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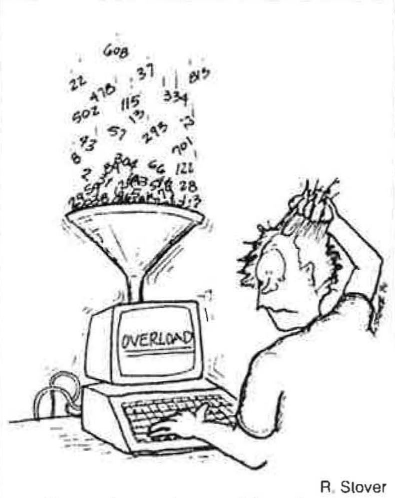
MEASURING RESULTS

Monitoring Made Easier

by Bill Mixon and Alan Meier

How much did that retrofit save? This question is asked with increasing frequency by utilities, weatherization agencies, and energy professionals, and requires energy monitoring and tracking for an answer. Tracking energy use is also a way to control quality, to test new conservation measures, and even to determine profits for some companies. For these reasons, monitoring of energy use in buildings has become increasingly important. Yet poor monitoring often yields data that are almost as good as no monitoring. Many ambitious monitoring projects produced computer disks full of useless and uninterpretable data. On the other hand, careful planning can simplify the monitoring itself and insure that the evaluator gets quality answers to the right questions.

Many monitoring projects fail because of poor experimental design. In other words, the project was destined to fail before a single measurement was made. The U.S. Department of Energy recognized this problem and developed "monitoring protocols" to assist those seeking to monitor the energy savings from a building retrofit. These protocols appear in various reports issued by Oak Ridge National Laboratory, Lawrence Berkeley Laboratory, and other institutions.[1]



Sometimes the problem is too much data.

Steps for proper planning and guidelines for experimental design are also summarized in a new chapter in the 1991 American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) *Applications Handbook* and the American Society for Testing and Materials (ASTM) is considering the protocol as a new Standard Practice.

Protocols provide a starting point for those beginning their first monitoring projects and a way to prevent many of the shortcomings that have been identified by experienced practitioners. Recurring themes include the need for better planning and the importance of collecting data in

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Table 1. Manufacturers of kW and kWh Monitoring Equipment

Type of Equipment	Manufacturer	Application	Cost
Multi-tenant kWh submeter: Single phase tenant double phase tenant triple phase tenant	Synergistic Control systems 660 Plaza Dr. New Orleans, LA 70127 (504)244-9852	Commercial tenant Condominiums, marina and apartment submetering.	$1,549
Portable Diversion kWh meter with clamp-on sensors	Fisher Pierce Weymouth, MA 02189 (617)340-0700	Detecting and measuring kWh usage from a secondary pole or pad service drops.	$550
Clip-on Ammeters	Yokogawa Corp. 2 Dart Rd. Shenandoah Industrial Park Newhan, GA 30265 (404)253-7000	Measures DC and AC currents without breaking the circuit under test. Amp range 0.2-20	$995
Portable Digital clamp-on kW, kWh meter (no wiring necessary)	TIF Instruments 9101 NW 7th Ave. Miami, FL 33150 (305)757-8811	Measures true power consumption (kW). Measures up to 10,000 kWh at 200 kW.	$950
Energy Teller	Energy Teller, Inc. 15440 Clayton Rd., Suite 114 Ballwin, MO 63011	Microprocessor. Measures the electricity use of appliances—appliance plugs into unit.	$139.50
(As an example of another type of monitor, a datalogger.)			
Datatrap A datalogger with 8 analog inputs able to handle most sensors.	Lambert Engineering 601 N.W. Harmon Blvd. Bend, OR 97701-3023 (503)388-2623	Can measure kWh of appliances.	$1,500

Table 2. Advantages and disadvantages of four experimental designs.[2]

Advantages	Disadvantages
ON-OFF	
No reference building required Can be performed multiply in one season The environment is the same The same model with the same parameter values can be used for most components in on and off states Long term changes of occupancy less important than in other designs	Requires reversible retrofit Time constants of building must be considered when length of on-off periods are chosen Outdoor climate during on and off periods may not be the same Requires a model to correct for differences in the outdoor climate Short term reactions of occupants may occur when switching from one state to another with unknown effects on consumption Dynamic model often required
BEFORE-AFTER	
No reference building required Often less variation in behavior of occupants than in other designs The outdoor environment is the same before and after The same model with the same parameter values can be use for most components before and after the retrofit	Often more than one heating season required for measurements Running-in and learning period often required to counteract initial change of behavior The outdoor climate is not the same before and after Requires a model to correct for differences in the outdoor climate The measurement equipment may have to be removed during the retrofitting
TEST-REFERENCE	
One heating season suffices for the measurements No difference in environment and outdoor climate if test and reference buildings are close Difference in energy consumption directly associated with retrofit affect if buildings identical The same model can be used for most building components	Reference building required Difficult to verify that occupancy behavior is the same in test and reference buildings Difficult to ascertain that test and reference buildings technically identical in all respects Values of the parameters can be different even if model is the same Requires calibration phase if previous difference in energy consumption Behavior of occupants in reference building may change if known that they are taking part in an experiment
SIMULATED OCCUPANCY	
Easy to study various occupant behavior effects or to perform parametric studies of its influence on energy use Easy monitoring of the occupancy One building of a kind often suffices for the experiment Retrofit effect separable from weather and occupancy effects Easy to study effects of *standard occupancy schedules*	Loss of information on behavior of real occupants Expensive and difficult to construct schemes for the simulated occupancy Extra cost for purchase or rent of the building If only one building of a kind is used variation of outdoor climate may be limited No information on variation in energy consumption due to varying habits of occupants

accordance with the objectives of the project. Too often, the monitoring hardware is selected first and all possible data are collected for analysis at the end of the project. In addition, the wide range of approaches used and types of data collected for similar projects prevents data exchange. Development and use of protocols based on proven and accepted practices should help alleviate such shortcomings and promote more efficient use of scarce monitoring resources.

An example of the information contained in the standard monitoring protocol is shown in Table 2. Here one can quickly assess the relative merits and drawbacks of different experimental designs. This table should be consulted immediately after deciding to monitor energy use. If the conditions permit only one experimental design, then its drawbacks can be seen in the table. Alternatively, the table can be used as a menu to select the experimental design where none of the drawbacks will interfere with the desired results. To be sure, the protocols still don't design the experiment, but they can save program evaluators from re-inventing the wheel and direct them towards the right kind of experiment (and equipment—see Table 1). ■

Endnotes

1. M.P. Ternes, "Single-Family Building Retrofit Performance Monitoring Protocol: Data Specification Guideline," Oak Ridge National Laboratory ORNL/CON-196, Oak Ridge, TN, June 1987. Also J. M. MacDonald, et al., "A Protocol for Monitoring Energy Efficiency Improvements in Commercial and Related Buildings," ORNL/CON-291, Sept. 1989.
2. R.F. Szydlowski and R.C. Diamond, "Data Specification Protocol for Multifamily Buildings," Lawrence Berkeley Laboratory Report No. LBL-27206, Berkeley, CA, May 1989. Table is adapted from G. Fracastoro and M. Lyberg, 1983.

Acknowledgement

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