Measurement and Verification: Monitoring Lighting Systems for Optimal Performance

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Summary

Introduction

Measurement and Verification is an increasingly common term being used within the energy efficiency and environmental communities. Simply stated, Measurement and Verification (sometimes referred to as M&V) is the process used to track the performance of a piece of equipment, a system, or an entire facility. The M&V plan compares the performance of a particular piece of equipment, system or building to:

a) the performance of the same equipment, system or building at an earlier time,

b) the performance predicted by a simulation,

c) or the performance of another piece of equipment, building or system.

M&V plans have become an essential component of many LEED® projects as well as many federal, state and local public energy projects. M&V is used to assure that projected savings occur, to identify opportunities that might impact greater efficiency, and as a means for quantifying and reporting emission reductions.

Since a commercial building's lighting system can account for up to 35 percent of a building's total energy load, lighting and lighting controls are key considerations when developing an M&V plan. This paper addresses the various types of M&V plans typically used for evaluating lighting systems, the benefits provided from these plans, along with the implementation of an M&V system.

M&V Overview

M&V beginnings can be tracked back to the oil embargo of 1973 when high energy prices spawned the Energy Service industry. New companies termed ESCO's (Energy Service Companies) emerged to offer various services for designing, implementing, and financing energy-related improvements for existing buildings. ESCO's would typically guarantee the building owner specific results; usually these results were lower utility costs. Various forms of performance verification resulted from these needs to assure contractual requirements were being met. Today's M&V plans were born from the work done during these early years of verifying energy performance.

The green community has also embraced M&V as a means for reporting both energy savings and other environmental aspects. In LEED certified and other high-performance buildings, an M&V plan is used to document the reduction in emissions, to ensure enhanced environmental quality is being maintained. For example, the *US Green Building Council's (USGBC)* standard requires, as a prerequisite, that an operations maintenance plan be established to ensure that a facility's energy efficiency targets are being met.

New high-performance building standards such as the *International Green Construction Code (IGCC)* requires that commissioning be performed on specific energy conservation measures (ECMs) and documented such that measures are meeting the design criteria. Draft versions of the ASHRAE Standard 189.1-2009, *Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings*, also outline requirements for metering and M&V verification.

The industry standard for M&V, both in the United States and internationally, is the International Performance Measurement and Verification Protocol (IPMVP). The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE); the United States Department of Energy (DOE), Federal Energy Management Program (FEMP); and the United States Green Building Council (USGBC) Leadership Environment and Engineering Design (LEED) Rating System use the IPMVP standard as the basic guideline for energy performance verification.

M&V Basics

The IPMVP guidelines group M&V methodologies into four general categories: Options A, B, C, and D. These are generic approaches with each option having its own advantages and disadvantages based on specific site criteria and the needs of the building owner.

The two most prevalent options for lighting and lighting control energy conservation measures are Options A and B. Option A is a popular approach for straightforward lighting retrofit projects that do not include any controls. In these projects, the parameters affecting savings include fixture power, hours of operation, and level of coincident operation (the percentage of operation when the building peak demand is established). Fixture power can be estimated based on manufacturer's specifications and spot-checked for compliance. Hours of operation are generally documented through a site survey. These operating periods are then used to determine both energy and demand savings during the performance period. This option is easy to implement compared with other approaches, and provides a high level of confidence, especially if the operating hours remain unchanged.

Option B is typically used in both new construction and retrofit projects that include the addition of lighting controls. Savings are determined by field measurement of all key performance parameters including fixture power, hours of operation, and level of coincident operation. Option B verification involves the same items as Option A, but requires more end-use metering. Results are generally more precise using Option B since actual metering values are made.

Option C pertains to whole facility utility analysis. This approach is generally used with complex equipment and controls projects where predicated savings can be substantial (i.e. > 20% of the building's total energy usage). Savings are determined by comparing a baseline analysis with the energy use reports provided for the entire building. Sub-metering may be used to provide data for overall energy profiles.

Option D utilizes computer software to model energy performance of the entire facility. Accuracy of modeling is ensured by using metered site data to describe both baseline and performance period conditions. Generally, Option D is used on very complex projects where the interactive effects between various ECMs are too complex for other methods. Option D is also useful for new construction or major building modifications where a baseline does not exist.

M&V Option	Description
A	Parameters are estimated based on historical data, manufacturer's specifications, or engineering judgment. Site spot checks are conducted for energy savings verification. Documentation of the source is required.
B	Savings are determined by field measurement of all key performance parameters which define the energy use of the ECM affected system.
C	Savings are determined by measuring energy use at the whole facility or sub-facility level.
D	Savings are determined through simulation of the energy use of the whole facility, or a sub-facility. Simulation routines are demonstrated to adequately model energy performance measured in the facility.

M&V Process

Implementation of an M&V plan for lighting and lighting controls generally can be broken down into the following steps:

1. Define a baseline and estimate energy performance for the individual systems.
2. Define the energy conservation measures (ECM's) and estimate initial savings. This is a comparison of the building's baseline energy performance to the building's energy profile once the ECMs are implemented.
3. Define the M&V approach (see above for options A, B, C and D).
4. Verify proper installation and commissioning of ECMs.
5. Determine actual savings resulting from the implementation of the ECMs using the agreed M&V approach.
6. Re-evaluate at scheduled intervals to ensure savings are being maintained while also looking at data for new energy savings opportunities.

The M&V Systems for Lighting Systems

Option A is often selected for simple lighting retrofits where the confidence level of the ECM (fixture) is high in terms of its power consumption, and operating hours can be accurately predicted based on a sample of spaces conducted during a site survey. An M&V plan for this type of project assumes:

- Operating hours will be measured prior to the retrofit. The hours the fixtures operate will be the same before and after the fixtures are replaced for the purposes of energy calculations.
- Fixture power before and after the retrofit will be measured.
- Interactive effects of the fixture retrofit on the heating, ventilation, and cooling system is not considered.
- Lighting levels remain constant.

Determining actual hours of operation is often performed using portable data loggers that time stamp the change-of-state that occurs between ON and OFF. Data collected from these loggers are also analyzed to determine if the surveyed area is ON during expected peak demand periods. Portable power meters are typically used for measuring power levels.

With the advent of green buildings and high performance building standards, Option B is quickly becoming the prevalent approach. Virtually every building energy code now requires lighting controls for any new construction or major alternation of a lighting system. As such, the need to measure power usage and time of operation becomes necessary. At a minimum, lighting controls affect the operational time a lighting system operates. Lighting controls, however, are also used to lower power consumption by dimming lights in response to available ambient daylight or in response to load shed commands. An M&V system for these types of installations must be able to track energy profiles, both kWH and kW by time of day. This means that adequate metering must be installed along with the ECM's.

Many green building standards' committees recognize this need and have included sections within the relevant standards to require metering at both main and sub-metering levels. Metering is required for each major system within the building as well as at sub-components of a system.

In the case of lighting systems, metering is generally employed for different areas and types of lighting used throughout a building. For instance as in the case of Harvard University's Green Building Standard*, lighting for parking garages are to be metered separately from a buildings commercial space.

Several types of metering options are currently available. Individual enclosed electronic meters are often used when there are a minimal number of metering points. More often, however the number of required metering points may be numerous and the practicality of mounting separately unenclosed meters is not practical. In these cases, enclosures containing several meters are preferred.

One particularly unique approach to metering lighting systems is to embed the metering functions within the lighting control. These hybrid solutions provide a complete energy monitoring and control package that reduces the total footprint required for the equipment. This complete package allows a single network to communicate data back to the central building management system while also independently monitoring and controlling individual branch circuits.

The Schneider Electric™ Powerlink™ Energy Management (EM) lighting control panel is one example of such a system. This panelboard provides four key functions critical to a lighting energy efficiency and M&V system: branch overcurrent protection, load scheduling whereby individual branch circuits can be independently scheduled for ON or OFF operation, override of scheduled events in the event of a load shed requirement, and data acquisition of individual branch circuit parameters including power consumption, peak kW load and cumulative power consumption kWH.

Having the ability to independently control and monitor individual branch circuit loads opens a wide range of options for an energy manager to better understand the dynamics of a building's performance. Through data acquisition software programs such as Schneider Electric's PowerLogic™ ION Enterprise™, an energy manager can quickly determine system performance by load type, building area or ECM.

Summary

It's an old adage: "if you can't measure it, you can't control it". Any energy conservation measure must be accompanied with a proper M&V plan if success is to be measured. A properly designed M&V plan and system will:

- Provide the energy manager the ability to measure actual energy consumption objectively and accurately,
- Account for energy usage on a time-of-day basis,
- Compare energy consumption and demand to an established baseline,
- Verify energy and dollar savings resulting from the energy conservation project,
- Monitor the performance of various systems to determine if they are operating as intended,
- Provide data for planning and subsequent further energy savings opportunities,
- Provide an objective means for prioritizing future energy management opportunities.

* 2009 Harvard University Green Building Standard, green.harvard.edu/theresource/.../green-building-standards-2010.pdf

About Schneider Electric

Schneider Electric is a $22 billion global leader in energy management with core competencies in buildings, energy and infrastructure, data centers and networks, industry, and residential. We help people and companies make the most of their energy, helping them make it safe, reliable, efficient, productive and green. Our expertise in energy management and our involvement in all end-user energy consumption, uniquely positions us to help address one of our world's largest dilemmas – energy. Schneider Electric is leading the "Intelligent Energy" movement, calling for businesses and consumers to be smarter about the way they use energy.

To further demonstrate its commitment in the energy efficiency space, Schneider Electric recently announced the Powerlink EM series. Powerlink EM Intelligent lighting panels provide a simple, cost effective and energy code compliant way to meter and control branch circuits from a standard panelboard.

Powerlink EM systems feature powerful microprocessor based controllers to provide lighting control and power metering. The Powerlink EM system integrates the features of the Square D PowerLogic Branch Circuit Power Meter with the Powerlink G3 system in one solution.

Scott Jordan joined Square D/Schneider Electric in 1978 and has worked in the company's lighting control business since 1992. Scott served as Product Marketing Manager of the company's Installation Systems & Control business. He has a bachelor of science degree in electrical engineering from the University of Kentucky.

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