

Monitoring Green Roof Performance With Weather Stations

In the world of environmentally sensitive and sustainable building, green roofs are becoming more popular in new construction and renovation projects. The investment in covering a roof with soil and plants can pay off through mitigating stormwater runoff, lessening the heat island effect, and offsetting interior heating and cooling costs.

In order to verify that a green roof is indeed providing the benefits to justify the investment, it's important to monitor performance. For building projects participating in the Leadership in Energy and Environmental Design (LEED®) Green Building Rating System®, documentation of green roof performance is a requirement.

Data logging weather stations are the ideal tools for the job. A weather station can measure parameters such as rainfall, stormwater runoff, temperature, relative humidity, and many others 24 hours a day, 7 days a week. The information a weather station collects can help you make wise choices about designing, tuning, and maintaining a green roof.

This guide will explain how a weather station can be a valuable component of a green roof project, and will share information particular to this type of application.

Green Roofs

A green roof is a roof covered with layers of synthetic and natural drainage layers, soil, and growing plants. The roof's base structural support is typically covered with insulation, waterproofing, drainage space, a filter membrane, a root barrier, and finally, soil and plants. Most large green roof projects are installed on flat roofs.

Green roofs are broken into two categories by soil depth and plant type. Extensive green roofs are covered in soil 1-6 inches deep, and are planted with shallow-rooted, ground-hugging plants such as succulents or grasses. Such roofs may or may not be designed for pedestrian traffic. Intensive roofs have a deeper soil layer, and can support large plants, shrubs, and even trees. Intensive roofs are often part of rooftop terraces or pleasure parks, and can require irrigation and dedicated landscape maintenance.

There are several benefits to investing in green roofs:

- They help in stormwater management by withholding water from drainage systems, thus lessening the burden on infrastructure and runoff treatment. A portion of rainwater is held in the soil, taken up by plants, and returned to the atmosphere as water vapor via evaporation and transpiration. A green roof can eliminate or lessen the need for rooftop stormwater detention tanks.
- Green roofs help mitigate the heat island effect. Typical black-membrane and asphalt roofs absorb solar radiation that raises the temperature above buildings, and in urban and suburban areas in

general. Green roofs are covered with soil and green plants, which absorb much less solar radiation than do dark-colored roofs. The soil also releases water vapor, which helps in regulating roof and surrounding area temperature.

- Building interior heating and cooling costs can be moderated by the use of a green roof. The roofs provide insulation from both sun and wind, and can make an impact on temperatures, especially for single-storey buildings.
- Green roofs can provide outdoor space for building inhabitants or the public, and can offset the loss of green spaces typical in cities. They can also be powerful tools for teaching the public about sustainable building practices.
- Installation of a green roof can contribute toward satisfying several credits for LEED® Certification, in particular by providing design and performance documentation pertaining to stormwater management and heat island effect mitigation.

In order to achieve the best possible performance from a green roof, it is best to monitor a range of environmental conditions including rainfall, temperature, wind speed and direction, relative humidity, soil moisture, runoff, solar radiation and others. For LEED® Certification, monitoring and documentation of performance is a requirement for some credits.

The more data you have, the better observations and decisions you can make about your green roof.

Data Logging Weather Stations

Data logging weather stations are ideally suited for monitoring a green roof's performance and operating conditions.

These systems are typically stand-alone units supporting sensors that monitor such parameters as temperature, wind speed, wind direction, rainfall, soil moisture and others. The weather station and its sensors are typically mounted on a metal tripod. Units typically run on battery and/or solar power and all components are designed to withstand long-term outdoor weather conditions.

Data logging weather stations eliminate human error from data monitoring, and can be counted on to collect unattended readings 24/7, 365 days a year and store it into logger memory. Operators download data remotely or manually, and use data logging software to configure, deploy, retrieve and analyze information from the station.

For more information about data logging weather stations, see the boxes in this paper, and refer to the guide in this series, Choosing a Data Logging Weather Station: 5 Important Considerations, available at www.onsetcomp.com.

Green Roof Monitoring Applications

Here are some approaches for using data logging weather stations to get the most out of your green roof performance and investment. Some of these applications can help satisfy requirements for LEED® Certification credits.

Design

During the preliminary design process, it's prudent to collect environmental data in order to choose the best green roof design suited to the site. Rainfall, temperature, wind speed, wind direction, and solar radiation all change seasonally, and can be affected by surrounding buildings and structures. It's best to measure some of these parameters at multiple points in the site. For retrofits, data collected before renovation can be a valuable measure of the new green roof's performance. The more data you have before you make design decisions, the better.

Stormwater Management

In order to verify that a green roof is helping to reduce the amount of stormwater released from a roof from a given rainfall event, you must know how much rain has fallen and how much has left the roof via downspouts and drains. In a green roof system, the roof runoff is equivalent to the total rainfall volume minus evapotranspiration and soil retention. One technique for measuring runoff involves deploying a flow sensor at each downspout and/or drain. Evapotranspiration can be calculated from solar radiation, air temperature, relative humidity and wind velocity at the site. The remaining portion of rainfall volume is retained in the soil, and can be measured/monitored with soil moisture sensors in order to observe where and when the soil is holding water, and for how long.

Heat Island Effect Mitigation

It is easiest to monitor the before-and-after heat island effects of green roofs on renovated roofs. It's a matter of simply using a weather station to monitor pre-renovation roof temperature over time at several points on and above the roof. Once the green roof is installed, temperature can be monitored at the same points to verify whether or not there has been a significant change. For new construction, you could use a weather station on the green roof and compare the temperature data with data from stand-alone battery-powered temperature loggers deployed on nearby surrounding conventional rooftops.

Maintenance of Plantings

Whether a green roof is extensive, with low, sparse groundcover, or intensive, with small trees and lush lawns, you can better maintain healthy plant cover if you have ongoing, reliable conditions data. A weather station can monitor soil moisture and rainfall, and thus help in making irrigation decisions. Temperature and wind monitoring can also be important in maintaining the health of rooftop vegetation. For extensive landscaped rooftop gardens, the data gathered by a weather station can be crucial to understanding how to care for them on a rooftop, where environmental conditions differ from those on the ground.

Offset of Interior Heating and Cooling Costs

A green roof acts as insulation from the sun and wind, and can affect a building's interior heating and cooling requirements. In the case of a renovation, you can compare the before-and-after effects by deploying a weather station on the roof and indoor temperature loggers in the building's top floor for a period of time before construction. Rooftop measurements should include temperature, solar radiation, and wind speed.

WEATHER STATION FEATURES – A BRIEF OVERVIEW

For more information about data logging weather stations, download our white paper, *Choosing a Data Logging Weather Station: 5 Important Considerations* at www.onsetcomp.com.

1. Sensors and Logging Capacity

The first step in thinking about a weather station is to decide what you want to measure, where, and how many of each sensor you will need. For example, would you like to monitor soil moisture content at four locations on your green roof? Then you'll need four soil moisture sensors. Each sensor you use requires a data channel at the logger, and weather station loggers have different capacities, depending on the model and manufacturer. Some weather stations allow for the use of third-party sensors, so if this flexibility is important to your application, shop around.

2. Configuration and Setup

Some weather stations require complicated wiring and programming, while others can be set up in about an hour with plug-and-play ease. The user-friendly systems have "smart sensors" that simply plug into any port on the logger. The logger and accompanying software automatically recognize the sensor. The user simply chooses a sampling interval and start time.

3. Data Download

Some of today's weather stations allow you to access data through the Internet, and you can also download data directly to a laptop or data shuttle. Data transfer takes only a few minutes on-site, and with internet-based data transfer, you can have up-to-the-minute data at your fingertips whenever you need it.

4. Software

Chances are, you'll want to work with your data, whether to enter data into models, or simply present the information clearly in a graph. Weather station software capabilities vary, but you'll want to look for an application that allows you to combine graphs to compare data between sites, or to view all of a site's data clearly in a single graph. Depending on your application, the manufacturer may also have special application-specific software available.

5. Cost and Support

Data logging weather stations can range in cost from several hundred to a few thousand dollars. Additionally, hardware and accessories such as a tripod and various sensor shields can add up. Ask colleagues about their experiences, and get a feel for how willing a manufacturer is to help you with your green roof application.

Once the green roof is installed, deploy the weather station and indoor loggers in the same or comparable locations, and observe how outdoor and indoor conditions correlate with one another both before and after renovations.

Education and Research

Green roofs are growing in popularity, and more and more sustainably-minded builders and building owners want to share their green roof projects with the public. The data gathered from a rooftop weather station can be made available over the internet to energy analysts, building occupants, schools and the interested public who all want to know how a green roof works and how it can help lessen a building's impact on the environment. Engineers, researchers and green roof component manufacturers can also use data logging weather stations to develop and test new materials and configurations in order to increase green roof performance in the future.

Conclusion

Whether your goal is LEED® Certification, measurement and verification of performance, pre-design data collection, research or all of the above, data logging weather stations can help you make wise, money- and resource-saving decisions about design, materials, and maintenance of green roofs.

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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