

PREDICTING HOURLY RESIDENTIAL AIR CONDITIONING LOAD

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INTRODUCTION

End-use modelling has recently become more popular relative to other electricity demand forecasting techniques such as the aggregate econometric and trending, because the end-use approach better represents the manner electricity is consumed. One of the major residential end-uses is the central air conditioning load which drives the peak growth of a summer peaking utility, such as PGandE, causing a the weather-related uncertainty in resource planning. As a result, PGandE sponsors an end-use metering project to better understand this weather-sensitive load.

The total air conditioning load for the residential class is the result of invoking the following accounting identity:

$$\text{Total load} = \text{Total residential customers} * \text{saturation rate} * \text{hourly use per air conditioner owner}$$

This paper illustrates a practical method to estimate the hourly use per air conditioner owner. Thus, the hourly prediction enters directly into the end-use forecasting framework.

THE METHOD

Figure 1 is a flowchart explaining the components of modelling the air conditioner load. The complex problem of estimating hourly load is broken down into two parts. The continuous part (i.e., Models 1 and 3) estimates hourly use, conditional upon the event that the unit is on. The discrete part (i.e., Model 2) computes the likelihood of the unit being on. The two parts are brought together by taking the mathematical expectation of air conditioner use (i.e., Model 4): the probability being on multiplied by the hourly use given the unit being on.

THE DATA

The four models above are estimated using data collected through PGandE's Appliance Metering Project (AMP) for the 1985 summer months. Hourly load data came directly from metering the central air conditioner

* Rate Planning, Pacific Gas and Electric Company (PGandE). This paper summarizes the findings in Woo, Gray, and Carl (1986) "Residential Air Conditioning Load Model." Views expressed here do not represent the position of PGandE. The authors wish to thank C.K. Woo for his comments. All errors are the responsibility of the authors alone.

with a magnetic tape recorder. Supplemental household demographics were acquired through a residential appliance saturation survey. The source of the weather data is PGandE's Load Research Weather Station Network.

THE RESULTS

It was found from Model 1 that square footage, ceiling insulation and wall insulation have a significant effect on the peak capacity of an air conditioner unit. A plausible reason for this is that the builder usually determines the size of the air conditioner unit in view of the thermal characteristics of the house. The results from the likelihood of use model (Model 2) fall into three groups: house construction characteristics, customer demographics and weather conditions. Included in the house characteristics are the age of the house, wall insulation, ceiling insulation and square footage. The customer demographics found to be significant were income, family size, the share of older people in the household (over 65) and the share of young people in the household (under 18). Also, as expected, the units were used more frequently on weekends when the household is home. Temperature and heat spells as well as the household's location in the service territory (i.e., inland vs coastal) influence the on/off decision. Model 3's results demonstrate that the duty cycle depends on customer demographics, house construction characteristics and weather conditions as well. Model 4 predicts the use per customer by multiplying the estimated capacity of the unit calculated from Model 1 by the duty cycle estimate from Model 3, adjusted by the probability of the unit being on estimated from Model 2.

Figure 2 shows the overall fit for the peak day is very good. The predicted loads are slightly above the actual ones in the morning, below them during the afternoon and evening, and above them again during the late evening. Figure 3 shows that the actual and predicted loads for the average weekday are also very close. The actual hour of air conditioner peak load is the same as the predicted hour. At the typical system peak hour (4:00 p.m.), the model overpredicts the actual value by 2 percent. At the residential peak hour (6:00 p.m.), the model overpredicts by 3 percent.

CONCLUSION

In this study, we have developed a general and computationally efficient method to estimate appliance specific load shapes with highly disaggregate end use load data. This kind of model should be included in the residential end-use forecasting process to improve the performance of the residential and therefore the system load shape forecast.

FIGURE 1
FLOWCHART FOR MODELLING AIR CONDITIONING LOAD

