

COMPARISON OF END USE ESTIMATION METHODS FOR COMMERCIAL BUILDINGS

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SUMMARY

The methods used to estimate end use in commercial buildings differ in measurement purpose, accuracy, and cost. In this summary, we define the issues in the comparison, and bullet the conclusions from examination of data. Actual data will be presented at the conference. The source file contains detailed engineering information from 5,000 commercial building energy audits, with corresponding monthly electric demand and consumption in all cases. In a fraction of these facilities (approximately 50), hourly metering data was also available.

Types of End Use Measurement

End use consumption can be estimated hourly (load analysis) or yearly (sales analysis), at either the individual building level, or for the building stock as a whole.

- o Annual-System Data: Annual totals by end use at the system level are the primary requirement for end use models (EUIs, etc.).
- o Annual-Individual Building Data: Annual end use consumption estimates for individual buildings are needed for energy audits or bill analysis. Statistical analysis of a valid sample of buildings, with the EUIs measured in each, is a method of producing system average EUIs and yields a data set where correlations of energy use to building characteristics can be evaluated empirically.
- o Hourly-System Data: Hourly loads by end use for the sector provide the basic raw material for demand-side planning.
- o Hourly-Individual Building Data: Estimating load curves by end use in individual buildings is needed to implement some load control options. Also, this data can be the "raw material" for system-wide analysis.

Tools of Measurement

The historical methods of individual building end-use measurement include:

- o Metering: This provides individual building end use loads or consumption.
- o Engineering Models: These are data-intensive end use models that are designed based on engineering theory.
- o Statistical Models. These models, generally less data intensive than engineering models, are based on empirical analysis of actual end use or of the results of engineering models.

New Hybrid Models

Two new approaches to end-use estimation combine the results of any of the above methods with customer billing data.

- o "Conditional Demand Analysis" produces population estimates on end use by regression of a data set, typically composed of a statistical model and corresponding measured billing data, of the form:

$$\text{Billing Data} = \text{Statistical Model} + \text{Error}$$

The result of the regression is an adjusted statistical model that minimizes error.

- o "Allocation" produces individual building estimates of end use, also using a model and the bills.

$$\text{Billing Data (individual building)} = \text{Model} + \text{Error}$$

The allocation process produces modified end use estimates such that the error is zero.

Evaluation Method

In the evaluation of end use consumption, the overriding issue is the comparison of accuracy vs. cost. Precision assessment is therefore critical, and the methods employed for analysis of end use options yielded precision assessments in each case. The methods varied: metered data was assumed to be precise; engineering models were measured against metered data; statistical models were measured against engineering models and metered data, as well as with regression statistics. Detailed methodology will be presented at the conference.

The costs of data collection were estimated by the author, based on company experience with implementation.

Summary Findings

The most important conclusions to date are summarized below:

- o Annual-system level estimation of end use consumption can most cost-effectively be accomplished with an end use survey employing statistical models of each end use, conditional demand using annual billing data, and allocation. Individual end use estimates in each customer file fall within 15-20% with 90% confidence (depending on end use) and are without bias. Collecting a proper sample of 25 to 40 surveys per building type will yield EUI's at the sectoral level with 10% precision or better.
- o Annual end use estimation in individual buildings requires an engineering model and allocation to annual bills to meet 10% precision. It is important to recognize the importance of allocation: engineering models by themselves do not produce adequately precise estimates of end use consumption. In fact, a statistical survey with allocation will out-perform a mainframe engineering model as an estimator of end use in an existing commercial building.
- o System-level estimation of end use load shapes can effectively be measured with an engineering model and allocation to monthly billing and demand data. Precision of 3-8% will result from sample sizes averaging 25-40 per sector, if sites are selected using an efficient sampling technique such as MBSS. End-use metering is more accurate, but only by 2-3% for these sample sizes as measured at the system level. The costs of end use metering for system estimation do not appear worthwhile. Allocation, again, is critical. Conditional demand with a statistical model for load estimation appears inadequately effective.
- o Individual building load estimation cannot be effectively estimated with any engineering model alone. A detailed engineering model will achieve approximately 15-20% precision. Allocation to annual billing and demand data will improve precision substantially and adequately for many analytic purposes (10-15% precision). Allocation to a total load meter will produce excellent estimates (5% precision). End use meters, again, may rarely be cost-effective.