Use of an Information Monitoring and Diagnostic System to Improve Building Operations

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ABSTRACT

This paper discusses a demonstration of a technology to address the problem that buildings do not perform as well as anticipated during design. We partnered with an innovative building operator to evaluate a prototype Information Monitoring and Diagnostic System (IMDS). The IMDS consists of a set of high-quality sensors, data acquisition software and hardware, and data visualization software, including a web-based remote access system that can be used to identify control problems and equipment faults. The IMDS allowed the operators to make more effective use of the control system, freeing up time to take care of other tenant needs. The operators report observing significant improvements in building comfort, potentially improving tenant health and productivity. Reduction in hours to operate the building are worth about $20,000 per year, which alone could pay for the IMDS in about five years. A control system retrofit based on findings from the IMDS is expected to reduce energy use by 20 percent over the next year, worth over $30,000 per year in energy cost savings. The operators recommend that similar technology be adopted in other buildings. While the current IMDS is oriented toward manual, human-based diagnostic techniques, we also evaluated automated diagnostic techniques. Strategies for utilizing results from this demonstration to influence commercial building performance monitoring for commissioning and operations will be discussed.

Background

Buildings rarely perform as well in practice as anticipated during design. There are many reasons for this, including improper equipment selection and installation, lack of rigorous commissioning and proper maintenance, and poor feedback on operational performance, including energy performance. A recent evaluation of new construction commissioning found that 81 percent of the building owners surveyed encountered problems with new heating and air conditioning systems (Hagler Bailly Consulting, 1998). Another study of 60 buildings by LBNL (Piette, et al, 1994) found that half were experiencing controls problems, 40 percent had HVAC equipment problems, 15 percent had missing equipment, and 25 percent had energy management systems, economizers, and/or variable speed drives which were not functioning properly. Such problems are widely reported in the building commissioning literature (PECI, 1998).

Systematic procedures to address these problems are beginning to emerge. For example, research at Texas A&M University has found that in almost all older buildings, and even in many new buildings, the use of the building is quite different from the original plan (Claridge, et al., 1998). These researchers use a monitoring process of “continuous commissioning” to tune building systems for optimal comfort and peak efficiency based on current operational requirements. Their methods have saved an average of over 20 percent of the total energy cost (over 30 percent of the heating and cooling cost) in over 80 buildings (Claridge, et al., 1998). While these researchers have demonstrated success in bringing in experts to "fix" building systems, few tools are available to the on-site engineer to conduct such improvements.

A related problem is that EMCS's are becoming more complex over time and are difficult for the average operator to understand (Hyvärinen and Kärki, 1996). Furthermore, most EMCS's do not include energy monitoring in their scope. Building operators have only the monthly utility bill to help track how much energy is used. One study that supplied building operators with energy use data found that after a few months of strong enthusiasm, building operators lost interest in standard energy use plots provided by the utility research project (Behrens & Belfer, 1996). Building operators need assistance in sifting through the large volume of data available with new monitoring technologies. Current EMCS's have limited capabilities in collecting, archiving, and displaying important building performance data.

Project Objectives and Approach

The broad goal of this multi-year project is to develop, introduce, and evaluate state-of-the-art information technology by continuously improving operations and maintenance (O&M). This project involved both market pull and market push goals to accelerate the adoption of the technology. Both of these goals include some market assessment activities. In the market pull area, the research team seeks to evaluate the decision-making process by building operations staff and understand what motivates them to accept or reject new technology. By advancing state of the art technology, we hope to help push the market toward greater overall performance. Further, we intend that our work will facilitate future market-pull initiatives by illuminating the decision-making criteria and processes of building operations staff. A final technical goal is to develop strategies that advance the technology from a passive monitoring system to an automated diagnostic system, taking advantage of emerging computational capabilities.

This paper presents a summary of the overall concept and findings from the use of a sophisticated Information Monitoring and Diagnostic System (IMDS) at 160 Sansome Street in San Francisco. Two companion papers describe additional elements of the project. Haves and Khalsa (2000) review automated fault detection methods in general, and present a specific case study of chiller modeling at the IMDS test site. Shockman and Piette (2000) summarize results from the analysis of the decision making processes and technology innovation and adoption issues relating to the IMDS.

This project was carried out in three phases. Phase One, conducted during the mid-1990s, included an investigation and evaluation of diagnostic methods, tools, and techniques (Sebald and Piette, 1997). Our analysis considered issues such as sensor and communications technology, bottom-up versus top-down diagnostics architecture, and the design of temporary versus permanent systems. We examined the status of techniques from the field of intelligent systems (e.g., artificial intelligence, fuzzy logic, and neural networks) and diagnostics used in process control industries. We identified innovative building operators and chief engineers in major metropolitan areas who were recruited to give us direct feedback on what they thought were the most serious problems in commercial buildings. The interviews concluded that there was no single outstanding problem that would define the priority area for diagnostics research. Rather, the problem was related to a lack of good information about the performance of their building overall, and the problem of poor information from the EMCS.

During Phase Two, the operations staff and the building were selected for a case study, and the system design was finalized and installed. A review of the building energy use and initial findings from the IMDS during Phase Two are reported in Piette et al. (1998). The IMDS began monitoring in May 1998. The building staff began using the system on a daily basis in late Summer, 1998.

The third phase of the research project began with the commissioning of the monitoring system. Data quality was assessed on a regular basis and building staff were interviewed biweekly to determine how the IMDS was used. A series of problems were indentifed and corrected, and several upgrades to the software and data acquisition system were performed. The most important upgrade was the addition of a graphical "bookmarking" capability within the data visualization software, which was well received by the operators and increased their usage of the system. A detailed analysis of the building's historical energy use was conducted to determine if any energy savings were achieved during the project time period. A specification for the IMDS is available on the web at http://poet.lbl.gov/tour/. Data were collected from May 1998 through December 1999.

IMDS Characteristics

The IMDS consists of a set of high-quality sensors, data acquisition software and hardware, and data visualization software, including a web-based remote access system. The IMDS is a prototype system in that we have deployed a unique combination of sensors, hardware, and software to examine its value in a controlled test. The system could be built up from individual components and installed in any commercial building. It is, however, a high-end system, intentionally designed for reliability, accuracy, and speed in data acquisition, archiving and retrieval.

The IMDS is oriented toward deploying the basic infrastructure for an advanced information system. This demonstration will allow the controls industry to examine the value of such systems that greatly exceed today's current EMCS technology. Such a system is the starting point for more advanced, automated, diagnostics, such as model-based or knowledge-based systems. The system is a distributed data collection and analysis system. The primary elements of the system, as installed in this project, are:

- A monitoring and data acquisition system that measures 57 physical and 28 calculated points using high-quality sensors, including points typically not available from an EMCS
- A PC that stores the data, runs the data visualization software (Electric Eye) and provides the onsite staff direct access to the data.
- An ISDN line connecting the system to the remote researchers and the Internet
- A web server hosting a real-time analysis tool that has a subset of the data visualization capabilities of the on-site system

The IMDS development in Phase One included creating nine standard plots available for viewing of key performance data. The operations staff was trained to interpret these plots. The IMDS also offers a series of more sophisticated browsing and statistical analysis tools, some of which may be of greater use to remote researchers. The PC server offers a subset of the real-time analysis graphics from the demonstration site to the public over the World Wide Web. The purpose of these graphics is to demonstrate the technology to interested organizations and potential service providers such as energy service companies, utilities, and control companies.

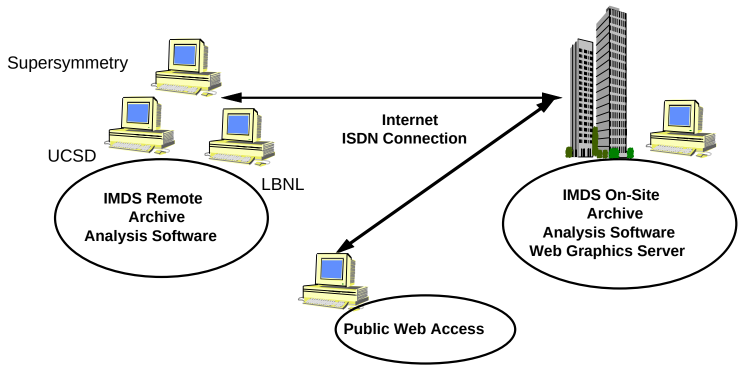

Figure 1. Components of the Information and Monitoring Diagnostics System. LBNL, UC San Diego, and the Supersymmetry Group received and reviewed data.

Four types of measurements are taken by the IMDS: temperature (including wet-bulb), electric power, flow speed, and pressure. The sensors include high quality thermistors, electric power transducers, magnetic flow meters, and aspirated psychrometers. Table 1 summarizes the monitoring scope. Further details of the sensors and sensor accuracy are presented in Piette et al. (1998). There were only three points of the IMDS that were also available from the EMCS: outside air, supply air, and return are temperatures.

Table 1. Systems and Sensors in the IMDS

System to be evaluated	**Measurement**	**Number of physical points**
Whole building	Electric power	1
Two chillers	Differential pressure (water) Water temperatures Flow rates (water) Electric power	4 8 5 2
Four pumps	Differential pressure (water) Electric power	4 4
One cooling tower	Drybulb temperature Wetbulb temperature Water temperatures Electric power	2 2 6 2
One air handler	Drybulb temperatures Electric power Static pressure	5 2 4
Local micro-climate	Drybulb temperature Wetbulb temperature	1 1
Miscellaneous (lights & plug)	Electric power	4
Total		57

The IMDS is designed to be permanently installed and continuously active. This is necessary because buildings continuously change. For example, some problems recur, such as those from modifications to schedules to handle special events. These modifications often lead to equipment being left on when not needed. The diagnostic system is designed to operate in parallel with an existing EMCS, rather than expanding or modifying the EMCS. The IMDS is therefore not constrained by EMCS data collection capabilities, which can be problematic with 50 points of one-minute data. This technology may, however, be incorporated in future EMCS's. The EMCS at 160 Sansome Street, our pilot demonstration site in San Francisco, focuses on scheduling and controlling building HVAC systems including air temperatures and flows and monitoring zone conditions. By contrast, in this installation, the IMDS measures energy, weather and water-side variables (temperatures, pressures, and flows).

Results

There have been three primary benefits of the IMDS at 160 Sansome:

1. A dramatic improvement in the understanding and use of the existing control system, resulting in greater automation of the controls and a control redesign which is expected achieve significant energy savings in the future.
2. A reduction in complaint calls and improved comfort, which increases tenant satisfaction and productivity.
3. Extended equipment life from reduced short cycling, which is a result of the improved control and reduction of air in the chilled water system.

The project has successfully demonstrated a new technology that was extremely useful to the building operations staff at 160 Sansome in evaluating the building's performance. The building operators perceive significant improvements in the performance of the building. These include improvements in control, reduced comfort complaints, and the identification of significant energy savings. The IMDS has been useful in identifying problems at the building that are related to problems inherent in the control techniques and systems themselves. These include the use of outdate technology, such as the EMCS's 286 PC with limited capabilities, which had Y2K problems. No further investments in the old software were considered viable. The chillers used thirty-year old pressure-electric controls with coarse control, limiting the ability to do any temperature reset control for energy efficiency. Seasonal steam control also required manually switching piping to use different valves during winter and summer. Furthermore, the fan VFD was operated by a separate controller. The older EMCS was unable to support integration of these separate systems.

Such problems can only be remedied with an EMCS retrofit, which is scheduled to begin this year. The IMDS has played a major role in designing the retrofit. The new EMCS will be required to perform functions similar to those that the IMDS provides. The following are features requested by the technical director for the new control system:

1. Abandonment of the "trend log" metaphor, replacing it with a "data archive."
2. A graphical interface that is not a picture of a fan or chiller system with readings attached, but is, instead, an x-y graph of system data; data to be selected "on-the-fly" by the operator.
3. Remote system access by any web browser, as opposed to dial-up software supplied by the vendor, or general-purpose remote access software.

There have not been significant energy savings to date. While we have not met the 15 percent savings objective, we have identified more than 15 percent in energy savings that could be achieved if the controls were properly functioning. The operations staff estimates they could reduce steam use by 50 percent, as shown in Table 2. They also expect chiller plant energy savings from reduced reheat. The original estimate from the operations staff was that the reduction in steam use would be similar in magnitude to chiller savings. For every British thermal unit (Btu) in steam savings, there would be an equivalent reduction in chiller energy. This estimate is approximately equivalent to the current chiller energy use based on a simple efficiency of one kilowatt per ton (kW/ton). We have simplified the assumption to estimate savings equivalent to about half of current chiller energy use.

Table 2. Predicted Savings from the Proposed Control Retrofit

	Current EUI (kBtu/sqft-yr)	**Predicted Savings (%)**	**Savings (kBtu/sqft-yr)**
Steam	36.9	50	18.5
Electricity	55.6	2.5	1.39
Total	92.5	22	20.0

Note: Energy Use Intensity (EUI) is based on 92,000 square feet of net rentable floor space. Total gross floor space is 100,000 square feet.

Table 3 lists the seven most significant problems identified and remedied in 1998-1999, including the data used, the resolution of data needed, and the primary benefits of the correction. The most significant correction has been the adjustments to the morning warm-up and supply air control. Prior to the IMDS, the operators had little feedback on the dynamics of the HVAC equipment. Because of a lack of understanding of the EMCS, the supply air was actually being controlled from the return air temperature. Only after more than six months of careful examination of IMDS data did the operations staff begin to understand how the controls actually functioned. While this may seem surprising, it is actually fairly common within the buildings industry that building engineers defeat and work around control systems that they do not understand. There were no drawings of control logic explaining how the controls worked.

Table 3. Problems Identified and Remedied with IMDS

Problem description	Date Discovered & Fixed	Which data used	Resolution needed	Benefits
Chiller false-start correction	D: 2 May 98 F: Over year	Chiller kW, Tons, Cooling Plant kW	1 minute	Avoiding false loading which could cause major chiller failure
Air in pipes	D: 1 Sep 98 F: 10 Sep 98	Flows, Tons	15 minute	Flow changed from 320 gpm to 580 gpm for Chiller 2, coils not starved now, improve pump life
Exhaust air re-circulating to towers	D: 16 Nov 98 F: 16 Nov 98	Return Air, Tower DB Temp	15 minute	Improve tower kW/ton
Morning warm-up tuning	D: Jan 99 F: Mar 99	Supply, Mixed, Return Air Temp, OSA	1 minute	Extend actuator life, improve comfort
Supply air tuning	D: Jan 99 F. Jun 99	Supply, Mixed, Return Air Temp	1 minute	Extend actuator life, improve comfort
Reduced fan power oscillations	D: Feb 99 F: Mar 99	Supply & Return Fan kW, Supply Air Temp	1 second & 1 minute	Tightened belts to extend fan life, improve control and comfort
Reduce dual-pump operation	D: Oct 98 F: Mar 99	Pump kW, Tons, Chiller kW	15 minute	Reduces energy use, extends pump life

The result of these control improvements has been a reduction in complaint calls. The building operator initially reported that complaint calls had been reduced from twenty to three per month. We followed up on this claim by compiling 16 months of complaints logged between December 1998 and May 1999. The data showed that the number of complaints varied from three to 21 per month. We did not see the reduction that was reported by the on-site staff. After showing these data to the operations staff we were informed that not all complaints were logged. Although we do not have concrete evidence from the complaint logs to support the belief that the building is more comfortable, the building management staff is confident that complaints have been significantly reduced.

It has become quite clear over the last year that there are significant problems with the chilled water plant controls. The chillers often operate for short periods of time, cycling too frequently and the cooling tower controller is often unstable. Lead-lag switching of the chillers to balance the run time and provide failure redundancy is hard-wired into the control system.

As mentioned, in addition to the energy savings opportunities identified, the IMDS has been used to improve the use of the existing controls. The operations staff estimates that the operator spends significantly less time operating the building because the current system is now as fully automated as possible. The IMDS has freed up time to provide other services to the building tenants. The staff estimates a reduction of labor-hours of about 20 percent, equivalent to about to about 416 hours per year, or about $20,000 per year. The operations staff can pursue other activities that provide value to the building, including billable tenant services. One significant activity that has occurred as a result of the additional time for operations is balancing of the air system. The operations staff has balanced the air-flow on each floor, which has contributed to the improved comfort and decrease in complaint calls. A $20,000 per year savings from the IMDS is equivalent to a five-year payback on O&M

savings independent of the forthcoming energy savings. Furthermore, comfort improvements may have significant effects on the productivity and health of office workers in the building (Fisk and Rosenfeld, 1997).

The importance of sensor accuracy is related to what one does with the data. The data have been most directly valuable to the operations staff in tracking and evaluating how the controls function. In general, most of the problems identified and remedied by the operations staff could have been diagnosed using lower-quality sensors. Identifying most of the problems did require the high-frequency (one-minute) data archive. Piette, et al. (1998) provides a detailed discussion of the IMDS sensor and calculated point measurement accuracies for full and part load conditions.

Figure 2 shows a problem with chiller cycling that would not have been detected without one-minute data. The problem occurred after a service technician made some modifications to the chiller inlet vane control. Figure 3 shows the same data using 15-minute average data. The building operator believed this graph represented normal operation. He further commented that he would have found the cycling problem the next day, but that would have been too long given the severity of the cycling. That is, such cycling could have destroyed the chiller had it continued for a few days. This was a new graphic for the operator, but he had grown accustomed to looking at such data with the IMDS. This is one example of how the IMDS was used to check the building HVAC systems following a visit from a service technician.

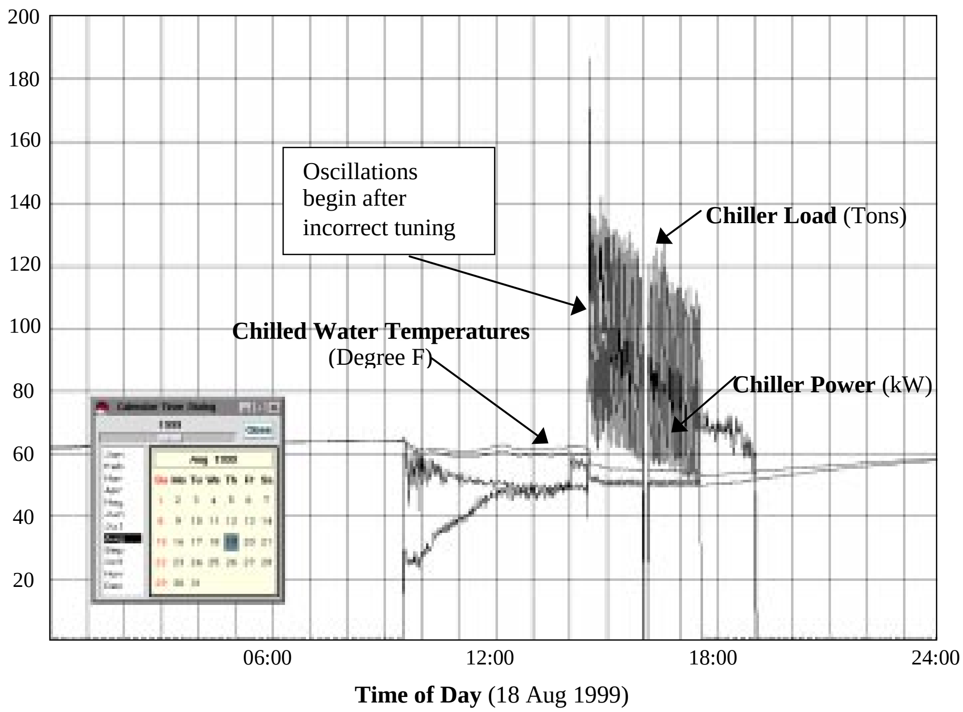

Figure 2. Oscillations viewed with 1-minute data.

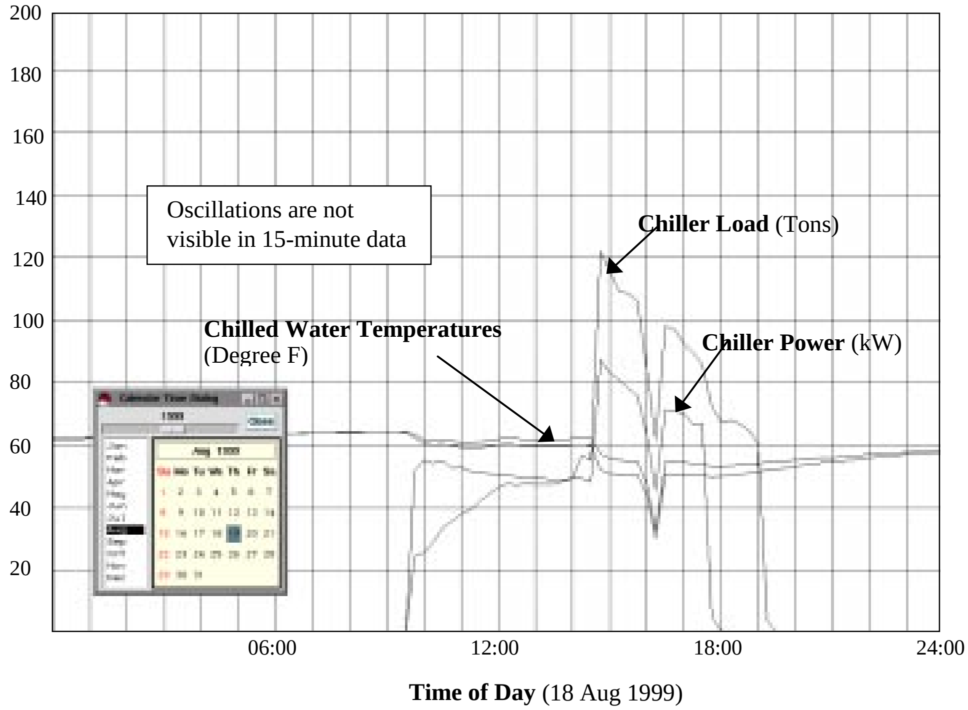

Figure 3. Oscillations not apparent using 15-minute data

Evaluate Costs and Economic Potential

During Phase Two, the IMDS was installed for about $63,000, including hardware, software, and one year of ISDN service (Table 4). The cost of the installation of the sensors on the site was self-reported by the building staff at $23,000 to $25,000. We believe the managers at the building have paid for some of the costs by "bolting the costs" on to other items. A 50 percent increase in the system cost to allow for sensor installation results in a total cost for hardware, software, and installation of about one dollar per square foot.

Table 4. Information Monitoring and Diagnostic System Prototype Costs

System	**Cost**
Data acquisition system (EnFlex®)	$8,535
Computer system	$3,938
Sensors	
Cooling system	$31,860
Air handlers	$5,784
Building power	$3,916
Sensor Total	$41,560
Networking (ISP and 1 year of ISDN)	$8,912
Grand Total	$62,945

The on-site staff has shown great interest in the overall system, but are not inclined to support the use of high quality sensors used in the demonstration. They are, however, interested in the power and flow measurements available from the system, which are rarely available from an EMCS. Power measurements from dynamic systems, such as fans, chillers, cooling towers, plug loads, and lighting loads are of interest. The remote access, data archival capabilities, and high quality visualization tools are also features of great interest.

There are some good opportunities to bring the system cost down. The cost of each point in the IMDS at 160 Sansome can be found at http://poet.lbl.gov/tour/physpts.html. It is likely that any future IMDS would not use the calibration procedure that cost about $350 per thermistor.

The operations staff estimates that they will save approximately $30,000 per year with the control system retrofit planned for next year. This is based on reducing steam use by about half (worth $25,000), and reducing chiller energy use by about 37,500 kilowatt hours (kWh). Overall, the system is likely to payback over the next few years if the controls retrofit is complete and the savings from the fan variable frequency drive and the steam are realized. The IMDS has not yet shown a payback based on energy savings. It has demonstrated that the technology is of significant value and the staff wants to continue to use such technology in other buildings.

Commercialization Potential

This technology has demonstrated its value, although it is likely to be expensive in its current form. As mentioned above, the on-site staff is extremely interested in remote, web-based data archival and visualization tools. They have examined other software that claims to provide the same capabilities as the current system, but they have not found any other system with the same reliability. Several dozen commercial buildings industry representatives have toured 160 Sansome in the last year, including software developers, energy service companies, utilities, and researchers. There are a variety of building monitoring technology development activities that are being influenced by this demonstration. Control companies were not asked to participate directly in this project as that participation might have constrained the project; however, the controls industry and other potential building information technology service providers are part of the target audience for this technology.

While the energy savings potential is significant, the technology is likely to be adopted for its non-energy benefits. This demonstration has shown that comfort is enhanced with IMDS-type technology. This could have far reaching affects on office workers, increasing productivity and health (Fisk and Rosenfeld, 1997). Improvements in equipment life and reduced maintenance costs are also likely.

Conclusions and Future Work

This research project has found the IMDS to be of significant value to building operators. We provide the following recommendations to outline both technical research and deployment research required to further understand and foster the development of the technical approaches considered in this study. The general recommendation from the evaluation of the IMDS is that significant improvements in building performance data measurements, archival, and visualization are needed to support operations staff. The IMDS is a high-end tool to support building operations. Further research is needed to explore how to best utilize these techniques given the current suite of EMCS and related tools available to operations staff.

Discussions are underway with the present operations staff and other building operations staff to demonstrate these concepts in other buildings. We are currently planning a second IMDS for installation in Sacramento. This site will allow us to more directly compare how a newer, state-of-the-art EMCS compares with the IMDS. Such demonstrations will help identify how universal the 160 Sansome finding are, considering diverse factors such as the building operations staff, climates, and HVAC system variations. The future work will also include additional investigations of the current chiller and related models to evaluate operational discrepancies and hence improve fault detection techniques.

We will also continue to track the operation of the IMDS at 160 Sansome Street to examine persistence of use and energy savings from the forthcoming control retrofit. After a series of bids were evaluated, the current IMDS technology suite has been selected to serve as the backbone for the new controls. This will allow us to collect and evaluate much more detailed control and operational data than the previous scope of the IMDS. We plan to test and deploy a series of model-based fault detection technology at the building in the near future.

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References

Behrens, David W. and Kenneth Belfer. 1996. "Commercial Customer Applications Demonstration: Open Systems Communication Architecture Project," Pacific Gas and Electric Company Research Development Report. Customer Systems File 006-96.1 December.

Claridge, D. E., J. Haberl, M. Liu, J. Houcek, and A. Athar. 1994. "Can You Achieve 150 percent of Predicted Retrofit Savings? Is It Time for Recommissioning?" *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings,* Vol. 5, ACEEE, Washington D.C., August.

Fisk, W. J. and A. H. Rosenfeld. 1997. “Estimates of Improved Productivity and Health from Better Indoor Environments,” *Indoor Air*, 7(3): 158-172.

Hagler Bailly Consulting, Inc. 1998. “Building commissioning: survey of attitudes and practices in Wisconsin.” Report #172-1. Madison, WI: Energy Center of Wisconsin.

Haves, P. and Khalsa, S. 2000. "Model-Based Performance Monitoring: Review of Diagnostic Methods and Chiller Case Study" Forthcoming, *Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings*, Washington D.C., August, 2000.

Hyvärinen, J. and S. Kärki, Editors. 1996. “Building Optimisation and Fault DiagnosisSystem Source Book,” IEA Annex 25: Real Time Simulation of HVAC systems for Building Optimization, Fault detection and Diagnosis, Technical Research Centre of Finland, ESPOO FINLAND, August.

Lawrence Berkeley National Laboratory, Building Technologies Department. 1999. IMDS Virtual Tour and Functional Specification. <http://poet.lbl.gov/tour/>.

Piette, M. A., S. Khalsa, P. Rumsey, K. L. Kinney, E. L. Lee, A. Sebald, and C. Shockman. 1998. “Early Results and Field Tests of an Information Monitoring and Diagnostic System for Commercial Buildings,” prepared for the California Energy Commission and the California Institute for Energy Efficiency, LBNL 42338, September.

Piette, M.A., B. Nordman, and S. Greenberg, “Quantifying Energy Savings from Commissioning: Preliminary Results from the Pacific Northwest,” *Proceedings of the Second National Conference on Building Commissioning*, May 1994.

Piette, M. A., S. Khalsa, P. Haves, P. Rumsey, K. L. Kinney, E. L. Lee, A. Sebald, and C. Shockman, "Performance Assessment and Adoption Processes of an Information Monitoring and Diagnostic System Prototype", Oct. 1999, report to the California Energy Commission, and LBNL #44453.

Portland Energy Conservation, Inc.. 1998. “National Strategy for Building Commissioning,” Portland, OR: Portland Energy Conservation, Inc.

Sebald, A. S., and M. A. Piette. 1997. “Diagnostics for Building Commissioning and Operations,” prepared for DOE and the California Institute for Energy Efficiency, LBNL 40512, December.

Shockman, C. and Piette, M. A. 2000. "Market Transformation and Third Party Property Managers: Routine versus Radical Technology Adoption Processes," Forthcoming, *Proceedings of the ACEEE 2000 Summer Study on Energy Efficiency in Buildings*, Washington D.C., August, 2000.