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The complete *Procedures for Commercial Building Energy Audits* are available under "Bookstore" at:

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Levels of Effort

Depending on the physical and energy-use characteristics of a building and the needs and resources of the owner, these steps can require different levels of effort. A commercial building energy analysis can generally be classified into the following levels of effort.

OVERVIEW

Preliminary Energy Use Analysis

Analyze historic utility use and cost. Develop the Energy Utilization Index (EUI) of the building. Compare the building EUI to similar buildings to determine if further engineering study and analysis are likely to produce significant energy savings.

Level I—Walk-Through Analysis

Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost/no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings. A walk-through analysis of a facility will utilize all the forms in this publication except those in the section on "Building and Systems Report."

Level II—Energy Survey and Analysis

This includes a more detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. This level of analysis will be adequate for most buildings and measures.

Level III—Detailed Analysis of Capital-Intensive Modifications

This level of engineering analysis focuses on potential capital-intensive projects identified during the Level II analysis and involves more detailed field data gathering as well as a more rigorous engineering analysis. It provides detailed project cost and savings calculations with a high level of confidence sufficient for major capital investment decisions.

Discussion

There are not sharp boundaries between these levels. They are general categories for identifying the type of information that can be expected and an indication of the level of confidence in the results. It is possible that while performing an energy analysis in a particular building, various measures may be subjected to different levels of analysis.

Some readers of an energy analysis report may be unable to comprehend the technical analysis involved, while others may demand a full presentation of the analysis for critique. Consequently, technical material should be presented in an appendix to the report, while the body of the report guides the reader through the technical material and summarizes the findings.

Information presented here outlines the engineering procedures that should be followed while performing an energy analysis. It is assumed that the analyst is a knowledgeable and competent individual. No attempt is made in this publication to prescribe specific methods of data gathering or data analysis.

To assist with the organization of the data collected and the calculation procedures, this publication contains guideline forms that suggest the type of data to be gathered and its organization. It is recommended that the analyst develop and use appropriate data collection and organization forms specific to the size and type of building(s) being analyzed.

The forms presented in the first two sections are building characteristic forms on which basic building information and energy use can be recorded. Use of these forms by all engineering analysts will result in a uniform procedure for reporting the results of an analysis. It is recommended that these forms be completed without modification.

PRELIMINARY ENERGY USE ANALYSIS

Before any level of energy analysis is begun, it is valuable to perform a preliminary energy use analysis to determine a building's current energy and cost efficiency relative to other, similar buildings. This is normally done by calculating the energy use and cost per square foot per year, which can indicate the potential value of further levels of analysis. This preliminary analysis generally includes the following steps.

1. Determine the building's gross conditioned square footage and record this on the building characteristics form. Classify the primary use of the building. Ensure that the standard definition of gross area is used.
2. Assemble copies of all utility bills and summarize them for at least a one-year period, preferably three years. Review the monthly bills for opportunities to obtain a better price through taking advantage of different utility rate classes. Review the monthly patterns for irregularities. Note if a bill is missing or if it is estimated rather than actual consumption.
3. Complete the energy performance summary to develop the energy index and the cost index for each fuel, or demand type, and their combined total using ASHRAE Standard 105 methods.
4. Compare the Energy Utilization Index (EUI) and the cost index with buildings having similar characteristics. The owner of the subject building may have similar buildings for this comparison. Comparison should also be made with publicly available energy indices of similar buildings. In all cases, care should be taken to ensure that comparison is made with current data, using consistent definitions of building usage and floor area.
5. Derive target energy, demand, and cost indices for a building with the same characteristics as this building. A range of methods are available for this work:
    - Pick from any database of similar buildings those buildings with the lowest energy index.
    - Pick an index based on the knowledge of an energy analyst experienced with this type of building.
6. Compare the energy and cost savings for each fuel type if the building were to reach the target Energy Utilization Index. Using these value(s), determine if further engineering analysis is recommended.

LEVEL I—WALK-THROUGH ANALYSIS

This process includes all of the work done for the preliminary energy use analysis, plus the following.

1. Perform a brief walk-through survey of the facility to become familiar with its construction, equipment, operation, and maintenance.
2. Meet with owner/operator and occupants to learn of special problems or needs of the facility. Determine if any maintenance problems and/or practices may affect efficiency.
3. Perform a space function analysis, guided by the forms in the "Walk-Through Data" section. Determine if efficiency may be affected by functions that differ from the original functional intent of the building.
4. Perform a rough estimate to determine the approximate breakdown of energy use for significant end-use categories, including weather and non-weather-related uses.
5. Identify low-cost/no-cost changes to the facility or to operating and maintenance procedures, and determine the savings that will result from these changes.
6. Identify potential capital improvements for further study, and provide an initial estimate of potential costs and savings.

The report for a Level I analysis should contain the building characteristics and energy use summary as well as the following.

1. Quantification of savings potential from changing to a different utility price structure.
2. Discussion of irregularities found in the monthly energy use patterns, with suggestions about their possible causes.
3. The energy index of similar buildings. Report the source, size, and date of the sample used in this comparison. The names of comparable buildings should be given if known.
4. The method used to develop the target indices. Where comparison is made to other buildings, state their names. Where the experience of someone other than the author is used to develop the target, provide the source. Where the target is developed by calculation, show the calculation or quote the name and version of software used and include both input and output data.
5. Total energy and demand cost by fuel type for the latest year and preceding two years if available. Show potential savings in dollars using the energy index format of ASHRAE Standard 105.
6. The fraction of current costs that would be saved if the energy index were brought to the target level.
7. A summary of any special problems or needs identified during the walk-through survey, including possible revisions to operating and maintenance procedures.
8. A preliminary energy use breakdown by major end uses.
9. The listing of low-cost/no-cost changes with the savings for these improvements.
10. The potential capital improvements, with an initial estimate of potential costs and savings

LEVEL II—ENERGY SURVEY AND ENGINEERING ANALYSIS

This analytical procedure is guided by Level I analysis and includes the following additional work:

1. Review mechanical and electrical system design, installed condition, maintenance practices, and operating methods. Where drawings have been kept up to date, this task will be much easier.

2. Review existing operating and maintenance problems. Determine planned building changes.
3. Measure key operating parameters and compare to design levels, for example, operating schedules, heating/cooling water temperature, supply air temperature, space temperature and humidity, ventilation quantities, and light level at the task. Such measurements may be taken on a spot basis, or logged, manually or electronically.
4. Prepare a breakdown of the total annual energy use into end-use components, as illustrated in the *1999 ASHRAE Handbook—Applications*, Chapter 34, Figure 4, or as shown in the section "Energy Analysis Summary and Recommendations." A number of calculation methods are available, ranging from simplified manual calculations to fully detailed computer simulation of hour-by-hour building operations for a full year.
5. List all possible modifications to equipment and operations that would save energy. Select those that might be considered practical by the owner. List preliminary cost and savings estimates.
6. Review the list of practical modifications with the owner/operator and select those that will be analyzed further. Prioritize the modifications in the anticipated order of implementation.
7. For each practical measure, estimate the potential savings in energy cost and its energy index. To account for interaction between modifications, assume that modifications with the highest operational priority and/or best return on investment will be implemented first. A number of calculation methods are available, ranging from simplified manual calculations to rerunning computer simulations, if performed in Step 4, above.
8. Estimate the cost of each practical measure.
9. Estimate the impact of each practical measure on building operations, maintenance costs, and non-energy operating costs.
10. Estimate the combined energy savings from implementing all of the practical measures and compare to the potential derived in the Level I analysis. It should be clearly stated that savings from each modification are based on the assumption that all previous modifications have already been implemented and that the total savings account for all of the interactions between modifications.
11. Prepare a financial evaluation of the estimated total potential investment using the owner's chosen techniques and criteria. These evaluations may be performed for each practical measure.
12. Following submission of the report of the Level II analysis, meet with the owner to discuss priorities and to help select measures for implementation or further analysis.

The report for a Level II analysis should contain at least the following.

1. A summary of energy use and cost associated with each end-use. Show calculations performed or quote the name and version of software used and include both input and output pages. Provide interpretation of differences between actual total energy use and calculated or simulated end-use totals.
2. A description of the building, including typical floor plans and inventories of major energy-using equipment. (This information may be included as an appendix.)
3. A list of measures considered but felt to be impractical, with brief reasons for rejecting each.
4. For each practical measure, provide
    - a discussion of the existing situation and why it is using excess energy;
    - an outline of the measure, including its impact on occupant health, comfort, and safety;

- a description of any repairs that are required for a measure to be effective;
- the impact on occupant service capabilities, such as ventilation for late occupancy or year-round cooling;
- an outline of the impact on operating procedures, maintenance procedures, and costs;
- expected life of new equipment, and the impact on the life of existing equipment;
- an outline of any new skills required in operating staff and training or hiring recommendations;
- calculations performed or provide the name and version of software used and include both input and output data.

5. A table listing the estimated costs for all practical measures, the savings, and financial performance indicator. For the cost of each measure, show the estimated accuracy of the value quoted. This table should spell out the assumed sequence of implementation and state that savings may be quite different if a different implementation sequence is followed.
6. A discussion of any differences between the savings projected in this analysis and the estimated potential derived in the Level I analysis.
7. Overall project economic evaluation.
8. Recommended measurement and verification method(s) that will be required to determine the actual effectiveness of the recommended measures.
9. Discussion of feasible capital-intensive measures that may require a Level III analysis.

LEVEL III—DETAILED ANALYSIS OF CAPITAL-INTENSIVE MODIFICATIONS

This analytical procedure is guided by Levels I and II analyses and the owner's selection of measures for greater definition. It must follow such Level I and II work.

1. Expand definition of all modifications requiring further analysis.
2. Review measurement methods, and perform additional testing and monitoring as required to allow determination of feasibility.
3. Perform accurate modeling of proposed modifications. Ensure that modeling includes system interaction.
4. Prepare a schematic layout of each of the modifications.
5. Estimate the cost and savings of each modification.
6. Meet with owner to discuss/develop recommendations.

The report for a Level III analysis should include the following, as a minimum.

1. Include text, schematics, and equipment lists necessary to completely describe all proposed changes to physical equipment. Matters of a final design nature may be left to subsequent engineering as long as the cost of such engineering is included in the budget. Firm price contractor quotations for key parts of any measure may be included. Cost estimates shall show contingencies separately and report the expected accuracy of the budget.
2. Prepare a financial evaluation of the estimated capital investment and projected savings. Use the owner's chosen techniques and criteria.