An Application of Bary Curves
To Develop Coincident Demands

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Background

The Potomac Electric Power Company (Pepco) is a member of the Pennsylvania, New Jersey and Maryland (PJM) Independent System Operator (ISO). PJM is responsible for establishing the peak load contributions for each of the operating zones (e.g. – service territories). The peak load contributions (PLC) are set once a year based on a summer weather-normalized peak demand for all of the PJM system. Each of the operating zones is assigned a portion of this weather-normalized peak based on that zone's contribution to the five highest PJM peak times occurring on different days.

For the electric distribution companies within PJM which have retail choice, we are then responsible for calculating the peak load contributions for our customers within our zone. The PLCs are calculated once a year for each customer and are effective January 1 through December 31. As part of Pepco's daily settlement processing, the PLCs for individual customers are summed by their respective electric supplier and reported to PJM. The electric suppliers are then responsible for providing the resources to meet their total PLC requirement, which is the sum of their individual customer PLCs.

General guidelines for calculating the individual customer peak load contributions were agreed to by the various stakeholders within PJM. Each electric distribution company (EDC) is required to calculate their customers' PLCs given the availability of data. An approach, similar to that which PJM uses to assign each zone its share of the total PJM weather normalized peak demand, is used to assign each customer its share of the zone PLC. Customer demands at the 5 PJM peak times are determine and then averaged. These averages are then summed, and their share of the total is applied to the zone PLC. For more information regarding PJM market rules, the reader is referred to www.pjm.com.

Introduction

As simple as it may sound, the above task can be quite an undertaking. At Pepco, there are three general classifications of metering equipment used to bill customers. Therefore, different types of information are available to calculate a customer's peak load contribution, depending on the metering equipment. The three types of equipment include interval metered, monthly meter, and monthly metered with demand data. Within the Pepco zone, approximately 50 percent of the load is interval metered. This information is used in our daily settlement operations, as well as to estimate customer's contribution to the annual PLC established by PJM. Of the three metering types, this is the easiest way to assign the PLC to a customer. A customer's demands at the five PJM peak times are retrieved, averaged and then loss factors are applied. The following formula is used:

$$PLC = \frac{1}{n}\sum_{i=1}^{n} (KW_i) \times (loss\_factor)$$

Where n = five highest PJM peak hours (on separate days).

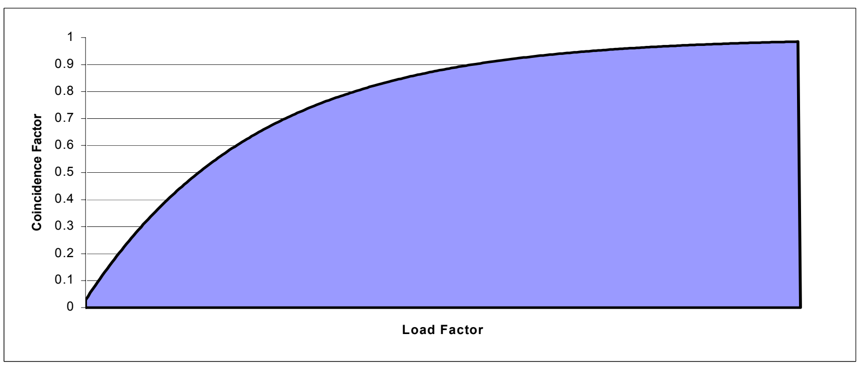
For the next type of metering equipment, monthly read with no demand data, the calculations for the customers' PLC are straightforward as well. For these customers, the month billing energy (kwh) is applied to the class average demands at the times of the 5 PJM peaks. A ratio of the daily kwh per day for the individual customer to the class average energy per day is used to scale up or down the class average demands. Class loss factors are also used. The following equation is used to estimate PLCs for profiled customers:

$$PLC = \frac{1}{n}\sum_{i=1}^{n}(KW_i)\left(\frac{KWH / DAY^{C}}{KWH / DAY^{P}}\right) \times (loss\_factor)$$

Where c = customer, p = profile class, and n = five highest PJM peak hours (on separate days).

For customers who are monthly read with demand data, Pepco used a load factor/coincident factor analysis to calculate the PLCs. This relationship has been referred to as a Bary Curve. Load factor is defined as the average demand for a time period divided by the maximum demand for the same time period. Expressed as a percentage, it represents the amount of time the customer's load is at its peak demand. The coincident factor is defined as the demand at the time of interest divided by the maximum demand. The coincident factor can never be greater than one. The relationship between the coincident factor and the load factor is shown below:

Relationship between load factor and coincidence factor



As shown in the figure, the load factor analysis will ensure that the coincident factor is less than or equal to one. The coincidence factors are calculated using the following estimated equation:

$$Coincidentfactor_i = \left[1 - \exp^{\alpha * Load\_factor}\right]$$

$$Loadfactor_i = \frac{KWH / DAY^C / 24}{MaxKW}$$

where α is a parameter resulting from the following regression:

$$Log\left(1 - Coincidentfact_i\right) = \alpha \times Loadfactor$$

Regressions were performed separately for District of Columbia and Maryland commercial customers using July 2000 load research data for the hours ending 16:00 PM and 17:00 PM, Monday through Friday (excluding holidays), and corresponding customer billing data from August 2000. The regressions were performed using the coincident and load factors based on the monthly maximum billing demands and the on-peak billing demands. (Pepco's on-peak period is 12:00 noon to 8:00 PM, Monday-Friday, excluding holidays.) The following is a summary of the parameter estimates resulting from the regressions. The parameter estimates were used to estimate a customer's demand for the PLC dates and times.

Parameter Estimates Results by Jurisdiction and Hour

	District of Columbia – Parameter Estimates Based On:		**Maryland- Parameter Estimates Based On:**	
Hour	Monthly Maximum Billing Demand	Monthly On-Peak Billing Demand	Monthly Maximum Billing Demand	Monthly On-Peak Billing Demand
16:00 PM	-3.2620	-3.4340	-2.9884	-3.3304
17:00 PM	-3.0647	-3.0647	-2.8381	-2.8381

Application of the Equation

For customers with maximum billing demands, using the load factor-coincident factor estimator instead of a ratio estimator ensures that the coincident demand calculated for an account is not greater than the customer's billing demand. Calculating a coincident demand greater than the billing demand when using a ratio estimation typically occurs for accounts that are high load factor when compared to the class average from the load research study. This is demonstrated in the examples below. (These are results from actual Pepco customers.)

The PLC was calculated for 100 customers which had on-peak billing demand data, using both the coincident factor and the ratio estimators. (These accounts do not have interval demand data.) The ratio estimation calculated a PLC that was higher than the maximum demand for 31 of the 100 customer. These 31 accounts were high load factor customers when compared to the class average. The results from this analysis are presented in the attachment.

In addition to the above analysis, a comparison was performed for 996 customers which had interval demand data for the PLC. In the analysis, we looked at how well the coincident factor estimator compared to the interval data. Below is a summary of the percent difference between the interval data and the estimator. (The absolute values of the percent differences were used.)

Absolute Value of the Percent Difference	Number of Customers In the Range	Percent of Total Customers in the Range
0 – 5 %	276	27.7 %
5.1 – 10 %	243	24.4 %
10.1 – 15 %	185	18.6 %
15.1 – 20%	94	9.4 %
20.1 – 25 %	59	5.9 %
25.1 – 30 %	28	2.8 %
30.1 – 35 %	15	1.5 %
35.1 – 40 %	31	3.1 %
> 40 %	64	6.4 %

We reviewed the results for those where the differences between the PLC and the coincident factor estimator were high. In most cases there were questionable billing data for the customer. For this group of 995 customers, the total difference between the two numbers was quite small. The total PLC from the interval data was 1,679,230 KW versus 1,674,779 from the coincident factor estimation. This represents a 0.3% difference.

Conclusions

Overall, applying a coincident factor to estimate the PLC is the preferred approach compared to using a ratio estimator. Application of the coincident factor ensures that the PLC demand is not higher that the customer's maximum demand while making use of additional customer specific information. In hindsight, a refinement of the regression equation used to estimate the coincident parameters could improve the performance of the coincident-load factor relation.