The role of site measurement

Measurement of systems performance increases accuracy of analysis and provides basis for determining new energy conservation opportunities

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ANY ENERGY consumption study is only as good as the quality of the input.

The measurement of existing energy system (i.e. any means by which energy is transformed or transferred) performance gives the analyst the best quality of information to perform an evaluation. New opportunities for energy conservation, that would be missed during a visual investigation, can be exposed when skilled site personnel locate the cause of system malfunctions by interpreting unusual readings.

Measurement of the systems can also display systems that are performing below the level adequate to serve the space loads. In these cases, the use of design values in analysis can lead to gross exaggeration of potential energy savings and inappropriate recommendations.

The case study of an energy conservation project at the YMCA in Windsor, Ontario, illustrates the effect of site measurement in the process of an energy study conducted in 1982.

The complex of 64,000 sq. ft. comprises a residence, general offices, meeting rooms, activity rooms, gymnasium, lockers, racquet courts and a swimming pool. One major addition to the residence (1927) had been made in 1977. Thus, this kind of a facility offered various kinds of construction components of different ages, types of HVAC equipment, and functions common to small recreational, commercial and residential facilities.

The primary source of energy used was natural gas for heating, and electricity for cooling and miscellaneous uses.

In this case study, a significant amount of energy conservation potentials were qualified by the measurement process.

Infiltration is probably the most important and elusive element to evaluate in any analysis. The movement of air through a building can, at best, only be retarded in an existing structure. However, by controlling the pressure in a building, costly attempts to seal building joints can be avoided with only a small sacrifice of conditioning additional outdoor air.

Two aspects were considered in this study: component performance and building pressurization.

Measurement of static pressures, supply and exhaust airflows revealed the following:

1. The positive or negative effect of the fan systems on the building pressurization as a whole, and its associated functional zones. An excess or deficiency in the air balance determined the amount of wasted energy required to condition outdoor air.

2. Whether the supply, outdoor and exhaust air flow levels met acceptable standards for current loads.

3. The impact of dirt loads in coils and filters on system performance.

4. Obstructions in the duct system, such as insulation plugs in some exhaust ducts, which had been left behind by roofers, one exhaust backdraft damper corroded in the open position, and a dislodged access door on a supply air duct.

The majority of the facility exterior is windowless with the exception of the residence, which is perforated with 162 double hung, single pane, wood frame windows. These windows were identified as a potential source of significant energy loss by natural ventilation during the initial visual inspection.

To quantify this impact, airflow rates under positive and negative pressures were induced using a variable area flow meter. A sample of three typical window assemblies were sampled at .1, .2 and .3 in.w.c. static pressure differential under three conditions: "as found," frame caulked, and frame caulked and weatherstrip-

ped. The difference in measured airflows could then be used to accurately determine the energy savings.

The resulting graph shown in *Figure 1* indicated that the ASHRAE Standard for double hung window performance was not applicable in this case. The use of this standard for calculations would have resulted in an under estimation of energy savings, and an overestimation of the impact of natural ventilation through the windows on historic energy consumption as a whole.

HVAC

Measurements of the HVAC system can be broken down into air, water and electrical flows.

Flows were measured under "as found" conditions to provide a data base and point of departure for comparisons.

Velocity traverses using an incline manometer are the most accurate method of determining airflows. Where the lack of access, or sufficient length of straight duct exclude its use, direct measurement of airflow at the terminals can be taken using a flowhood, rotating vane anemometer or velometer. Where any system is expected to vary in performance during normal operation, these variations should first be identified, then measured over the range of operation, to assess the true performance. Fan rpm should also be read as a reference for future adjustments to the airflow.

Combustion analysis was performed on heating plants using a CO_2 analyzer and high temperature thermometer. In addition, gas pressures were checked with an incline manometer in the process of evaluating combustion efficiency.

This information was used to assist in the determination of system efficiency, and comparison to space loads.

In the locker area, the "as found" airflows exposed outdoor air levels that were inadequate for ventilation. An increase in ventilation with the accompanying energy increase was required.

Water flows can be determined using flow probes, or a combination of pressure readings at "as found" flow and no flow conditions plotted on a pump curve. These readings indicated whether flows were adequate in the domestic hot water and filtration systems, and lead to energy savings by flow reductions.

The electrical performance of motors in terms of volts, amps, kVA, kW and power factor were directly measured using hand-held devices. Although motors generally operated below normal power factor expectations, replacement was only cost effective when motor burnout occurred.

Variable loads can be measured using various recording tape devices.

Total building wide load variations can be monitored at 15-minute intervals using a Load Survey Package device. These units are available on a monthly rental basis from most large electrical manufacturers or utility companies at 15-minute intervals.

Schedules

The measurement of hourly occupation schedules during a typical week provided a basis for anticipating domestic hot water consumption and

Energy Conservation Measures and Projected Savings

	MCF	kWh/yr
Resetting Air Flows	810	39,700
Revision of Operating Schedule	970	47,000
Window Infiltration Control	590	-----
Others	280	5,777
Total	2,650	92,477

Historic Total Equivalent Consumption: 4,105,520 kWh/yr, 64.2 kWh/yr/sq ft
Projected Total Equivalent Consumption: 3,217,295 kWh/yr, 50.3 kWh/yr/sq ft
Projected Equivalent Energy Savings: 888,225 kWh/yr, 13.9 kWh/sq ft, 21.7%, $15,445

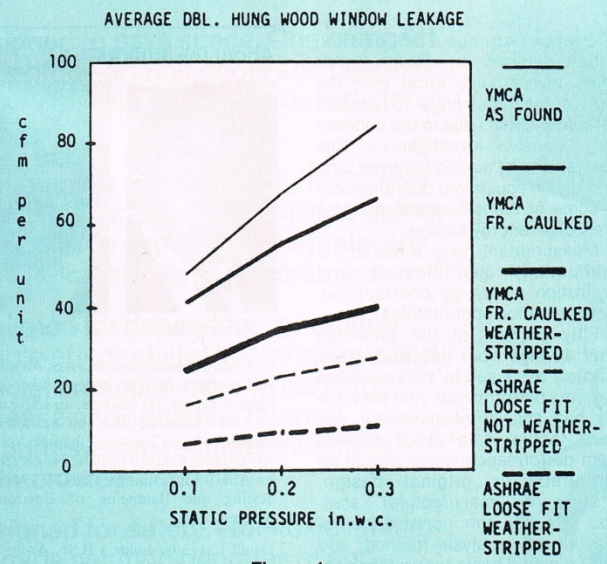

Figure 1

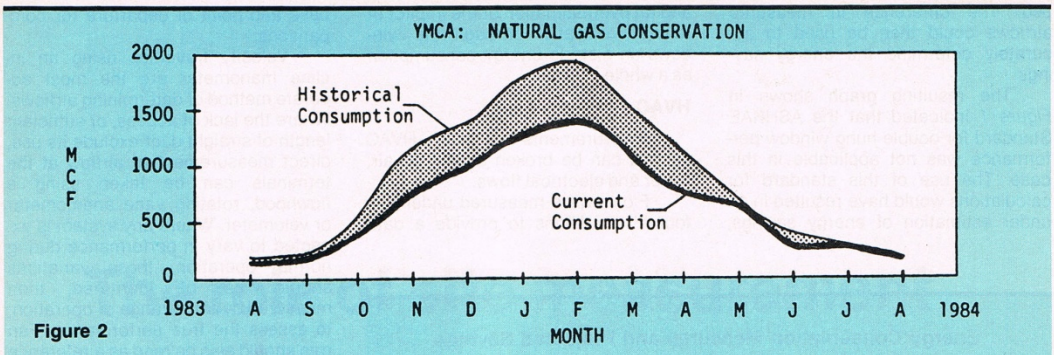

Figure 2

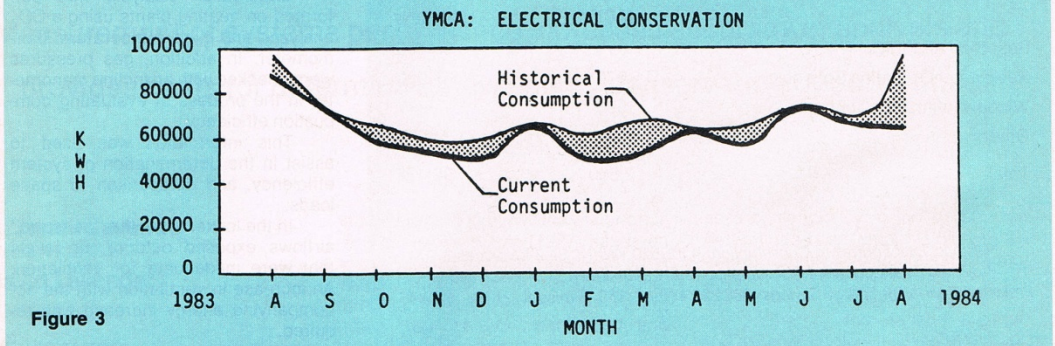

Figure 3

the minimum temperature for storage tanks.

Study results

The single source responsibility for the project included: energy study, implementation of energy conservation measures, and a monitoring/maintenance phase, to ensure the continued satisfactory performance of the equipment during the payback period. Costs for the program were born by the company and repaid through energy savings.

This relieved the client from the burden of a non-budgetary expenditure, and guaranteed that the energy savings would be achieved.

Through this process the potential energy savings were verified for the building as a whole.

The monitored energy savings during the 1.7 year payback period were 25.1 percent for natural gas and 7.1 percent for electricity. A graphic representation on energy consumption for natural gas and electricity are shown in *Figure 2* and *Figure 3*, respectively.

Energy studies of existing facilities demand an equal, if not greater, investigative effort than the design of new buildings to achieve satisfactory results due to the necessity of extensive investigations. The understanding of human behavior, and alterations in equipment operation, are only some of the issues that must be addressed in energy studies.

Measurement plays a role in the identification, quantification and prioritization of energy consumption, and conservation opportunities.

Fifty percent of the projected energy savings from this study were accurately assessed by measurement of systems performance. And the case study has shown measurement can provide factual data about existing system performance which should be substituted for original design, laboratory or manufacturer standards. This data can increase the accuracy of any analysis method, and provide a sound basis for professional judgement in determining energy conservation opportunities. ■

About the authors

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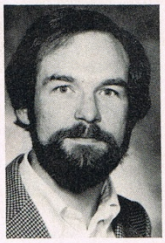

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