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UER-216

Residential End-Use Load Shape Data Analysis

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ABSTRACT

Reliable data on end-use load shapes are important for forecasting electricity demand in least-cost utility planning. This report analyzes available residential end-use metered data collected by California utilities to use with an electricity peak demand forecasting model developed by the California Energy Commission. Representative daily load shapes for four seasons are developed for seven residential non-space-conditioning end uses. Hourly energy use for space conditioning end uses (central air conditioning and room air conditioning) is modeled with matrices that express energy use as a function of time of day, temperature and humidity. Exploratory work to represent these matrices with analytic functions is also presented.

I. INTRODUCTION

Accurate forecasts of energy demand are important for least-cost utility planning. In particular, demand-side management planning requires that forecasts represent in detail the load shape impacts of the end uses affected by demand-side programs. End-use load data, however, are scarce and expensive to obtain. The work described in this report analyzes recent metered data from California utility studies, intended for use by the California Energy Commission's (CEC) peak demand forecasting model.

The California Energy Commission developed and uses a peak model to forecast electrical load growth separately for each utility planning area in the state. The model calculates hourly loads for a system peak day based on end-use-specific daily load shapes and seasonal allocation factors. It is part of a suite of interconnected models that are used by the Commission staff to develop independent forecasts of energy and load growth for comparison to those submitted biennially by the utilities. In each forecasting cycle, CEC upgrades its models and data to improve forecasting capability. As part of this effort, the commission has contracted with the Energy Analysis Program of the Lawrence Berkeley Laboratory (LBL), through the University-wide Energy Research Group at the University of California, to provide more recent data on daily load shapes for CEC's residential peak model. (CEC funding was supplemented with support from the Department of Energy's Least-Cost Utility Planning project.)

The major purpose of the work reported here is to use available, measured, end-use hourly data to develop new load shapes for the CEC residential peak model. The load shapes currently used were derived from monitored load data, engineering estimates, and staff judgment. The monitored data were not measured in California and are generally 15 to 20 years old. The engineering data have never been validated with measured data.

A second purpose of this project is to assist CEC staff in transforming the peak model into an hourly load forecasting model. Forecasting hourly loads throughout the year will create connections between the demand forecast models and supply planning models used by CEC. We will use our analysis to comment on the availability of end-use load data to support this transformation.

This report consists of seven sections following the introduction. In section II, we briefly summarize existing documents that describe the formal structure of the CEC Residential Peak Model. In section III, we describe our utility sources for data. In section IV, we report our analysis for the non-conditioning end uses. In section V, we discuss results for the conditioning end uses. In section VI, we compare the new load shapes to those currently used by CEC. In section VII, we use our analysis to comment on additional areas for analysis and on prospects for hourly load shape forecasting. In addition, the report also includes six technical appendices.

II. THE CEC RESIDENTIAL PEAK MODEL

The analysis described in this report provides new load shape inputs for use in the CEC Residential Peak Model. We first present a brief review of the unique features of this model to help the reader understand our results. A detailed treatment of the equations used by the model is provided in Appendix A.

The CEC Residential Peak Model (RPM) forecasts peak day residential electricity demands by end use for each utility planning area in California. The RPM relies on forecasts of end-use annual electricity consumption from the CEC Residential Energy Demand Forecasting Model. However, the forecasts of annual electricity consumption are richer in detail than those accepted by the RPM, so aggregations of end uses from the annual forecasts are required. For example, the forecast of annual electricity use for refrigerators is developed separately for several vintages, but the RPM produces only a single load shape for the end use called refrigerators. Table II-1 summarizes the end uses of the RPM and indicates those analyzed in this report.

Table II-1. CEC Residential Peak Model End Uses

Non-Conditioning	Conditioning
Refrigerators *	Central A/C - Single Family *
Freezers *	Central A/C - Multi-Family
Water Heaters - Single Family *	Room A/C *
Water Heaters - Multi-Family	Space Heating - Single Family
Clothes Washers *	Space Heating - Multi-Family
Cooking *	
Dryers *	
Dishwashers *	
Lighting and Miscellaneous	
Television	
Pool Pumps	
Solar Backup	
Solar Pool Pump	
Solar Water Heater	

* End uses analyzed in this study

In three steps, the RPM allocates annual residential electricity consumption, by end use, into an hourly load profile for the system peak day. First, the model allocates the annual electricity consumption to peak day electricity consumption. Second, it distributes the peak day electricity consumption to hourly loads using daily load shapes. Third, the model sums the hourly loads

III. DATA SOURCES

Until recently, measured end-use load shape data were only available from a handful of limited load metering experiments. Despite the high cost of collecting these data, several utilities have recently begun large-scale projects. The best known include Bonneville Power Authority's End-use Load and Conservation Assessment Program [Stokes and Hauser 1986], Sierra Pacific Power Company's Energy Information Project [Sierra Pacific Power Company 1986], Pacific Gas and Electric Company's Appliance Metering Project [Pacific Gas and Electric Company 1987], and Southern California Edison Company's Residential Appliance End-Use Survey [Quantum Consulting 1988].

For this study, we were fortunate to use data from projects of the Pacific Gas and Electric Company (PG&E) and Southern California Edison Company (SCE). We were also able to analyze some of the data collected by the San Diego Gas and Electric Company (SDG&E) from evaluations of their residential load management programs. Appendix B reviews all data sources considered for the study.

We present background and unique features of these data in this section so the reader can compare the resulting analyses to his or her needs. One example of limits on interpreting our data comes from the PG&E metering project. The metering sites used by PG&E, were identified through application of specific statistical sampling procedures. We did not incorporate the associated statistical sampling weights developed by PG&E, however, so our analyses may not be statistically representative of residential loads for the PG&E system. They are, nevertheless, representative of residential loads for the specific sample of metered PG&E sites.

Table III-1 summarizes, for each end use, the number of households monitored by each utility. As described in Section IV, not every end use was analyzed, and separate but closely related end uses were combined into a single category. For example, heat pumps were metered by both the PG&E and SCE studies but we did not analyze them because the CEC residential peak model does not currently treat this end use separately from electric resistance heating. Another example: PG&E metered several cooking technologies, but because the load shapes were very similar and because the CEC model does not distinguish individual cooking technologies, we combined them into a single end-use load shape for cooking.

Pacific Gas and Electric

In 1983, PG&E began the first large-scale end-use load metering project in California [Pacific Gas and Electric Company 1987]. The Appliance Metering Project (AMP) was designed to measure load patterns of domestic appliances for a subset of PG&E residential customers. The sample was drawn from single-family, owner-occupied residences in the PG&E electricity service territory (which includes most of the northern two-thirds of California). The subpopulation with central air conditioners, heat pumps, or a window/wall air conditioner in the hottest part of the service territory were targeted for intensive sampling because PG&E wanted to determine the contribution of these customer's loads to summer peak loads.

In each household, two end uses, in addition to total household load, were metered. Over the whole sample, a total of seven end uses were metered: air conditioning, clothes drying, space heating, refrigeration, water heating, cooking, and generic kitchen end use, which included all end uses in the kitchen except cooking.

PG&E provided us with several data tapes, which included cleaned and validated end-use load data (aggregated to half hourly loads) for 742 households for the years 1985 and 1986, responses by load study participants to PG&E's 1983 Residential Appliance Saturation Survey, survey weights for calculating PG&E system-level statistics from the data (not used in the current study), and hourly temperature from 25 PG&E weather stations along with codes that enabled us to assign weather data to each metering site. All information that would identify individual customers was removed by PG&E and replaced by a single variable, which identified households across data sets.

In analyzing the PG&E data, we did not use the survey weights developed by PG&E.[1] Consequently, our load shape analysis, although representative of the households metered by PG&E, may not be representative of the end-use load shapes for all households in the PG&E service territory.

Southern California Edison

In 1984, SCE began the second major end-use load metering project in California [Quantum Consulting 1988]. The Residential Appliance End Use Study was designed to collect appliance time-of-use demand profiles, to determine seasonal impacts on appliances, to target new applications for load management, and to evaluate new submetering equipment. Initially, only residential customers living in single-family dwellings with a consumption threshold of 800 kWh/month for the summer months were chosen for metering. This consumption threshold was applied

[1] Additionally, the responses to the PG&E survey were not required for our analyses.

IV. NON-CONDITIONING END USES

CEC's residential peak demand model assumes that non-conditioning end uses are relatively independent of weather. Although it captures seasonal influences, daily hourly load shapes are assumed to be identical for peak and non-peak days.[1] Consequently, our analysis of non-conditioning end uses has two components. First, the average monthly electricity consumption in kWh is calculated for each service area; the monthly averages are summed to give seasonal averages, and seasonal adjustment factors are calculated. Second, the average daily load shape in each season is calculated. The daily load shape represents the fraction of the day's electricity consumption that occurs in each hour. In developing hourly load shapes, we combined data from the half-hour prior to and the half-hour following the clock hour.

In this section, we present analyses separately for each utility. We present tabular summaries of seasonal adjustment factors, graphical summaries for each set of daily end-use load shapes, and commentary on the analysis. Following presentation of the analyses of conditioning end uses (Section V), we make an initial comparison of all seasonal adjustment factors and daily load shapes across utility studies and against existing data used by CEC in its forecasting model (Section VI).

It is important to remember that each daily load shape has been normalized by the amount of energy used in each season. One effect of this normalization is that *the graphical presentations of load shapes may incorrectly suggest that the loads are similar in magnitude both for a given end use and across end uses.* In the first instance, the reader should consider that the actual loads developed by the CEC forecasting model will adjust the normalized loads up or down by multiplication with the seasonal adjustment factors. In the second instance, the relative magnitude of the load shapes will be determined by the annual amount of energy (or UEC) accounted for by a given end use.

We have reserved much methodological and tabular information from our analyses for appendices. Methodological details (e.g. treatment of missing values) are documented in Appendix C. Tables of the data used to develop our graphical summaries are in Appendix D. Appendix E provides tables of statistical summaries from our analyses (e.g., number of hourly observations contributing to a given load shape, variances about mean hourly load shape values, etc.).

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[1] Although not currently designed as an hourly forecasting model for each hour of the year, the structure of the CEC model implies that, within a season, weekday, and weekend daily energy use are also identical.

products during the summer season and on weather influences on refrigerator compressor operation is consistent with the observed pattern, but caution in interpreting these results is warranted because of the relatively small number of households metered for this end use compared to the other three end uses.

The daily load shapes for refrigerators show a consistent diurnal pattern of gradually increasing use through the day, reaching a maximum in the late afternoon, and declining through the evening hours (see Figure IV-1). The range of variation over the daytime hours is much smaller than that found for other end uses, but is not flat, probably because of a combination of behavioral and weather influences.

The daily load shapes for water heating were developed from a somewhat larger sample of households than those for refrigerators (72 vs. 21). These data indicate a very strong double peak for water heater use, with the morning peak being slightly higher than that for the evening (see Figure IV-2). This trend is consistent in all seasons.

The very large sample of households metered to develop daily load shapes for clothes dryers (373) gives us confidence in our analysis. Although seasonal variations are pronounced (see the seasonal adjustment factors in Table IV-1), daily load shapes are quite stable across seasons. The load shape rises to a maximum value shortly before midday, drops to a plateau throughout the afternoon and early evening hours and then rapidly falls to a minimum value for the morning hours (see Figure IV-3).

As with clothes dryers, the large numbers of cooking appliances metered by the PG&E study (338) suggest that our load shape accurately represents the "norm" for these appliances. Despite seasonal variations in total energy use, the daily load shapes are quite similar. They are characterized by a dramatic and very sharp peak value in the early evening (dinner) hours. Daytime use is relatively flat up to this point, and late night use is essentially zero (see Figure IV-4).

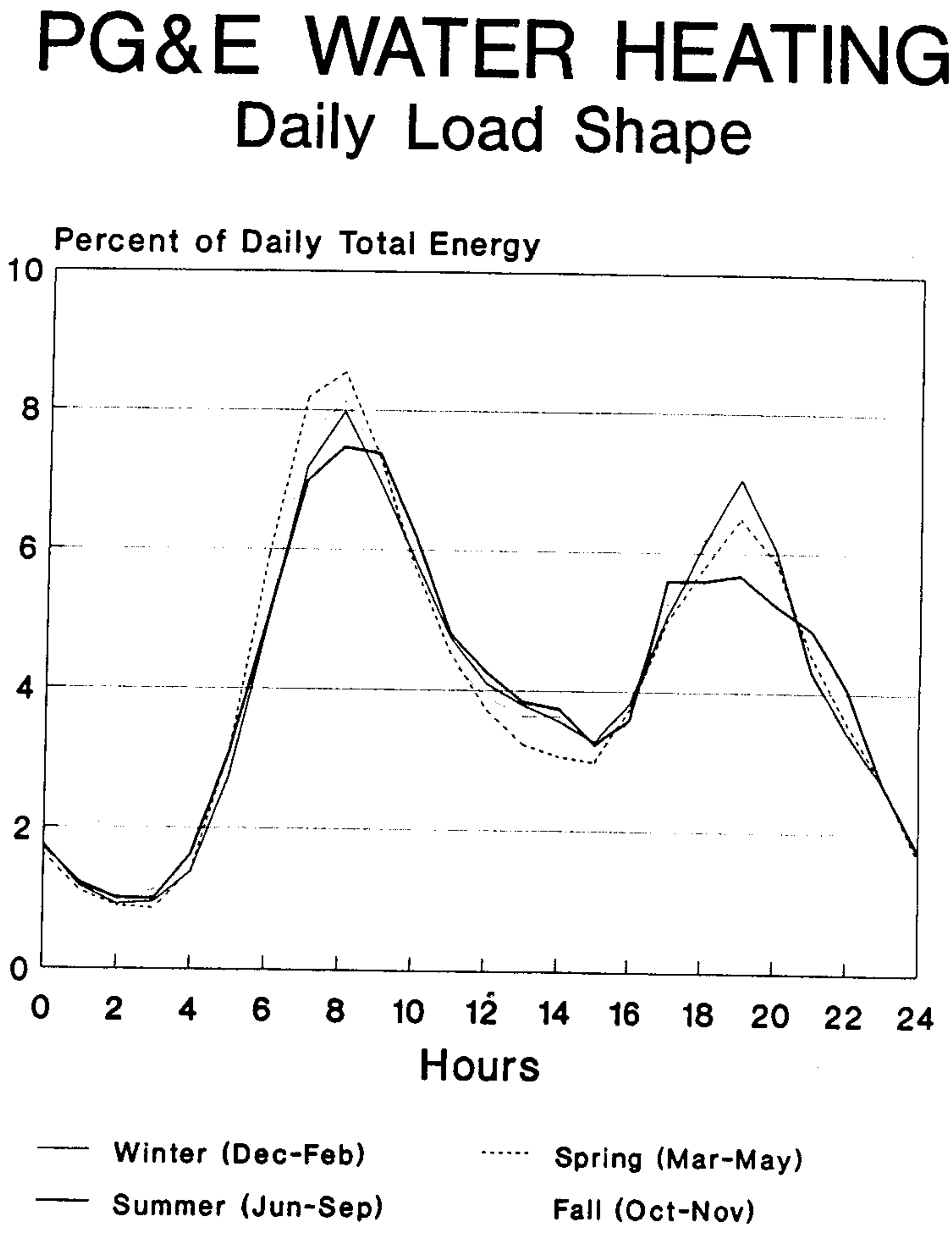


Figure IV-2. **PG&E Water Heater - Daily Load Shape.** Unweighted LBL analysis of PG&E end-use metering data recorded during calendar years 1985 and 1986 from 72 households. The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with the seasonal adjustment factors and the annual UEC to derive actual kW load shapes (see Table IV-1).

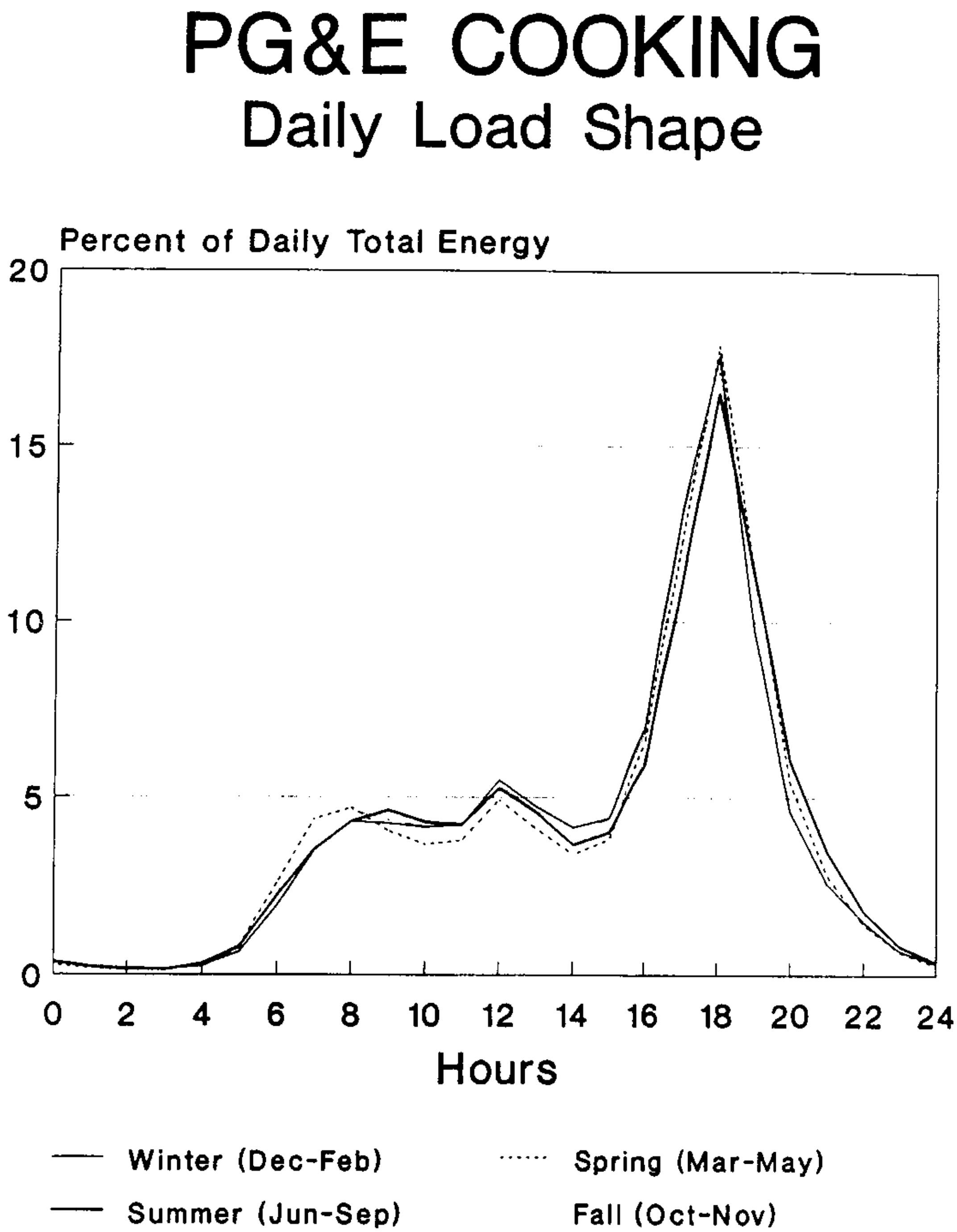


Figure IV-4. **PG&E Cooking - Daily Load Shape.** Unweighted LBL analysis of PG&E end use metering data recorded during calendar year 1985 and 1986 from 338 households. The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with the seasonal adjustment factors and the annual UEC to derive actual kW load shapes (see Table IV-1).

(for example, clothes washers and clothes dryers) are much closer. It is also difficult to conclude much from the analysis of the television set and pool pump because of the relatively smaller number of households metered.

Despite apparent seasonal differences in energy use, the daily load shapes for the refrigerator and freezer are quite similar across seasons and when compared to one another (see Figures IV-5 and IV-6). Loads rise gradually throughout the day, peak in the afternoon/early evening, and then decline to a minimum value at night. We observe that the freezer reaches a maximum value somewhat earlier than the refrigerator. However, the range of variation during the daytime hours is smaller than that of many other end uses.

The daily load shape for the SCE cooking data is presented in Figure IV-7. Although in each season a dramatic peak occurs in the early evening, the daily load shape for winter peaks approximately an hour earlier than the peaks in the other seasons. Conclusive explanations for this finding are difficult, and the relatively small number of households contributing to this load shape (a maximum of 19) makes definitive interpretation difficult. The daily load shapes for all seasons are relatively flat during the other daytime hours and show little use at night.

We expected to find close similarities between the daily load shapes for the clothes dryer (Figure IV-8) and clothes washer (Figure IV-9) because these end uses are typically used sequentially. Although we did observe similarities in the seasonal adjustment factors, comparison of the daily load shapes only produced agreement on the overall shape. For both end uses, loads rise fairly rapidly from negligible values in the early morning to a maximum value around lunchtime, then declining in the late evening. For fall and summer, however, the clothes dryer load shape does not rise to a single peak value, but is more spread out over all hours of the day. This pattern is somewhat different from that of the corresponding clothes washer load shape (especially for the summer season). The large number of households metered (a maximum of 28 for the clothes dryer and a maximum of 59 for the clothes washer) suggest that these patterns may accurately represent typical use.

The daily load shape for the dishwasher peaks in the morning and again in the evening (see Figure IV-10). There are noticeable, almost random, differences between the daily load shapes for each season. We suspect these differences are, in part, a result of the small number of households metered for this end use (17).

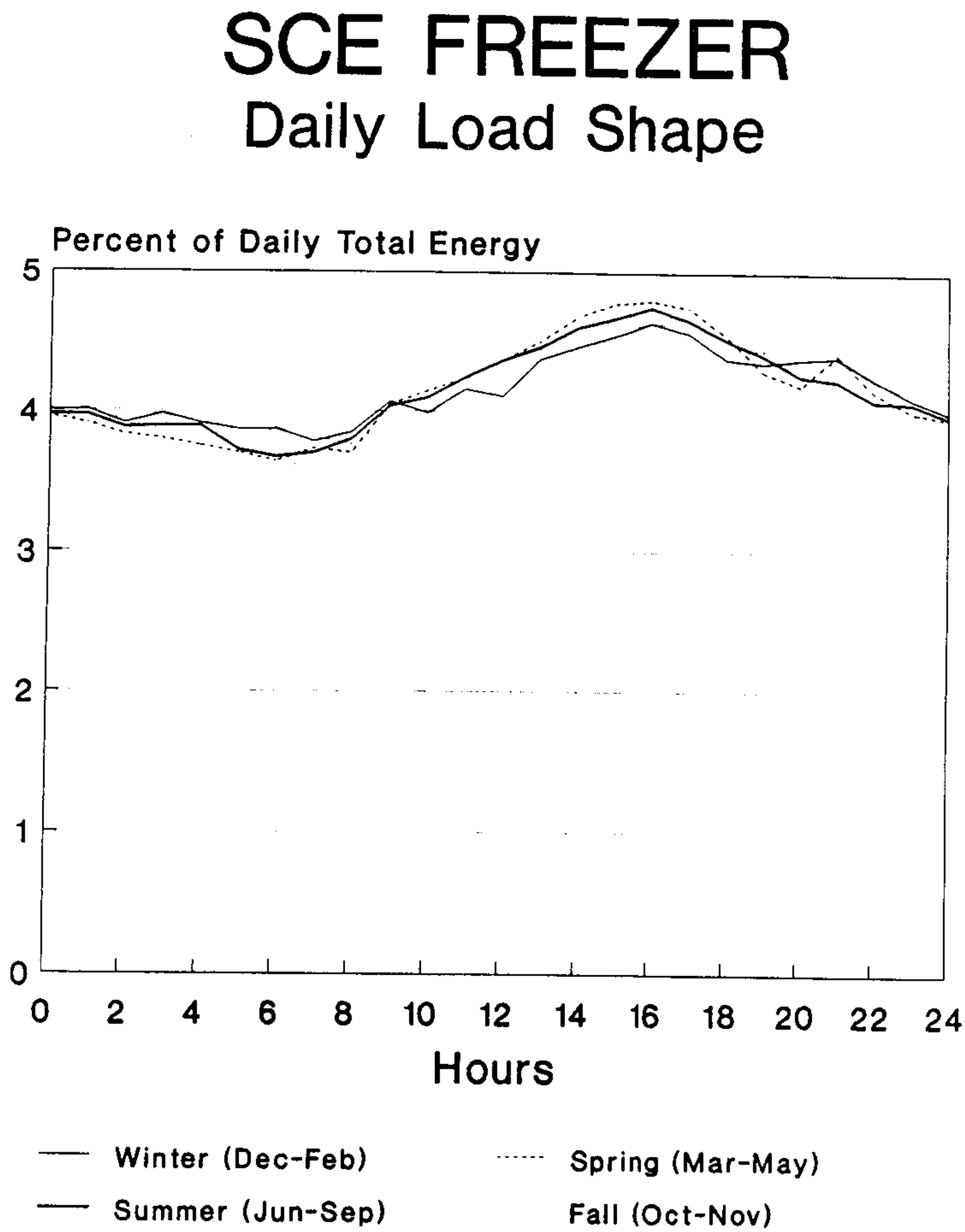


Figure IV-6. **SCE Freezer - Daily Load Shape.** Unweighted LBL analysis of SCE end use metering data recorded during calendar year 1986 from a maximum of 28 households (sample size was increasing throughout the metering period). The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with the seasonal adjustment factors and the annual UEC to derive actual kW load shapes (see Table IV-2).

SCE DRYER
Daily Load Shape

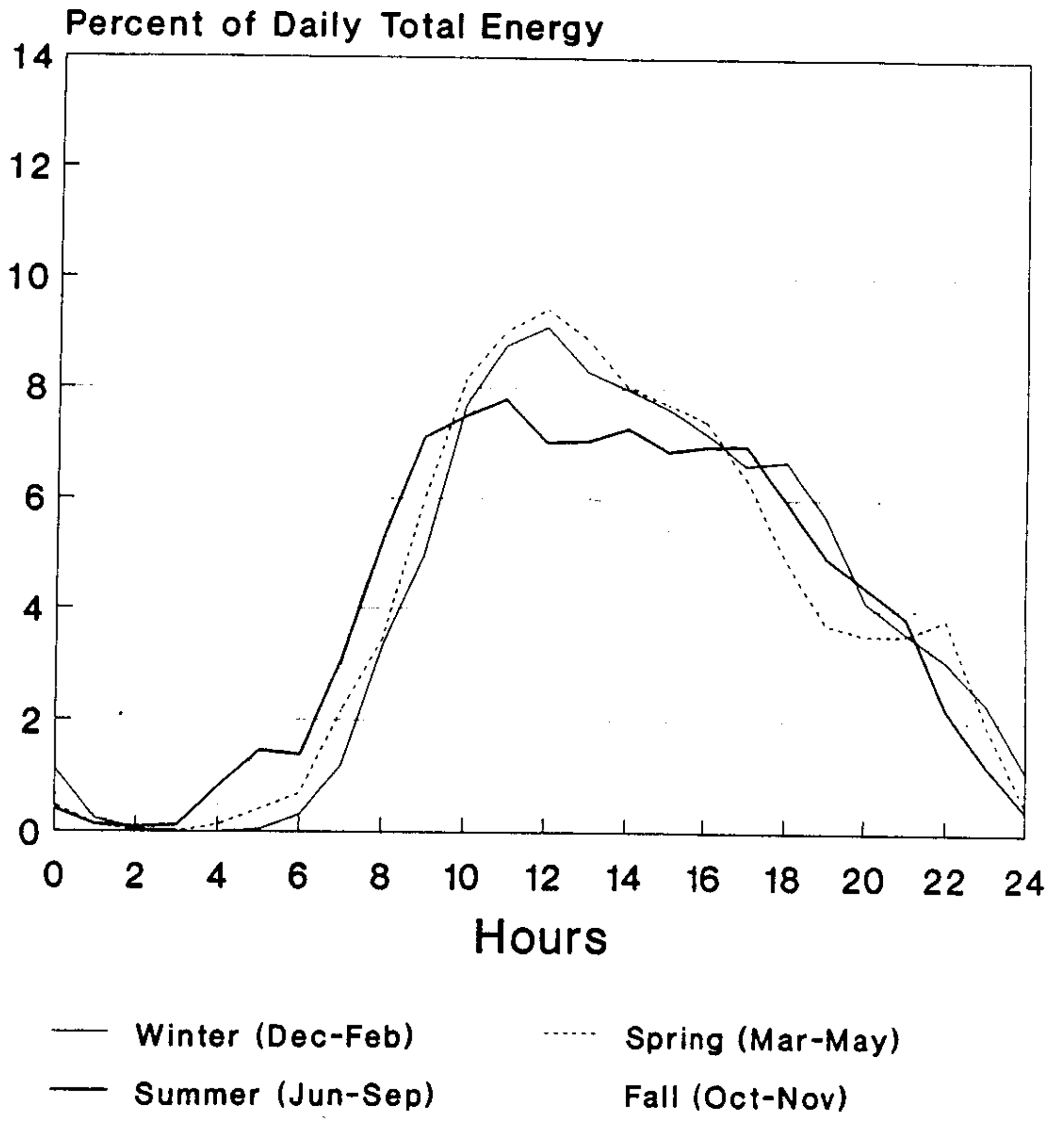


Figure IV-8. **SCE Clothes Dryer - Daily Load Shape.** Unweighted LBL analysis of SCE end use metering data recorded during calendar year 1986 from a maximum of 17 households (sample size was increasing throughout the metering period). The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with the seasonal adjustment factors and the annual UEC to derive actual kW load shapes (see Table IV-2).

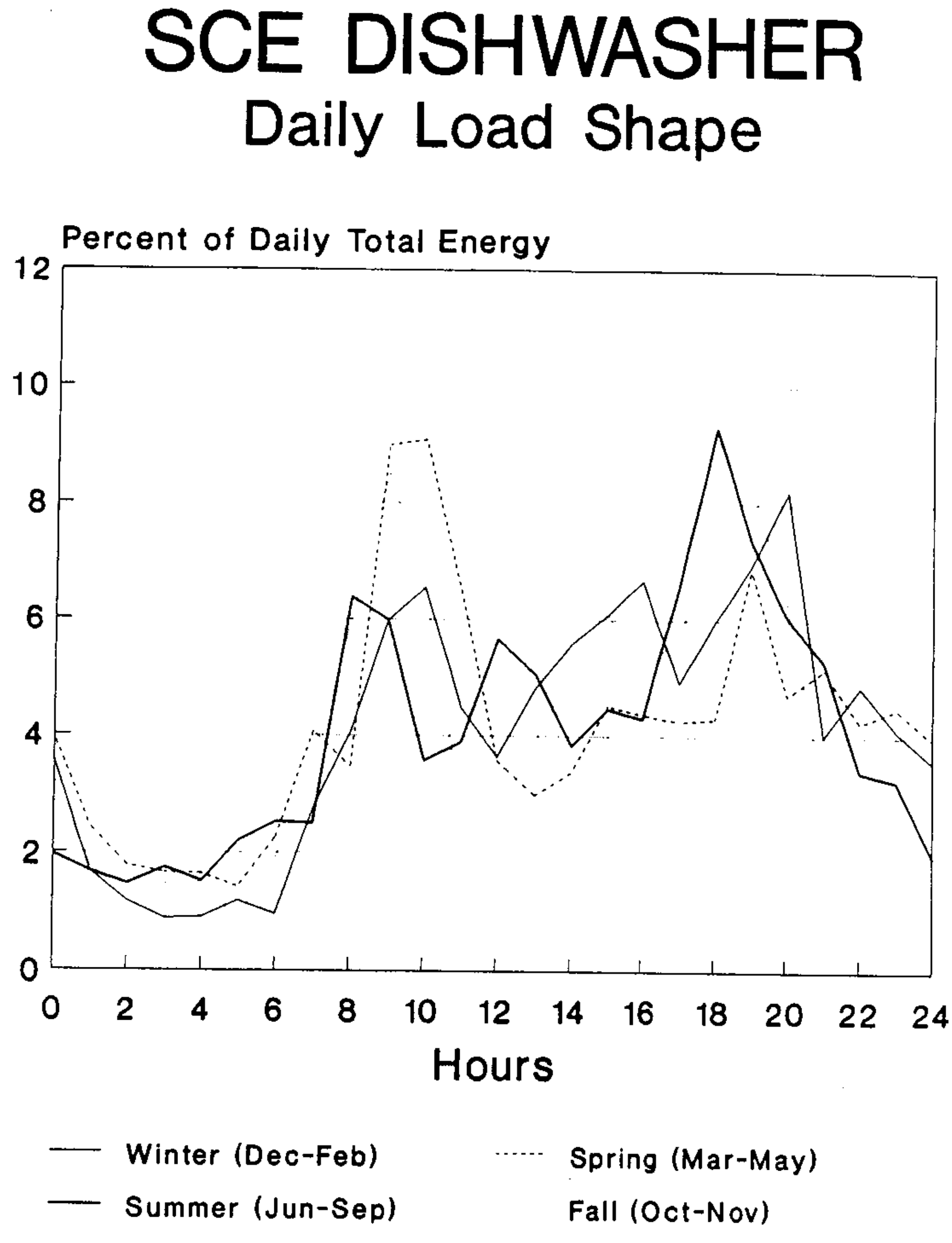


Figure IV-10. **SCE Dishwasher - Daily Load Shape.** Unweighted LBL analysis of SCE end use metering data recorded during calendar year 1986 from a maximum of 30 households (sample size was increasing throughout the metering period). The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with the seasonal adjustment factors and the annual UEC to derive actual kW load shapes (see Table IV-2).

SDG&E WATER HEATING
Daily Load Shape

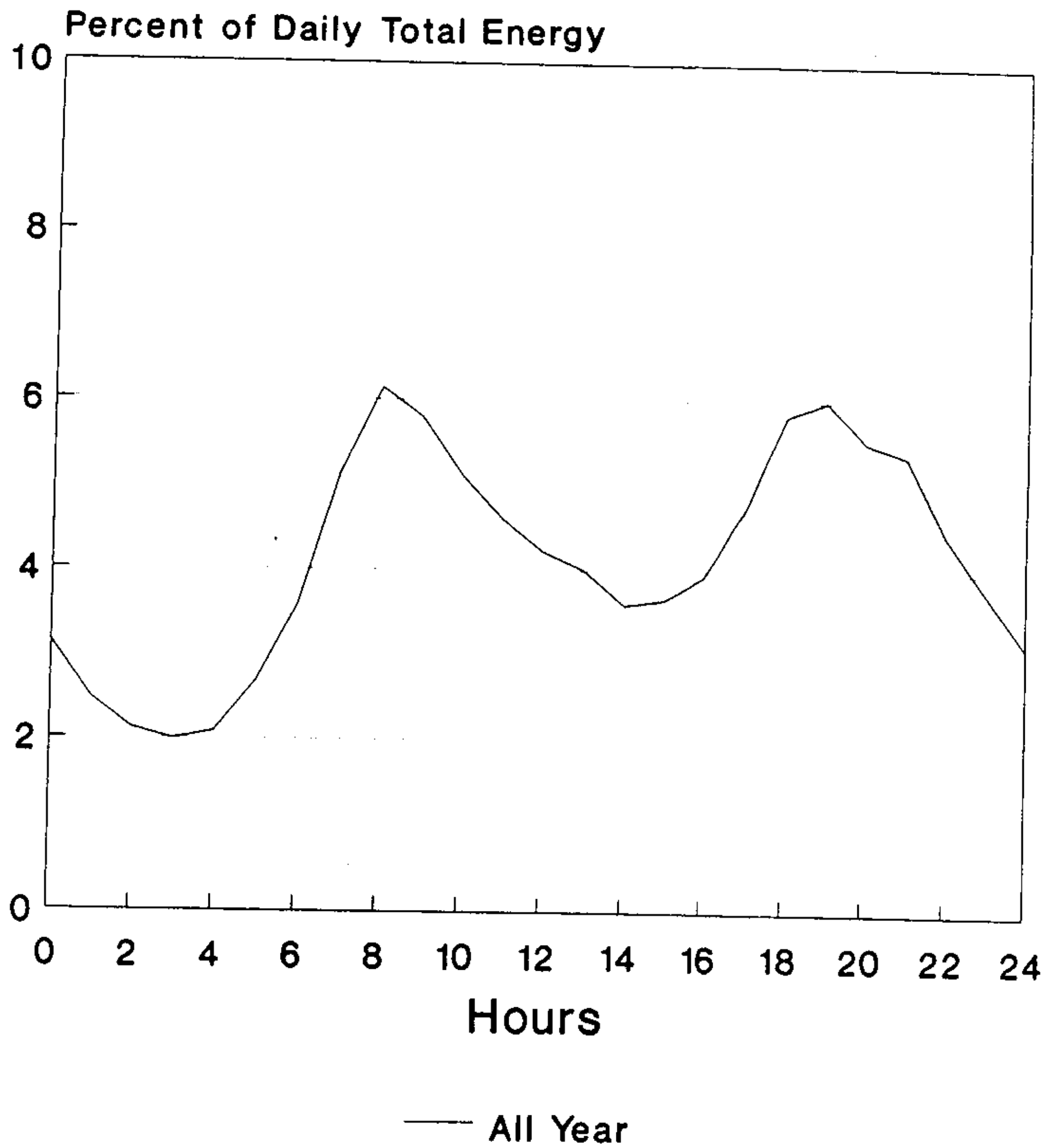


Figure IV-11. **SDG&E Water Heating - Daily Load Shape.** Unweighted LBL analysis of SDG&E end use metering data recorded during calendar years 1982 through 1985 from a total of 50 households. The analysis was performed by combining data from the half-hour prior to and the half-hour following the clock hour. The data have been normalized and expressed as fractions of total daily energy used in a given hour; they must be combined with an annual UEC to derive actual kW load shapes.

V. CONDITIONING END USES

The CEC's Residential Peak Demand model is unique because it forecasts daily and hourly loads and expresses conditioning energy use (cooling and heating) as a function of time and weather (see Section II and Appendix A for more details of the CEC's model). We developed new time, and temperature and humidity matrices (also referred to as time-temperature matrices) from the metered data, including separate matrices for central air conditioners and room air conditioners from the PG&E and SCE metered data. We did not re-estimate the coefficients used to determine the amount of energy consumed on the peak day.

The analysis consisted of binning and summing the hourly household conditioning loads by time and temperature-humidity index (THI).[1] To produce the average load, we divided the summed load by the number of observations for a given time and temperature combination. Appendix C describes the binning in detail. Appendix D contains tables of the raw, average-load time-temperature matrices. These raw matrices are not, in our opinion, suitable for use in the CEC's model because of statistical fluctuations between nearby bins and, more importantly, because there are many time and THI combinations for which we had no data. Appendix F describes exploratory analysis for fitting the empirical data with analytic functions in order develop a complete matrix of values.

Pacific Gas and Electric

We developed separate time-temperature matrices for central air conditioning and room air conditioning from the PG&E residential load data.[2] Figures V-1 and V-2 illustrate raw average load data.

The absence of data for many of the higher THI values leads to a very jagged edge above which observations were not available because temperatures remained in a limited range during the metering period. Empirically, the only recourse is to extend the metering period and hope that subsequent summers bring higher temperatures.

Despite the relatively large numbers of households that provided metered data (384 for central air conditioners and 55 for room air conditioners), we observe significant unevenness in average load values. This unevenness is evident both for a given hour across increasing THI values and for a given THI across the hours of the day.

[1] For heating, which we did not examine, the only weather parameter is of dry-bulb temperature.

[2] PG&E also supplied data on central resistance space heat and on heat pumps. These data are not presented in this study because the number of households monitored for central space heat was low (6) and because the CEC model does not forecast heat pump load shapes separately from those for resistance electric heating.

Figure V-1. **PG&E Central Air Conditioning Time-Temperature Matrix.** Unweighted LBL analysis of PG&E end use metering data recorded during calendar year 1985 and 1986 from 384 households. Energy use is presented as a function of weather, represented with a combined measure dry bulb temperature and humidity (temperature-humidity index or THI) and time of day.

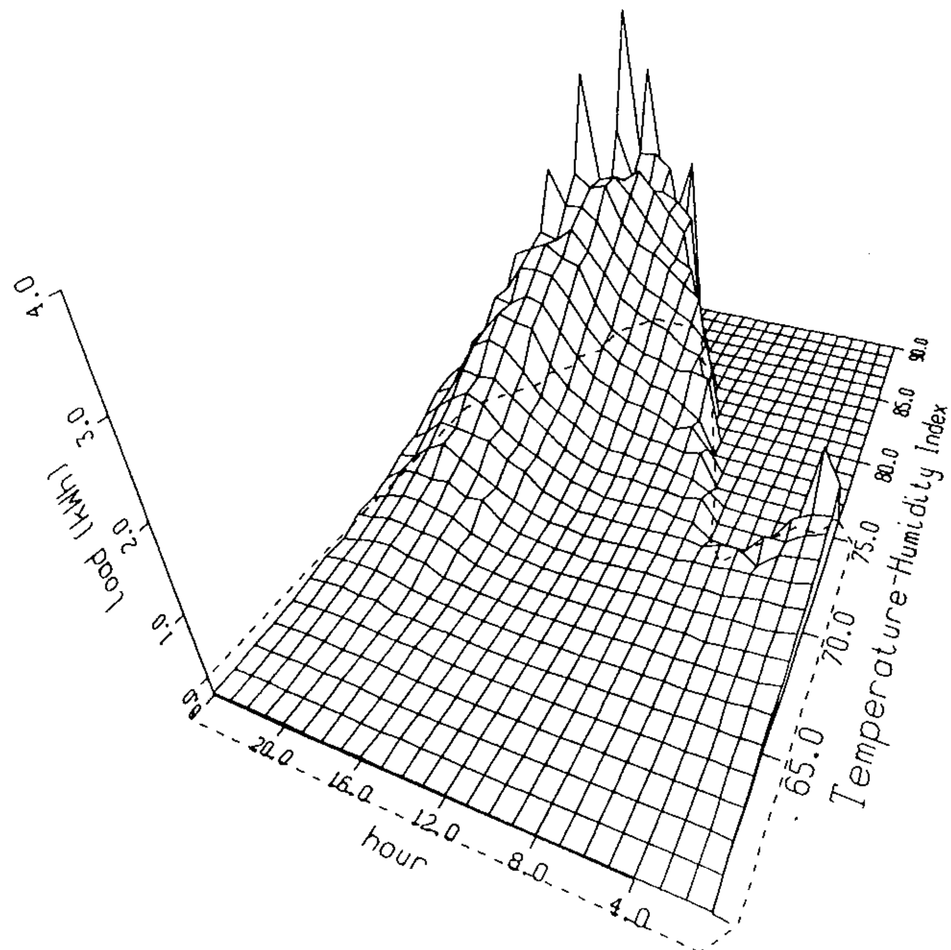
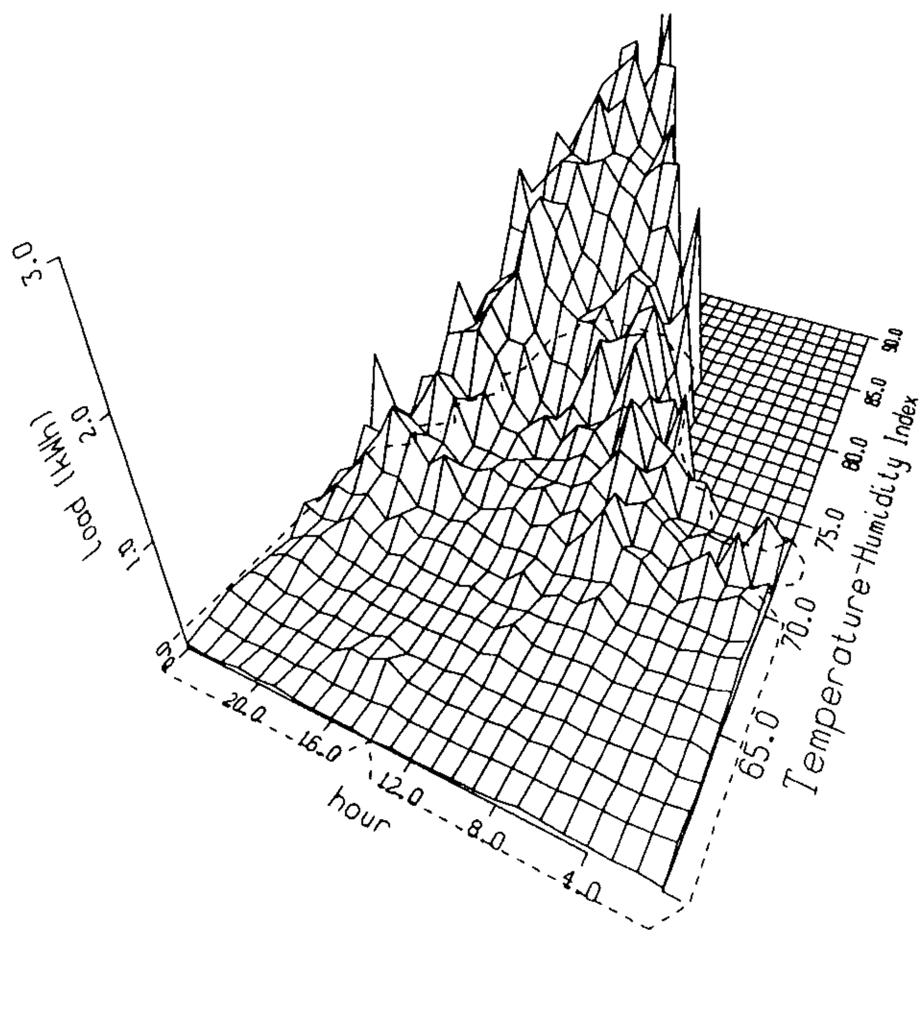


Figure V-3. **SCE Central Air Conditioning Time-Temperature Matrix.** Unweighted LBL analysis of SCE end use metering data recorded during calendar year 1986 from 39 households. Energy use is presented as a function of weather, represented with a combined measure dry bulb temperature and humidity (temperature-humidity index or THI) and time of day.



VI. COMPARISON WITH EXISTING CEC LOAD SHAPE DATA

In this section, we compare the load shape data developed in this study with those now used by CEC. First, we examine seasonal adjustment factors for allocating non-conditioning annual electricity consumption to the peak day. Second, we examine peak day load shapes for the non-conditioning end uses. Third, we examine the time-temperature matrices developed for central air conditioning and room air conditioning. Because direct comparison of the matrices themselves is difficult, we have introduced weather data for a typical hot day in several California climates in order to compare the load shapes that might be generated by use of the matrices to forecasted peak demand.[1]

Non-Conditioning Seasonal Adjustment Factors

Table VI-1 compares the seasonal adjustment factors currently used by CEC to those developed from the PG&E and SCE data. The percentage differences from the values used by the CEC are reported, along with the annual UEC from integration of the metered data, and the number of metered households from the two studies.

We find agreement in seasonal adjustment factors between those used by CEC and those developed in this study within 10% for all end uses except the SCE refrigerator (winter and spring), the SCE freezer (fall), the PG&E and SCE cooking (fall - PG&E, winter and summer - SCE), the SCE and PG&E clothes dryer (fall), the SCE dishwasher (fall), the SCE television (spring and summer), the SCE pool pump (all seasons). These differences are probably most important for the SCE refrigerator, the PG&E cooking, and the PG&E clothes dryer, because for these end uses, large numbers of households were metered suggesting that the results are accurately representative of some kind of "norm". For the clothes dryer, this observation is reinforced by the consistently higher fall season adjustment factors found in both the PG&E and SCE studies. The same observation (although the results are opposite in sign) also applies for the winter season adjustment factor for the refrigerator. Where other large differences are found, the small numbers of households metered (especially, the SCE television set and pool pump) prevents meaningful interpretation of these differences.

[1] The comparison is illustrative only. CEC selects system peak day weather data from an analysis of historic weather and system peak conditions (see Appendix A). Strictly for purposes of comparison, we have selected data for typical hot days from a data tape of synthetic, average weather.

Non-Conditioning Daily Load Shapes

Figures VI-1 through VI-7 compare daily load shapes for: refrigerator, freezer, cooking, clothes dryer, clothes washer, dishwasher, and water heating. For each end use, the y-axis has been re-scaled to a common value (where necessary) to facilitate visual comparison.

The refrigerator daily load shapes that were developed from the analysis of the PG&E and SCE data are very similar to those used currently by CEC (see Figure VI-1); they are also quite similar to each other (despite a three to one difference in sample sizes for these two studies). This suggests that the daily load shape for refrigerators is reasonably well-defined. From a sample of 62 SCE households, a more important source of differences for this end use is the seasonal adjustment factor; we found lower winter and higher spring energy use than current CEC figures.

The freezer load shape developed from the SCE data exhibits greater diurnal fluctuation than the one used currently by CEC (see Figure VI-2). As previously noted, the load shape closely resembles that for the refrigerator, with a slightly earlier peak load. However, the number of households metered for this end use was comparatively small (28).

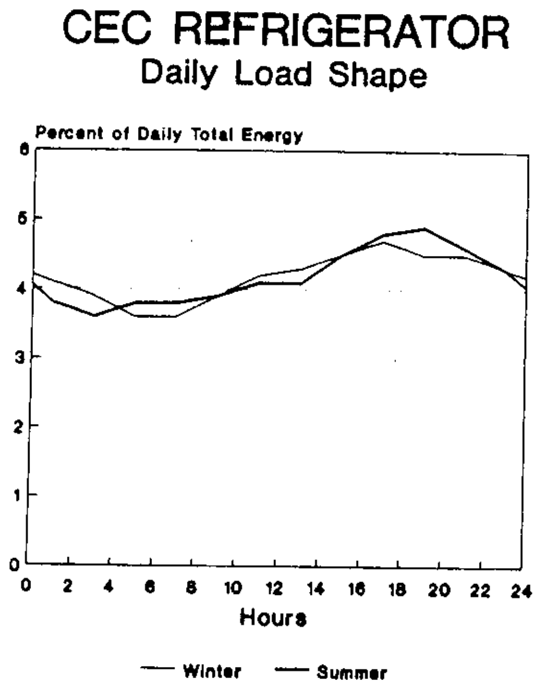
The cooking load shapes are quite similar to one another (see Figure VI-3), with one exception. Both sets of load shapes we analyzed, especially those from the PG&E data, appear to peak slightly later than the load shapes currently used by CEC. The load shapes developed from the PG&E data also have a slightly higher peak value than the ones developed from the SCE data.[2] The numbers of households metered by PG&E were substantially greater than those metered by SCE, in part because several combinations of cooking appliances metered by PG&E were merged into a single end use for this study.

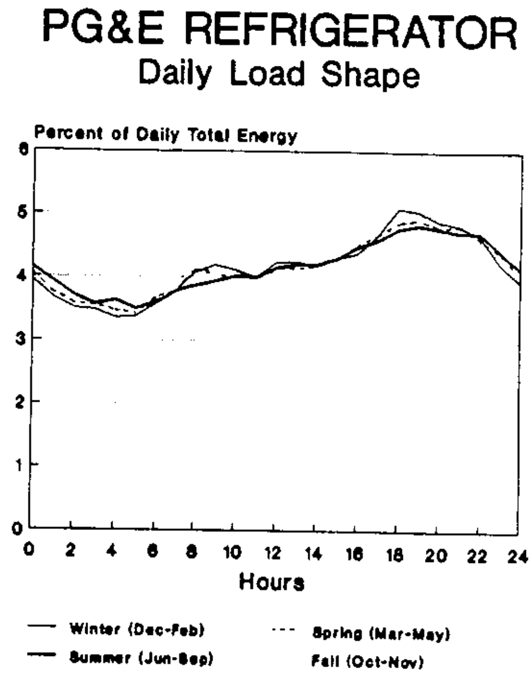
The clothes dryer and clothes washer load shapes developed from the PG&E and SCE data differ significantly from those used by CEC (see Figures VI-4 and VI-5). The peaks found in this study are lower and less pronounced, and loads are more uniformly spread over the other "on" hours. The start and stop times of the shoulder periods remain similar to those in the CEC load shapes. We note that the load shapes developed in this study came from relatively large samples of households (especially for the clothes dryer from the PG&E data, which came from a sample of 373 households).

The dishwasher load shape developed from the SCE data differs visibly from that used by the CEC (see Figure VI-6). As with the differences found for the comparison of our data and CEC's for clothes washers and dryers, the peak values are lower and loads are more uniformly spread

[2] The higher peak value refers to a greater percent of total daily energy occurring in this hour. Actual loads are a function of total energy for the year and the seasonal adjustment factors.

Figure VI-1. **Load Shape Comparison - Refrigerator.** Comparison of LBL's analysis of metered data (gathered by PG&E and SCE) to the daily load shapes currently used by the CEC Residential Peak Model. The PG&E daily load shape was developed from an analysis of 21 households. The SCE daily load shape was developed from an analysis of 62 households.





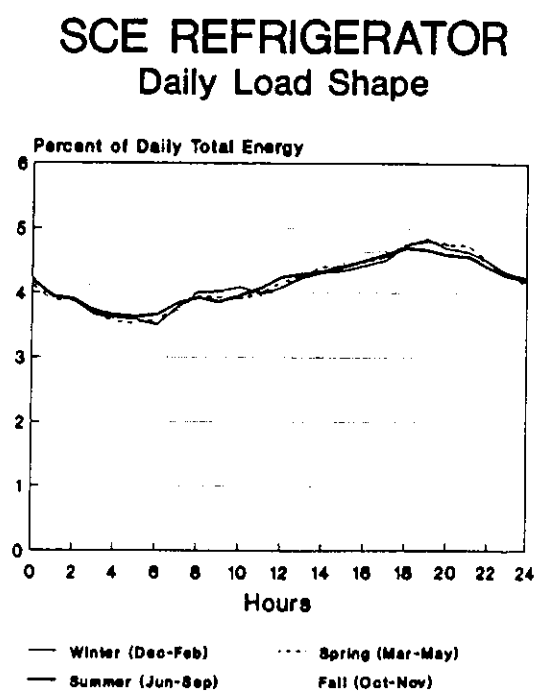


Figure VI-3. **Load Shape Comparison - Cooking.** Comparison of LBL's analysis of metered data gathered by PG&E and SCE to the daily load shapes currently used by the CEC Residential Peak Model. The PG&E daily load shape was developed from an analysis of 338 households. The SCE daily load shape was developed from an analysis of 19 households.

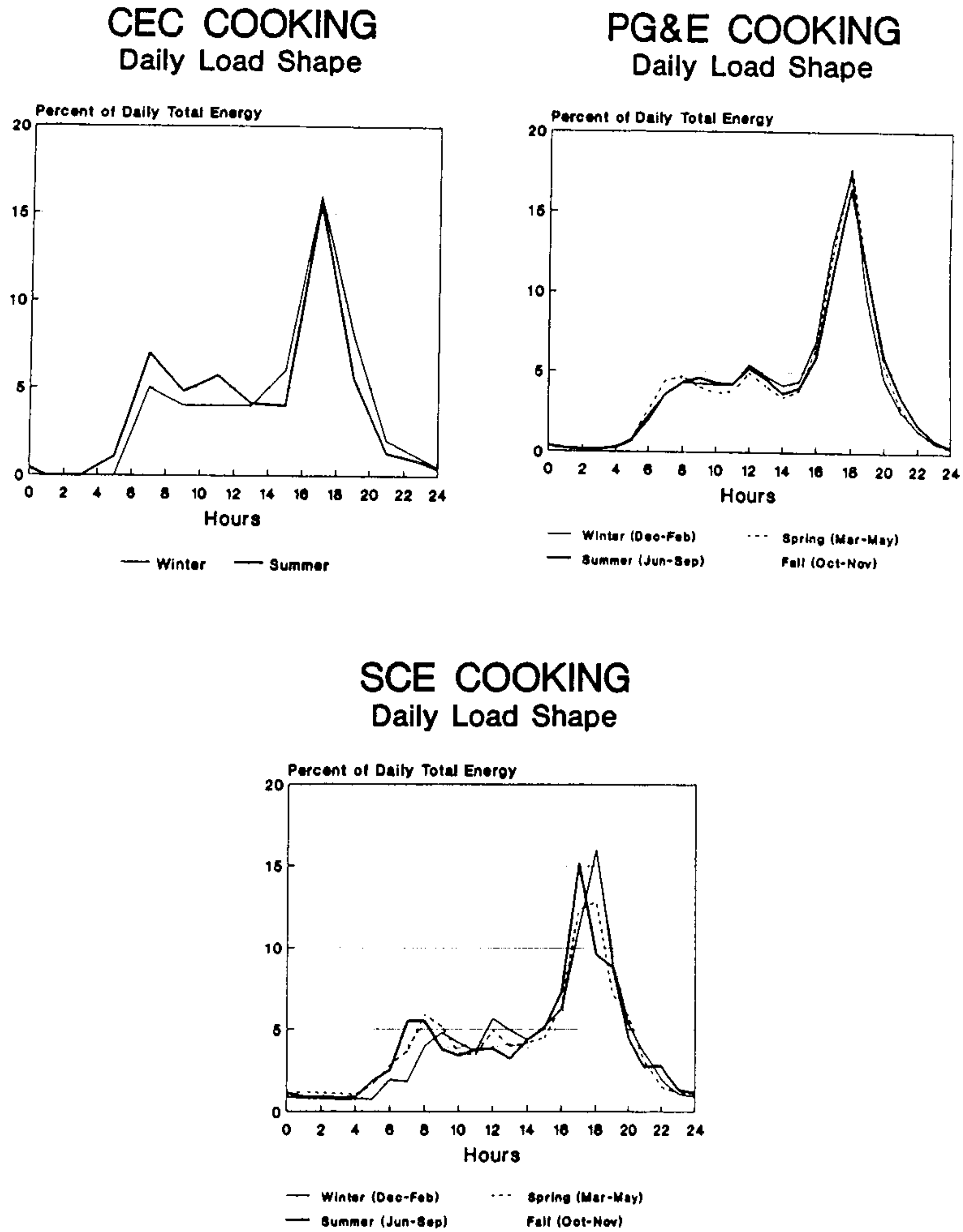
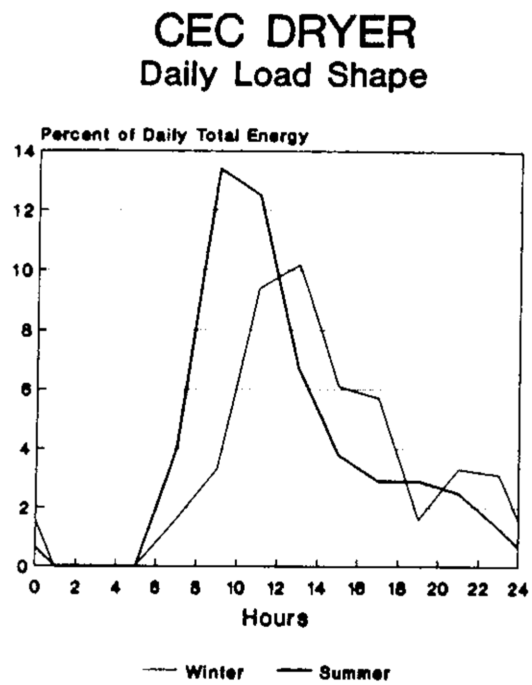
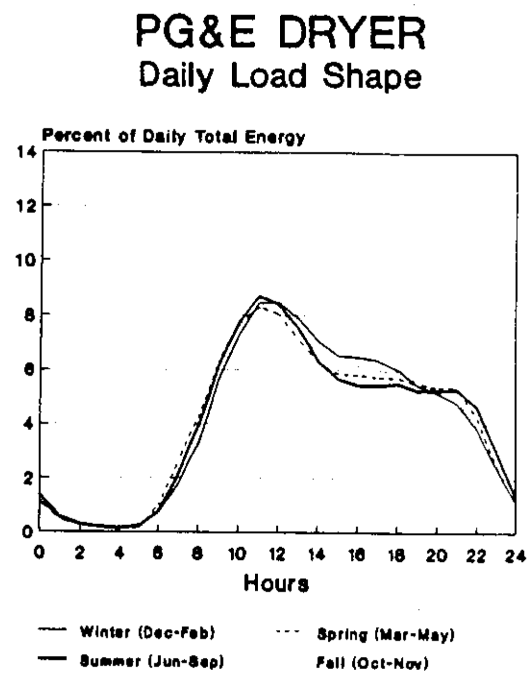


Figure VI-5. **Load Shape Comparison - Clothes Dryer.** Comparison of LBL's analysis of metered data gathered by PG&E and SCE to the daily load shapes currently used by the CEC Residential Peak Model. The PG&E daily load shape was developed from an analysis of 373 households. The SCE daily load shape was developed from an analysis of 30 households.





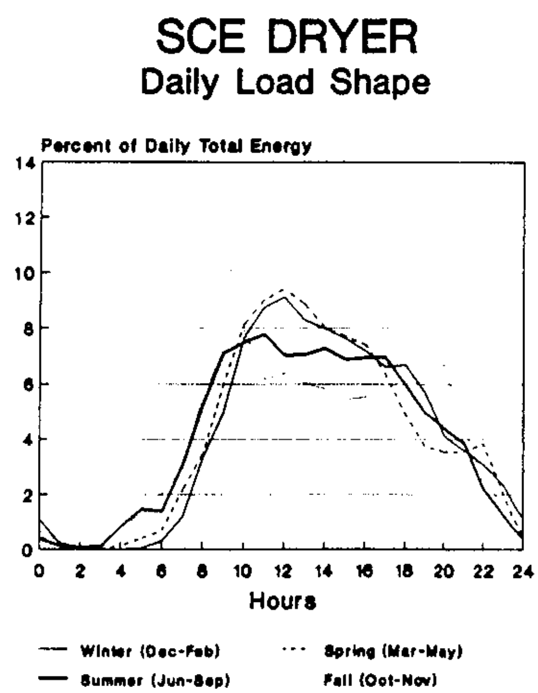
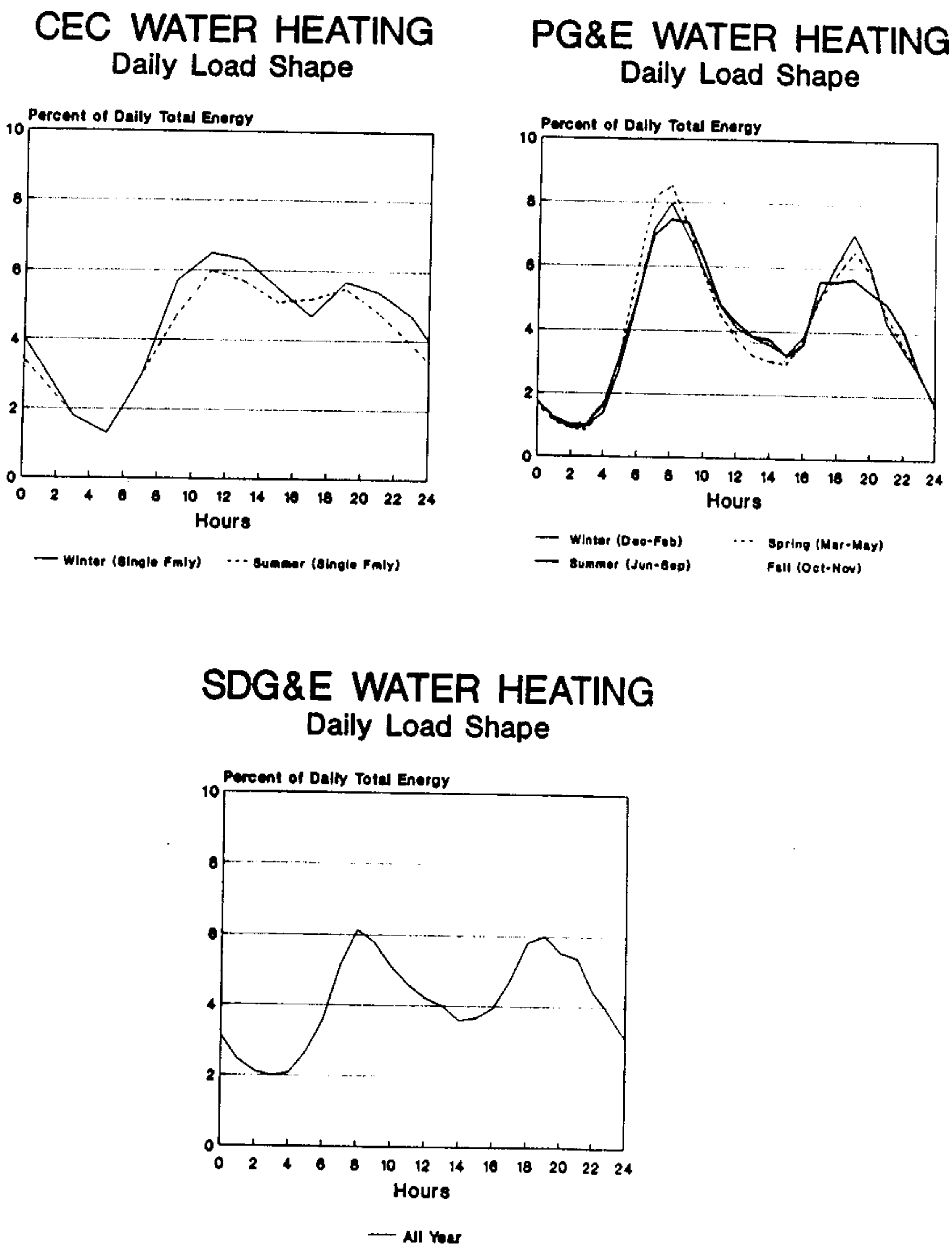


Figure VI-7. **Load Shape Comparison - Water Heating.** Comparison of LBL's analysis of metered data gathered by PG&E and SDG&E to the daily load shapes currently used by the CEC Residential Peak Model. The PG&E daily load shape was developed from an analysis of 72 households. The SDG&E daily load shape was developed from an analysis of 50 households.



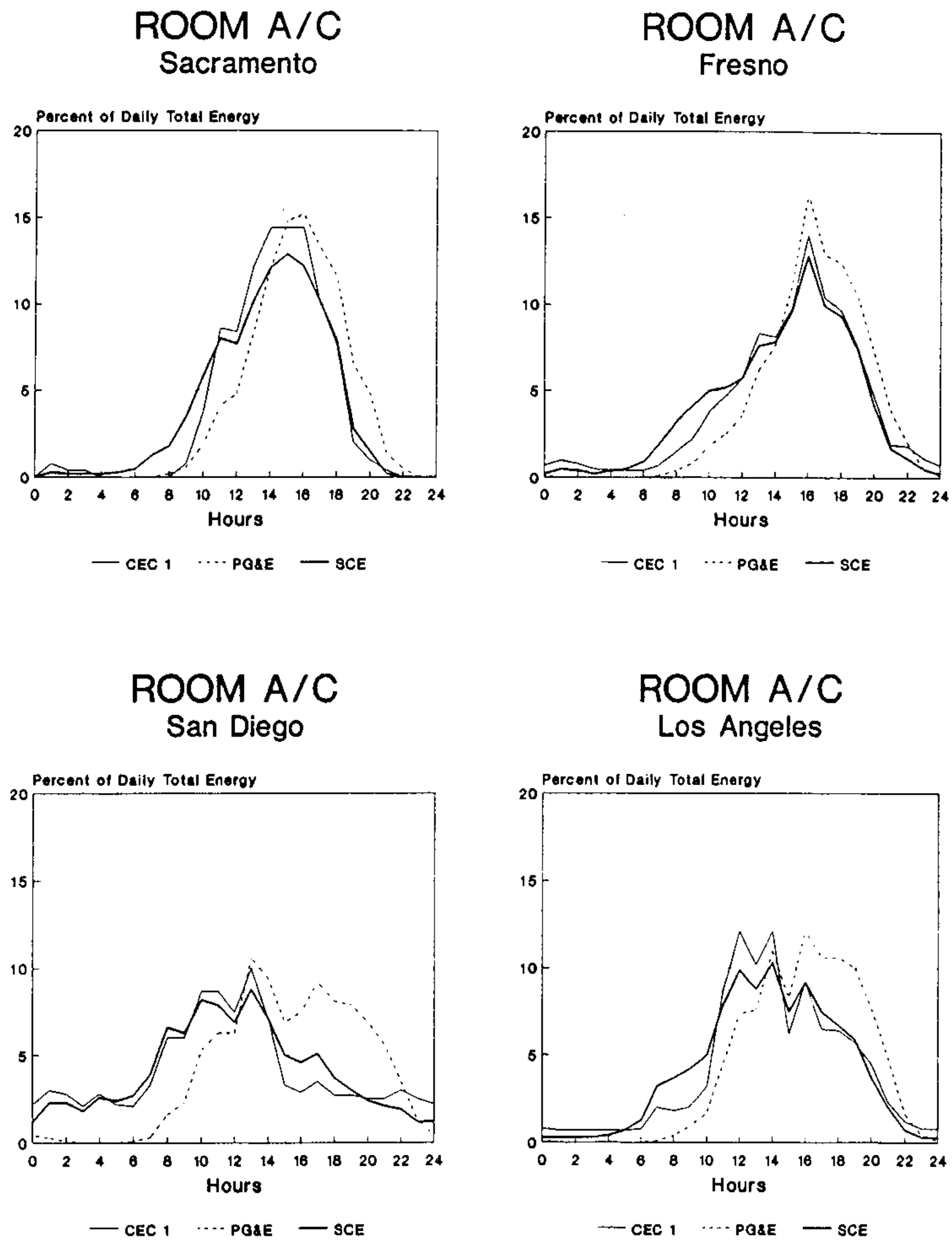
temperatures matrices for living room, bedroom, and 2-room spaces. We found the peak day load shapes developed from the 2-room time-temperature matrix closely resemble those developed from the living room time-temperature matrix and chose not to present an additional, essentially identical, comparison.

We find general agreement in overall peak day load shapes for all climates except San Diego. Application of peak day weather for San Diego (and, to a lesser degree, Los Angeles) to the time-temperature matrix developed from PG&E data produces a much narrower range of peak demand hours than those predicted by the matrix developed from the SCE data and the current CEC matrix. We suspect this may be the result of our smoothing procedure and the lack of measured data (from the PG&E monitoring project) for the time temperature conditions found in the early morning on San Diego peak days. Nevertheless, we find the overall consistency in our results encouraging; the sample size for PG&E was 55, while for SCE it was 21.

The matrix developed from the SCE data produces loads that follow those predicted by the CEC matrix quite closely. Significant differences occur only when comparing these loads to those predicted by CEC bedroom matrix for San Diego. The CEC living room matrix predicts slightly higher loads for Sacramento and Los Angeles, although the overall shapes of the peak day loads are similar.

The matrix developed from the PG&E data yields consistently higher peak loads for all climates when compared to those predicted by the existing CEC matrices. For Sacramento and Fresno, the timing of the peak demand is roughly identical. For San Diego, the timing is identical for the CEC living room, but very different for the CEC bedroom. For both San Diego and Los Angeles, the matrix developed from the PG&E data yields a peak day load shape that appears shifted several hours latter than the ones developed from CEC's existing matrix. The overall flatness of these load shapes, however, tends to mask these differences because the absolute magnitude and timing of the peak demand are similar and close together.

Figure VI-9. **Load Shape Comparison - Room Air Conditioning.** Comparison of peak day load shapes generated from LBL's analytic representation of the time-temperature matrix from PG&E and SCE data to the peak day load shapes generated from the time-temperature matrix currently used by the CEC Residential Peak Model (living room). The weather data used in this presentation are representative of peak day conditions, but should not be confused with actual peak day weather used by the CEC in forecasting. The raw data used to develop the PG&E time-temperature matrix was gathered from an analysis of 55 households. The raw data used to develop the SCE time-temperature matrix was gathered from an analysis of 21 households.



VII. DIRECTIONS FOR FUTURE RESEARCH

The analyses performed for this project suggest several directions for future research. In this section, we briefly identify these areas.

Residential Load Data Analyses - Existing Data

Analytic representation of time-temperature matrices. Appendix F describes exploratory work on fitting the time-temperature matrices with analytic functions in order to smooth and extrapolate the measured data. The work described in the Appendix is preliminary; additional work is required to validate the existing analytic representation and to consider other analytic functions.

Analysis of the three-day weighting factors for conditioning end uses. The weighting scheme used to allocate annual energy use to peak day energy use should be examined in order to, first, re-estimate the weighting coefficients and, second, determine whether other functional forms might better represent the relationship between multi-day weather patterns and peak day conditioning loads.

Additional geographic disaggregation of the space conditioning time-temperature matrices. The current project developed separate time-temperature matrices using data from PG&E and SCE. Within these service territories, additional geographic disaggregation may be warranted to distinguish, for example, a coastal from an inland time-temperature relationship.

Load data transferability. Could time-temperature matrices and daily load shapes for one geographic area be used to forecast peak loads in another region?

Residential Load Data Analyses - New Data

End uses not monitored in current load studies. Several end uses were not analyzed in the current project because data were not available. These end uses included lighting and miscellaneous, television, pool pumps, and various end uses associated with solar energy consumption.

Validation with whole-building load shape data. To check both the aggregate of the load shapes developed and the Residential Peak Model, load research data collected by utility rate departments can be analyzed to determine the accuracy of the CEC residential peak forecasts at a customer class level. Such analyses would be especially valuable in determining the impacts of coincidence between residential and system peak loads, and between individual residential end uses.

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Appendix A. The California Energy Commission Residential Peak Model

An important goal of our analysis is to provide the CEC with new load shape data in a form that is compatible with their existing forecasting model. For the reader unfamiliar the unique data requirements of the CEC's model, this appendix provides a detailed description of the Residential Peak Model (RPM). Our description borrows extensively from existing CEC documentation, notably CEC [1987].

The RPM does not "forecast" energy use in the traditional sense of the term, rather, it determines hourly peak day energy use from a prior forecast of annual energy use. It is probably best thought of as a post-processor to an energy demand forecasting model. All interactions between changing demographic features of the population, appliance choice and use, and energy use are captured in the energy demand forecasting model; it is the output of this forecasting model that is the primary input for the RPM. As noted in section II, these outputs are aggregated across vintages to annual energy use for the nineteen residential end uses in two building types. (see Table II-1).

The RPM allocates annual residential electricity consumption by end use into an hourly load profile for the system peak day in three steps. First, the model allocates the annual electricity consumption to peak day electricity consumption. Second, it distributes the peak day electricity consumption to hourly loads using daily load shapes. Third, the model sums the hourly loads across end uses to produce the total hourly residential loads for the peak day. The first two steps are performed separately for non-conditioning and conditioning end uses.

Non-Conditioning End Uses

Allocation of annual electricity consumption to peak day electricity consumption for non-conditioning end uses assumes that peak and average day consumption are identical. The relevant differences in consumption are seasonal in nature. Formally,

$$\mathbf{PNC_{ij} = SF_{ij} \times \frac{ANC_i}{365}} \qquad [1]$$

where,

$\mathbf{PNC_{ij}}$ = Peak day electricity consumption for end use i in season j [kWh/d]
$\mathbf{SF_{ij}}$ = Seasonal adjustment factor for end use i in season j [dimensionless]
$\mathbf{ANC_i}$ = Annual electricity consumption for end use i in season j [kWh/y]

Allocation of peak day electricity consumption to hourly loads relies on daily load shapes.

$$\mathbf{HNC_{ijk} = PNC_{ij} \times HF_{ijk}} \qquad [2]$$

where,

$\mathbf{WTHI\text{-}DD_d}$ = Weighted sum of THI-DDs about the peak day, d [°F/d]

Fourth, determine peak day energy use based on the ratio of of $\mathbf{WTHI\text{-}DD_d}$ to a long-term annual average sum of **THI–DDs**.

$$\mathbf{PC_i = AC_i \times \frac{WTHI\text{-}DD_d}{ATHI\text{-}DD}} \qquad [6]$$

where,

$\mathbf{PC_i}$ = Peak day electricity consumption for cooling end use i [kWh/d]
$\mathbf{AC_i}$ = Annual electricity consumption for cooling end use i [kWh/y]
ATHI–DD = Long-term annual average sum of **THI–DD** for the year [°F/y]

Allocation of peak day electricity consumption to hourly loads follows the same general procedure as that used for the non-conditioning loads. However, the load shape values are taken from a two-dimensional matrix of energy use as a function of THI and hour of the day.[1] The process requires re-use of the peak day hourly **THI** values, as defined previously. Separate matrices are used for single family central A/C, multi-family central A/C and room A/C. For room A/C, an adjustment is introduced to account for the number of rooms served by each room A/C unit.

The goal of our analysis of the PG&E and SCE metered data is to re-estimate the values for the two-dimensional matrices of energy use as a function of time and THI.

Heating. Although, we did not analyze the PG&E and SCE data to re-estimate heating time-temperature matrices, we include a review of the RPM's treatment of heating for completeness.

For heating end uses, allocation of annual electricity consumption to peak day electricity consumption is also based on the identification of a maximum value from daily weather conditions. It differs from the process used for cooling end uses in that the conditions for only the peak day are used (rather than a weighted average of several days) and that dry-bulb heating degree-days (rather than a temperature humidity index) are the weather parameter.

First, define heating degree-days:

$$\mathbf{HDD = \sum_{k=1}^{24} max[65 - (\frac{DB_{max} + DB_{min}}{2}),0]} \qquad [7]$$

where,

HDD = Heating degree per day [°F/d]
$\mathbf{DB_{max}}$ = Maximum dry bulb temperature on day d [°F/h]
$\mathbf{DB_{min}}$ = Minimum dry bulb temperature on day d [°F/h]

[1] These values are renormalized by the model, so that the daily integral of the hourly values sums to unity, as with the $\mathbf{HF_{ijk}}$s.

Appendix B. Sources of Residential End-Use Load Shape Data

The first task in our analysis of California end-use load shape data was to review existing sources of these data. This appendix summarizes our findings.

Available data were divided into *primary* and *secondary* sources. The primary sources were California programs with recent and readily available data, or large *state-of-the-art* programs from other parts of the country. The primary sources were identified through contact with the California utilities, and from discussions and presentations made at the Workshop on Residential Load Shapes, held at UC Berkeley on September 25, 1987. Secondary sources were identified in order to provide an alternative source of information that could not be found in the primary sources, especially for non-weather sensitive end uses. These secondary sources were identified primarily through contacts with the utilities and from reports by the AEIC and EPRI [AEIC 1982-1983 through 1985-1986, AEIC 1985, EPRI 1984]. Sources from both categories are summarized in Table B-1.

Table B-1 lists, for each utility (or other organization), and for each end use, the number of units metered. Also shown the beginning and ending years of the projects. Each line entry may include several projects spanning many years, so the years indicated should not be taken as to represent the number of years of data available. If the ending year is missing or greater than '87, the project is ongoing and data may not yet be available. In many cases no distinction was made between *room* and *central* air conditioning; for these cases, the total number of air-conditioning units was entered under both columns. If only the number of homes and the represented end uses are known, "'" indicates that the quantity represents the number of homes and not the number of actual end-use units metered. Most of the projects meter only single-family dwellings, those which include monitoring of multifamily dwellings are indicated with "*". Some of this information has not been verified with the utilities.

Table B-1 cont. Sources of Residential End-Use Load Shape Data

Utility	Years	Clo Wshr	Clo Dryr	Refg	Frzr	Pool Pump	Solr Pool	TV	Lit Msc
primary sources									
PG&E	85-		373	21					
SMUD	85-87								
SDG&E	82-85					10			
SCE	85-87	17	19	59	30	62	28	9	16
BPA	84-	211	422	211	100				422
SierraPac	84-	'65	'65	'65	'65				'65
secondary sources									
BG&E	63-74		33	33	33				
CleveElect	64-65		65						
ConEd	85-86			272					
Consumers	75-85		30						
EPRI	75-80	110							
Miss.Pwr	84-86		40						
NiMo	85-88			50					
PG&E	65-82		22						
PG&E	86-		120	107	37				
PSE&G (NJ)	84-85			100					
UtahP&L	72-73		36						

' - Data present, exact number unknown
* - Data includes multifamily

Appendix C. Data Analysis Procedures

This appendix summarizes the methods used to develop seasonal adjustment factors and peak day load shape by season for non-conditioning end uses and to develop new time-temperature matrices for conditioning end uses. The results are presented in Sections IV and V. Supporting data tables for these results are contained in Appendix D. Additional data tables are contained in Appendix E.

For each set of utility data three different estimations were performed. First, the monthly consumption for each appliance was estimated. For the non-conditioning end uses, the monthly consumption figures were aggregated into seasons for use in the CEC model. Second, the hourly average consumption for the non-conditioning appliances was estimated. Third, when possible[1], the weather-consumption relationship was estimated for each of the conditioning appliances. The analyses of each utility data set (PG&E, SCE, and SDG&E) were similar in concept but differ in the details. The following sections describe each analysis separately.

Pacific Gas and Electric

This data set contains 48 half-hourly observations for each household per day. There are 742 households; the observed period is from 1 Jan 1985 to 31 Dec 1986. Three measurements were made for each household, one of which was the whole-building load. The observed appliances (or groups of appliances) are central air conditioner, wall (room) air conditioner, clothes dryer, electric space heat, heat pump compressor, refrigerator, stove and range top, stove range and oven, stove oven, stove range and microwave oven, water heater, miscellaneous kitchen, and heat pump heating strip.

Monthly Analysis

This step aims to estimate the average monthly kWh used by each appliance, and to estimate the maximum and minimum kWh used. The average kWh use per month is a simple average over the number of households in each month. The maximum (minimum) for each month is the kWh used by the household with the highest (lowest) consumption level per month. This analysis is done for each month of the 24 observed months (i.e., 1985-1986) and then the corresponding months in the two years are averaged. The above analysis is repeated for each appliance in the data set. The different steps of this estimation are given below.

a) Averaging the half hourly observations into hourly observations. This is done by adding each two half-hourly loads and then dividing by 2. The half hour prior to and following the clock hour are averaged for each clock hour. The total use per day is then a simple summation over the 24 hours. For each case with missing data the following averaging process was performed: define the number of missing half-hourly data for appliance j in day d as $\mathbf{m_j^d}$, and the total kWh use of appliance j in a day as $\mathbf{T_j^d}$ ($=\sum_{24}$ hourly kWh used). Then, if

[1] We performed the analysis for the SDG&E data, but did not report our results, due to the unusual source of the metering data (i.e., from the monitoring of direct load control projects).

dry-bulb temperature and relative humidity from selected weather stations for the two years and each household metered was assigned to one of these stations. The detailed steps of this part of the analysis are discussed below.

a) As a first step toward calculating the weather-kWh load matrix the wet-bulb temperature is calculated by interpolation in a table of wet-bulb temperature vs. dry-bulb temperature and relative humidity.

b) Averaging the half hourly data into hourly data. The missing observations are treated in such a way that if there exists a missing observation before an operation (e.g., wet-bulb temperature for 9:30-10:00 a.m. is missing) it will still be missing after the operation (e.g., wet-bulb temperature for 9-10 a.m. is missing).

c) Transforming the dry-bulb temperatures (DBT) and wet-bulb temperatures (WBT) into the temperature humidity index (THI) was accomplished by doing the following operation

$$\mathbf{THI = 15 + 0.4 \cdot (DBT + WBT)}.$$

Again, the missing values were treated as in step (b).

d) Transforming the THI values to discrete values with "jumps" of 1 (e.g., THI = 35, 36, 37,...).

e) Every hourly observation with a missing value of the hourly kWh or hourly THI is deleted.

f) The data were checked to make sure that each household is related to its corresponding weather station. Those households with missing information as to their designated weather regions were deleted.

g) The final matrix is estimated. For every hour of the day and for every observed THI (with discrete jumps of 1) the following quantities are calculated: (1) mean kWh used, (2) number of observed households, (3) standard error of the mean (= **standard deviation** / $\sqrt{\textbf{no. of households}}$), and (4) coefficient of variation (=[**100×standard deviation**] / **mean**).

h) The above analysis was repeated by season. The two seasons are Winter (January, February, March, April, May, November, December) and Summer (June, July, August, September, October).

i) All of the above steps were repeated for all the different types of air conditioners.

Southern California Edison

The SCE data contain five minute interval load data associated with the appliance end use. The observed period is 1 Jan 1986 to 31 Dec 1986. The different appliances in this data set are central air conditioner, central heat pumps, clothes dryer, clothes washer, dishwasher, freezer, gas dryer, microwave, oven and range, pool pump, refrigerator, room air conditioner, electric spa, evaporative cooler and television set. Unlike the PG&E data set that include a large number of informative variables, the SCE data include only a few variables, which makes the analysis slightly different. The steps of the analysis are described below where only the differences (from the PG&E analysis) are discussed in detail.

Monthly Analysis

Estimating the average, minimum, and maximum monthly kWh use per appliance.

analyzed included the "no cycling" households plus all weekends and all even weekdays for 1983-1984.

Hourly Analysis of Conditioning Appliances.

The only conditioning appliance is central air conditioners. No weather data are included in the data set (except high, and low, dry-bulb temperature for each day). As in the SCE analysis another weather data set obtained from NOAA was used, which included both dry and wet bulb temperatures. The new weather data are from only one region (weather station number 23232), which is used to analyze all three climate zones in the original SDG&E data set (Maritime, Coastal, Transitional).

The rest of this step is similar to the PG&E analysis described before.

Appendix D. Data Tables for Sections IV and V

To facilitate presentation in the body of the report the values used to produce the graphs contained in Sections IV and V are presented separately in this appendix.

Table D-2. PG&E Water Heater - Daily Load Shape

	Percent of Total Daily Energy			
Hour	Winter Dec-Feb	Spring Mar-May	Summer Jun-Sep	Fall Oct-Nov
1	1.17	1.10	1.22	1.15
2	0.91	0.89	1.00	1.02
3	0.95	0.86	1.00	1.12
4	1.38	1.39	1.63	1.71
5	2.74	3.09	3.08	3.05
6	4.96	5.92	5.03	5.05
7	7.18	8.19	6.98	7.64
8	7.99	8.55	7.48	8.14
9	6.99	7.33	7.39	7.30
10	5.86	5.75	6.20	5.64
11	4.75	4.53	4.80	4.41
12	4.10	3.73	4.26	3.91
13	3.80	3.23	3.84	3.64
14	3.57	3.06	3.74	3.64
15	3.27	2.98	3.23	3.02
16	3.83	3.75	3.60	3.59
17	5.09	5.02	5.60	5.26
18	6.14	5.80	5.60	6.19
19	7.06	6.50	5.68	6.58
20	6.05	5.88	5.26	5.93
21	4.31	4.53	4.90	4.25
22	3.44	3.58	4.06	3.51
23	2.70	2.72	2.69	2.59
24	1.76	1.62	1.73	1.69

Table D-4. PG&E Cooking - Daily Load Shape

	Percent of Total Daily Energy			
	Winter	Spring	Summer	Fall
Hour	Dec-Feb	Mar-May	Jun-Sep	Oct-Nov
1	0.23	0.19	0.23	0.25
2	0.17	0.14	0.17	0.20
3	0.17	0.14	0.15	0.19
4	0.26	0.30	0.32	0.23
5	0.66	0.82	0.80	0.74
6	1.97	2.62	2.25	2.32
7	3.52	4.40	3.54	4.11
8	4.33	4.72	4.34	4.64
9	4.27	4.07	4.64	4.36
10	4.17	3.68	4.31	4.18
11	4.24	3.81	4.25	4.28
12	5.49	4.95	5.27	5.35
13	4.75	4.13	4.58	4.63
14	4.17	3.41	3.69	4.00
15	4.43	3.84	4.03	4.41
16	6.99	6.54	5.93	6.80
17	13.16	12.30	11.10	12.99
18	17.59	17.87	16.53	17.13
19	9.71	11.42	11.34	9.78
20	4.63	5.45	6.04	4.46
21	2.59	2.81	3.48	2.48
22	1.50	1.43	1.79	1.43
23	0.68	0.65	0.83	0.70
24	0.34	0.28	0.37	0.35

Table D-6. SCE Freezer - Daily Load Shape

	Percent of Total Daily Energy			
Hour	Winter Dec-Feb	Spring Mar-May	Summer Jun-Sep	Fall Oct-Nov
1	4.01	3.91	3.97	3.89
2	3.91	3.83	3.88	3.96
3	3.98	3.80	3.89	3.98
4	3.91	3.75	3.89	3.83
5	3.87	3.70	3.72	3.77
6	3.87	3.64	3.67	3.88
7	3.78	3.73	3.70	3.81
8	3.85	3.70	3.80	3.76
9	4.07	4.05	4.04	3.93
10	3.99	4.15	4.10	3.97
11	4.16	4.24	4.25	4.18
12	4.11	4.37	4.37	4.31
13	4.38	4.51	4.47	4.45
14	4.47	4.69	4.61	4.52
15	4.55	4.78	4.68	4.59
16	4.64	4.80	4.75	4.64
17	4.57	4.75	4.66	4.62
18	4.38	4.55	4.52	4.44
19	4.35	4.29	4.41	4.45
20	4.38	4.19	4.26	4.26
21	4.40	4.42	4.23	4.39
22	4.24	4.15	4.08	4.23
23	4.10	4.01	4.07	4.13
24	4.00	3.96	3.97	4.02

Table D-8. SCE Clothes Dryer - Daily Load Shape

	Percent of Total Daily Energy			
Hour	Winter Dec-Feb	Spring Mar-May	Summer Jun-Sep	Fall Oct-Nov
1	0.23	0.14	0.13	0.29
2	0.03	0.01	0.09	0.04
3	0.00	0.01	0.12	0.04
4	0.00	0.13	0.82	0.48
5	0.04	0.41	1.46	1.47
6	0.31	0.69	1.39	2.04
7	1.18	2.17	3.09	2.95
8	3.33	3.46	5.27	5.67
9	4.95	5.96	7.11	7.23
10	7.68	8.16	7.50	7.92
11	8.76	9.03	7.80	6.16
12	9.11	9.43	7.03	6.39
13	8.30	8.88	7.05	6.03
14	7.98	8.02	7.29	5.82
15	7.64	7.71	6.87	5.44
16	7.20	7.41	6.95	5.52
17	6.61	6.37	6.97	6.65
18	6.69	4.90	5.96	7.31
19	5.68	3.74	4.95	6.66
20	4.15	3.55	4.42	6.69
21	3.59	3.55	3.87	4.45
22	3.09	3.83	2.23	2.48
23	2.32	1.96	1.23	1.60
24	1.12	0.47	0.40	0.68

Table D-10. SCE Dishwasher - Daily Load Shape

	Percent of Total Daily Energy			
Hour	Winter Dec-Feb	Spring Mar-May	Summer Jun-Sep	Fall Oct-Nov
1	1.69	2.43	1.68	1.78
2	1.18	1.78	1.47	1.26
3	0.89	1.66	1.74	1.46
4	0.90	1.64	1.52	1.50
5	1.19	1.42	2.20	0.88
6	0.96	2.26	2.53	1.93
7	2.75	4.07	2.50	3.36
8	4.05	3.46	6.38	6.00
9	5.98	8.98	5.99	8.52
10	6.55	9.07	3.58	6.38
11	4.48	6.45	3.89	2.90
12	3.63	3.58	5.66	3.37
13	4.81	2.99	5.06	3.87
14	5.59	3.38	3.83	5.14
15	6.10	4.52	4.46	6.10
16	6.67	4.37	4.30	5.11
17	4.91	4.25	6.62	5.75
18	5.99	4.30	9.29	7.30
19	6.94	6.87	7.36	8.31
20	8.21	4.70	6.04	6.27
21	4.00	5.15	5.28	3.14
22	4.86	4.24	3.40	2.38
23	4.10	4.48	3.24	4.03
24	3.56	3.95	1.96	3.25

Table D-12. PG&E Central Air Conditioner Time-Temperature Matrix

THI	Time of Day 1	2	3	4	5	6	7	8	9	10	11	12
40	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
41	nd	nd	nd	nd	nd	nd	0.07	nd	nd	nd	nd	nd
42	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
43	nd	nd	0.02	0.02	0.03	0.03	0.03	nd	nd	nd	nd	nd
44	nd	nd	nd	0.04	0.05	0.03	0.05	0.02	nd	nd	nd	nd
45	0.02	0.02	0.04	0.03	0.01	0.02	0.03	0.09	nd	nd	nd	nd
46	0.03	0.05	0.02	0.01	0.02	0.02	0.04	0.05	0.13	nd	nd	nd
47	0.04	0.01	0.01	0.02	0.02	0.03	0.03	0.07	0.02	nd	nd	nd
48	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.02	nd	nd	nd
49	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.03	0.03	0.10	nd	nd
50	0.03	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.06	0.10	0.09
51	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.09	0.08
52	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.02	0.06	0.05
53	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.05	nd
54	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.08
55	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03
56	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02
57	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.02	0.02
58	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.03
59	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02
60	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03
61	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
62	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
63	0.06	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02
64	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02
65	0.11	0.09	0.08	0.08	0.06	0.05	0.05	0.05	0.04	0.03	0.03	0.02
66	0.15	0.14	0.11	0.09	0.07	0.07	0.05	0.06	0.04	0.03	0.03	0.03
67	0.19	0.14	0.12	0.09	0.09	0.07	0.07	0.07	0.05	0.04	0.03	0.03
68	0.21	0.18	0.15	0.12	0.08	0.10	0.09	0.08	0.06	0.05	0.05	0.04
69	0.26	0.20	0.17	0.17	0.14	0.12	0.11	0.12	0.10	0.07	0.06	0.06
70	0.30	0.25	0.26	0.20	0.14	0.14	0.11	0.11	0.13	0.10	0.09	0.06
71	0.37	0.30	0.28	0.25	0.24	0.19	0.18	0.13	0.13	0.13	0.11	0.09
72	0.42	0.37	0.33	0.10	0.26	0.24	0.14	0.18	0.17	0.15	0.14	0.13
73	0.51	0.42	0.26	0.26	0.00	nd	0.00	0.17	0.17	0.22	0.19	0.18
74	0.52	0.47	0.34	nd	nd	nd	nd	0.27	0.22	0.24	0.25	0.28
75	0.72	1.12	nd	0.00	nd	nd	nd	0.15	0.27	0.29	0.34	0.33
76	nd	nd	nd	nd	nd	nd	nd	nd	0.42	0.37	0.42	0.44
77	nd	nd	nd	nd	nd	nd	nd	nd	0.29	0.54	0.46	0.57
78	nd	nd	nd	nd	nd	nd	nd	nd	0.00	0.45	0.60	0.74
79	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.86	0.90	0.87
80	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.96	1.03
81	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.97	1.22
82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.41
83	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.59
84	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
85	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
86	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
87	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
88	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
89	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

nd - no data recorded at this time temperature interval

Table D-13. PG&E Room Air Conditioner Time-Temperature Matrix

THI	Time of Day 1	2	3	4	5	6	7	8	9	10	11	12
40	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
42	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
43	nd	nd	0.00	0.00	0.00	0.00	0.00	nd	nd	nd	nd	nd
44	nd	nd	nd	0.00	0.00	0.00	0.00	0.00	nd	nd	nd	nd
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd	nd
46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
49	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	nd	nd
50	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	nd
54	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
59	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
61	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
62	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00
63	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
64	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
65	0.01	0.01	0.03	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
66	0.03	0.04	0.01	0.02	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01
67	0.03	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01
68	0.06	0.03	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.02	0.01	0.02
69	0.04	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.02	0.02
70	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.05	0.03	0.02
71	0.03	0.01	0.01	0.03	0.01	0.01	0.01	0.00	0.04	0.06	0.05	0.03
72	0.01	0.01	0.06	0.01	0.01	nd	0.01	0.01	0.01	0.04	0.04	0.04
73	0.01	0.06	0.01	0.01	nd	nd	nd	0.01	0.04	0.07	0.09	0.06
74	0.09	0.01	0.01	nd	nd	nd	nd	0.01	0.05	0.06	0.11	0.11
75	0.00	nd	nd	nd	nd	nd	nd	nd	0.01	0.08	0.16	0.12
76	nd	nd	nd	nd	nd	nd	nd	nd	0.06	0.10	0.10	0.19
77	nd	nd	nd	nd	nd	nd	nd	nd	0.01	0.05	0.10	0.28
78	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.01	0.21	0.26
79	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.06	0.18	0.25
80	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.39	0.25
81	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00	0.15
82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.77
83	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00
84	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
85	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
86	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
87	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
88	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
89	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

nd - no data recorded at this time temperature interval

Table D-14. SCE Central Air Conditioner Time-Temperature Matrix

THI	Time of Day 1	2	3	4	5	6	7	8	9	10	11	12
40	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
42	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
43	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
44	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
45	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
46	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
47	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
48	nd	nd	nd	nd	0.02	nd	nd	0.02	nd	nd	nd	nd
49	nd	nd	nd	nd	nd	0.02	0.02	nd	nd	nd	nd	nd
50	nd	nd	nd	0.02	0.02	0.03	0.03	nd	nd	nd	nd	nd
51	nd	nd	0.02	0.02	0.02	0.03	0.03	0.02	0.02	nd	nd	nd
52	nd	0.02	0.02	0.02	0.02	0.04	0.03	0.08	nd	nd	nd	nd
53	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	nd	nd	nd	nd
54	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.03	0.02	nd	nd	nd
55	0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.02	nd	nd	nd
56	0.03	0.02	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.02	nd	nd
57	0.03	0.02	0.02	0.02	0.03	0.04	0.03	0.03	0.04	0.02	nd	nd
58	0.03	0.03	0.04	0.03	0.05	0.05	0.03	0.03	0.04	0.03	0.05	nd
59	0.07	0.07	0.07	0.06	0.06	0.04	0.04	0.03	0.03	0.03	0.02	0.03
60	0.03	0.06	0.05	0.07	0.06	0.08	0.10	0.05	0.04	0.04	0.03	0.02
61	0.14	0.11	0.09	0.09	0.09	0.07	0.07	0.07	0.05	0.04	0.03	0.03
62	0.12	0.08	0.06	0.06	0.07	0.07	0.09	0.06	0.09	0.06	0.05	0.03
63	0.08	0.05	0.10	0.08	0.07	0.05	0.07	0.05	0.03	0.04	0.04	0.07
64	0.08	0.11	0.06	0.07	0.07	0.07	0.08	0.08	0.04	0.06	0.11	0.05
65	0.11	0.11	0.12	0.10	0.07	0.05	0.11	0.09	0.07	0.07	0.19	0.06
66	0.17	0.10	0.06	0.06	0.02	0.09	0.12	0.14	0.12	0.09	0.10	0.06
67	0.25	0.17	0.15	0.07	0.08	0.06	0.08	0.27	0.12	0.14	0.05	0.23
68	0.19	0.10	0.10	0.09	0.10	0.12	0.08	0.21	0.15	0.12	0.08	0.17
69	0.27	0.34	0.21	0.17	0.03	0.14	0.32	0.37	0.67	0.37	0.16	0.32
70	0.33	0.21	0.16	0.42	0.25	0.09	0.21	0.19	0.65	0.23	0.36	0.24
71	0.02	0.02	0.50	nd	nd	0.18	0.32	0.45	0.37	0.33	0.48	0.35
72	0.37	0.54	0.14	0.14	0.16	0.04	0.18	0.34	0.59	0.69	0.44	0.53
73	0.18	nd	nd	nd	nd	nd	nd	0.50	0.36	1.04	0.39	0.62
74	nd	nd	nd	nd	nd	0.28	0.25	0.47	0.58	0.81	0.77	0.58
75	nd	nd	nd	nd	nd	nd	nd	0.91	0.28	0.80	1.24	0.67
76	nd	nd	nd	nd	nd	nd	nd	nd	0.67	0.59	1.23	1.17
77	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.67	1.39	1.28
78	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.66	1.10	1.41
79	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.23	0.98	1.33
80	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.48	1.81
81	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.14	2.30
82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.85	0.91
83	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.56
84	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
85	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
86	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
87	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
88	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
89	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

nd - no data recorded at this time temperature interval

Table D-15. SCE Room Air Conditioner Time-Temperature Matrix

THI	Time of Day 1	2	3	4	5	6	7	8	9	10	11	12
40	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
41	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
42	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
43	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
44	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
45	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
46	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
47	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
48	nd	nd	nd	nd	0.00	nd	nd	0.00	nd	nd	nd	nd
49	nd	nd	nd	nd	nd	0.00	0.00	nd	nd	nd	nd	nd
50	nd	nd	nd	0.00	0.00	0.00	0.00	nd	nd	nd	nd	nd
51	nd	nd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
52	nd	0.00	0.00	0.00	0.01	0.00	0.00	nd	nd	nd	nd	nd
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd	nd
54	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
55	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd	nd
56	0.01	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	nd	nd
57	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	nd	nd
58	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	nd	nd
59	0.01	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
61	0.03	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
62	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00
63	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.00	0.00	0.01	0.02	0.00
64	0.02	0.01	0.01	0.01	0.02	0.01	0.03	0.01	0.00	0.01	0.04	0.00
65	0.02	0.02	0.02	0.01	0.01	0.01	0.03	0.01	0.00	0.02	0.07	0.01
66	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.03	0.01	0.01	0.02	0.02
67	0.02	0.02	0.03	0.02	0.03	0.03	0.03	0.10	0.02	0.01	0.00	0.06
68	0.06	0.04	0.08	0.05	0.06	0.01	0.04	0.10	0.04	0.02	0.00	0.03
69	0.09	0.09	0.08	0.08	0.00	0.01	0.11	0.08	0.21	0.13	0.03	0.08
70	0.10	0.13	0.00	0.00	0.00	0.04	0.00	0.00	0.21	0.04	0.09	0.02
71	0.00	0.00	0.00	nd	nd	0.59	nd	0.15	0.12	0.06	0.11	0.09
72	0.00	0.00	0.16	0.28	0.28	0.29	0.31	0.03	0.30	0.18	0.12	0.14
73	0.17	nd	nd	nd	nd	nd	nd	0.01	0.13	0.27	0.11	0.16
74	nd	nd	nd	nd	nd	nd	nd	nd	0.16	0.34	0.24	0.13
75	nd	nd	nd	nd	nd	nd	nd	0.69	0.11	0.61	0.37	0.22
76	nd	nd	nd	nd	nd	nd	nd	nd	0.23	0.20	0.41	0.36
77	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.17	0.62	0.32
78	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.46	0.24	0.52
79	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.82	0.25	0.30
80	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.43	0.60
81	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.23	0.64
82	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.22	0.45
83	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.42
84	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
85	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
86	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
87	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
88	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
89	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

nd - no data recorded at this time temperature interval

Appendix E. Supporting Data Tables for Section IV

For the interested reader, this appendix reproduces intermediate data used to develop the results presented in Section IV. These tables contain statistical information, such as numbers of hourly observations, mean hourly values, standard deviations, etc., for each end use in each set of utility data analyzed.

Stove Range and Oven PG&E
Summary of Average Monthly Use

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	41.6	0.7	183.9	9.51%	1.34	Winter	27.28%	1.11
2	35.1	1.4	172.0	8.01%	1.25	Spring	24.85%	0.99
3	40.0	0.1	147.0	9.14%	1.29	Summer	29.75%	0.89
4	35.0	3.1	140.7	8.00%	1.17	Fall	18.12%	1.08
5	33.8	0.6	154.0	7.72%	1.09			
6	29.9	1.0	148.8	6.83%	1.00			
7	32.1	0.0	186.0	7.34%	1.04			
8	33.3	0.9	206.6	7.61%	1.08			
9	34.9	0.6	185.0	7.96%	1.16			
10	37.7	0.7	182.7	8.61%	1.22			
11	41.6	0.2	168.5	9.51%	1.39			
12	42.8	1.1	155.0	9.77%	1.38			
Total	437.8	10.4	2030.3		1.20		100.00%	

Stove Oven PG&E
Summary of Average Monthly Use

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	26.9	1.0	57.7	9.46%	0.87	Winter	27.58%	1.12
2	22.0	0.4	56.0	7.75%	0.79	Spring	24.63%	0.98
3	26.3	0.9	72.5	9.28%	0.85	Summer	29.28%	0.88
4	23.5	1.2	63.2	8.27%	0.78	Fall	18.50%	1.11
5	20.1	0.1	54.1	7.09%	0.65			
6	18.5	0.4	42.8	6.52%	0.62			
7	19.8	0.0	60.0	6.96%	0.64			
8	20.2	0.0	62.0	7.10%	0.65			
9	24.7	0.0	77.5	8.70%	0.82			
10	23.5	1.6	89.0	8.27%	0.76			
11	29.1	1.5	112.1	10.23%	0.97			
12	29.5	3.6	100.3	10.37%	0.95			
Total	284.1	10.7	847.1		0.78		100.00%	

Miscellaneous Kitchen PG&E
Summary of Average Monthly Use

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	174.0	48.0	472.4	8.48%	5.61	Winter	24.04%	0.98
2	154.0	48.3	404.8	7.51%	5.50	Spring	24.44%	0.97
3	167.6	54.4	448.9	8.17%	5.41	Summer	35.18%	1.05
4	164.6	52.8	447.9	8.02%	5.49	Fall	16.33%	0.98
5	169.2	60.8	439.6	8.25%	5.46			
6	178.5	51.5	462.2	8.70%	5.95			
7	193.8	56.8	481.6	9.45%	6.25			
8	180.0	43.5	474.5	8.77%	5.81			
9	169.5	68.7	438.4	8.26%	5.65			
10	172.3	62.6	466.8	8.40%	5.56			
11	162.8	49.4	443.0	7.93%	5.43			
12	165.3	48.6	463.4	8.06%	5.33			
Total	2051.4	645.4	5443.6		5.62		100.00%	

Stove Range and Microwave Oven PG&E
Number of Households

Month	1985	1986	Total
1	15	19	34
2	16	17	33
3	15	17	32
4	16	20	36
5	16	19	35
6	16	19	35
7	15	18	33
8	19	18	37
9	19	19	38
10	19	19	38
11	19	19	38
12	19	19	38
Total	204	223	427

Stove and Range Top PG&E
Number of Households

Month	1985	1986	Total
1	79	84	163
2	82	76	158
3	80	84	164
4	85	85	170
5	84	85	169
6	82	84	166
7	73	86	159
8	84	77	161
9	86	86	172
10	85	78	163
11	86	86	172
12	83	83	166
Total	989	994	1983

Stove Range and Oven PG&E
Number of Households

Month	1985	1986	Total
1	175	181	356
2	185	168	353
3	188	182	370
4	186	180	366
5	186	172	358
6	178	161	339
7	155	173	328
8	175	163	338
9	179	177	356
10	183	162	345
11	182	171	353
12	179	164	343
Total	2151	2054	4205

Refrigerator
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	131.4	0.0	275.4	7.77%	4.24	Winter	20.59%	0.84
2	97.5	0.0	245.8	5.76%	3.48	Spring	27.31%	1.08
3	142.7	0.0	293.0	8.44%	4.60	Summer	36.52%	1.09
4	153.4	4.1	272.1	9.07%	5.11	Fall	15.59%	0.93
5	165.7	8.2	300.3	9.80%	5.34			
6	169.4	20.4	295.5	10.02%	5.65			
7	143.6	0.0	329.0	8.49%	4.63			
8	154.9	0.0	306.1	9.16%	5.00			
9	149.6	0.0	309.2	8.85%	4.99			
10	142.9	0.0	308.2	8.45%	4.61			
11	120.7	0.0	296.4	7.14%	4.02			
12	119.4	0.0	244.6	7.06%	3.85			
Total	1691.0	32.7	3475.7		4.63			

Range-Oven
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	15.9	0.0	49.3	7.05%	0.51	Winter	23.53%	0.95
2	14.1	0.0	42.4	6.25%	0.50	Spring	26.86%	1.07
3	19.0	0.3	49.1	8.39%	0.61	Summer	33.96%	1.02
4	19.5	7.7	50.3	8.63%	0.65	Fall	15.65%	0.94
5	22.3	6.1	55.7	9.85%	0.72			
6	21.6	0.0	63.2	9.55%	0.72			
7	17.2	0.0	64.9	7.61%	0.55			
8	20.3	0.0	67.9	8.96%	0.65			
9	17.7	0.0	57.2	7.84%	0.59			
10	16.1	0.0	55.8	7.11%	0.52			
11	19.3	0.0	63.8	8.54%	0.64			
12	23.1	0.0	57.0	10.23%	0.75			
Total	226.0	14.0	676.6		0.62			

Clothes Dryer
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	89.9	0.0	279.5	9.74%	2.90	Winter	25.95%	1.05
2	77.5	0.0	223.6	8.40%	2.77	Spring	25.65%	1.02
3	75.2	0.0	251.4	8.16%	2.43	Summer	32.27%	0.97
4	72.1	0.0	219.6	7.82%	2.40	Fall	16.13%	0.97
5	89.2	0.0	243.8	9.67%	2.88			
6	86.0	0.0	243.1	9.32%	2.87			
7	71.0	0.0	304.6	7.69%	2.29			
8	64.9	0.0	375.7	7.03%	2.09			
9	75.8	0.0	342.2	8.22%	2.53			
10	71.8	0.0	349.5	7.79%	2.32			
11	76.9	0.0	327.7	8.34%	2.56			
12	72.0	0.0	222.0	7.80%	2.32			
Total	922.3	0.0	3382.7		2.53			

Clothes Washer
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	7.2	0.0	34.1	9.31%	0.23	Winter	24.79%	1.01
2	5.6	0.0	16.7	7.17%	0.20	Spring	25.76%	1.02
3	6.7	0.0	23.0	8.67%	0.22	Summer	33.46%	1.00
4	7.0	0.0	25.9	9.07%	0.23	Fall	15.99%	0.96
5	6.2	0.0	22.9	8.01%	0.20			
6	7.1	0.0	22.8	9.10%	0.24			
7	5.7	0.0	17.7	7.35%	0.18			
8	6.4	0.0	23.4	8.26%	0.21			
9	6.8	0.0	20.4	8.75%	0.23			
10	6.1	0.0	19.5	7.83%	0.20			
11	6.3	0.0	16.9	8.15%	0.21			
12	6.5	0.0	38.0	8.32%	0.21			
Total	77.6	0.0	281.2		0.21			

Freezer
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	103.2	0.0	188.2	8.28%	3.33	Winter	22.62%	0.92
2	84.4	0.0	169.9	6.77%	3.01	Spring	23.39%	0.93
3	91.4	0.0	193.1	7.33%	2.95	Summer	36.44%	1.09
4	94.0	0.0	199.3	7.54%	3.13	Fall	17.55%	1.05
5	106.4	18.4	226.3	8.53%	3.43			
6	107.9	0.0	224.2	8.66%	3.60			
7	122.0	0.0	235.2	9.79%	3.94			
8	122.5	0.0	237.7	9.83%	3.95			
9	101.9	0.0	214.5	8.17%	3.40			
10	122.6	2.0	221.9	9.83%	3.96			
11	96.2	0.0	205.5	7.71%	3.21			
12	94.4	0.0	222.9	7.57%	3.05			
Total	1246.9	20.4	2538.6		3.42			

Dishwasher
Summary of Average Monthly Use SCE

Month	Average Monthly	Average Minimum	Average Maximum	Monthly Fraction	Average Daily	CEC Season	Seasonal Fraction	Adjust Factor
1	7.8	0.0	27.0	9.54%	0.25	Winter	28.19%	1.14
2	6.1	0.0	24.5	7.53%	0.22	Spring	25.08%	1.00
3	7.2	0.0	27.3	8.87%	0.23	Summer	27.51%	0.82
4	6.7	0.0	25.9	8.18%	0.22	Fall	19.22%	1.15
5	6.5	0.0	26.3	8.03%	0.21			
6	6.6	0.0	25.0	8.07%	0.22			
7	4.3	0.0	25.6	5.27%	0.14			
8	5.2	0.0	28.9	6.40%	0.17			
9	6.3	0.0	24.6	7.78%	0.21			
10	6.5	0.0	26.5	7.99%	0.21			
11	9.1	0.0	30.9	11.23%	0.30			
12	9.0	0.0	26.9	11.12%	0.29			
Total	81.4	0.0	319.4		0.22			

Refrigerators Winter PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	2617	0.168	0.130	0.000	0.80	439.7	0.017	3.68%
2	2617	0.160	0.124	0.000	0.81	419.9	0.015	3.51%
3	2617	0.159	0.124	0.000	0.81	415.8	0.015	3.48%
4	2617	0.154	0.119	0.000	0.81	402.1	0.014	3.36%
5	2617	0.155	0.120	0.000	0.80	404.5	0.014	3.38%
6	2617	0.164	0.120	0.000	0.78	428.6	0.014	3.59%
7	2617	0.173	0.126	0.000	0.82	451.7	0.016	3.78%
8	2617	0.186	0.133	0.000	1.03	487.6	0.018	4.08%
9	2617	0.192	0.139	0.000	1.50	501.2	0.019	4.19%
10	2617	0.188	0.141	0.000	0.81	492.1	0.020	4.12%
11	2617	0.183	0.138	0.000	1.09	478.0	0.019	4.00%
12	2617	0.193	0.136	0.000	0.80	506.1	0.019	4.24%
13	2617	0.194	0.138	0.000	0.81	507.3	0.019	4.25%
14	2617	0.191	0.140	0.000	1.17	500.4	0.019	4.19%
15	2617	0.197	0.141	0.000	0.99	514.8	0.020	4.31%
16	2617	0.201	0.143	0.000	1.28	525.0	0.020	4.39%
17	2617	0.214	0.148	0.000	1.09	560.5	0.022	4.69%
18	2617	0.233	0.166	0.000	1.13	610.2	0.028	5.11%
19	2617	0.231	0.166	0.000	1.04	605.1	0.028	5.06%
20	2617	0.224	0.164	0.000	1.08	585.4	0.027	4.90%
21	2617	0.221	0.160	0.000	1.11	577.7	0.026	4.83%
22	2617	0.213	0.152	0.000	1.00	558.2	0.023	4.67%
23	2617	0.193	0.141	0.000	1.01	505.7	0.020	4.23%
24	2617	0.180	0.131	0.000	0.78	472.0	0.017	3.95%
Total	2617	4.566	2.917	0.005	18.18	11949.1	8.508	100.00%

Refrigerators Spring PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	3082	0.181	0.127	0.000	0.76	557.1	0.016	3.75%
2	3082	0.173	0.122	0.000	0.75	532.4	0.015	3.59%
3	3082	0.171	0.121	0.000	0.76	528.1	0.015	3.56%
4	3082	0.167	0.115	0.000	0.82	514.8	0.013	3.47%
5	3082	0.165	0.116	0.000	1.08	508.1	0.013	3.42%
6	3082	0.178	0.121	0.000	0.75	548.3	0.015	3.69%
7	3082	0.182	0.125	0.000	0.80	561.4	0.016	3.78%
8	3082	0.198	0.129	0.000	0.94	610.8	0.017	4.12%
9	3082	0.194	0.131	0.000	0.80	599.0	0.017	4.04%
10	3082	0.193	0.134	0.000	0.82	595.1	0.018	4.01%
11	3082	0.193	0.137	0.000	1.03	596.1	0.019	4.02%
12	3082	0.201	0.135	0.000	0.85	618.9	0.018	4.17%
13	3082	0.200	0.135	0.000	0.78	615.3	0.018	4.15%
14	3082	0.201	0.138	0.000	0.90	620.0	0.019	4.18%
15	3082	0.207	0.140	0.000	0.77	639.3	0.020	4.31%
16	3082	0.218	0.142	0.000	0.77	672.3	0.020	4.53%
17	3082	0.226	0.149	0.000	1.02	695.9	0.022	4.69%
18	3082	0.235	0.151	0.000	1.09	725.6	0.023	4.89%
19	3082	0.237	0.151	0.000	1.43	731.5	0.023	4.93%
20	3082	0.232	0.149	0.000	1.31	714.4	0.022	4.81%
21	3082	0.232	0.152	0.000	1.21	715.0	0.023	4.82%
22	3082	0.223	0.145	0.000	0.99	686.4	0.021	4.62%
23	3082	0.212	0.142	0.000	0.98	653.5	0.020	4.40%
24	3082	0.196	0.134	0.000	0.79	604.4	0.018	4.07%
Total	3082	4.816	2.897	0.000	17.27	14843.2	8.390	100.00%

Refrigerators Summer PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	4123	0.225	0.166	0.000	1.13	926.1	0.028	3.94%
2	4123	0.212	0.160	0.000	1.25	872.6	0.026	3.71%
3	4123	0.204	0.155	0.000	1.19	841.7	0.024	3.58%
4	4123	0.207	0.151	0.000	1.28	853.4	0.023	3.63%
5	4123	0.199	0.149	0.000	1.09	821.9	0.022	3.50%
6	4123	0.205	0.151	0.000	1.12	845.5	0.023	3.60%
7	4123	0.215	0.156	0.000	1.19	888.3	0.024	3.78%
8	4123	0.220	0.154	0.000	1.08	909.1	0.024	3.87%
9	4123	0.224	0.162	0.000	1.20	925.2	0.026	3.94%
10	4123	0.229	0.162	0.000	1.36	943.5	0.026	4.02%
11	4123	0.228	0.159	0.000	1.24	938.8	0.025	4.00%
12	4123	0.237	0.158	0.000	1.33	976.4	0.025	4.16%
13	4123	0.240	0.156	0.000	1.44	988.9	0.024	4.21%
14	4123	0.240	0.160	0.000	1.24	988.8	0.026	4.21%
15	4123	0.245	0.168	0.000	1.31	1011.6	0.028	4.31%
16	4123	0.257	0.170	0.000	1.36	1058.0	0.029	4.50%
17	4123	0.262	0.171	0.000	1.38	1080.8	0.029	4.60%
18	4123	0.272	0.175	0.000	1.28	1122.4	0.031	4.78%
19	4123	0.276	0.179	0.000	1.42	1137.8	0.032	4.84%
20	4123	0.272	0.174	0.000	1.28	1122.2	0.030	4.78%
21	4123	0.269	0.181	0.000	1.53	1111.0	0.033	4.73%
22	4123	0.269	0.182	0.000	1.31	1107.8	0.033	4.72%
23	4123	0.253	0.177	0.000	1.31	1041.6	0.031	4.43%
24	4123	0.237	0.171	0.000	1.25	978.2	0.029	4.16%
Total	4123	5.698	3.583	0.000	23.50	23490.9	12.837	100.00%

Refrigerators Fall PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	2073	0.188	0.151	0.000	1.30	389.3	0.023	3.76%
2	2073	0.182	0.149	0.000	1.13	376.8	0.022	3.64%
3	2073	0.179	0.143	0.000	1.14	370.9	0.020	3.59%
4	2073	0.172	0.134	0.000	1.09	356.8	0.018	3.45%
5	2073	0.175	0.133	0.000	0.94	362.5	0.018	3.50%
6	2073	0.181	0.135	0.000	1.08	376.2	0.018	3.64%
7	2073	0.197	0.141	0.000	0.90	408.0	0.020	3.94%
8	2073	0.205	0.141	0.000	1.01	425.7	0.020	4.12%
9	2073	0.205	0.147	0.000	1.15	424.1	0.022	4.10%
10	2073	0.203	0.153	0.000	1.12	421.7	0.023	4.08%
11	2073	0.201	0.154	0.000	1.15	416.0	0.024	4.02%
12	2073	0.205	0.149	0.000	1.23	425.1	0.022	4.11%
13	2073	0.209	0.152	0.000	1.21	433.3	0.023	4.19%
14	2073	0.213	0.155	0.000	1.25	441.6	0.024	4.27%
15	2073	0.216	0.152	0.000	1.01	447.7	0.023	4.33%
16	2073	0.222	0.150	0.000	1.09	460.6	0.022	4.45%
17	2073	0.231	0.158	0.000	1.10	478.6	0.025	4.63%
18	2073	0.243	0.166	0.000	1.24	503.4	0.027	4.87%
19	2073	0.247	0.167	0.000	1.31	511.4	0.028	4.94%
20	2073	0.240	0.169	0.000	1.21	497.6	0.028	4.81%
21	2073	0.234	0.164	0.000	1.44	485.2	0.027	4.69%
22	2073	0.229	0.161	0.000	1.32	475.7	0.026	4.60%
23	2073	0.215	0.156	0.000	1.03	446.3	0.024	4.31%
24	2073	0.198	0.149	0.000	0.98	410.1	0.022	3.96%
Total	2073	4.990	3.243	1.357	21.87	10344.3	10.516	100.00%

Clothes Dryers Winter PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	51136	0.014	0.169	0.000	4.71	740.0	0.029	0.51%
2	51136	0.008	0.119	0.000	4.98	402.4	0.014	0.28%
3	51136	0.005	0.091	0.000	5.02	256.6	0.008	0.18%
4	51136	0.004	0.065	0.000	3.10	187.3	0.004	0.13%
5	51136	0.006	0.088	0.000	3.90	305.3	0.008	0.21%
6	51136	0.020	0.186	0.000	4.67	1035.8	0.035	0.71%
7	51136	0.051	0.300	0.000	4.56	2629.8	0.090	1.80%
8	51136	0.092	0.418	0.000	4.96	4713.4	0.175	3.23%
9	51136	0.158	0.573	0.000	5.04	8079.2	0.328	5.54%
10	51136	0.208	0.665	0.000	5.11	10616.3	0.442	7.28%
11	51136	0.241	0.721	0.000	5.27	12319.0	0.520	8.45%
12	51136	0.242	0.724	0.000	5.70	12371.9	0.524	8.48%
13	51136	0.225	0.699	0.000	5.43	11508.3	0.488	7.89%
14	51136	0.202	0.659	0.000	5.56	10319.5	0.435	7.07%
15	51136	0.186	0.632	0.000	5.44	9513.8	0.400	6.52%
16	51136	0.185	0.627	0.000	5.26	9443.4	0.393	6.47%
17	51136	0.182	0.614	0.000	5.23	9300.9	0.377	6.38%
18	51136	0.172	0.599	0.000	5.44	8805.9	0.359	6.04%
19	51136	0.155	0.573	0.000	5.54	7945.1	0.328	5.45%
20	51136	0.147	0.565	0.000	5.39	7542.6	0.319	5.17%
21	51136	0.137	0.550	0.000	5.27	6987.4	0.302	4.79%
22	51136	0.110	0.492	0.000	5.16	5604.0	0.242	3.84%
23	51136	0.069	0.384	0.000	5.26	3541.1	0.148	2.43%
24	51136	0.033	0.216	0.000	4.75	1698.5	0.047	1.16%
Total	51136	2.852	4.350	0.000	53.99	145862.8	18.925	100.00%

Clothes Dryers Spring PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	58611	0.011	0.141	0.000	5.43	647.1	0.020	0.45%
2	58611	0.007	0.106	0.000	4.38	391.6	0.011	0.27%
3	58611	0.004	0.068	0.000	4.21	218.5	0.005	0.15%
4	58611	0.003	0.048	0.000	2.87	157.6	0.002	0.11%
5	58611	0.005	0.076	0.000	4.38	277.6	0.006	0.19%
6	58611	0.024	0.192	0.000	4.29	1394.4	0.037	0.97%
7	58611	0.065	0.334	0.000	4.92	3791.0	0.112	2.64%
8	58611	0.103	0.437	0.000	4.54	6061.4	0.191	4.22%
9	58611	0.153	0.551	0.000	5.14	8984.1	0.303	6.26%
10	58611	0.189	0.619	0.000	5.27	11088.3	0.383	7.72%
11	58611	0.203	0.643	0.000	5.49	11926.6	0.413	8.30%
12	58611	0.197	0.638	0.000	5.45	11557.5	0.407	8.05%
13	58611	0.175	0.598	0.000	5.33	10252.2	0.358	7.14%
14	58611	0.154	0.559	0.000	5.26	8999.0	0.312	6.27%
15	58611	0.143	0.536	0.000	5.38	8402.7	0.287	5.85%
16	58611	0.143	0.529	0.000	5.36	8359.7	0.280	5.82%
17	58611	0.140	0.519	0.000	5.46	8222.5	0.270	5.73%
18	58611	0.140	0.524	0.000	5.04	8229.3	0.274	5.73%
19	58611	0.134	0.517	0.000	5.31	7865.8	0.267	5.48%
20	58611	0.132	0.514	0.000	5.35	7718.2	0.264	5.37%
21	58611	0.131	0.523	0.000	5.29	7702.8	0.273	5.36%
22	58611	0.105	0.469	0.000	5.10	6139.8	0.220	4.28%
23	58611	0.062	0.349	0.000	5.03	3618.5	0.122	2.52%
24	58611	0.028	0.190	0.000	4.63	1612.6	0.036	1.12%
Total	58611	2.450	3.809	0.000	38.06	143614.5	14.508	100.00%

Clothes Dryers Summer PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	68595	0.013	0.144	0.000	4.03	862.5	0.021	0.58%
2	68595	0.006	0.094	0.000	4.28	442.7	0.009	0.30%
3	68595	0.004	0.069	0.000	4.07	297.7	0.005	0.20%
4	68595	0.003	0.059	0.000	4.29	238.7	0.003	0.16%
5	68595	0.005	0.075	0.000	4.14	369.8	0.006	0.25%
6	68595	0.016	0.149	0.000	5.22	1101.1	0.022	0.74%
7	68595	0.046	0.273	0.000	5.00	3178.2	0.075	2.13%
8	68595	0.085	0.386	0.000	5.10	5838.0	0.149	3.91%
9	68595	0.132	0.495	0.000	5.08	9060.7	0.245	6.07%
10	68595	0.169	0.561	0.000	5.06	11572.8	0.314	7.76%
11	68595	0.189	0.598	0.000	5.19	12971.4	0.358	8.69%
12	68595	0.183	0.590	0.000	5.00	12537.1	0.348	8.40%
13	68595	0.164	0.558	0.000	5.40	11245.8	0.311	7.54%
14	68595	0.138	0.509	0.000	5.21	9455.2	0.259	6.34%
15	68595	0.123	0.475	0.000	4.94	8459.8	0.225	5.67%
16	68595	0.118	0.461	0.000	5.18	8123.5	0.213	5.44%
17	68595	0.118	0.457	0.000	4.91	8119.0	0.209	5.44%
18	68595	0.120	0.461	0.000	5.22	8207.4	0.213	5.50%
19	68595	0.115	0.454	0.000	5.09	7861.8	0.206	5.27%
20	68595	0.115	0.461	0.000	5.17	7854.5	0.212	5.26%
21	68595	0.116	0.467	0.000	5.21	7924.6	0.218	5.31%
22	68595	0.101	0.442	0.000	5.17	6951.5	0.196	4.66%
23	68595	0.066	0.356	0.000	5.14	4509.4	0.126	3.02%
24	68595	0.030	0.192	0.000	3.80	2037.2	0.037	1.37%
Total	68595	2.175	3.445	0.000	36.07	149215.9	11.869	100.00%

Clothes Dryers Fall PGE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	37140	0.012	0.144	0.000	4.90	429.0	0.021	0.47%
2	37140	0.006	0.101	0.000	3.77	227.4	0.010	0.25%
3	37140	0.004	0.073	0.000	3.14	151.7	0.005	0.16%
4	37140	0.003	0.061	0.000	3.94	123.0	0.004	0.13%
5	37140	0.008	0.103	0.000	3.85	278.9	0.011	0.30%
6	37140	0.020	0.177	0.000	4.65	724.3	0.031	0.79%
7	37140	0.058	0.314	0.000	5.51	2147.3	0.099	2.33%
8	37140	0.097	0.423	0.000	4.71	3609.4	0.179	3.92%
9	37140	0.151	0.552	0.000	5.03	5625.2	0.304	6.11%
10	37140	0.189	0.623	0.000	5.25	7034.1	0.388	7.64%
11	37140	0.205	0.649	0.000	5.53	7611.8	0.421	8.27%
12	37140	0.207	0.658	0.000	5.06	7682.4	0.433	8.35%
13	37140	0.182	0.612	0.000	5.33	6758.5	0.375	7.34%
14	37140	0.165	0.577	0.000	5.55	6126.7	0.333	6.66%
15	37140	0.151	0.545	0.000	5.37	5611.8	0.297	6.10%
16	37140	0.152	0.544	0.000	4.56	5654.5	0.296	6.14%
17	37140	0.150	0.536	0.000	5.13	5570.9	0.287	6.05%
18	37140	0.144	0.525	0.000	4.98	5339.3	0.276	5.80%
19	37140	0.139	0.526	0.000	5.44	5170.7	0.276	5.62%
20	37140	0.130	0.512	0.000	5.63	4816.1	0.262	5.23%
21	37140	0.123	0.504	0.000	5.13	4553.2	0.254	4.95%
22	37140	0.095	0.448	0.000	5.33	3524.9	0.200	3.83%
23	37140	0.058	0.348	0.000	5.14	2168.7	0.121	2.36%
24	37140	0.030	0.202	0.000	3.27	1122.6	0.041	1.22%
Total	37140	2.479	3.875	0.000	41.68	92059.6	15.013	100.00%

Clothes Dryers Winter SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	1930	0.006	0.110	0.000	3.14	11.7	0.012	0.23%
2	1930	0.001	0.035	0.000	1.52	1.8	0.001	0.03%
3	1930	0.000	0.002	0.000	0.03	0.2	0.000	0.00%
4	1930	0.000	0.002	0.000	0.03	0.2	0.000	0.00%
5	1930	0.001	0.031	0.000	1.06	2.1	0.001	0.04%
6	1930	0.008	0.147	0.000	3.80	15.8	0.022	0.31%
7	1930	0.031	0.255	0.000	4.44	60.6	0.065	1.18%
8	1930	0.089	0.419	0.000	4.29	171.2	0.176	3.33%
9	1930	0.132	0.529	0.000	4.20	254.2	0.280	4.95%
10	1930	0.205	0.688	0.000	4.98	394.9	0.473	7.68%
11	1930	0.233	0.703	0.000	4.60	450.2	0.494	8.76%
12	1930	0.243	0.740	0.000	4.68	468.1	0.548	9.11%
13	1930	0.221	0.691	0.000	4.23	426.5	0.478	8.30%
14	1930	0.213	0.671	0.000	4.42	410.2	0.451	7.98%
15	1930	0.204	0.645	0.000	4.21	392.9	0.417	7.64%
16	1930	0.192	0.634	0.000	4.14	370.1	0.402	7.20%
17	1930	0.176	0.585	0.000	4.17	340.0	0.343	6.61%
18	1930	0.178	0.594	0.000	3.81	343.8	0.353	6.69%
19	1930	0.151	0.544	0.000	4.08	292.0	0.296	5.68%
20	1930	0.111	0.467	0.000	4.13	213.4	0.218	4.15%
21	1930	0.096	0.421	0.000	4.09	184.5	0.177	3.59%
22	1930	0.082	0.400	0.000	4.03	159.0	0.160	3.09%
23	1930	0.062	0.383	0.000	4.75	119.1	0.147	2.32%
24	1930	0.030	0.245	0.000	3.74	57.8	0.060	1.12%
Total	1930	2.663	4.611	0.000	31.11	5140.5	21.263	100.00%

Clothes Dryers Spring SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	1473	0.004	0.072	0.000	2.12	5.6	0.005	0.14%
2	1473	0.000	0.003	0.000	0.04	0.6	0.000	0.01%
3	1473	0.000	0.003	0.000	0.04	0.6	0.000	0.01%
4	1473	0.003	0.086	0.000	3.18	5.0	0.007	0.13%
5	1473	0.011	0.175	0.000	4.20	16.3	0.031	0.41%
6	1473	0.019	0.217	0.000	3.87	27.5	0.047	0.69%
7	1473	0.058	0.365	0.000	4.08	85.9	0.133	2.17%
8	1473	0.093	0.456	0.000	4.33	137.1	0.208	3.46%
9	1473	0.160	0.615	0.000	4.87	235.7	0.378	5.96%
10	1473	0.219	0.698	0.000	4.74	322.9	0.487	8.16%
11	1473	0.243	0.728	0.000	4.55	357.5	0.529	9.03%
12	1473	0.253	0.750	0.000	4.44	373.0	0.562	9.43%
13	1473	0.238	0.724	0.000	4.80	351.2	0.524	8.88%
14	1473	0.215	0.706	0.000	4.50	317.3	0.498	8.02%
15	1473	0.207	0.677	0.000	4.25	305.0	0.458	7.71%
16	1473	0.199	0.646	0.000	4.72	293.3	0.418	7.41%
17	1473	0.171	0.599	0.000	4.16	251.9	0.359	6.37%
18	1473	0.132	0.516	0.000	4.56	194.0	0.267	4.90%
19	1473	0.100	0.448	0.000	4.04	147.8	0.201	3.74%
20	1473	0.095	0.432	0.000	3.63	140.3	0.187	3.55%
21	1473	0.095	0.466	0.000	4.50	140.4	0.217	3.55%
22	1473	0.103	0.499	0.000	5.23	151.6	0.249	3.83%
23	1473	0.053	0.347	0.000	4.90	77.6	0.120	1.96%
24	1473	0.013	0.157	0.000	3.71	18.6	0.025	0.47%
Total	1473	2.686	4.770	0.000	34.86	3956.5	22.756	100.00%

Clothes Dryers Summer SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	3015	0.003	0.053	0.000	2.39	9.5	0.003	0.13%
2	3015	0.002	0.037	0.000	1.71	6.7	0.001	0.09%
3	3015	0.003	0.060	0.000	3.03	9.1	0.004	0.12%
4	3015	0.020	0.194	0.000	3.21	61.8	0.038	0.82%
5	3015	0.036	0.297	0.000	4.22	109.4	0.088	1.46%
6	3015	0.035	0.275	0.000	4.13	104.4	0.075	1.39%
7	3015	0.077	0.384	0.000	4.13	232.5	0.147	3.09%
8	3015	0.131	0.516	0.000	4.12	396.4	0.267	5.27%
9	3015	0.177	0.606	0.000	4.12	534.7	0.367	7.11%
10	3015	0.187	0.576	0.000	4.09	563.3	0.332	7.50%
11	3015	0.194	0.620	0.000	4.14	585.8	0.385	7.80%
12	3015	0.175	0.580	0.000	4.39	528.1	0.336	7.03%
13	3015	0.176	0.561	0.000	3.93	529.7	0.315	7.05%
14	3015	0.182	0.583	0.000	5.13	547.6	0.339	7.29%
15	3015	0.171	0.555	0.000	4.42	516.2	0.308	6.87%
16	3015	0.173	0.551	0.000	4.80	522.4	0.304	6.95%
17	3015	0.174	0.561	0.000	5.12	523.7	0.315	6.97%
18	3015	0.149	0.503	0.000	4.16	447.9	0.253	5.96%
19	3015	0.123	0.453	0.000	3.59	372.3	0.205	4.95%
20	3015	0.110	0.458	0.000	4.60	332.4	0.210	4.42%
21	3015	0.096	0.419	0.000	4.59	290.9	0.176	3.87%
22	3015	0.056	0.304	0.000	4.06	167.4	0.092	2.23%
23	3015	0.031	0.245	0.000	4.62	92.8	0.060	1.23%
24	3015	0.010	0.115	0.000	2.99	30.1	0.013	0.40%
Total	3015	2.493	4.154	0.000	30.65	7515.2	17.252	100.00%

Clothes Dryers Fall SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	1541	0.007	0.125	0.000	3.44	11.4	0.016	0.29%
2	1541	0.001	0.026	0.000	1.01	1.4	0.001	0.04%
3	1541	0.001	0.023	0.000	0.78	1.7	0.001	0.04%
4	1541	0.012	0.130	0.000	2.16	18.9	0.017	0.48%
5	1541	0.038	0.299	0.000	4.10	58.4	0.089	1.47%
6	1541	0.052	0.334	0.000	4.59	80.7	0.112	2.04%
7	1541	0.076	0.370	0.000	3.89	117.0	0.137	2.95%
8	1541	0.146	0.572	0.000	4.62	225.0	0.327	5.67%
9	1541	0.186	0.633	0.000	4.21	286.6	0.401	7.23%
10	1541	0.204	0.658	0.000	4.22	313.8	0.433	7.92%
11	1541	0.158	0.549	0.000	4.08	244.2	0.301	6.16%
12	1541	0.165	0.582	0.000	4.24	253.5	0.338	6.39%
13	1541	0.155	0.552	0.000	3.79	239.2	0.304	6.03%
14	1541	0.150	0.534	0.000	4.58	230.6	0.286	5.82%
15	1541	0.140	0.526	0.000	5.12	215.7	0.276	5.44%
16	1541	0.142	0.514	0.000	4.03	218.7	0.264	5.52%
17	1541	0.171	0.582	0.000	4.96	263.4	0.338	6.65%
18	1541	0.188	0.586	0.000	4.03	290.0	0.344	7.31%
19	1541	0.171	0.571	0.000	4.17	263.8	0.326	6.66%
20	1541	0.172	0.577	0.000	4.47	265.1	0.333	6.69%
21	1541	0.114	0.481	0.000	4.10	176.3	0.231	4.45%
22	1541	0.064	0.354	0.000	3.68	98.5	0.125	2.48%
23	1541	0.041	0.283	0.000	3.38	63.5	0.080	1.60%
24	1541	0.017	0.187	0.000	3.34	26.9	0.035	0.68%
Total	1541	2.573	4.478	0.000	30.73	3964.4	20.055	100.00%

Dishwashers Winter SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	944	0.004	0.029	0.000	0.61	4.1	0.001	1.69%
2	944	0.003	0.022	0.000	0.60	2.9	0.000	1.18%
3	944	0.002	0.009	0.000	0.04	2.2	0.000	0.89%
4	944	0.002	0.009	0.000	0.04	2.2	0.000	0.90%
5	944	0.003	0.025	0.000	0.72	2.9	0.001	1.19%
6	944	0.002	0.011	0.000	0.21	2.3	0.000	0.96%
7	944	0.007	0.045	0.000	0.72	6.7	0.002	2.75%
8	944	0.010	0.062	0.000	0.82	9.8	0.004	4.05%
9	944	0.015	0.077	0.000	0.63	14.5	0.006	5.98%
10	944	0.017	0.078	0.000	0.72	15.9	0.006	6.55%
11	944	0.012	0.064	0.000	0.69	10.9	0.004	4.48%
12	944	0.009	0.058	0.000	0.73	8.8	0.003	3.63%
13	944	0.012	0.063	0.000	0.70	11.7	0.004	4.81%
14	944	0.014	0.068	0.000	0.67	13.5	0.005	5.59%
15	944	0.016	0.074	0.000	0.79	14.8	0.006	6.10%
16	944	0.017	0.084	0.000	0.76	16.2	0.007	6.67%
17	944	0.013	0.067	0.000	0.70	11.9	0.004	4.91%
18	944	0.015	0.078	0.000	0.83	14.5	0.006	5.99%
19	944	0.018	0.084	0.000	0.76	16.8	0.007	6.94%
20	944	0.021	0.096	0.000	0.88	19.9	0.009	8.21%
21	944	0.010	0.054	0.000	0.79	9.7	0.003	4.00%
22	944	0.012	0.069	0.000	0.86	11.8	0.005	4.86%
23	944	0.011	0.057	0.000	0.64	9.9	0.003	4.10%
24	944	0.009	0.063	0.000	0.99	8.6	0.004	3.56%
Total	944	0.257	0.401	0.000	2.22	242.5	0.161	100.00%

Dishwashers Spring SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	860	0.005	0.028	0.000	0.49	4.1	0.001	2.43%
2	860	0.004	0.019	0.000	0.46	3.0	0.000	1.78%
3	860	0.003	0.016	0.000	0.39	2.8	0.000	1.66%
4	860	0.003	0.013	0.000	0.34	2.8	0.000	1.64%
5	860	0.003	0.010	0.000	0.04	2.4	0.000	1.42%
6	860	0.004	0.026	0.000	0.53	3.9	0.001	2.26%
7	860	0.008	0.045	0.000	0.60	6.9	0.002	4.07%
8	860	0.007	0.038	0.000	0.57	5.9	0.001	3.46%
9	860	0.018	0.079	0.000	0.69	15.3	0.006	8.98%
10	860	0.018	0.079	0.000	0.66	15.4	0.006	9.07%
11	860	0.013	0.061	0.000	0.71	11.0	0.004	6.45%
12	860	0.007	0.040	0.000	0.59	6.1	0.002	3.58%
13	860	0.006	0.036	0.000	0.54	5.1	0.001	2.99%
14	860	0.007	0.036	0.000	0.53	5.7	0.001	3.38%
15	860	0.009	0.052	0.000	0.78	7.7	0.003	4.52%
16	860	0.009	0.051	0.000	0.66	7.4	0.003	4.37%
17	860	0.008	0.044	0.000	0.64	7.2	0.002	4.25%
18	860	0.009	0.048	0.000	0.62	7.3	0.002	4.30%
19	860	0.014	0.072	0.000	0.71	11.7	0.005	6.87%
20	860	0.009	0.050	0.000	0.57	8.0	0.002	4.70%
21	860	0.010	0.058	0.000	0.67	8.8	0.003	5.15%
22	860	0.008	0.049	0.000	0.65	7.2	0.002	4.24%
23	860	0.009	0.049	0.000	0.51	7.6	0.002	4.48%
24	860	0.008	0.045	0.000	0.70	6.7	0.002	3.95%
Total	860	0.198	0.340	0.000	2.48	170.3	0.115	100.00%

Dishwashers Summer SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	1096	0.003	0.014	0.000	0.35	3.2	0.000	1.68%
2	1096	0.003	0.009	0.000	0.06	2.8	0.000	1.47%
3	1096	0.003	0.020	0.000	0.59	3.4	0.000	1.74%
4	1096	0.003	0.010	0.000	0.11	2.9	0.000	1.52%
5	1096	0.004	0.027	0.000	0.63	4.2	0.001	2.20%
6	1096	0.004	0.042	0.000	1.12	4.9	0.002	2.53%
7	1096	0.004	0.026	0.000	0.57	4.8	0.001	2.50%
8	1096	0.011	0.064	0.000	0.67	12.3	0.004	6.38%
9	1096	0.011	0.060	0.000	0.84	11.5	0.004	5.99%
10	1096	0.006	0.040	0.000	0.67	6.9	0.002	3.58%
11	1096	0.007	0.040	0.000	0.70	7.5	0.002	3.89%
12	1096	0.010	0.093	0.000	2.72	10.9	0.009	5.66%
13	1096	0.009	0.053	0.000	0.65	9.7	0.003	5.06%
14	1096	0.007	0.037	0.000	0.50	7.4	0.001	3.83%
15	1096	0.008	0.046	0.000	0.71	8.6	0.002	4.46%
16	1096	0.008	0.048	0.000	1.06	8.3	0.002	4.30%
17	1096	0.012	0.071	0.000	1.10	12.7	0.005	6.62%
18	1096	0.016	0.083	0.000	0.86	17.9	0.007	9.29%
19	1096	0.013	0.068	0.000	0.80	14.2	0.005	7.36%
20	1096	0.011	0.061	0.000	0.80	11.6	0.004	6.04%
21	1096	0.009	0.054	0.000	0.86	10.2	0.003	5.28%
22	1096	0.006	0.038	0.000	0.61	6.5	0.001	3.40%
23	1096	0.006	0.038	0.000	0.67	6.2	0.001	3.24%
24	1096	0.003	0.020	0.000	0.49	3.8	0.000	1.96%
Total	1096	0.176	0.348	0.000	3.52	192.4	0.121	100.00%

Dishwashers Fall SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	675	0.005	0.040	0.000	0.88	3.3	0.002	1.78%
2	675	0.003	0.025	0.000	0.61	2.3	0.001	1.26%
3	675	0.004	0.042	0.000	1.07	2.7	0.002	1.46%
4	675	0.004	0.032	0.000	0.59	2.8	0.001	1.50%
5	675	0.002	0.009	0.000	0.04	1.6	0.000	0.88%
6	675	0.005	0.036	0.000	0.54	3.6	0.001	1.93%
7	675	0.009	0.055	0.000	0.68	6.2	0.003	3.36%
8	675	0.016	0.083	0.000	0.73	11.0	0.007	6.00%
9	675	0.023	0.107	0.000	1.01	15.7	0.012	8.52%
10	675	0.017	0.084	0.000	0.94	11.7	0.007	6.38%
11	675	0.008	0.048	0.000	0.66	5.3	0.002	2.90%
12	675	0.009	0.054	0.000	0.74	6.2	0.003	3.37%
13	675	0.011	0.055	0.000	0.58	7.1	0.003	3.87%
14	675	0.014	0.068	0.000	0.59	9.4	0.005	5.14%
15	675	0.017	0.081	0.000	0.79	11.2	0.007	6.10%
16	675	0.014	0.063	0.000	0.54	9.4	0.004	5.11%
17	675	0.016	0.078	0.000	0.86	10.6	0.006	5.75%
18	675	0.020	0.097	0.000	0.91	13.4	0.009	7.30%
19	675	0.023	0.096	0.000	0.81	15.3	0.009	8.31%
20	675	0.017	0.084	0.000	0.95	11.5	0.007	6.27%
21	675	0.009	0.055	0.000	0.98	5.8	0.003	3.14%
22	675	0.006	0.045	0.000	0.79	4.4	0.002	2.38%
23	675	0.011	0.066	0.000	1.00	7.4	0.004	4.03%
24	675	0.009	0.049	0.000	0.58	6.0	0.002	3.25%
Total	675	0.272	0.438	0.000	4.48	183.6	0.192	100.00%

Refrigerators Winter SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	3516	0.153	0.109	0.000	0.49	536.2	0.012	3.97%
2	3516	0.149	0.108	0.000	0.48	523.0	0.012	3.87%
3	3516	0.141	0.103	0.000	0.49	494.2	0.011	3.66%
4	3516	0.139	0.100	0.000	0.46	487.7	0.010	3.61%
5	3516	0.138	0.103	0.000	0.46	485.3	0.011	3.59%
6	3516	0.135	0.099	0.000	0.46	473.1	0.010	3.50%
7	3516	0.145	0.106	0.000	0.47	510.5	0.011	3.78%
8	3516	0.154	0.111	0.000	0.70	541.9	0.012	4.01%
9	3516	0.155	0.109	0.000	0.66	545.0	0.012	4.03%
10	3516	0.157	0.111	0.000	0.79	553.1	0.012	4.09%
11	3516	0.154	0.107	0.000	0.70	541.3	0.011	4.00%
12	3516	0.157	0.110	0.000	0.71	551.0	0.012	4.08%
13	3516	0.163	0.112	0.000	0.50	572.5	0.012	4.24%
14	3516	0.166	0.113	0.000	0.50	583.9	0.013	4.32%
15	3516	0.167	0.116	0.000	0.49	588.1	0.014	4.35%
16	3516	0.170	0.119	0.000	0.80	598.2	0.014	4.43%
17	3516	0.173	0.119	0.000	0.50	609.6	0.014	4.51%
18	3516	0.183	0.121	0.000	0.49	641.8	0.015	4.75%
19	3516	0.186	0.123	0.000	0.49	654.9	0.015	4.84%
20	3516	0.180	0.120	0.000	0.50	634.3	0.014	4.69%
21	3516	0.178	0.119	0.000	0.49	626.5	0.014	4.64%
22	3516	0.173	0.116	0.000	0.50	608.9	0.013	4.50%
23	3516	0.166	0.117	0.000	0.50	585.2	0.014	4.33%
24	3516	0.162	0.117	0.000	0.48	570.8	0.014	4.22%
Total	3516	3.844	2.331	0.000	10.72	13516.8	5.433	100.00%

Refrigerators Spring SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	2530	0.193	0.106	0.000	0.49	489.4	0.011	3.87%
2	2530	0.196	0.111	0.000	0.50	494.9	0.012	3.91%
3	2530	0.184	0.103	0.000	0.48	466.0	0.011	3.68%
4	2530	0.178	0.098	0.000	0.46	449.1	0.010	3.55%
5	2530	0.177	0.099	0.000	0.48	447.9	0.010	3.54%
6	2530	0.179	0.097	0.000	0.48	452.5	0.009	3.58%
7	2530	0.189	0.102	0.000	0.47	478.1	0.010	3.78%
8	2530	0.197	0.111	0.000	0.67	498.3	0.012	3.94%
9	2530	0.197	0.104	0.000	0.69	498.8	0.011	3.94%
10	2530	0.196	0.105	0.000	0.65	495.8	0.011	3.92%
11	2530	0.200	0.108	0.000	0.70	506.3	0.012	4.00%
12	2530	0.208	0.110	0.000	0.51	527.2	0.012	4.17%
13	2530	0.214	0.110	0.000	0.48	540.8	0.012	4.27%
14	2530	0.220	0.116	0.000	0.60	557.7	0.013	4.41%
15	2530	0.221	0.113	0.000	0.50	558.2	0.013	4.41%
16	2530	0.224	0.113	0.000	0.49	567.8	0.013	4.49%
17	2530	0.228	0.113	0.000	0.50	577.1	0.013	4.56%
18	2530	0.238	0.114	0.000	0.50	603.0	0.013	4.76%
19	2530	0.241	0.113	0.000	0.49	608.5	0.013	4.81%
20	2530	0.238	0.114	0.000	0.55	602.7	0.013	4.76%
21	2530	0.237	0.113	0.000	0.49	599.7	0.013	4.74%
22	2530	0.225	0.111	0.000	0.50	569.4	0.012	4.50%
23	2530	0.215	0.112	0.000	0.49	544.8	0.012	4.30%
24	2530	0.206	0.113	0.000	0.50	522.2	0.013	4.13%
Total	2530	5.003	2.264	0.000	10.86	12656.3	5.127	100.00%

Refrigerators Summer SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	4575	0.201	0.122	0.000	0.49	917.8	0.015	3.95%
2	4575	0.199	0.126	0.000	0.52	908.2	0.016	3.91%
3	4575	0.189	0.119	0.000	[illegible]	866.1	0.014	3.73%
4	4575	0.185	0.115	0.000	0.52	847.7	0.013	3.65%
5	4575	0.184	0.115	0.000	0.51	842.7	0.013	3.63%
6	4575	0.186	0.113	0.000	0.51	849.7	0.013	3.66%
7	4575	0.195	0.120	0.000	0.50	892.6	0.014	3.84%
8	4575	0.199	0.128	0.000	0.52	912.5	0.016	3.93%
9	4575	0.196	0.120	0.000	0.49	897.0	0.014	3.86%
10	4575	0.202	0.121	0.000	0.52	921.9	0.015	3.97%
11	4575	0.207	0.122	0.000	0.50	946.8	0.015	4.08%
12	4575	0.216	0.123	0.000	0.49	988.1	0.015	4.25%
13	4575	0.218	0.125	0.000	1.34	999.3	0.016	4.30%
14	4575	0.220	0.128	0.000	0.50	1007.5	0.016	4.34%
15	4575	0.224	0.129	0.000	0.53	1025.6	0.017	4.41%
16	4575	0.229	0.131	0.000	0.96	1047.7	0.017	4.51%
17	4575	0.234	0.128	0.000	0.61	1068.5	0.016	4.60%
18	4575	0.239	0.128	0.000	0.51	1091.6	0.016	4.70%
19	4575	0.237	0.126	0.000	0.50	1085.6	0.016	4.67%
20	4575	0.233	0.127	0.000	0.51	1067.4	0.016	4.59%
21	4575	0.232	0.127	0.000	0.65	1059.7	0.016	4.56%
22	4575	0.223	0.124	0.000	0.51	1021.1	0.015	4.40%
23	4575	0.217	0.128	0.000	0.57	994.4	0.016	4.28%
24	4575	0.213	0.129	0.000	0.52	972.9	0.017	4.19%
Total	4575	5.078	2.665	0.000	11.19	23232.4	7.101	100.00%

Refrigerators Fall SCE

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	2809	0.171	0.119	0.000	0.49	479.5	0.014	3.90%
2	2809	0.171	0.122	0.000	0.48	479.0	0.015	3.90%
3	2809	0.161	0.113	0.000	0.49	451.3	0.013	3.67%
4	2809	0.156	0.109	0.000	0.48	439.5	0.012	3.58%
5	2809	0.153	0.106	0.000	0.50	428.4	0.011	3.49%
6	2809	0.155	0.104	0.000	0.49	436.2	0.011	3.55%
7	2809	0.163	0.111	0.000	0.44	458.1	0.012	3.73%
8	2809	0.177	0.128	0.000	0.52	496.8	0.016	4.04%
9	2809	0.169	0.117	0.000	0.49	473.8	0.014	3.86%
10	2809	0.172	0.114	0.000	0.50	482.1	0.013	3.92%
11	2809	0.174	0.117	0.000	0.49	488.4	0.014	3.97%
12	2809	0.180	0.118	0.000	0.50	505.1	0.014	4.11%
13	2809	0.186	0.116	0.000	0.49	523.3	0.014	4.26%
14	2809	0.190	0.124	0.000	0.49	534.6	0.015	4.35%
15	2809	0.195	0.125	0.000	0.49	548.1	0.016	4.46%
16	2809	0.203	0.132	0.000	0.54	570.7	0.017	4.64%
17	2809	0.203	0.126	0.000	0.48	571.2	0.016	4.65%
18	2809	0.208	0.125	0.000	0.49	584.0	0.016	4.75%
19	2809	0.209	0.126	0.000	0.50	588.0	0.016	4.79%
20	2809	0.208	0.127	0.000	0.49	584.9	0.016	4.76%
21	2809	0.201	0.124	0.000	0.49	564.6	0.015	4.59%
22	2809	0.195	0.123	0.000	0.50	548.0	0.015	4.46%
23	2809	0.188	0.123	0.000	0.49	529.1	0.015	4.31%
24	2809	0.186	0.130	0.000	0.52	522.6	0.017	4.25%
Total	2809	4.374	2.521	0.000	10.68	12287.4	6.355	100.00%

Electric Water Heaters SDG&E

Hour	N	Mean	Standard Deviation	Minimum Value	Maximum Value	Sum	Variance	Load Shape
1	506	0.519	0.637	0.000	4.92	262.8	0.405	2.47%
2	506	0.447	0.495	0.000	4.34	225.9	0.245	2.12%
3	506	0.418	0.466	0.000	5.39	211.5	0.218	1.99%
4	506	0.438	0.496	0.000	4.90	221.8	0.246	2.08%
5	506	0.562	0.842	0.000	9.41	284.5	0.710	2.67%
6	506	0.755	0.937	0.000	6.11	382.2	0.878	3.59%
7	506	1.080	1.282	0.000	11.72	546.7	1.643	5.14%
8	506	1.290	1.579	0.000	10.90	653.0	2.493	6.14%
9	506	1.219	1.489	0.000	13.82	616.9	2.218	5.80%
10	506	1.075	1.296	0.000	9.94	543.7	1.679	5.11%
11	506	0.968	1.132	0.000	7.16	490.0	1.281	4.60%
12	506	0.889	1.109	0.000	7.96	449.8	1.230	4.23%
13	506	0.843	1.136	0.000	8.52	426.3	1.290	4.01%
14	506	0.758	0.980	0.000	7.09	383.4	0.960	3.60%
15	506	0.773	1.010	0.000	8.39	391.0	1.019	3.67%
16	506	0.829	1.093	0.000	10.63	419.3	1.194	3.94%
17	506	0.994	1.174	0.000	9.78	503.0	1.379	4.73%
18	506	1.225	1.366	0.000	9.06	619.9	1.865	5.83%
19	506	1.263	1.370	0.000	9.40	639.2	1.876	6.01%
20	506	1.164	1.215	0.000	8.00	588.8	1.477	5.53%
21	506	1.130	1.211	0.000	9.31	571.7	1.467	5.37%
22	506	0.935	1.081	0.000	8.75	473.3	1.169	4.45%
23	506	0.798	1.007	0.000	7.58	403.8	1.014	3.79%
24	506	0.658	0.899	0.000	8.42	333.1	0.809	3.13%
Total	506	21.030	15.179	0.000	117.73	10641.3	230.400	100.00%

Appendix F. Smoothing the Time-Temperature Matrices

The analysis of PG&E and SCE air conditioning data to develop new time-temperature matrices for the CEC's Residential Peak Model (Section V) was limited by the range and numbers of observations found during the monitoring period. Many values at temperature-humidity extremes (both high and low) were not observed in the historic data. Moreover, the measured data exhibited uneveness across adjacent values when plotted. Intuition suggests that the time-temperature matrices ought to behave smoothly for the range of both observed and un-observed time and temperature-humidity values.

This appendix describes preliminary work to develop a statistical method for smoothing the random fluctuations in the observed matrix of load vs. time-of-day and temperature-humidity index. We begin with a formal description of the the assumptions behind the fitting procedure and the mathematical model used. We continue with a presentation of our preliminary results for the central and room air conditioner loads from both the PG&E and SCE data.

Assumptions in the Model

The model we use for smoothing the load data arises from the following observations about the data. First, at any given hour, the air conditioning load appears to increase with increasing temperature.[1] Second, at a given value of the temperature, the load appears to vary smoothly across the day. Third, the load appears to approach a maximum value at extreme temperatures which is independent of the time of day. One way to think of this behavior is that the observed load equals the average installed air conditioner capacity times the probability that the average air conditioner is on; thus, the probability increases with temperature, approaching one at very high temperatures, and that it varies smoothly from hour to hour. The model is derived from these probabilistic considerations.

We make the following formal assumptions:

1. Weather conditions can be measured in some scalar index, whose effect on electric consumption is monotonic. In other words, we assume that the many components of "weather" (which includes elements like temperature, humidity, cloudiness, angle of incidence of sunlight, etc.) can be adequately represented for the purpose of predicting electric consumption by a scalar-valued index.[2] Furthermore, we assume that index can be formed in such a way that electric energy consumption is monotonic in that index, i.e., it only rises or only falls with increases in the index, never both.
2. There exists some maximum energy demand occurring at some extreme (not necessarily infinite) levels of this index. That maximum demand is of interest and should be explicitly identifiable in the model. Furthermore, although this maximum demand is unchanging across different periods of the day, the level of the weather index necessary to bring it about

[1] For simplicity, we will discuss the model in terms of the air conditioning load and use temperature as a generic label for the appropriate weather index.

[2] For simplicity and tractability, that index will most commonly be based on temperature and/or humidity only.

That point at which the rate of increase of demand is steepest is the mode of the distribution, and has the value

$$\text{mode} = \beta\left[\frac{\alpha - 1}{\alpha}\right]^{1/\alpha}$$

whenever α is greater than or equal one. For "reasonable" values of α estimated from actual data sets (generally α greater than five or six), this value is just slightly less than β, or, in other words, the value of β is usually a slight overestimate of the position of the mode of the distribution.

We use the following notation:

t	=	the weather index (commonly just temperature, hence the notation "**t**")
h	=	the time-of-day index (commonly just hours on a 1 to 24 scale, hence the notation "**h**")
L(h,t)	=	the estimated average electric load at hour **h** and weather index **t**; i.e., the dependent variable to be fitted to independent variables **h** and **t**.
$\sigma_{h,t}$	=	the estimated standard deviation of normally-distributed additive error in **L(h,t)**, i.e., **L(h,t)** is modeled as being an estimate with a Normal distribution whose mean is the true value of the average load given **h** and **t** and whose error has standard deviation $\sigma_{h,t}$.
M	=	the maximum average electric consumption reached at some "extreme enough" value of the weather index **t**.
α	=	the "shape" parameter of the fitted Weibull distribution.
β	=	the "scale" parameter of the fitted Weibull distribution.

With this notation, we propose to model average electric load as

$$\begin{aligned} \mathbf{L(h,t)} &= \hat{\mathbf{L}}\mathbf{(h,t)} + \mathbf{e(h,t)} \\ &= \mathbf{M\,F_h(t)} + \mathbf{e(h,t)}, \end{aligned} \qquad (1)$$

where $\mathbf{F_h(t)}$ is a Weibull(α,β) probability distribution with shape parameter α(**h**) and scale parameter β(**h**) each having an explicit dependence on the time-of-day **h**, and **e(h,t)** is an error term distributed as $\mathbf{N(0,\sigma_{h,t})}$.

We deliberately chose a slightly unusual weighting function for use in equation (5). The weighting function we used was

$$w(\sigma_{h,t}, L(h,t)) = \frac{\sigma_{h,t}}{L(h,t)} \qquad (6)$$

i.e., the coefficient of variation of the data **L(h,t)**, rather than the more commonly-used standard deviation. We recognize that the common practice of setting the weight function **w(·)** equal to the estimated standard deviation of the assumed additive normal error **e(h,t)** in equation (1) eliminates the assumed heteroscedasticity of the data, a desirable goal. However, in this case, combinations of time-of-day and weather that produce extremely low electric loads also produce less variation in that load; the result was that low values of **L(h,t)** were generally estimated with much greater accuracy (i.e., smaller values of $\sigma_{h,t}$) than high levels. This led the residual-minimizing algorithm to fit the small values of load much more accurately than the large values. Since the goal of the analysis was to estimate the dependence of maximum electric load on weather and time-of-day effects, this result seemed counter-productive. Substitution of the coefficient of variation in place of the standard deviation in **w(·)** places greater weight on larger values of load. Essentially, we place greater emphasis on fitting those data points **L(h,t)** which are proportionally well-estimated (i.e., those that have a small coefficient of variation) rather than those which are absolutely well estimated.

Figures F-1 through F-4 present the fitted matrices. This model produced fitted values which were visually very satisfying (i.e., they varied smoothly in an intuitive fashion, and very rarely produced a fitted data point more than two standard deviations away from the actual data point). Because the objective of the procedure was to obtain a smooth representation of the data and because of the weighting scheme used, we did not consider it appropriate to make any tests of "goodness of fit". If a more accurate representation is needed, the number of terms in the Fourier series for $\alpha(\mathbf{h})$ and $\beta(\mathbf{h})$ could be increased.

The analysis presented should be regarded as exploratory and preliminary in nature. We anticipate future work to explore other representations of the weather index (currently, we are using a temperature-humidity index), different probability density functions, and most importantly additional validation with measured data.

Figure F-2. **PG&E Room Air Conditioning Time-Temperature Matrix - Smoothed.** Developed through application of the 8-parameter fitting procedure to the PG&E room air conditioning time-temperature matrix presented in Section V. Peak day load shapes developed from application of this matrix to selected peak day weather conditions are presented in Section VI.

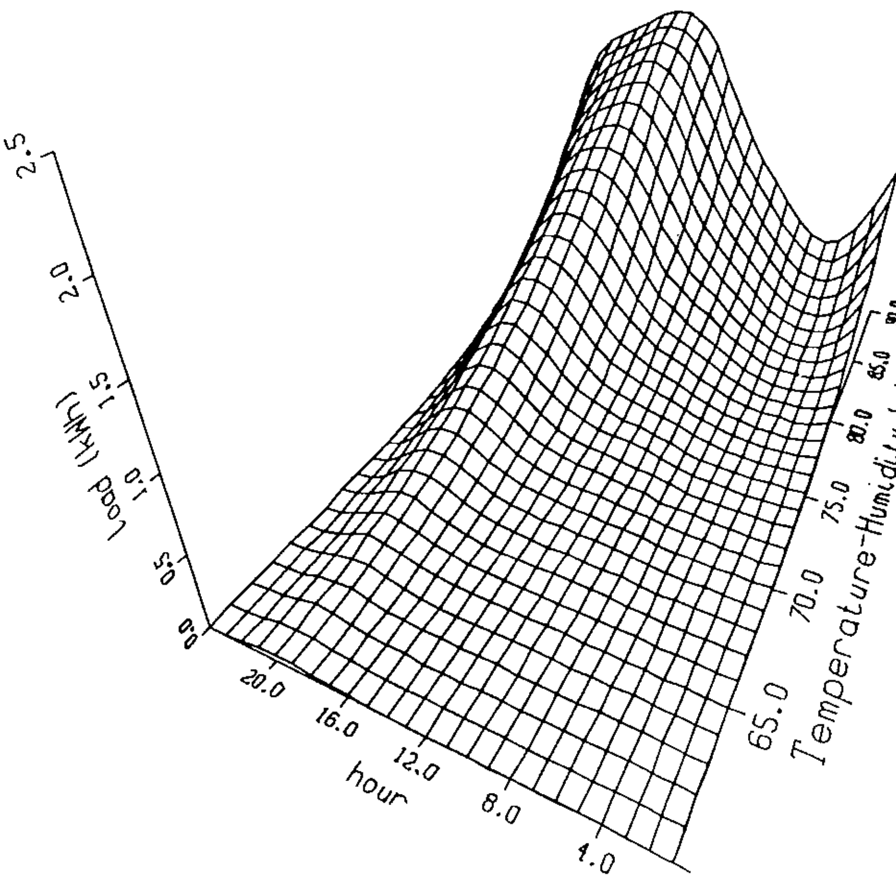

Figure F-4. **SCE Room Air Conditioning Time-Temperature Matrix - Smoothed.** Developed through application of the 8-parameter fitting procedure to the SCE central air conditioning time-temperature matrix presented in Section V. Peak day load shapes developed from application of this matrix to selected peak day weather conditions are presented in Section VI.