LBL-33934
UC-1600

The Use of EMCS in Building Monitoring: Experience From Energy Edge and LoanSTAR Programs

April 1993

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This work was jointly supported by the Bonneville Power Administration, the Texas Governor's Energy Office (as part of the LoanSTAR Monitoring and Analysis Project, through Texas A&M University), and the Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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ABSTRACT

Monitoring building energy performance can provide important immediate feedback to building personnel in building commissioning, operation and maintenance. It also provides an essential ''reality-check'' and feedback (immediate and longer-term) in many utility efforts such as demand-side management impact evaluation, forecasting, and conservation measure technology assessment. However, monitoring can be quite expensive, often resulting in either the need to reduce experimental sample sizes (with resulting reduced accuracy) or to forgo monitoring altogether. Analysis of data from in-place Energy Management and Control Systems (EMCSs) may be an effective alternative to dedicated monitoring in many cases. EMCS-based monitoring can have several advantages: reduced cost due to the fact that the equipment has already been purchased and installed, an increased amount of available data, information on building operation, and an on-site data processing capability.

The use of EMCSs for monitoring has been investigated at several sites within two different conservation programs: the Energy Edge Evaluation Project (new construction), and the Texas LoanSTAR Monitoring and Analysis Program (retrofit). The text that follows provides an overview of the potential role that EMCS-based monitoring may play in conservation efforts, and a summary of the findings of these investigations. The presentation at the *National Conference on Building Commissioning* will provide greater detail on the experiences with EMCS monitoring in the two conservation programs.

POTENTIAL USE OF EMCS

Monitoring the energy performance of buildings plays an important role in many different efforts:

- by providing short-term diagnostic feedback to building operations staff during commissioning of buildings or conservation measures;
- by providing longer-term operational feedback to building operations staff over the lifetime of a building or conservation measure, in order to improve operational control;
- by measuring energy savings to support impact evaluation of demand-side management and other conservation programs;
- by providing a detailed baseline for use in energy forecasting and program planning;
- by satisfying the verification requirements in third-party financing, shared savings, and demand-side resource auction contracts;
- or by providing a "reality check" in almost any type of energy conservation measure technology assessment.

However, effective monitoring can be quite expensive, often costing thousands of dollars for each point monitored, for equipment (sensors, wiring, dataloggers), installation, and testing of the data acquisition system. All of this required equipment is likely to be present at a site in the form of an EMCS. It would seem advantageous to make use of it in a monitoring project.

In many cases, an EMCS can collect the same information that would be collected by a dedicated data acquisition system. In order to implement demand limiting strategies, most systems are capable of monitoring whole-building demand. Retrofit energy savings can often be estimated from before and after whole-building energy data collected by the EMCS. The consumption should be normalized for factors such as weather and building operation, and often these contextual factors can also be monitored by the EMCS. In some cases, an EMCS will be configured to enable direct monitoring of end-use energy consumption, although this is less common.

In addition to mimicking the monitoring capabilities of dedicated data acquisition systems, part of the power of EMCS-based monitoring comes from the different data and computing capabilities that it offers. Hundreds or thousands of data points are often accessible in an EMCS. Since there is usually a sophisticated microcomputer present on site, the EMCS could be used not only as the source of raw data, but as a tool to carry out the data analysis. The EMCS also has access to a different type of data—operational data—since it is controlling the building. Using this type of information, along with the monitored energy consumption, it might be possible, for example, to evaluate the performance of individual energy conservation *measures,* rather than monitoring the energy consumption of *end uses.* The operational data would also be useful for validating estimates made during building audits, or for providing clues needed in calibrating simulations to match measured consumption.

Beyond this usefulness to building researchers, the EMCS should be able to provide information useful to the on-site personnel in operating the building. For example, the on-site processing capabilities of an EMCS would enable the system to provide immediate feedback to the building

operator on the performance of energy conservation measures, and to compare that performance to the designed values. The system could also calculate energy consumption targets that were specific to the current operating conditions and objectives, in order to allow operators to assess the building's current status.

INVESTIGATIONS OF EMCS-BASED MONITORING

In order to evaluate the use of EMCSs for monitoring in support of energy savings estimations, several EMCS installations within two different conservation programs have been investigated:

- *Energy Edge Evaluation Project.* Energy Edge is a $16 million research-oriented demonstration program in the Pacific Northwest, sponsored by the Bonneville Power Administration (see Diamond et al. 1992). The program included a design competition, leading to the construction of 28 new commercial buildings, which were designed to consume 30% less energy than they would have, had they simply been built to the regional building code. The energy savings of these buildings is evaluated by using monitored end-use energy consumption to calibrate as-built DOE-2 simulations, and comparing these results to an assumed base case that is identical except for the absence of the identified energy conservation measures. Of the 28 buildings, seven were large office buildings, five with EMCSs installed as energy conservation measures. The EMCSs in these buildings are currently being investigated, and their potential use in supporting the evaluation efforts is being explored. These five large offices with EMCSs are summarized in Table 1. In one of these buildings, the EPUD Headquarters, the output of several EMCS sensors is monitored using the dedicated data acquisition equipment. The points thus monitored are equipment status, duct temperatures, zone temperatures, mass temperatures, and lighting levels.

- *Texas LoanSTAR Monitoring and Analysis Program.* LoanSTAR (Loan to Save Taxes and Resources) is a $98.6 million revolving loan fund established by the Texas Governor's Energy Office, with money from Texas' oil overcharge funds (see Claridge et al. 1991). Loans are made available to fund energy conservation retrofits in state, public school and local government buildings. The energy consumption of each loan recipient is measured before and after installation of the retrofit, and savings are estimated after accounting for the effects of weather and changes in operation. Monitoring ranges from whole-building utility billing data to detailed sub-metered data. Many of the sites in the program had EMCSs, and expansion of the EMCS was often one of the retrofit measures included in the loan. Five of the sites have been investigated in order to evaluate how the EMCSs might be used to collect information for the savings analysis (see Heinemeier and Akbari 1993, Heinemeier et al. 1992). These five sites were two college campuses, two medical research buildings, and a government office building complex. These sites are summarized in Table 1. The buildings from which data were collected, on a trial basis, are indicated with a "*".

Throughout this work, several limitations became apparent. First of all, it is often somewhat awkward to use EMCSs for monitoring. There is no inherent reason why they would not be capable of monitoring, but often systems are not programmed to do so, and are not sufficiently flexible to be easily reprogrammed. Small changes in the design of the systems would greatly enhance their capabilities for collecting data. Secondly, each site must be evaluated individually. It is difficult to generalize on EMCS capabilities, due to differences in model characteristics, installed functions, and the degree of system utilization. It is also difficult to assess EMCS capabilities, because the EMCS operator often lacks the information, resources, and incentives to

Table 1. Characteristics of Buildings and EMCSs in Studies

		Location	EMCS Description	Size	Energy-Efficiency Measures
	Texas LoanSTAR:				
*	Prairie View A&M	Prairie View, TX	Johnson Controls *JC/85/40*	46 bldgs.	Efficient chiller, VSD pumps, Pump controls, Steam leaks, Lighting
*	Texas Tech	Lubbock, TX	Honeywell *Delta 1000*	811,000 ft^2	Pump controls, VSD fans, Economizer, Steam leaks, Night setback, Lighting
*	UTSMC	Dallas, TX	Landis & Gyr Powers *System 600*	23 bldgs.	(dropped from program)
*	Texas A&M	College Station, TX	Landis & Gyr Powers *System 600*	200 bldgs.	VSD pumps, VAV, Lighting
	State of Texas Capitol Complex	Austin, TX	Teletrol *Integrator 286*	42 bldgs.	
	Energy Edge:				
*	EPUD Headquarters	Eugene, OR	Barber Colman *(custom)*	25,000 ft^2	Night Flushing, Structural Storage, Envelope, Lighting
	Bellevue Place	Bellevue, WA	Trane *Tracer 1000*	389,000 ft^2	Cool storage, Low temp. supply, Heat recovery, Economizer,
	Director Building	Portland, OR	Simplex *2120 Multiplex*	80,000 ft^2	Water-loop heat pump, Envelope, Lighting
	Montgomery Park	Portland, OR	IBX-2000 *(custom)*	783,000 ft^2	Heat pump, Lighting
	Gateway Tower	Seattle, WA		1,090,000 ft^2	Efficient motors, Efficient chiller, Heat pump, Fan/pump optimization, VAV, Envelope, Lighting

* EMCS has been used to collect data.

provide the necessary assistance in this assessment. In order to address these difficulties, a set guidelines have been drafted to aid the building researcher in evaluating the use of EMCS for monitoring, and for carrying out that monitoring (see Heinemeier and Akbari 1992). Thirdly, there are often operation and maintenance problems with the EMCS itself, which can affect its ability to collect data. For example, in the Energy Edge buildings studied, there were problems with sensor location and calibration, improper programming and programming that was far too complex, disabled controls for daylighting, overridden scheduling control for heat pumps, and equipment that was not tied into the EMCS as originally anticipated. These issues point out the importance of commissioning EMCSs. It is even more important if the EMCS is to be used for monitoring building performance. One final conclusion, however, is that it *is* possible to use existing EMCSs to collect data on building energy performance. In most cases, we were able to obtain data without installing any hardware or software. This technology works, and it may hold even greater promise in the future.

ACKNOWLEDGEMENTS

This work was jointly supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Technologies, Building Systems Division of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098, and by the Bonneville Power Administration. Earlier work on the Texas LoanSTAR Monitoring and Analysis Program was sponsored by the Texas Governor's Energy Office. I would also like to thank Hashem Akbari and Mary Ann Piette for their participation in the work.

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