When Energy Measurement and Verification is WRONG...

What Do You Do?

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ABSTRACT

Performance contracting is all the rage for facility and energy managers today. All the ESPs and ESCOs include facility infrastructure services and commodity in their list of offerings (as a quick tour of the Internet will reveal.) But who is actually qualified to do an Energy Savings Performance Contract, and is "counting the beans" at the end of the process all you need to do for a building owner? This article provides a down-to-earth discussion of the "dark" side of energy Measurement and Verification—what to do about it when it goes "south" on you. It is based on the author's two decades of experience in the performance contracting field, and from his nationwide seminar on performance contracting.

It's real important at this point to remember what measurement and verification is all about. While in itself it is a fairly complicated and involved topic and endeavor, its essence is very simple.

As a practical matter, it is often good to think of measurement and verification in exactly the reverse order than which it is usually referred to. That is, verification is perhaps the more important part and the one that should be done **first** in the process of doing measurement and verification.

In the process of verification, we literally verify that the retrofit project has the ability to produce savings (or as we prefer to refer to it, "cost avoidance," remembering that if a 10 percent reduction in energy is concurrent with a 10 percent increase in the unit cost of energy, will produce no actual savings in a one million dollar utility bill, but will avoid an additional cost that would otherwise have been incurred).

In the process of verification we should be physically examining and observing the physical condition and function of the retrofit work. For example, on a variable air volume retrofit we should be observing that the digital control system is still monitoring the duct static pressure, that the static pressure actually changes over time (as a result of the distribution box dampers performing their control function), and that the digital controls are actually slowing down the fan speed as static pressure rises, in order to reduce fan power consumption. Not uncommonly, this is done on an annual basis, or perhaps on a continuing basis.

The second part of the measurement and verification process is to, in one form or another, account for the energy savings produced by a retrofit project. This may involve relatively simple and infrequent measurements, or, perhaps rather complex and continuous measurements.

One of the principal characteristics of measurement and verification is that it is potentially the most contentious part of a performance contract. It is literally "where the rubber meets the road." It is incidentally also a fairly controversial topic in the industry and a source of expert testimony assigmnents for our firm. In **Figure 1**, we can see that the simplistic concept of performance contracting and measurement verification is that energy use is relatively stable over time prior to the performance of the retrofit project.

Assuming that all things are equal (i.e. no interfering changes have taken place), it is assumed that what took place in the past, i.e., stable and relatively constant energy use, would have continued into the future and after the retrofit is done the level of energy consumption is reduced and the difference between the pre-retrofit or "baseline" energy use and the post-retrofit, measured energy use is savings.

Referring to **Figure 2**, we can see that if things are not equal, or interfering changes have taken place (such as the 3 percent annual "creep" or increase in electrical energy use such as we typically see in hospitals) then the post-retrofit energy use may also tend to rise and ultimately catch up with our supposedly stable baseline, thereby potentially eliminating our savings.

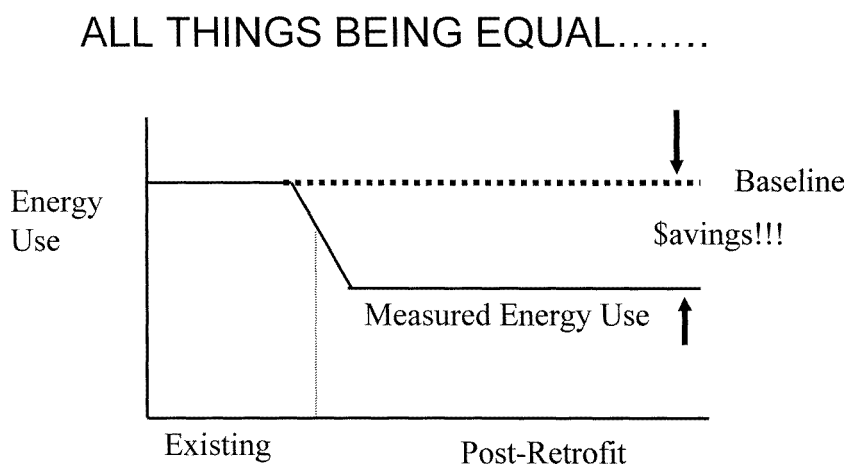

Figure 1

THE ESSENCE OF THE DEAL

The essence of the performance contracting "deal" is extremely compelling and includes the following:

- the performance contractor figures out what's wrong with your facilities
- the performance contractor engineers the correction to these problems
- the performance contractor installs the work necessary to implement the corrections
- the performance contractor guarantees that it will work
- and the owner's total costs go down (i.e., the debt service is paid out of the savings, or results of the project)

In other words, performance contracting represents a "guaranteed free lunch."

Now, in most sales situations, the buyer, when presented with what appears to be a guaranteed free lunch, would ordinarily be somewhat doubtful and appropriately leery. However, the performance contracting

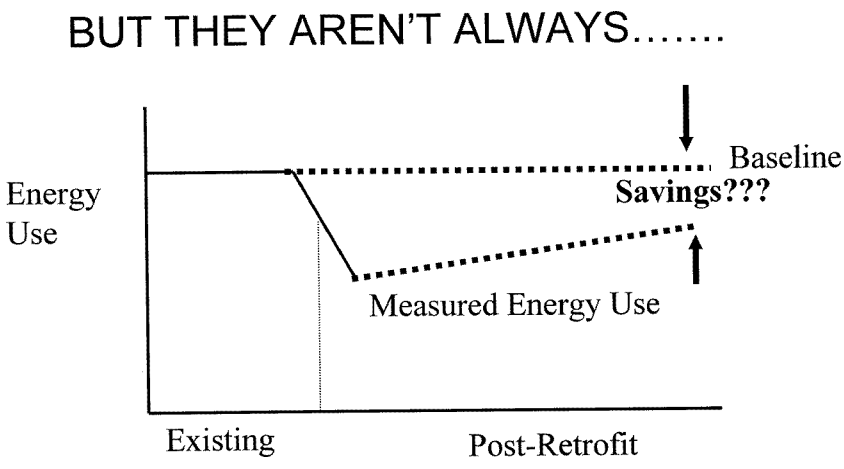

Figure 2.

sales environment and the nature of the work are sufficiently complex and complicated, and the sales proposition is so compelling, that this natural skepticism is often missing. This circumstance is additionally compounded by the nature of the performance contracting business.

THE NATURE OF PERFORMANCE CONTRACTING

While performance contracting has been around for more than 20 years, it is still a unique enough business proposition that is frequently not recognized for what it really is.

Performance contracting, at its essence, is **design built contracting**. Because it is design built, and because it is retrofit (as opposed to new construction) it really cannot be competitively bid, a fact which in general seems to be, in our experience, poorly understood by public agencies in particular.

Furthermore, because of this design build, the vendor or contractor does and should exercise a great deal of control over the process of implementing the project. Furthermore, the vendor or performance contractor does most of the work, including investigation and design, and has most of the information—a very important consideration with respect to measurement and verification (i.e., the performance contractor

is the one doing virtually all the measuring and verifying). The bottom line here is that, especially for public agencies, this is "not your father's Oldsmobile" when it comes to contract award and contract management (i.e., plans and specs/competitive bid won't work).

SOME PROBLEMS WITH MEASUREMENT AND VERIFICATION

Not only is the entire performance contracting process different from what most public agencies, and many private agencies, are accustomed to, but there are some fundamental problems associated with measurement and verification.

First of all, ***savings cannot be measured!*** In attempting to measure savings, you are actually trying to measure something that is no longer there. Savings are literally the stream or flow of energy which is no longer flowing. While you can put a clamp-on amp meter around the wire that's carrying current and measure the current (and the power flow), putting a clamp-on meter around a wire that has no current flowing allows you to measure nothing. Therefore, **it is in fact impossible** to measure something which no longer exists, which is what savings are.

As explained by Dr. Kelly Kissock of the University of Dayton at the Department of Energy's Cool $ense forum in September of 1997 at the Presidio in San Francisco, the statistical methods used in measurement and verification are frequently invalid, or at least questionable in their validity. The underlying problem here, as explained by Dr. Kissock, who is an expert on statistical methods, is that virtually all statistical methods are based on the assumption that the subject of the statistics represents a random population.

While this might be true about people or plants or animals, buildings, their methods of construction, their occupancy and use, and even the lighting fixtures in a single given building are hardly random at all. In fact, they are each unique. Therefore, statistical methods used for measurement and verification rest on a weak, if not invalid foundation.

Finally, there are the interfering factors. These are manifest, and include, among others, the following:

- **bad baseline information** (such as a small complex of buildings served by single electric meter, one of which is outlying, and the owner forgets to mention it to his performance contractor)

- **failures of new and/or existing equipment** resulting in a change in building operations which increases energy use and which the performance contractor (or the owner) may or may not be aware of
- **changes in use and/or occupancy and the documentation thereof** (such as the County sheriff s department on one project who had their own federally funded budget to build a fingerprint archival/retrieval computer system in the basement of the county admin building, which the facilities management department for the County was not informed of, coordinated with, or in charge of, since it wasn't their budget; or a two-shift-per-day tenant that moves into a commercial office building and the performance contractor is not informed about it)
- **additions to or demolitions of occupied space** (such as one famous national park facility which doubled its occupied square footage with a building addition after the energy retrofit project was complete, yet expected the utility bill to go down regardless)
- **sabotage** (such as the assistant chief engineer in one County building who didn't get his promotion to chief and periodically snipped a few wires in the building automation and digital control system, causing the buildings HVAC to run continuously instead of on an appropriate time schedule)

And the list goes and on, and on, and on…. as long as your imagination can conjure up possibilities.

MOTIVATIONS AND/OR PLANNING

While measurement and verification is frequently thought of as the *last* thing which is done on a performance contract, in fact, the planning for and implementation of measurement and verification steps must begin at the very beginning of a project and the folks involved must be willing to view the project results in the clear cold light of dawn.

The person frequently assigned to accomplish the measurement and verification task is all too often a *low-ranking* "techie" who may not have been there for the planning and implementation of the project and has so little authority in the organization that he has no ability to react

to or correct problems that may be discovered in the performance of the project. This person may also feel that their job is on the line should negative results be discovered (see the next paragraph).

No one (the ESCO and the owner included) really wants to hear that a project is not performing. Imagine yourself as the Director of General Services for a large County having to turn to the County Administrator or the Board of Supervisors and explain that your multi-million dollar project was ill-conceived and/or mismanaged and it is now a big black hole sucking funds out of the County's general fund. This is especially so when you're the one who actually went in front of the Board of Supervisors and convinced them that this innovative financing and project implementation technology was the "greatest thing since sliced bread."

We also refer to this aversion to hearing or knowing bad results as the "Jurassic Park Syndrome." This is very much like the scene in the movie "Jurassic Park" where Jeff Goldblum, who is playing the role of a chaos theorist, asks the computer wizard how they keep track of the animals they've released. The computer wizard demonstrates by bringing up a screen of the park with the locations of all the animals indicated by brightly colored "Xs" of a very specific number.

Jeff Goldblum goes on to ask, "Well, how do you know how many animals there are?" to which the computer wizard explains that only females have been released and that they know exactly how many animals have been released. At this point in the scene, just for fun Jeff Goldblum asks the computer wizard to request the computer to locate some 300 animals instead of the 200 believed to be in the park, and indeed, the computer finds the new, much larger number of animals as requested.

The explanation of course is that, like certain species of frogs, some of the dinosaurs have transmuted their gender from female to male in order to continue the species. Unfortunately, performance contracting can be much like the computer system looking for animals in "Jurassic Park," **in that frequently only the correct answer is sought and all other answers are ignored, are dismissed or are incapable of being observed by the methods being used**.

The final little problem is the fact that organizations that are most likely to do a bad project (i.e. an unscrupulous and/or inexperienced performance contractor) are simultaneously the least likely to engage in remediation should problems with project performance be discovered.

In its own way this is sort of a self-fulfilling prophecy that has been chronicled by the numerous utility company subsidiaries that have come into and gone out of business in the last decade—**in some cases multiple times for a single utility company**.

SO... THE PROJECT DOESN'T WORK!

In the following discussion, we will describe two scenarios, as follows:

1. **A little shortfall**, which generally means the project was probably pretty well done and needs to be addressed in the fashion referred to as "Plan A" below.

2. **A big shortfall** (perhaps no savings at all, as we have observed on actual projects) meaning that the project in the majority was ill-conceived and/or mismanaged, which will be addressed in the discussion below, "Plan B."

PLAN "A" (A LITTLE SHORTFALL)

In the case of a small shortfall in savings, say, in the range of 10-30 percent, a number of steps would be appropriate, including the following:

- The first thing to do is compare the engineer's **projection** of savings, end use, with the documented savings. By end use we means things such as air distribution (variable air volume conversion), cooling (such as a chiller retrofit), lighting, etc.

- Assuming Options A and B (under the IPMVP) have been used for measurement verification, the M & V documentation can simply be compared to the original projection of savings. If the portion of the project that is not performing cannot be identified by this comparison, then the "verification" portion of M & V can be used to go out in the field and examine the various retrofit measures to determine which, if any, are no longer performing as expected.

- The next step would be to fix or "tweak" the retrofit measure by repairing failed control components, installing additional devices

(say that chiller isolation valve that should have been part of the project but was inadvertently left off), or,

- Negotiate an adjustment to the baseline, because, in the process, it has been discovered that the "plug" load in the building has doubled from 0.6 watts per square foot to 1.2 watts per square foot since the building baseline was established (as we observed on one 1.8 million square foot building in Texas), or
- Get out the checkbook and write the owner a check to make up the difference in the missing savings (assuming you are the ESCO).

Curiously enough, not that many years ago, one of the bigger names in the performance contracting business was reputed (per a former employee) to allocate fully 10 percent of their annual sales volume to make good on projects that had gone bad (of course, only on those projects where the owner actually noticed that there was a problem)!

PLAN "B" (BIG SHORTFALL)

In this case, we're talking about a project that has seriously "gone south." As mentioned, we have audited large projects that weren't just producing ten or twenty or thirty or forty percent less savings than guaranteed, but no savings at all! In this case, an audit of the entire job from beginning to end is in order, including the following steps:

- The baseline. Was a baseline ever established? In one case, 18 months after the retrofit project was placed in operation, a very well nationally-known performance contractor sent our firm an RFP requesting a flat fee (fixed price) proposal to develop the baseline!
- Examine the energy audit and its documentation. Was an investment-grade energy audit performed? Or was a sales engineer's "back-of-the envelope" estimate of savings the only actual "audit" performed? In one case we consulted on, the owner unfortunately signed a one-page audit agreement, agreeing to pay the performance contractor $75,000 for a "detailed energy audit." Those three words were the entire specification for what was supposed to be an

investment-grade energy audit. Our firm uses a seven-page standard to define the steps involved in an investment-grade energy audit. Somewhat not unsurprisingly, this particular owner (a school district) received a 36-page report in return for their $75,000. Smartly, they did not accept the 36-page report, but then found themselves in a year-long "wrestling match" trying to extract enough information from the performance contractor to be able to know whether or not they should sign a $3,000,000 performance contract. Unfortunately, the performance contractor stated that "the reason we don't give our clients any detail is because they trust us." Astoundingly, this performance contractor could not see the error of their ways, and actually ended up hurting themselves because, not only was the baseline not defined in any appropriate documentation for use by either side in the ongoing relationship, but, the ultimate sale of the three million dollar project was delayed for over a year and almost cost the sales engineer and the performance contracting sales manager their jobs.

- Next, the individual energy conservation measures that were proposed need to be examined for their reasonableness. Could they actually work? Unfortunately, at times, the salesmen exercise too great an amount of control over the process to incorporate measures into a project that their own engineers would reject but for the fact that they cannot overpower their own company's salesman.

- Examine the savings projections for each energy conservation measure as to their reasonableness. In one project examined, the sales engineer's audit counted cooling savings at the air handling units and then counted them once again at the chiller. Needless to say, if you measure the flow going in one end of a pipe and out the other end of the pipe, the total flow is not the sum of both measurements. Yes, the errors are really that fundamental at times.

- The guarantee should be examined for its reasonableness. In another project that we performed expert testimony work on, we discovered that the sales engineer substituted his own calculations for digital controls for the consulting engineer's savings derived from computerized simulation. Unfortunately, because there were no "bounds" on the hand-done calculations, they were most optimistic and the sales engineer wrote into his contract a guarantee of

$150,000 per year savings in natural gas for a building that *only used $50,000 of natural gas in the baseline period*. Astoundingly, this salesman's corporate headquarters were not astute enough to make even the most rudimentary judgment of the reasonableness of this guarantee by comparing it to the annual consumption of the facility.

- Examine the energy conservation measure designs for correctness. In one case, a performance contractor attempted to cut costs by combining a supply air reset point for both an interior and a perimeter air handling unit in a hospital. Now, while the interior air handling unit needed to provide cooling most of the time, the perimeter air handling unit needed to provide cooling when it was warm outside and heating when it was cold outside. Needless to say, the use of a single reset point could never have worked.

- Physically examine the energy conservation measures to see that they have been properly installed. This one speaks for itself, but for example, the addition of an outside air economizer to a building without simultaneously providing for building pressurization relief, will most likely ultimately result in the outside air economizer being overridden and disabled.

- Examine the energy conservation measures to see that they have been properly commissioned. In one case, we observed a variable flow chilled water system with the pump speed controlled by a pressure transmitter at the discharge of the main building chilled water pump. It takes a bit of knowledge of hydronic system design to understand that a differential pressure transmitter must be used and that this differential pressure transmitter must be located at or near the end of the distribution system in order to work.

- Examine whether or not the energy conservation measures have been maintained. In one case we discovered that the entire building automation system had been disabled due to a software problem and that the entire plant was operating in essentially a manual mode of control.

- Examine the measurement and verification plan to see that it is sensible. Is the right information being gathered, and is it being processed properly? In one case we observed that supply air tem-

peratures were being monitored in order to determine the energy units saved by means of supply air temperature reset. Unfortunately, this data was being inserted into a formula that was intended to receive units of enthalpy, not degrees Fahrenheit, and it was overstating the savings being produced by a factor of four.

The remediation under a "Plan B" disaster generally is going to take two courses, depending upon whether the flaws are fatal or non-fatal.

With fatal flaws, the performance contractor will need to get out their checkbook and simply start writing the customer a big, fat check, possibly for every year of a multi-year contract. Undoubtedly, this performance contractor will also find it necessary to emulate the Queen of Hearts in the novel *Alice in Wonderland* in also recommending "off with their heads" with respect to their own project staff.

If the flaws are non-fatal, the project may be recoverable and may include modifying energy conservation measures to add controls or needed additional equipment, re-commissioning the energy conservation measures, redesigning the measurement and verification approach, or, if one is very lucky, renegotiating the deal with the owner. We have seen all of these done to good effect.

OUR RECOMMENDATIONS TO OWNERS:

Our recommendations to owners when considering and implementing performance contracting are short and simple, including the following:

- **Only hire a performance contractor based on their qualifications. This is after all primarily a professional service, not a commodity.**
- **Insist on the use of detailed criteria for how each part of the project is to be implemented and documented.**
- **Manage the entire process and do not become an absentee owner.**
- **Stick to the basics and use your common sense, and remember… there is no free lunch!**

When these rules have been followed, we've never seen a project fail.

ABOUT THE AUTHOR

James P. Waltz, President of Energy Resource Associates, Inc., is an acknowledged pioneer in the field of energy management.

Specializing in the mechanical, electrical and control systems of existing buildings, Mr. Waltz's firm has accomplished a wide variety of facilities projects, recently including a corporate-wide energy management program review for a major hospital chain, design of a replacement chilled water plant for a northern California hospital, on-site recommissioning of the entire building automation system for another large northern California hospital and audit and expert testimony relating to a failed energy services contract for a large southern California hospital.

Mr. Waltz's firm was the State of California's sole performance contracting consultant for the development of the State's ESPC program and provides performance contracting owner's representative services for such clients as San Francisco Unified School District.

Mr. Waltz's credentials include a bachelors degree in mechanical engineering, a masters degree in business administration, Professional Engineering Registration in three states, charter member of and Certified Energy Manager of the Association of Energy Engineers (AEE), member of the Association of Energy Services Professionals (AESP), Demand Side Management Society (DSMS) and the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE).

Mr. Waltz serves as a member of the DOE's measurement and verification protocol technical committee, which is responsible for the recently released International Performance Measurement and Verification Protocol (IPMVP), formerly known as the North American Energy Measurement & Verification Protocol (NEMVP).

Mr. Waltz was named International Energy Engineer of the Year in 1993 by the Association of Energy Engineers (AEE) and teaches a nationwide performance contracting seminar through the AEE. He may be reached at eraenergy. com.

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