AN END-USE APPROACH TO BUILDING ENERGY ANALYSIS USING ACTUAL LIGHTING ENERGY CONSUMPTION

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Using graphical methods of data analysis, this presentation is focused to the examination of the variation of particular end-use energy consumptions in commercial buildings. The source of the information is early data collected as part of the End-use Load and Conservation Assessment Program (ELCAP) being conducted for Bonneville Power Administration (BPA) by Battelle, Pacific Northwest Laboratory (PNL). The lack of daily variation in hourly lighting profiles over several months in most commercial buildings is particularly noteworthy and is examined in some detail. Variation by daytype, season, and the ranges of variation are explored. The sample sizes at this time are too small to draw conclusions but the strength of the smooth profile argument is clear in the lighting consumption data. In most of the buildings examined to date the lighting profile follows a strong regular daily profile with most variation accountable to the differences in work and non-work days. The three dimensional profiles of daily hourly lighting consumption across days appears to be almost perfectly smooth for some buildings.

These lighting profiles are contrasted to the standard assumptions applied in building energy simulations such as DOE 2.1 and generally support the schedule driven loads as used in the models. The exact relationships of the sizes of the loads compared to capacity and hours of occupancy are sometimes at variance to the standard assumptions. One expects that individual buildings will have such variance, it will require a large sample to determine if the average assumptions are correct.

Most of this early data analysis is focused to buildings with regular office type schedules but other building use type schedules such as retail are illustrated. As expected these also show a regular, predictable schedule different from the office type schedule but fairly common between buildings of similar use.

The first commercial building installation of instrumentation was completed over a year ago, but the main body of the commercial buildings will not be instrumented until late this year. The extensive data verification efforts applied to each installation has resulted in a considerable delay in the availability of data for energy use analysis. PNL has chosen to diagnose and correct installation problems as early as possible in the project. Ultimately this approach will result in the largest amount of high quality data being collected, but the short term impact is to reduce the amount of available data.

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The data base for a typical single logger commercial building in the ELCAP project has over 40,000 channel level data points collected each month. Even when summed to an end use level, it is usual to have as many as 10,000 data entries per month per building. Thus there is great value in the analysis opportunities and flexibility afforded by this hourly end-use approach, but much of the analysis will be based on summarizations of the data because the data set in raw form is simply too large to deal with effectively.

A redundant metering scheme has been applied resulting in the ability to conduct robust tests of data quality following the conservation of energy principle. This has proven invaluable in diagnosing initial installation problems as well providing an easy to apply ongoing test of data quality. An additional benefit allows us to recapture data resulting from building modifications by subtraction. This entire concept is discussed as it relates to the ELCAP effort.

The graphical techniques applied in this presentation illustrate that the data appears to be correct. At least it fits with the assumptions we have about how buildings should consume energy. This technique has located many data anomalies in early examinations. Some were real excursions, explainable by special events such as inventory nights and equipment modifications. Other problems represented errors in the early data sets. In fact any data set of this size and complexity must be expected to contain bad data points. Graphical techniques reveals outliers rapidly, but outliers in this set are not necessarily wrong. If one desires a truly unbiased "real" data set then outliers with explanations should be retained. It is up to the analyst to decide how they should be treated if one is interested in only average data.

A few quick glimpses of relationships available from other kinds of data available in ELCAP are presented. The intention is to illustrate the depth of energy consumption data and other characteristics data which has been collected.