ABSTRACT

This paper details how the U.S. Department of Energy, Federal Energy Management Program (FEMP) is applying metering technology to conduct empirically based analyses of energy use by federal agencies. Continuing developments in sensors, data acquisition systems, microcomputers and monitoring protocols are reducing the costs of metering to the point that it is becoming "too cheap not to meter" energy and the determinates of energy use at federal facilities. This has widespread consequence for FEMP if one accepts the axiom that "one can't manage what one doesn't measure." Several recently completed and ongoing activities being managed by Pacific Northwest Laboratory (PNL) for FEMP are highlighted in this paper. This includes the metering of energy end-uses for a research laboratory building to support an energy savings contract, analysis of utility billing records, climate, and characteristics data for entire military bases to prioritize energy use testing requirements, and advancements to simplified energy analysis tools to help federal energy decision makers identify and evaluate cost-effective energy savings opportunities.

INTRODUCTION

The U.S. Department of Energy (DOE), Federal Energy Management Program (FEMP) mission is to provide leadership to make the federal government more energy efficient. This mission is accomplished through a broad-based program of research and development coordination, information dissemination, and interagency cooperative development ventures. Commercially available technologies, emerging technologies, and experimental technologies are among the options that FEMP encourages other agencies to consider, as appropriate, to help meet energy efficiency goals. Coordination of energy management activities among federal agencies is an important element of FEMP, including the education and training of federal energy decision makers with regard to energy-efficient technologies. To accomplish this mission and achieve these goals, the FEMP has supported several applied research and development activities at Pacific Northwest Laboratory (PNL), one of the DOE multipurpose research facilities. This paper summarizes significant research efforts and provides sample applications of various tools and methods appropriate for widespread application. These efforts include advanced energy use metering techniques, energy use baseline forecasting approaches, and energy use simulation and conservation measure evaluation methods.

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MONTHLY NNMC STEAM PRODUCTION

MONTHLY NNMC CHILLER PRODUCTION

FIGURE 1: STEAM AND CHILLED WATER PRODUCTION VERSUS AVERAGE OUTDOOR TEMPERATURE FOR THE NATIONAL NAVAL MEDICAL CENTER (NNMC) CENTRAL PLANT IN BETHESDA, MD

ELECTRICAL COST COMPARISON FOR THE NATIONAL NAVAL MEDICAL CENTER

FIGURE 2: ELECTRIC UTILITY CHARGES FOR A MILITARY FACILITY - COMPARISON OF PREVIOUS AND CURRENT TARIFFS

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energy use can be distinguished for working and non-working days. It is also useful to examine electrical use according to billing components that may include peak demand, and consumption during off-peak, on-peak, and intermediate periods. This yields additional insight of the nature of electrical energy use and the impact of potential conservation and load management measures on utility costs. Because energy costs are a function of utility tariffs, it is important to examine past habits and anticipated utility rates. Figure 2 depicts the monthly time series for energy consumption at the National Naval Medical Center facility under the actual rates in 1988 and early 1989, as contrasted with what the charges would be if consumption is identical to the current year. The monthly distribution and production of charges are estimated based upon the peak 30-minute demand, and the highest 30-minute demand during the on-peak period of the summer months, respectively. The change in the utility tariff commencing in May of 1989 significantly increases electricity costs during the summer with a commensurate reduction during the winter months (also the "summer" months have been shifted to begin in June rather than May). While the overall impact on the annual electrical cost is small, this change significantly affects the cost-effectiveness of individual energy conservation measures.

While much is learned from careful analysis and presentation of the utility billing data, supplemental measurements are often cost justified to better understand energy end-uses and conservation potentials. Consequently, FEMP supports the development and application of new energy metering technologies and analysis methods for federal facilities. As new tools and methods are developed, the FEMP supports applied research to evaluate and refine them before promoting more widespread adoption.

FEMP administers four FEMP Mobile Energy Laboratories (MELs) for use by federal agencies to conduct energy use measurements and efficiency tests. The laboratories are customized for federal agencies to provide equipment storage and work space for specially trained technicians to conduct energy efficiency tests in conjunction with on-site operations personnel. These laboratories are made available to federal agencies through interagency agreements on the basis of "need" for Energy, that provide for FEMP to provide the laboratory equipment, from which federal agencies agree to conduct energy efficiency tests. The United States Naval Medical Center laboratory is currently preparing a catalog of standardized energy efficiency testing procedures for common investigations such as combustion efficiency measurement, electrical power distribution system evaluation, and heating, ventilation, and air conditioning system testing. These procedures follow guidelines established by the American Society for Testing and Materials (ASTM), and will be published for use by federal agencies through interagency agreements. The FEMP is presently preparing a catalog of standardized energy efficiency testing procedures for common investigations such as combustion efficiency measurement, electrical power distribution system evaluation, and heating, ventilation, and air conditioning system testing. These procedures follow guidelines established by the American Society for Testing and Materials (ASTM), and will be published for use by federal agencies through interagency agreements. The FEMP is presently preparing a catalog of standardized energy efficiency testing procedures for common investigations such as combustion efficiency measurement, electrical power distribution system evaluation, and heating, ventilation, and air conditioning system testing. These procedures follow guidelines established by the American Society for Testing and Materials (ASTM), and will be submitted for ASTM approval as they are finalized.

Another benefit of baselining energy consumption is to facilitate the implementation of performance-based shared energy savings contracts. Under these contracts, which are now permitted by the federal government, an energy service company can help the federal government save money by designing and constructing energy efficiency projects and other changes that will help the federal government save energy.
MEASURED ENERGY USE FOR INTERIOR LIGHTS
BEFORE AND AFTER AWARENESS PROGRAM

FIGURE 2: SAMPLE MEASUREMENTS PROVIDED BY FEMP MOBILE ENERGY LABORATORY EQUIPMENT
CONDUCTED AT LAWRENCE BERKELEY LABORATORY
BY THE FEDERAL ENERGY MANAGEMENT PROGRAM

FIGURE 4: ENERGY USE SUBMETERING FOR A SYSTEMS ISOLATION BASELINE AT A MULTI-PURPOSE LABORATORY

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use baseline, two seemingly conflicting requirements. Typically, a preliminary investigation of energy use that can be reliably baselined from those that cannot. This may be necessary where the baseline uncertainty would otherwise be too great in relation to the potential savings. An example of data for DOORS isolation approach is depicted in Figure 4 where a set of end-use measurements are used for a multipurpose laboratory building to baseline the energy use systems that will be affected by a shared energy savings project. Because no retrofits are anticipated for the scientific equipment and methods to forecast their use would be futile, the energy they consume is measured and subtracted from the building energy use to determine a more reliable baseline. Other sensors measure the interior and exterior climate conditions to adjust the baseline for changes in key parameters that are beyond the control of the energy savings contractor.

A third pathway to baselining is described below, where a calculated baseline is developed based upon energy use simulation model. Once the model is calibrated to measured data, it can be used not only to identify cost-effective energy efficiency improvement opportunities, but may also serve as an energy use base1 ine 

VALIDATION

ENERGY USE SIMULATION AND CONSERVATION MEASURE EVALUATION

With the advent of inexpensive and widely available desk-top computers, FEMP is supporting the development and enhancement of public domain energy use analysis software. This software facilitates detailed analysis of the complex and diverse energy uses of building systems by providing energy use cause and effect relationships. All software developed by the FEMP is placed in the public domain to facilitate widespread use and to provide an open architecture for educational purposes and customization as may be desired.

Recently, the FEMP is continuing development and user support for "A Simplified Energy Analysis Method" (ASEAM) that uses bin temperature data and the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) approved calculation methods to estimate building energy end-use intensities. This tool uses the life cycle costing procedure developed by the National Bureau of Standards to determine the savings-to-investment ratio of potential energy efficiency improvements. The output of this menu driven software can be read directly, or formatted for input to popular spreadsheet programs and analysis packages.

This simplified method was originally developed to operate on IBM personal computers with only 256K of random access memory. Now that most energy analysts have access to computers with enhanced capabilities the software is being upgraded to take advantage of these capabilities and improve ease of use, flexibility, and accuracy. However, even with these improvements the simplified calculations are not adequate for sophisticated energy control simulations and utility load management options investigations.

Consequently, the FEMP is embarking on a project to integrate the ASEAM and DOE-2 hourly simulation programs into a common computing environment. The objective is to slightly modify the ASEAM program inputs and develop an interface to accommodate use of the more sophisticated and computationally intensive DOE-2 program. The public domain DOE-2 program can presently be run on enhanced desk-top computers only by using proprietary software. It is FEMP's goal to release an integrated public domain program thereby permitting the federal energy analyst to quickly examine a wide number of potential conservation measures using ASEAM and then readily use the DOE-2 program for the most promising energy efficiency improvements. An important caution is required to ensure effective use of these tools. The output estimates are only as good as the input data and to a lesser degree the software algorithms. Without well informed users, these tools can be incorrectly applied and the results can be easily misinterpreted. As a check on this the FEMP is continuing efforts to measure the actual end-use consumption of building energy systems and developing methods by which improved estimates of stable conditions may apply metered data to calibrate the baseline for their building and improve retrofit options analysis. By documenting these experiences, and supporting user training, the FEMP hopes to be able to provide guidance and low-cost approaches to calibrate the simulation models and check the validity of their estimates against accumulated measurements.

SUMMARY

This paper has described several applications of metering for facility and whole building energy analysis, and identified areas of ongoing investigation by the FEMP. Our experiences with field data collection have been particularly valuable, providing an empirical basis to evaluate energy
Analysis methods, and revealing the measurement complexities and capabilities of metering hardware. When coupled with the increasing sophistication and affordability of energy metering systems and computational environments, the future is particularly bright for improving the understanding and efficiency of energy use.

However, this paper also identifies areas where additional research and applications testing is necessary to achieve the goals of optimal energy use efficiency. Specifically, improved energy use metering technologies must be investigated, software to efficiently apply the data and computers now available must be maintained and enhanced, and more scientifically sound energy use baselining and forecasting methods must be developed. All this requires funding and institutional support that is challenging to obtain in this era of energy complacency and focus on sources of new energy supply. It is hoped that the increasing awareness of the environmental impacts of energy production, and the indisputable merits of energy efficiency improvement to reduce these impacts, will compel public and private sources to continue and accelerate this applications-oriented research. Ultimately, these investments will be small in relation to the value of the energy savings that will be realized as the methods are put into practice.

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References


