Laying the Foundation for Energy Efficiency Potential Estimates through Market Assessment

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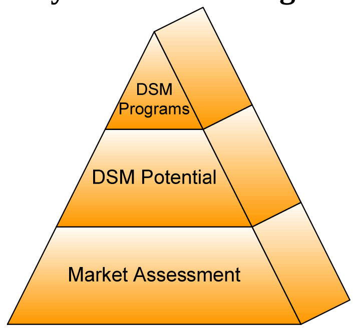
ABSTRACT

Accurate estimates of energy efficiency potential require a great deal of understanding of the utility customer base. A detailed market assessment, including demographic and firmographic characteristics as well as load profiles by customer segment and major end-use should be established. This paper describes a process for developing a market assessment that uses utility and secondary data to describe the unique attributes and energy usage characteristics for a utility service area. The task of developing customer segments and the blending of internal utility data with secondary data unique to the service territory is discussed. Results from energy usage models are also incorporated into the market assessment findings. These models are based on sampled billing from each segment and take advantage of detailed customer information, such as appliance saturation surveys, when available. When complete, the market assessment work provides the foundation for understanding energy savings opportunities. A subset of the market assessment work is presented using commercial floor space and energy intensity calculations based on actual data from a composite of several electric utilities.

Overview of Process

DSM program planning often begins with an estimate of DSM potential (Gellings & Chamberlain 1993). Understanding the opportunities for energy efficiency improvements is an obvious precursor to planning effective programs. Likewise, understanding the characteristics of the customers for which DSM programs are to be developed is important for developing estimates of DSM potential. The term "market assessment" is used in this paper to describe the process and results from a detailed analysis of utility customer characteristics. These characteristics include descriptive information of the customer segment as well as energy usage analysis. In other words, market assessment provides the foundation layer of the analysis and supports the work of developing DSM potential estimates and DSM programs. This relationship is represented in Figure 1 below, with market assessment supporting the work required for effective DSM program planning.

Figure 1. Layers of DSM Program Planning



The objective of the market assessment component is to describe customers and loads in sufficient detail to provide an understanding of energy usage by market segment. Market assessment is typically completed using a blend of internal data provided by the utility along with secondary data specific to the service territory. By blending internal utility data with secondary data sources, a much richer market assessment is possible. Key to the market assessment layer is a rigorous analysis of actual customer billing and, if available, hourly load data to construct electric usage models for each residential and non-residential segments.

Although this paper lays out the steps we follow for completing a market assessment, the primary focus of this paper is an example from a subset of the market assessment task. Our example demonstrates the blending of internal data, energy usage modeling results and secondary data to construct commercial segment floor space and energy intensity estimates. Before discussing the example, however, it is useful to take a wide view and consider the market assessment task as a whole. The steps we typically follow to complete a market assessment include:

- Step 1-Develop customer segments
- Step 2-Sample actual energy usage
- Step 3-Develop base period estimates of end-use energy usage by segment
- Step 4-Describe customer segments

These steps are typically included in one form or another in most approaches to market assessment and energy potential studies.[1] The first two steps are described in this section of the paper. Although the results of the detailed energy usage modeling, Step 3, are used in our example, the actual model development is beyond the scope of this paper.[2] Descriptive analysis of customer segments, the last step in the market assessment process, is presented in the next section of this paper using the example of commercial floor space and energy intensity.

Market assessment begins with market segmentation; disaggregating the customer base into smaller groups of customers. These customer segments are typically chosen so that customers with similar structural, behavioral and energy need attributes are grouped for modeling purposes. Working from a complete extract of utility customer information system (CIS) records, we develop segments by first separating customers into residential and non-residential classes based on rate schedule.

[1] See, for example, EPA and DOE (2007).
[2] See Reichmuth (2008) for a complete discussion of the energy usage modeling process.

Residential customers are then further segmented based on type of housing and vintage of construction. If vintage and housing type are not directly available from the utility CIS, they can be approximated using other CIS variables. The initial service date, for example, can serve as an estimate for vintage of construction. There are typically many important differences between older and newer homes that have large impacts on energy use and energy efficiency potential. Differences in the thermal integrity of the building shell, size of the home and appliance penetration rates, for example, can lead to large differences in annual usage between older and newer homes. Vintage can be used to segment and contrast the energy usage differences between existing and new housing stock.

Segments based on housing type are also an important element of customer segmentation. Distinguishing between single family and multifamily premises allows important differences in these housing types to be reflected in the market assessment. Many utilities have some sort of housing type variable in the CIS database that allows single family and multifamily premises to be identified. Although this level of housing type differentiation is the most important, it may also be possible to further segment residential customers by splitting manufactured homes out of single family and breaking out multifamily into 2-4 unit buildings and buildings with five or more living units. If the CIS does not provide adequate information for housing type identification it may be possible to establish an estimate of housing type based on the service address of the premise. By testing for the presence of an apartment number in the service unit number field or the unit number extracted from the street address, premises can be assigned as single or multifamily. While this approach lacks the accuracy of a well maintained housing type field, our experience is that it typically results in logical outcomes in terms of percentages of customers by housing type and weather normalized consumption per premise.

For non-residential customers, the focus of the example used in this paper, we use a segmentation strategy based on type of business. Ideally, either the North American Industrial Classification System (NAICS) code or its predecessor, the Standard Industrial Classification (SIC) code, is available from the utility CIS.[3] These codes offer a convenient method for segmenting non-residential customers according to the type of business. The table below shows the assignment of business type based on NAICS code.

Table 1. Business Type Assignments from NAICS Code

NAICS Code	Business Type Assignment
01-30	Agriculture, Mining and Construction
31-33	Manufacturing
42, 48-49	Wholesale and Warehousing
445	Grocery
722	Restaurants
721	Lodging
62 (except 622)	Health Services (excludes hospitals)
622	Hospitals
61	Schools
44-45	Retail
51-56 and 92	Office
All other	Other

[3] When NAICS or SIC code are not available from CIS, the code can be obtained from purchased business records and match-merged to customer records.

Once customer segments have been developed, the next step is to select a sample of customers from each segment for detailed energy modeling. Since we are interested in site specific energy usage, it may first be necessary to aggregate meter level data to the premise level if the CIS data does not already provide for premise level usage data. Given the skewed distribution of energy usage between non-residential customers, it is sometimes desirable to take a census sample or to further segment by annual usage to assure that the segment usage results accurately reflects the distribution of usage for the segment as a whole. Once the sample is selected, monthly billing data is aggregated by period for each segment. Weather variables are also aggregated from the individual billing periods of each customer included in the sample so that energy consumption and weather data align perfectly for each segment. The resulting file used for modeling purposes is typically only twelve records per segment, one for each month, although it may be composed from thousands of billing records.

Example Results

An example was selected to illustrate the blending of data sources and analysis as part of the descriptive step in the market assessment task. As such, the example itself represents a subset of the market assessment effort that focuses on the descriptive elements of the commercial customer segments. Specifically, we show the square footage and energy intensity of commercial customer segments. The example used in this study is based on a composite of market assessment results from multiple utilities. Although not utility specific, the composite is derived from actual results in a manner that preserves the empirical relationships within and between segments. The results for the composite utility serve to illustrate the way internal and external data are blended with usage model results to better understand the nature and opportunities in non-residential customer segments.

A summary of energy usage and square feet empirically derived form the market assessment approach described in this paper is shown in Table 2.

Table 2. Annual Weather Normalized Usage and Square Feet by Segment

			kWh per Square Foot (EUI)	
Customer Segment	**GWh (A)**	**Square Feet (B)**	**Utility (C)**	**CBECS (D)**
Grocery	637	13.3	47.8	49.4
Hospitals	362	7.6	47.7	27.5
Hotels	338	20.0	16.9	13.5
Office	4,151	284.1	14.6	17.3
Other	582	78.3	7.4	22.5
Health	650	25.0	26.0	16.1
Restaurant	820	47.9	17.1	38.4
Retail	1,758	89.5	19.6	14.3
Schools	1,014	136.2	7.4	11.0
Warehouse	742	199.6	3.7	7.6

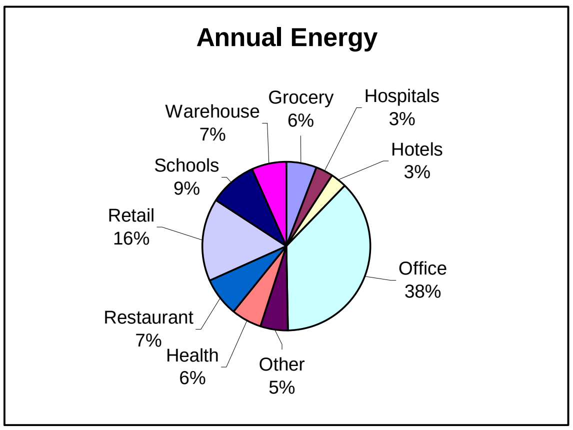
Note: CBECS refers to the 2003 Commercial Building Energy Consumption Survey, all US. All other data are for a composite of electric utilities.

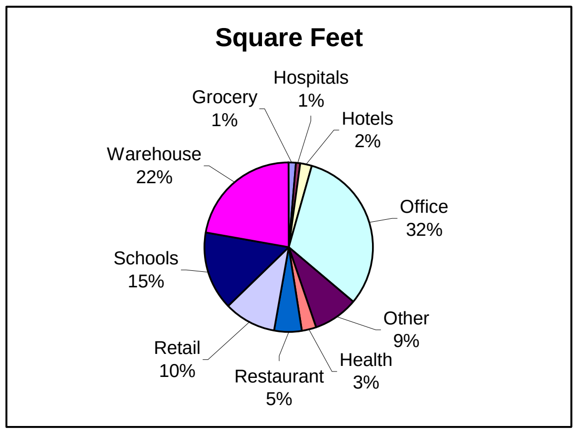
Weather normalized annual usage by commercial segment is shown in Column A. As explained earlier, annual usage is derived from modeling aggregated usage data from individual customers. While the models provide estimates of energy usage by major end use, total usage is used in Table 2 to demonstrate how energy intensity per square foot can be calculated.

Total square footage in each segment is shown in Column B of Table 2. Square footage estimates are derived by multiplying employment in each segment by an estimate of employment density, square feet per employee, for that type of business. Employment data can come from either purchased site specific business data for the service territory, government reported data, typically at the county level, or customer surveys. While purchased site specific employment data can be specified to closely match the geographical boundaries of the service area, it is the most expensive approach. If the geographic boundaries of the service territory can be closely approximated using county level data then government reported employment series can be used with little or no cost.

Employment density estimates can be obtained from either specially designed customer surveys or secondary studies, typically conducted for urban planning objectives. Employment density estimates used in the projects represented in this paper were obtained from a technical report developed for urban planning purposes (Yee & Bradford 1999). The distribution of energy usage and square footage for the composite utility service area is shown in the pie charts below.

Figure 2. Distribution of Annual Energy and Square Feet – Commercial Segments



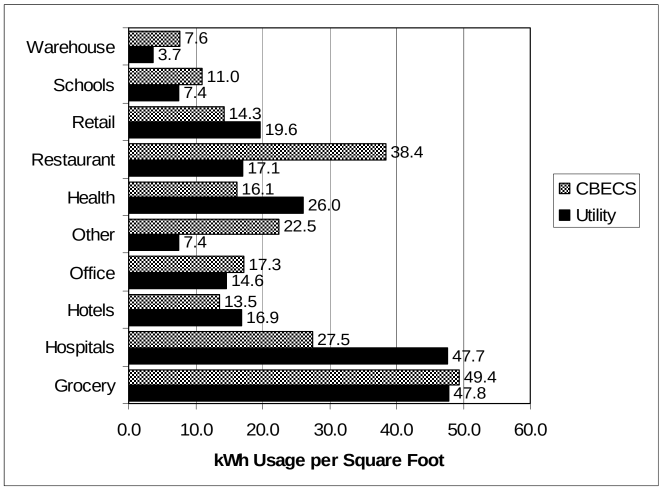


Having both energy usage and square footage by segment allows a comparison of the two distributions. In this utility example, grocery stores and hospitals are shown to be energy intensive with each segment accounting for a proportionally higher amount of energy than square footage. Likewise, warehouses account for about three times the percentage of square feet in the commercial sector than they do energy consumption, clearly on the low end of energy intensity.

Charting the energy utilization index (EUI), which shows kWh per square foot, is perhaps the easiest way to compare relative energy intensity between segments.[4] EUI's are shown in the figure below.

[4] EUI is defined as energy use per unit of floor area; for example, see Violette et al (1991).

Figure 3. EUI by Commercial Customer Segment



Utility and CBECS results are shown in Figure 3 to allow contrasts between segments and between the utility results and the national study of energy usage in commercial buildings. Overall, there is a high degree of concurrence between the two studies. The utility EUIs reveal that grocery and hospitals are the most energy intensive segments. However, our analysis has also shown that these two segments account for a very small amount of the square footage, limiting the energy savings potential from these segments.

On the other end of the energy intensity scale, warehouses and schools both have relatively low EUIs. The large amount of square footage in these facilities, nearly 40 percent of all commercial square footage, is of course, the other side of the energy savings potential story.

Contrasting market assessment results to other studies can be useful for helping to understand the unique attributes of the utility service area as well as for discovering data issues and other problems in the calculations. Hospitals, for example, have significantly higher EUI in the CBECS study than the utility customer analysis. One possible explanation is a higher penetration of non-electric fuels in the CBECS sample than is found in hospitals in the utility service area. Another possible explanation is that the approach underestimated the square footage of hospitals in the service area due possibly to use of employment data that excluded key service areas. Whatever the reason, the difference serves as a flag to highlight the need for additional review. Restaurants are another example but in the other direction. The utility EUI is only about half of the CBECS EUI. Again, this serves as a flag to review fuel shares, secondary data coverage and other elements of the calculation.

The result of this review will serve to either build confidence in the observed differences or, hopefully, uncover ways to improve the estimates. For example, it may be that differences in fuel market shares can explain the observed differences between studies. In this case no adjustment is warranted and the investigation leads to highlighting an important difference in the service area. On the other hand, a review may find that one or more large customers were misclassified due to incorrect NAICS codes. The remedy in this case is simply a reassignment of the impacted customers and a recalculation of the analysis. It may not always be possible to either find an adequate explanation for differences or obvious errors in the source data. Under these circumstances judgment calls must be made as to possible calibration adjustments to bring the results more in line with other findings or to simply let the difference stand. Regardless of the outcome and judgments imposed, identifying and investigating the difference between studies should strengthen the overall market assessment work.

Summary

We have presented a case for blending internal CIS data, secondary data and energy modeling results when conducting market assessment work. Using a composite of actual utility data, we have presented one aspect of the results of market assessment for commercial customers, namely square footage and energy intensity by customer segment. The results clearly show significant differences in market characteristics between customer segments with implications for estimates of DSM potential. Similarities as well as significant differences between the energy usage characteristics of the utility customers and results from the CBECS survey were also shown. Likewise, these similarities and differences provide insights for utility planners when it comes to estimating the expected savings from DSM technologies and programs in their specific service area.

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