ENERGY MONITORING -- OBJECTIVES VS RESULTS

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INTRODUCTION

Universities, hospitals and similar institutions as well as manufacturers and plants have implemented programs of utility submetering. Submetering of utilities is defined as the measurement of energy at or near the point of use as opposed to gross measurement of energy coming into a building or facility. Without exception, the results achieved have met or exceeded expectations. Most of the programs are continuing in an expanding mode. Results of improvements to the utility distribution system can be measured in reduced usage and improved efficiency after submetering is in place. Networking of this monitoring system further enhances information collection and analysis. When other factors such as outside temperature and time of day are included in the data base, an emerging picture of energy usage for an entire facility is developed.

A summary of highlights from several of these programs will be discussed in terms of what has been and is being accomplished. The importance of the commitment of both management and technologists/operators becomes evident as the initial objectives are achieved and expanded to match the innovation and skills of these professionals.

The programs highlighted represent a group of progressive companies and institutions which have joined a "savings club." We are familiar with the savings clubs based on the investment of capital, depending strictly on interest to generate funds for us. The kind of savings clubs to be discussed in this paper joins capital with the more important human element to generate significant savings in deferred energy expenses. Steps necessary to "join the club" are listed and the ingredients of commitment and planning are discussed.

HIGHLIGHTS OF EXISTING PROGRAMS

The following highlights are taken from scores of successful energy monitoring programs. To select just one or two case histories would leave many isolated, however significant, stories untold. Those seeking additional information and documentation have an abundant reference source in addition to those cited by this paper.

At least two Ivy League universities have energy monitoring programs. Both facilities have energy managers who are responsible for efficient utilization of energy (i.e., "holding down the cost"). The managers realized, that in order to implement efficiency improving methodology and measure the results, they had to know the current level of energy use and be able to continuously monitor usage of primary utilities, i.e., steam, chilled water, electricity and natural gas. The challenges the energy managers faced were to justify capital expenditures for monitoring equipment when it was generally accepted that metering did not save energy. The savings do indeed come from changes in piping, equipment and maintenance which are planned to improve efficiency and eliminate waste. The subject of justification of metering programs has been addressed in other papers for those managers currently contemplating such a program.[1, 2, 3]

A stepped approach was taken at one facility. They delivered steam and chilled water to a hospital which was a part of the institutional "family." The energy manager wisely proposed submetering instead of continuing the imprecise practice of allocation of utilities to the hospital on a square foot basis. The success of this approved installation led to the approval for installation of sixty-four (64) metering points providing data to eight flow processors. The networking of these eight flow processors has allowed the manager and others (accounting and plant maintenance) to monitor and analyze information which provides credible accounting of energy usage as well as identifying potential areas for efficiency improvements.

The other university installed its system in a similar fashion. One of the innovative methods of monitoring identified a potential for significant savings. Data was taken for both flow and pressure from steam lines providing heat to a block of dormitories. A clock-driven chart recorder showed that late in the evenings the demand dropped, resulting in high pressures in the pipes in the utility tunnels. The energy (heat) loss was cut significantly by reducing the pressure in these lines during this low-demand period. Perhaps this opportunity would have been identified without submetering; however, the savings would not have been quantified.

Benefits to these institutions are described in terms of "knowing what is going on in the system on a continuing basis" or "submetering paid for itself in six months." Another eastern university's energy manager quantified the saving in steam usage alone as approximately

$500,000 the first year after installation of submetering. This represented a 13% reduction in the university's utility budget.[4]

In identifying losses in a steam system, the most prevalent method is looking for steam vapor. One steam trap was located near a cooling tower and the vapor from the tower masked the vapor from a steam trap which was stuck in the open position. This waste was identified and eliminated because information from steam submeters was utilized by knowledgeable and dedicated operators. Needless to say, the payback on this system was a very short period of time.

Opportunities for saving also exist in monitoring the "invisible" fluids such as air and natural gas. Savings of $50,000/year by averting air and gas leaks with inplant metering have been reported.[5] Accurate metering of natural gas has allowed one plant to pay off investment in metering in just five months. This savings is realized by having information to determine when to switch to another fuel just before the allocation runs out and a higher rate is in effect.[6]

Steam usage information from two similar university cafeterias was compared and analyzed. During the period being studied, the ratio of usage between these facilities ranged between 4:1 and 22:1. This significant discrepancy prompted an investigation which uncovered the fact that the facility with the highest usage dumped cooking steam rather than return it to the condensate receiver as did the other facility. It was also discovered that the big user was injecting raw steam into the building heating air for humidification.[7]

One large manufacturer wisely installed BTU submetering on the chilled water system servicing the main office building complex. This submetering was installed prior to the installation of enthalpy sensor controls on the dampers providing outside air for the air distribution system. Meters were strategically placed so that departmental usage could be accurately determined and efficient usage could be rewarded. Months after installation and trimming, an increase in the energy usage ratio (BTU/sq.ft/degree day) of one exchanger was noted. An investigation uncovered a damper that was "propped" open. A lack of operator training on the damper control was cited as the basic source of the problem. An operator will reduce the complexity of equipment down to his level of understanding.

At the Buick Division of General Motors, an in-plant submetering system for steam, natural gas, compressed air and electricity has helped reduce the energy use per vehicle by 16.7 percent in five years.[8] General Motors has found that using energy meters to measure a manager's performance (and help determine the size of a manager's bonus) promptly produces energy savings of five to ten percent "because a manager is less likely to ignore the energy consequences of his decision".(9) Other very excellent papers which identify the importance of submetering in GM's extensive Energy Conservation Program are included in the references.[10, 11] Most plants have found that to save energy, you have to first know how you are using it. You cannot save it until you can measure it . . . ."[12] This quote is exemplary of the theme of the many papers written on the subject of energy conservation.

Further support for the concept of establishing accountability by accurate submetering comes from a two-year study conducted by Houston Power and Light Company. Two groups of apartment dwellers were monitored. One group's electric usage was metered individually and the individual usage by the other group was determined by allocation of a percent of the total for the group recorded by the master meter. Over the two-year period, the tenants who were accountable for their energy consumption (individually metered) consumed 40% less energy than those who were not accountable.[13]

Medical facilities now include a complex association of separate entities in the same or annexed buildings including hospitals, professional offices, schools, research labs, etc.

Submetering provides the answer to distributing utility costs accurately and continually. Military bases also have a need for accurate accounting of utility usage when different branches or commands are located together.

HOW TO JOIN THE CLUB

The club dedicated to energy saving companies and institutions cited earlier is not exclusive. All that is required of prospects is an awareness on the part of management of the opportunity to save energy in their facility and a commitment to take advantage of this opportunity by establishing and supporting a program to achieve this savings. The progression toward the savings goal should be taken in steps. The sequence to monitoring maturity, from guessing to knowing, is described in Figure 1. Hardware capabilities are expanded in steps until the proper amount and form of information are in place. The important human element then applies knowledge and wisdom which result in more efficient utilization of energy, i.e., savings.

EVOLUTION STEPS FROM AN ALLOCATION SYSTEM TO A FULLY DEVELOPED MONITORING PROGRAM.

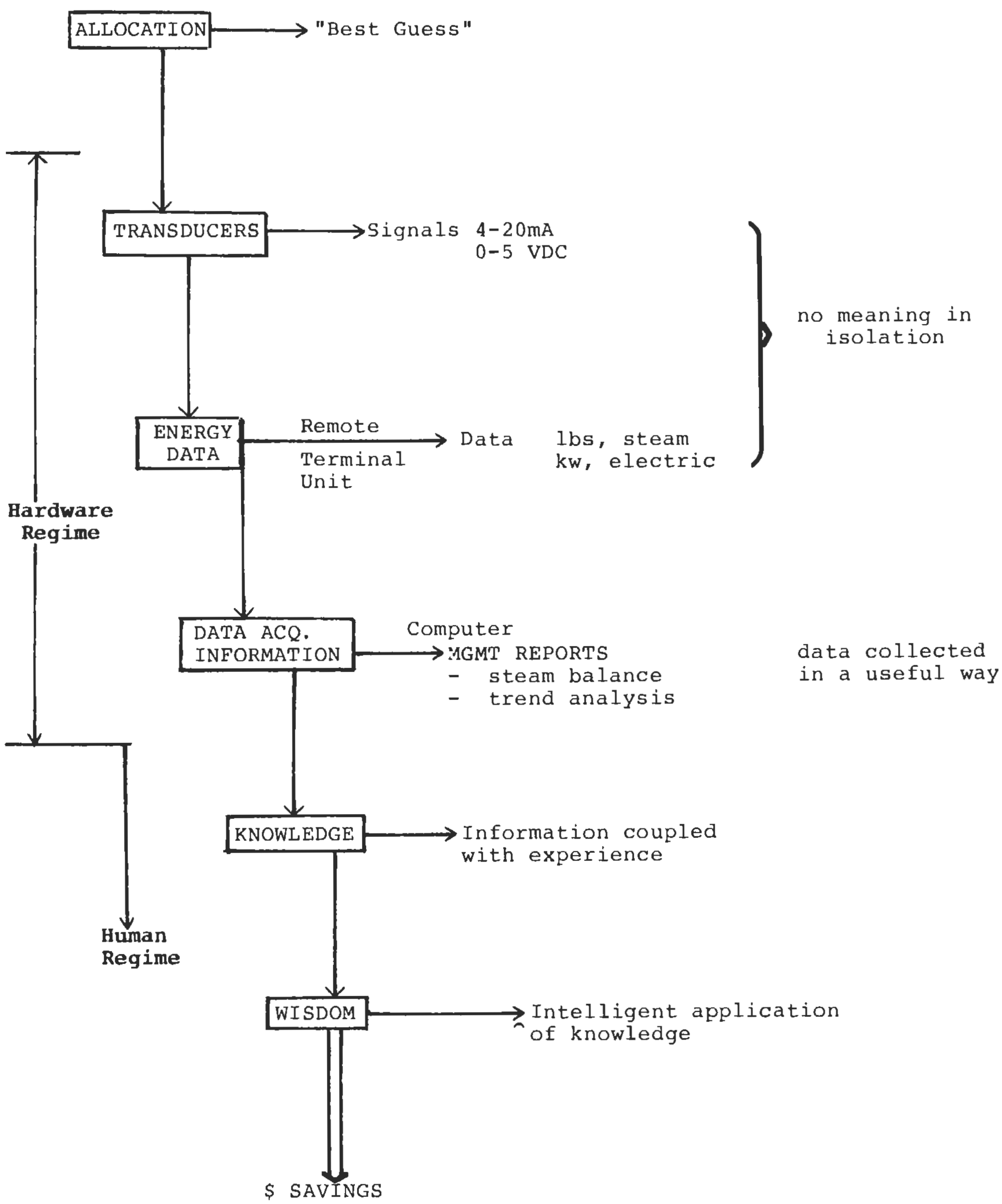

Figure 1.

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The team concept is one of the characteristics that successful programs share. Once the commitment is made and the leadership responsibility is assigned (usually to a technical professional manager) a team or task group is selected from both inside the institution and outside (equipment vendors and if necessary, energy management consultants). Plant engineering, maintenance and operations, as well as system users such as accounting and administration should be represented.

A valued team member will be the equipment manufacturer's representative. These professionals have specialized knowledge and experience that are extremely beneficial at early planning and design stages, therefore, vendor selection should be done very early in the program. Consultants with special knowledge and experiences can also provide very valuable direction in the planning for submetering as well as guidance in the utilization of information collected from monitoring systems.

The technology exists today that meets the most stringent requirements for energy monitoring systems. Flow transducers, remote processing units and central processing software designed specifically for energy monitoring are providing accurate information necessary for balancing energy systems closely. It is no longer necessary to wait on technical advances before implementing a monitoring program.

The selection criteria for the equipment vendor should center around total capability and credibility. Select the best meter available. Many programs have fallen short of final objectives because the meters were selected for initial rough cut objectives and were not capable of providing the accurate information required by the final refined system. Also, select metering that does not have built-in operating cost in the form of a permanent pressure loss. The energy manager of today is more fortunate than his predecessor of a few years ago, because at that time, today's technology was still on the drawing boards or in the testing labs.

The type of program under consideration here is not unlike the planning and implementation of a significant data processing system which many of us have experienced. Having a knowledgeable professional with equipment and capabilities covering all aspects of the project, from primary meters to networking systems and follow-up maintenance, can mean the difference between gathering and analyzing useful information and merely collecting large amounts of isolated data.

Since each institution/facility has different requirements, the first task should be to state precisely what objectives the program is expected to achieve. This exercise can prevent over-designing or under-designing the system. Projects whose completion is noted with the observation "What do we need all this for?" are less rewarding than those ending with "Why didn't we do more?" The flexibility and modular design of advanced monitoring equipment allow expansion and "add-on" in steps usually without interruption of operations.

Typical questions which should be answered early in the planning stage are:

- o What types of utilities are we interested in monitoring -- steam, chilled water, heated water, natural gas, domestic water, electricity, etc.?

- o How will the information from the monitoring system be utilized to improve efficiency (reduce cost) and improve service to client/customer -- identifying defective equipment, identifying wasteful practices, pinpointing piping modifications not previously documented, reduce down-time, etc.?

- o At what distribution level do we need to monitor -- building, floor, department, generating unit, etc.?

- o Who will use the information developed -- accounting, maintenance, management, operations, etc.?

- o What type of information will be required by each function -- mass flow, heat flow, system status (faults) system configuration, history (for billing and trend analysis) etc.?

- o What form will the information be required in by each function -- printed reports, analog/digital signals, communication interface to PC's (RS-232) local readout, etc.?

- o What features related to equipment selection are required -- installation without interruption of operations, wide range of data values, energy efficient meters (no permanent pressure loss) uniform meter design (one meter for all line sizes) capabilities of vendor personnel (metering experts) etc.?

- o What system, equipment, etc., currently exists that can be incorporated into the program by interfacing?

- o Who will be responsible for operation and maintenance and how will they be trained? Meters often become the responsibility of individuals who are not metering experts. Should contract servicing be considered?

A planning process that will provide the answers to questions including those listed will result in objectives that can be targeted by the program. The monitoring program will, by definition, provide the information necessary to determine if objectives were achieved, even though, in today's rapidly changing environment, the objectives are likely to be moving targets.

GETTING STARTED IN THE REAL WORLD

A major challenge facing the team and its leadership is to bridge the gap between a "blue sky" approach and the real world. The active participation by administrative personnel and other policy makers will greatly improve communication and understanding between management and operations. "Energy conservation is 95% management and 5% technical."[2] As previously discussed, the technology is in place and the opportunity for saving exists. The major effort in installing an energy monitoring program is overcoming the organizational inertia which is an obstacle to many new ideas and philosophies.

The opportunity for savings does exist. The situations described earlier did occur and to some degree are prevalent in many facilities today. The payback from installing a monitoring system will be great for those facilities with significant problems. For those fortunate enough to have only minor problems, the payback is knowing that the facility is and, most importantly, will continue to run smoothly and efficiently.

The sequence to monitoring maturity is defined in steps. The first step in any effort is normally the most difficult -- getting started. Do not allow an averaging type allocation system to rob you any longer of the knowledge that an exceptionally efficient facility (manager) may exist unrecognized or that an inefficient facility exists unidentified, representing an opportunity for significant savings.

REFERENCES

1. Hayes, J. W. and J. J. Rusnak. "Use Meters to Put Teeth into Your Conservation Program," Proceedings of the 1980 Conference on Industrial Energy Conservation Technology. Vol. 1, p. 356, April 1980.

2. Rusnak, J. J. "You Can Justify Meters for Your Energy Conservation Program," Proceedings of the 1981 Industrial Energy Conservation Technology Conference. Vol. II, p. 755, April 1981.

3. Turner, W. C. and Case, K. E. "Economic Analysis of Energy Proposals," Proceedings of the Fall Industrial Engineering Conference, Houston, Texas, November 1979.

4. Wisch, A. J. and Porter, P. E. "Slashing Steam Use At Carnegie-Mellon University," Sixth World Energy Congress, Atlanta, Georgia, 1983.

5. Johnson, R. S., Jr. "Plant Saves $50,000/Year By Averting Air and Gas Leaks With In-Plant Metering," Chemical Processing, Mid-November 1977, pp. 121-123.

6. "Metering", Modern Industrial Energy, November 1980, p. 13.

7. Foster, A. L. "Information Gathering for Energy Management," Presented at the AIPE National Conference, 1980.

8. Brandt, C., "Accountability Promotes Conversation," Power, September 1978, pp. 78-81.

9. "Keeping Tabs on Energy Flow," Business Week, August 13, 1979.

10. Kelly, R. L. "Energy Responsibility Accounting -- An Energy Conservation Tool for Industrial Facilities," Proceedings of the 1980 Conference on Industrial Energy Conservation Technology, Houston, Texas, April 13-16, 1980, pp. 718-724.

11. Kelly, R. L. "Nothing Is Constant But Change," Proceedings of the Sixth Annual Industrial Energy Conservation Technology Conference and Exhibition, Houston, Texas, April 15-18, 1984.

12. Haft, A. J. "Why Energy Audits Aren't Enough -- An Energy Management System Is Required," Proceedings of the 1980 Conference on Industrial Energy Conservation Technology, Houston, Texas, April 13-16, 1980, pp. 466-473.

13. Murnane, T. "California College System Sets Energy Goals," Energy User News, February 25, 1980, p. 1 ff.