an introduction to

MEASUREMENT & VERIFICATION

How M&V Benefits You

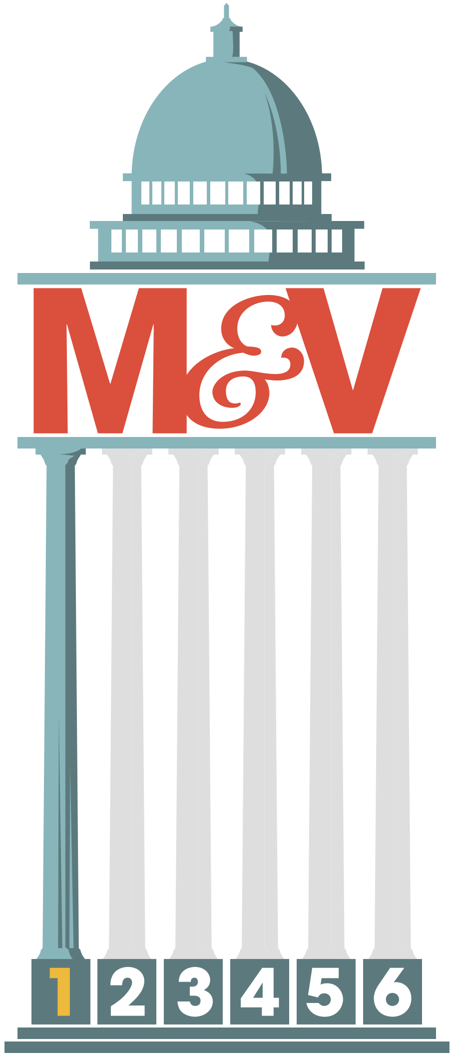
EnergyCAP

This eBook is most relevant for energy stakeholders new to the concept of energy savings project assessment.

This eBook presents information on the Measurement and Verification (M&V) process. This will help you understand the value of M&V and how it can fit into your energy management program.

Table of Contents

M&V-
What and Why?



What is M&V and why is M&V important? M&V is the energy industry's term for Measurement & Verification. More specifically, it is the measurement and verification of energy savings or cost avoidance resulting from any sort of energy initiative such as a relamping project, new construction, retrofit or retro commissioning, or even a behavior-based energy savings program.

M&V is important as one of the six foundational pillars of many energy efficiency initiatives. These pillars are:

1 **The Purpose.** The first pillar is the purpose—the benefit that is the reason or reasons the project exists. Unless the purpose of an initiative is clearly understood and communicated, the project may not be implemented correctly, if at all. Each benefit has a beneficiary, which is often the person or institution that will benefit most directly from any energy savings resulting from the initiative. The beneficiary usually has claim to the asset that will be affected by the initiative.

2 The Product. This is supplied by the manufacturer. The manufacturer builds the equipment that is being installed, whether it be mechanical equipment or high efficiency windows or lighting or insulation or any type of building components.

3 The Process. This is overseen by the contractor. Most energy projects require a contractor, or at least an individual who serves in that capacity regardless of title. The contractor is responsible for ensuring that the project gets done. He/she coordinates the process of program implementation.

4 The Design. This is done by a designer. In most energy scenarios, the designer is an engineer who creates the specifications that define the project.

5 The Financing. Funding for the project comes from the financer, who provides the money and/or other needed resources for a particular undertaking. Sometimes the financer is the owner, and sometimes a third party.

Share this eBook!

6 The Performance Assessment. Performance assessment provides a level of assurance that the project purpose has been achieved. Measurement & Verification is a kind of post-project quality assurance. M&V helps determine in an objective way if, or to what extent, promised benefits have been obtained.

All six pillars play an important role in completing the energy initiative. The M&V component ties these different pieces and players together by supplying objective assurance that the initiative has been completed successfully. At the end of the day, M&V reveals how much money and energy the project really saved. M&V provides an agreed-upon point of reference for all the stakeholders for evaluating the benefit of the energy initiative.

Share this eBook!

An M&V **Quiz**

We can demonstrate the value of Measurement & Verification with a hypothetical situation. Suppose that last year we spent $3 million dollars on utilities. Then we hired an Energy Manager on the first of January this year who implemented some sort of energy management program. By the end of the year, we had spent $4 million dollars, so we went from $3 million dollars to $4 million dollars of utility spend (plus the energy manager's salary) in one year. Should we:

Mr. Energy Manager

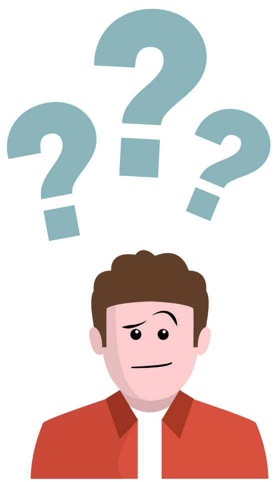
A **Fire the Energy Manager.**

B **Praise the Energy Manager.**

C **We don't have enough information to decide.**

Well, the right answer is C. We don't have enough information to know if the energy manager was effective or not. This is the purpose of M&V.

More Space
+
Increased Enrollment
+
Increased Rentals
+
Price of Electricity
+
Weather
=



Now let's add some additional information to our example. Let's assume that in the current year, we added 75,000 square feet of managed space, we increased enrollment at our facility (which we will say is a high school), we increased community rentals, and we had an increase in the price of the electricity commodity. On top of that, we had a record-setting hot spell this summer. So how shall we answer the quiz question? Fire the Energy Manager, praise the Energy Manager, or do we still need further information?

Well, the new information is valuable, but we still don't have enough of it to be able to say if the energy manager did a good job or not. We don't know what the electricity price increase was, or what percentage of the utility spend is represented by the electric commodity. We don't know if the electric spend is weather-dependent, and to what degree.

We don't know how much the enrollment increased or how enrollment affects our utility bills. And we don't know the impact of the community rentals in terms of utility use or expense. We don't even know the size of the facility, so it's very difficult to assess the significance of the increase in square footage.

B. Praise
Mr. Energy Manager

Let’s take the example a couple of steps further by inserting a Measurement & Verification component. Using data from the baseline year—the year before we implemented the initiatives—our Measurement & Verification software calculated that we could expect to spend $4.8 million this year on utilities.

That was a calculated expectation of what **would have been spent** based on the new conditions including the increased floor area, the increased enrollment, commodity price changes, and the severity of the weather. So the software analysis suggested that had we done nothing—had we just continued our wasteful ways—we would have spent $4.8 million. In actuality, the spending was $4.0 million, so the cost avoidance this year amounted to $800,000.

The correct answer to our quiz is B: We should praise the energy manager.

We have to determine fairly what we would have spent in the absence of the energy management project. And that's the concept of the avoided spending—**Cost Avoidance**.

This example illustrates the essence of the M&V problem—how to calculate energy and cost savings fairly and accurately. It's not enough to simply compare year to year out-of-pocket expenditures. We can't run down the hall to the accounting department and ask, "What does general ledger say?" because things have changed. The weather, utility rates, occupancy, and square footage may have all changed. So we have to determine fairly what we would have spent in the absence of the energy management project. And that's the concept of the avoided spending—Cost Avoidance.

M&V **History**

Cost Avoidance was first introduced to computerized utility bill tracking in 1985 with the introduction of the Cost Avoidance module in FASER Energy Accounting software (now EnergyCAP). Today, several software systems incorporate some sort of Cost Avoidance feature.

In the 1990s, in response to needs of the performance contracting marketplace, the US Department of Energy took a leadership position and pulled together various other agencies to develop a written guideline which came to be called the IPMVP – the International Performance Measurement and Verification Protocol. The intent was to provide a guidance document that would explain the proper way of doing M&V calculations, with the understanding that such a document would provide value to all parties involved in an energy management initiative.

Today, IPMVP is managed by an international non-profit corporation called EVO. The Federal government currently uses a version of the EVO documentation to value the savings of all federal energy projects, which in total make up billions of dollars of energy performance contracts.

The Four IPMVP
M&V Methods

The IPMVP guidance document (it is not a law or regulation) provides four different options for M&V calculations. So the first thing that should be done to evaluate an energy management initiative is to decide which of the four M&V options is appropriate for your project.

Option A: Retrofit Isolation

Option A is called *Retrofit Isolation*. In this method, you measure and estimate only the key parameters (*key parameter measurement*). An example would be a lighting retrofit. For a lighting retrofit, the wattage reduction is known “in advance” because we know the original wattage and we know the total wattage to be installed. If necessary, we can measure for some period of time how many lights are on and for how many hours. Then the Measurement & Verification process involves doing the math to determine watts saved and resulting cost savings. The key parameters for this example would be hours of use and wattage changes.

Option B: Retrofit Isolation

Option B is also called *Retrofit Isolation*, but for this option, all relevant parameters are tracked. A simple example might be a chiller replacement. We can submeter all inputs to the old chiller for maybe a few weeks or months before the retrofit. Then we remove the old one and install the new one. By submetering everything coming in and out of the new chiller, and comparing those operating parameters with those of the previous chiller, we can achieve a highly accurate picture of actual savings over some limited period of actual operation.

M&V

With behavior-based programs, the only feasible way to assess performance is with a **"Whole Facility"** perspective.

Option C: Whole Facility

Option C is called *Whole Facility*. In Option C, the method originally used in FASER and in EnergyCAP today, we compare facility utility bills before and after the energy management initiative. A good application for Option C would be a behavior-based energy management program. In a behavior-based program, the energy manager might be doing a hundred things in a building to reduce energy usage. Many of those activities would be impossible to isolate or measure individually.

It's almost impossible to submeter every light switch, and it's tough to measure resolve. So with behavior-based programs, the only feasible way to assess performance is with a "Whole Facility" perspective. This perspective can be achieved by analyzing utility bills for the facility before and during/after the initiative, and then comparing them, isolating and accounting for as many unrelated variables as possible.

Option D: Calibrated Simulation

The final IPMVP method for M&V, Option D, is called *Calibrated Simulation*. This option uses comprehensive computer modeling, often hour-by-hour. A good candidate for this type of M&V might be a complex HVAC controls retrofit affecting many systems in a building, especially a very complex building. If you do something in a hospital, for instance, it's more difficult to use Option C because whatever you're doing in the hospital might be only a small percentage of savings. So it's hard to see it when you compare utility bills because of the statistical "noise" produced by activities unrelated to energy management. Calibrated simulation could be a better way to calculate the effect of the retrofit.

Using IPMVP Option C:
Whole Facility Methodology for M&V

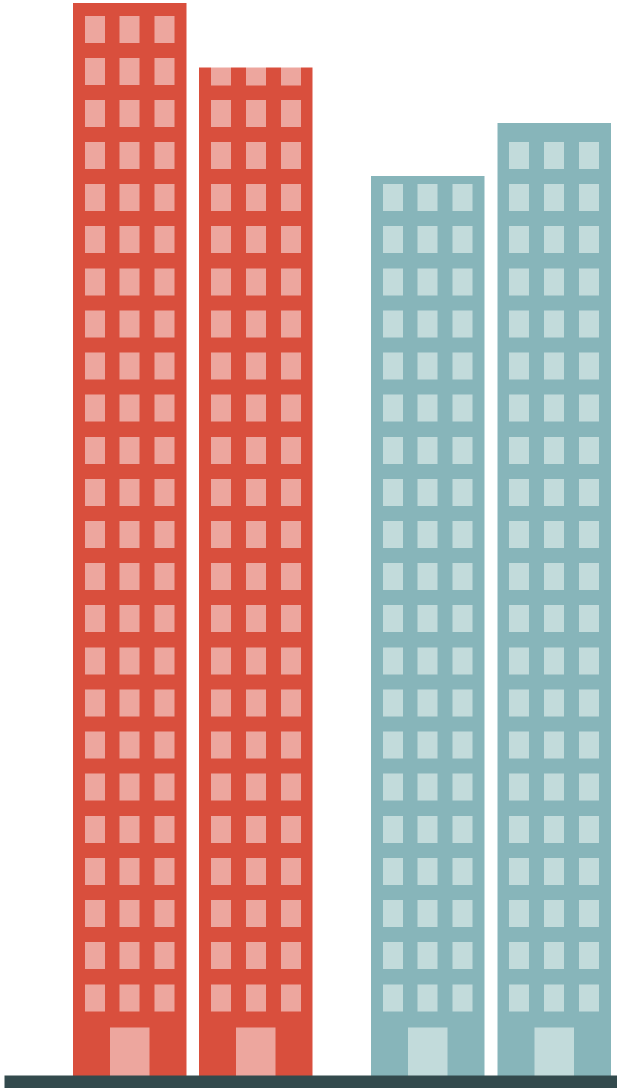
Since most energy management projects can be assessed effectively with Option C, let's look at how this methodology works.

1 Establish a Baseline.

In Option C, we must first establish a baseline year. Typically this period is the twelve months immediately prior to the implementation of the energy management initiative.

2 Adjust the Baseline to Today's Conditions

The next step is to adjust the baseline year to today's conditions, accounting for factors outside the parameters of the energy management program. For example, if the weather was hotter today, we would need to determine the extent of the weather variable in terms of energy use and then adjust the baseline use to match the current conditions. This is a matter of fairness.



If the summer was hotter in the current year, and air conditioners had to run longer and harder to maintain comfortable temperatures in managed buildings, it would be unfair to fault the energy management initiative. Other “fairness” adjustments need to be made for commodity costs to account for any rate variations.

Another important adjustment, especially for monthly reporting, is billing period length. If the square footage of the facility had changed from the baseline period, then that adjustment would also need be made.

Eventually, when all known variables have been accounted for, we would arrive at an energy cost value for the Baseline Year Adjusted To Current Conditions, which is referred to as the BATCC in EnergyCAP.

3 Compare the BATCC to the current utility bills

The final step is to compare the actual utility bill cost with the BATCC cost. This compares what was actually spent with what would have been spent in a similar baseline year.

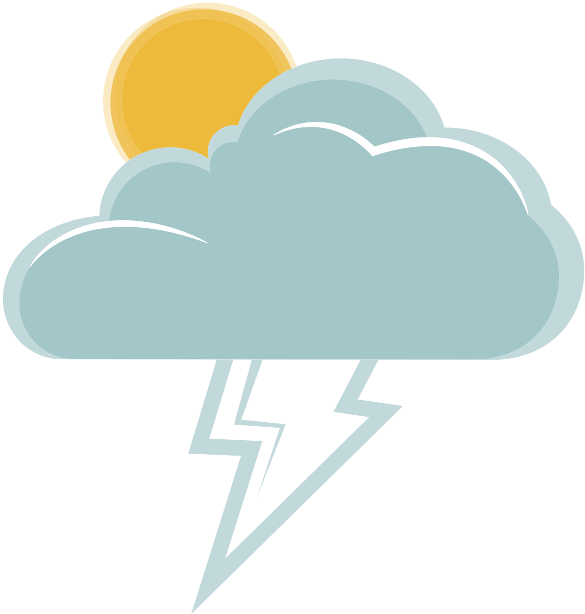
Consider this example:

In the base year, a facility consumes 10,000 kilowatt hours of electricity. At that time, the cost of the electric commodity was $0.10/kWh, so the cost was $1,000.

Today, following the implementation of an energy initiative, consumption was reduced to 8,000 kWh at a price of $0.15/kWh. Today's cost: $1,200.

Now the company financial officer might see the bill and complain about the increased cost (up $200 from the base year). But using the Option C methodology, we can demonstrate that BATCC cost would have been $1,500 (10,000 kWh x $0.15/kWh current commodity cost) without the energy management initiative. We can then subtract the actual cost of $1,200 from the BATCC cost to discover that our Cost Avoidance was $300.

Common Adjustments in Determining BATCC



In the interests of fairness and accuracy, it is necessary to make adjustments to the baseline year to provide a fair apples-to-apples comparison of energy use. What are the most significant and appropriate adjustments?

These are the most common adjustments:

Weather

Weather is a prime contributor to variations in month-to-month energy use and cost. Weather differences and severity are measured using degree days. Degree day values are determined daily by comparing the mean daily temperature for a location with an unchanging balance point temperature or BPT value (usually 55 or 60 degrees Fahrenheit) —that point at which neither heating or cooling is required. Cooling degree days are used when the mean daily temperature is higher than the BPT. Heating degree days are used when the mean daily temperature is lower than the BPT. Here are two examples to illustrate the concept:

Example 1: Florida in summer.

> Q: On July 15, the daily mean temperature reported for one weather station was 90° F. The BPT value for the affected

building/meter is 60° F. What would the degree days be for that day and location?

A: 30 cooling degree days.

Example 2: Siberia in summer.

Q: On July 15, the daily mean temperature reported for one weather station was 40° F. The BPT value for the affected building/meter is 60° F. What would the degree days be for that day and location?

A: 20 heating degree days.

Note that heating and cooling degree days are determined independently and never combined together in weather calculations, since this would nullify their ability to represent weather severity. For example, it might be possible at certain points in the “swing” seasons of fall and spring that a degree day value for one day might be 5 heating degree days, while the next day might be 5 cooling degree days. If the mean temperature values for these two days were combined and averaged, the resulting degree day value would be “0”, but this value would not reveal that the building heating or cooling systems were probably necessary on both days to regulate building temperature.

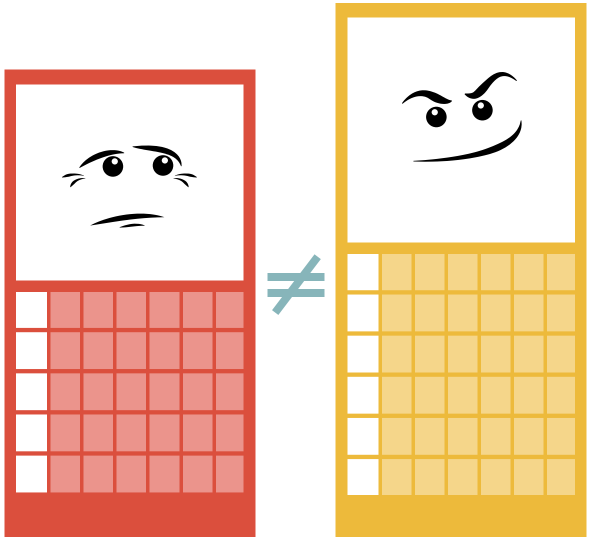
Unit Price of a Commodity

If utility rates change, the energy management approach should be to normalize any comparison data for cost per unit of the relevant commodity, in order to fairly assess and report on energy use.

Example:

Q: In March, the electricity rate for a facility was 10 cents per kilowatt-hour (kWh), and the use was 100,000 kWh. Cost was $10,000. On April 1, the rate changed to 11 cents per kilowatt-hour. The use was 100,000 kWh. The energy bill for the facility in April was $11,000. Normalizing for the rate change, in which month was the facility operating most efficiently?

A: This question has at least two possible answers. If we are only looking at use and cost, factoring in the rate change, we would say that the energy efficiency for both months was equal, since we used the identical amount of the commodity—the cost increase simply reflected the rate change. But we also know that March has 31 days and April has only 30 days. So we could argue that we were less efficient in April, since we used as much energy in 30 days as we had in the previous 31 days.



Billing Period Length

The answer to the previous example question demonstrates the importance of normalizing for billing period length when comparing monthly data, including most utility bills. It would be unfair to compare a 28-day bill with a 32-day bill.

We would expect that the longer month would be associated with a higher utility bill simply because there is more time in the month for the commodity to be used. Energy management software should be able to compensate for the difference. The usual procedure for normalizing for billing period length is to break the monthly bill into daily segments by dividing the monthly total by the number of days in the month.

Other Factors to Consider for Normalization

In addition to the primary variables of weather, commodity rate changes, and billing period length, there are several other important considerations:

Enrollment: A school might want to consider compensating for the number of students when comparing commodity use month-to-month or year-to-year.

Production: A factory might want to consider compensating for the number of units produced, particularly if energy is a key part of the production process.

Occupancy: A hotel chain might want to compensate for the number of rooms occupied per night or some other related figure.

Load Creep: Load creep refers to a tendency for managed spaces to accumulate additional energy-using devices, especially in some kinds of office environments. An engineering study might be able to reveal and quantify the number and type of these devices. For some projects, it may be important to normalize for this factor to obtain a more accurate picture of project effectiveness when using the Option C methodology.

Option C
Limitations

Option C M&V does have some limitations. If several different projects have been implemented in the same building at the same time, and it is necessary to obtain the results of each one separately, the Whole Facility method will not provide the granular data to do that. Option C provides only an aggregate value for the entire facility.

Another limitation relates to the base year used for Cost Avoidance calculations. The principle is that the farther back in time the base year, the less reliable the calculations are going to be. If the baseline is 15 years old, there's a good chance that all these adjustments that are being made year after year are becoming less and less reliable. A best practice might be to "reset" the baseline periodically—perhaps every 3-5 years.

Another complication of Option C is that if electric demand charges are a major cost driver, then it becomes very difficult to value savings accurately. This is especially true when attempting to make weather adjustments when peak demand charges are a significant portion of energy cost. It can also become difficult with more complex rate schedules. Consider these situations carefully when considering implementing Option C for a facility.

Share this eBook!