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Conservation in California During the Summer of 2001

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Acknowledgements

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Introduction

The goal of this study is to approximately measure the total result of energy-conservation, energy-efficiency, and load-reduction measures in the California Independent System Operator (CAISO) region during the summer and the year of 2001. This is done by correcting for weather effects and matching loads across two years. The assumption is that any residual difference can be approximately assigned to the sum of the three effects listed, although there are other possible factors not considered here, such as changing levels of business activity.

During the period leading up to summer 2001, California experienced power outages and unprecedented instability in electricity and natural gas markets. Expecting that hot summer temperatures would exacerbate the already unstable energy market, state agencies and utilities created conservation and load-reduction programs that included advertisements and publicity, bill discounts for decreased customer electricity use, and financial payments for real-time load interruptions. Because the state avoided major electricity grid disturbances during the summer, few of the load-reduction programs were tested; however, the conservation and energy-efficiency programs appear to have been quite effective.[i] [ii]

The purpose of this study is to determine the extent to which electricity loads decreased in year 2001 relative to year 2000 and year 1999, and for the corresponding summers (June through September), independent of differences in weather patterns. Our assumption is that the portion of load reduction that is not attributable to weather can be attributed to energy-efficiency and conservation measures. While other factors may certainly have had an effect on electricity load, e.g. the economic slowdown, these factors are not explored here.

To determine the load reduction in California, hourly loads from 2000 were adjusted to simulate what load would have been under year 2001 weather conditions given the year 2000 electricity use patterns. The resulting load growth profile for 2001 was then compared with the load growth between 1999 and 2000 to determine how the pattern of load growth may have been affected by the energy crisis and the conservation programs put into place in response to it.

Method

Electricity loads in two different years could be compared directly by simple subtraction. However, this method does not isolate the effect of changes in consumer behavior on energy demand, which is the goal of this study. Some variables that influence load are unrelated to customer behavior, such as weather and the business cycle; these variables change from year to year and their fluctuations can mask changes in load that result from changes in consumer demand for electricity, including changes that result from conservation efforts.

Weather is perhaps the most important of these "non-behavioral" variables. As examination of Figure 1 suggests, electrical load is often clearly tied to temperature.

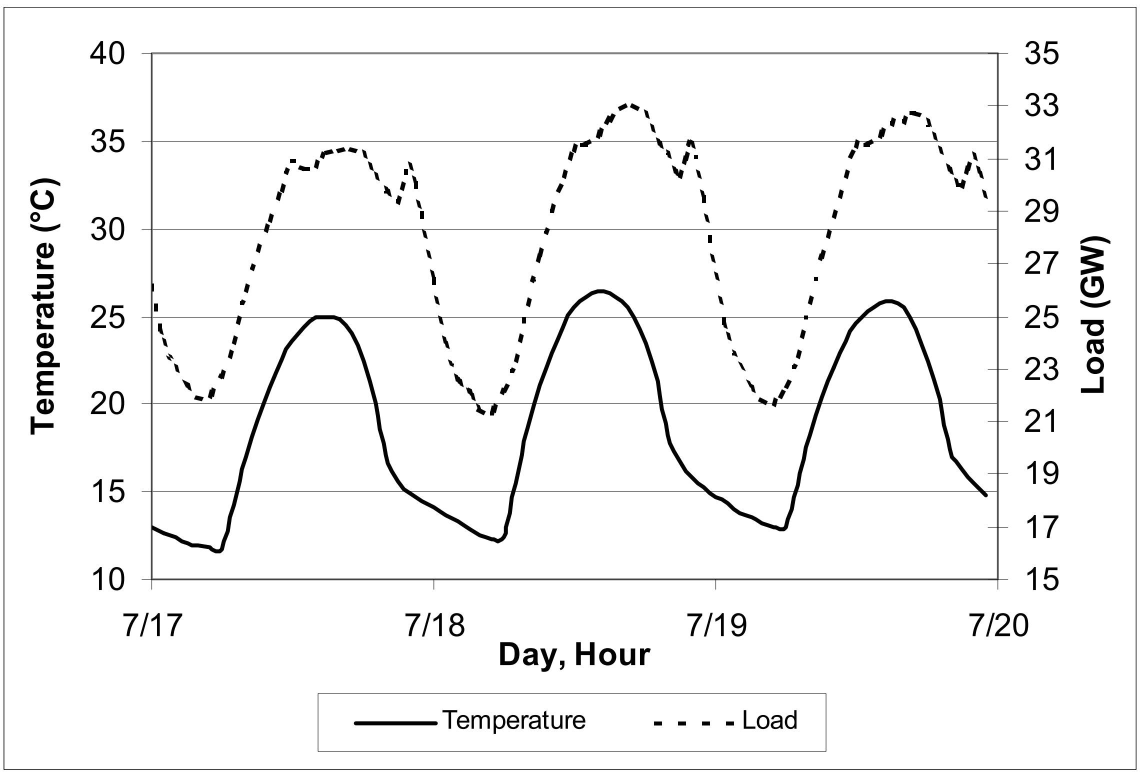

Figure 1. Load and temperature, July 17 - 20

Figure 1 shows the relationship between the population-weighted average temperature in California and electrical load report for the CAISO area during a three-day period in the summer of 2001. The high degree of correlation between temperature and electrical load is mainly caused by air conditioning use. Air conditioning use, which is clearly temperature-dependent, is also a major reason for year-to-year, weather-related discrepancy in load, making the direct year-to-year comparison of load ineffective for purposes of our analysis.

A meaningful year-to-year load comparison should account for the effects of weather. Unfortunately, isolating electrical load from weather is challenging, and there is no widely accepted method for doing so. The approach used in this study was to adjust the loads from a previous year (e.g. 2000) to the level that would have been expected if the weather had been the same as it was in the comparison year (e.g. 2001); in other words, the load data from the year 2000 were adjusted to reflect what loads would have been if the weather conditions had been the same as those in 2001. The difference between the actual year 2001 load value and the adjusted year 2001 load value – i.e., the year 2000 load adjusted using the year 2001 actual temperature data – indicates to what extent actual loads in 2001 decreased relative to 2000 loads. The following equation represents the technique of using year 2000 loads and year 2001 temperatures to determine how load changed between 2000 and 2001; Δ_{LOAD} is the difference in load between the two years, adjusted for weather:

$$\Delta_{LOAD} = L_{actual2001}(T_{2001}) - L_{adjusted2000}(T_{2001})$$

The adjusted year 2000 load profile, shown as $L_{adjusted2000}(T_{2001})$ in the above equation, was calculated by taking actual load data from the year 2000 and adjusting them for year 2001 weather.

The data needed for this analysis are population-weighted hourly temperatures for California and hourly actual CAISO electricity load for each year studied.

Temperature data were gathered from more than 100 weather stations across the state. Because climate varies significantly in different areas of the state, it was important to weight each temperature to reflect the proportion of the population affected. Temperatures from areas of the state with larger populations were given greater weight than temperatures from areas with smaller populations. To calculate these weights, each weather station was associated with the county in which it was located. Then the population of each county was divided by the number of weather stations within that county, to produce the number of people associated with each station. The resulting portion of the population associated with each weather station was used as the respective weight for the temperature recorded at that station. To calculate a single representative statewide temperature, the total sum of the weighted temperatures was divided by the total population.

The hourly load data were obtained from CAISO and represent only the load from the CAISO area, roughly 75 percent of California. The load data were downloaded from the Open Access Same-Time Information System (OASIS) website maintained by CAISO. The data are hour-ending instantaneous loads. For example, the load posted for hour 1 is the instantaneous load at 1 a.m. on the given day.

Analysis

The objective of this study is to produce a weather-normalized comparison of electrical load from 1999, 2000, and 2001 in California to determine the reduction in load that resulted from conservation efforts during the summer of 2001. To create a complete picture, loads were compared between sequential years from 1998 through 2001. These comparisons established a profile of electricity load change from 1998 to 2000, when no special conservation efforts were under way; this profile was compared to 2001, during which significant conservation efforts were publicized.

To account for weather effects, the actual load value for 2001 was compared to the adjusted value for 2000, as described above. However, adjusting for weather alone does not produce an accurate year-to-year comparison because other variables influence load. In addition to weather, three additional variables were taken into account: day of the week, hour of the day, and presence or absence of natural light.

The effects of these variables are as common sense would predict. More electricity is used during the day than at night. More specifically, electrical load varies according to the hour of the day in a fairly consistent pattern.

A direct relationship also exists between load and day type. The three day-types examined in this study are weekday (Monday through Friday), weekend (Saturday and Sunday), and holiday.[iii] Electrical use is typically higher on weekdays than on weekends or holidays.

The presence of natural light decreases the need for artificial light both indoors and outdoors. The effects of this variable can be observed in Figure 2, which shows both electrical load and sunrise/sunset times for a typical day in 2001. A sharp rise in load can be seen between the 19th and 20th hours; actual sunset time for that day was 19:41. When comparing loads from different days and years, it is important to isolate the daylighting effect of sunrise and sunset times. The algorithm used to calculate the sunrise/sunset times was based on one published in the *1990 Almanac for Computers* published by Nautical Almanac Office of the United States Naval Observatory[iv]. The algorithm takes into account daylight savings time and is calculated for San Francisco's latitude and longitude.

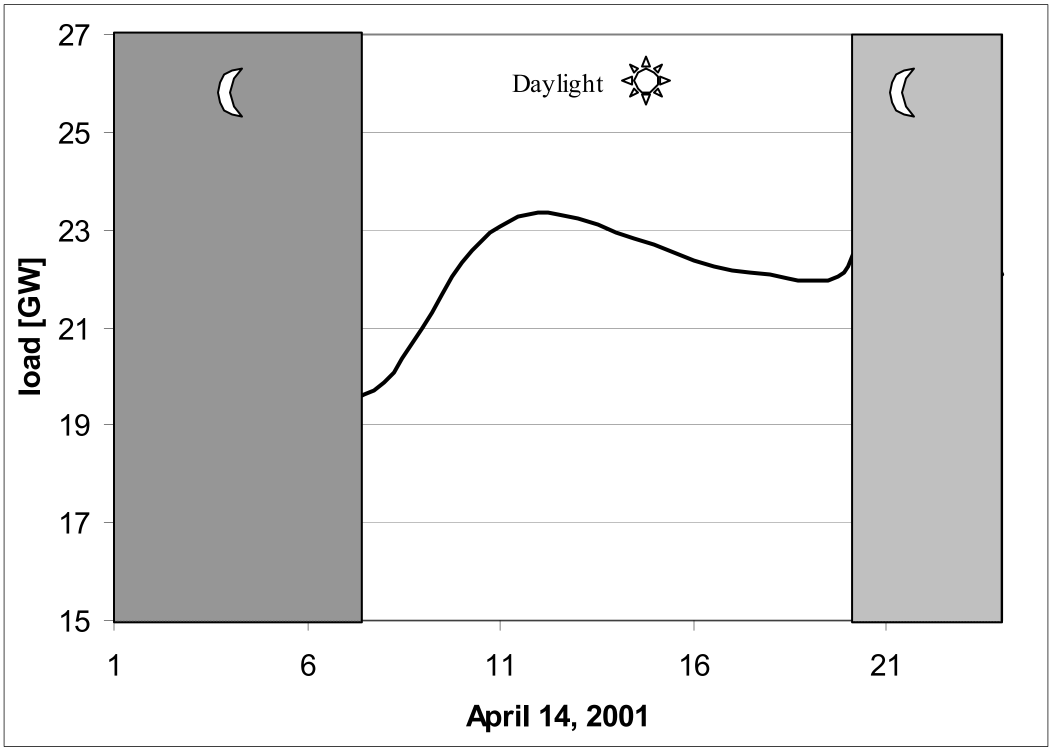

Figure 2. Daylighting effect as observed April 14, 2001

To account for the factors just described, a computer program sorted actual yearly load and temperature data into bins based on the following:

1. Hour of the day
2. Day type (weekday, weekend, holiday)
3. Presence of natural light

Separating the data resulted in load-versus-temperature profiles for each hour of each type of day (weekday, weekend, or holiday) and the presence or absence of natural light. An example of the profiles created by sorting actual load and temperature data into these bins is shown in Figure 3.

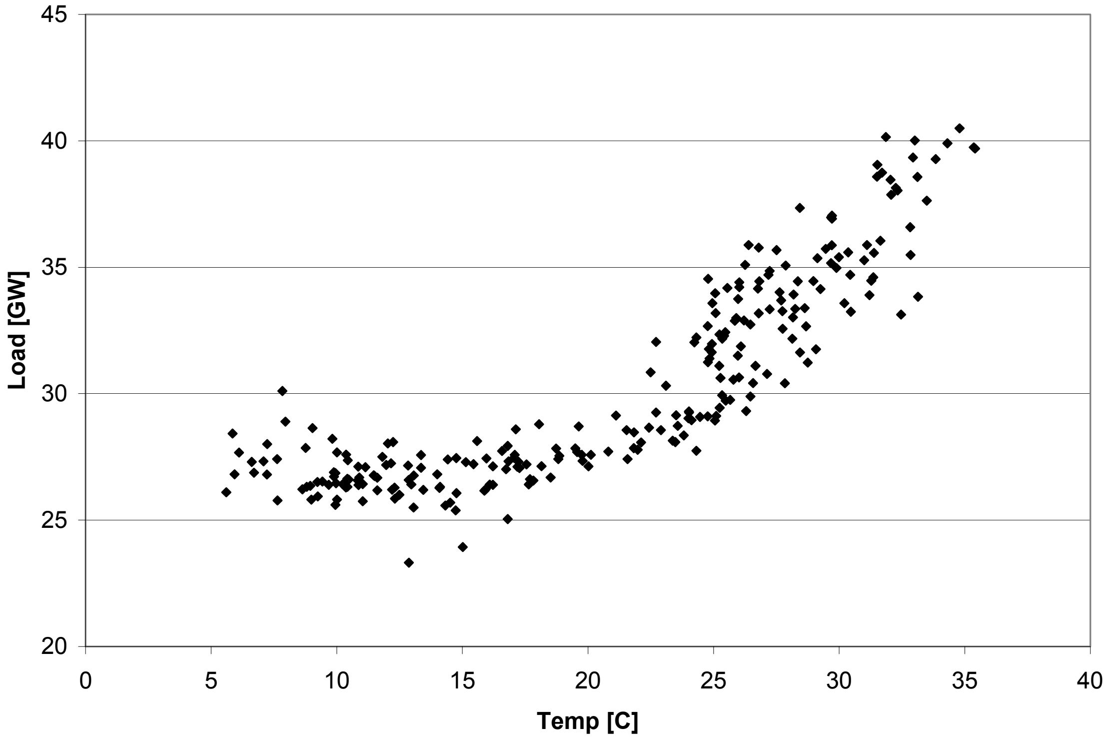

Figure 3. Load (recorded on Weekdays, Hour 16, Year 2001 with natural light present) vs. Temperature

The relationship between temperature and load within each of the bins – day type, daylighting, and hour of the day – was assumed to be a function. In other words, the load value is assumed to be directly dependent on temperature, for each combination of day type, daylighting and hour of the day.

As can be seen in Figure 3, the load profile for each parameter group is not a smooth function. It contains noise and variation that result from many different causes that are beyond the scope of this study. To eliminate the small, hourly variations in data points that can cloud the picture of overall trends, the load-versus-temperature functions were smoothed using a mathematical process that is described in detail in Appendix A.

Figure 4 shows the result of smoothing the load and temperature data set pictured in Figure 3.

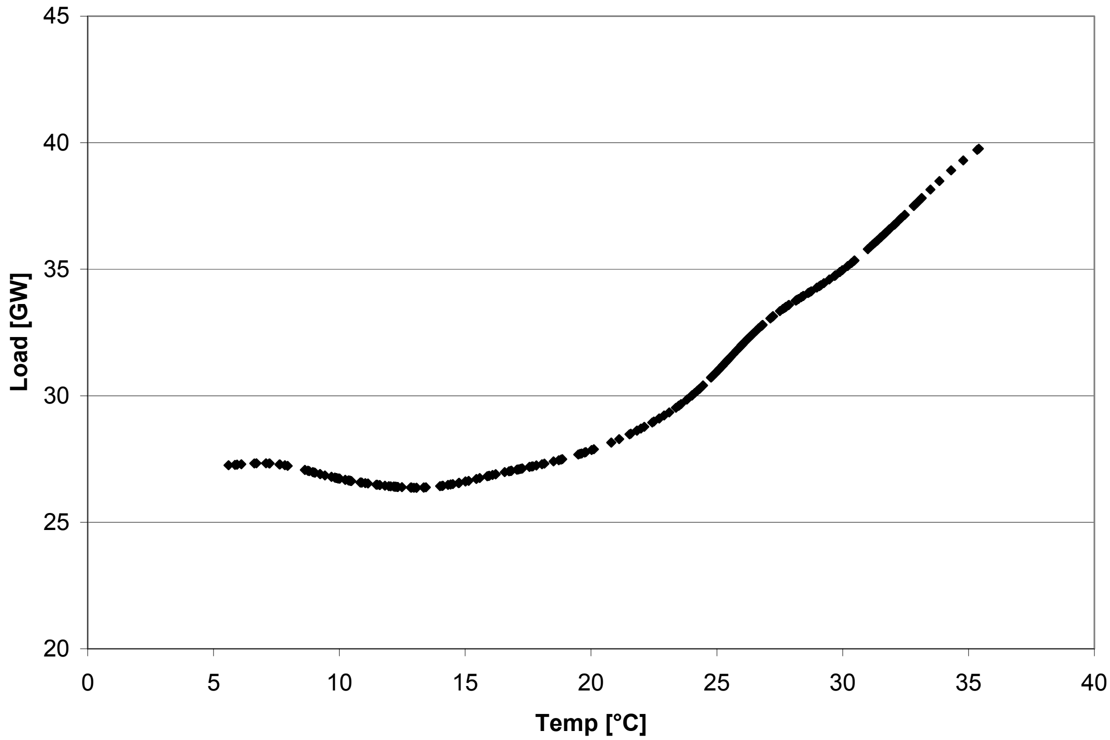

Figure 4. Smoothed Load (recorded at Hour 16, Year 2001) vs. Temperature

Once each function was smoothed, the year 2000 load was adjusted for year 2001 temperatures. This adjustment calculation is described in detail in Appendix A. The difference between the loads from the two years was then calculated. Figure 5 shows actual and adjusted hourly load data for August 11, 2000 compared to actual load data for August 11, 2001, and temperature data for both years. Notice that the 2000 temperature is higher overall than the 2001 temperature. The actual 2000 load was appropriately scaled down, because lower temperatures typically induce lower load. However the adjusted 2000 load is still higher than the 2001 actual load. Because the effects of weather have been effectively isolated, this indicates that factors other than weather were the cause of the difference. Similar data sets were generated for each day and hour of all years being compared, i.e., 1999-1998, 2000-1999, 2001-2000, and 2001-1999. The result was a complete, weather-adjusted, hourly set of loads for each paired set of years. The *Results* section below describes how these graphs were used to determine non-weather related changes in load during the year 2001.

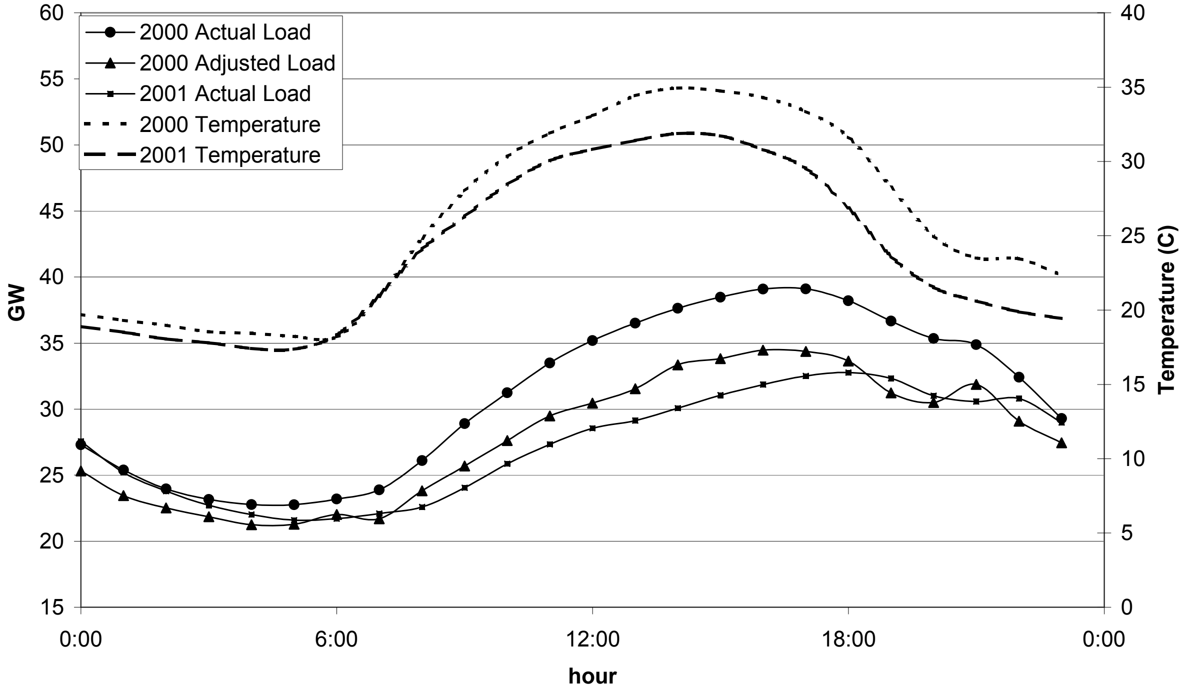

Figure 5. Temperature and Actual and Weather-Adjusted Hourly Load for August 11, 2001 and 2000

Results

The results of the load comparisons were used to estimate the actual weather-independent load savings during 2001 and also to examine the patterns of load growth from 1998 to 2001 to determine whether this pattern changed during the energy crisis.

Actual Load Reduction

The analysis indicates that there was a significant reduction in load during 2001 that bucks the increasing load trend seen from 1998 to 2000, and cannot be explained by weather. The result of the weather-adjusted year-to-year comparisons between all compared years can be seen in Figure 6 through Figure 9. Note that the 1998 to 1999 comparison begins on April 1 due to data availability. These graphs show a running 24-hour average[v] of the difference between the actual load from the more recent year (e.g. 2001) and the adjusted load from the earlier year (e.g. 2000). The numbers represent the change from the earlier year to the more recent year; all positive values indicate an increase in energy consumption from one year to the next, and vice versa.

The load difference between 24-hour running average is highly volatile. This suggests that estimates for any one hour are probably not very accurate because behavior is unlikely to have varied this erratically. Nonetheless, these estimates do provide a basis for estimating overall average load increases or decreases. To obtain a visual indication of this average, each graph also includes a least-squares fit of the data. When this trend line is positive, on average electrical load increased between the earlier year and the more recent year.

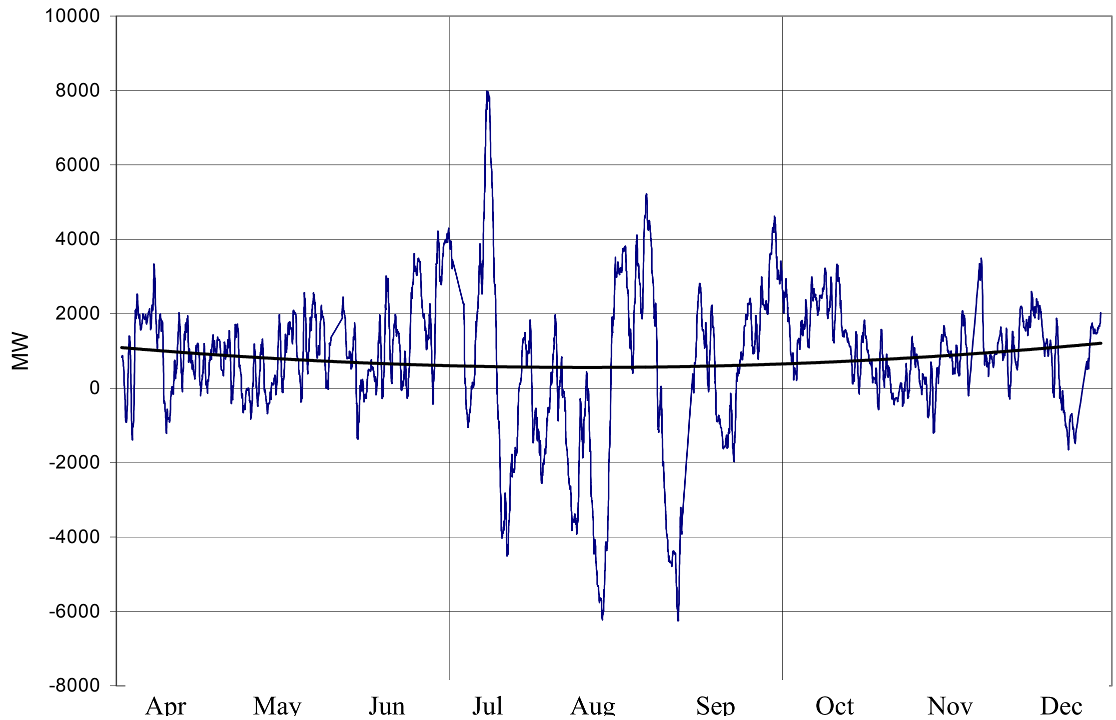

Figure 6. Weather-Adjusted Difference in Load between 1999 and 1998, shown as a running 24-hour average.

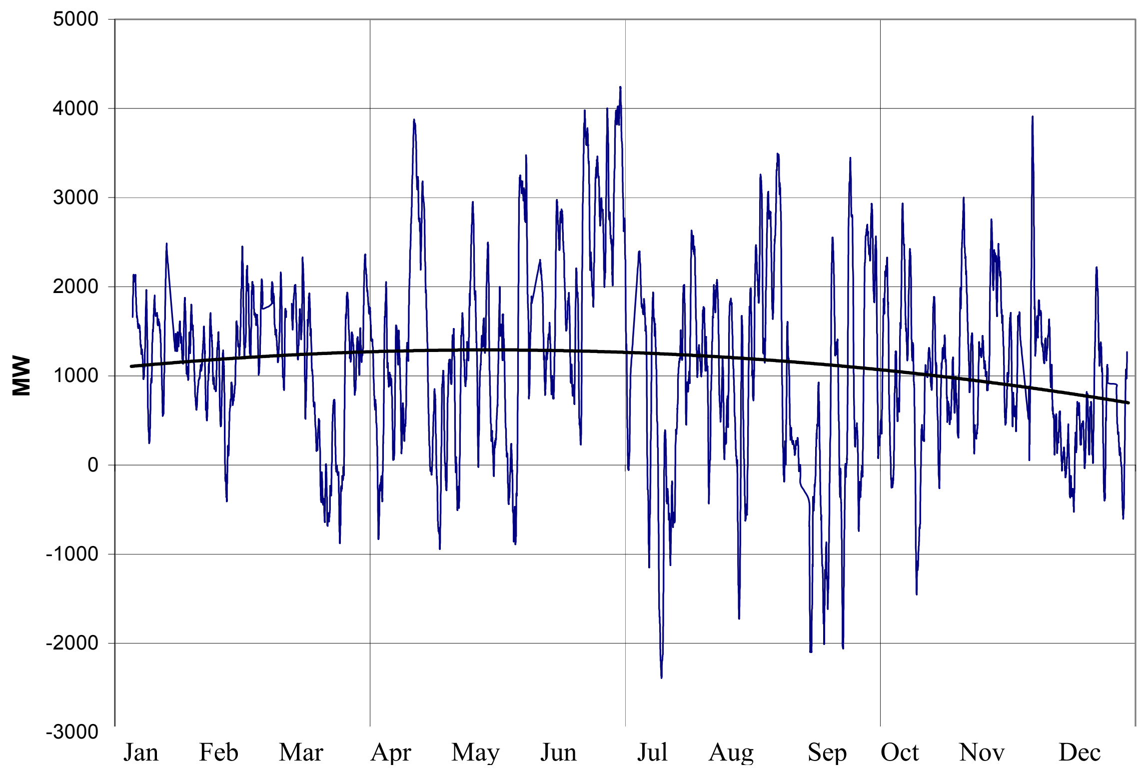

Figure 7. Weather-Adjusted Difference in Load between 2000 and 1999, shown as a running 24-hour average

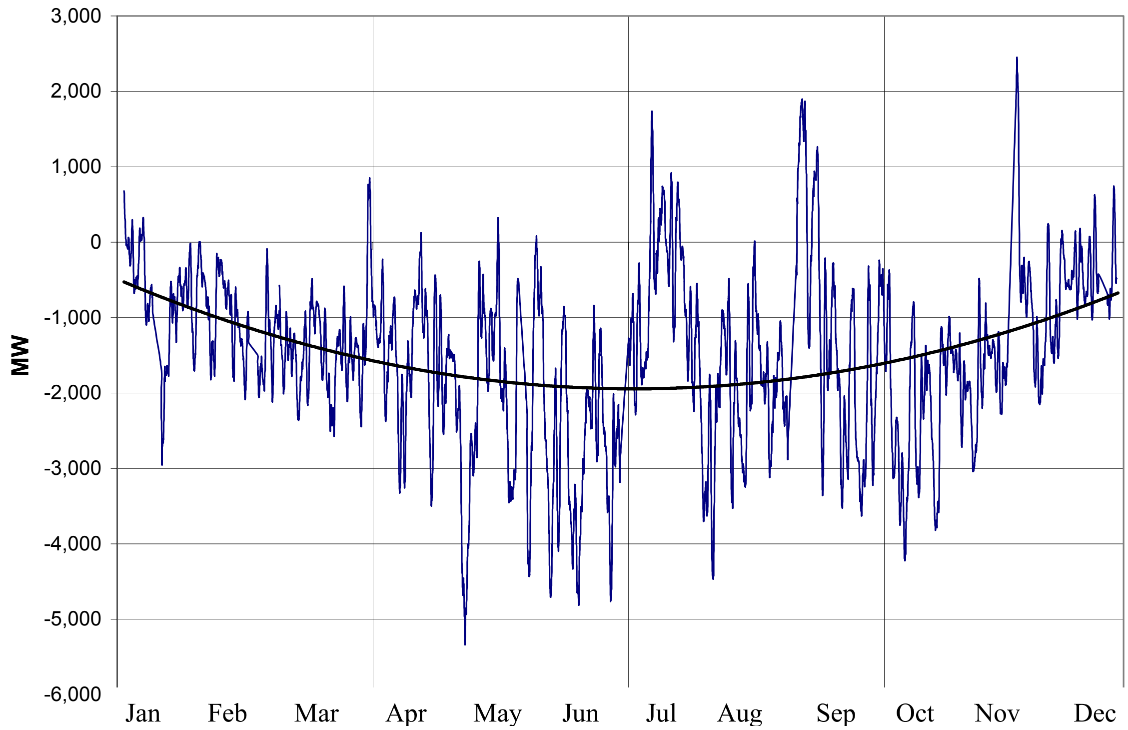

Figure 8. Weather-Adjusted Difference in Load between 2001 and 2000, shown as a running 24-hour average

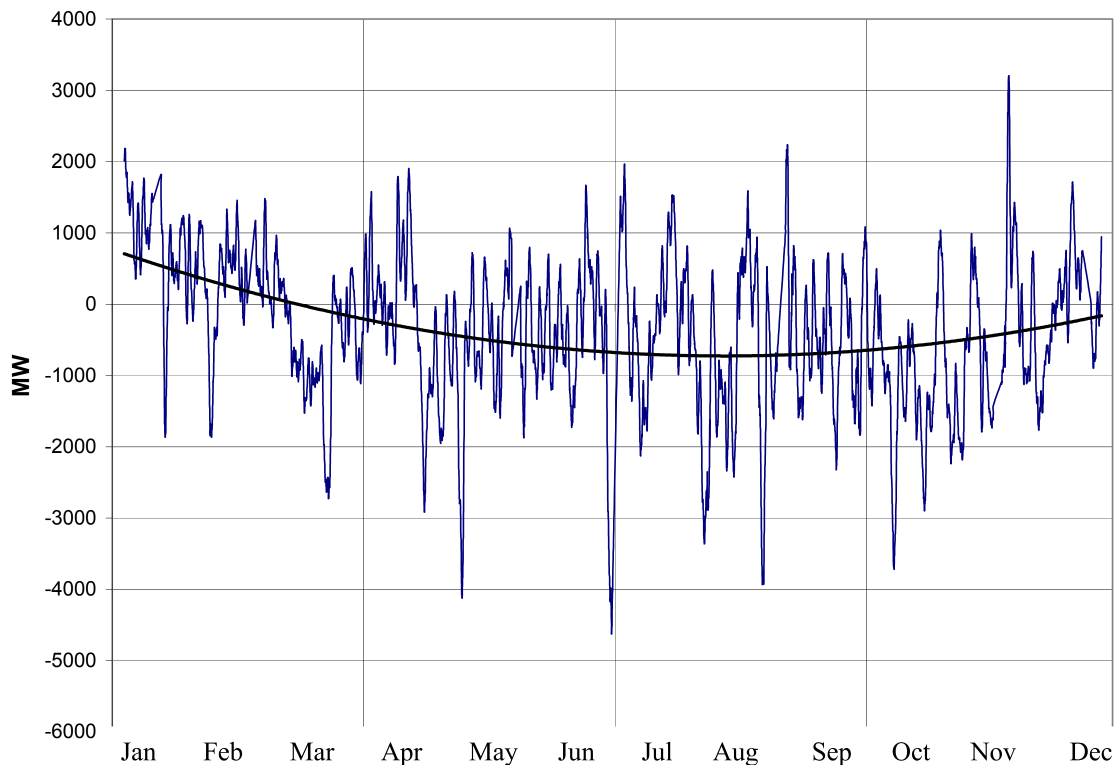

Figure 9. Weather-Adjusted Difference in Load between 2001 and 1999, shown as a running 24-hour average

It should be noted that in these graphs, holidays and the days before and after holidays are not shown. The characteristics of holidays and the immediately preceding and subsequent days are difficult to generalize because people may take vacation on these days as well, or display other behavioral changes, depending on the day of the week on which the holiday itself falls; when more people than average take vacation, electrical load is noticeably lower.

As seen in Figure 6 and Figure 7, in general, electricity consumption from 1998 to 2000 was increasing. The actual total load differences and percent increases, displayed below in Table 1, show that the actual weather-adjusted load growth between 1998 and 1999, and 1999 and 2000, were 2.70 percent and 4.61 percent, respectively.

Table 1. Load Comparison Results (Total Hours)

	Non-Weather-Adjusted		**Weather-Adjusted**	
	Load Difference	**Percent Difference**	**Load Difference**	**Percent Difference**
Year Total				
1999 – 1998[vi]	5,919 GWh	3.50%	4,601 GWh	2.70%
2000 – 1999	11,276 GWh	4.96%	10,519 GWh	4.61%
2001 – 2000	-11,088 GWh	-4.64%	-12,640 GWh	-5.26%
2001 – 1999	188 GWh	0.08%	-2,816 GWh	-1.22%
Summer				
1999 – 1998	160 GWh	.19%	1,303 GWh	1.61%
2000 – 1999	4,929 GWh	5.98%	3,718 GWh	4.45%
2001 – 2000	-5,291 GWh	-6.06%	-4,632 GWh	-5.35%
2001 – 1999	-362 GWh	-0.44%	-1,167 GWh	-1.40%

This pattern of load growth changed in 2001. As can be seen in Figure 8, the weather-adjusted difference between 2001 load and 2000 load was negative on the whole. The total decrease in load for the entire year was roughly 12,640 GWh, and the total decrease in load for the summer (June through September) 2001 was roughly 4,600 GWh. This translates to a 5.26 percent decrease over the year, and a 5.35 percent decrease for the summer.

Figure 9 indicates that the 2001 load was also slightly lower than 1999 load, even though the magnitude of the difference is smaller than the difference between 2000 and 2001 load. The reduction in electrical load from 1999 to 2001 was 1.4 percent for the summer months and 1.22 percent for the entire year, which represents an actual savings of almost 1,200 GWh for the summer and approximately 2,800 GWh for the entire year. This reduction is smaller than the reduction between 2000 and 2001 because load increased between 1999 and 2000, so the decrease in 2001 is in comparison to this increase.

The load growth profile from 1999 to 2001 will be examined in greater detail later in this section.

In an attempt to further characterize the load reduction observed above, these data were broken down into daily time periods, and relationships between the "peak" and "off-peak" hours are examined further. Table 2 shows summary data for all hours between noon and 6 p.m. on all days of the year and for summer days only. The load reduction observed between year 2000 and 2001 during these daily peak hours was larger than the load reduction during all hours of the year. During summer months, the load during these peak hours was reduced 8.15 percent, a savings of nearly 2,500 GWh. Load during these peak hours for the whole year went down by more than 7 percent, a total savings of slightly more than 5,700 GWh.

Table 2 . Peak hours (12:00 to 18:00) load comparison

	Non-Weather-Adjusted		**Weather-Adjusted**	
	Load Difference	**Percent Difference**	**Load Difference**	**Percent Difference**
Year				
1999 – 1998	2,344 GWh	4.16%	-339 GWh	-0.58%
2000 – 1999	4,109 GWh	5.49%	3,718 GWh	4.94%
2001 – 2000	-4,652 GWh	-5.91%	-5,710 GWh	-7.15%
2001 – 1999	-744 GWh	-0.99%	-2,125 GWh	-2.79%
Summer				
1999 – 1998	-59 GWh	-0.21%	-522 GWh	-1.81%
2000 – 1999	2,012 GWh	7.12%	1,444 GWh	5.01%
2001 – 2000	-2,674 GWh	-8.84%	-2,448 GWh	-8.15%
2001 – 1999	-662 GWh	-2.34%	-1,059 GWh	-3.70%

Load reduction during peak hours from 1999 to 2001 was also larger than load reduction during all other hours during the year. During summer, there was a 3.7 percent decrease in peak load (1,000 GWh in savings) while the total load for the year during peak hours decreased by 2.79 percent (a little more than 2,000 GWh in savings).

Examining the top three peak hours of each day reveals that on average, approximately 20 percent of load reduction occurred during the top three hours of each day. For this analysis the top three peak hours refer to the three hours of each day when the actual loads were the highest for that particular day. Figure 10 shows the daily energy difference between year 2001 and year 2000 total daily load and load of the top three peak hours.

The average daily energy savings for all days in 2001 and 2000 were a little more than 36 GWh. The daily average peak-hour energy savings for the same time period were a little more than 7 GWh. On average, almost 20 percent of the energy savings in 2001 occurred during the three peak hours of each day. The fact that almost 20 percent of the non-weather related electricity reduction occurred during 12.5 percent of the hours during the day is significant, and could indicate that consumers were consciously conserving more during peak hours and shifting some of the energy use to off-peak hours.

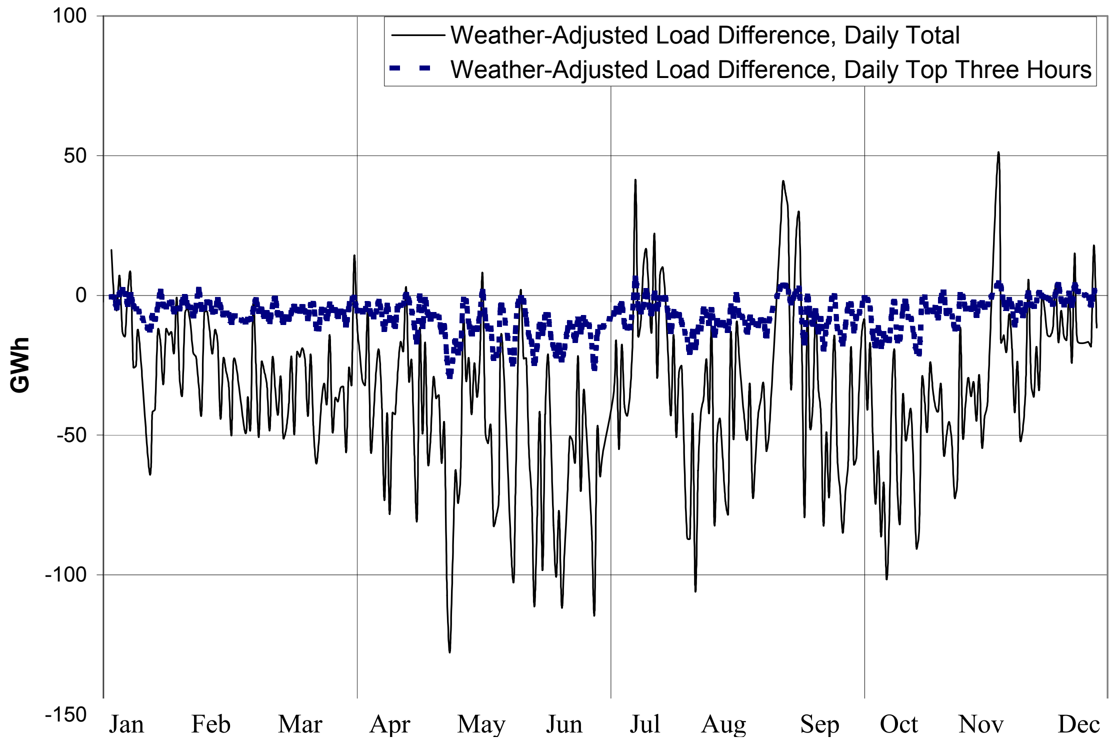

Figure 10 . Weather-Adjusted Difference in Total Daily Energy and Top Three Peak Hours between years 2000 and 2001

The energy savings calculated in this study were compared to the values published by the California Energy Commission (CEC)[vii], and are included below in Table 3. The year 2000 to 2001 load-reduction calculated in this study agree well with those published by the CEC, differing by roughly 300 GWh, or 0.16 percent. The summer 2000 to 2001 load-reduction calculated by this study, however, is not as similar. This difference of nearly 700 GWh, or 0.7 percent, can mostly likely be attributed to the difference between weather adjustment calculations were made in this study and the CEC study. When looking at the entire year, the differences in values that arise due to different calculation methods are averaged together and the final answer is closer.

Table 3 . Energy Comparison between 2001 and 2000

	Non-Weather-Adjusted		Weather-Adjusted	
	Load Difference	Percent Difference	Load Difference	Percent Difference
Year 2001 - 2000				
This study	-11,088 GWh	-4.64%	-12,640 GWh	-5.26%
CEC[viii]	-10,462 GWh	-4.33%	-12,351 GWh	-5.10%
Summer 2001 - 2000				
This study	-5,291 GWh	-6.06%	-4,632 GWh	-5.35%
CEC	-5,263 GWh	-6.02%	-5,315 GWh	-6.05%

In a forthcoming report[ix], the CEC, working jointly with Washington State University (WSU), performs similar year-to-year comparisons of load in the ISO region, adjusting for weather and economic growth. In this study two sets of peak load data are analyzed. One is the publicly available ISO load data, which is the same as the load data used in this study and in previous CEC reports. The other set of data is settlement-quality load data, based on actual metered energy usage, and were obtained directly from the ISO. The results from both sets of data indicate peak load reduction between 10 and 12 percent for year 2001 summer months. This value is greater than the value presented in the current paper, which is around 8 percent. This discrepancy is most likely due to the fact that the study described in this report looks at all peak hours, that is all hours between noon and 6 P.M., and the CEC study examines the actual highest load for the month.

Growth Rate Patterns

The load profile between the years 1999 and 2001 was examined in the above analysis to get an understanding of increasing or decreasing load between years, and to determine actual energy savings. Examining the load growth rate from 1999 to 2001 reveals many more interesting patterns.

The smoothed, adjusted plot indicates that the first sign of load reduction occurred during the second quarter of 2000, which coincided with a major decline in the stock market and unprecedented high prices in the energy market. A significant conservation effort started during the last quarter of 2000 and lasted through the second quarter of 2001. During this time, the load growth rate decreased by about 11 percentage points.

Beginning just prior to the third quarter of 2001, the load growth rate appears to be rebounding, which could suggest that conservation behavior was diminishing. However, because conservation measures were already under way during the second half of 2000, it is not surprising that 2001 load levels might be similar to levels from the second half of 2000, and the data might seem to show a false rebound in late 2001. To get a more accurate picture of the growth rate during the last half of 2001, we compared the rate of apparent change in load between the years 2000 and 2001. The resulting rate, which is shown in the plot as the "Cumulative Difference in rate", is approximately zero for the second quarter of 2001, and actually decreases by a few percentage points during the second half of 2001. This suggests that consumers were not only maintaining conservation practices after the height of the energy crisis but that they were taking further measures to conserve. The deceleration in the rate of load reduction was perhaps because all the easy and cheap (or free) conservation measures had been employed, and methods for increasing conservation further were more complicated or expensive, such as installing sophisticated temperature control systems or buying energy-efficient appliances.

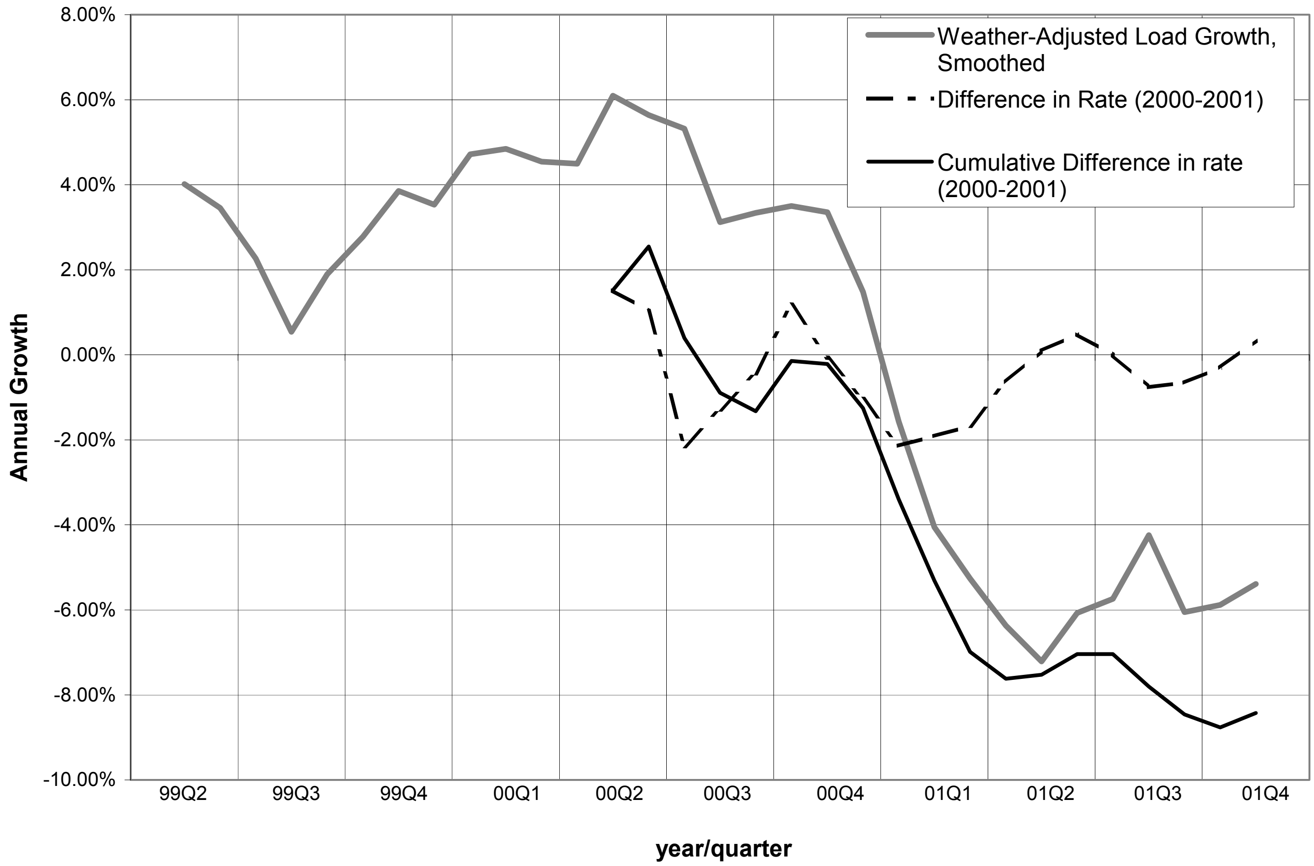

Figure 11 . Analysis of Load Growth from 1999 to 2001

The forthcoming CEC report mentioned above analyzes load reduction in the first part of 2002. The peak load reduction in 2002, when calculated using publicly available data, appears to rebound almost to zero percent in January, and then fluctuate between 1 and 6 percent until July 2002. However, results using the more reliable settlement-quality data indicate that the load reduction during the first part of the year 2002 fluctuated between 4 and 8 percent. Both sets of data suggest the conservation behavior that resulted in load reduction during the summer of 2001 is continuing at least to some extent in the year 2002.[x]

Conclusion

This study finds the weather-adjusted energy savings within the CAISO service area during both the year and summer of 2001 in comparison to the previous two years and summers. Compared to 2000 summer loads, the 2001 CAISO summer electrical load decreased by 5.35 percent overall, and by 8.15 percent during peak hours. One possible explanation for this load reduction is consumer conservation activities, which can entail a combination of behavioral changes, such as lowering air-conditioner temperatures and turning off lights, as well as some effects from the purchase of efficient appliances. The difference between on- and off-peak reductions could be a result of load-shifting behavior or changes in industrial schedules.

The load growth rate pattern seems to suggest that this conservation trend is continuing though it may be slowing. The growth rate in the later half of 2001 did not decrease as dramatically as it did between the summer 2000 and spring 2001; however, it did not rebound to pre-crisis levels. The slowing pace of load reduction could be attributed to a number of factors. One reason may be that customers have already taken advantage of the relatively easy and inexpensive ways to conserve energy. In order to save additional energy, customers would have to make more expensive or inconvenient changes, such as discarding current appliances and replacing them with energy-efficient ones. Another possible reason for the slowing of load reduction is that people perceive the energy crisis to be finished and are therefore less vigilant about conservation behavior as they were at the height of the crisis. In this case, energy-efficiency changes that consumers made during the crisis, such as replacing older appliances with energy-efficient ones, would continue to save energy, but conservation behavior, such as turning up air-conditioner temperatures, could subside. Whether the conservation behavior and the other factors that lead to load reduction in 2001 will persist is a complicated topic, one that will be addressed in a forthcoming report by the CEC.[xi]

At this point in time it is difficult to predict the future of electrical load growth in California. It is possible that consumers have changed their habits permanently and conservation will continue with no additional effort from the state or utilities. It also is possible that in order to keep conservation a priority for consumers, conservation incentives, such as the 20/20 program, and the publicity campaign staged by the state during the energy crisis, should continue in some form. What is clear is that the load in California was reduced by a significant amount during the summer of 2001, and it is likely that state efforts to encourage energy conservation and consumer choices to conserve during the crisis helped to lower electricity demand.

Appendix A

A major part of this study of energy conservation during the year 2001 energy crisis in California entailed developing a way to account for the effect of weather differences on electrical load in different years. As described in the body of the accompanying paper, weather-independent load comparisons were generated by adjusting year 2000 electrical loads to determine what they would have been under year 2001 weather conditions and accounting for the impacts of other variables that affect load: day type (weekday, weekend, holiday), hour of the day, and presence of absence of natural daylight. This appendix describes the mathematical treatment or smoothing of the load, temperature, day type, day hour, and daylight data.

The data were collected as described in the body of the accompanying paper and used to created load-versus-temperature profiles for each hour of each type of day (weekday, weekend, or holiday) and whether natural light is present or not. An example of the profiles created by sorting actual load and temperature data into these bins is shown in Figure A-1.

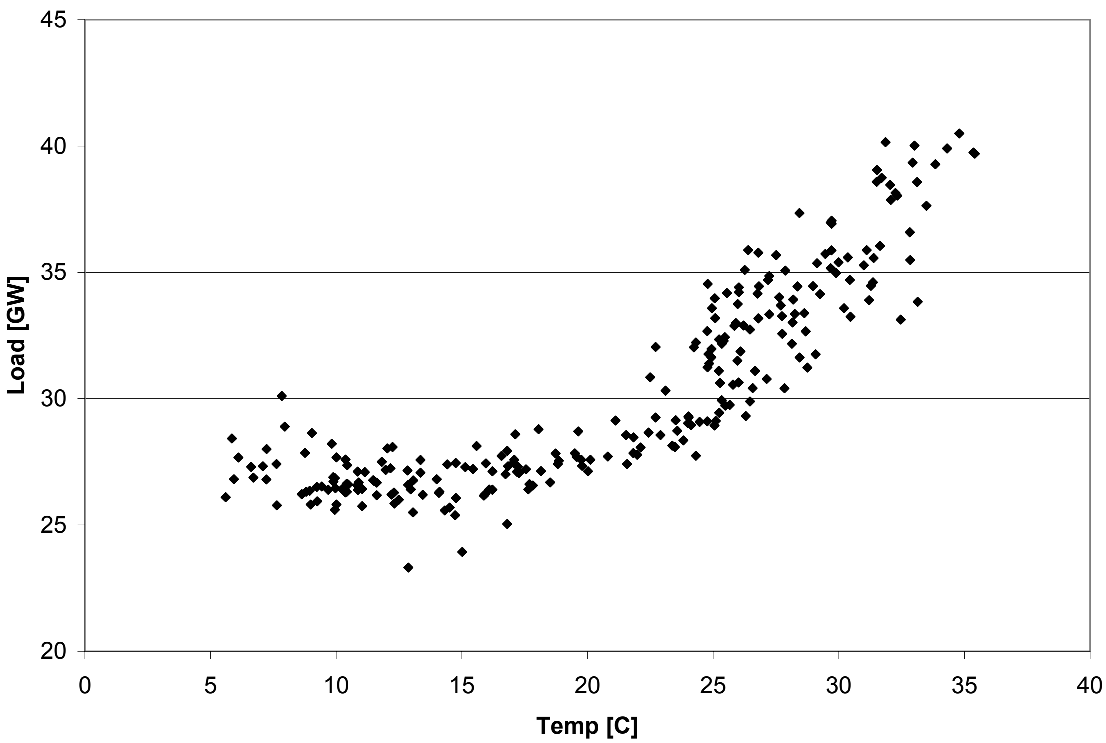

Figure A-1: Load (recorded on Weekdays, Hour 16, Year 2001 with natural light present) vs. Temperature

As can be seen in Figure A-1, the resulting load profile for each parameter group is not a smooth function. It contains noise and variation that result from numerous influences that are beyond the scope of the current study. To effectively use the data represented in Figure A-1 to determine the weather-adjusted load, we smoothed the load-versus-temperature graph for each parameter bin (day type, hour of the day, and daylight condition) to eliminate the small, hourly variations in data points that can cloud the picture of overall trends.

Typical smoothing techniques include use of least-squares fitting or functional smoothing algorithms. The approach used in this study was a version of a Savitzky-Golay smoothing filter.[xii] Savitzky-Golay smoothing executes a moving least-squares fit of a subset of N points. The lowest-order implementation fits the N points locally to a line. A simplified Savitsky-Golay smoothing with linear local fitting using the classic heat equation, which has a linear local equilibrium solution, is applied to smooth the points locally.[xiii]

Figure A-2 illustrates the smoothed graph that was obtained by applying the Savitsky-Golay smoothing filter to the actual load-versus-temperature data for weekdays on hour 16, (the same day type and hour shown above in Figure A-1). The same smoothing method was applied to each set of parameter permutations.

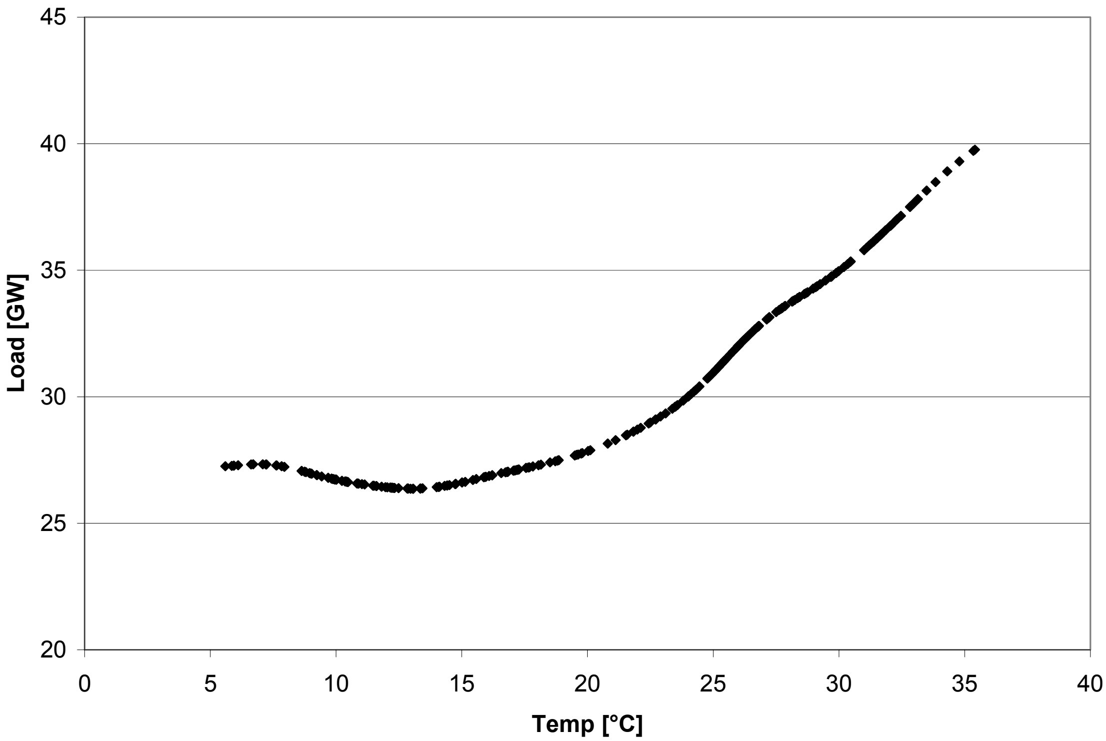

Figure A-2: Smoothed Load (recorded at Hour 16, Year 2001) vs. Temperature

The actual equation used to arrive at the adjusted load for the comparison year is a bit more complex than simply plugging a temperature into a load function. In order to isolate the effects of temperature further, we adjusted the smoothed load from the comparison year by the temperature-induced difference between the two years. The temperature-induced difference is the difference between the load function at the temperature for a comparison year and the load function at the temperature for the original year; for example, a temperature-induced difference would be the difference between the smoothed year 2000 load at year 2000 temperatures minus the smoothed year 2000 load at year 2001 temperatures. The following equation characterizes the calculation of the temperature-induced difference; SmoothL is the smoothed load function at a temperature for a given year, T_{year}:

$$\Delta_{\text{Temperature-Induced}} = \mathbf{SmoothL_{2000}(T_{2001}) - SmoothL_{2000}(T_{2000})}$$

To calculate the weather adjustment, the actual load from the year being adjusted is modified by the difference between the smoothed year 2000 load at year 2001 temperature, and the smoothed year 2000 load at year 2000 temperature.

$$\mathbf{L_{adjusted}(T_{2001}) = L_{actual}(T_{2000}) + [SmoothL_{2000}(T_{2001}) - SmoothL_{2000}(T_{2000})]}$$

The actual weather-adjusted load comparison was then calculated by subtracting this year 2000 adjusted load from the year 2001 actual load.

$$\mathbf{\Delta_{LOAD} = L_{actual2001}(T_{2001}) - L_{adjusted2000}(T_{2001})}$$

The following example illustrates this method for calculating the adjusted load for one hour of one set of comparison years. This method was repeated for each hour of the year.

Consider one data point from 2000: August 16th, hour 11. The electrical load for this data point is 37,927 MW, and the parameters for this data point are:

1. hour: 11
2. day type: weekday
3. daylight: daylight
4. temperature: 32.31°C (90.15 °F)

This data point is adjusted by adding the difference in smoothed 2000 load at the 2001 and 2000 temperatures, which are 32.69°C (90.85 °F) and 32.31°C (90.15 °F), respectively. Evaluating the appropriate smoothed load function at those temperatures, we obtain the following loads: 38,407 MW for the 2001 temperature and 37,865 MW for the 2000 temperature. The load adjustment equation then becomes:

$$\begin{aligned} L_{adjusted}(32.31°C) &= 37{,}927 \text{ MW} + [38{,}407 \text{ MW} - 37{,}865 \text{ MW}] \\ &= 38{,}469 \text{ MW} \end{aligned}$$

The actual year 2000 load of 37,927 MW would have been 38,469 MW in the year 2001 if the temperature and energy use patterns had been the same in both years.

This calculation was performed for each hour of each set of years being compared, to produce a substantial profile of load comparisons.

[i] CEC. 2002. "The Summer 2001 Conservation Report." Sacramento, CA: California State and Consumer Services Agency. www.energy.ca.gov/efficiency/2001_CONSERVATION_REPORT.PDF (as of 9/16/2002).
[ii] Goldman, Charles, Joseph Eto and Galen Barbose. 2002. "California Customer Load Reductions during the Electricity Crisis: Did They Help to Keep the Lights On?" Berkeley, CA: Lawrence Berkeley National Laboratory Report. LBNL-49733
[iii] Holidays include New Year's Day, MLK Jr. Day, Presidents' Day, Memorial Day, Fourth of July, Labor Day, Thanksgiving, and Christmas Day.
[iv] National Observatory. 1990. "Almanac for Computers." Washington, D.C.; Nautical Almanac Office, United States Naval Observatory.
[v] The running 24-hour average is calculated by taking the average of 24 hours and assigning the resulting value to the 12th hour of the running time range. For example, the 24-hour running average for hour 5 of a given day would be the average of values from hour 17 the previous day to hour 16 of the current day.
[vi] These load data are for the months April through December, due to data availability.
[vii] The CEC numbers are consistent with what is published on the CEC website as of 9/16/2002 (http://www.energy.ca.gov/electricity/peak_demand/DEMAND_REDUCTION.XLS)
[viii] The CEC numbers are consistent with what is published on the CEC website as of 9/16/2002 (http://www.energy.ca.gov/electricity/peak_demand/DEMAND_REDUCTION.XLS)
[ix] The final report has not been released as of 10/04/2002. A preliminary summary of the report has been released as part of a discussion of conservation behavior persistence.
[x] California Energy Commission, Response to Scoping Question in California Power Authority's July 25, 2002 Rulemaking on the Establishment of Target Reserve Levels for the Investment Plan, Docket Number: 2002-07-01
[xi] California Energy Commission, note 11.
[xii] Press, William H., Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery. 1996. "Numerical Recipes in Fortran 77: The Art of Scientific Computing." New York, NY: Cambridge University Press.
[xiii] We implement the Savitsky-Golay smoothing filter by evolving the load (L) as a function of temperature (T) for a fixed period in a generic time (t) according the following equation:

$$\frac{dL}{dt} = \frac{d^2 L}{dT^2}$$

Note that the equilibrium solution of this equation is where the second derivative on the right-hand side is zero, which implies that the L(T) is locally linear. As we increase the psuedo-time variable, the temperature range of the smoothing increases, so there is more smoothing.