Load Research Program
Analysis of Load Research Data

Load Research Program

Analysis of Load Research Data

NEWFOUNDLAND POWER

Newfoundland Power's Load Research Program
Analysis of Load Research Data

Table of Contents

Table of Figures and Illustrations

Appendix C Figures and Tables

Executive Summary

The Load Research Program began in 1989 when load metering equipment was placed on a group of Rate 2.4 (General Service 1000 kVA plus) customers. Since then samples have been designed and implemented for the Residential and Rate 2.3 (General Service 110 to 1000 kVA) customer classes. The objective of the study was to accurately identify the usage patterns of these classes of customers.

The samples were designed using a probabilistic sampling approach so quantitative measures of reliability and confidence could be attributed to the load estimates. The Delanius-Hodges Method for stratification and the Neyman Allocation Method for calculating optimal sample size were two statistical techniques utilized in the design of the samples. The samples were designed to achieve results within an error bound of 10% at a 90% confidence.

Demand data on a 15-minute interval bases was collected from the studied customers. The retrieved demand data from the studied group of Rate 2.4 customers was simply summed to represent the group of Rate 2.4 studied customers (this group did not include all Rate 2.4 customers -- technical problems and uncertainties in the continuation of some customers operations resulted in some customers being excluded).

The data that was collected from the Residential and Rate 2.3 samples was used to make estimates of population demands using Ratio Estimation. This procedure made a demand to energy correlation for the sample and then applied that correlation to the population energy (the total billed energy of the class). Based on the variance of the sample demands measures of accuracy for the population load estimates were calculated.

Three winter seasons were included in the study, 1991/92, 1992/93 and 1993/94. The highest peak during these seasons was 1,098,337 kW on Wednesday, February 9, 1994 at 8:15 AM. The 1991/92 peak was 1,090,068 kW on Monday, March 2, 1992 at 12:00 PM and the 1992/93 peak was 1,027,735 kW on Wednesday, January 20, 1993 at 5:30 PM. In addition to these peaks the alternate peak for the 1991/92 winter season was analyzed. It occurred on a weekend day and demonstrated different load characteristics than the weekday peaks. This peak occurred on Sunday March 1, 1992 at 8:00 PM, the peak load was 1,041,660 kW.

During the 1993 calendar year the system maintained 90% of its peak load for 2.2% of the year. The load factor for the system load for the 1993 calendar year was approximately 52%.

The largest portion of system load was comprised of the Residential class. It made up over 59% of the three peak intervals and maintained a monthly coincidence factor of over 88% for all three of these intervals. The Residential class annual load factor based on its class peak was approximately 42%. The Residential load factor based on its demand at the time of system peak was approximately 45%.

The demand load estimates for the Residential class peak demands during the three winter seasons all meet the desired accuracy. The accuracies for the Residential class at the time of the winter season system peaks were also within the desired accuracy except for the 1991/92 winter season peak. The accuracy was 12%. A higher variance in sample demands during this interval caused the accuracy to be outside the desired range.

The Rate 2.3 class of customers made up over 12% of each of the winter season system peaks. The monthly coincidence factors for the Rate 2.3 class during these intervals was over 80%.

The demand load estimates for the Rate 2.3 class peak demands and demands at the time of system peaks during the three winter seasons all meet the desired accuracy. There were also good accuracies achieved in off peak months for the Rate 2.3 class.

The load data that was collected for the Rate 2.4 customers showed they made up a larger portion of the system load in months with warmer weather. The size of their load remained fairly constant throughout the year. Consequently, the Rate 2.4 customers maintained load factors of 60% based on the class peak and 66% based on Rate 2.4's class demand at time of system peak.

The data that has been collected and summarized in this report has provided a foundation for understanding the usage patterns of Newfoundland Power's customers. The data will be a useful source of input into such applications as the Cost of Service Study and Long Term Forecasting.

Introduction

1.0 INTRODUCTION

Newfoundland Power became involved in load research in the 1970's as a result of Order 36(1976) of the Public Utilities Board which required the company "to conduct load research on its various classes of service". The initial program was based on a non-probabilistic sample and therefore its accuracy could not be gauged. This program changed very little over the next decade and in 1987 a revised load research program was proposed and adopted.

Implementation of Phase I of the revised program began in late 1989 when load monitoring equipment began to be installed on Rate 2.4 customers. The bulk of the equipment installations were completed by mid 1990.

In the following year a sample of Rate 1.1 (Residential) customers was selected, followed by a sample of Rate 2.3 (General Service 110 kVA - 1000 kVA) customers being selected in late 1991. Presently the equipment that has been installed on the Rate 1.1 class is being removed and prepared for installation on a combined sample of Rate 2.1 (General Service 0-10 kW) and Rate 2.2 (General Service 10-100 kW) customers in 1995. Illustration 1.1 gives an overview of the Phase implementations and the plans of the program.

Illustration 1.1 Schedule of Phase Implementation

Phase\Year	1989	1990	1991	1992	1993	1994	1995
Phase I G.S. 2.4 Over 1000 kVA							
Phase II Residential Study							
Phase III G.S. 2.3 110-1000 kVA							
Phase IV G.S. 2.1 & 2.2 0-10 kW & 10-100 kW							

The report that follows contains the results of this load research study that has been ongoing at Newfoundland Power since 1989. More specifically the load characteristics of the Residential customer class, and the General Service classes Rate 2.3 and Rate 2.4 will be analyzed.

Study Objectives

2.0 STUDY OBJECTIVES

Planning and operating functions within the utility require reliable data describing customer load characteristics. This data is used in such applications as cost of service studies, rate design, energy and peak load forecasting, and system planning. These applications typically require data such as the time and magnitude of class peak loads, class contribution to system peak, individual customer peak loads and the diversity of these loads, and typical daily load profiles of each customer class.

Load research is seen as an effective means of addressing this need for data. By installing load survey meters/data recorders on statistical samples of representative customers, reliable data describing customer load characteristics can be obtained.

In 1989 when the study was initiated, the Residential and General Service Rate 2.3 and Rate 2.4 classes accounted for almost 85% of total energy sales. Rate 2.4 accounted for over 7% of total energy sales while it comprised a fraction of a percent of total customers serviced. Rate 2.3 accounted for over 17% of total energy sales and made up less then half a percent of total customers serviced. The Residential customer class was the largest group of customers both in terms of energy sales and percentage of customers, accounting for approximately 59% of total energy sales and comprising approximately 85% of all customers serviced. The relative size of these rate classes and the fact that little was known about their load characteristics made them prime candidates for the load research study.

It was not practical to include all customer classes in the study at the same time. The cost and logistics involved in undertaking such a massive study would be restrictive given the available resources. Hence, General Service Rate 2.1 and Rate 2.2 were not included in the initial study.

The primary reason for collecting load research data was to derive load factors for allocating demand costs in Newfoundland Power's Cost of Service Study. This objective to provide information to the Cost of Service Study was the focus of the sample design. The stratification and sample size procedures were gauged such that the designed strata reflected the customer groups used in the Cost of Service Study (i.e., primary versus secondary voltage supply, Residential with electric space heating as their primary source of heating versus Residential with an alternate form of space heating). Sample sizes were then calculated to achieve reasonable accuracies within these groups.

Basic data being collected from sample customers includes:

I) A record of kilowatt-hour consumption by billing month (obtained from the billing system).

II) 15-minute kW demand data (obtained from load research meters/data recorders). For General Service customers kvar demand data was also obtained on a 15-minute basis.

This basic sample data is analyzed and expanded such that it can be used in the various applications that require load information. In doing this, care is taken to maintain the integrity and validity of the data. The provision of this data to the end user in an accurate and valid state is the primary objective of the Load Research Program.

Sample Design and Selection

3.0 SAMPLE DESIGN AND SELECTION

Since the population of the Rate 2.4 customer class was less than fifty customers and their individual loads were so large and diverse, it was determined that a sample would not be representative and that a census of all Rate 2.4 customers and potential Rate 2.4 customers would be required. However, the opposite was true of the Residential and Rate 2.3 customer classes in that the populations of those classes were so large that a census was impractical. Therefore, samples were designed for each of these classes.

The samples were designed using a probabilistic sampling approach so quantitative measures of reliability and confidence could be attributed to estimates of load. This also ensured that the best possible estimates of population characteristics could be made, given a set of expensive resources (i.e. metering equipment).

The objective of the sample design was to estimate class loads (kW) at time of system peak within an error of ten percent with a ninety percent confidence. Two techniques used in the development of the samples were: 1) the Delanius-Hodges Method, for dividing a population into optimal strata (called "stratification"); and 2) the Neyman Allocation Method, for calculating the optimal sample size (for a given reliability and confidence level) within each stratum.

3.1 STRATIFICATION

A stratified random sampling technique was utilized in the design of the samples. By stratifying the populations it divided them into smaller homogeneous sub-populations that did not require as large a sample size to meet the precision requirements. This was beneficial because of the high marginal cost per sample point.

The variable to stratify on was also of importance in designing the samples. When stratifying the populations it was desirable to do so based on the variable of interest, kW demands at time of system peak. This information was not available for the classes being studied, consequently, auxiliary variables had to be used. These are variables that are highly correlated with the variable of interest. For the Residential class, 12 month averages of monthly billed kWh's were used, and for the Rate 2.3 class, monthly billing demands were used.

3.1.1 RESIDENTIAL STRATIFICATION

The Residential class was treated as two distinct groups when its sample was being designed. One group was made up of customers with electric space heating (All Electric) and the other group was made up of customers with an alternate form of space heating (Domestic Regular). These two groups were then stratified based on the auxiliary variable of 12 month averages of monthly billed kWh's. This resulted in the definition of three strata for each group.

The boundaries of these strata were defined with the aid of the Delanius-Hodges Method. A frequency distribution of energy intervals and customers was formulated. The cumulative sum of the square root of the number of customers per energy interval was then used to identify stratum boundaries. An example of the calculation of the stratum boundaries for the Domestic Regular customer group is provided in Appendix B. Illustration 3.1 depicts the defined boundaries.

Illustration 3.1	Domestic Regular
Strata	**Stratum Boundaries**
Stratum 1	0 to 600 kWh
Stratum 2	601 to 1120 kWh
Stratum 3	1121 plus kWh
	All Electric
Strata	**Stratum Boundaries**
Stratum 1	0 to 1350 kWh
Stratum 2	1351 to 2500 kWh
Stratum 3	2501 plus kWh

3.1.2 RATE 2.3 (GENERAL SERVICE 110 kVA TO 1000 kVA) STRATIFICATION

A multi-dimensional sampling procedure was utilized in the design of the Rate 2.3 class. This involved stratifying the population by two variables. First it was stratified into two groups based on customer voltage supply. One group contained customers with primary voltage supply (4 to 25 kV) and the other contained customers with secondary voltage supply (less than 4 kV). The primary and secondary voltage groups were then further stratified based on demand. This resulted in a total of four strata in the Rate 2.3 class, two in the primary voltage group and two in the secondary voltage group. The boundaries of these strata within each group were based on historic rate breaks (i.e. the Delanius Hodges Method was not used). It was felt that these breaks adequately broke the population into homogeneous sub-populations. The boundaries that were used are depicted in Illustration 3.2.

Illustration 3.2	Rate 2.3 Secondary Voltage Supply
Strata	**Stratum Boundaries**
Stratum 1	110 to 350 kVA
Stratum 2	350 to 1000 kVA
	Rate 2.3 Primary Voltage Supply
Strata	**Stratum Boundaries**
Stratum 3	110 to 350 kVA
Stratum 4	350 to 1000 kVA

3.2 SAMPLE SIZE ESTIMATION

In calculating the optimum number of sample points for a stratified random sample the following formulae were applied to the classes.

$$n_o = \frac{(Z_{\alpha/2})^2 \times (\Sigma(W_h \times \delta_h))^2}{B^2}$$

$$n = \frac{n_o}{1 + n_o/N}$$

Where:
- B = the desired absolute accuracy of the mean.
- $Z_{\alpha/2}$ = the standard normal deviate for the desired confidence level.
- n = the required sample size.
- δ_h = the standard deviation of peak demands in stratum h.
- W_h = N_h/N = the proportion of customers in the class in stratum h.

This provided a sample size for the entire class, unadjusted for minimum sample size restrictions or for data loss. This is referred to as the raw sample size. The number representing the $Z_{\alpha/2}$ at 90% confidence is 1.65.

3.2.1 RESIDENTIAL SAMPLE SIZE ESTIMATION

Estimates of sample size for the Residential groups were calculated using hourly demand data from Nova Scotia Power. Data from their customers with and without electric heat was used. The reason for using borrowed data was due to the fact that Newfoundland Power's Residential class is not demand metered, and the borrowed data would give better estimates of demand mean and demand variance, hence improving the estimates of sample size for the Residential class.

Using this data, raw sample sizes were calculated for the All Electric and the Domestic Regular groups. The sample sizes were then allocated to the strata. This was accomplished using the Neyman Allocation Method. The following formula was used.

$$n_h = n \times \frac{W_h \times \delta_h}{\Sigma(W_h \times \delta_h)}$$

Where:

n_h = the sample size for each stratum.
n = the required sample size of the class.
δ_h = the standard deviation of peak demands in stratum h.
W_h = N_h/N = the proportion of customers in the class in stratum h.

The resulting sample sizes were then adjusted for data loss and a minimum stratum sample size of 12. The resulting sample sizes are outlined in Illustration 3.3 along with the corresponding population sizes at the time of sample design.

Illustration 3.3	Domestic Regular	
Strata	**Sample Size**	**Population Size**
Stratum 1	27	33091
Stratum 2	41	33064
Stratum 3	22	12016
	All Electric	
Strata	**Sample Size**	**Population Size**
Stratum 1	14	28898
Stratum 2	16	37198
Stratum 3	16	15743

The much smaller sample size requirements for the All Electric group as opposed to the Domestic Regular group indicated the relatively low variance in demands at peak times for customers with electric heat.

3.2.2 RATE 2.3 SAMPLE SIZE ESTIMATION

Estimates of sample size for the Rate 2.3 strata were calculated using monthly maximum demands for the Rate 2.3 customers. The mean demand used in calculating the absolute accuracy in the sample size calculation was adjusted to reflect the non-coincidence of monthly maximum demands at time of system peak. The class sample size formulae were applied to come up with a raw class sample size. This was then allocated to the strata using the Neyman Allocation Method and the resulting numbers were adjusted for data loss and a minimum sample size per stratum of 12. The minimum sample size was chosen to achieve a higher level of accuracy on a stratum basis to meet the requirements of the Cost of Service Study. Illustration 3.4 outlines the sample and population sizes at time of sample design.

Illustration 3.4	Rate 2.3 Primary Voltage Supply	
Strata	Sample Size	Population Size
Stratum 1	12	35
Stratum 2	18	49
	Rate 2.3 Secondary Voltage Supply	
Strata	Sample Size	Population Size
Stratum 1	60	644
Stratum 2	30	142

3.3 SAMPLE SELECTION

Once the strata were identified, and sample sizes calculated the sample customers were chosen. Customers were selected randomly for each class. If customers from the initial random selection did not respond positively to the project, alternates with roughly the same characteristics were chosen.

Data Analysis

4.0 DATA ANALYSIS

This section provides analysis of the data collected from the studied customer classes. It will focus on system peak characteristics, and the attributes of individual class loads. The methodology used in estimating population representative data will be defined. As well, Appendix C provides tabular and graphical representation of the results of the analysis.

4.1 METHODS OF CALCULATION AND RELIABILITY OF ESTIMATES

To adequately study the load characteristics of a class of customers, data representative of their population is required. The sample data that was collected from the Residential and Rate 2.3 customers was expanded to depict their class populations using ratio estimation. This procedure basically made an interval by interval correlation between average sample demand and average sample energy. It then applied the same correlations to the population energy to come up with total class load profiles.

With the use of statistical techniques quantitative measures of reliability were then attributed to estimated population values for a given level of confidence. The Residential and Rate 2.3 samples were designed to achieve a relative accuracy of ten percent with ninety percent confidence at time of system peak load. This level of accuracy was primarily affected by the variance of the sample demands (the higher the variance the higher the error) and the number of sample customers.

4.2 SYSTEM PEAKS SUMMARY

Twenty five months of system data was included in the analysis of the system peaks. This data spans from March 1992 to March 1994, covering three winter season system peaks. Tables in Section 4.4 summarize this data, outlining the time and magnitude of monthly system peaks (taken from 15-minute data). The peak days for the 1991/92, 1992/93 and 1993/94 winter seasons were the focus of the system peak analysis. These are three of the largest system loads in the past three years. The alternate peak day for the 1991/92 winter season was also included. This peak occurred on a Sunday and demonstrated different load characteristics than the other peak days.

The system characteristically peaked on weekdays (Monday to Friday) during the winter season (late December to early March). The 1991/92 winter season peak load was 1,090,068 kW on Monday, March 2, 1992 at 12:00 PM. The 1992/93 winter season peak load was 1,027,735 kW on Wednesday, January 20, 1993 at 5:30 PM. The 1993/94 winter season peak load was 1,098,337 kW on Wednesday, February 9, 1994 at 8:15 AM. This was the highest peak attained by the system in the twenty five months studied. The alternate peak for the 1991/92 winter season was 1,041,660 kW on Sunday, March 1, 1992 at 8:00 PM.

For illustrative purposes figures have been provided that plot average hourly loads for the system and the class contributions on these key days. Figures 4-1A to 4-1D illustrate the system load and the class usage patterns in a non-stacking format. Smaller loads such as Company Use and Wheeled have been omitted from these figures due to the large scale required to plot the system curve. Figures 4-3A to 4-3D plot the smaller loads on a lower scale allowing more detail to be seen in their load profiles. All the load elements presented in this report are plotted on the stacking curves in Figures 4-2A to 4-2D. As well, Table 4-1 breaks down the class demand contribution for the four peak intervals.

A load duration curve for the system load for the 1993 calendar year is plotted in Figure 4-7A. It illustrates the percent of peak load the system maintained for what percent of the year. The system load was above 90% of system peak load for 2.2% of 1993 calendar year. The peak load for the 1993 calendar year was 1,027,735 kW, and the total energy that passed through the system for that year was 4,688,001 MWh. The 1993 calendar year load factor for the system was approximately 52%.

4.2.1 RESIDENTIAL LOAD CHARACTERISTICS

Table 4-2 illustrates monthly peak load estimates for the Residential class (i.e., All Electric and Domestic Regular combined). The Residential load like the system load peaks in the winter season. The Residential winter season class peaks all occurred in the same months as the system peaks. The highest Residential class peak during the study period was 725,170 kW on Monday March 2, 1992 at 5:15 PM.

The Residential class peaked on the same day as the March 2, 1992 system peak. The Residential monthly coincidence factor (class load at the time of system peak as a percent of class peak load for the month in question) was 88%, and the Residential class accounted for 59% of the system load. The Residential class peaked on different days for the other winter season system peaks but maintained a coincidence factor of over 93% for both peak intervals. The Residential class accounted for over 65% of the 1992/93 winter season peak, and 62% of the 1993/94 winter season peak. The monthly percent contributions to system peaks and monthly coincidence factors are presented in Table 4-2.

Figure 4-0 plots in a non-stacking format the class contributions to monthly system peaks. The Residential kW peak contribution was twice as high in winter months as opposed to summer months. Its contribution was around 700 MW in the winter and 300 MW in the summer. This seasonal difference can be attributed to the large electric heating load of the Residential customer class. On the three peak days studied the weather was colder than normal. Consequently, the Residential load was considerably higher. This increase in load on peak days is illustrated in Figures 4-6A to 4-6C which plots the weekly loads of the studied rate classes during the weeks of peak days.

Load factors that were calculated for the Residential class for several different time periods are presented in Table 4-4. The Residential annual load factor based on Residential class peak is generally around 42%. Their load factor calculated using Residential class demand at time of system peak is generally around 45%. This higher load factor is due to the difference in magnitude and time of the class peak versus the system peak.

A load duration curve for the Residential load during the 1993 calendar year is plotted in Figure 4-7B. The Residential load was above 90% of the Residential peak load for 0.8% of the 1993 calendar year.

Figures 4-5A to 4-5H illustrate Typical Day curves for the studied rate classes. The Residential class load pattern is provided for the four seasons of the year and for weekdays versus weekend days. The typical time of the morning peak varies considerably for weekdays versus weekend days. On weekdays the Residential load peaks at around 8:30 AM whereas on weekend days it peaks later in the day at around 11:00 AM.

The afternoon and evening characteristics are very similar between the typical weekdays and weekend day loads. The load typically drops off in the afternoon and picks up to a peak in the evening between 5:00 and 9:00 PM.

The large winter loads are also illustrated in the typical day curves. The typical winter curves are twice as large as the typical summer curves. There is however, a consistency in the shape of the curves from season to season. This is possibly due to a consistency in customer usage patterns from one season to another.

Table 4-2 also provides the accuracies of the load estimates. The sample was designed to meet the accuracy of plus or minus ten percent at time of system peak. Accuracies within this range were not expected for months outside of the winter season. The sample design was based on winter demand variances. In the summer season the variances between customers increase and less reliable estimates are achieved. In order to achieve the desired accuracy throughout the year, a larger sample would have to be implemented.

The accuracies of the three Residential load estimates at the time of system peaks were all within the desired relative accuracy, except for the estimate for the 1991/92 winter season peak. The relative accuracy for this interval was ±12.0%. Further investigation showed that the number of contributors did not decrease on that day from what they were for the month. The sample demand variance however, increased for the peak interval causing the error to increase. The relative accuracies for the other peak days were ±8.7% at the time of the 1992/93 winter season system peak, and ±7.7% at the time of the 1993/94 winter season system peak. The accuracies at the time of the winter season class peaks all met the desired accuracy as is illustrated in Table 4-2.

The All Electric versus Domestic Regular split in the Residential class is shown in Figures 4-4A to 4-4C for the class peak, and subclass peaks of the 1993 calendar year. Illustration 4-1 provides the kW loads, percent contributions and 1993 calendar year coincidence factors for the peak intervals for the class and subclasses.

Illustration 4-1 1993 Calendar Year Residential Class Peak Wednesday, December 29, 1993 at 6:30 PM				
Class/Subclass	kW-Load	% of Class	% of System Load	Coincidence Factor
Residential Class	714,648	–	72%	100%
All Electric Subclass	555,123	78%	16%	96%
Domestic Regular Subclass	159,523	22%	56%	88%
1993 Calendar Year All Electric Subclass Peak Sunday, January 3, 1993 at 1:00 PM				
Class/Subclass	kW-Load	% of Class	% of System Load	Coincidence Factor
Residential Class	713,848	–	78%	99%
All Electric Subclass	577,937	81%	15%	100%
Domestic Regular Subclass	135,900	19%	63%	76%
1993 Calendar Year Domestic Regular Subclass Peak Saturday, December 25, 1993 at 11:45 AM				
Class/Subclass	kW-Load	% of Class	% of System Load	Coincidence Factor
Residential Class	648,213	–	78%	91%
All Electric Subclass	463,832	72%	22%	78%
Domestic Regular Subclass	184,059	28%	56%	100%

Note: Coincidence factors are based on the class and subclass peaks for 1993 calendar year.

4.2.2 RATE 2.3 LOAD CHARACTERISTICS

Table 4-3 illustrates monthly peak load estimates for the Rate 2.3 class. The Rate 2.3 class peaks in the winter season. The highest Rate 2.3 class kW peak during the study period was 176,749 kW on Wednesday, February 9, 1994 at 9:30 AM.

The Rate 2.3 winter season peaks for the 1991/92 and 1993/94 winter seasons occurred on the same days as the system peaks. The Rate 2.3 percent contribution to the system peak intervals for both these intervals was 15%. The Rate 2.3 peaks and system peaks occurred at different times on these days. However, the Rate 2.3 class maintained a monthly coincidence factor of 97% for the 1991/92 peak interval and 93% for the 1993/94 peak interval.

The Rate 2.3 peak for the 1992/93 winter season did not occur in the same month as the system peak. Rate 2.3 maintained an 80% monthly coincidence factor with this peak and made up 12% of the peak load. The monthly percent contributions to system peaks and monthly coincidence factors are presented in Table 4-3.

The class contributions to monthly system peaks that are illustrated in Figure 4-0 give insight into Rate 2.3's sensitivity to weather. The Rate 2.3 contribution to system peak load in the winter months was around 170 MW as opposed to around 90 MW in the summer months.

Load factors that were calculated for the Rate 2.3 class for several different time periods are presented in Table 4-5. The Rate 2.3 annual load factor based on the Rate 2.3 class peak is generally around 51%. Their load factor calculated using Rate 2.3 class demand at time of system peak is generally around 64%. This higher load factor is due to the difference in magnitude and time of the class peak versus the system peak.

A load duration curve for the Rate 2.3 load during the 1993 calendar year is plotted in Figure 4-7C. The Rate 2.3 load was above 90% of the Rate 2.3 peak load for 1.0% of the 1993 calendar year.

Figures 4-5A to 4-5H illustrate the typical load profiles for the Rate 2.3 class. This class typically maintains the same load profile during off peak hours (8:00 PM to 6:00 AM) for weekdays versus weekend days. During peak hours the load is greater on weekdays than on weekend days. This weekday versus weekend day comparison is also illustrated in the weekly load plots in Figures 4-6A to 4-6C.

The accuracies for the Rate 2.3 load estimates are provided in Table 4-3. The Rate 2.3 sample like the Residential sample was designed to meet the accuracy of ten percent at time of system peak.

The accuracies of the three Rate 2.3 load estimates at the time of system peaks were all within the desired relative accuracy. The relative accuracy for the Rate 2.3 load estimate at the time of the systems 1991/92 winter season peak interval was ±5.0%, at the time of the 1992/93 winter season system peak interval it was ±6.7% and at the time of the 1993/94 winter season system peak interval it was 4.6%. The accuracies at the time of the winter season class peaks all met the desired accuracy as is illustrated in Table 4-3.

4.2.3 RATE 2.4 LOAD CHARACTERISTICS

Table 4-6 illustrates monthly Rate 2.4 load characteristics. All the data that is provided in this table is not completely representative of the Rate 2.4 class because as previously mentioned, all Rate 2.4 customers were not included in the study. The number of customers missing varied from two to eight. For the most part the customers that were missing maintained only a small portion of the total load. This is reflected in the comparison of energy values in Table 4-6.

The Rate 2.4 studied customers peaked on the same day as the 1991/92 and the 1993/94 winter season system peaks. The studied customers comprised 5% of the system peak load and maintained monthly coincidence factors of 99% and 92% respectively.

The studied Rate 2.4 customers did not peak on the same day as the 1992/93 winter season system peak. They comprised 4% of this system peak load and maintained a 88% monthly coincidence factor.

Table 4-6 also illustrates the sensitivity of the Rate 2.4 load to weather. The energy and demands for studied customers change very little from season to season. This results in the Rate 2.4 contribution to system peak load to be greater in summer months than winter months when the system load is largest.

The Rate 2.4 annual load factor based on the Rate 2.4 class peak is generally around 60%. Their load factor calculated using Rate 2.4 class demand at time of system peak is generally around 66%. This higher load factor is due to the difference in magnitude and time of the class peak versus the system peak.

A load duration curve for the Rate 2.4 load during the 1993 calendar year is plotted in Figure 4-7D. The Rate 2.4 load was above 90% of the Rate 2.4 peak load for 3.5% of the 1993 calendar year.

Figures 4-5A to 4-5H illustrate the typical load profiles for the Rate 2.4 studied customers. This class typically maintains the same load profile during off peak hours (8:00 PM to 6:00 AM) for weekdays versus weekend days. During peak hours the load is greater on weekdays then on weekend days. The same load patterns was demonstrated in all four seasons. This weekday versus weekend day comparison is also illustrated in the weekly load plots in Figures 4-6A to 4-6C.

4.3 APPLICATIONS FOR NEWFOUNDLAND POWER'S COST OF SERVICE STUDY

Average load factors are applied to subclass energy to derive non-coincident demand estimates by subclass. The non-coincident demand estimates are then used in the Cost of Service Study to calculate allocation factors for demand related costs. These load factors are presented for several twelve month periods in Illustrations 4-2 to 4-4. The average load factors are used for deriving the demand estimates for the Cost of Service Study (i.e., for the All Electric subclass a load factor of 38% was used and for the Domestic Regular subclass a load factor of 41% was used).

$$\text{Load Factor} = \frac{\text{Actual Energy (kWh)}}{\text{Class/Subclass non-coincident demand} \times \text{\# of hours in time period}}$$

Illustration 4-2	Residential Load Factors Based on Non-Coincident Demand		
Time Frame	All Electric	Domestic Regular	Total Domestic
Apr/91 - Mar/92	37%	38%	40%
1992 Calendar Year	38%	41%	41%
Apr/92 - Mar/93	39%	44%	42%
1993 Calendar Year	39%	40%	42%
Apr/93 - Mar/94	39%	41%	42%
Average	38%	41%	42%

Illustration 4-3 **Rate 2.3 Load Factors Based on Non-Coincident Demand**

Time Frame	110-350 Primary Voltage	110-350 Secondary Voltage	350-1000 Primary Voltage	350-1000 Secondary Voltage	Total Rate 2.3
Apr/91 - Mar/92	57%	45%	58%	52%	50%
1992 Calendar Year	56%	45%	57%	51%	50%
Apr/92 - Mar/93	58%	48%	55%	51%	51%
1993 Calendar Year	58%	48%	57%	52%	52%
Apr/93 - Mar/94	56%	43%	53%	50%	49%
Average	57%	46%	56%	51%	50%

Illustration 4-4 **Rate 2.4 Load Factors Based on Non-Coincident Demand**

Time Frame	Primary Voltage	Secondary Voltage	Transmission	Total Rate 2.4
1992 Calendar Year	60%	46%	37%	62%
Apr/92 - Mar/93	59%	43%	37%	58%
1993 Calendar Year	59%	50%	28%	63%
Apr/93 - Mar/94	58%	51%	29%	63%
Average	59%	47%	33%	62%

Summary

5.0 SUMMARY

The objective of Newfoundland Power's load research study was to accurately identify the usage patterns of its customers by rate class. The data collected and summarized in this report provides a sound foundation for understanding the usage patterns of these rate classes.

The study was designed to meet the data requirements of the Cost of Service study, the primary user of the load research data. Load factors derived from the data are an important input into this application. The load research data is also useful for other applications such as long term forecasting and end use studies. Post stratification of the sample customers can allow the data to be represented in a form that is useful to these applications. However, it should be noted that post stratification can result in strata with small sample sizes that are unable to meet desired accuracies.

When data begins to be retrieved from the Rate 2.1 and 2.2 samples in 1995, it will allow for further analysis of the results presented in this report. Better comparisons of the load pieces and the system load will be able to be made. As well, having data on all the rate classes will provide a better understanding of Newfoundland Power's rate classes and system load.

References

6.0 REFERENCES

Association of Edison Illuminating Companies. (1990) Load Research Manual. Birmingham, Alabama.

Association of Edison Illuminating Companies. (1990) Fundamentals of Load Research. New Orleans, LA.

Board of Commissioners of Public Utilities. (February 1993). Proposed Cost of Service Methodology at Newfoundland Hydro. St. John's, NF.

Dominion Bureau of Statistics. (December 1970). Standard Industrial Classification Manual. Ottawa, Canada.

Edison Electric Institute. (1984) The Art of Rate Design. Washington, DC.

Newfoundland Power. (September 1988) A Summary of The Costs Involved in The Implementation of a Statistically Acceptable Load Research Program. St. John's, NF.

Newfoundland Power. (1993). Applications of Load Research Data at Newfoundland Power. St. John's, NF.

Newfoundland Power. (February 1991). Long-Term Forecasting Methodologies. St. John's, NF.

Newfoundland Power. MV90 Load Research Data Archive. St. John's, NF.

Newfoundland Power. (July 1993). Schedule of Rates Rules & Regulations. St. John's, NF.

Newfoundland Power. (1994). Load Research Steps and Procedures at Newfoundland Power. St. John's, NF.

Utility Translation Services, Inc. (April 1991). MV90 Reference Guide. Raleigh, North Carolina.

Appendix A

Glossary of Terms

Glossary of Terms

All Electric: Residential customers who use electric heat as their primary source of space heating.

Auxiliary Variable: A variable that is highly correlated with the variable of interest.

Coincidence Factor: The class demand for the interval in question divided by the maximum demand for the class. This report expresses monthly and yearly coincidence factors. The monthly coincidence factors uses the maximum demand for the month, and the yearly coincidence factor uses the maximum demand for the year.

Cost of Service Study: A study of the costs incurred by the utility in producing, transmitting, and distributing electricity to its customers, by customer class, in relation to revenues collected from each class or projected to be collected under average historical embedded cost of the existing plant and expenses in a test year, past or future; or they may be the long-run incremental costs of the utility's service, that is, the cost, per year, of the capacity and customer load planned for a future period of time expressed in constant current dollars.

Demand: The rate at which electric energy is delivered to or by a system, part of a system, or piece of equipment. It is expressed in kilowatts, kilovoltamperes or other suitable unit at a given instant or averaged over any designated period of time. The primary source of "Demand" is the power-consuming equipment of the customers.

Domestic Regular: Residential customers that do not use electric heat as their primary source of space heating.

Energy: The kilowatthours supplied to or used by an individual customer, group of customers or class or service. Energy use may be determined by calculation or by measurement.

Load Factor: The ratio of average load in kilowatts supplied in a designated period to the peak or maximum load in kilowatts occurring in that period.

Load Profile: As supplied to a customer, class or system, a load profile shows the power supplied during a specific period of time plotted against the time of occurrence.

Load Research: An activity embracing the measurement and study of electrical loads so as to provide a thorough and reliable knowledge of trends and general behaviour of the load characteristics of the more important electrical services rendered by the electrical utility.

Multi-Dimensional Sampling: A stratified sampling procedure involving two or more stratification variables.

Post Stratification: Stratification of a sample after selection based on criteria other than those used to originally select the sample.

Wheeling Service: The use of the transmission facilities of one system to transmit power and energy by agreement of, and for, another system with corresponding wheeling charge.

Appendix B

Dalanius-Hodges Method to Define Stratum Boundaries

Appendix B

Domestic Regular
Dalanius-Hodges Method to Define Stratum Boundaries

Average Monthly Consumption Range Lower Limit	Upper Limit	# of Customer	Square Root of # of Customers	Cumulative Square Root
		Stratum 1		
0	20	2901	53.9	54
21	40	1240	35.2	89
41	60	1033	32.1	121
61	80	879	29.6	151
:	:	:	:	:
521	540	1457	38.2	864
541	560	1490	38.6	903
561	580	1498	38.7	941
581	600	1535	39.2	981
		Stratum 2		
601	620	1492	39	1019
621	640	1583	40	1059
641	660	1568	40	1099
661	680	1526	39	1138
:	:	:	:	:
1041	1060	937	31	1818
1061	1080	856	29	1847
1081	1100	773	28	1875
1101	1120	753	27	1902
		Stratum 3		
1121	1140	741	27	1930
1141	1160	641	25	1955
1161	1180	606	25	1979
1181	1200	620	25	2004
:	:	:	:	:
3941	3960	1	1	2835
3961	3980	1	1	2836
3981	4000	0	0	2836
4000		30	5	2842

Stratum 1

The cumulative square root break for a three stratum scenario equaled 947. The closest cumulative square root that was larger than 947 was 981 which was taken as the first stratum break. This gave stratum 1 a boundary between 0 and 600 kWh. All Domestic Regular customers with an average monthlyl consumption in that range were included in stratum 1.

Stratum 2

The second stratum break started where the first ended and it ended at twice the cumulative square root break which was 1895. The closest cumulative square root that was larger than 1895 was 1902. This gave stratum 2 in a three stratum break a boundary between 601 and 1120 kWh. All Domestic Regular customers with an average monthly kWh consumption in that range were included in stratum 2.

Stratum 3

The third stratum break was defined as anything over the cumulative square root of 2842. That is, all customers with an average monthly kWh consumption of 1121 kWh and over were included in stratum 3.

Shown above is part of the frequency distribution that was used in calculating the stratum breaks for the Domestic Regular Sub-Class. To come up with the stratum breaks the cumulative square root (2842) was divided by the desired number of strata. The resulting number gave the cumulative square root length of each stratum. In the case of the Domestic Regular a three stratum scenario was desired. This resulted in a cumulative square root length of 947, that was used to define the kWh boundaries.

Appendix C

Figures and Tables

Figures and Tables

The following section provides graphical and tabular representation of the results of the data analysis. The text that proceeds the tables and graphs attempts to explain/clarify the methodology and terminology used in the analysis.

Residential and Rate 2.3

As previously mentioned the class load data referred to in this report for the Residential and Rate 2.3 customer classes was estimated using ratio estimation. This procedure basically made an interval by interval correlation between average sample demand and average sample energy. It then applied the same correlations to the population energy to come up with total load profiles. Measures of reliability were then attributed to the ratio estimates using statistical formulae.

Rate 2.4

Rate 2.4 as referred to in this report does not include every customer in this class. When recorders were initially placed on Rate 2.4 customers it was a census of Rate 2.4 customers that was used. However, due to technical problems and uncertainties in the continuations of some customers operations, not all Rate 2.4 customers were metered with load research equipment. As a result, the data that was used for this rate class only includes those customers that were included in the study. Table 4-6 provides a comparison of the monthly energy for the Rate 2.4 load research metered customers versus the Rate 2.4 billed customers (total number of Rate 2.4 customers for the month in question).

Street Lighting

The Street Lighting load profiles used in the report are based on the assumption that all street lights come on an go off within the hour surrounding the defined times of sunset and sunrise. The size of their load was calculated based on the number of active fixtures for the month in question and the defined rate based wattage for these fixtures.

Company Use

Load profiles for company use were derived using a method similar to ratio estimation. Instead of using sample data to estimate population representative data, estimated population data was used to estimate a single user. Sample customers in the professional services, public administration and communications/utility field of work (SIC-Category 6) were stratified and totalized using ratio estimation to represent the population of these customers. Interval by interval demand to energy correlations for this group were then applied to the total energy for the company for the month in question. This method of estimating the company load profile is based on the assumption that the company has similar usage patterns as the customer group SIC-Category 6.

Losses
Losses were calculated assuming an average of eight percent losses of total system load on peak days.

System Load
System load refers to Newfoundland Power's total system load. It is comprised of 15-minute data from Newfoundland Hydro in-feed points, plus Newfoundland Power's generation data. The in-feed data from Newfoundland Hydro includes wheeled power.

Other
Data presented for Other is the residual of the measured and estimated loads subtracted from the system load. This residual is comprised of the Rate 2.1 and Rate 2.2 classes, plus the Rate 2.4 customers not metered with load research equipment.

Other Information

Standard Time: All data presented in this report is in standard time.

All Electric: Residential customers that have electric heat as their primary heating source.

Domestic Regular: Residential customers that use some other form other than electric heat as their primary heating source.

Winter Season: The calendar defined Winter season December 21 to March 20.

Spring Season: The calendar defined Spring season March 21 to June 20.

Summer Season: The calendar defined Summer season June 21 to September 20.

Fall Season: The calendar defined Fall season September 21 to December 20.

Table 4-1

Newfoundland Power
System Peaks Summary

System Load Components	Winter Season 1991/92 Peak day Monday MAR 2, 1992	Winter Season 1991/92 Alternate Peak day Sunday MAR 1, 1992	Winter Season 1992/93 Peak day Wednesday JAN 20, 1993	Winter Season 1993/94 Peak day Wednesday FEB 9, 1994
Loads in kW				
Time	12:00	20:00	17:30	8:15
Peak Load	1,090,068	1,041,660	1,027,735	1,098,337
Transformer/Line Losses	87,205	83,333	82,219	87,867
Company Use	3,755	2,780	3,276	3,831
Wheeled	13,818	10,959	11,957	12,163
Peak Load Sales	985,290	944,589	930,283	994,476
Contributions to Peak Load Sales:				
Street Lighting	0	9,518	9,518	0
Residential Rate 1.1	640,007	708,447	663,705	686,257
General Service Rate 2.3	166,215	127,551	127,798	164,962
Rate 2.4 customers	53,692	39,274	43,992	54,637
Other	125,376	59,799	85,270	88,620
Total	985,290	944,589	930,283	994,476
Relative Accuracies at 90% Confidence:				
Residential Rate 1.1	12.0%	8.6%	8.7%	7.7%
General Service Rate 2.3	5.0%	4.9%	6.7%	6.2%

Table 4-2

Newfoundland Power
Residential Load Estimates
March 1992 to March 1994

	Mar-92	Apr-92	May-92	Jun-92	Jul-92	Aug-92	Sep-92	Oct-92	Nov-92	Dec-92	Jan-93	Feb-93
Residential sample size	94	91	87	91	94	96	95	97	101	102	104	101
Residential billed energy (MWh)	312494	260221	216731	162103	147818	122977	127739	156841	210660	269141	333490	317717
Residential peak load (kW)	725170	591816	467276	347098	362621	352454	335936	463260	597000	713224	713848	704840
Date	2	14	6	17	3	27	3	7	22	30	3	7
Time	1715	700	715	2115	2015	1145	1600	745	1845	1715	1215	1200
Relative accuracy at 90% confidence	10.0%	10.4%	17.5%	15.7%	14.4%	19.4%	14.7%	11.8%	11.6%	8.0%	9.6%	9.2%
Residential load at time of system peak (kW)	640007	441283	411083	276281	253884	335310	263312	429059	482580	668132	663705	577014
Date	2	14	3	18	3	27	4	7	20	30	20	1
Time	1200	830	1045	1100	1100	1100	1045	1100	1715	1745	1730	1000
Relative accuracy at 90% confidence	12.0%	17.1%	15.1%	20.2%	18.0%	15.3%	18.0%	16.7%	11.2%	11.4%	8.7%	11.7%
Coincidence factor	88%	75%	88%	80%	70%	95%	78%	93%	81%	94%	93%	82%
System peak (kW)	1090068	868080	697448	559984	576426	498803	528096	648565	857250	969315	1027735	1018046
Residential contribution as a % of system peak	59%	51%	59%	49%	44%	67%	50%	66%	56%	69%	65%	57%

	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94
Residential sample size	99	100	100	103	101	100	93	95	96	102	98	97	95
Residential billed energy (MWh)	291566	271244	204665	188337	146493	130236	126534	154794	212295	262478	326172	329425	307866
Residential peak load (kW)	625495	528171	573829	436059	335353	297429	374091	482027	607926	714648	693554	720599	662133
Date	14	15	11	24	6	28	19	26	26	29	20	8	12
Time	1000	1045	715	1545	1045	1100	930	1615	1645	1830	1730	1800	1200
Relative accuracy at 90% confidence	11.7%	14.0%	11.3%	15.8%	21.6%	24.7%	17.0%	9.9%	12.2%	7.9%	7.7%	6.3%	9.6%
Residential load at time of system peak (kW)	535808	446154	439229	392727	335871	245801	323234	452167	552984	629598	557917	686257	644435
Date	16	1	10	13	6	31	1	26	25	30	26	9	12
Time	1015	915	1100	1000	1100	1115	1100	1800	1715	1700	1730	815	1215
Relative accuracy at 90% confidence	12.2%	13.0%	19.9%	14.6%	17.8%	19.3%	13.6%	10.3%	9.3%	6.1%	9.3%	7.7%	9.3%
Coincidence factor	86%	84%	77%	90%	100%	83%	86%	94%	91%	88%	80%	95%	97%
System peak (kW)	938250	826855	795093	663881	543244	498043	537727	723912	956001	1027034	1021667	1098336	942103
Residential contribution as a % of system peak	57%	54%	55%	59%	62%	49%	60%	62%	58%	61%	55%	62%	68%

Table 4-3

Newfoundland Power
Rate 2.3 Load Estimates
March 1992 to March 1994

	Mar-92	Apr-92	May-92	Jun-92	Jul-92	Aug-92	Sep-92	Oct-92	Nov-92	Dec-92	Jan-93	Feb-93
Rate 2.3 sample size	99	91	64	95	100	99	101	99	96	96	93	95
Rate 2.3 billed energy (MWh)	80894	69324	58986	51484	51435	47077	46435	51997	60839	70988	82171	83039
Rate 2.3 peak load (kW)	171085	152795	125643	103054	96587	89995	97623	122535	149554	147554	160280	167462
Date	2	14	6	15	3	26	25	26	24	11	20	8
Time	930	915	815	845	1045	845	815	915	900	845	945	930
Relative accuracy at 90% confidence	5.1%	5.9%	8.8%	6.9%	5.6%	7.0%	9.0%	10.9%	7.7%	5.2%	6.6%	5.7%
Rate 2.3 load at time of system peak (kW)	166215	151997	83749	97911	93833	83249	90928	114254	112777	117577	127798	159145
Date	2	14	3	18	3	27	4	7	20	30	20	1
Time	1200	830	1045	1100	1100	1100	1045	1100	1715	1745	1730	1000
Relative accuracy at 90% confidence	5.0%	6.0%	7.5%	8.2%	5.6%	7.1%	7.3%	9.4%	6.8%	5.7%	6.7%	6.0%
Coincidence factor	97%	99%	67%	95%	97%	93%	93%	93%	75%	80%	80%	95%
System peak (kW)	1090068	868080	697448	559984	576426	498803	528096	648565	857250	969315	1027735	1018046
Rate 2.3 contribution as a % of system peak	15%	18%	12%	17%	16%	17%	17%	18%	13%	12%	12%	16%

	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94
Rate 2.3 sample size	99	96	88	94	95	95	104	102	97	90	95	91	89
Rate 2.3 billed energy (MWh)	76541	73017	56840	54852	54840	50767	44253	51854	62509	69990	80924	84481	80440
Rate 2.3 peak load (kW)	151586	134682	136233	118525	90825	87398	107284	134846	151289	141561	174629	176749	167591
Date	16	1	10	14	16	3	27	26	25	1	26	9	1
Time	900	915	900	900	930	1015	800	800	900	900	900	930	900
Relative accuracy at 90% confidence	5.7%	6.3%	7.7%	8.5%	8.4%	10.0%	9.7%	9.8%	8.1%	5.6%	5.2%	4.3%	4.4%
Rate 2.3 load at time of system peak (kW)	150366	134682	126793	73739	88111	80759	89766	94230	116183	115167	136313	164962	117089
Date	16	1	10	13	6	31	1	26	25	30	26	9	12
Time	1015	915	1100	1000	1100	1115	1100	1800	1715	1700	1730	815	1215
Relative accuracy at 90% confidence	4.9%	6.3%	6.7%	7.5%	9.3%	11.6%	5.9%	7.2%	5.9%	5.3%	3.8%	4.6%	4.9%
Coincidence factor	99%	100%	93%	62%	97%	92%	84%	70%	77%	81%	78%	93%	70%
System peak (kW)	938250	826855	795093	663881	543244	498043	537727	723912	956001	1027034	1021667	1098336	942103
Rate 2.3 contribution as a % of system peak	16%	16%	16%	11%	16%	16%	17%	13%	12%	11%	13%	15%	12%

Table 4-4

Newfoundland Power
Residential Load Factors
March 1992 to March 1994

	Mar-92	Apr-92	May-92	Jun-92	Jul-92	Aug-92	Sep-92	Oct-92	Nov-92	Dec-92	Jan-93	Feb-93
Hours in month	744	720	744	720	744	744	720	744	720	744	744	672
Residential billed energy (MWh)	312494	260221	216731	162103	147818	122977	127739	156841	210660	269141	333490	317717
Residential peak load (kW)	725170	591816	467276	347098	362621	352454	335936	463260	597000	713224	713848	704840
Load factors based on class peaks												
Monthly load factors	58%	61%	62%	65%	55%	47%	53%	46%	49%	51%	63%	67%
12 month moving load factor												42%
System peak (kW)	1090068	868080	697448	559984	576426	498803	528096	648565	857250	969315	1027735	1018046
Residential load at time of system peak (kW)	640007	441283	411083	276281	253884	335310	263312	429059	482580	668132	663705	577014
Load factors based on coincidence with system peaks												
Monthly load factors	66%	82%	71%	81%	78%	49%	67%	49%	61%	54%	68%	82%
12 month moving load factors												47%

	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94
Hours in month	744	720	744	720	744	744	720	744	720	744	744	672	744
Residential billed energy (MWh)	291566	271244	204665	188337	146493	130236	126534	154794	212295	262478	326172	329425	307866
Residential peak load (kW)	625495	528171	573829	436059	335353	297429	374091	482027	607926	714648	693554	720599	662133
Load factors based on class peaks													
Monthly load factors	63%	71%	48%	60%	59%	59%	47%	43%	49%	49%	63%	68%	62%
12 month moving load factors	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%	42%
System peak (kW)	938250	826855	795093	663881	543244	498043	537727	723912	956001	1027034	1021667	1098336	942103
Residential load at time of system peak (kW)	535808	446154	439229	392727	335871	245801	323234	452167	552984	629598	557917	686257	644435
Load factors based on coincidence with system peaks													
Monthly load factors	73%	84%	63%	67%	59%	71%	54%	46%	53%	56%	79%	71%	64%
12 month moving load factors	45%	45%	45%	45%	45%	46%	46%	45%	46%	45%	45%	44%	44%

Table 4-5

Newfoundland Power
Rate 2.3 Load Factors
March 1992 to March 1994

	Mar-92	Apr-92	May-92	Jun-92	Jul-92	Aug-92	Sep-92	Oct-92	Nov-92	Dec-92	Jan-93	Feb-93
Hours in month	744	720	744	720	744	744	720	744	720	744	744	672
Rate 2.3 billed energy (MWh)	80894	69324	58986	51484	51435	47077	46435	51997	60839	70988	82171	83039
Rate 2.3 peak load (kW)	171085	152795	125643	103054	96587	89995	97623	122535	149554	147554	160280	167462
Load factors based on class peaks												
Monthly load factors	64%	63%	63%	69%	72%	70%	66%	57%	57%	65%	69%	74%
12 month moving load factors												50%
System peak (kW)	1090068	868080	697448	559984	576426	498803	528096	648565	857250	969315	1027735	1018046
Rate 2.3 load at time of system peak (kW)	166215	151997	83749	97911	93833	83249	90928	114254	112777	117577	127798	159145
Load factors based on coincidence with system peaks												
Monthly load factors	65%	63%	95%	73%	74%	76%	71%	61%	75%	81%	86%	78%
12 month moving load factors												52%

	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94
Hours in month	744	720	744	720	744	744	720	744	720	744	744	672	744
Rate 2.3 billed energy (MWh)	76541	73017	56840	54852	54840	50767	44253	51854	62509	69990	80924	84481	80440
Rate 2.3 load (kW)	151586	134682	136233	118525	90825	87398	107284	134846	151289	141561	174629	176749	167591
Load factors based on class peaks													
Monthly load factors	68%	75%	56%	64%	81%	78%	57%	52%	57%	66%	62%	71%	65%
12 month moving load factors	51%	51%	51%	51%	52%	52%	52%	52%	52%	52%	50%	49%	49%
System peak (kW)	938250	826855	795093	663881	543244	498043	537727	723912	956001	1027034	1021667	1098336	942103
Rate 2.3 load at time of system peak (kW)	150366	134682	126793	73739	88111	80759	89766	94230	116183	115167	136313	164962	117089
Load factors based on coincidence with system peaks													
Monthly load factors	68%	75%	60%	103%	84%	84%	68%	74%	75%	82%	80%	76%	92%
12 month moving load factors	67%	67%	67%	67%	68%	68%	68%	68%	68%	68%	68%	53%	53%

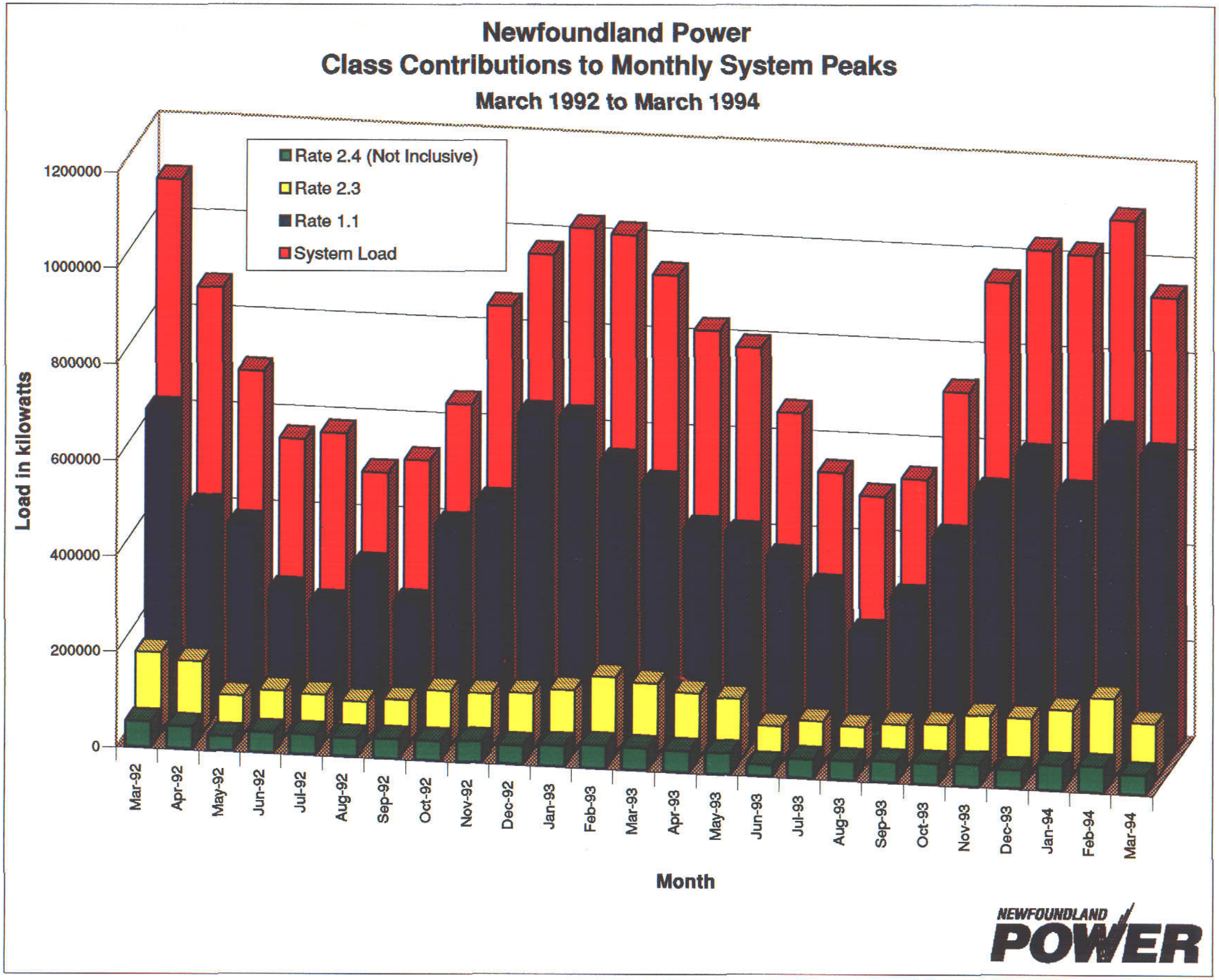
Table 4-6

Newfoundland Power
Rate 2.4 Load Characteristics
March 1992 to March 1994

	Mar-92	Apr-92	May-92	Jun-92	Jul-92	Aug-92	Sep-92	Oct-92	Nov-92	Dec-92	Jan-93	Feb-93
Rate 2.4 studied customers	35	33	32	31	31	31	31	32	31	31	25	25
Rate 2.4 studied customers energy (MWh)	31329	25986	23688	27359	23645	22904	22919	24099	25036	25895	25671	26247
Rate 2.4 billed customers	38	39	39	39	38	37	36	36	35	34	31	30
Rate 2.4 billed energy (MWh)	31515	28713	26507	27432	27293	25506	26068	26573	27847	28588	28233	28233
Studied customers peak load (kW)	54317	48927	44820	44979	46692	42984	44981	47009	50311	48448	50089	52112
Date	2	14	6	15	8	18	30	22	18	10	14	10
Time	1315	945	1030	1215	1030	1315	945	1200	1115	1315	1030	1115
Studied customers load at time of system peak (kW)	53692	47216	30518	42186	42229	39019	40958	41766	45034	39814	43993	48638
Date	2	14	3	18	3	27	4	7	20	30	20	1
Time	1200	830	1045	1100	1100	1100	1045	1100	1715	1745	1730	1000
Coincidence factor	99%	97%	68%	94%	90%	91%	91%	89%	90%	82%	88%	93%
System peak (kW)	1090068	868080	697448	559984	576426	498803	528096	648565	857250	969315	1027735	1018046
Rate 2.4 contribution as a % of system peak	5%	5%	4%	8%	7%	8%	8%	6%	5%	4%	4%	5%

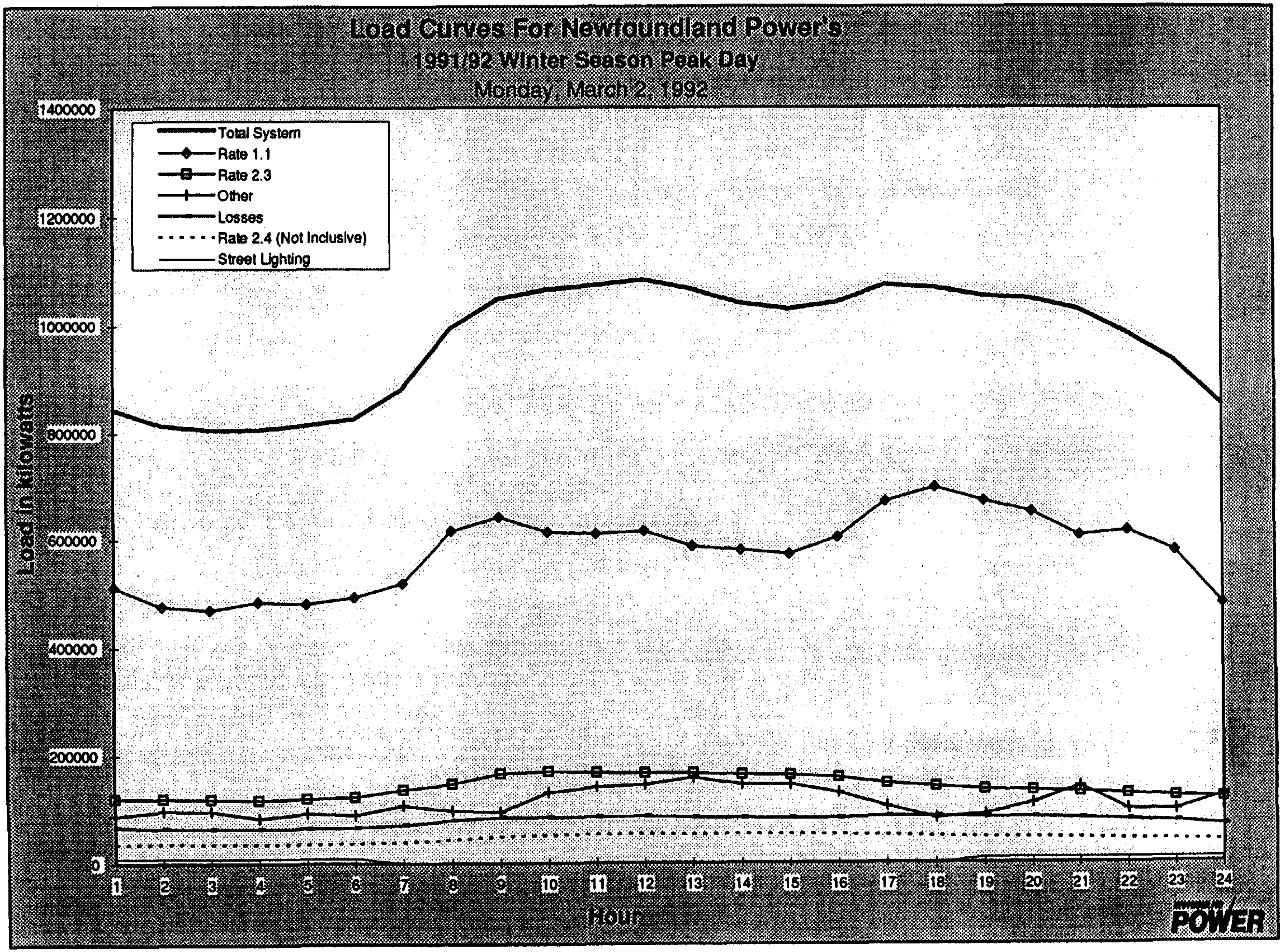
	Mar-93	Apr-93	May-93	Jun-93	Jul-93	Aug-93	Sep-93	Oct-93	Nov-93	Dec-93	Jan-94	Feb-94	Mar-94
Rate 2.4 studied customers	26	27	28	29	27	25	27	28	27	25	28	27	27
Rate 2.4 studied customers energy (MWh)	25077	25215	21598	25950	22592	21780	23694	25474	26530	25184	29796	30883	28847
Rate 2.4 billed customers	31	32	33	33	33	33	33	34	34	31	31	32	32
Rate 2.4 billed energy (MWh)	28315	29749	26179	27784	26055	27989	26700	27643	29831	30234	30136	32621	30449
Studied customers peak load (kW)	48774	46530	45968	49612	44852	41485	47704	50170	52482	48599	59014	59164	54812
Date	16	1	11	24	15	31	28	27	25	1	26	9	1
Time	1415	1030	1030	1300	1015	1230	1315	1000	1115	1115	1145	1115	1045
Studied customers load at time of system peak (kW)	46915	45332	45246	24168	40256	40682	43742	44520	47005	38765	53085	54637	41146
Date	16	1	10	13	6	31	1	26	25	30	26	9	12
Time	1015	915	1100	1000	1100	1115	1100	1800	1715	1700	1730	815	1215
Coincidence factor	96%	97%	98%	49%	90%	98%	92%	89%	90%	80%	90%	92%	75%
System peak (kW)	938250	826855	795093	663881	543244	498043	537727	723912	956001	1027034	1021667	1098336	942103
Rate 2.4 contribution as a % of system peak	5%	5%	6%	4%	7%	8%	8%	6%	5%	4%	5%	5%	4%

Figure 4-0



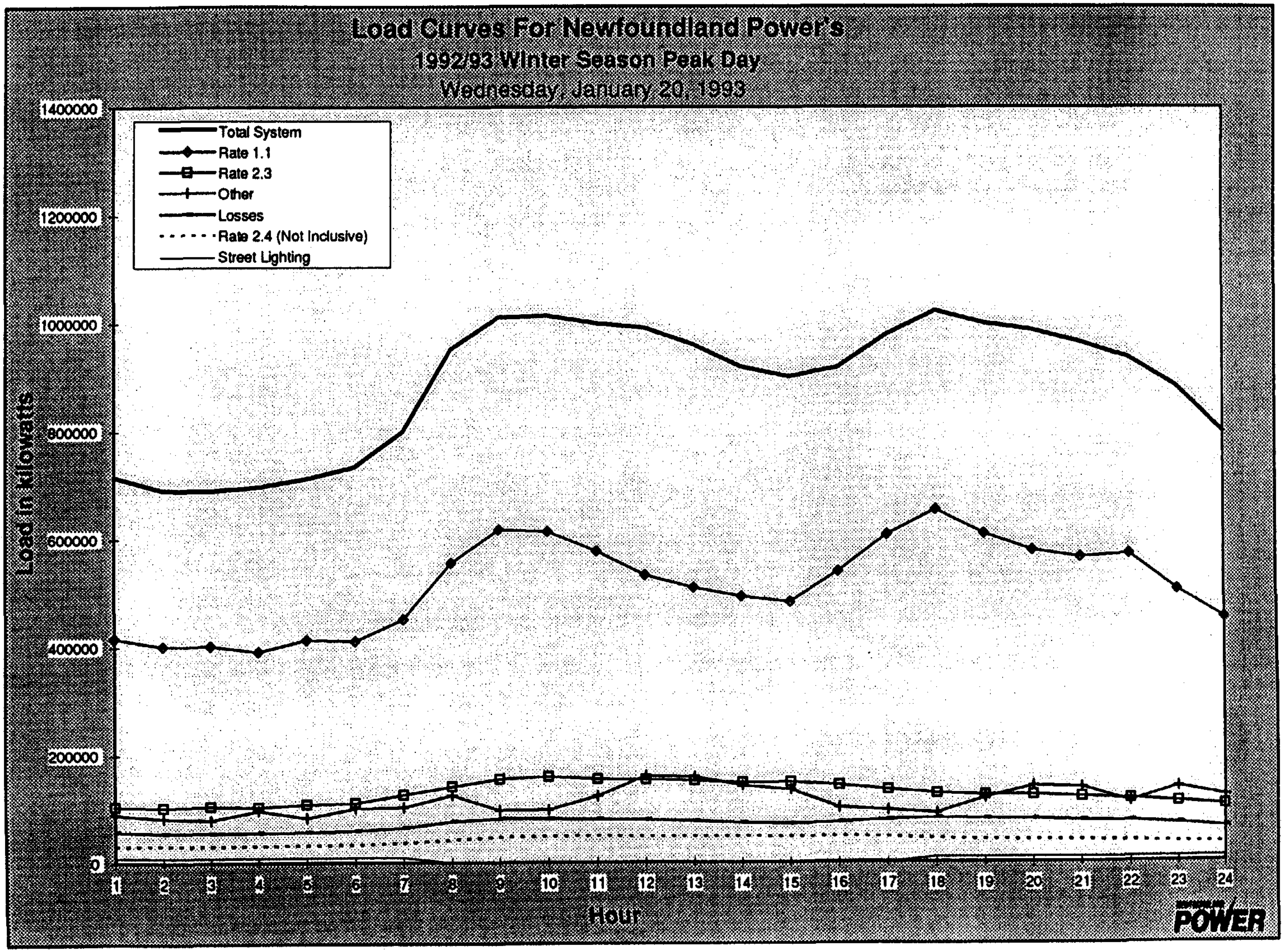
Newfoundland Power
Class Contributions to Monthly System Peaks
March 1992 to March 1994
Rate 2.4 (Not Inclusive)
Rate 2.3
Rate 1.1
System Load
Load in kilowatts
1200000
1000000
800000
600000
400000
200000
0
Mar-92
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Dec-92
Jan-93
Feb-93
Mar-93
Apr-93
May-93
Jun-93
Jul-93
Aug-93
Sep-93
Oct-93
Nov-93
Dec-93
Jan-94
Feb-94
Mar-94
Month
NEWFOUNDLAND POWER

Figure 4-1A



Load Curves For Newfoundland Power's
1991/92 Winter Season Peak Day
Monday, March 2, 1992
Total System
Rate 1.1
Rate 2.3
Other
Losses
Rate 2.4 (Not Inclusive)
Street Lighting
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-1B



Load Curves For Newfoundland Power's
1992/93 Winter Season Peak Day
Wednesday, January 20, 1993
Total System
Rate 1.1
Rate 2.3
Other
Losses
Rate 2.4 (Not Inclusive)
Street Lighting
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-1C

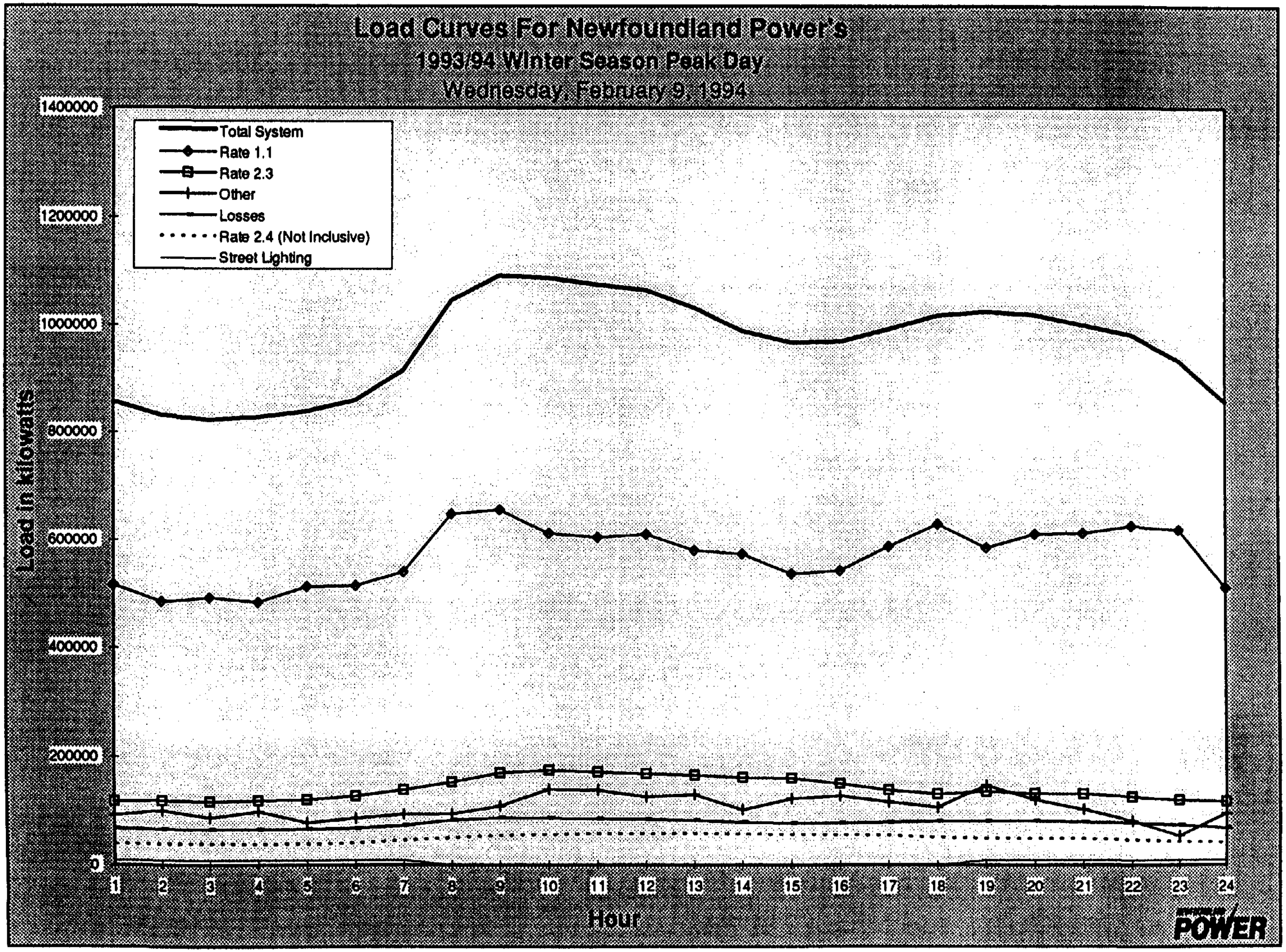

Load Curves For Newfoundland Power's
1993/94 Winter Season Peak Day
Wednesday, February 9, 1994
Total System
Rate 1.1
Rate 2.3
Other
Losses
Rate 2.4 (Not Inclusive)
Street Lighting
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-1D

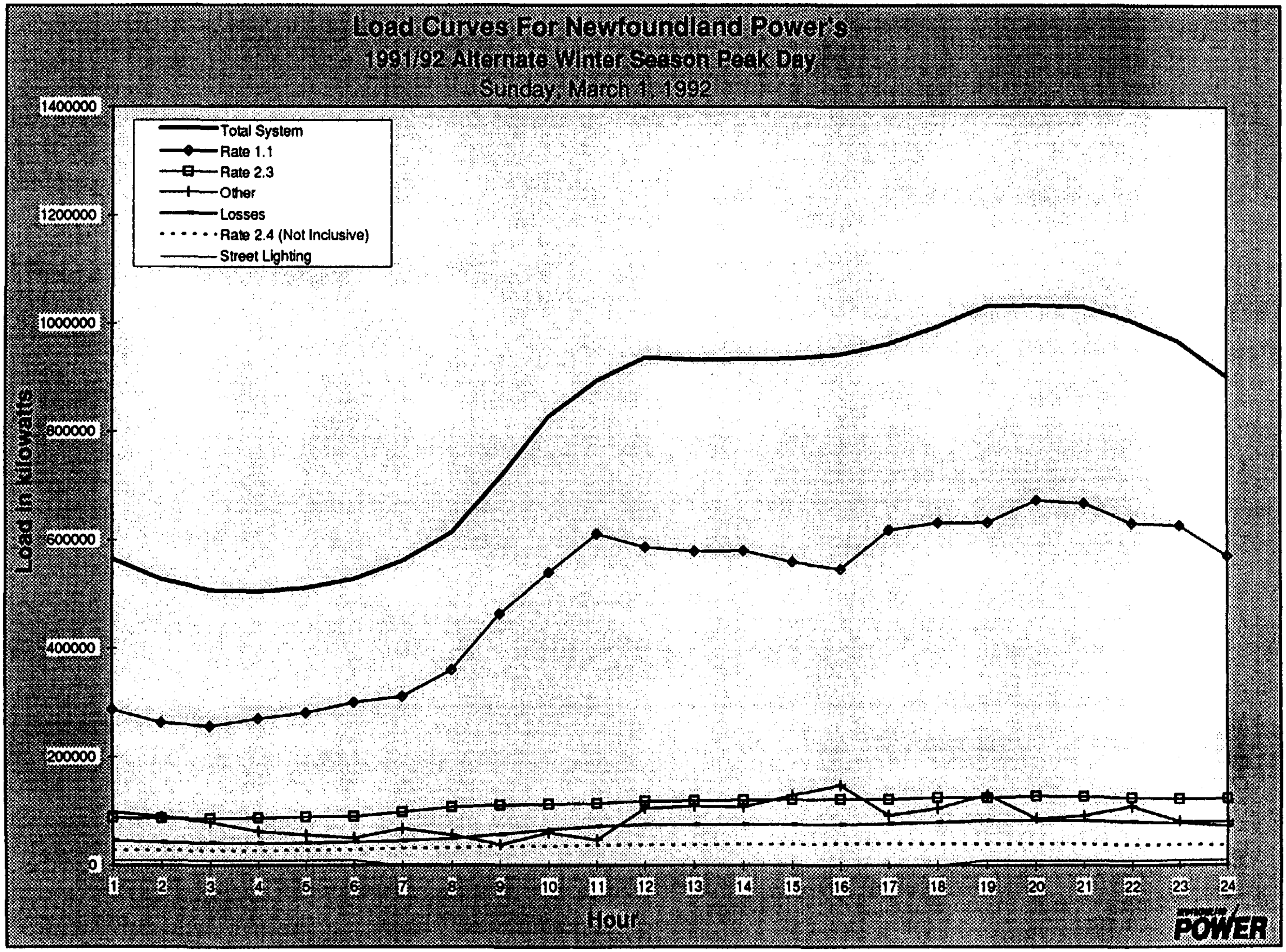
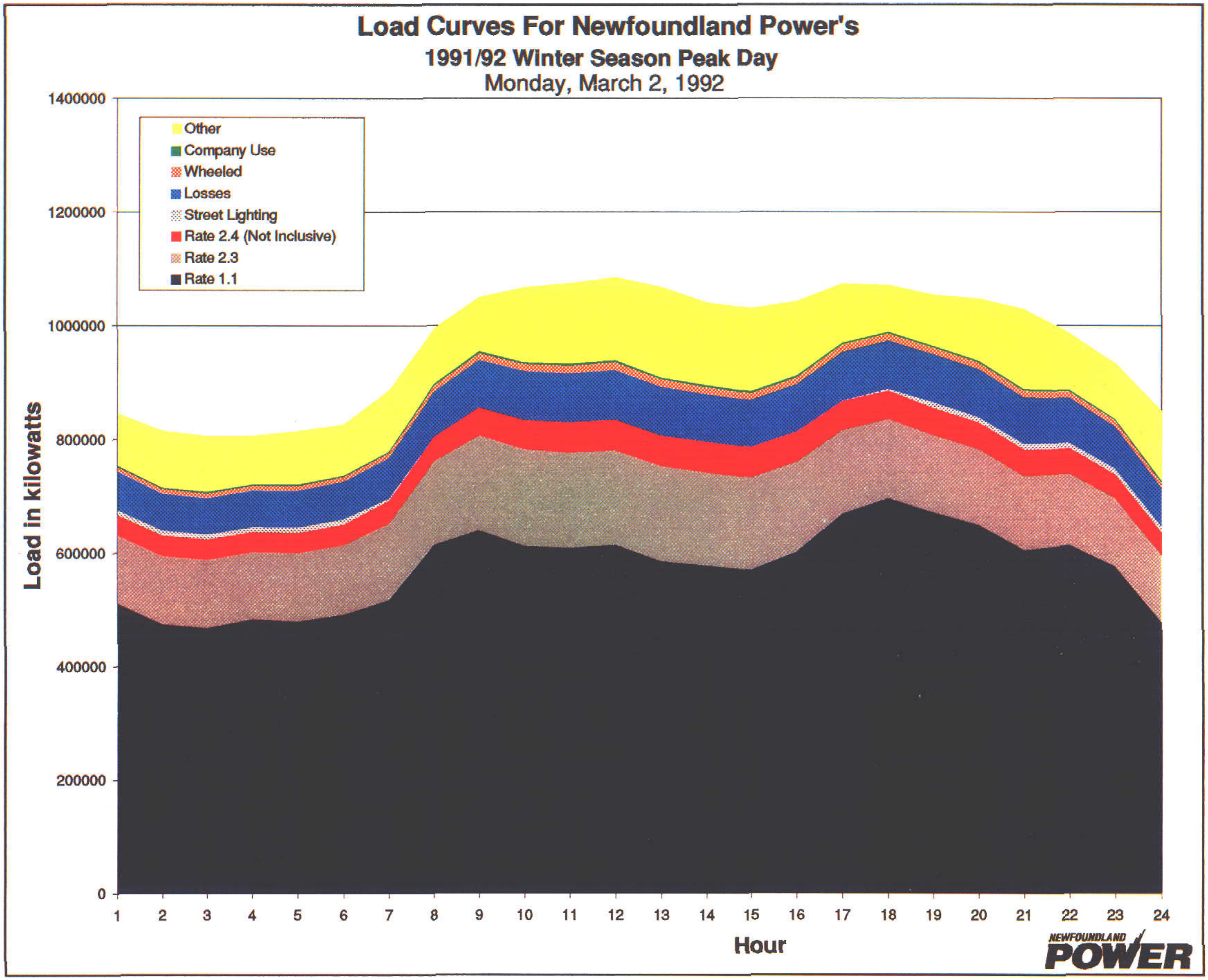
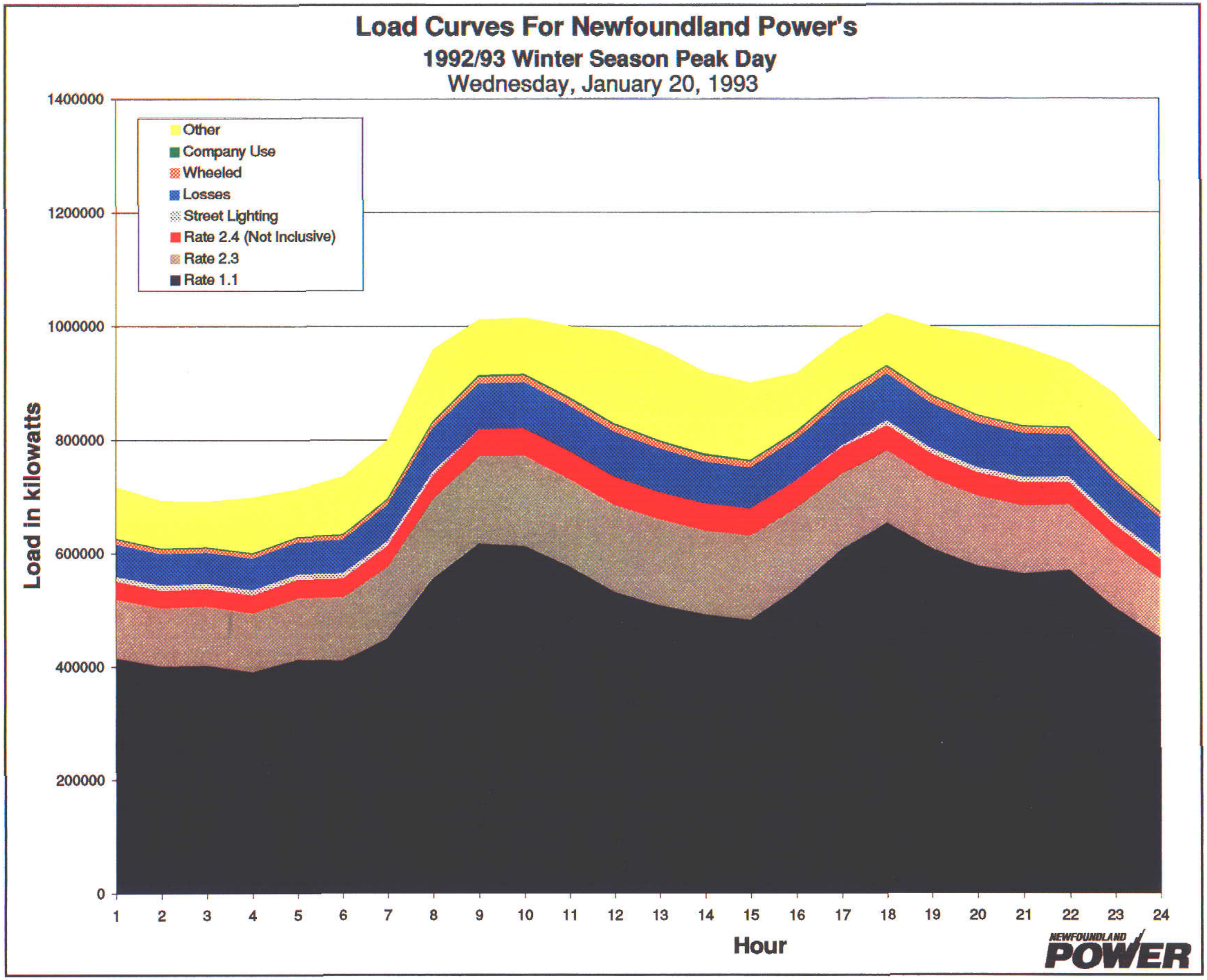

Load Curves For Newfoundland Power's
1991/92 Alternate Winter Season Peak Day
Sunday, March 1, 1992
Total System
Rate 1.1
Rate 2.3
Other
Losses
Rate 2.4 (Not Inclusive)
Street Lighting
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-2A



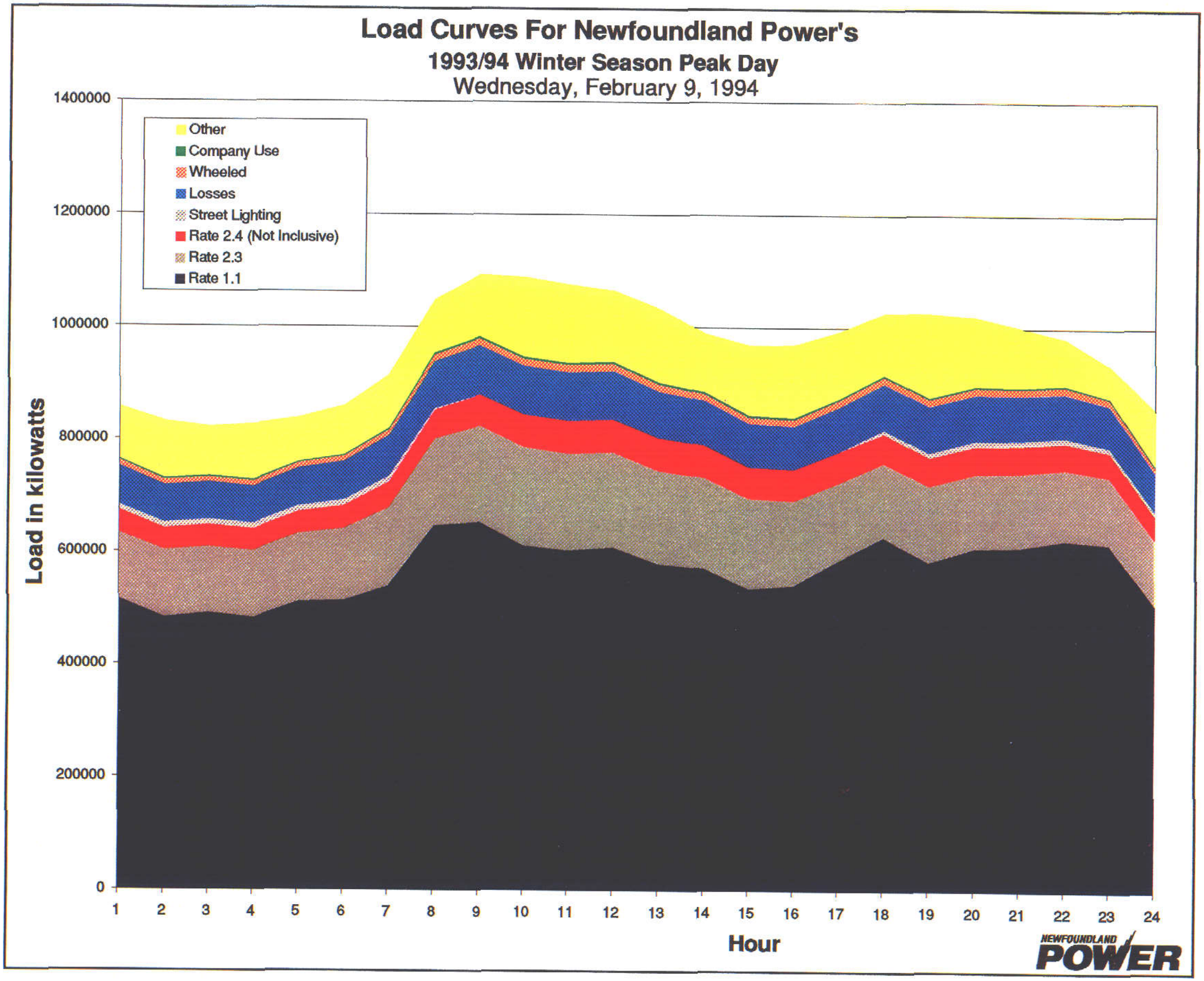
Load Curves For Newfoundland Power's
1991/92 Winter Season Peak Day
Monday, March 2, 1992
Other
Company Use
Wheeled
Losses
Street Lighting
Rate 2.4 (Not Inclusive)
Rate 2.3
Rate 1.1
1400000
1200000
1000000
800000
600000
400000
200000
0
Load in kilowatts
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
NEWFOUNDLAND POWER

Figure 4-2B



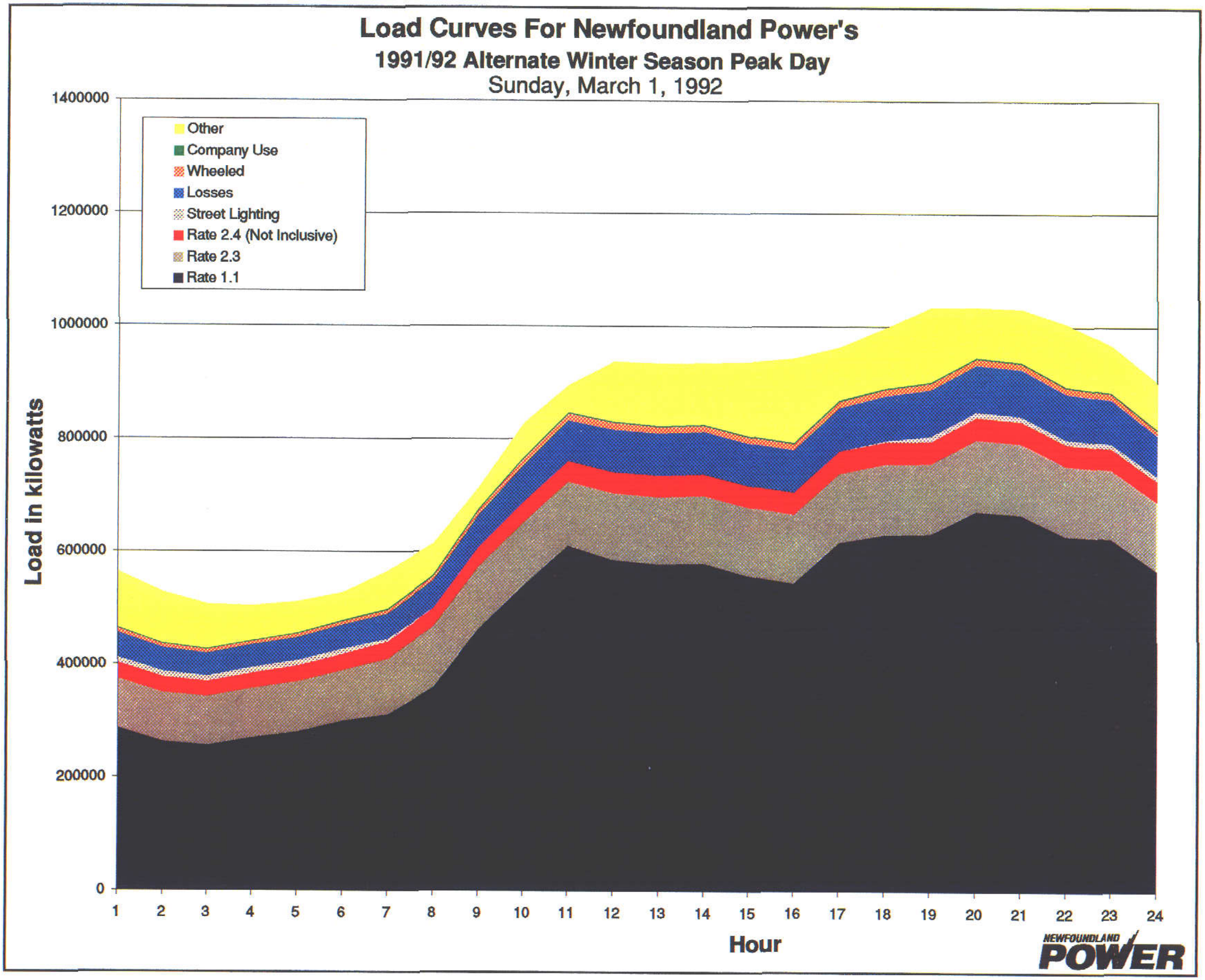
Load Curves For Newfoundland Power's
1992/93 Winter Season Peak Day
Wednesday, January 20, 1993
Other
Company Use
Wheeled
Losses
Street Lighting
Rate 2.4 (Not Inclusive)
Rate 2.3
Rate 1.1
1400000
1200000
1000000
800000
600000
400000
200000
0
Load in kilowatts
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
NEWFOUNDLAND POWER

Figure 4-2C



Load Curves For Newfoundland Power's
1993/94 Winter Season Peak Day
Wednesday, February 9, 1994
Other
Company Use
Wheeled
Losses
Street Lighting
Rate 2.4 (Not Inclusive)
Rate 2.3
Rate 1.1
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
NEWFOUNDLAND POWER

Figure 4-2D



Load Curves For Newfoundland Power's
1991/92 Alternate Winter Season Peak Day
Sunday, March 1, 1992
Other
Company Use
Wheeled
Losses
Street Lighting
Rate 2.4 (Not Inclusive)
Rate 2.3
Rate 1.1
Load in kilowatts
1400000
1200000
1000000
800000
600000
400000
200000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
NEWFOUNDLAND POWER

Figure 4-3A

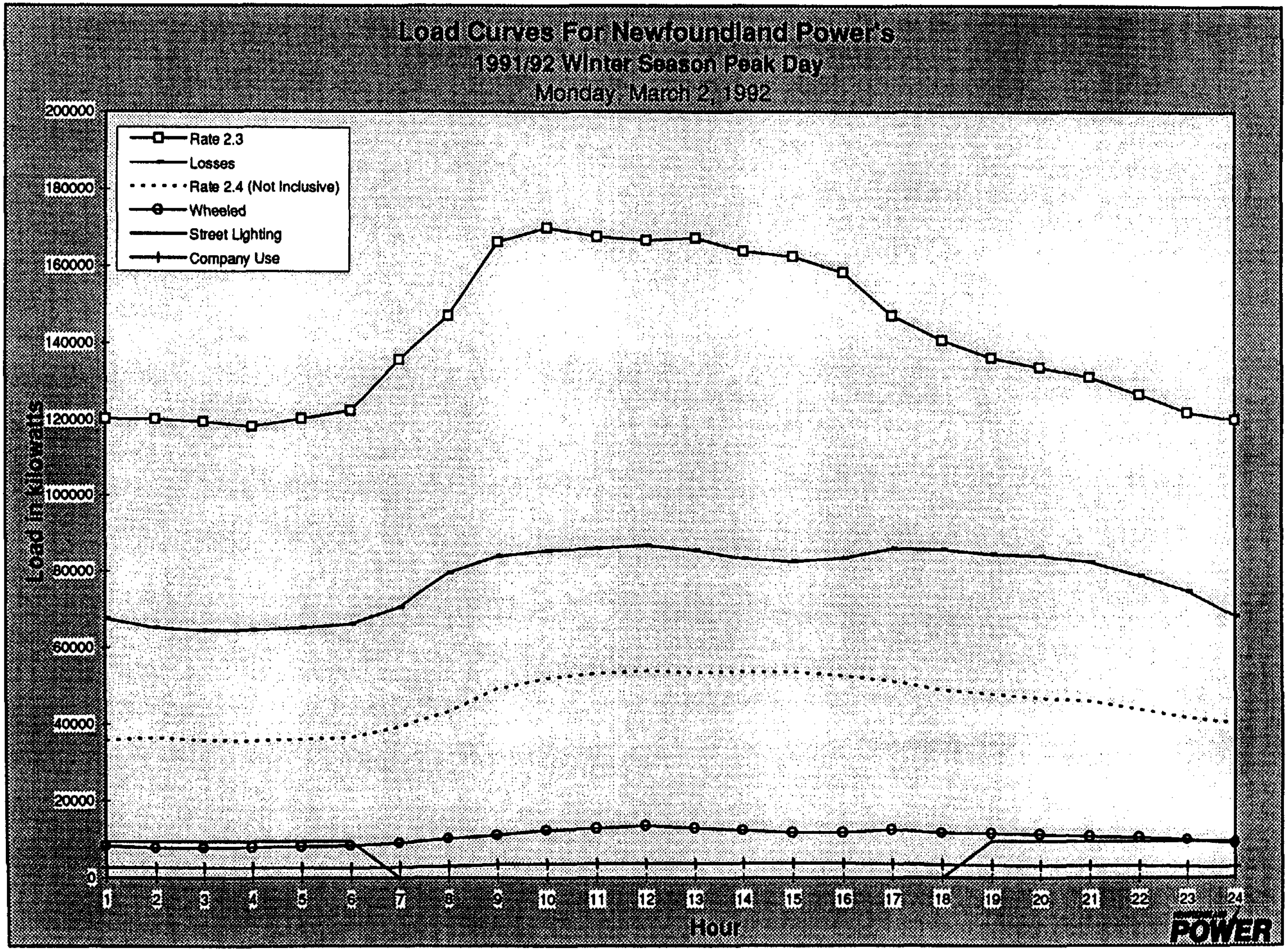
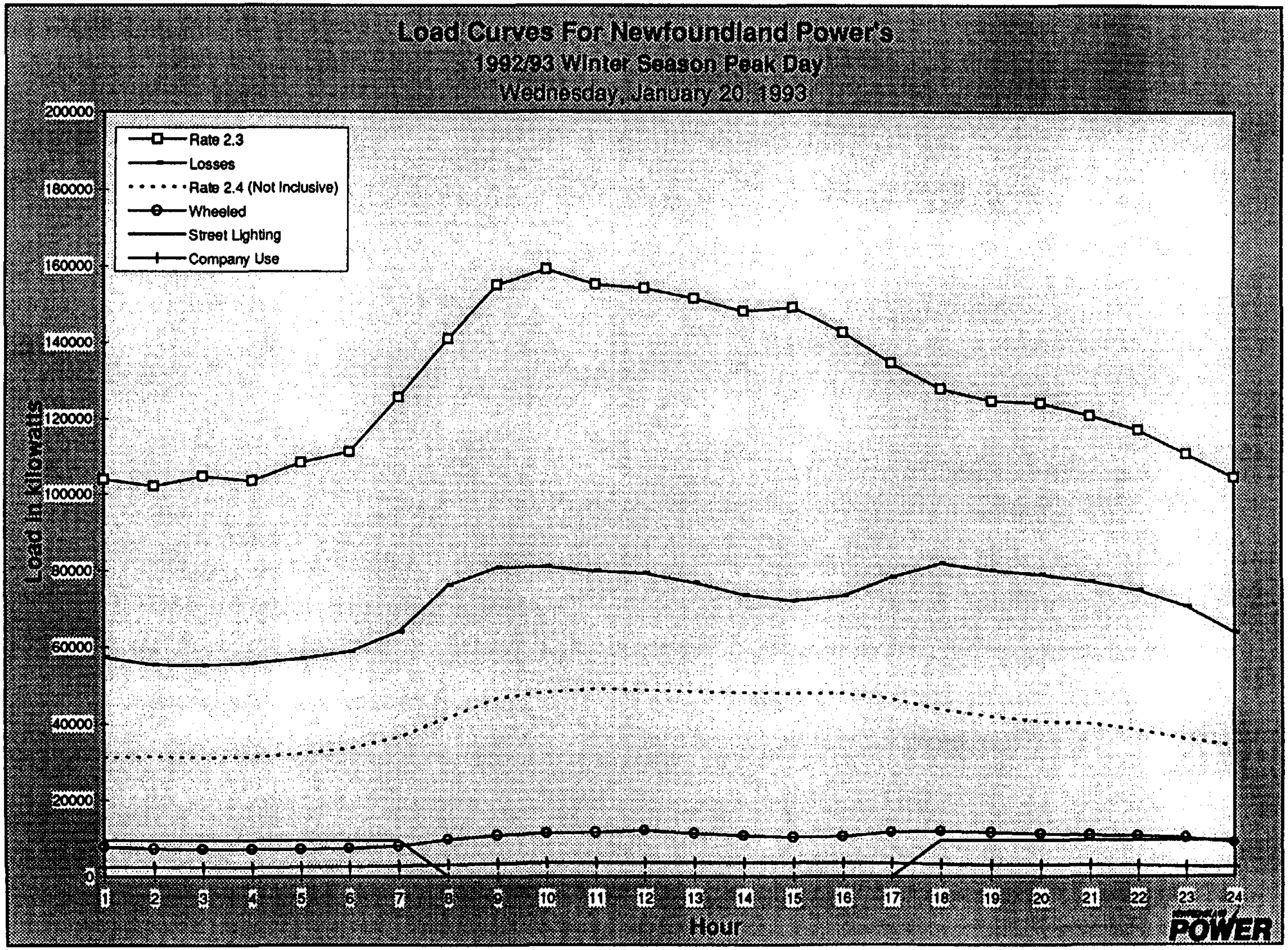

Load Curves For Newfoundland Power's
1991/92 Winter Season Peak Day
Monday, March 2, 1992
Rate 2.3
Losses
Rate 2.4 (Not Inclusive)
Wheeled
Street Lighting
Company Use
Load in kilowatts
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-3B



Load Curves For Newfoundland Power's
1992/93 Winter Season Peak Day
Wednesday, January 20, 1993
Rate 2.3
Losses
Rate 2.4 (Not Inclusive)
Wheeled
Street Lighting
Company Use
Load in Kilowatts
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-3C

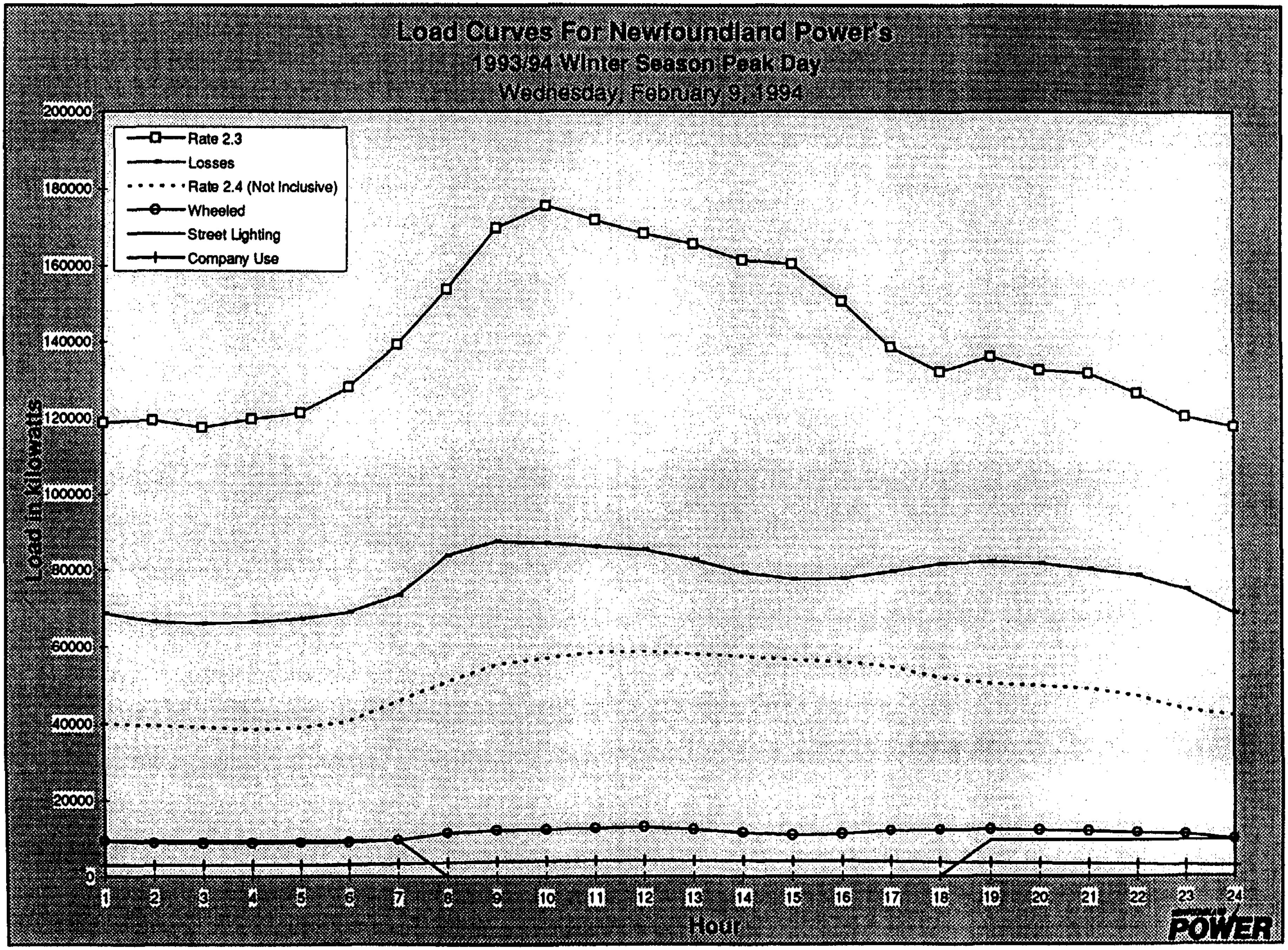

Load Curves For Newfoundland Power's
1993/94 Winter Season Peak Day
Wednesday, February 9, 1994
Rate 2.3
Losses
Rate 2.4 (Not Inclusive)
Wheeled
Street Lighting
Company Use
Load in Kilowatts
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-3D

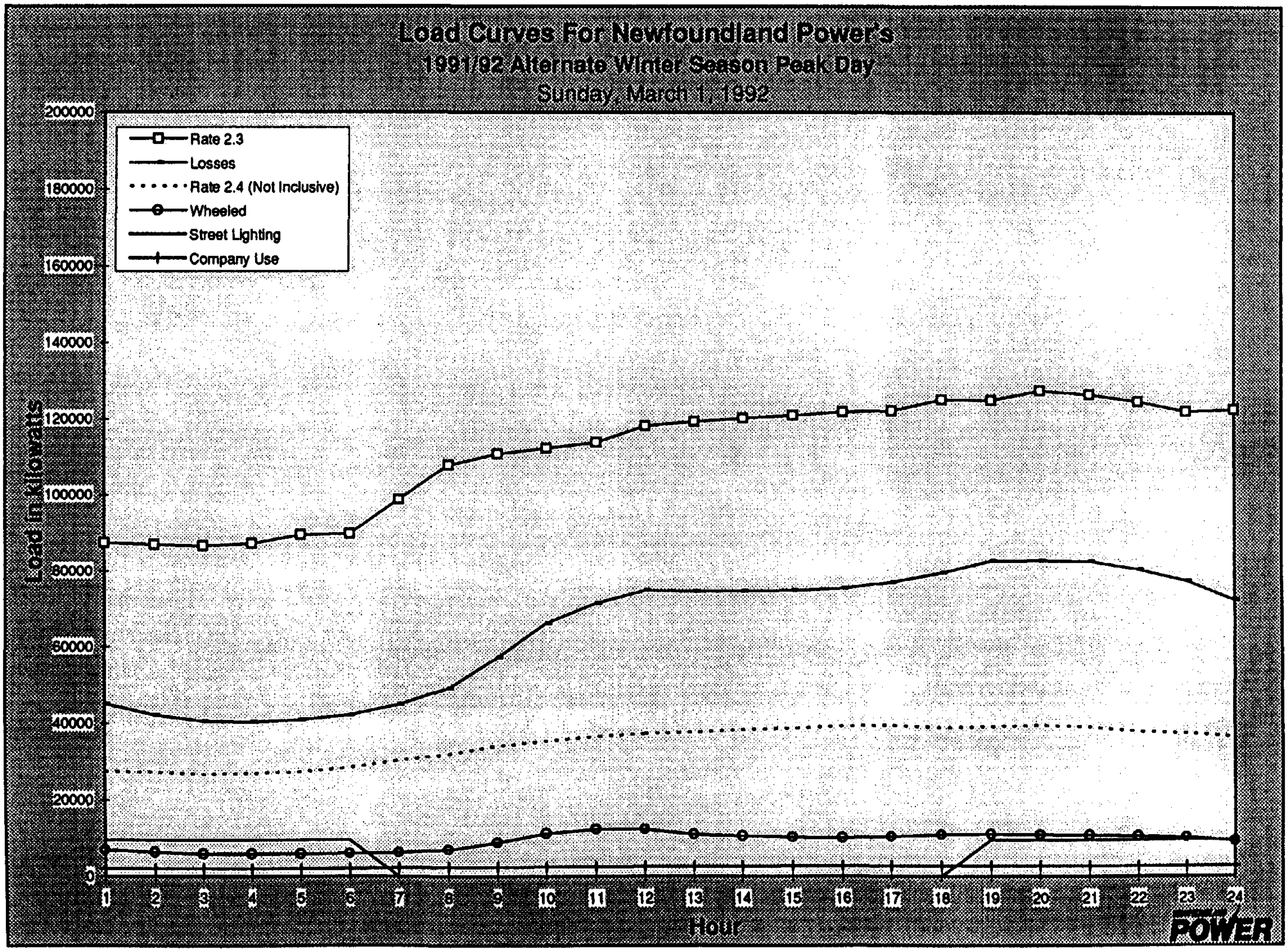

Load Curves For Newfoundland Power's
1991/92 Alternate Winter Season Peak Day
Sunday, March 1, 1992
Rate 2.3
Losses
Rate 2.4 (Not Inclusive)
Wheeled
Street Lighting
Company Use
Load in kilowatts
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-4A

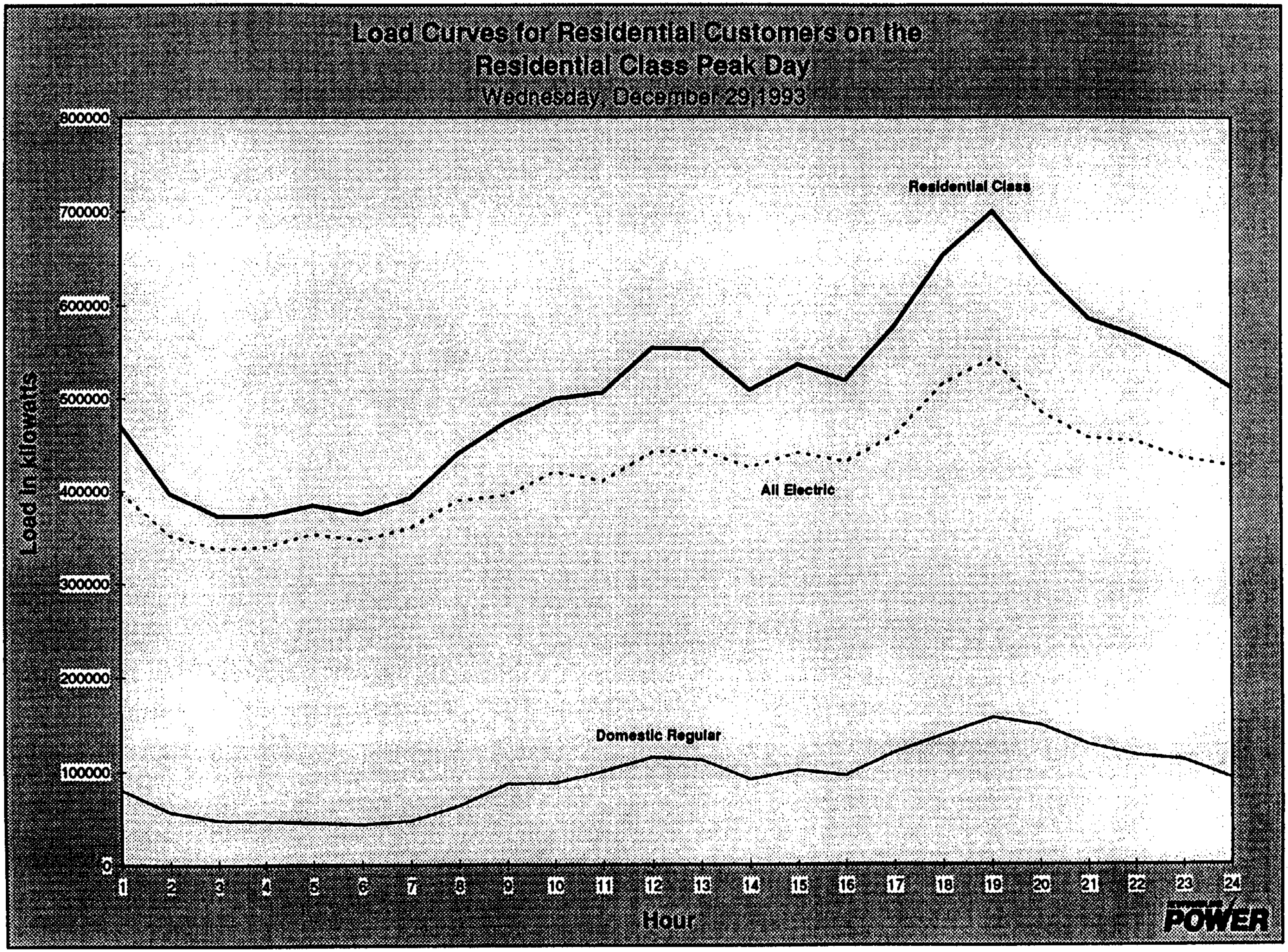
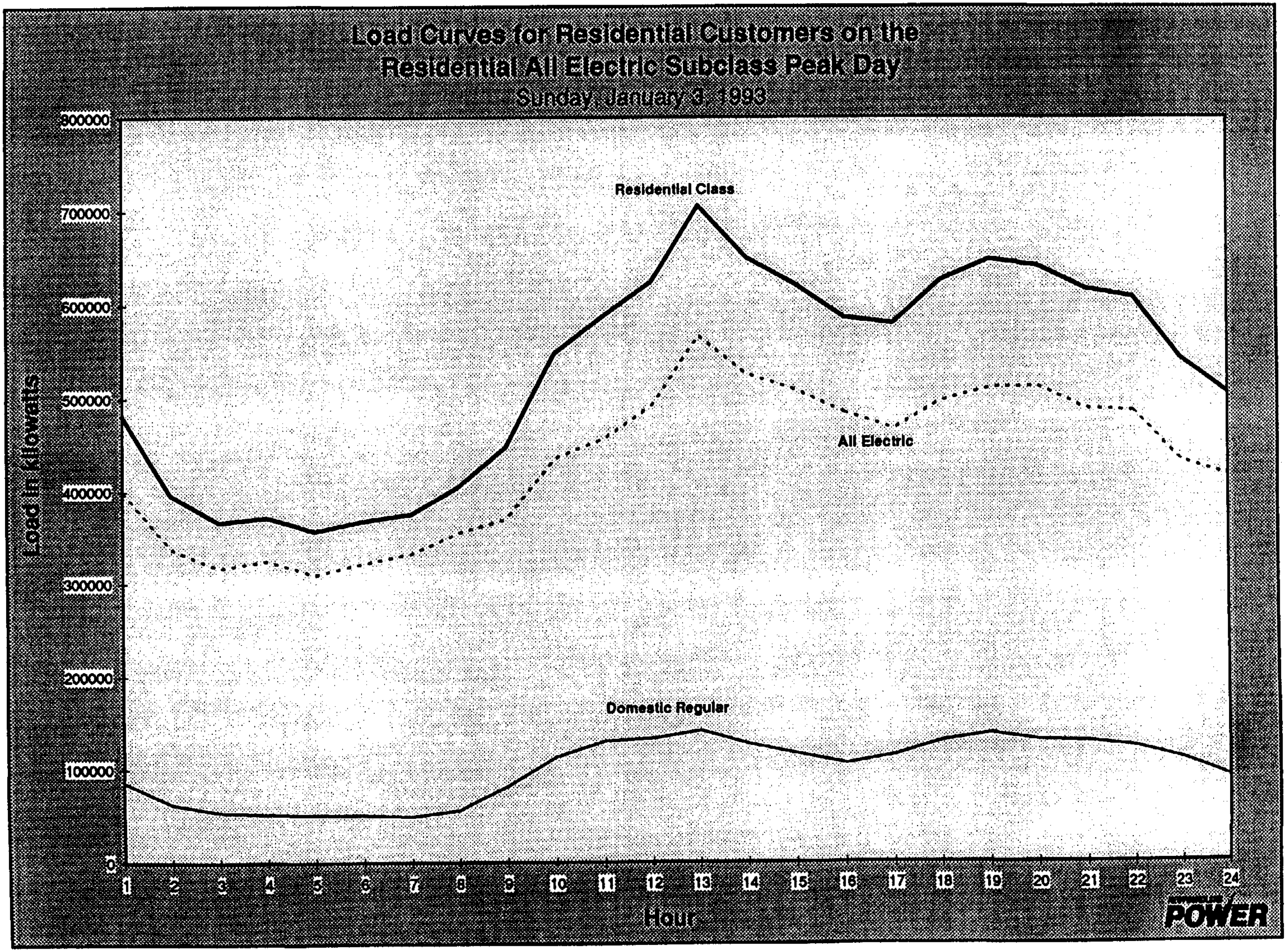

Load Curves for Residential Customers on the
Residential Class Peak Day
Wednesday, December 29,1993
800000
700000
600000
500000
400000
300000
200000
100000
0
Load in kilowatts
Residential Class
All Electric
Domestic Regular
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-4B



Load Curves for Residential Customers on the
Residential All Electric Subclass Peak Day
Sunday, January 3, 1993
Load in Kilowatts
800000
700000
600000
500000
400000
300000
200000
100000
0
Residential Class
All Electric
Domestic Regular
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
POWER

Figure 4-4C

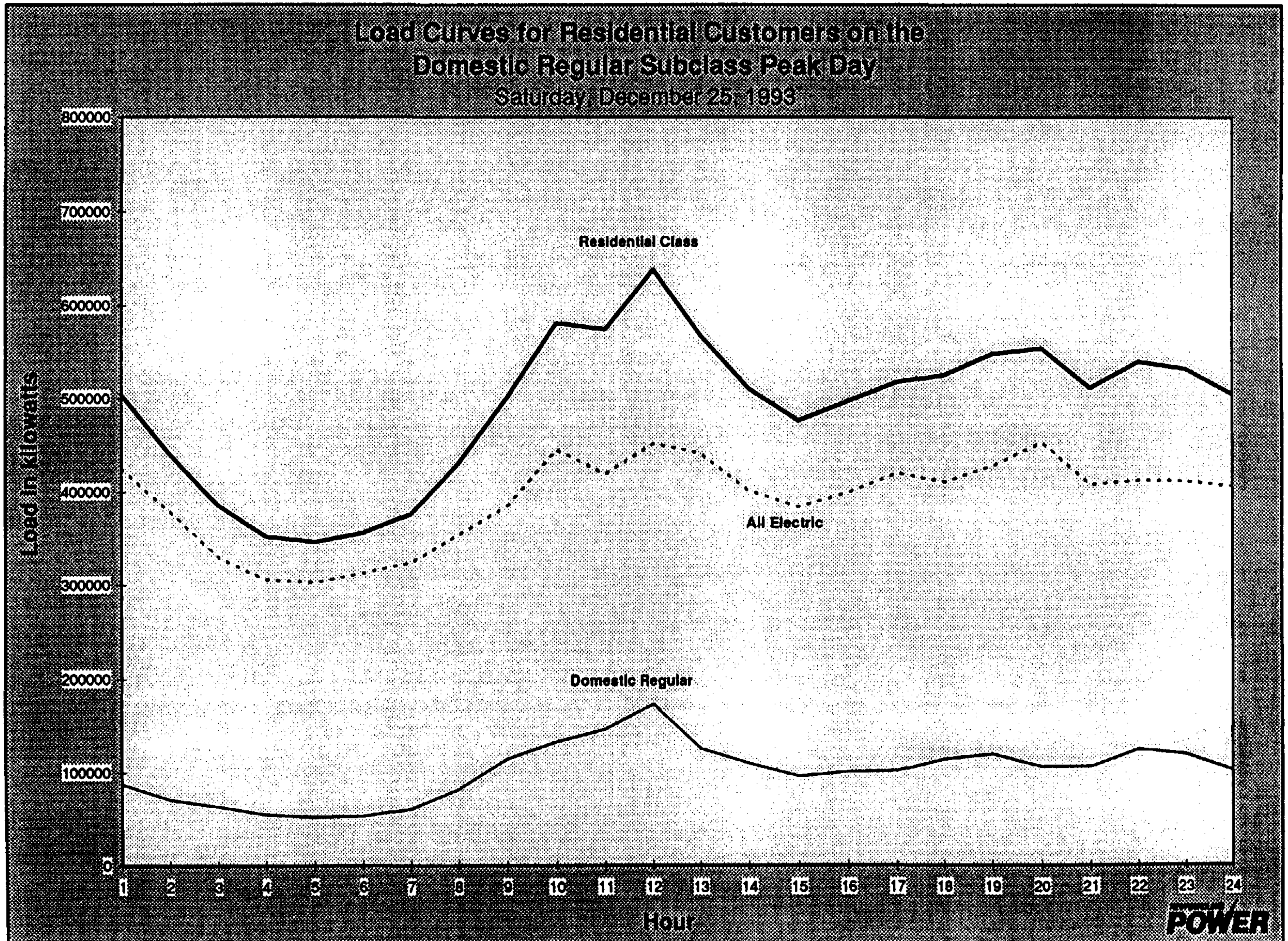
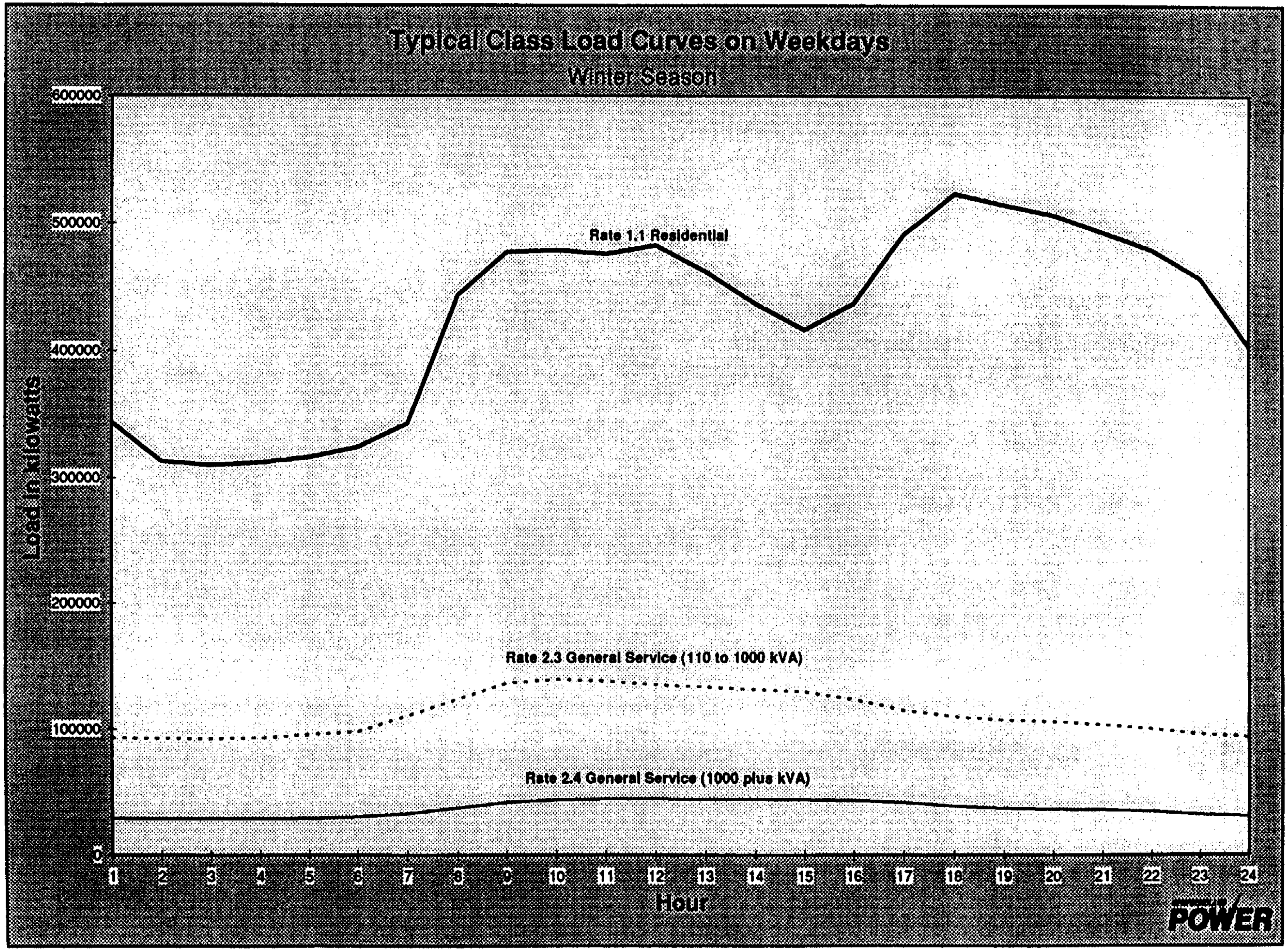
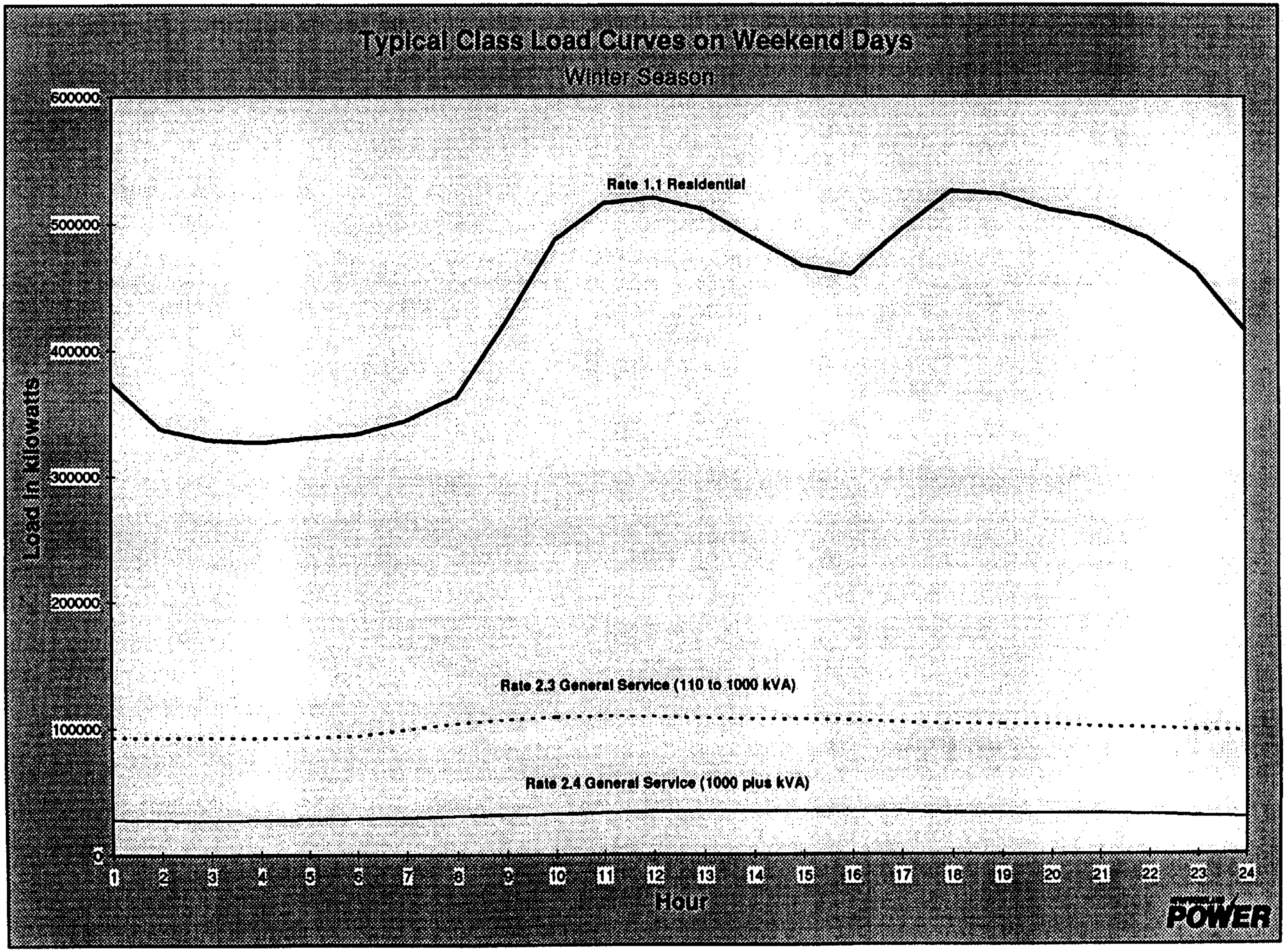

Load Curves for Residential Customers on the
Domestic Regular Subclass Peak Day
Saturday, December 25, 1993
Load in kilowatts
800000
700000
600000
500000
400000
300000
200000
100000
0
Residential Class
All Electric
Domestic Regular
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5A



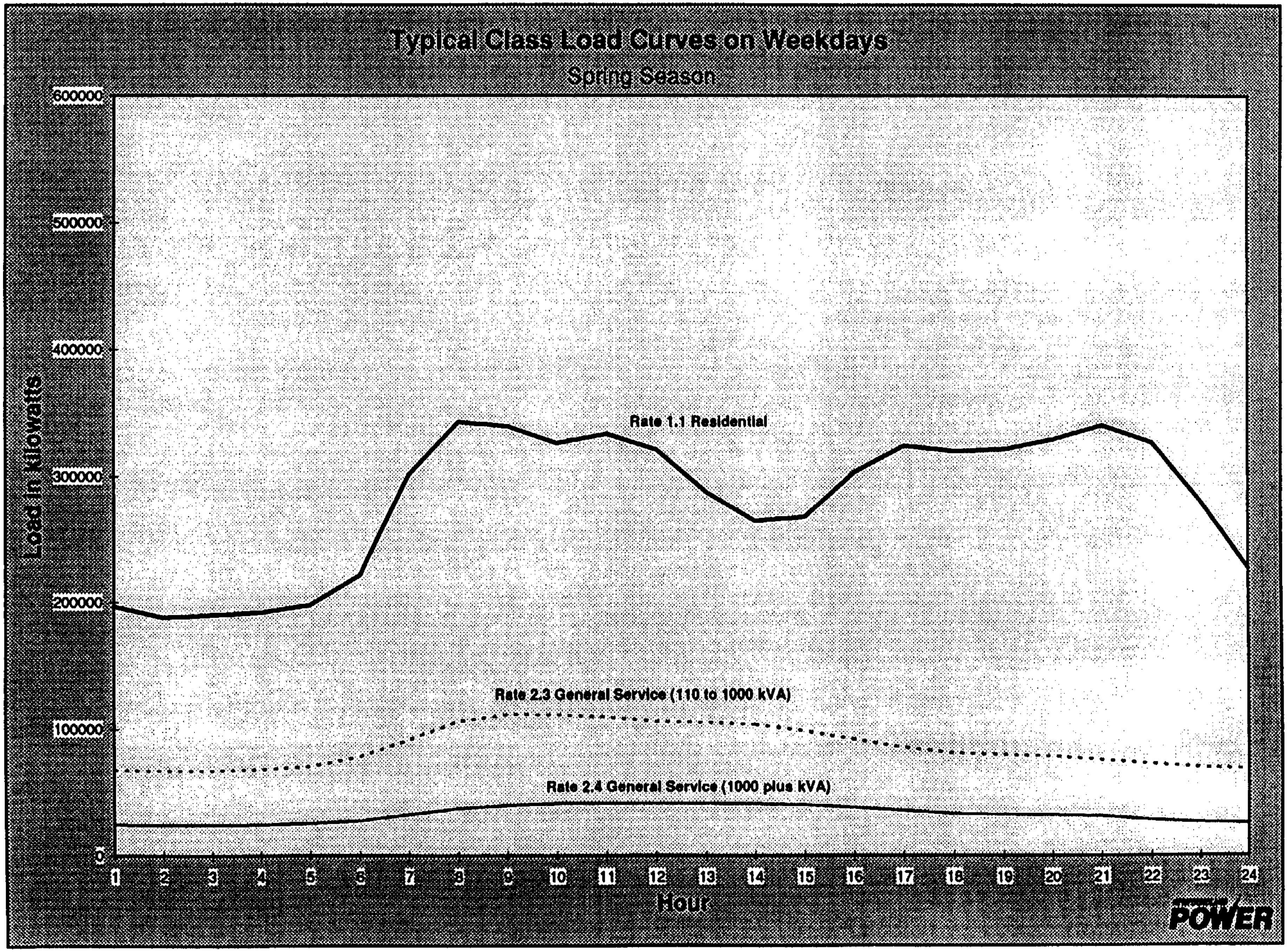
Typical Class Load Curves on Weekdays
Winter Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5B



Typical Class Load Curves on Weekend Days
Winter Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour
POWER

Figure 4-5C



Typical Class Load Curves on Weekdays
Spring Season
Load in Kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5D

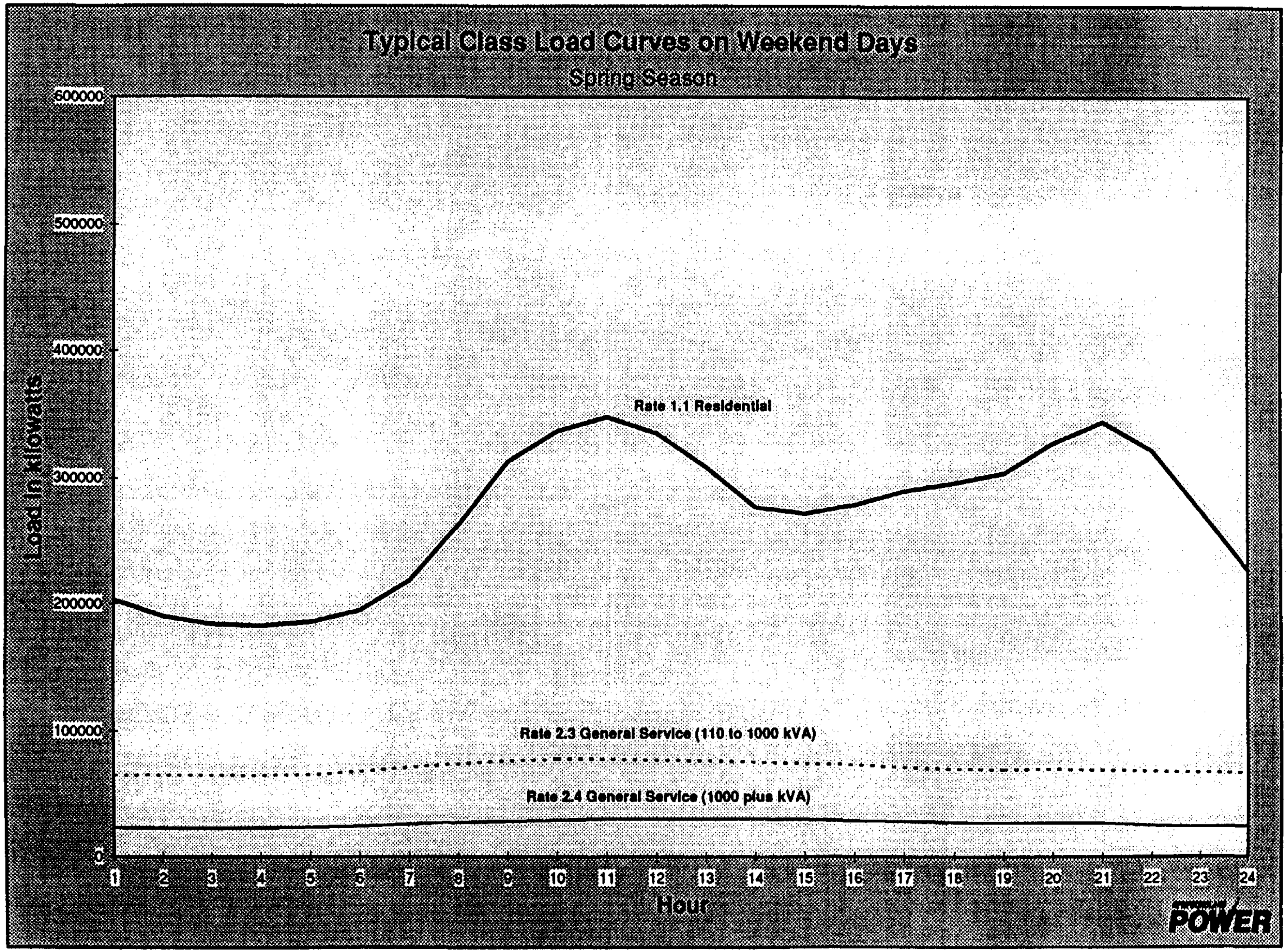

Typical Class Load Curves on Weekend Days
Spring Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5E

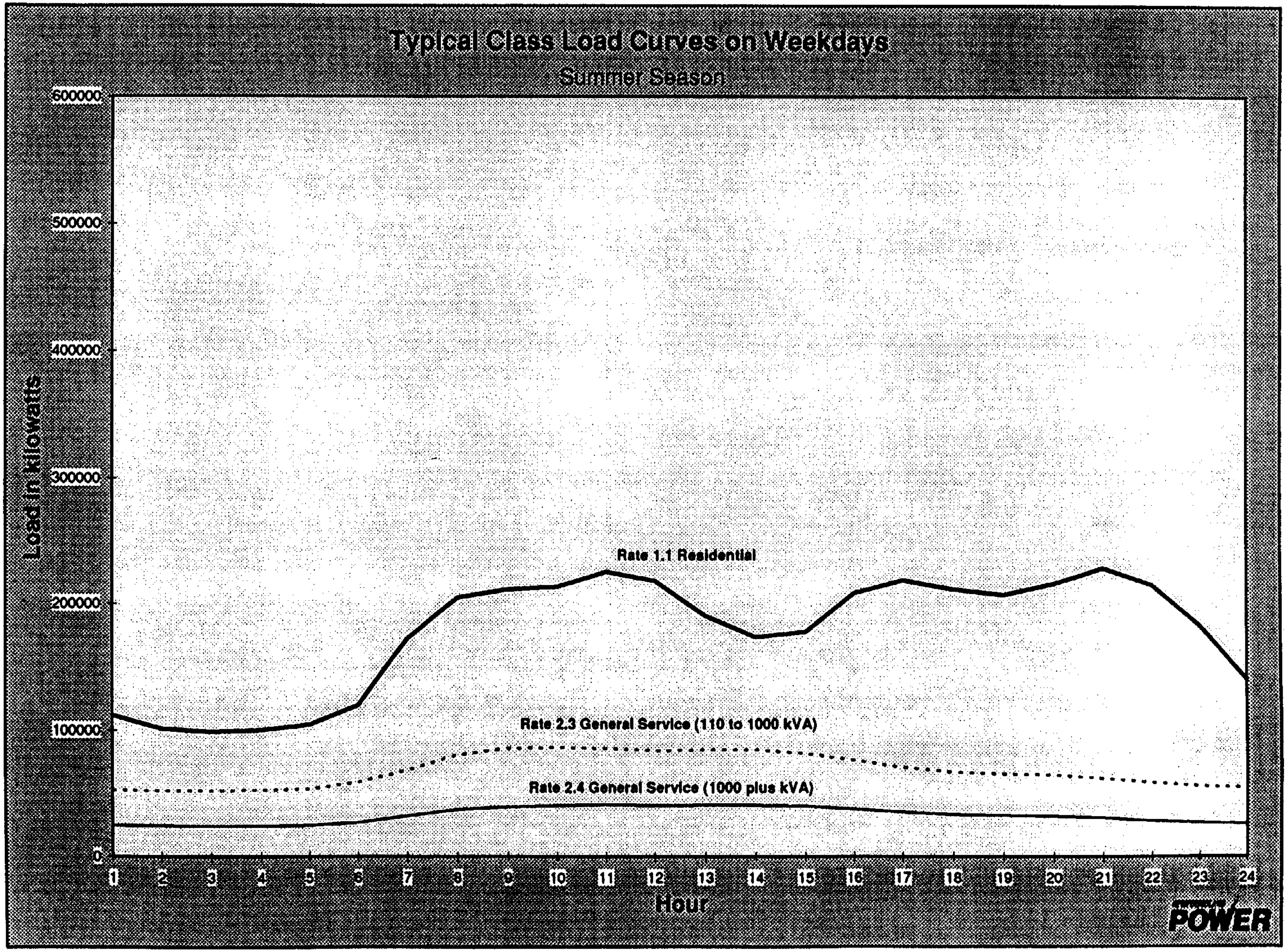
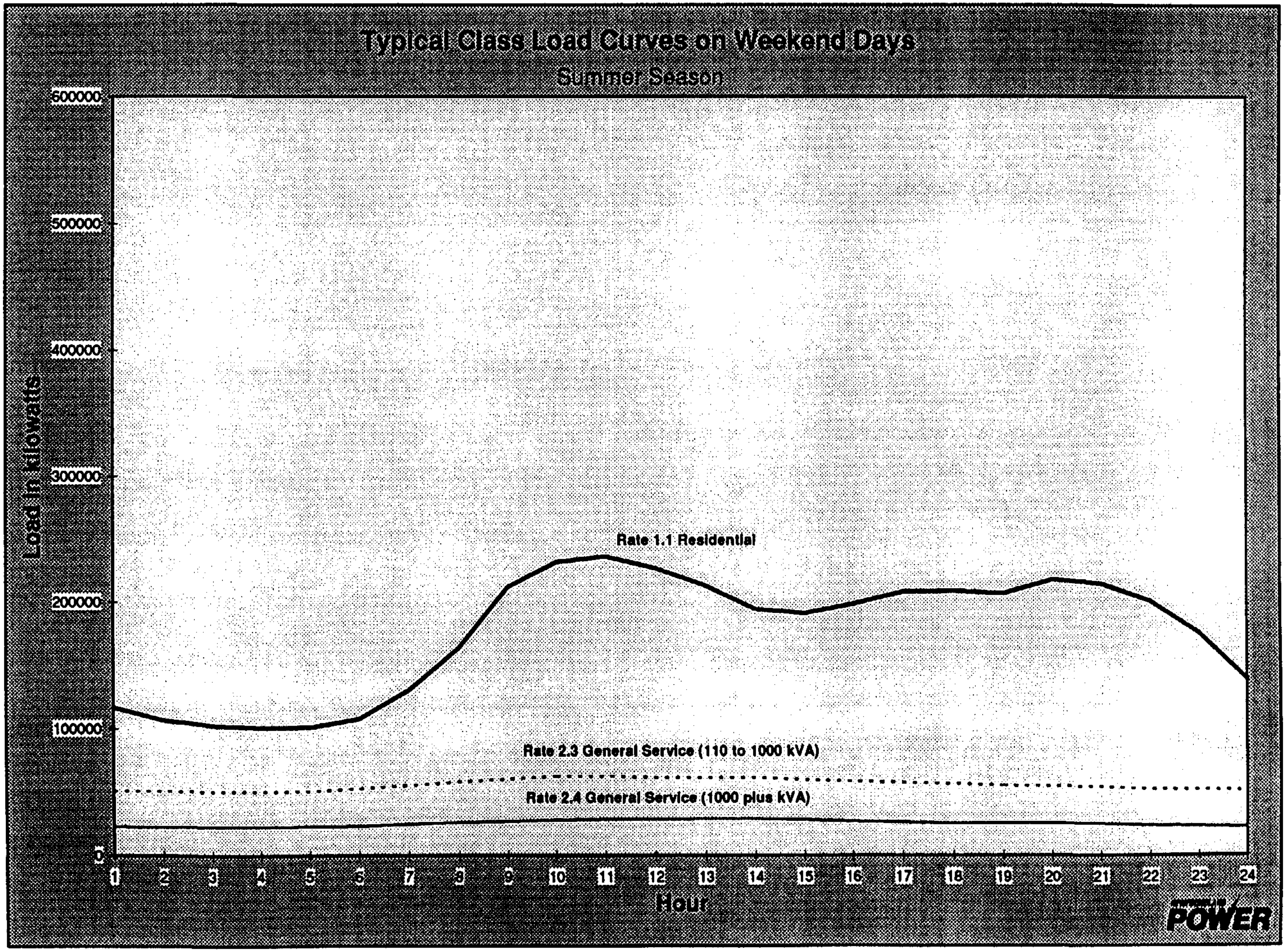

Typical Class Load Curves on Weekdays
Summer Season
Load in Kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5F



Typical Class Load Curves on Weekend Days
Summer Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5G

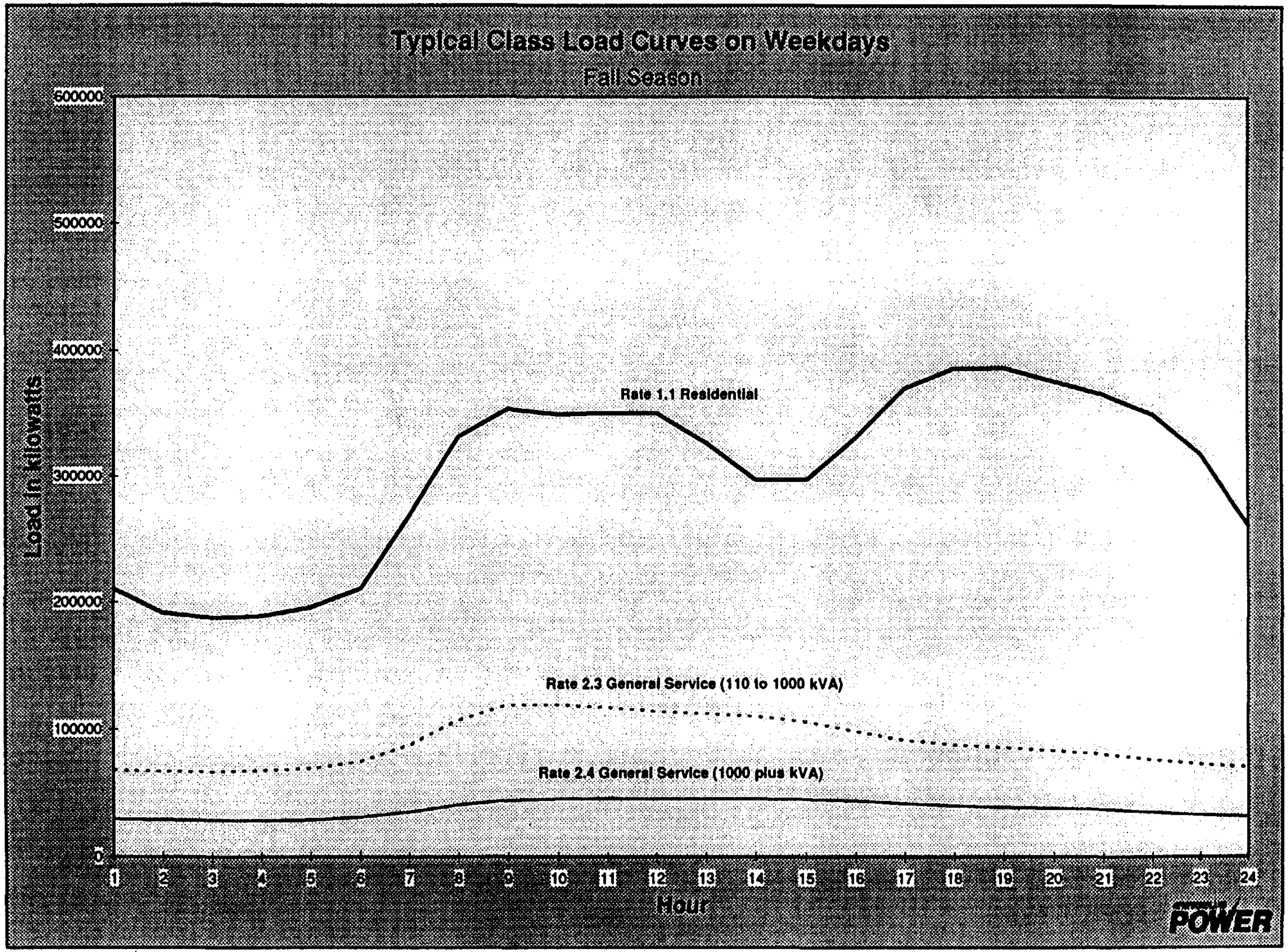
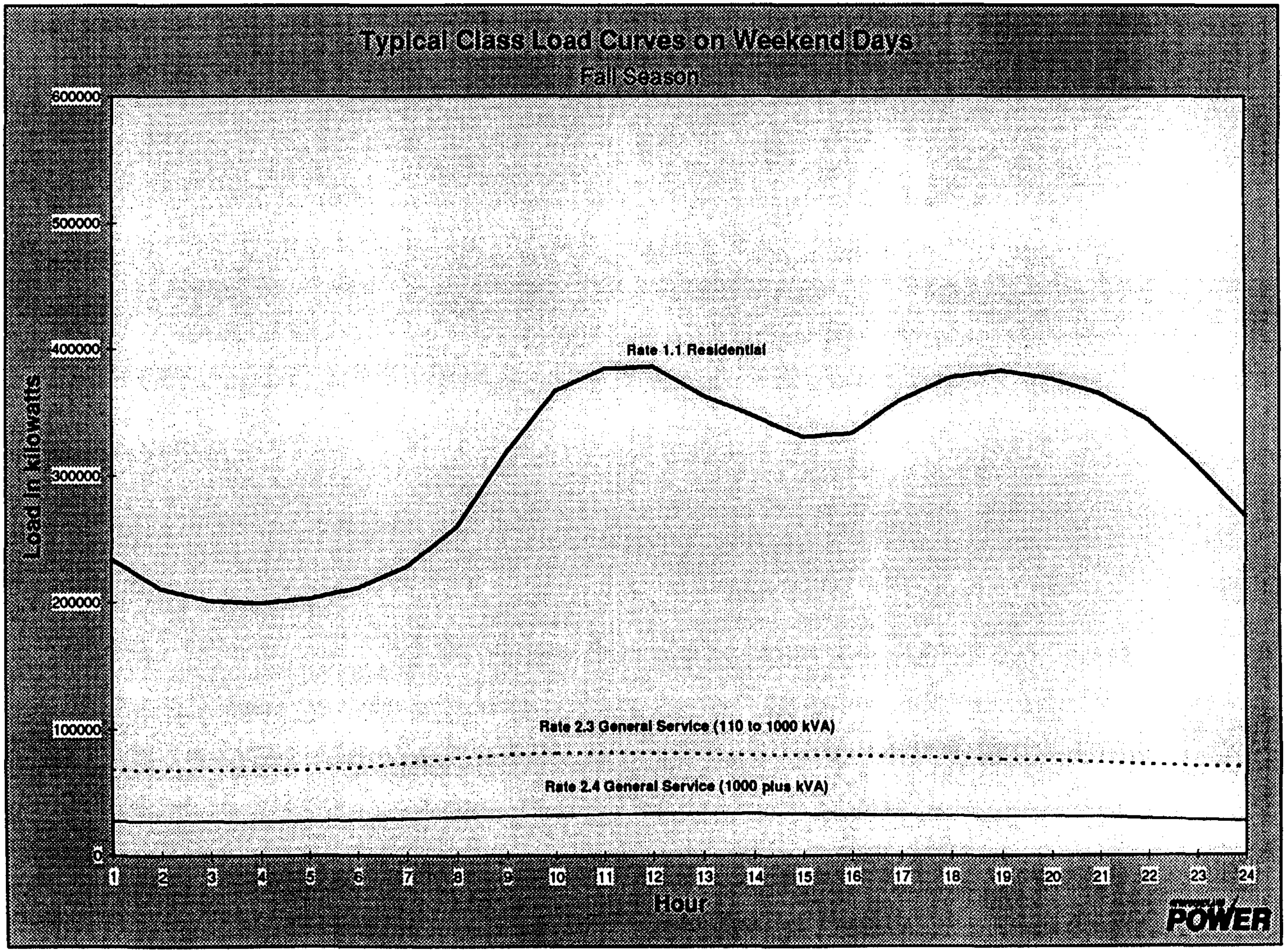

Typical Class Load Curves on Weekdays
Fall Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-5H



Typical Class Load Curves on Weekend Days
Fall Season
Load in kilowatts
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
POWER

Figure 4-6A

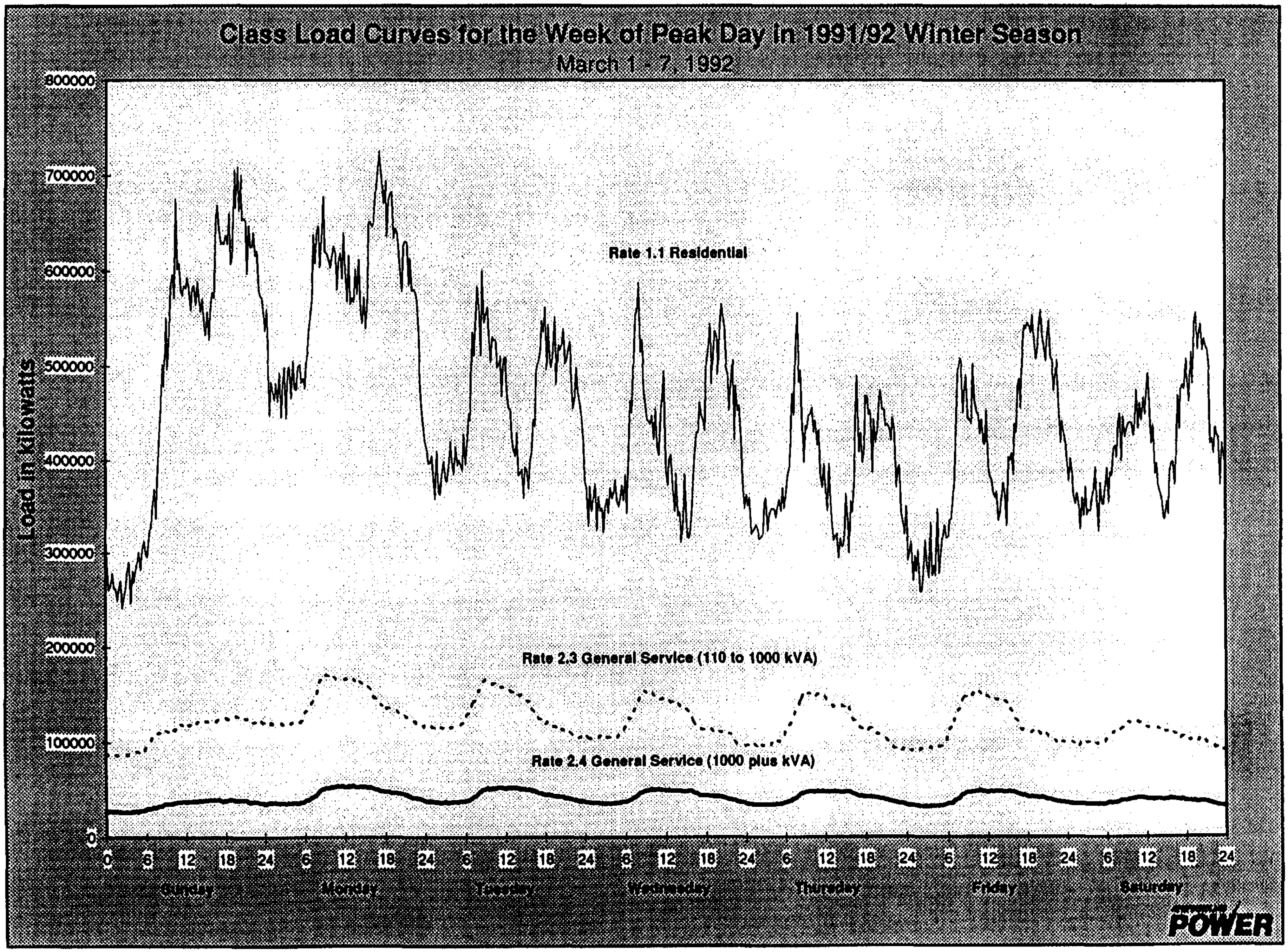

Class Load Curves for the Week of Peak Day in 1991/92 Winter Season
March 1 - 7, 1992
Load in kilowatts
800000
700000
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
0 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
POWER

Figure 4-6B

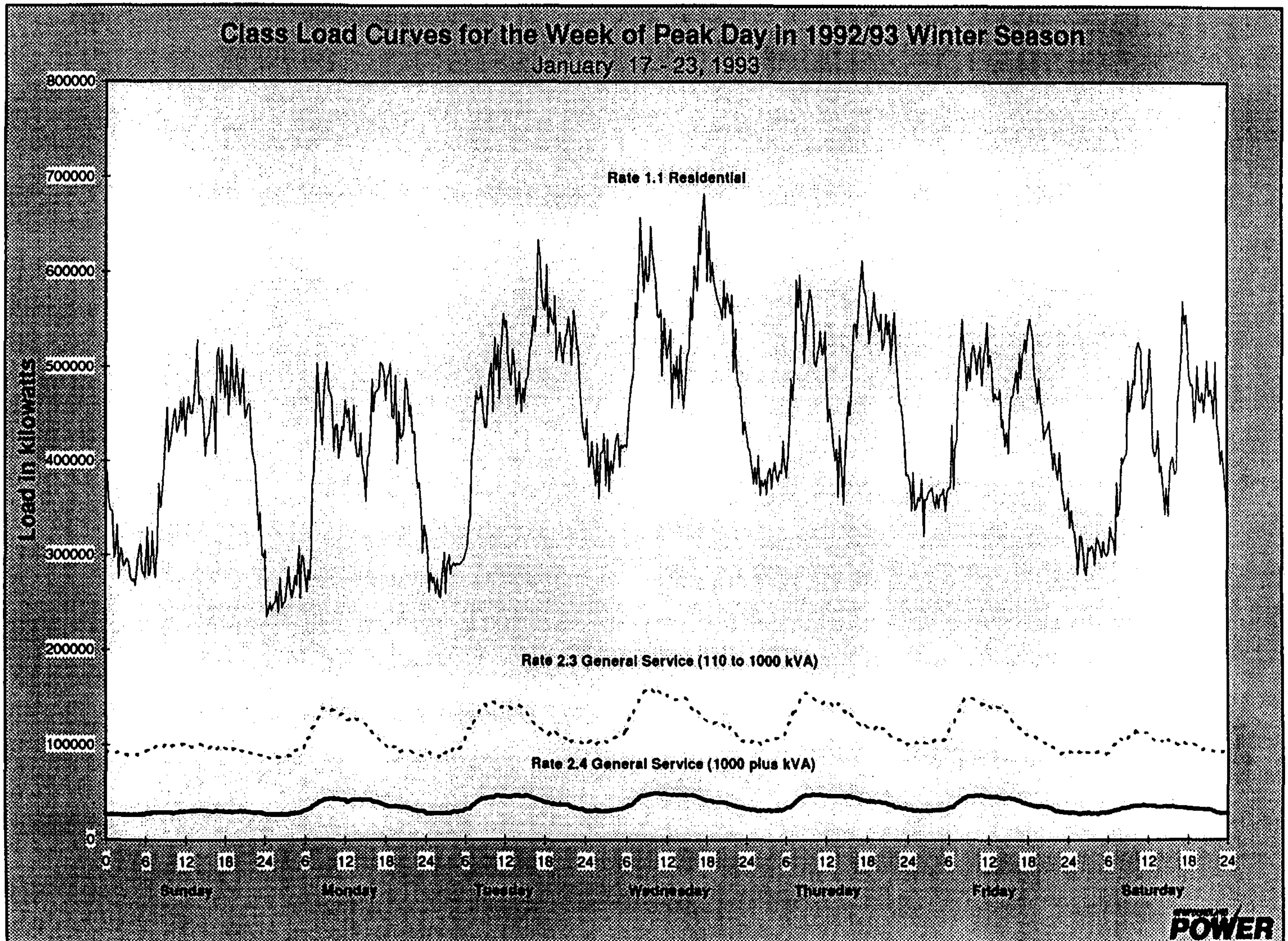
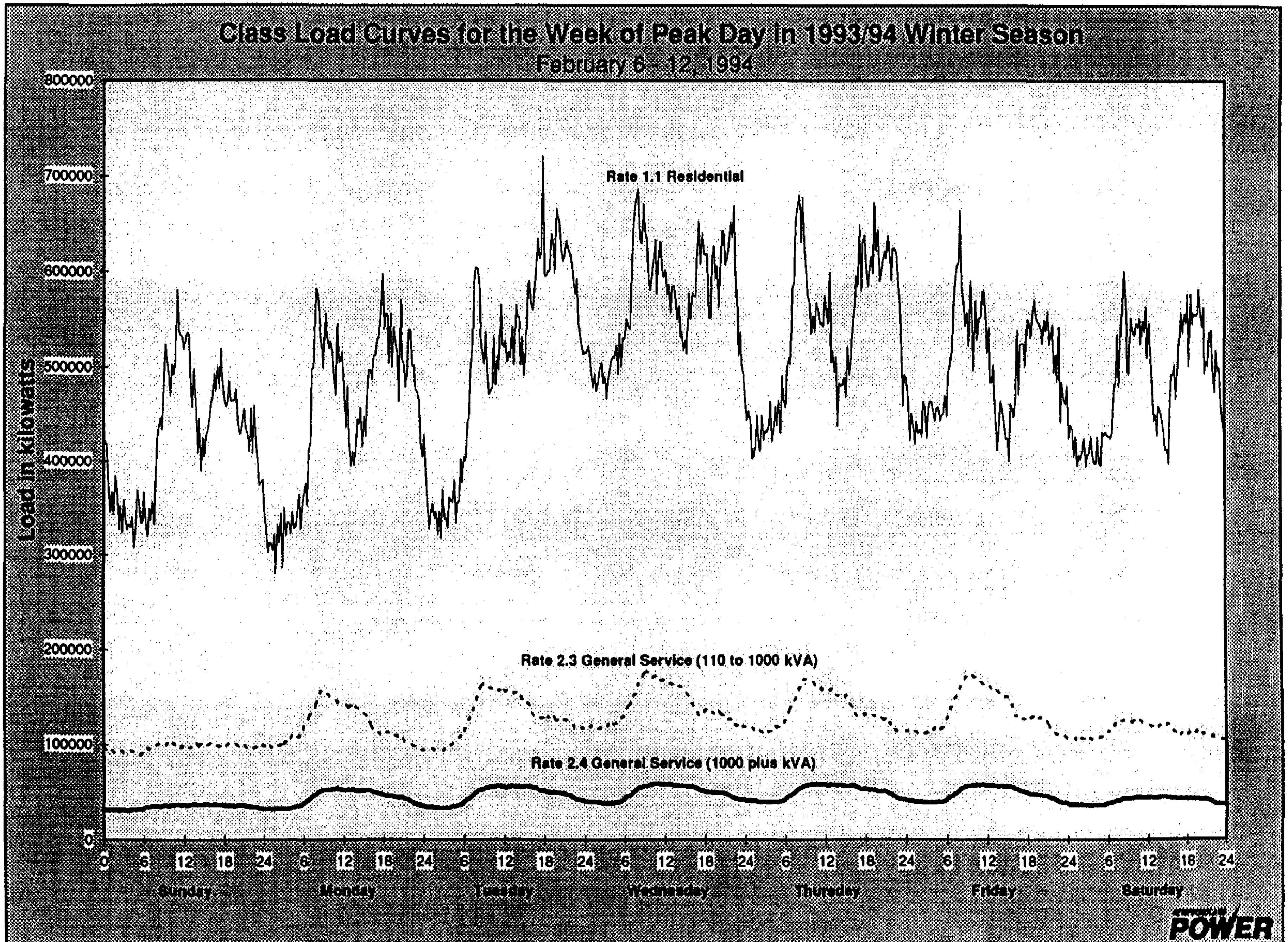
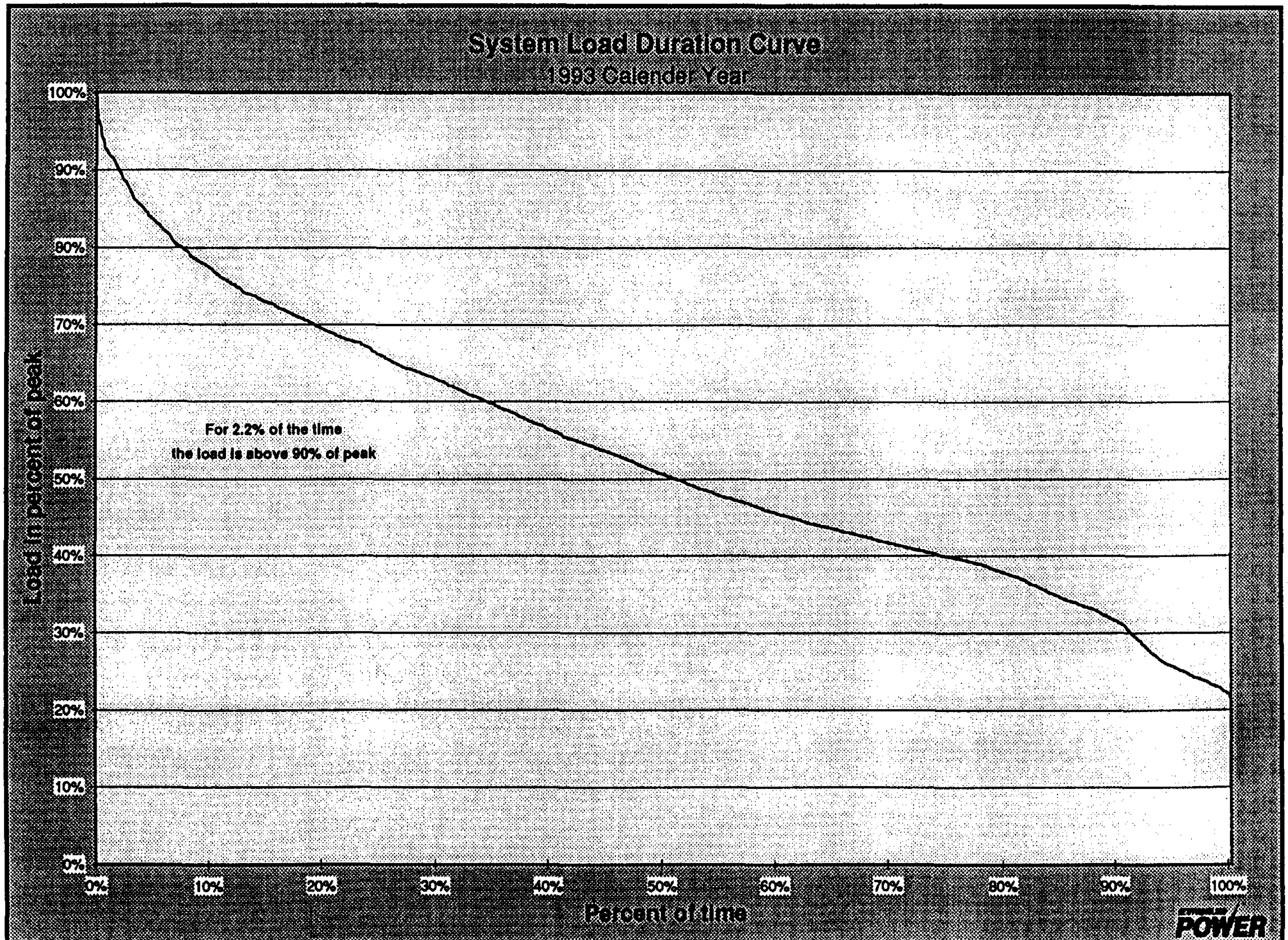

Class Load Curves for the Week of Peak Day in 1992/93 Winter Season
January 17 - 23, 1993
Load in kilowatts
800000
700000
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
0 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
POWER

Figure 4-6C



Class Load Curves for the Week of Peak Day in 1993/94 Winter Season
February 6 - 12, 1994
Load in kilowatts
800000
700000
600000
500000
400000
300000
200000
100000
0
Rate 1.1 Residential
Rate 2.3 General Service (110 to 1000 kVA)
Rate 2.4 General Service (1000 plus kVA)
0 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24 6 12 18 24
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
POWER

Figure 4-7A



System Load Duration Curve
1993 Calender Year
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Load in percent of peak
For 2.2% of the time
the load is above 90% of peak
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time
POWER

Figure 4-7B

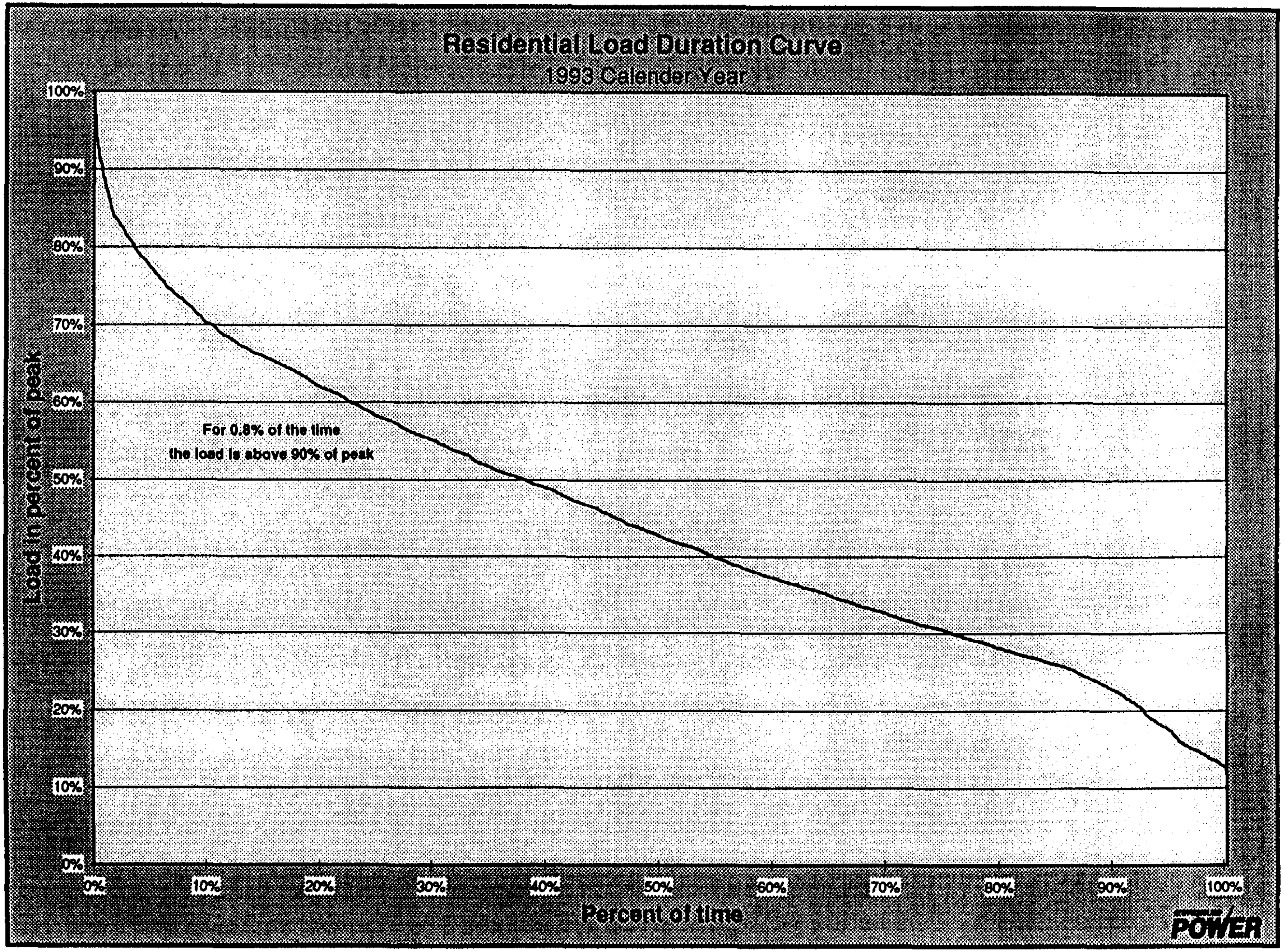
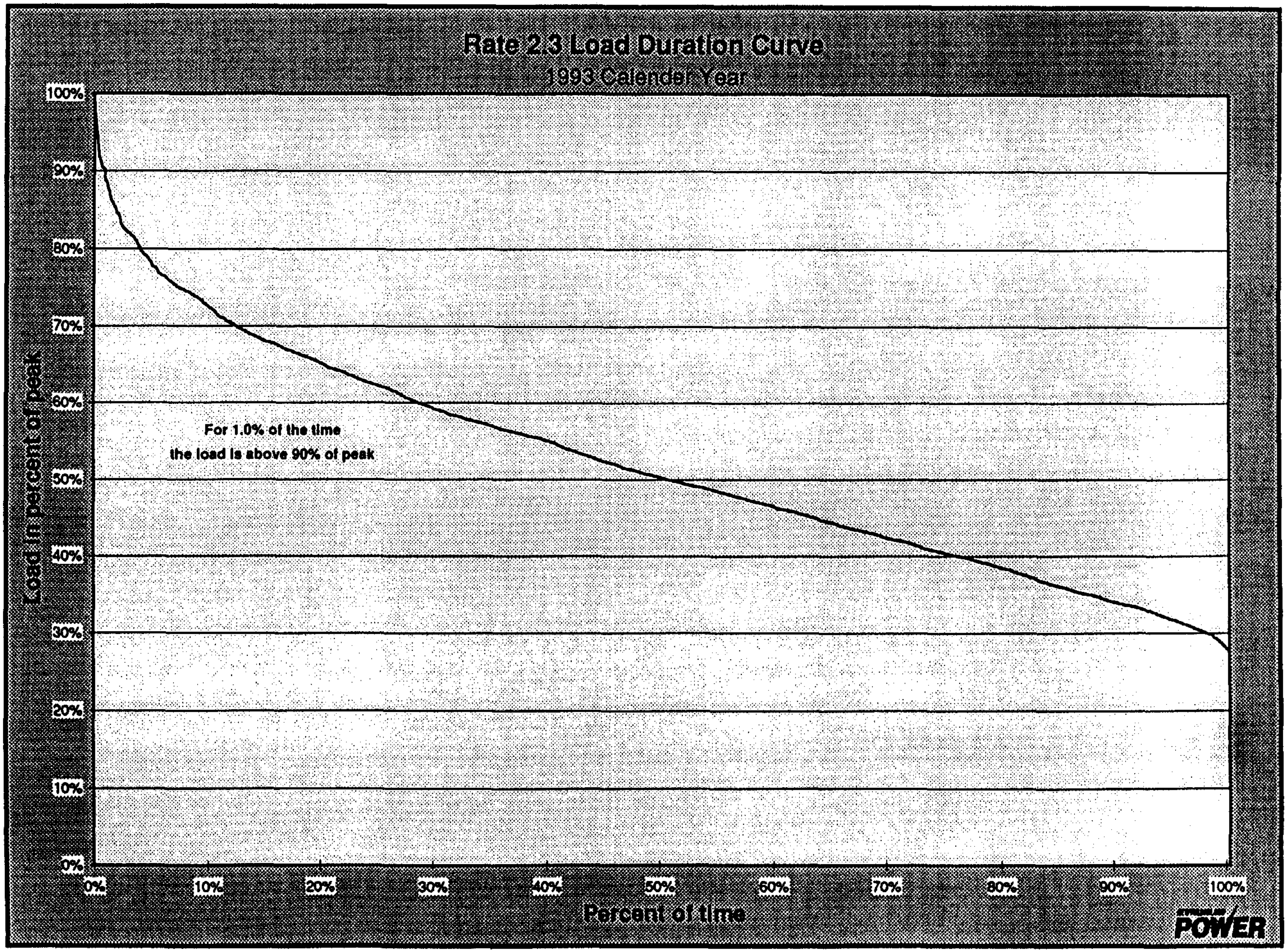
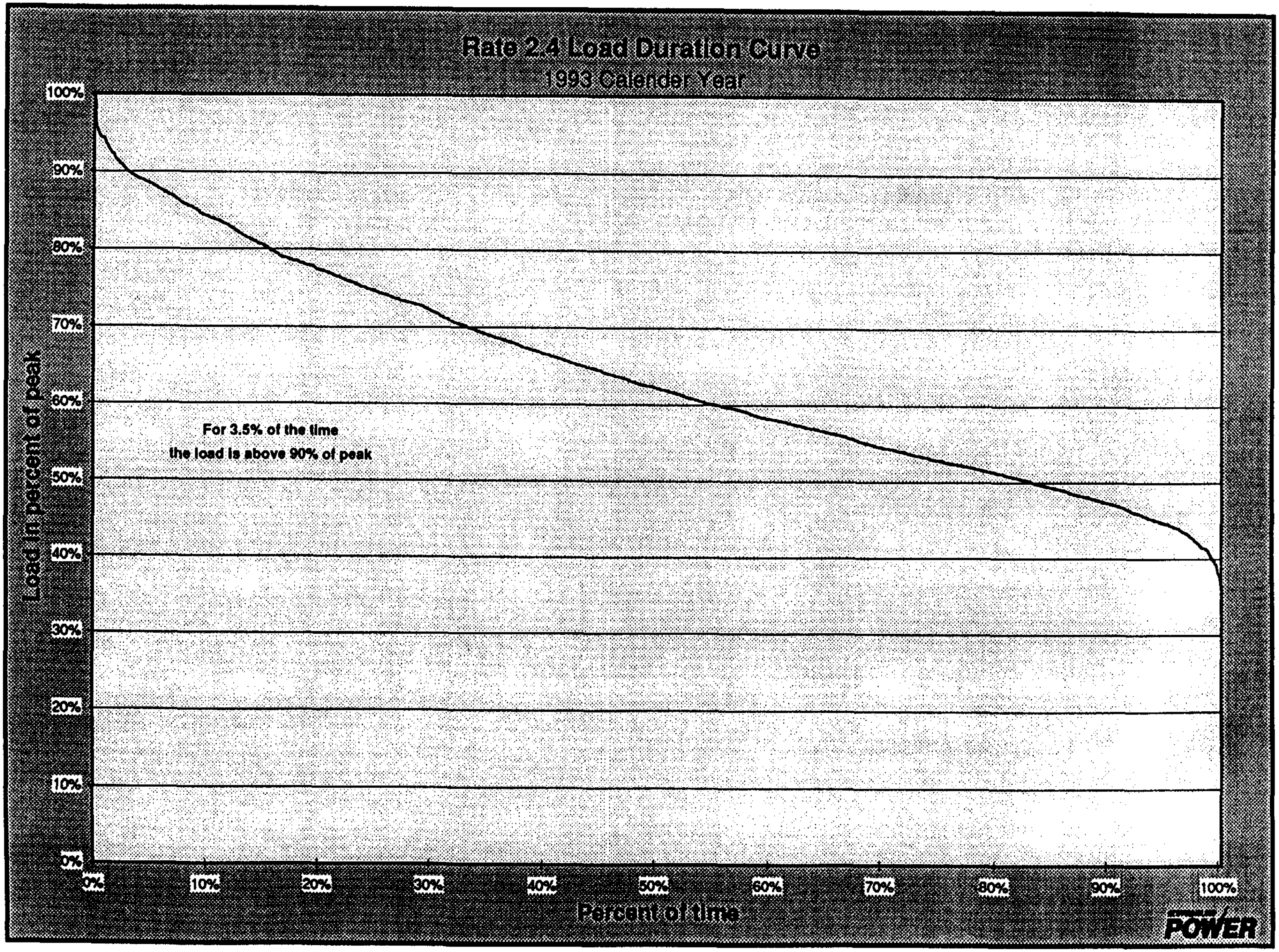

Residential Load Duration Curve
1993 Calender Year
Load in percent of peak
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
For 0.8% of the time
the load is above 90% of peak
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time
POWER

Figure 4-7C



Rate 2.3 Load Duration Curve
1993 Calender Year
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Load in percent of peak
For 1.0% of the time
the load is above 90% of peak
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time
POWER

Figure 4-7D


Rate 2.4 Load Duration Curve
1993 Calender Year
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Load in percent of peak
For 3.5% of the time
the load is above 90% of peak
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of time
POWER