PECI O&M Best Practices Series

Portable Dataloggers

Diagnostic Tools for Energy-Efficient Building Operation

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- W. Mark Arney, Architectural Energy Corporation
- Peter Herzog, Herzog/Wheeler

For additional copies of this guidebook, contact:

Portland Energy Conservation, Inc.
921 SW Washington, Suite 312
Portland, OR 97205
(503) 248-4636
e-mail: peci@peci.org
Also available on-line at www.peci.org

If you are an ENERGY STAR® Buildings partner or ally, contact:

Energy Star Buildings
U.S. EPA
401 M Street, SW (6202J)
Washington, DC 20460
Toll-free hotline: 1-888-STAR-YES (1-888-782-7937)
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INTRODUCTION

Investigating building operational problems that affect energy use, comfort, or indoor air quality (IAQ) can be time consuming and expensive. However, hidden O&M problems that may not obviously affect comfort or environmental quality cause owners to pay much more than necessary for energy and equipment repair and replacements. Sophisticated, user-friendly tools known as portable dataloggers can save troubleshooting time and detect hidden O&M problems that may be costing a building owner hundreds, thousands and even tens of thousands of dollars annually in wasted energy and premature equipment failures.

Dataloggers should be as common in building technicians' toolboxes as a multimeter or thermometer.

Whether for troubleshooting a known problem or proactively seeking opportunities to optimize building systems, portable dataloggers and their accessories should be as common in building technicians' toolboxes as a multimeter or thermometer. This document describes how professionals in the energy service industry are making use of datalogger technology and the importance and advantages of short-term diagnostic monitoring[1] for building owners and managers. It also provides a sample of typical points to monitor, presents examples of data-logger findings (case studies), offers tips on how to choose a complete portable datalogging system and gives a short list of companies that sell the products.

[1] Short-term diagnostic monitoring uses portable dataloggers over short time periods (several hours to two weeks) for troubleshooting and identifying a building's electrical, mechanical, control system performance problems and strategies to optimize performance.

TABLE 1
Reactive vs. Proactive Operation and Maintenance

If it ain't broke, don't fix it.	Let's find and fix the problem before we can see, feel or hear it.
If no one complains, then everything must be working properly.	Silence is not always golden; energy waste is often hidden.
We have a preventive maintenance program, so everything must be working properly	Focusing on preventive maintenance without checking operation only addresses part of the problem.

The research and development of this document was conducted by Portland Energy Conservation Inc. (PECI) and funded by the Climate Protection Division of the Environmental Protection Agency (EPA) in cooperation with the U.S. Department of Energy (DOE). The list of companies presented on page 15 does not constitute an endorsement or recommendation for any of the products or companies by PECI, the EPA or DOE. It simply presents a sample of companies for readers to use as a starting point for investigating the technology.

WHAT ARE PORTABLE DATALOGGERS?

Portable dataloggers are small, paperless, lightweight, battery-powered, electronic monitoring devices used for data acquisition. They are easily installed and removed without disrupting building occupants. The more sophisticated models are capable of storing tens of thousands of readings and can be set up to gather data at almost any time frequency (every 2 seconds to every 12 hours). Dataloggers can gather electrical data such as amperage, voltage, or power, and can also gather data on temperatures, flows, pressures, lighting levels, and more.

Dataloggers are small, light and easy to use.

There are two basic types of dataloggers: those with integrated sensors (often referred to as "stick-on" dataloggers) and those with separate sensing devices. The dataloggers with separate sensors may be classified as single-channel or multi-channel loggers. Single-channel dataloggers are only capable of collecting data for one input type at a time such as a temperature. Multi-channel dataloggers can collect data for several input types simultaneously. For example, a four-channel logger may be set up to collect four different temperatures or may be set up to collect a mix of inputs such as temperature, pressure, and amperage.

Many of today's energy management systems (EMS) have trend logging capabilities and can be used to gather important data for troubleshooting and improving building operation. However, they are often installed with a limited number of points and without adequate ability to collect, store and present data. Also, EMS points are permanent, making it impossible to take measurements other than where the point was originally installed. Portable dataloggers overcome these limitations and are also useful in troubleshooting and monitoring the EMS to check that it is operating optimally and as intended. For buildings lacking an EMS or for those with limited EMS data points, portable dataloggers increase building technicians' ability to find problems and optimize equipment operation.

For analysis purposes, many loggers are packaged with easy-to-use software allowing the gathered data to be downloaded into a computer for analysis. This combination of a datalogger and its software is often referred to as portable data acquisition system. Most software is capable of presenting the data in typical line graphs (time series format), such as the one on page 7. Some software is capable of graphing one parameter against another. Also, most software allows more than one line of data to be placed on one graph so that technicians can analyze multiple variables simultaneously. These capabilities make troubleshooting, analysis, and presentation extremely user-friendly.

WHO TYPICALLY USES PORTABLE DATALOGGERS?

Engineering and energy service professionals such as building commissioning providers, energy service contractors, test engineers and indoor air quality (IAQ) specialists use portable dataloggers in the course of their work.[2] Dataloggers have become a standard tool for these professionals, because they do not require the use of auxiliary power, are easily installed to directly collect data in critical locations, and offer the ease of quick computer analysis. Commissioning providers and test engineers often use dataloggers to test new building equipment and systems under a variety of conditions and modes to ensure that building systems are performing as intended before they are turned over to the owner.

See Table 2 on page 8 for some sample uses for dataloggers.

Portable dataloggers allow these professionals to obtain more accurate information on how systems are performing over time (usually several days to two weeks). Whether commissioning new or existing buildings, this method provides assurance to the building owner, facility staff, and contractors that equipment is operating as expected and is usually superior to performing brief spot checks (a "snapshot" in time) with hand-held instruments (such as thermometers, multimeters, ammeters, pitot tubes). Also, by placing several dataloggers within the various building systems, information is gathered on how well equipment and systems work together. Attempting to obtain this level of information with hand-held instruments can be next to impossible and very labor intensive, reducing the cost-effectiveness of equipment testing.

Although engineering and energy-service professionals routinely use portable dataloggers, they are not common place for energy managers or for the hands-on building technicians who work with building systems and equipment on a daily basis. Because the benefits, costs, and uses for these tools are not well understood, they remain categorized as special-use tools—too expensive or complex for facility staff or service contractors to include in their toolboxes. However, portable dataloggers offer many benefits to energy managers, facility staff and contractors.

[2] Commissioning is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. *ASHRAE Guideline 1: The HVAC Commissioning Process, 1996.*

BENEFITS FOR ENERGY MANAGERS

We must be able to measure energy use in order to manage it.

Energy managers of efficient buildings know "you can't manage, what you can't measure." Energy use occurs over time and therefore needs to be measured over time. Portable dataloggers increase energy managers' ability to manage energy by increasing their ability to measure it. Persistent energy waste is often hidden. Placing dataloggers on critical energy using equipment or electrical panels can reveal a wealth of information about after-hours energy use. The following true story along with the data analysis plots illustrates this point.[3]

In order to demonstrate the importance of tracking energy over time, an energy manager placed portable dataloggers on two out of three typical electrical panels dedicated to plug loads on the 4th floor of a six-story, owner-occupied, commercial office building. One panel is for 4th Floor North and one is for 4th Floor South. The 4th floor central panel, although similar, was not tracked. After one week the energy manager removed the dataloggers and analyzed the information (see Figure 1 for both data plots).

Although the data plots show a drop in energy usage during unoccupied hours, they also indicate that this energy usage could be further reduced. The 4th floor north panel consumed 61% of its kWh during unoccupied hours, and the 4th floor south panel consumed 56% of its kWh during unoccupied hours. This information was given to the 4th floor department manager and she was asked to come up with a strategy for reducing energy use during unoccupied time. From discussions with employees and a little more research she determined that two thirds of the equipment that was left on after hours could be turned off. A policy was established to turn off all equipment that wasn't absolutely necessary during unoccupied hours.

Using the dataloggers, the energy manager established a benchmark to show the after-hours energy use when only the necessary equipment is left on. The department manager then requested that data be gathered and given to her every quarter. This data helps her periodically track changes in energy use and manage staff behavior so that only necessary equipment is left on after hours. The annual energy savings from one panel is approximately $1,700

[3]Provided by Peter Herzog, Herzog/Wheeler Associates.

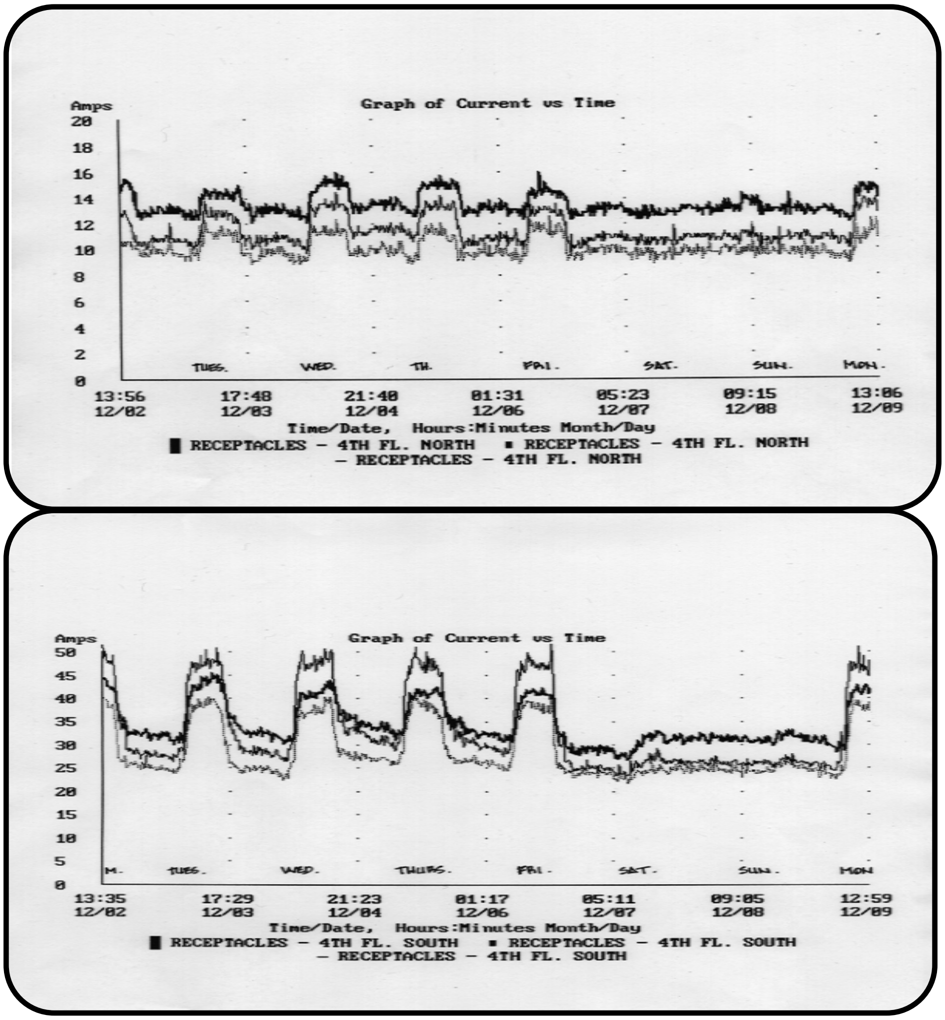

FIGURE 1

Data Logger Plots of 4th Floor North and 4th Floor South Energy Use

per year. Assuming the building has 12 panels, projecting these savings over the entire building results in annual savings of $20,400.

Often energy managers track monthly utility bills to understand a building's energy use and demand. On a gross level, this helps managers understand when energy use or demand has increased. Although good energy accounting practices can often indicate that a problem may exist, they do not always help in understanding where, at what time, and why the increases are occurring or whether they are appropriate. Using portable dataloggers in concert with energy accounting practices fills this information gap. Portable dataloggers can help pinpoint and document when and where energy waste is occurring, which allows those in charge to proactively manage energy.

Dataloggers help pinpoint the source of energy waste.

TABLE 2
Sample Uses for Portable Data Loggers

Unless otherwise stated, data should be logged for 6 typical days including a weekend at the designated time intervals.

Monitoring Issue	Suggested Points to Monitor	Suggested Sampling Interval	Analysis Summary
Identify unnecessary equipment operation (chillers, pumps, air handlers, exhaust fans, lights, plug loads, etc.)	Equipment current (this may be taken at motor control centers, electric panels, motor electric disconnects, etc.)	15 Minutes	Determine if HVAC equipment is ON during unoccupied periods. Verify that lighting ON-times appropriately match occupied and janitorial schedules.
Identify short cycling of equipment	Equipment current	2 Minutes	Determine if motors (fan, pump compressor, etc.) are short cycling
Chiller start	Chiller current, cooling coil valve position, OSAT, etc.	10 to 15 Minutes	Make sure chiller is on only when the desired conditions are met.
Chiller loading	Chiller current or kW, OSAT	10 to 15 minutes	Make sure the chiller current draw or kW goes up with OSAT. Make sure the chiller is not ON when OSAT < 55F without good reason.
Reset schedules	Chilled water supply temperature, CHWST reset parameter (OSAT, valve position, etc.)	5 to 10 minutes	Graph CHWST against OSAT or valve position and compare to reset schedule.
Cooling tower (CT) operation and capacity strategies (fans, mixing valve and entering condenser reset)	Current for all CT fans, valve position, tower sump, entering and leaving condenser water temperature, reset parameter (OSA, WB, DB), fan stage parameter	5 minutes	Compare the fan staging with tower sequences of operation, compare the entering condenser temperature with its schedule, and compare actual valve operation to expected operation (closed when entering condenser water ≤ setpoint).
Equipment staging (DX compressors, chillers, cooling towers, boilers)	Stage, controlling parameter, OSAT, RAT, SAT. (DX stage is rarely an EMS point. Consider dataloggers.)	2 minutes	Make sure that the stages are not short cycling, that the minimum ON/OFF times are not violated, and that the staging is reasonable relative to the causal conditions (OSAT and RAT).
Variable speed drives, (chilled water pumps, fans, etc.)	Rpm or Hertz, speed controlling parameter value and setpoint (pressure, temp., etc.), related load parameters (OSAT, chilled water temp., supply air temp., etc.)	2 minutes	Verify that speed modulates with load and the controlling setpoint is maintained without hunting. Verify that when the cooling or heating load is at its minimum, the rpm is as low as the motor can safely handle without overheating or cavitating.
Economizers	MAT, RAT, and OSAT	5 minutes	Compare air stream temperatures to ensure dampers are modulating to meet expected control strategies. Dampers at minimum position at 75 degrees OSAT.
Simultaneous heating and cooling	Heating element enable or valve position, SAT, cooling coil valve position, hot and cold deck temperatures	2 minutes	For single duct, make sure that when the cooling coil valve is open, the heating coil valve is closed. For multizone, make sure deck dampers are not leaking when closed.

Table Abbreviations: OSAT outside air temperature. WB wet bulb. DB dry bulb. CHWST chilled water supply temperature. CHWRT chilled water return temperature. EMS energy management system. VSD variable speed drive. MAT mixed air temperature. RAT return air temperature. SAT supply air temperature. DX direct expansion.

Energy managers are often hesitant to propose changes to owners or building managers in the way building systems are operated and maintained on either the policy or implementation level. Dataloggers and their analysis software offer energy managers a way to graphically present specific data on activities in the building that increase or decrease energy use, comfort or IAQ. This clear information based on measured data can help energy managers to convince building managers and owners of the benefits of making operational changes.

Benefits for Maintenance Staff and Service Contractors

Low-cost operational improvements can reduce annual energy bills 5-20%.

Performing preventive maintenance (PM) alone is not enough. No matter how well technicians maintain equipment, if it operates inefficiently, or more often than needed, energy waste occurs. The cost of not paying attention to operational issues along with the maintenance issues can be significant. Several commissioning and O&M studies performed over the past seven years indicate that most energy savings opportunities are operational in nature. Energy savings of five to twenty percent of the annual energy bill can be realized through low-cost O&M improvements, with operating improvements accounting for most of the savings. Both in-house facility staff and maintenance service contractors can serve the building owner and occupants better by addressing operational issues as well as typical maintenance issues.

Measuring the performance of energy-using equipment over time is the only way to verify whether the equipment or system performs optimally. Stocking even a few portable dataloggers for building operators or service technicians to use increases their ability to locate costly building operation problems quickly. Periodically monitoring critical pieces of building equipment to ensure proper operation should be as important as periodically performing maintenance tasks such as cleaning coils, lubricating motors or changing filters. Portable dataloggers allow facility staff and maintenance service providers to expand their PM program to include preventive operation tasks. Table 2 presents a sample of typical points to monitor using portable dataloggers.

CASE STUDY

The owner of a 15-story Class-A office building heated with in-line electric resistance duct heaters located in each zone and controlled by zone thermostats added an EMS to the building. As part of the EMS retrofit, relays were installed on each floor to help control the duct heaters and reduce heating costs. An EMS control strategy locked out the heaters whenever the average zone temperature on each floor exceeded 72.5°F "or" the outside air temperature (OSAT) fell between 60°F-70°F (depending on the orientation of the building).

A few years later the building underwent an O&M assessment and dataloggers were placed on a sample of duct heaters to assess the control of the heaters and indicate opportunities for improvement. Sixteen circuits on three floors were monitored, representing 8% of the total connected load. Figure 2 shows the data from three monitored circuits on one of the floors. The plot demonstrates that all three circuits operated excessively during the monitoring period (July 21 through August 4, 1995). The duct heaters came on even when the OSAT was above 80°F, indicating a control strategy problem. The OSAT lockout strategy was clearly not working. The different grouping of data points represent the times when all circuits were off; or one, two, or three, circuits were energized.

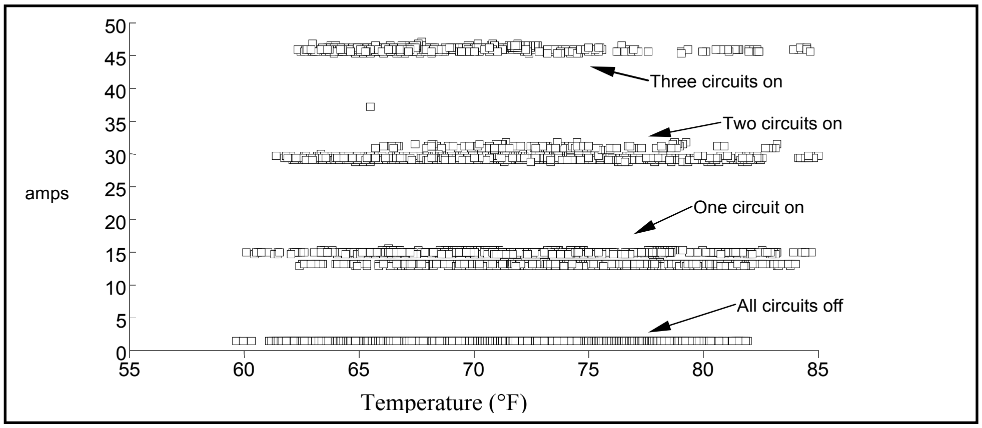

FIGURE 2
Duct Heater Circuit Data

An investigation of the EMS program strategy revealed a programming error. The "or" statement for locking out the duct heaters had been programmed as an "and" statement which explained why the strategy was not working correctly. A new control strategy was proposed to lower the ambient lockout temperatures and change the conditional statement from "and" to "or", so that meeting only one of the conditions would shut off the heaters.

Following the control strategy change, the assessment consultants conducted a second round of monitoring to ensure that the program worked as expected. In general, the edited control routine appeared to be working except for one zone. Since the software problem appeared to be solved the only other possibility was a hardware problem. The building manger called in the control contractor who found that a burned out relay was preventing the heaters from being locked out in one area.

A comparison of the pre and post monitoring data indicates that fixing these problems resulted in annual savings of $3,330. The potential savings could significantly exceed $3,330 if the lockout temperatures are further reduced. Many similar office buildings in the area do not use any heating in the summer months, so it seems reasonable to assume that this building could be operated in a similar fashion.

The cost for fixing these problems was minimal, so the payback was almost immediate. This type of programming error is not unusual, can cost tens of thousands of dollars in energy waste, and can often be fixed in less than an hour. The key is discovering these hidden problems. In this example, datalogging detected the energy waste and provided the data to quantify the savings achieved by fixing the problem.

Adapted from "*Uncovering Hidden O&M Problems with Short-term Diagnostic Testing*" by W. Mark Arney, P.E. in Proceedings of the Fourth National Conference on Building Commissioning, Organized by PECI, 1996.

Facility staff and contractors can also use portable dataloggers to benchmark equipment efficiencies under various conditions. Once equipment benchmarks are established, staff and contractors can periodically use dataloggers to ensure that equipment continues operating efficiently and only when needed. (For more information on efficient scheduling, see *Putting the "O" Back in O&M Best Practices in Preventive Operations, Tracking and Scheduling*, another report in the O&M Best Practices Series.)

Portable dataloggers increase facility staff and service contractor troubleshooting skills and reduce the time they spend identifying the sources and frequency of problems. Furthermore, once they identify and implement a solution to the problem, logging the results gives them immediate feedback as to whether the solution is working as expected or whether opportunities exist for further improvements.

Dataloggers make troubleshooting easier and faster.

Dataloggers also provide feedback that can take the risk out of implementing proposed changes to operating procedures. For example, HVAC equipment is often started before building occupants arrive in the morning in order to ensure that the building is comfortable when they arrive. Operators and facility managers are usually hesitant to reduce these pre-occupancy start times for fear the building will be uncomfortable and the occupants will complain. In other words they would rather overcompensate by allowing the air handlers to operate sooner than really necessary rather than risk occupant complaints. By datalogging early-morning space temperatures, operating staff can determine more accurately how long it takes for the building to arrive at the desired temperature. The data gathered allows operating staff to confidently set pre-occupancy start times for HVAC equipment (for each season) more optimally thus reducing energy waste without sacrificing comfort.

WHICH LOGGERS ARE BEST FOR MY STAFF?

Because there are numerous portable dataloggers on the market with a range of capabilities at a variety of prices, it is best to first understand the needs of facility staff or service contractors before purchasing a portable data acquisition system. For some businesses or facilities it may be useful to purchase more than one type of system. Purchasing several simple, inexpensive, single-channel dataloggers that only monitor the on /off status of equipment (sometimes called "stick-on" loggers) along with a few more expensive multi-channel dataloggers with a software package may appropriately meet the needs of the technical staff.

Purchase a datalogger that complements the diagnostic capabilities of your control system.

For building owners or facility managers one of the first steps in deciding what to buy is to evaluate the diagnostic capabilities and limitations of the present building control system. If the building has a reasonably new EMS that staff believe is functioning well, and trending and data analysis is straightforward, then only a few dataloggers may be needed to augment the system. Other things to consider are the size and number of buildings or pieces or equipment involved as well as the complexity of the building systems, plant, and controls. Complexity coupled with multiple buildings or pieces of equipment offers increased chances for costly operating errors. In this case, purchasing a more sophisticated data acquisition system may be more attractive since the payback can be quite reasonable. On the other hand, purchasing an expensive, sophisticated package for a single, small building with only roof top HVAC units is probably not a good investment.

When evaluating dataloggers for purchase, it is also important to understand the interest level (and fear level), knowledge, and capability of the hands-on technicians that will use the equipment. Some building technicians may not be eager to embrace new solutions, especially if they do not understand the benefits or how to use the equipment. However, it's not unusual for technical staff to become quite proficient with the technology once they understand its vast troubleshooting and analytical capabilities. Educational activities can help motivate the staff. Most vendors are happy to demonstrate their products. They may even be willing to setup a small pilot project within the building to show what their products can do.

Once an organization has assessed its diagnostic needs, EMS capabilities and staff interest skills, the next step is researching the types of systems available. The following checklists include some basic factors to consider when evaluating and comparing the various data acquisition systems. The first checklist addresses the hardware considerations and the second checklist addresses the software considerations. Every company should be able to supply the information contained in these checklists.

General Questions

- What technical support (such as a technical hotline) is available and how accessible is it?
- What training support is available for both the datalogging devices and analysis, and what is the cost?
- What is the company's plan for upgrades and will the system be upwardly compatible (at a low cost)? Avoid buying a system that will become obsolete and unsupported in the future.
- Is there an annual licensing fee?
- Are parts and components readily available and quickly obtainable?

Evaluation Checklist for Portable Dataloggers:

- ❑ Physical size and weight
- ❑ Ease of installation for field mounting
- ❑ Single or multiple channels for measuring
- ❑ Battery type
- ❑ Battery life (rechargeable battery or length of life and cost of replaceable battery)
- ❑ Ease of logger setup before field placement
- ❑ Time or clock accuracy
- ❑ Data storage capacity
- ❑ Sampling rate limitations(2 seconds, 2 minutes, hourly, etc.)
- ❑ Starting modes (programmable start time and date, triggered start, etc.)

Portable dataloggers can easily pay for themselves in a short period of time, but only if they are used on a regular basis.

- ❑ Running modes such as continuous (memory wraps), stops on trigger, or stop when memory is full
- ❑ Resolution such as 12, 10 or 8 bits (lowering resolution can affect reading storage capacity)
- ❑ Type of sensors and modules available for the range of measurable phenomena (lighting levels, temperatures, current, pressures, flows, relative humidity, electrical pulse counting, resistance, RPM, power quality, IAQ, etc.)
- ❑ True RMS current measuring capability
- ❑ Data retention (length of time, and upon battery failure)
- ❑ Accuracy and calibration
- ❑ Real-time readout on the face of the logger
- ❑ Outdoor (weatherproof) or submersible use
- ❑ Temperature limits for best operation (operating range)
- ❑ Confirmation of operation once installed
- ❑ Sensor compatibility
- ❑ Software available
- ❑ Price list (discounts on packages available?)
- ❑ Unaffected by radio frequencies, electromagnetic interference and airport x-ray machines
- ❑ Product approvals (FCC etc.)
- ❑ Remote monitoring capabilities

Evaluation Checklist for Portable Datalogger Software

- ❑ Versions available (Windows, Macintosh)
- ❑ Ease of graphic analysis (display, zoom and print charts, overlay several graphs)
- ❑ Ease of presentation (data easily exported to spreadsheet programs and easily pasted into reports)
- ❑ Analysis features beyond time-series graphing (can one parameter be graphed against another parameter?)
- ❑ What are the minimum requirements for the present computer system to run the software (processor, RAM, disk space, and version)
- ❑ Price (sold separately from dataloggers or as a package)
- ❑ Plans for upgrades and price of upgrades

WHO SELLS PORTABLE DATALOGGERS?

Table 3 lists some companies that specialize in data acquisition equipment. This list is not complete nor does it constitute any endorsement of products or companies by EPA, DOE or PECI. Only those companies that were easily located on the Internet using obvious key words such as "datalogger" or "data logger," are listed along with their Internet address. The companies are presented in Table 3 in alphabetical order.

TABLE 3
Companies Providing Portable Data Acquisition Equipment

Company Name	Web Site / E-mail	Phone Number
ACR Systems Inc	http://www.acrsystems.com E-mail: acr@acrsystems.com	1-800-663-7845
Architectural Energy Corporation	http://www.archenergy.com or http://www.datalogger.com E-mail: AECinfo@archenergy.com	1-800-450-4454
Claritech Ltd.	http://www.claritech.demon.co.uk/dlog.htm E-mail: sales@claritech.demon.co.uk	Telephone: +44 (0) 1530-412-488
Field Diagnostic Services, Inc.	http://acrx.com E-mail: rossi@fielddiagnostics.com	215-741-4959x15
Omega (OM-NOMAD)	http://www.omega.com E-mail: das@omega.com	888-663-4214
Onset Computer Corporation	http://www.onsetcomp.com	508-563-9000
Pace Scientific	http://www.pace-sci.com E-mail: sales@pace-sci.com	704-568-3691
Pacific Science and Technology	http://www.pacscitech.com E-mail: webinfo@pacscitech.com	800-388-0770
Trak-R Logger	http://www.trak-r-logger.com E-mail: info@trak-r-logger.com	800-865-6443
Valitec	http://www.valitec.com E-mail: contact@valitec.com	937-291-0250

Once the loggers and software are purchased, keep them in use. If the loggers sit on the shelf they can't help technicians discover ways to enhance building performance. A portable diagnostic system can easily pay for itself in a short period of time, but only if it is used on a regular basis. Developing an analysis plan for the loggers and integrating it with PM activities is one approach to ensuring their use. Based on the plans, staff or contractors rotate the loggers among the various pieces of equipment, building spaces, and systems to monitor operating parameters with the goal of optimizing building performance and occupant comfort.

CONCLUSION

Over the last two decades buildings have become increasingly complex and their control systems have become more sophisticated. Sporadically spot checking equipment performance with hand-held instruments, performing typical PMs, or waiting for complaints to reveal problems is no longer enough. Often, persistent and hidden energy waste that costs an owner several thousands of dollars per year can only be found by tracking building systems' performance over time. The portable datalogging systems available today are powerful, user friendly tools that can increase the technical ability of energy managers and building technicians. By adding a portable data acquisition system to building technicians' toolboxes, building owners, managers, and service contractors can better serve their clients. These devices and their accompanying software repeatedly demonstrate their worth by assisting engineering professionals in identifying areas of energy waste, locating potential IAQ problems, and reducing the time spent troubleshooting problems and verifying building performance.

GLOSSARY

Baseline. The "before" data that is used in a "before & after" comparison. Baseline data may refer to energy consumption values, efficiency parameters, or other indications of building (or system) performance.

Datalogger. A stand-alone electronic data gathering device that utilizes sensors to collect equipment information over time. Data collected could include temperature, pressure, current, humidity, or other operational information.

Data Plot. A graphical display of data that is collected through a **datalogger**, an **energy management system**, or some other data collection method.

Energy Accounting. The process of tracking and analyzing energy use for the purpose of detecting problems, trends, or savings opportunities. Typically, energy accounting is performed for an entire building. In the analysis process, adjustments may be made for variations in weather, space use, or other variables from year to year.

Energy Management System. The automatic system used for controlling equipment in a building. Most likely, this will be a computer-based system, including either pneumatic or digital components, or both.

Equipment Efficiency. A measure of the output of some piece of equipment as it relates to the energy input. Higher efficiency indicates that a machine can produce more heating, cooling, etc. for each unit of fuel (electricity, gas, etc.) consumed. For some equipment, the efficiency varies with the load on the equipment. In those cases the efficiency is plotted against load. This efficiency curve illustrates the performance of the equipment over its range of operational conditions.

Indoor Environmental Quality (IEQ). A term that refers to the total environment of a building and includes thermal comfort, proper illumination, adequate outside air ventilation, and control of indoor air pollutants.

Lockout Strategy. A control strategy that is used to ensure that equipment does not come on at a point when it is rarely, if ever, needed. This protects against nuances in the control system programming that may cause the equipment to turn on unnecessarily. For example, a chiller may have a lockout parameter stating that the chiller cannot run if the outside air temperature is less than 55°F.

Monitoring. The practice of collecting data on equipment operation over a period of time. This data may be obtained through a **datalogger** or an **energy management system**. This data may consist of time-series or change-of-value (COV) data that can be collected for digital points such as temperature, pressure, or status.

Payback. The length of time that an energy efficiency improvement will take to provide the full return on investment. If a $1,000 investment will yield $1,000 in energy or maintenance savings by the end of the first year, that investment has a 1-year payback.

Preventive Maintenance Program. A program that is implemented in an effort to proactively address equipment maintenance issues. The goal of such a program is to perform maintenance tasks on a regular schedule so as to maximize the operational efficiency and lifetime of the equipment.

LIST OF ACRONYMS

DOE	U.S. Department of Energy
EMS	Energy Management System
EPA	U.S. Environmental Protection Agency
HVAC	Heating, Ventilating, and Air Conditioning
IAQ	Indoor Air Quality
kWh	Kilowatt Hour
O&M	Operation & Maintenance
OSAT	Outside Supply Air Temperature
PM	Preventive Maintenance
RMS	Root Mean Squared
RPM	Revolutions per Minute

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