onset®
HOBO® Data Loggers

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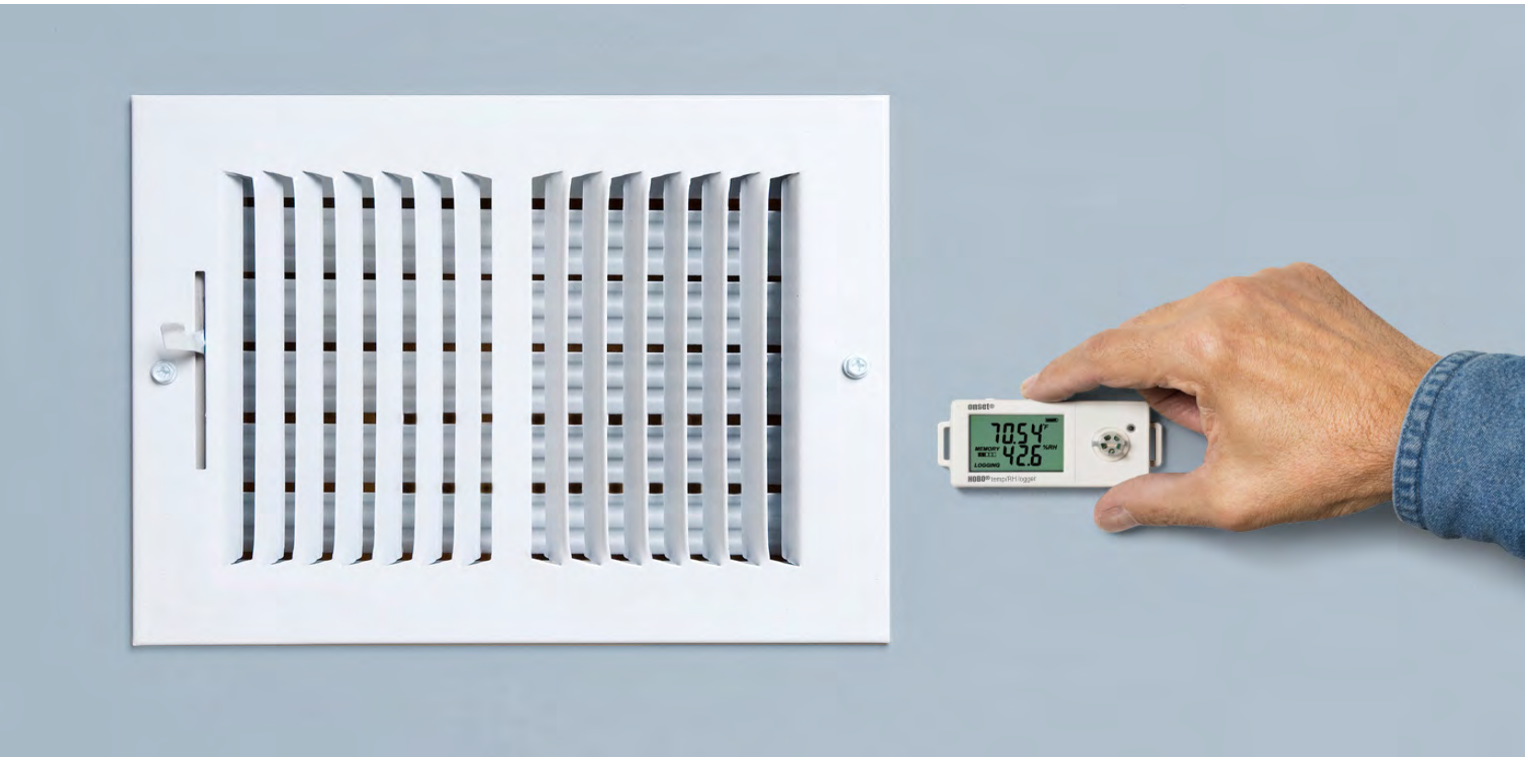


Data Logger Basics

Introduction

In today's data-driven world of satellite uplinks, wireless networks, and the Internet, it is common to hear the terms "data logging" and "data loggers" and not really have a firm grasp of what they are.

Most people have a vague idea that data logging involves electronically collecting information about the status of something in the environment, such as temperature, relative humidity, or energy use. They're right, but that's just a small view of what data logging is.

In the fields of building performance and environmental research, everyone seems to be using data loggers. But what are they, and why are they useful?

This guide will introduce you to the wide world of electronic data loggers and data logging, and will help to clarify your understanding, whether you

- are a new hire embarking on a project or career where data loggers are required
- have been asked by a supervisor or team member to purchase data loggers
- must persuade a decision-maker that data loggers will be useful for your work (for starters, they can save labor costs and increase efficiency by reducing travel time)
- have heard about data loggers and are just curious about their applications, or,
- are a longtime user of the devices and want to refresh your understanding and stay up-to-date with the technology and capabilities offered today.

In the following pages, we'll cover data logger basics (the what, where, and why); explain the steps involved in using a data logger; outline important considerations to keep in mind when selecting data loggers; and finish with real-world examples of data loggers being used by professionals in fields ranging from building energy efficiency to water quality management to basic scientific research.

Throughout you'll find examples, resources, and helpful information for you to use in evaluating data loggers for your work, and you'll have a solid sense of why professionals worldwide rely on electronic data loggers more than ever as part of their toolkit.

Data logger basics

What is a data logger?

A data logger is an electronic instrument that records measurements at set intervals over a period of time. Depending on the particular data logger, such measurements can include:

- Air temperature
- Relative humidity
- AC/DC current and voltage
- Differential pressure
- Time-of-use (lights, motors, etc.)
- Light intensity
- Water temperature
- Dissolved oxygen
- Soil moisture
- Rainfall
- Wind speed and direction
- Leaf wetness
- Pulse signals
- Room occupancy
- Plug load

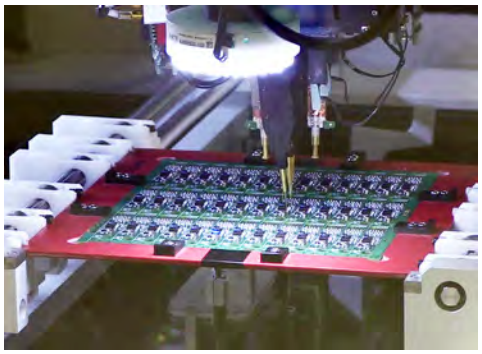
…and many more

Data loggers are typically compact, battery-powered devices equipped with an internal microprocessor, data storage, and one or more sensors. They can be deployed indoors, outdoors, and underwater, and can record data for up to months at a time, unattended. A data logger may be a single-unit, stand-alone device with internal sensors, which fits in the palm of a hand, or it may be a multi-channel data collection instrument equipped with one or more external sensors.

Why use data loggers?

Data loggers are valuable tools for anyone who wants to continuously monitor conditions without having to be on site. Environmental consultants, building managers, energy auditors, research scientists, and many more professionals all rely on data loggers because of their:

Low cost



The price of data loggers has come down with advances in microprocessors in recent years, and a single, one-sensor logger can cost less than $100. Users save time and money by launching and leaving a logger unattended to take time-stamped measurements, rather than having to be on site themselves. The low cost of data loggers also allows for deployment of multiple loggers at a time, in some cases reducing project length and enhancing the volume of data available for analysis.

Because of the long battery life characteristic of many portable data loggers, they can be deployed for long periods of time, meaning less time spent traveling to and from the logger to download data. For remotely-placed loggers, or in situations where many loggers are used, that can be a huge savings in time and money.

Once configured and deployed, you can rely on a battery-powered data logger to gather the information you need, for as long as you need.

Ease of use

Data loggers are certainly used by engineers and research technicians, but they're also used by elementary schoolchildren in science projects. It can be a mere 15 minutes from opening the box to deployment of a data logger; for some models, simply connect the logger to a computer, use the data logger's software to configure the sampling frequency and start/stop times, and you're ready to go. Bluetooth Smart loggers don't even require a computer, only a mobile device and app.

Downloading data is simple as well, and it can be easily analyzed, graphed, and formatted for presentation or export to other applications. We'll cover this in more detail in another section.

Reliability

Once configured and deployed, you can rely on a battery-powered data logger to gather the information you need, for as long as you need. No human error, schedule conflict, inclement weather, bad handwriting, or data entry errors will affect your data collection. And whether indoors or out, data loggers are rugged instruments designed to withstand a wide range of environmental conditions, including salt water, refrigeration, strong winds, and constant sunlight.

Time-stamped data

Collection of data is, of course, at the core of these devices, and their purpose is to provide objective, time-stamped proof of conditions over time, which can be used to test theories, confirm operations, provide a record for supervisors or regulatory agencies, and supply information to decision-makers. The data they collect allows for better interpretations and choices, and can save time and money in the long run.

Where are data loggers used?

Data loggers are used in a broad range of indoor, outdoor, and underwater environments, from high-rise buildings to the Arctic – essentially anywhere data is needed and the convenience of battery power is preferred

Common data logging applications

Building Performance

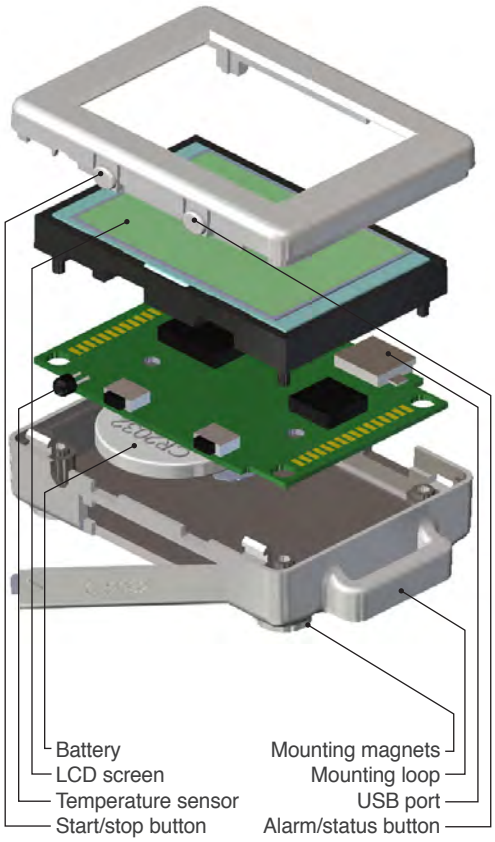
- Track building electricity usage to understand energy profiles and manage peak demand
- Verify energy cost savings to determine ROI of new equipment
- Monitor equipment runtimes to ensure efficient operation
- Monitor equipment for leaks to cut wasteful energy consumption
- Diagnose causes of occupant comfort complaints
- Ensure healthy indoor air quality
- Track room occupancy and light use patterns
- Optimize HVAC system performance
- Better manage peak energy demand

Environmental Research

- Perform ecological studies that provide a detailed picture of the habitat
- Conduct agricultural research that reveals opportunities for improving yields
- Set up animal studies that verify the impact of climate on species
- Perform soil studies to understand the effects of climate on soil quality
- Gather essential data for more effective stormwater management
- Perform detailed water quality studies
- Conduct rigorous oceanographic research
- Run long-term climate change studies
- Study and measure environmental impact
- Do in-depth hydrology research that reveals the movement, distribution, and quality of water – even across a broad area

Anatomy of a data logger

When most people use the term "data logger," they're usually referring to the whole device, which is comprised of a data logger, which does the logging, and sensors, which measure the parameters.



Let's dig a bit deeper into what the device actually is and does. A data logger at its most basic is a small device with an internal microprocessor, data storage, and one or more sensors, all housed in a hard plastic casing that is weatherproof and/or tamper resistant, depending on the model.

When most people use the term "data logger," they're usually referring to the whole device, which is comprised of a data logger, which does the logging, and sensors, which measure the parameters. The sensor or sensors may be housed inside the data logger's case, or they may be attached to the logger's sensor ports via a cable. Data loggers also have either a cable port or an optical sensor, through which data can be transmitted to the user. Finally, some models have LCD screens that provide operating information, while others have simple light indicators.

All data loggers share these basic parts and characteristics; where they diverge is in exactly how data can be downloaded to the user. To this end, there are four main types of data loggers: stand-alone USB data loggers, web-based data logging systems, wireless data nodes, and Bluetooth Smart data loggers.

Stand-alone USB data loggers are compact, reusable, and portable, and offer low cost and easy setup and deployment. Internal-sensor models are used for monitoring at the logger location, while external-sensor models (with flexible input channels for a range of external sensors) can be used for monitoring at some distance from the logger. Most stand-alone loggers communicate with a computer via a USB interface. For greater convenience, a data shuttle device can be used to offload data from the logger for transport back to a computer.

Web-based data logging systems enable remote, around-the-clock Internet-based access to data via GSM cellular, Wi-Fi, or Ethernet communications. These systems can be configured with a variety of external plug-in sensors and transmit collected data to a secure web server for accessing the data.

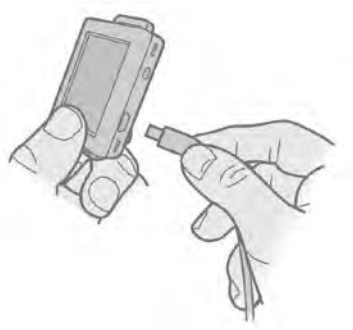
Wireless data nodes transmit real-time data from dozens of points to a central computer, eliminating the need to manually retrieve and offload data from individual data loggers.

Bluetooth Smart enabled data loggers measure and transmit temperature and relative humidity data wirelessly to mobile devices over a 100-foot range.

Depending on the scope of your data logging needs, your budget, the distances involved, and the time you have to access sites, you can choose among these four types of data logging systems for your application.

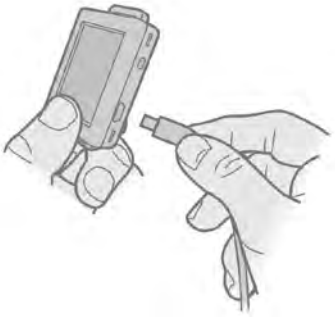
Using a data logger

Today's data loggers are easy to use, and require only a computer with a USB port for configuration and launch, or a mobile device and app, as well as a few simple hand tools for securing the units in place.

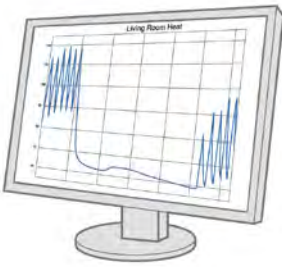


1. Configure and launch - First, connect the data logger to a computer via a USB interface. Next, use the accompanying data logger software to select logging parameters (sampling intervals, start time, etc.) and activate the logger. Some software allows for configuring large numbers of data loggers at the same time, which can be a huge time savings. (Bluetooth Smart loggers can be configured and launched wirelessly, after deployment.)

2. Secure in place – Next, deploy the data logger in the desired location. Securing it in place can be as simple as using a magnet, screw, or lanyard to fasten it to a wall. In other instances, installation can be more complex, particularly when dealing with multi-channel data logging systems such as a weather station, where the user needs to assemble and secure a weather station tripod, arrange and protect sensors from elements and animals, plug everything in, and weatherproof all connections.



3. Download or access data - After the desired monitoring period, reconnect the data logger to the computer, and launch the software to read out the data. In the case of web-based data logging systems, data are pushed to the Internet for access; with wireless data nodes, data are transmitted to a central receiver; and with Bluetooth Smart loggers, data are downloaded directly to your mobile device.



4. Process/analyze/present data – The data logger's software allows you to combine and compare data, and display the measurements in graphs that show profiles over time. Alternatively, tabular data can be viewed as well, or exported to a spreadsheet for further manipulation.

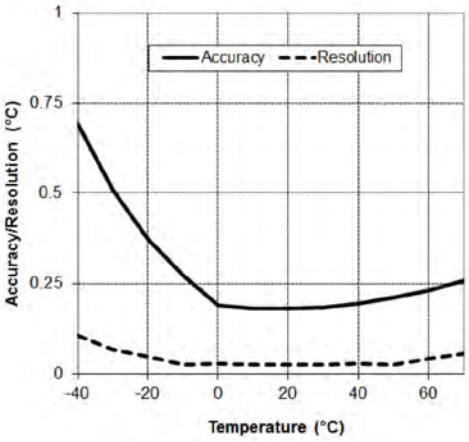
Considerations for evaluating data loggers

Now that you have an overview of what data loggers are and how they work, you can make some educated choices about them for your particular application. Before you start to look around or contact any data logger manufacturers, it's a good idea to have a clear understanding of your requirements and preferences. Here are some questions to consider:

- What do you need to measure? Where? For how long? This will help to identify which sensors you need, as well as the type of housing the logger requires.
- Is yours a one-time data-logging situation, or will it be part of an ongoing project or toolkit? This will inform whether you choose data loggers with internal, hard-wired sensors, or more flexible multi-channel loggers that can accept a range of sensors.
- How often would you like to access data? Will you collect the logger and plug it into your laptop, or would you rather save the travel time and expense and access the data on the Internet, or opt for the convenience of downloading data directly to a mobile device?

We'll touch on these in more detail below, but having the answers to these questions will help narrow down your choices.

Measurement accuracy



Plot A: Temperature Accuracy and Resolution

No matter what you need to measure, understanding your measurement accuracy requirements is essential. For example, if you're monitoring air-conditioning temperature in an office space, you may only require a temperature measurement accuracy of +/- 2 degrees, while monitoring conditions in a research lab may require far greater accuracy. Or when monitoring streams for suitability for certain fish species, for example, accuracy on the order of 0.2C is typically required.

Accuracy specifications vary widely among different types of data loggers, and a good understanding of specific accuracy requirements will help you avoid paying for accuracy you might not need. When looking at the accuracy specifications for a given data logger, be sure to look for charts that indicate accuracy over an entire measurement range, not just a single value. The accuracy a data logger can achieve at the high or low end of a given range may be far different from the accuracy at the middle of the range.

Another important factor is data logger resolution; that is, the number of increments of a value a data logger is capable of reporting. For example, a data logger with 12-bit resolution can report 4,096 values over a given temperature range. While a 12-bit data logger may offer more resolution than an 8-bit model, it's important to keep in mind that higher resolution does not necessarily mean better measurements.

If you're unsure about the data logger accuracy and resolution requirements of your application, an experienced data logger supplier should be able to help you determine which product will best meet your needs.

Data access options

With the simplest stand-alone data loggers, data are directly offloaded to a computer via a USB interface. In many instances, however, it's not practical to bring a computer out to a site, nor is it always convenient to bring a data logger back to the office. In such cases, data retrieval from stand-alone loggers can instead be easily and quickly accomplished using a pocket-sized device called a data shuttle. With a shuttle (or waterproof shuttle) you can download and store the collected data without having to interrupt or move the logger, and later link the shuttle to a computer for downloading and analyzing the data.

Wireless data logging sensors transmit highly accurate real-time energy and environmental monitoring data from dozens of points to a central location. With a networked arrangement, the chore of manual retrieval and offloading of data from individual loggers is eliminated.

Web-based data logging systems can be used in both indoor and outdoor environments. They enable real-time remote access to data via GSM cellular, Wi-Fi, or Ethernet communications, and can be configured with a wide range of plug-and-play sensors for monitoring everything from weather conditions to building energy consumption. Data can be accessed easily through a secure web site or integrated into custom systems with a relatively simple-to-implement set of web services

Bluetooth Smart data loggers, which measure and transmit temperature and relative humidity data wirelessly to mobile devices over a 100-foot range, are particularly useful in applications where data loggers need to be deployed in hard-to-reach spaces or in limited-access areas within a facility.

Wireless data logger sensors transmit highly accurate real-time energy and environmental monitoring data from dozens of points to a central location.

USB Loggers

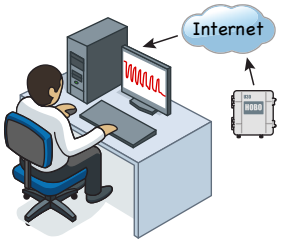
Short or long-term trend logging with manual offload

Wireless Sensors

Short-range centralized data collection

Web-Based Systems

Long-range wireless internet access



Bluetooth Loggers

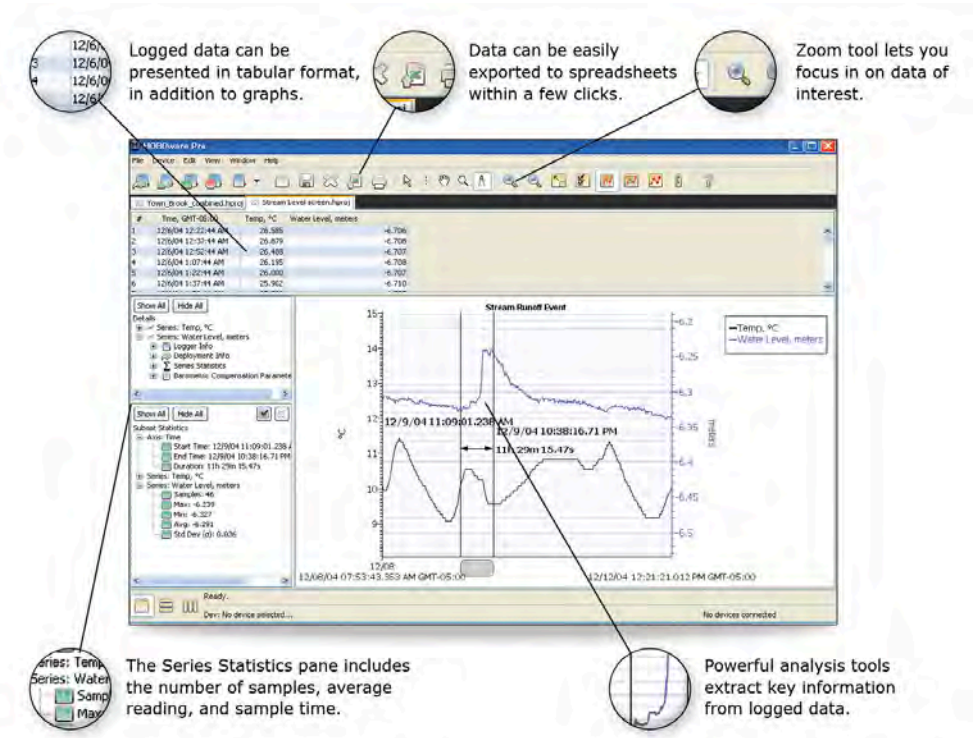
Wireless data access via mobile devices

Software capabilities

The software should enable you to quickly and easily perform tasks such as configuring parameters, launching the data logger, and offloading data, with point-and-click simplicity.

Just as there are many different types of data loggers available, there are also many different types of data graphing and analysis software packages. In general, look for software that is Windows®- or Mac-based, depending on your requirements, and highly intuitive so the learning curve is minimal. The software should enable you to quickly and easily perform tasks such as configuring parameters, launching the data logger, and offloading data, with point-and-click simplicity. Certain packages allow you to batch-configure and read out hundreds of loggers very quickly.

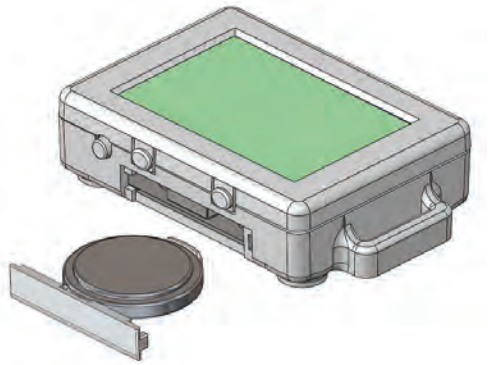
The data logging software package should also offer powerful data plotting capabilities, with an ability to easily merge, append, and crop data, and enable you to easily export data to other programs, such as Microsoft® Excel®, for analysis.



Durability

When buying a data logger, make sure the product's enclosure is designed to withstand the conditions of the environment where it will be located. For example, if you plan to conduct monitoring in an office hallway, a hard plastic enclosure should suffice. If the data logger needs to work in a condensing environment, however, you would want to choose a product with a moisture-protective enclosure. It's also a good idea to ask about the availability of protective cases and other enclosure accessories for situations where increased durability and/or protection may be necessary.

Battery life



Overall, data loggers are extremely low-power devices. However, because they are used in a variety of environmental conditions and sample at different rates, battery life can vary widely. As a general rule of thumb, make sure the data logger you select has a battery life of at least one year. For some remote situations, you may want to investigate whether a solar-powered option is available.

You may also ask a supplier about whether or not the data logger battery is user-replaceable, as this can eliminate the time and expense of having to ship the logger back to the manufacturer for battery replacement. Finally, data loggers that run off standard household batteries offer greater convenience than those requiring specialized batteries.

Cost of ownership

The lower cost of microprocessors and sensors in recent years has helped push down the price of battery-powered data loggers. Although many data products available today are attractively priced, it's important to look closely at the total cost of ownership before making your purchase. Here are some questions you may want to ask your potential supplier:

- Will the logger need to be calibrated by the manufacturer periodically, and if so, what are the cost implications over time?
- Will I need to invest in a pricey software package to analyze my results?
- Will I be able to use AA batteries, or will the logger require a proprietary or hard-to-find power source?
- Are cables included with the logger?
- Will I need to purchase a data plan for my web-based system, and if so, what types of plans are available?

Answers to these questions will help you understand the true cost of owning the data logger over the long term.

Product support

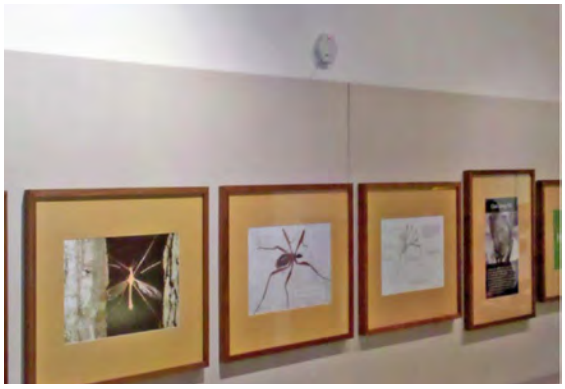
In general, data loggers should be easy to use, without requiring a great deal of technical assistance, even during the initial phases of use. Nevertheless, as with any high-tech product, there will always be questions. When evaluating data loggers, look for a supplier that offers a range of product support services. These services often start with a preliminary assessment of your application requirements, and should include both telephone support and Internet-based support resources.

In general, data loggers should be easy to use, without requiring a great deal of technical assistance, even during the initial phases of use.

It's also a good idea to find out if the supplier has the track record and stability to maintain the role of a long-term solutions provider; after all, you will have these data loggers for years. Then you can be assured that the company will be there to meet your future data logging requirements. Finally, you may want to ask the supplier for application notes and other references to gain a sense for how the data loggers performed in applications similar to yours.

Building Performance

Indoor Environmental Monitoring



Challenge:

- Prevent deterioration of irreplaceable natural history museum collection
- Comply with restrictions associated with historical landmarks
- Monitor and maintain stable temperature/RH levels throughout 420,000 sf of museum space

Solution:

- 50 wireless data loggers with integrated temperature and RH sensors
- Discreet deployment of data nodes via non-marking 3M adhesive strips
- Real-time data, instant notification potential, and onboard buffer memory to ensure no data are lost

Results:

- Convenient data offload from multiple locations
- Prompt identification, diagnosis, and resolution of HVAC equipment dysfunction

Energy Monitoring

Challenge:

- Reduce energy costs associated with 9,000 sf facility that generates $25K in utility bills annually and decrease its carbon footprint
- Determine which energy-saving equipment best fits the needs of the facility
- Calculate potential return-on-investment of the new equipment

Solution:

- Data-driven approach involving the deployment of portable data loggers throughout the facility
- Collection of large quantities of diverse data in a short amount of time
- Motor On/Off data loggers deployed directly on loop motors
- Temperature data loggers deployed discreetly in office areas to log zone temperatures

Results:

- Based on data analysis, recommended actions to install new HVAC controls and a web-enabled system for centralized/automated control of HVAC system, install energy recovery ventilation system, install a solar photovoltaic energy solution, and implement building shell improvements
- Estimated energy cost savings of $215K over the next 15 years

Environmental Research

Climate Monitoring

Challenge:

- Manage agricultural risks related to weather and pests; minimize use of pesticides
- Fully utilize the power of weather-based models
- Provide a user-friendly decision support tool that doesn't involve additional work for growers

Solution:

- Deployment of on-site web-based weather stations
- Transmittal of live weather data to the Internet via integrated Wi-Fi communication modules

Results:

- Accessible, accurate, farm-specific weather data
- Information helps growers with actionable pest management decisions

Water Monitoring

Challenge:

- Restore and preserve freshwater ecosystem
- Decrease stream temperature to increase pool habitat for native fish
- Support healthier fish populations and a larger beaver population

Solution:

- Create active connections between three natural springs and the creek to provide new sources of cool water and additional stream-flow
- Install water temperature data loggers above and below each spring confluence with the creek to collect pre- and post-project stream temperature data

Results:

- Charted stream-flow and temperature information from data collected at 30-minute intervals and download approximately four times per year via HOBO Waterproof Shuttle
- Data helped determine how effective the connection of the springs to the creek was in lowering stream temperature

Other informational resources available from Onset:

Analyzing Air Handling Unit Efficiency with Data Loggers

Operating a heating, ventilation and air conditioning (HVAC) system at optimum efficiency in a commercial setting is complicated, to say the least. There is a very real chance that any number of setpoints, levels, and feedbacks at boilers, chillers, pumps, fans, air delivery components and more can cause costly inefficiencies.

Finding Hidden Energy Waste with Data Loggers: 8 Cost-Saving Opportunities

The first step to reducing building energy costs is identifying energy waste. Statistics on utility bills or name plates on equipment, while useful, are not enough to identify what practices and equipment are contributing to high energy use. Portable data loggers can be used to obtain critical energy use information in a wide range of commercial building types – from manufacturing plants to office buildings.

Monitoring HVAC Performance with Data Loggers

Building operators and managers have the difficult job of providing comfortable working conditions and coaxing aging mechanical equipment to operate at peak performance while minimizing energy costs. If the mechanical equipment is old or has inadequate controls, maintaining comfort at a reasonable cost may prove difficult or impossible. Although energy costs typically represent only 1% of a building's operating expense when occupant salaries are included, they are easily managed expenses. Energy cost savings flow directly to the bottom line as increased profits.

The Energy Professional's Guide to Data Loggers & Building Performance

This 30-page guide, developed in conjunction with Stetz Consulting LLC, details how portable data loggers can be applied in a number of building monitoring applications, such as HVAC systems monitoring, commissioning, Measurement & Verification, and load profiling. The guide offers practical tips and techniques on a range of topics, including data logger installation, monitoring plan development, safety, and data interpretation.

Addressing Comfort Complaints With Data Loggers

This paper offers facility managers, HVAC contractors, and others with valuable tips on how low-cost data loggers can be used to validate temperature-related comfort complaints.

Optimizing Solar Thermal Performance with Data loggers

This paper discusses how solar thermal systems, with the help of portable data loggers, can be optimized to deliver the financial benefits residential and commercial users hope to achieve through their investments. The paper shows installers and engineers how portable data logging devices can be used to measure performance of solar thermal systems, pinpoint any defects or inefficiencies, and optimize performance for greater return on investment.

Monitoring Green Roof Performance with Weather Stations

Data logging weather stations are the ideal tools for documenting green roof performance. A weather station can measure weather parameters such as rainfall, stormwater runoff, temperature, relative humidity, wind speed, solar radiation, and a host of non-weather parameters such as soil moisture on a continuous basis (say every five minutes, hourly, or an interval appropriate to the situation). For the purpose of this discussion, "weather station" may refer to a data logger that measures and stores data from weather sensors. The information a weather station collects can help you make wise choices about designing, tuning, and maintaining a green roof.

Measurement & Verification: Tapping into ARRA Stimulus Funds

This paper provides guidance on identifying potential sources of ARRA stimulus funding for energy performance monitoring projects. It details new programs from the ARRA, explains the growing importance of Measurement Verification (M&V) services, and discusses specific ways ESCOs can apply portable data logging technology to document building energy savings.

Using Data Loggers to Meet LEED® Existing Building Certification Credits

This paper provides information about how data loggers can make it simple to satisfy many LEED Existing Buildings Operations & Maintenance credits. It discusses how the devices can help with the certification process and documenting performance improvements for submission to the U.S. Green Building Council.

Monitoring Wetlands with Data Loggers: A Best Practices Guide

Wetlands act as a natural filter for polluted water and thus play an essential role in water quality protection. They serve as floodwater storage to help minimize erosion, and create a habitat for many fish and wildlife.

Access our full resources library at: www.onsetcomp.com/learning

About Onset

Onset is the world's leading supplier of data loggers. Our HOBO data logger products are used around the world in a broad range of monitoring applications, from verifying the performance of green buildings and renewable energy systems to agricultural and coastal research.

Based on Cape Cod, Massachusetts, Onset has sold more than 2 million data loggers since the company's founding in 1981.

Contact Us

Our goal is to make your data logging project a success. Our product application specialists are available to discuss your needs and recommend the right solution for your project.

Sales (8am to 5pm ET, Monday through Friday)
- Email sales@onsetcomp.com
- Call 1-800-564-4377
- Fax 508-759-9100

Technical Support (8am to 8pm ET, Monday through Friday)
- Email loggerhelp@onsetcomp.com
- Call 877-564-4377

Onset Computer Corporation
470 MacArthur Blvd.
Bourne, MA 02532