

# Using Data Loggers for Energy Management and Indoor Air Quality

**L**ow-cost data loggers can provide information to save thousands of dollars in energy costs, while helping ensure that indoor air quality and comfort are maintained throughout a facility. By monitoring and recording simple variables like temperature, RH, CO<sub>2</sub>, and light or motor On/Off, data loggers can help detect and document whether “too hot or too cold” comfort complaint conditions are real, whether your facility is threatened by conditions suitable for mold growth, and whether energy savings can be realized through ensuring that lights are off when areas of the building are unoccupied. More sophisticated measurements – such as AC Current, AC Voltage, power demand (kW), energy consumption (kWh), pressure, and differential air pressures – provide valuable information for troubleshooting HVAC/R systems, sub-metering, building commissioning, and Measurement & Verification of energy savings.

This paper will present case studies and demonstrate how low-cost data loggers are used throughout buildings to identify opportunities for energy savings and to document when those savings have been effectuated, while maintaining conditions that contribute to the comfort and productivity of building occupants.

## Data Logger Basics

Data loggers are battery-operated, standalone measurement tools containing a microprocessor, memory, and sensors for measuring and recording one or more variables over time. They are typically quite small, enabling them to be deployed almost anywhere throughout a building, with some packaged to work in outdoor or more hostile industrial environments. Some data loggers have internal sensors, so that measurements are made only at the logger location, while others utilize sensors on external cables that allow for monitoring at some distance from the data logger itself. A logger may offer a combination of internal and external sensors, as well as external channels accepting pulse, 4-20mA or DC voltage inputs from other sensors for even greater flexibility. The loggers operate unattended for hours, days, or months at a time. Specialized software is used to configure the logger (select sampling intervals, synchronize logger and computer clocks, etc.) and to offload the recorded data from the logger to a PC for graphing and analysis.

Temperature is the most common measurement required for most building applications, as it is important in moni-

toring the human environment as well as equipment operation and efficiency. Relative humidity (RH) and carbon dioxide (CO<sub>2</sub>) are two other common measurements for indoor air quality (IAQ) and comfort complaint investigations. Combined temperature and RH measurements are also critical indicators of conditions that may be conducive to mold growth, which is an important concern for today’s building owners, managers, and occupants.

Typical measurements for energy auditing and management include AC current, AC voltage, power demand (kW), total energy consumption (kWh), light On / Off, and motor On / Off. AC current/voltage and power (kW), along with pressure and/or differential air pressure are also of use in troubleshooting of HVAC/R equipment and systems.

## Determining Factors

When looking for the “right logger” for your particular needs, consider the following parameters:

Measurement accuracy	Cost
Ease of use (software)	Technical support
Environment	Data readout
Battery life	Flexibility

## Data Logger Advantages

Data loggers provide several advantages for building monitoring, including portability, reliability, and value.

### Portability

Because data loggers are battery operated, highly portable, and relatively unobtrusive, they can typically be deployed anywhere in a building where data monitoring is required. They are often used in buildings with extensive automation and control systems, as several loggers can be placed in a specific area or system to provide additional data to aid in troubleshooting at a fraction of the cost of wired sensors. Once a project has been completed, data loggers can be moved easily to another location for another project.

### Reliability

Data loggers typically record data in non-volatile, internal memory, so data is recorded even during a power outage and, most importantly, when no one is in attendance. Most have large memories and can store 40,000 readings and more. Such loggers can provide long-term data for trending or pre- and post-upgrade monitoring.

## Value

As the cost of electronic equipment has decreased over the years, so too have the costs of data loggers, with a variety of temperature-only data loggers available for less than \$75 – some as low as \$39. Monitoring system costs typically increase with the number and type of measurements offered, with some sensors (e.g., CO<sub>2</sub>, kW or kWh) costing more than the data logger itself. A minor investment in loggers can save thousands of dollars in facility costs.

## Data Retrieval & Analysis

At periodic intervals, or upon completion of the monitoring term, the data is offloaded or read out to a computer for plotting and analysis. Although the logger may be brought back to the computer for data readout, a data shuttle is a convenient accessory. The data shuttle is used to read out data from one or more loggers deployed in the building. The data shuttle is then brought back to the computer and downloaded, while the loggers can be left in place or deployed in another location. If loggers are connected to an Ethernet network, data can be acquired from any logger on the network via any PC connected to the network and running the logger's software.

There are also wireless recording devices on the market. However, at present they are relatively expensive, and interoperability remains a challenge. Watch for more, lower cost products coming into the market in the near future once wireless communication standards are established.

Plotting of the data involves choosing which data channels to graph. The best software plots the data easily and quickly, yet has tools allowing for advanced display of multiple data files on one graph, zooming in on data of interest, and comparing multiple parameters from multiple graphs.

In addition to plotting data, software allows you to view individual data points in tabular form and provides statistical data, e.g., the total time and percentage of time that equipment was on and off, or the minimum and maximum values measured during the deployment.

In most cases, data can be exported to another program, for example to Microsoft Excel, for purposes of displaying the data in a different format (charts, tables, etc.).

## APPLICATIONS

For commercial, industrial, and residential buildings, the typical applications for data loggers include IAQ, facility management, and energy management.

## IAQ

A 2004 study at Wood's Hole Research Center in Mas-

sachusetts was performed to investigate the indoor air quality of a four-story multi-use building. Temperature, humidity, and CO<sub>2</sub> loggers, set for 5-minute sampling intervals, were deployed to monitor the air of each floor of the building including basement level. Several loggers were strung at 6-foot intervals in stairwells to measure air temperature stratification. CO<sub>2</sub> loggers were placed outside of windows as well as inside rooms to compare readings of both levels while windows and/or ventilation vents were open and closed.

The accumulated data revealed a high (over 1000 ppm) CO<sub>2</sub> level when certain windows were closed and a range of temperatures among floors. The study recommended a number of ventilation corrections and reinforced the importance of balancing natural and HVAC ventilation techniques needed to maintain consistent comfort levels throughout a multi-level building. {1}

Other IAQ-related parameters loggers can monitor include radon level, moisture content, and airflow.

## FACILITIES MANAGEMENT

### HVAC/R Troubleshooting

Airflow pressure, monitored with an external airflow pressure sensor mounted within an air duct, or attached to heating coils or pipes, can provide valuable insight into heating distribution or air balance problems. Multiple airflow points may be used to evaluate a larger section of an air distribution system for larger scale analyses along with temperature readings (at supply and return vents). In addition, (On / Off or State) loggers can also be used to monitor HVAC/R equipment to detect short cycling of, for example, a compressor or blower, or other equipment run-time in order to evaluate potential failures for scheduling repairs or replacements.

Chiller system efficiency is easily and accurately monitored by logging outdoor temperatures, water temperatures and flow rates at supply and returns, and when pumps are turning on.

### Retro-commissioning

Building mechanicals and control systems will go out of adjustment over time. During this same time the building's operational needs may have changed as well. Data loggers can be used to gather data, not just opinions, to provide accurate whole building benchmarking information.

Temperature as well as differential pressure sensor loggers can be deployed at all critical interior comfort zones to verify HVAC/R and ventilation control / setback settings. A good example of how loggers were used in a very successful setback strategy will be reviewed in a later section.

Motor On/Off loggers can record that compressors, blowers, pumps, VSDs, and other motor-driven equipment are not running when not needed. Light On/Off loggers can verify lighting controls schedules and effectiveness.

## Energy Management

Data loggers can be used to track energy usage in various parts of a building to verify equipment operating efficiencies and to identify areas where energy costs can be reduced.

## Sub-metering

With ever increasing energy costs, it is more important than ever to first know where the energy is being used before coming up with a plan to correct problem areas or make improvements that could lower energy bills. Assuming access is available to individual power input lines or at service entry panels, wattage measuring and On/Off loggers can be used to identify specific energy wasters by monitoring blowers, compressors, pumps, boilers, heaters, or lights that are cycling too often or running for too long. Also, individual areas within buildings can be monitored for total unit energy usage to locate high-energy-use abnormalities.

## Lighting

Total light usage in any type of facility can gobble up a good share of power, especially if left on unnecessarily for long periods of time. Light intensity (loggers which have built-in photo sensors) or On / Off loggers can be placed as close as possible to individual light sources or on ceilings or walls to record when lights are on over various times. Data should be logged for a period long enough to cover various times of day and night, as well as occupied and unoccupied periods. The data gathered will not only detect direct light usage but can also help in deciding whether the expense of permanently installed occupancy light sensor/switches or some other remediation is justified. If changes are made to reduce light use (or wattage reduction), the very same loggers can be re-deployed in the same spaces later on to generate data to verify that the changes were successful.

A 1998 research study by Lawrence Berkeley National Labs used light On/Off loggers and motion sensors to monitor hotel room light usage patterns as a function of the time of day and over a three-month period. As a result of the study, it was determined that changing over to CFL lighting and adding occupancy sensors would save significant energy costs, \$40 per fixture per year, with an estimated payback period of less than two years. {2}

## Heating & Cooling

HVAC/R systems represent significant opportunities for en-

ergy savings due to their large electricity demand. Once a system's overall efficiency has been established, the next step that can be taken is to determine if heating and cooling system on-times can be adjusted to save power usage.

A South Dakota school district (thirty-three buildings) deployed loggers to document temperature changes within various rooms. The recorded data indicated that the rooms held the heated air much longer than thought and that the building heating systems could be shut down sooner in the evening and started later in the morning without adversely affecting the comfort level of students and teachers. The reduction of heating system on-hours resulted in an annual energy savings of \$500,000 in return for the district's \$1000 investment. {3}

## Renewable Energy Site Investigation and Validation

Data loggers can be instrumental for site evaluation and post-installation validation of alternative energy sources such as wind, solar, and mini-hydro systems.

Outdoor loggers equipped with wind speed sensors can be used to gather accurate wind data over a long period of time to help choose the right site for a wind turbine installation. A logger equipped with a solar radiation sensor can do the same for placement of a solar array. A flow meter outputted to a logger can provide a history of water flow rates over months of time to determine appropriate hydro sites.

Once the new energy source has been installed and operating, the system outputs can be measured and verified by kW or kWh data loggers.

Loggers are also used for trend measurement and performance verification of co-generation installations.

## Federal & State Energy Reduction Incentives

Besides helping to identify and rectify energy losses previously described, loggers can help to reduce building energy costs by earning federal tax credits such as those offered by the Energy Policy Act of 2005, or your own state or city sponsored energy reduction incentive programs. The pertinent data recorded by loggers, both the "before" and the "after" of an energy reduction project, is an easy way to substantiate your claim.

## Conclusions

Portable data loggers are inexpensive and easily deployed measurement-recording tools that can have a positive impact on containing building energy costs without sacrificing occupant comfort levels. With so many possible uses in a building—performing energy audits, verifying comfort

and IAQ conditions, validating HVAC/R and building control system operation, predicting equipment degradation, assisting renewable energy projects, and substantiating energy tax credit claims—they may be the ultimate measurement and recording tools for balancing and managing a building's energy usage and environmental qualities.

### References

{1} Agents of Change Workshop, Woods Hole Research Center, October 14-16, 2004.

{2} Page, E., Simonovitch, M., Ernest Orlando Lawrence Berkeley National Laboratory, University of California, October 1999.

{3} Brioda, R., "Turning On the Savings, by Turning Off the Juice". District Administration, Copyright 2006 Professional Media Group, LLC.

For more information about data loggers, please contact Onset Computer Corporation at [www.onsetcomp.com](http://www.onsetcomp.com) or call 1-800-564-4377.

### About Onset

Onset Computer Corporation has been producing small, inexpensive, battery-powered data loggers and embedded controllers since 1981, and has sold over one million loggers that are used around the world by over 50,000 customers. The company manufactures a broad range of data logger and weather station products that are used to measure temperature, humidity, light intensity, voltage, and a broad range of other parameters. Onset products are used widely in research, commercial, industrial, and educational applications.

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