Measuring and Verifying Your Energy Performance Contracts...

What are Your Options? How do You Choose?

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ABSTRACT

Performance contracting is all the rage for facility managers today. Where "the rubber meets the road" in performance contracting is "counting the beans" after the work is done—otherwise known as **measurement & verification** (M&V). This article provides a down-to-earth explanation of the measurement & verification options for performance contracts as identified in the Department of Energy's International Performance Measurement and Verification Protocol (IPMVP)—formerly known as the North American Energy Measurement and Verification Protocol (NEMVP). The article also provides recommendations for the choice of M&V methods.

Determining the post-retrofit results of an energy saving project is the greatest source of disagreement in the energy services and performance contracting business. The following article was written to provide readers with a basic introduction to measurement and verification, and guide their efforts in ensuring that the results of a performance contract are appropriately and accurately measured and verified. This article will:

A. Explain what measurement & verification is, and
B. Provide recommendations for measurement and verification.

The process of measurement and verification of the results of a retrofit project is a challenging endeavor and requires a relatively high level of HVAC and other building systems experience and insight and skill in reviewing contractor submittals and contract management in general. Readers lacking in experience in this technical specialty are encouraged to attend performance contracting and M&V seminars and review the available literature, articles, etc. to further educate themselves. Another option would be to hire a consultant with the necessary expertise to perform the measurement and verification work.

A. WHAT IS "M&V" (MEASUREMENT & VERIFICATION)?

First of all, it must be stated that savings cannot be measured! The problem here is the fact that we are endeavoring to measure something that is no longer there. As a result, the task is a challenge at best. Considerable efforts have been made to define and organize the methods for establishing the value of the results of an energy saving project. Indeed, a small "industry" has sprouted up in attempts to deal with this issue.

The Department of Energy (among others) has sponsored efforts to develop standards for determining the amount of energy saved by energy retrofit projects (and indirectly, the dollar value of the savings as well). This standard, originally released in mid-1996, is entitled the "North American Energy Measurement and Verification Protocol" (NEMVP).

Another document, similar in nature, and intended to be compatible with the NEMVP, is the Federal Energy Management Program's "Measurement and Verification (M&V) Guidelines for Federal Energy Projects." Released in late 1997 is an updated version of the NEMVP entitled the "International Performance Measurement and Verification Protocol" (IPMVP). Because these documents are pretty "heavy" reading, it may be helpful for some readers to turn to Appendix II in the new IPMVP which is an abbreviated manual on measurement and verification (largely taken from the FEMP Guidelines).

As defined in the IPMVP (and the NEMVP), and as generally accepted in the industry, there are three principal ways to establish the quantity of energy saved by a project, as follows:

Option-A, or "stipulated values/calculations"
(generally including one-time measurement)
Option-B, or "measure-specific instrumentation & metering
(using ongoing measurements)
Option-C, or "utility-bill/overall-building comparison"
(using the utility company meter or a whole-building sub-meter as the measuring device)

Each of these approaches to the task is described below in the *chronological order* in which they came upon the scene, in order to make their current existence more understandable for those "tackling" M&V for the first time.

Option-C, Utility-Bill/Overall-Building Comparison

In the early days of the energy services industry, the standard method of determining the post-retrofit performance of a project was utility bill comparison. In fact, the very first model energy service agreements developed by Lane and Edson, P.C., under contract to the DOE in the very early 1980's included this method as the only method of determining project performance.

Utility bill comparison contrasts post-retrofit utility consumption, as invoiced by the utility company, to pre-retrofit consumption (otherwise known as the "baseline" period) and generally multiplies the difference in units of consumption by the then-current unit cost for each type of energy. For utility-company metered buildings, the utility bill is the raw data source. For multi-building complexes, individual building meters would need to be installed to monitor the energy use of the building in question.

This can get somewhat involved if the buildings share heating and cooling sources, for example. This methodology also includes corrections for the effects of "random" variables such as weather, hours of occupancy, changes in the use of the facility, etc.

Option-A, Stipulated Values/Calculations

As time passed the projects and the buildings in which they were installed grew more complicated. It became clear that there were situations that just could not be handled with a total-building approach such as utility bill comparison. As a result, another method evolved, called "stipulated calculations." In a lot of ways, this can be the simplest of the approaches. Interestingly, based upon informal discussions with various ESCo's, this methodology is very commonly used, primarily because of its simplicity.

This approach consists of establishing pre-determined and Owner-and-ESCo-agreed (or "stipulated") values or precise formulas for the calculation of energy cost savings being achieved. In the case of a *stipulated value*, using lighting fixtures for example, a set number of watts are agreed by the parties to be saved by a particular lighting fixture retrofit (say replacing a 100 watt incandescent lamp with a 32 watt compact fluorescent replacement unit).

In addition, the parties also agree to a stipulated value for the annual operating hours for the fixture (say 8760 hours for a hallway fixture in a government office building). The determination of energy savings then is simply the watts saved per fixture, multiplied by the number of fixtures, and then multiplied by the stipulated hours per year—*and never changes throughout the term of the contract*. To arrive at cost savings, the units of energy saved are then multiplied by the cost of electricity (which is taken from the current rate schedules or utility invoices—as further discussed below).

Similarly, *stipulated calculations* are formulas that have one or more variables which are measured (perhaps once, or periodically—say the final connected electrical load of a high efficiency motor) and other variables which are stipulated (say the hours of operation as recorded during the feasibility study). The calculation of energy cost savings is the difference between the original connected load and the new connected load, multiplied by the hours of operation, all of which is again multiplied by the cost of electricity.

In the case of a CFC chiller retrofit, stipulated calculations might consist of periodically measuring the performance of the chiller at a variety of different load percentages and then creating a power-at-load algorithm to which is then applied a stipulated annual load profile (which was probably established during the feasibility study and agreed to by the parties). In this case the performance of the chiller would need to be maintained by the performance contractor if they are to receive the anticipated savings for the improved chiller efficiency which they created.

Option-B, ECM-Specific Instrumentation

Finally, as the performance contracting industry and marketplace evolved further, some people felt that yet a more precise way of determining the energy cost savings needed to be created and ECM-specific instrumentation was created. Under this concept of demonstrating energy cost savings, temperature sensors, event sensors, flow meters, power transducers, and other instruments are applied to the equipment or loads affected by the energy conservation measures. The data gathered by these devices is then manipulated and integrated by the building automation computer system or other computer to calculate the actual energy cost savings produced by individual energy conservation measures.

As regards an integrated chiller retrofit, under Option-B, the scenario might be that the annual load profile in ton-hours per month and the annual energy consumed by the chiller and its various auxiliaries is monitored and established as a baseline during the feasibility study. Once the retrofit is done, both the actual load (in ton-hours) and the chiller plant's total energy consumption (including perhaps a variable frequency drive chilled water pump) is measured continuously.

If load reductions (say due to the addition of an outside air economizer) are created by the performance contractor, then the savings achieved would be the plant's present energy consumption subtracted from the baseline condition (with some possible adjustments for changes in weather, etc.). If load reductions were not a part of the performance contractors work, then the savings might be the reduction in energy use per ton-hour multiplied by the baseline load in ton-hours.

Energy Cost Savings

Unfortunately, the new IPMVP (and the old NEMVP) do not deal directly with the issue of energy cost. This is a fairly complicated issue, particularly because the cost of on peak power continues to grow—and will likely continue to grow even further following restructuring of the electric utility industry. This is even more important for chiller retrofit since air conditioning energy use tends to fall primarily in the on-peak period defined by most utility companies (for example, under Pacific Gas and Electric's E-19 Secondary rate tariff, the cost of on-peak air conditioning use, including demand charges, averages out to about 20 to 25 cents per kWh, against about 5 cents at night!).

As regards Option-C, Utility Bill Comparison, it has been traditional to simply use average unit cost to convert units of energy saved into dollars saved (or "avoided" actually—see comments below). Average unit cost is determined by dividing the total utility cost by the total energy units consumed during the billing period.

As regards Option-B, Stipulated Calculations, a number of alternates are possible. One is to simply use average unit cost. Another is to use a weighted average based upon the utility company's rate schedule and reasonable assumptions about the time patterns of energy use or savings. This can be done with a mildly sophisticated spreadsheet (e.g., ERA's *TOUCANS* program).

As regards Option-A, ECM-Specific Instrumentation, a number of alternates are also possible. Again, one option is to simply use average unit cost. However, given the more rigorous nature of instrumented M&V, average unit cost seems really inappropriate in the face of such rigor. Another, again, is to use a weighted average based upon the utility company's rate schedule and reasonable assumptions about the time patterns of energy use or savings as mentioned above for Option B.

Yet a third alternative is to "build" the rate schedule right into the monitoring system. For example, if a full-time monitoring system were integrated with a computer-based front end (perhaps a building automation system) and were calculating and integrating energy units saved in real time, the software operating this system could easily have the local utility company's rate schedule built into the calculation and produce real time dollar savings as well. Of course, any such system would need to be well documented and gather data in an open and "auditable" fashion so that both parties to the performance contract could review and verify the savings figures produced.

Unique M&V Terminology

Newcomers to the field of energy services and performance contracting may find themselves confused when encountering some of the terminology employed in the leading guidelines for determining the actual performance of a project (such as the FEMP M&V Guidelines or the IPMVP/NEMVP). Specifically, the definitions of the terms "energy savings" and "energy savings estimates" may be very confusing for the uninitiated.

First of all, the term "energy savings" is used to encompass many things that are not actually energy savings. This is because the term is used to refer to many of the things a performance contractor may do to a building (demand control, cogeneration, thermal energy storage, fuel switching, etc.) that do not save energy, but principally affect the cost of the energy consumed. Indeed, some of these techniques (say ice storage) can actually increase the energy consumed in a facility, while producing a cost savings.

While an alternative term, "cost avoidance," is popular in some circles and speaks more directly to what is actually taking place, the term "energy savings" has become, *de facto*, re-defined to refer to utility cost reductions achieved by virtually any means.

Furthermore, use of the term "energy savings estimates" is also confusing and potentially harmful. In the construction industry, the term "estimate" has traditionally been used to describe something that is done during the planning and development stages of a project (*before* the project is actually done), such as cost *estimates*, load *estimates*, and, in the case of energy retrofit, energy savings *estimates*. By contrast, once the project is underway, the industry has traditionally switched to different terminology to describe that which is happening or *has already happened*, such as *financial accounting*, *project job cost accounting*, or *cost avoidance accounting*.

Without facetious intent, calling the post-retrofit results of a project an "estimate" is like calling your post-holiday-season bills, as they come due in January, just an "estimate" of what you owe. It therefore can be very confusing (particularly to newcomers to the field of energy services and performance contracting) to realize that the *de facto* vocabulary being used in the protocols to describe the *post* retrofit performance of an energy retrofit project is the term "estimate"—particularly when the engineer performing the energy audit also refers to his projection of future energy savings as an "estimate."

Unfortunately the term "energy savings estimates" is used to indicate both the "before" and "after" in different places in the IPMVP/NEMVP. Replacement of the term "energy savings" with "cost avoidance" is under consideration by the NEMVP (IPMVP) Technical Committee, but has not yet been adopted for use in the protocol.

B. RECOMMENDATIONS FOR MEASUREMENT & VERIFICATION

Each of the approaches described above has its advantages and disadvantages. Interestingly enough, some people state very strongly that one method or the other is the only "accurate" way to measure post-retrofit energy savings and that the other methods are bogus. The truth is that ***they are all accurate …and they are all potentially bogus***. It all depends upon the circumstances of the facility, the types of retrofit being performed, the "stability" of the facility and the relationship between the parties.

Because reasonable people can find reasonable ways to agree, **all of these approaches can be made to work and they all have their shortcomings**, as is discussed at great length in the references cited above. As an aid to readers, presented below is a synopsis analysis of the various methods and their relative merits, as well as discussion of other relevant M&V issues. For consistency, once again, they are presented in their historical order.

Utility Bill Comparison, Option-C

A first glance, utility bill comparison may appear to be "foolproof." After all, what could be simpler than to compare the bill before and after—the results are there for anyone to see. Indeed, upper (non-technical) management has been known to take exactly this point of view. However, a number of factors can influence this methodology, including changes in the use, occupancy, and operation of the facility, and changes in weather.

For example, should a tenant in a commercial office building decide to install a main-frame computer in their space they might well do it with the knowledge of the building owner (and are known to actually have done so), but without this fact being communicated to the energy services company. The result is an increase in the utility consumption in the building, and a decrease in the energy cost savings determined by utility bill comparison, *which has absolutely nothing to do with any energy conservation measures which may have been implemented by the energy services company*. This situation is generally viewed as a risk in the eyes of the energy services company and is one that an ESCo will likely seek to avoid if such uncontrolled changes are anticipated in a facility.

The principal advantages and disadvantages of this approach include:

UTILITY BILL COMPARISON (Option "C")

ADVANTAGES	*DISADVANTAGES*
Simple, small number of data data sources, with resulting low cost to use/administer	The effects of energy conservation measures can be "masked" by unrelated changes in use and occupancy.
Since savings come "right off the bill," the figures are often considered more "real"	Adjustments for changes in facility use, weather, etc., can be complex and an administrative burden—extensive adjustments can make the figures appear "artificial" and therefore untrustworthy

This methodology would generally find application in simple, single-use facilities, with stable histories of facility occupancy and use and energy consumption (such as office buildings). Simple or complex retrofits can be accommodated by this method.

Facilities consisting of multiple buildings on a single utility meter (and which may not have sub-meters installed, particularly on the thermal side), may find scant use of this methodology. Where individual buildings are fully sub-metered (electric and thermal) or are separately metered by the utility, and the facility is relatively stable, both the Owner and the ESCo may find this a cost-effective and low-risk measurement and verification technique.

Those facilities electing to use utility bill comparison would do well to employ a commercially available software product, and one that embodies a "white box" rather than "black box" methodology. As used herein, a "white box" program means one that shows all the calculations and adjustments that are being performed so that the report can be audited by an independent third party. Such programs include FASER, Metrix and Utility Manager, among others.

Stipulated Calculations, Option-A

This approach requires that both parties possess both a high degree of confidence in the effectiveness of the chosen energy conservation measures to reduce energy use and confident knowledge of (and willingness to agree to stipulating) the annual hours of use of the systems/loads being retrofitted. Use of this methodology requires an ESCo that is willing to determine and document the existing conditions and examine and document their retrofit plans in considerable detail and Owner's facility staff willing and capable of participating in the feasibility study and carefully evaluating the results of the study. Independent consultants may be needed on the Owner's side of the table, for example, if facility staff is unavailable or lacking in the needed expertise.

The advantages and disadvantages of this approach are:

STIPULATED CALCULATIONS (Option "A")

ADVANTAGES	*DISADVANTAGES*
Extremely simple—frequently the only variables are either work stipulated or measured once at the the completion of the installation—often these figures are more "real" than other methods, especially in a complex, unstable building environment and where simple, periodic measurements are made.	Can work to reduce the motivation of the installing contractor to work carefully and accurately since "their work is done" once they get the facility staff to agree to the stipulation
Administrative costs are kept to a minimum	Savings figure are sometimes viewed as "artificial" or "unreal" if they are based on too many stipulations.

This method would generally find use in facilities:

- With constantly changing occupancy or facility use which would "mask" or counterbalance the savings that would otherwise be shown by the use of utility bill comparison,
- Where a wide variety of conservation measures are being employed (making instrumentation prohibitively expensive), but each only have a modest effect on the facility's total use of energy (and are thereby easily "masked"), or

- Where very complex retrofits are being employed (making instrumentation prohibitively expensive).

As mentioned above, this methodology finds itself in very wide use among many ESCo's on many projects. Because it does depend upon the parties to disclose considerable information and to operate in an atmosphere of considerable faith and trust, this faith and trust must be manifested by both sides, else an agreement cannot and should not be arrived upon.

Acting in good faith, however, the parties can collaboratively examine and decide upon worthy retrofit work, agree on fairly simple and efficacious means of "proof" (e.g., before and after measurement of lighting panel load or chiller kW on a high temperature day, or a one-week monitoring and profiling of the kW draw of a variable flow/vfd chilled water pump). This allows them to focus their efforts on properly installing, commissioning and operating and maintaining the equipment and systems, instead of contending over the "counting of the beans" at the end of the project.

Indeed, excessive reliance upon elaborate measurement and verification schemes instead of expending energy on project implementation can result in a very poor ESCo/Owner relationship and remorse and distress following project implementation.

ECM-Specific Instrumentation, Option-B

Factors that impact the effectiveness of this approach include the complexity of the energy conservation measures implemented, the accuracy and reliability of the instrumentation equipment, and the validity of the mathematical formulas used in the energy calculations. Advantages and disadvantages for this approach are shown on the following page, as Option "B."

This methodology would generally find application in:

- Process-intensive environments (where instrumentation is the only way to "prove" that the retrofit works and the retrofit involves only a few systems, e.g., a chiller plant only retrofit).

- Large and/or expensive projects (e.g., variable volume conversion of a 200 HP air handling system) where the cost of the instrumentation (and associated data gathering, reduction and reporting) is

ECM-SPECIFIC INSTRUMENTATION (Option "B")

ADVANTAGES	*DISADVANTAGES*
Separates the effect of ECMs from other changes in building use and occupancy	Very expensive except on the simplest of energy conservation measures—takes a big project to support the instrumentation cost (e.g., a 1,000-ton chiller plant v. a single 200 ton chiller)
Due to continuous direct measurement, cost avoidance figures are often considered more "real" and/or more "accurate"	Requires considerable administrative manpower to maintain, calibrate, and troubleshoot the instrumentation and calculational software—again, only a larger project can reasonably support the cost
Data gathering and calculations are verifiable	Verification can be time consuming and costly

relatively small due to economies of scale and/or the relative high cost of the retrofit work. (Simply put, it takes the same amount of instrumentation to monitor a 20 HP air handling system as a 200 HP system, yet the 200 HP system will produce 10 times the savings for the same amount of M&V cost), or,

- Projects where only a very small number of simple retrofit measures are replicated in great quantity (and only a representative sample will need to be instrumented—say, lighting controls in a large office building),

- Projects where very authoritative accounting of the savings produced by the project is of paramount importance (for organizational or technical reasons, i.e., where upper management insists on "proof" of savings or say where the project is a "demonstration" project and added documentation of results is needed).

For example, the retrofitting of a sizable central chilled water plant (say 1,000 tons or more) might be just the place to employ extensive instrumentation since a large portion of the instrumentation will likely be needed to properly monitor and automate the plant anyway and the project can probably absorb the cost fairly easily.

Choosing a Methodology

As a practical matter, it is likely that Stipulated Calculations (Option "A") will continue to be the methodology of dominant choice. This is due to its relatively low cost, the fact that it tends to minimize time-consuming contention, and the fact that a well-prepared and well-documented energy audit (as strongly recommended by the author) will leave relatively little uncertainty regarding the likely effectiveness of the ECM's being pursued.

Annual verification in such a case would primarily consist of verifying functional performance of the equipment (say, confirming that the variable flow pump does indeed track the system differential pressure and the speed varies as needed to support the system's cooling demand) and possibly repeating some instantaneous measurements (say to reconfirm chiller kW/ton, for example).

In a sense, the foregoing discussion of measurement and verification implies that a single option should be chosen for a given project. This is not necessarily the case. It is altogether reasonable to combine a variety of methods to account for the energy and cost savings achieved by a project. For one notable integrated retrofit project in the west, a mix of methodologies was combined, for example, as follows:

- **For air handling unit retrofit, Option-A, Stipulated Calculations was used**. Based upon calibrated computer simulation, hourly savings values (for cooling, heating and fan operation) were established for each month of the year for "hours off" (hourly savings achieved by turning the system off) and "hours on" (improvement in efficiency while system is in operation). These values were then multiplied by the reduction in run hours and the new run hours respectively, to determine the energy units saved.

- **For lighting fixture retrofit, Option-A, Stipulated Calculations was used**. The watts per fixture retrofit was stipulated and multiplied by the fixture count and the stipulated hours of operation to determine energy units saved.

- **For chiller retrofit, Option-B, ECM-Specific Instrumentation was**

used. Chiller operating parameters were monitored continuously through the building automation system and entered into a formula that calculated the chiller savings achieved.

- **For securing the steam distribution system in the summer months, Option-C, Utility Bill Comparison was used**. For the summer months only, the gas use baseline, less the savings attributed to air handling unit savings, was compared to the actual current utility bill for natural gas. The difference was the savings attributed to securing the steam distribution system.

When to Finalize the M&V Details

Finally, and perhaps most importantly, the methodology for determining the results of the project (the actual savings being achieved) must be defined in detail prior to executing the delivery order. Since the "rubber meets the road" in energy services at the point of determining the actual savings being achieved, this challenging part of the delivery order must really be done up front, not later when the "horses are out of the barn"—no matter how tempting it may be to put this off, say, until the project design is complete.

The detailed feasibility study must include a project-specific M&V plan and must include the (sometimes excruciating) details of how the project is to be measured and verified. This will be particularly complex, for example, if Option "B" is employed for an integrated chiller plant retrofit that combines a number of interrelated retrofits, such as variable flow chilled water and variable air volume.

Other Issues

There are a few other things that it is wise to consider relating to M&V, including:

- Over-reliance on M&V (i.e., not putting all your "eggs" in the M&V "basket")
- Commissioning
- Data sourcing
- Double checking results
- Adjustments for changes in end use
- Measure interaction

Over-reliance on M&V

As mentioned earlier, **savings cannot actually be measured**. As a result, it is a big mistake to put all your reliance on M&V as your first and last line of defense. Many projects suffer from the "Jurassic Park Syndrome" wherein the answer that is found is the answer that was expected (i.e., when tracking the dinosaurs that were released the computer software in the movie assumed that the female-only dinosaurs could not reproduce, and therefore looked only for the number that were released—and no more—whereas one species could transmute to the opposite sex, just as some frogs do, and then reproduce).

All too often any data that would lead to an answer that is other than expected (like the project not working) is ignored, and not reported. As mentioned in the article entitled "How to Marry an ESCo" (appearing in the Fall 1995 issue of *Energy & Environmental Management*), we have found million-dollar projects where none of the installed equipment actually worked, yet glowing monthly M&V reports were being submitted to the Owner each month! The best "guarantee" you can have is to work the process of developing the project, including:

- a detailed feasibility study
- Owner and ESCo select measures to implement
- detailed final design and Owner's review
- managed installation
- start-up and commissioning

Commissioning

This last item in the list above is critically important. Savings cannot be achieved unless the installed equipment has the potential to produce savings, i.e., it must be working. A regular inspection and verification of equipment function is an essential part of any M&V program (and should be a precursor to final project acceptance).

Data Sourcing

It should be a standard practice that the source data be accessible by both the facility staff and the ESCo. This takes a number of forms. The machinery or apparatus recording pertinent data being fed into the M&V calculations should be something that the technical project manager on the facility side and the ESCo should have equal access to. In addition, the data that is uploaded should be shared with both parties, generally on a disk, and clearly labeled.

Double Checking Results

The machinery used to "crunch" the numbers (say a spreadsheet), should be available to both parties, even if the ESCo needs to buy the facility a copy of the software for their use. While it's good to have faith in the other side, the facility should occasionally check out the data and see if they get the same results as the ESCo. An honest ESCo won't mind this at all and will welcome someone on the other side actually taking an interest.

It may also be a good idea to have a disinterested third party involved in doing the checking. In this fashion egos can be sidestepped and the third party "expert's" word may carry more weight with the officials who are in a position to act on the results (a not uncommon phenomenon in large organizations). This idea has even more merit if ECM-specific instrumentation is employed, as the in-house staff may not have the time to keep up with the extensive data reduction that is associated with such an M&V approach.

Adjustments for Changes in End Use

Assuming that a model of the facility has been used during the feasibility study and stipulated calculations are being used for M&V, then when a change in the end-use load occurs, the new end-use load can be re-modeled on both the original and the retrofitted facility models to show the impact on energy savings. This impact should then be equitably settled between the parties. **It is good to keep in mind that being fair to the other side is probably a good idea since these sort of "swords" can frequently cut both ways**.

Say a 24-hour load suddenly reduces to 12 hours because a program has left a facility unexpectedly. While it might seem fair to reduce the ESCo's savings by half, they made the investment in the facility with the assurance that the "rug" was not going to be pulled out from underneath them. Conversely, when a 12 hour load suddenly becomes a 24-hour load, it is equally valid not to reward the ESCo with a doubling of savings. Putting "floors" and "caps" on adjustments of this sort is a sage idea for inclusion in the M&V plan, which is part of the energy services agreement or performance contract.

In fact, for example, such adjustments may be excluded completely for Option-B, Stipulated Calculations (since hours of use, etc. are already stipulated), with only adjustments made in the event of failures of the ESCo-installed equipment.

Measure Interaction

In most cases, the interactive effects are generally fairly benign. For example, a lighting retrofit will generally produce additional cooling savings in a range of 10 to 30% of the lighting savings—depending upon whether an outside air economizer is in use, the hours of use and whether or not the HVAC system is a mixing system (for terminal reheat HVAC, for example, there may be additional no cooling savings!).

By contrast, for variable air volume, variable air flow and other "high powered" retrofits (these, for example, vary according to the cube of the load being served), it is wise to consider interactions carefully. A 10 or 20% change in load could possibly double the savings that could occur, say, from a variable volume retrofit.

CONCLUSIONS

While it is not possible to actually measure savings, reasonable people can agree to practical and simple ways to establish with a high level of certainty and confidence the actual results of the energy savings measures being installed. As is common in virtually any facility engineering and operations situation, keeping it simple will make life livable!

ABOUT THE AUTHOR

James P. Waltz, President of Energy Resource Associates, Inc., is a pioneer in the field of energy management. Prior to the Arab Oil Embargo of 1973, Mr. Waltz made a personal commitment to energy management as a principal focus of his engineering career. Since that time, he has served as energy management program manager for the Air Force Logistics Command and the University of California's Lawrence Livermore National Laboratory. In addition he has worked as an energy management engineer for consulting and contracting firms. In 1981 he founded Energy Resource Associates for the purpose of helping to shape the then-emerging energy services industry—and did so through a

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Mr. Waltz's credentials include BSME and MBA degrees, professional engineering registration in three states, founding member and Certified Energy Manager of the Association of Energy Engineers (AEE), and member of the Association of Energy Services Professionals (AESP), Demand Side Management Society (DSMs), the American College of Forensic Examiners and the American Society of Heating Refrigeration and Air Conditioning Engineers (AS H RAE).

A noted speaker and author, Mr. Waltz was named International Energy Engineer of the Year for 1993 by the Association of Energy Engineers, has taught performance contracting and building simulation seminars for AEE, teaches energy auditing at the University of California, Berkeley, and was a member of the DOE's 1997 International Performance Measurement & Verification Protocol (IPMVP) Technical Committee

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