.030	:	0.177**	0.035	0.086	0.268

Table D-6. Comparison of Experimental and Control Rates - June 1976

PARAMETER	PARAMETER ESTIMATES FOR CHT			:	PARAMETER ESTIMATES FOR EXP.			:	TEST FOR TREATMENT DIFFERENCES		
	N	ESTIMATE	STD.ERR.		N	ESTIMATE	STD.ERR.		DIFFERENCE	STD.ERR.	99% CONF. LIMITS
1	147	5.561	0.364	:	182	3.394	0.205	:	-2.168**	0.403	-3.206 -1.129
2	147	13.874	0.728	:	182	10.727	0.559	:	-3.147**	0.860	-5.362 -0.932
3	147	10.210	0.526	:	182	9.849	0.479	:	-0.361	0.666	-2.077 1.354
4	147	2.649	0.182	:	182	1.425	0.090	:	-1.223**	0.196	-1.730 -0.719
5	147	2.775	0.184	:	182	1.983	0.121	:	-0.792**	0.213	-1.339 -0.244
6	147	29.646	1.450	:	182	23.970	1.106	:	-5.676**	1.691	-10.032 -1.320
7	147	3.180	0.151	:	182	2.198	0.098	:	-0.982**	0.167	-1.412 -0.551
8	147	12.705	0.491	:	182	10.569	0.395	:	-2.137**	0.553	-3.561 -0.713
9	147	8.588	0.370	:	182	8.616	0.348	:	0.029	0.459	-1.154 1.211
10	147	1.526	0.075	:	182	0.952	0.045	:	-0.574**	0.083	-0.787 -0.361
11	147	1.688	0.076	:	182	1.279	0.055	:	-0.409**	0.087	-0.633 -0.184
12	147	24.473	0.947	:	182	21.383	0.782	:	-3.089**	1.079	-5.868 -0.311
13	147	1.259	0.101	:	182	0.767	0.055	:	-0.491**	0.113	-0.782 -0.201
14	147	5.435	0.188	:	182	4.983	0.170	:	-0.452	0.233	-1.051 0.147
15	147	1.213	0.057	:	182	0.872	0.038	:	-0.341**	0.063	-0.503 -0.178
16	147	1.354	0.083	:	182	0.847	0.045	:	-0.506**	0.091	-0.740 -0.273
17	0			:	0			:			
18	147	0.188	0.006	:	182	0.142	0.006	:	-0.046**	0.008	-0.067 -0.025
19	147	0.130	0.003	:	182	0.103	0.003	:	-0.027**	0.004	-0.038 -0.016
20	147	0.810	0.051	:	182	1.161	0.072	:	0.351**	0.088	0.125 0.577

Table D-7. Comparison of Experimental and Control Rates - July 1976

PARAMETER	PARAMETER ESTIMATES FOR CNI			PARAMETER ESTIMATES FOR EXP			TEST FOR TREATMENT DIFFERENCES			
	N	ESTIMATE	STD.ERR.	N	ESTIMATE	STD.ERR.	DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
1	141	4.658	0.296	183	5.314	0.206	-1.343**	0.348	-2.239	-0.448
2	141	11.899	0.652	183	9.347	0.445	-2.553**	0.743	-4.466	-0.639
3	141	9.290	0.487	183	8.517	0.407	-0.773	0.592	-2.297	0.752
4	141	2.281	0.171	183	1.343	0.076	-0.938**	0.183	-1.410	-0.466
5	141	2.441	0.159	183	1.926	0.111	-0.515**	0.186	-0.994	-0.036
6	141	25.847	1.286	183	21.178	0.932	-4.669**	1.475	-8.467	-0.870
7	141	5.032	0.149	183	2.214	0.099	-0.818**	0.166	-1.245	-0.391
8	141	12.235	0.541	183	10.430	0.410	-1.805**	0.610	-3.377	-0.234
9	141	8.559	0.413	183	8.227	0.332	-0.332	0.488	-1.588	0.925
10	141	1.508	0.071	183	0.994	0.047	-0.515**	0.080	-0.720	-0.309
11	141	1.591	0.077	183	1.274	0.056	-0.316**	0.089	-0.545	-0.088
12	141	23.826	1.048	183	20.872	0.786	-2.955*	1.179	-5.992	0.083
13	141	1.104	0.080	183	0.707	0.046	-0.397**	0.090	-0.628	-0.165
14	141	5.030	0.183	183	4.913	0.167	-0.117	0.219	-0.681	0.446
15	141	1.161	0.061	183	0.813	0.038	-0.347**	0.067	-0.521	-0.174
16	0			0						
17	0			0						
18	141	0.180	0.006	183	0.156	0.006	-0.024**	0.009	-0.046	-0.001
19	141	0.127	0.003	183	0.106	0.003	-0.021**	0.004	-0.031	-0.011
20	141	0.900	0.048	183	1.230	0.066	0.330**	0.082	0.120	0.541

Table D-8. Comparison of Experimental and Control Rates - August 1976

PARAMETER	PARAMETER ESTIMATES FOR CWT			:	N	PARAMETER ESTIMATES FOR EXP		:	TEST FOR TREATMENT DIFFERENCES			
	:	ESTIMATE	STD.ERR.			ESTIMATE	STD.ERR.		DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
1	: 136	5.384	0.309	:	180	3.720	0.229	:	-1.663**	0.421	-2.749	-0.578
2	: 136	15.199	0.706	:	180	11.316	0.579	:	-1.883*	0.863	-4.107	0.341
3	: 136	10.205	0.598	:	180	10.693	0.522	:	0.487	0.759	-1.467	2.442
4	: 136	2.655	0.175	:	180	1.634	0.106	:	-1.021**	0.200	-1.536	-0.506
5	: 136	2.792	0.180	:	180	2.112	0.124	:	-0.680**	0.210	-1.222	-0.138
6	: 136	28.788	1.423	:	180	25.729	1.205	:	-3.059	1.751	-7.570	1.452
7	: 136	2.978	0.146	:	180	2.195	0.096	:	-0.783**	0.162	-1.202	-0.365
8	: 136	12.871	0.538	:	180	11.121	0.425	:	-1.749**	0.619	-3.344	-0.155
9	: 136	8.502	0.406	:	180	8.289	0.325	:	-0.213	0.480	-1.450	1.023
10	: 136	1.477	0.071	:	180	0.962	0.043	:	-0.516**	0.077	-0.715	-0.316
11	: 136	1.572	0.076	:	180	1.243	0.054	:	-0.329**	0.087	-0.554	-0.104
12	: 136	24.351	1.043	:	180	21.605	0.791	:	-2.746*	1.184	-5.795	0.302
13	: 136	1.346	0.113	:	180	0.803	0.058	:	-0.543**	0.125	-0.865	-0.220
14	: 136	5.350	0.192	:	180	5.252	0.177	:	-0.097	0.233	-0.697	0.502
15	: 136	1.228	0.062	:	180	0.937	0.043	:	-0.291**	0.071	-0.475	-0.108
16	: 136	1.351	0.080	:	180	0.931	0.051	:	-0.419**	0.092	-0.655	-0.183
17	: 0			:	0			:				
18	: 136	0.187	0.007	:	180	0.145	0.006	:	-0.042**	0.009	-0.066	-0.019
19	: 136	0.122	0.003	:	180	0.102	0.002	:	-0.021**	0.004	-0.030	-0.011
20	: 136	0.754	0.056	:	180	1.122	0.068	:	0.368**	0.088	0.141	0.594

Table D-9. Comparison of Experimental and Control Rates - September 1976

PARAMETER	PARAMETER ESTIMATES FOR CNT			PARAMETER ESTIMATES FOR EXP			TEST FOR TREATMENT DIFFERENCES			
	N	ESTIMATE	STD.ERR.	N	ESTIMATE	STD.ERR.	DIFFERENCE	STD.ERR.	99% CONF. LIMITS	
1	160	3.676	0.215	179	2.865	0.154	-0.811**	0.255	-1.469	-0.154
2	160	10.783	0.475	179	9.138	0.368	-1.646**	0.559	-3.085	-0.207
3	160	8.356	0.362	179	8.426	0.352	0.070	0.462	-1.121	1.261
4	160	1.757	0.108	179	1.301	0.086	-0.456**	0.134	-0.802	-0.111
5	160	2.095	0.116	179	1.682	0.096	-0.414**	0.146	-0.789	-0.038
6	160	22.816	0.939	179	20.429	0.764	-2.387*	1.106	-5.235	0.461
7	160	2.575	0.115	179	1.973	0.081	-0.602**	0.129	-0.933	-0.271
8	160	12.271	0.441	179	10.750	0.370	-1.521**	0.498	-2.803	-0.239
9	160	7.911	0.313	179	7.902	0.293	-0.010	0.380	-0.988	0.969
10	160	1.273	0.059	179	0.868	0.038	-0.404**	0.056	-0.573	-0.236
11	160	1.397	0.058	179	1.151	0.049	-0.247**	0.070	-0.427	-0.067
12	160	22.757	0.829	179	20.625	0.689	-2.133*	0.931	-4.530	0.265
13	160	0.846	0.057	179	0.632	0.049	-0.214**	0.073	-0.402	-0.026
14	160	5.254	0.166	179	5.015	0.168	-0.240	0.211	-0.784	0.305
15	160	0.937	0.046	179	0.661	0.030	-0.276**	0.054	-0.414	-0.137
16	0			0						
17	0			0						
18	160	0.161	0.006	179	0.140	0.005	-0.021**	0.008	-0.041	-0.001
19	160	0.113	0.003	179	0.096	0.002	-0.017**	0.004	-0.027	-0.008
20	160	1.121	0.065	179	1.360	0.100	0.239*	0.119	-0.067	0.546

D-10

APPENDIX E: AVERAGE DAILY LOAD CURVES, SELECTED MONTHS

Appendix E contains average daily load curves for the months of December 1975, January - March and June - September 1976. Four types of average daily load curves are given for each month: day of monthly system peak, weekend days during the month, weekdays during the month, and all days during the month.

Figure E-1. Average Daily Load Curve for Control and Experimental Rate Schedule, December 1975

DAY OF SYSTEM PEAK

WEEKEND DAYS

Figure E-2. Average Daily Load Curve for Control and Experimental
Rate Schedule, January 1976

Figure E-3. Average Daily Load Curve for Control and Experimental
Rate Schedule, February 1976

E-4

Figure E-4. Average Daily Load Curve for Control and Experimental Rate Schedule, March 1976

E-5

Figure E-5. Average Daily Load Curve for Control and Experimental
Rate Schedule, June 1976

9-E

Figure E-6. Average Daily Load Curve for Control and Experimental Rate Schedule, July 1976

Figure E-7. Average Daily Load Curve for Control and Experimental Rate Schedule, August 1976

Figure E-8. Average Daily Load Curve for Control and Experimental Rate Schedule, September 1976

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