ANALYSIS OF THE EFFECT OF DEMANDS CREATED BY COMMERCIAL FOOD SERVICE APPLIANCES ON ELECTRICITY BILLS: A CASE STUDY

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Demands created by electrical loads can have a significant effect on a commercial customer's electricity bill. The method for determining these effects involves simulating the actions of electric billing meters.

BACKGROUND

Electricity bills for commercial customers are often based on the maximum electrical demand created, as well as the total energy consumed during a billing period. Some utilities now have mandatory or optional rates, which require that bills be calculated using time-of-use consumption and demand. Therefore, any study of the effects of demand on billing must be general enough to simulate these billing situations.

The purpose of this study was to determine the effect on billing of demands created by major electric cooking appliances in PG&E's Production Test Kitchen, a cafeteria-style operation in San Ramon, California, serving an average of 300 customers per day. This facility was used to prepare three meals per day on Monday through Thursday, so only these days were in the data set. This facility is one building in a large complex and was not metered separately. The demand effect of the appliances on billing was determined as if it were a stand-alone restaurant. The appliances monitored for 1 year included a 7.1-kW fryer, an 11.7-kW griddle, a 9.0-kW convection oven, an 18.4-kW combination oven/steamer, and an 11.2-kW tilting skillet, for a total connected load of 57 kW.

METHOD

Building electrical loads continuously create demands as they consume energy. Electric billing meters "sample" these demands at regular set time intervals, which can range from 1 to 60 minutes. The meter samples a demand to compare it with previously recorded demand(s) and records the new one if it is larger. It samples demands by averaging the energy consumption of all building loads over a period of time called the demand interval. Utilities commonly use 15-, 30- and 60-minute demand intervals. Demand intervals should be distinguished from the set time intervals mentioned above, since the two can be different lengths of time.

To show the greatest effect of the appliance load, demands were calculated at a set time interval of 1 minute, using a 15-minute demand interval. They were calculated from appliance energy consumption data recorded every minute of the day by a data acquisition system. This system accumulated pulses from standard electric meters equipped with pulse outputs. These pulses were converted into energy input rates which can be plotted as a "LOAD" curve such as the one shown in Figure 1. Also shown are points plotted on the "DEMAND" curve that correspond to demands created by the changing load. These points are plotted for every minute against clock time. This mimics meter sampling demands at a set time interval of 1 minute. The demand values shown result from averaging the load's energy consumption over a 15-minute demand interval. Each point is a plot of the average energy used during that minute plus the previous 14 minutes. Each point on the "DEMAND" curve, therefore, corresponds to the end of a 15-minute demand interval.

In practice, the meter may only sample every third, fifth, or fifteenth point on the "DEMAND" curve, possibly missing the highest point shown. The points it does sample depends on when the meter begins to operate, how often it samples demands (e.g. every 1, 3, 5 or 15 minutes) and, for some meters, how long

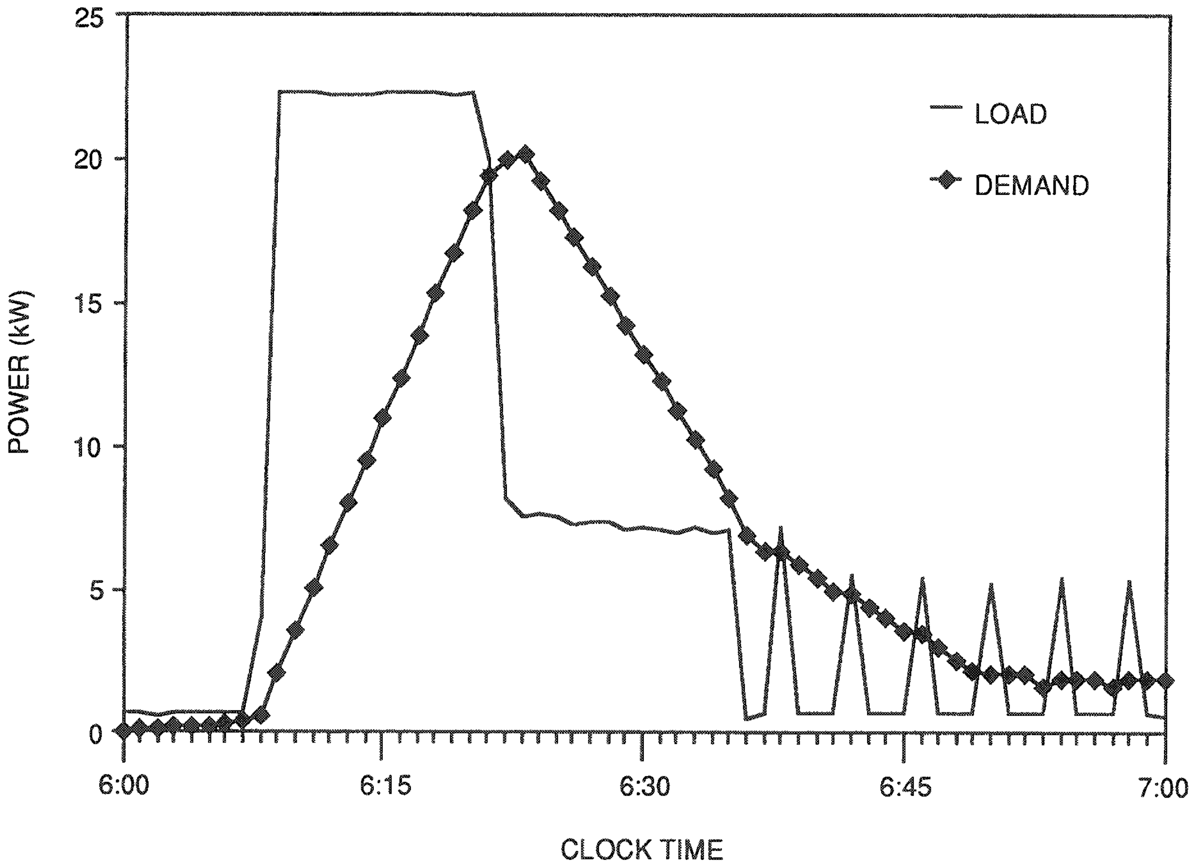

Figure 1. Appliance Load and All Possible One Minute Demands

it takes the meter to reset at the end of each demand interval. This last factor can shift the demand interval relative to clock time, causing it to end at different clock times on successive days.

These factors make it difficult to calculate the effect of appliance load on billing demand since the time when the billing demand interval occurs cannot be easily determined. Therefore, an alternative method was used in this study. First, all demands a meter could possibly sample on a 1-minute basis were calculated for the hours between 4 a.m. and 8 p.m., as discussed above. These calculated demand values were then sorted into integral power (kW) value bins for each hour of the day. From this, the probability of integral power (kW) values of demand occurring during each hour was calculated. The highest occurring and the most frequently occurring demands were found from this analysis. The isolated effect of these demands were then found by calculating electricity bills using applicable PG&E rates.

The highest occurring demand was used, because bills calculated with it showed the maximum effect of the appliance load. Only one occurrence of this demand during the billing period is sufficient to affect billing. The most likely effect was found using the most frequently occurring demand. With a connected load of 57 kW, the electric appliances in this case study were likely to increase the maximum demand for the month by 7 kW and the demand during PG&E's peak period (noon to 6 p.m.) by 2 kW. This increased annual electricity cost between $300 and $400. Where the highest occurring demands were used, the maximum monthly demand increased by 23 kW, and the maximum peak period demand increased by 17 kW. This caused an increase in electricity cost between $900 and $1,900 (using non-time-of-use and time-of-use rates, respectively). With PG&E rates, cost increases would have been larger if the effect of the appliance load on the maximum monthly demand occurred during the peak period.

CONCLUSION

This method could be used to find the effect of all building loads, as well as those of a single load on billing. It also provides a means of finding the effect of a range of demand values since the probabilities of individual demand values can be added together. This may be more useful since single values of demand may only have a small chance of occurring whereas a narrow range of demands may have a relatively large chance of occurring.

Since meters calculate demands by averaging building loads' energy consumption, minimizing demand effects depends on reducing their consumption. This has a dual benefit, since saving energy saves money related to energy charges, as well as demand charges. Also, electricity rates during high demand periods are often above the average cost of energy, in ¢/kWh, for the billing period; so reducing demand usually saves premium-priced electricity. As long as a load consumes electricity during the billing demand interval, the cost-effectiveness of reducing its energy consumption should reflect this benefit.