BUILDING SIMULATION RECONCILIATION USING EMPIRICAL DATA

by

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ABSTRACT

Building simulation software alone can sometimes fall short of providing a reliable building model. The user can improve the fit by using empirical data to fine tune the simulation and properly reconcile the building's loads and it's systems' operations. The empirical data may take various forms but will generally include metered utility data and information from site visits and load monitoring. This entire process can be assisted using computerized techniques which in themselves model the building's energy balance. Together with the building simulation program this technique provides the user with a reliable base building model from which to model other building load and systems' scenarios.

This paper will deal with the experiences of the author in using the building simulation program LOADSHAPER along with data gathering techniques and an in-house computer program TRACKER to properly reconcile building simulation models. These are described below.

LOADSHAPER is a building simulation program marketed primarily to utilities in support of demand-side management and strategic conservation programs which support planning, marketing, load research and customer service areas at the utility. The program calculates space heating and cooling loads on an hourly basis, following the 1985 ASHRAE handbook. it calculates HVAC and plant performance using algorithms from the Lawrence Berkeley Laboratory DOE-2 Engineering Manual and the ASHRAE TC4.7 modified bin method, extended to use a four point interpolation of solar gains. The program provides for quick and intuitive choices of building parameters with systems' selection and design support. This particular building simulation program was chosen primarily for it's ease of use, flexibility, speed of execution and reference documentation.

TRACKER is a spreadsheet model which requires the user to input metered utility data, local weather data and building end use loads and profiles. In return, the model provides tabular and graphical reports on building monthly end-use profiles and annual totals. TRACKER was developed to enable engineering staff to easily and quickly reconcile building loads and profiles from utility metered electrical and fuel data.

Building load information for both LOADSHAPER and TRACKER is generally obtained through site visits, a review of mechanical and electrical drawings and interviews with building operating staff. Cyclic and intermittent loads may also be monitored using current recording equipment **providing demand and** energy use levels and schedules.

INTRODUCTION

In the study of building energy use the energy analyst will typically use one of the usual two approaches available to him. He will either use a building simulation or some energy accounting technique to break down total building energy use into discrete end uses. The former relies on simulated energy use while the latter relies on actual energy use obtained through utility metering. Both techniques have their benefits and limitations. The subject of this paper is to present a methodology which provides a blend of both techniques, capitalizing on the better features of both.

We will first examine the techniques individually and then present them as one methodology using a step by step approach.

Building Simulation Techniques

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The use and application of building simulation programs has been traditionally limited to analysts with one foot firmly planted in building system design and operation and the other in computer modelling techniques. By the very nature of the problem the solution requires a detailed amount of data and a keen eye for the straying results. The exercise can truly endorse the familiar rhetoric of any computer school, "garbage in, garbage out". In spite of the effort required though, the results are worth it. One has only to consider the advantages of having a well behaved building model. A well behaved building model will provide the analyst with the ability to change any building parameter whatsoever and gauge the effects on other parameters. The effects can be evidenced and quantified in changes to heating and cooling loads, equipment capacities and end use demands and energy use.

This leads us to an obvious question, "How easy is it to obtain a reliable building simulation model", or rather, "which one computer program provides the most expeditious route to the most reliable building simulation model". We point out here that the most expeditious is not necessarily the most reliable. The analyst must usually choose among programs which offer versatility and quick turnaround versus those that offer the highest level of detail and accuracy. These criteria provides us with a range of choices from block load to bin to selective-day hourly to hour-by-hour techniques. The optimal blend of speed and reliability has been generally with the bin type program. Other factors to consider in selecting software today also apply, namely, data input features, reporting capability and general ease of use. These other features should all be inherent to the building simulation program you choose.

The program chosen by this analyst is Loadshaper from Morgan Systems Corp. in Berkeley, California. It is a bin type program which provides the user with a friendly interface for data entry, building system sizing and report generation. A five zone, two system model with two options can be entered and executed within an hour on an MS-DOS 286 class personal computer with co-processor. With a re-execution time of under three minutes this program allows for quick iteration towards a reliable working model.

Utility Data Techniques

The alternative to the building simulation model is to begin with known utility data and systematically break it down using additional information. The final results are seasonal or end use breakdowns of total building energy use profiles. These may be monthly, daily or hourly depending on the metering available and the detail required. As with the simulated building model, the reliability of this empirical model rests strictly with the credibility of the data provided. However, in the latter case we can fall back on real historical data. Although data sound, this model fails to provide us with the flexibility to see cause and effect in building energy use. Therefore, as a predictive tool, it can't compare to the simulation model.

The process of creating an empirical model involves a number of steps;

- Collecting building utility data for all energy types along with actual meter reading dates. Building or load hourly data may also be obtained using datalogging techniques.
- Collecting weather data for the same period as the utility data.
- Determining end use monthly demands, annual consumptions and profiles. Profiles may include heating, cooling, occupancy, etc.
- Collecting building floor area and total energy costs.

The steps outlined above illustrate the non-trivial nature of this exercise. As a means of providing ready fields for storing the data collected, as well as, expediting the analysis, a spreadsheet program may be used. The spreadsheet developed by this analyst is called Tracker.

Tracker requires utility data by energy type, end use data by demand and consumption and use profile data to describe load and use requirements by month for a representative year. The utility data is relatively easy to obtain although the analyst must be careful to obtain accurate billing dates for proper accounting. End use data may come from reviewing building drawings, visiting the building site and interviewing operating personnel. Load profiles may come from dependencies on weather, occupancy, daytime hours or production units. As the end use data and profiles are brought together they can be compared on a monthly and annual basis to the actual utility data. This provides the analyst with a representative picture of the building's energy use built up from end use loads and calibrated to match its use history. In the final iteration Tracker provides a clear snapshot of a building's energy use by energy type and end use, monthly and annually.

The Combined Approach

The use of the building simulation model and empirical model together can yield the best overall result. As the simulation model provides the precise specification for the building, it's systems and operation, the empirical model provides the historical cookie cutter to best fit the building's simulated energy use profiles.

The combined approach involves the following steps;

1) The analyst inputs building load and system parameters into a building simulation program to obtain monthly end use profiles.

2) The analyst uses utility metered data and field audited information to obtain the same monthly end use profiles.

3) The analyst makes adjustments to bring both models in line by superimposing and comparing both profiles. This quickly reveals any anomalies and points to the most likely adjustments required to resolve the models. A matrix is useful here to systematically fine tune the models.

By this method, the base building model is resolved in a minimum number of iterations and has the reliability of matching load and system parameters with empirical data. The user is then free to investigate other building system alternatives. The analyst may repeat the process for typical daily profiles using datalogging or chart recording equipment to gather empirical data and compare these to simulated hourly profiles for building demand.

Experience and Practice

As energy use analysts we are normally given the tasks of auditing building energy use, identifying excessive use and prescribing remedial measures. Let's carry this discussion forward using our combined approach for a typical office building.

Given the task of auditing building energy use we can get a quick start by using utility data and Tracker to arrive at average energy use for the building. Based on our experience with energy use in other local office buildings we can determine if our building exhibits excessive use by energy type. Adding end use and profile information to Tracker then allows us to pin point excessive use by heating or cooling season or by specific end uses such as heating, cooling, hot water, lighting, etc. At this point we may clearly identify apparently excessive uses or at least be able to speculate about their cause. At best, we note the months and end uses that are suspect. Finally, we use Tracker to provide us with the best fit of protypical profiles of building and end use energy and demand. This final picture may be used to correlate and reconcile the building simulation to follow.

Given the final task of examining and prescribing remedial measures for excessive energy use we set up a building simulation model using Loadshaper. Starting with a typical office building file already on the computer we collect specific building data via Loadshaper's input form or directly into Loadshaper's input screens. The program dynamically checks for computational inconsistencies and assists us with multiple choice style menus, to make quick work of the input process. We ask for Loadshaper's engineering summary report and review monthly demands and energy use. We check end use profiles for anomalies and inconsistencies with our input data and the Tracker protypical profiles we found above. We then fine tune our model and arrive at a reliable base building model from which to continue our analysis.

Based on documented load densities for energy efficient office buildings and our knowledge of building systems' application and operation, we can now use the simulation model to measure the impact of various measures. The simulation model will not only let you quickly make the change but will also automatically make the necessary adjustments to other building parameters. Plugging cost and interest information into Loadshaper then provides you with a payback analysis for the measure, thus completing the exercise. The process may repeated for numerous measures and operations scenarios.

Summary

In this paper, we have presented a mix of computational techniques which the energy analyst may use to optimize his tasks. Although we focused on two particular programs, it is the technique of combining building simulation programs with empirical data analysis that is important. We can summarize using the following points;

- Utility data may be used to obtain building energy and demand profiles.

- End use and utility data may be used to obtain protypical end use and building energy and demand profiles.

- Building simulation programs with protypical load profiles may be used to quickly obtain a reliable building model.

- Building simulation programs with knowledge of building systems and operation may be used to evaluate optimizing measures.