



**ENERGY SAVINGS PERFORMANCE AND
MEASUREMENT & VERIFICATION
ONLINE TRAINING COURSE**

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ENERGY SPECIALIST CURRICULUM





**MEASUREMENT AND VERIFICATION+
FOR ENERGY PROFESSIONALS**

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WHAT SHOULD YOU LEARN



What are the basic ways M&V can be performed?

Measurement and Verification Options

How interactions are handled for each option.

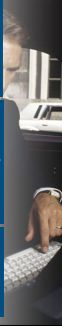


WHAT ARE THE BASIC WAYS M&V CAN BE PERFORMED?

The M&V concept is simple enough, but the details are sometimes difficult, and solutions vary. In a simplified case, lighting may be the single largest component of electric use in a warehouse after installing more efficient lighting throughout the warehouse, the savings will be noticeable on next month's electric bill.

Verified!! But in a large manufacturing facility with varying production output, a project may be substantial enough to want to know but still only affect a portion of the utility bill in this case, looking at the electric bill may not be conclusive because of the many other variables at play. So, the one-size- fits-all approach doesn't work with M&V very well.

The specifics of the M&V options occupy as much paper as a Chicago phone book. But they boil down to four basic options, each one with a general category of applicability. The four classic IPMVP options are shown in Table 1. Application examples for each option are provided.



MEASUREMENT AND VERIFICATION OPTIONS

M&V Option	Description
Option A: Retrofit Isolation with Key Parameter Measurement	Savings are determined by partial field measurement of energy use by the system to which an energy conservation measure (ECM) was applied. Partial measurement refers to the fact that some (but not all) key parameters may be stipulated rather than measured, assuming the total impact of possible errors will not significantly affect the resulting savings. The measured and stipulated parameters will be those that that define the energy use of the measure. Measurements may be short-term or continuous.
Option B: Retrofit Isolation with All Parameter Measurement	Savings are determined by comprehensive field measurement of energy use by the system to which an ECM was applied. This option is noted as 'all parameter' because stipulation of a key parameter is not allowed. Measurements may be short-term or continuous and are taken throughout the post-retrofit period.
Option C: Whole Facility Measurement	Savings are determined by taking energy measurements at the whole facility level. Requires a detailed inventory of all equipment included in the meter reading as well as knowledge of equipment use patterns and factors that affect energy use. Regression analysis correlates energy use with independent variables such as weather and occupancy to normalize differences between before/after periods. Measurements may be short-term or continuous and are taken throughout the post-retrofit period.
Option D: Calibrated Simulation	Savings are determined through simulation of the energy use of component systems or the whole facility. Energy use simulation is calibrated with utility billing data and / or end-use metering. After calibration, savings are determined by comparing a simulation of the baseline with either a simulation of the performance period or actual utility data.



SAMPLE APPLICATIONS FOR M&V OPTIONS

Options A and B or 'sub metered' approaches are suited for specific measures and provide good accuracy. For example, if only lighting is replaced, measurements on the lighting circuits before and after will tell exactly what changed. The difference between A and B is whether all or a representative sampling are measured.

Option A is well applied to a lighting retrofit where lighting power before/after is measured and applied to a stipulated operating schedule (hours per year) for the lights. Option A could also apply to a replacement air compressor by measuring compressor power before/after at 10% increments of load and apply this to a stipulated typical load profile.

An example of option B is a chiller replacement where long term seasonal measurements record power and load. Note the difficulty in applying Option B arising from the need to have long term measurement of the before-condition as well as the new unit.



SAMPLE APPLICATIONS FOR M&V OPTIONS +

Option C or 'whole facility' approach uses utility meter readings. It is the simplest but has limitations. If used on smaller projects, buildings with variable occupancy or buildings that undergo additions, etc., different methods may be required. Option C can also be applied to a 'system'; for example metering of all use in a chiller plant that captures ancillary loads will also capture the interactions as a 'bottom line' measurement.

Option D is the 'calibrated simulation' approach. This method may be used when measures are easily defined and interaction between measures is minimal. Many engineering software models are in use for this purpose and provide varying degrees of accuracy. In cases where load profiles are steady or strongly weather dependent or when loads are constant, simple calculations or spreadsheets work well.

Often it is true of these models that the accuracy is more in the differential between the compared systems than the absolute values they produce. In all cases, actual measurements are more accurate than these estimates. Often it is cost that suggests using this method over others. This method can be very practical when both parties accept the limitations and agree on the assumptions and algorithms used.



INTERACTIONS

Interaction between measures is common and, if overlooked, can result in over-stated savings. For example, if high efficiency lighting, delamping, and occupancy sensor options are proposed, it is possible that the customer will choose one or two or all three. Calculating each one individually and adding those respective savings up will over-state savings. In this case, the more efficient bulbs only provide savings for the bulbs that exist and if fewer bulbs exist (from delamping) there are less savings.

Conversely, interactions can erode savings. Consider again the common lighting replacement. The reduced energy of the lighting means additional heating is needed in winter but less cooling in summer – how that balances for net gain or increase will be climate dependent and, in some cases, envelope dependent. Suffice it to say that interactions are a concern when trying to calculate savings and skip the measurement method.



HOW INTERACTIONS ARE HANDLED FOR EACH OPTION

☑Options A and B: Interactions are calculated and incorporated into before/after results.

☑Option C: Interactions are conveniently baked into this option since the measurement is overall energy use. This points out that an Option C project that is strictly electric will need to do whole building measurement for heating fuel use as well as electric.

☑Option D: Interactions are intended to be incorporated into the computer simulation; professional hourly models do this, spreadsheet calculations may or may not do this depending on the creator of the spreadsheet model.



BASELINE ADJUSTMENTS AND NORMALIZING DATA

Utopia in the M&V world is a building with no changes at all other than the measures implemented. But in the real world, other things change. When this happens, the baseline is adjusted. The methods vary but have the same goal of establishing an 'apples to apples' comparison to demonstrate whether the measures did or did not achieve the savings. These calculations should be reviewed mutually and, if complex, the owner can stipulate in the contract the option for reviewing them, including ample time to do so. Examples that mess up the math are:

- ✓ Adding a new wing to the building
- ✓ Increasing or decreasing the number of people
- ✓ Different activities inside the building that change energy usage
- ✓ Changes in weather year-to-year

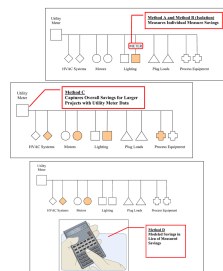
BASELINE ADJUSTMENTS AND NORMALIZING DATA +

How data normalizing is handled for each option

✓ **Option A:** Usually, normalizing is NA for this option. This is easy to understand in the classic application of option A where lighting kW is measured and hours per year are stipulated. This method focuses on the component only, and 'freezes' the variable of occupancy.

✓ **Option B:** The measurement focus is the component, but weather or occupancy need to be normalized. This is easy to understand in the Option B application of a replacement chiller. Here, the efficiency is well defined for the before/after machine, but between years there can easily be a change in 'load' from weather or occupancy or something else, i.e. without normalizing the load, a very efficient chiller could still show increased energy use if the load in the post-retrofit period is higher. The load becomes a 'proxy' for energy use and is part of the methodology.

BASELINE ADJUSTMENTS AND NORMALIZING DATA +



✓ **Option C:** Changes in load and site conditions can plague Option C projects. The normalization effort via regression is used to negate most of the effects of year-over changes in weather or occupancy. The detailed inventory of equipment and usage patterns is used as a baseline for identifying changes, especially handy if post-project results are less than expected (PC contractors will re-visit the site to look for changes to help explain why).

✓ **Option D:** This option inherently is immune to occupancy and weather changes. Standardised weather data and stipulated schedules and hours of use for the equipment loads remain static. This fact favours post-retrofit use values (used to quantify savings) that use the model rather than actual usage. This is a plan discussion item since the actual performance of the machine becomes 'frozen' as well, and so any dysfunction of the machine would go unnoticed using just the model.