Why Do We Calculate Uncertainty?

John Avina

ABSTRACT

Measurement and verification have become more complicated in recent years to address the concerns of utility energy efficiency practitioners. Their concerns, outlook and background are different than those of performance contractors. Many of the concepts that are applicable to the utility energy efficiency practitioners are not useful to performance contractors. One example is uncertainty calculations which are not necessary for a performance contract. This paper critiques the latent and overlooked inconsistencies associated with uncertainty calculations.

WHY ONLY ONE MENU FOR LOW BROWS AND HIGH BROWS?

I come from an energy service company (ESCO) background. I used to do measurement and verification (M&V) for a large ESCO. I relied on the North American Energy Measurement and Verification Protocol (NEMVP) and later the International Protocol for Measurement and Verification (IPMVP) and the U.S. Department of Energy, Federal Energy Management (FEMP) Measurement and Verification (M&V) Guidelines. These documents were fairly straightforward back then. Then, the American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE) Guideline 14, Measurement of Energy, Demand, and Water Savings, came out, which added more complication, some of which didn't necessarily make our jobs any easier. It seems the latest document revisions from the Evaluation Efficiency Organization (EVO) have made the issue more complicated rather than more understandable.

I think I am starting to understand it all now. You have to take a step back and see it from afar. It seems so obvious now.

There are two different worlds of people who do M&V, and they do

M&V for different reasons. These two distinct worlds are the ESCOs and their clients in one world, and the utility energy efficiency people in another world. Individuals from these two different worlds have different jargon that are often incomprehensible to each other when they try to communicate. ESCOs try to keep M&V simple to both cut down on engineering costs and to communicate clearly to their clients, who are usually administrators, not statisticians, engineers, or Ph.Ds. An ESCO M&V practitioner reports how much energy and costs were saved, and that is about it. If there is not enough savings, the ESCO writes a check to the client. The utility people are more interested in determining how effective energy efficiency (EE) programs are run, how many building owners would have done EE projects without the EE programs, the impact of the programs on the state, and how the programs transform the market for EE. Clearly ESCOs and utility people see M&V differently. Given their objectives, the utility world is much more statistics oriented. Generally, the utility people, but not the ESCO people, speak of uncertainty.

The utility world produces dozens of papers on M&V, and they generally contain many concepts and statistical complexity that are not useful to ESCO M&V practitioners. I get it. Utility people write for utility people. They are not writing for ESCO people.

Although this is now obvious to me, it is often not taken into account that the ESCO and utility worlds do not interface much, nor should they. Occasionally ESCO practitioners read utility-oriented M&V papers and either become confused or try to apply these concepts, which are generally not useful in their work. M&V budgets are tight. ESCOs keep it simple—report the savings, explain it clearly in terms the client understands, and move on. On the other hand, the budgets in the utility world are relatively lavish, and seem to have no problem paying for this added complexity. For example, what ESCO client is going to want to hear that you are 68% confident that the savings is within 57% of this number. How do you write a shortfall check based on that? The ESCO client wants to know what they saved … period!

One of the reasons ESCO people are reading more and more about uncertainty is that the utility people and their ideas have slowly taken hold in EVO. The original IPMVP (the NEMVP) was released in 1996, and it wasn't until 2012, that uncertainty appeared in an appendix of the IPVMP.

So, the first point I would like to make is that M&V is different for ESCO people than for utility people. EVO doesn't seem to take this into account when they write guidelines, as their documents are including more and more esoteric M&V and statistics concepts, which just do not apply to ESCOs. As a result, I don't recommend EVO manuals to new M&V practitioners anymore. FEMP Guidelines are straight-forward and perfectly suited to the ESCO world.

It's akin to having a restaurant that serves corn dogs and tater tots to the low-brow clients, along with cognac shrimp with *beurre blanc* to the high-brow clients. Maybe it would be better to have two separate restaurants for the two different clienteles. They don't often mix well together.

WHY DO WE CALCULATE UNCERTAINTY?

As most in the industry are aware, M&V protocols define 4 primary options: A, B, C, and D. So why is it that people only talk about uncertainty for Option C M&V and not for Option A, B, and D M&V? I mean, really? We invalidate Option C models because there is a high uncertainty, yet we go forward with Option A models, which we do not even calculate uncertainty for? Think about it. That doesn't make any sense at all. There is a reason behind this, but if you think about it on a meta-level, perhaps the entire discussion about uncertainty is moot.

We all know that Option A M&V is usually not very accurate. Large assumptions are made, which, if uncertainty were calculated, would embarrass everyone concerned in most cases. By agreeing on Option A, the parties are agreeing that they are willing to tolerate inaccurate savings numbers.

Option B should be more accurate than Option A. There should be less uncertainty, but due to interactive effects, say of various measurements, calculating uncertainty is not done. It is too difficult.*

---

*An argument can be made that Option A and B only measure the retrofit in question, and therefore much uncertainty has been taken away. Option C and D measure the entire building, which means, all the noise associated with unrelated things is wrapped up into the measurement. So, conceptually, then you may be able to claim that uncertainty for Option A or Option B is less than it is for Option C. On the other hand, Option C measurement is done on an ongoing basis, whereas the measurements for Option A and B may be done during a short period and may be extrapolated over an entire year. How do you estimate the uncertainty associated with extrapolation? So many questions, and it all seemed so simple.

Option D, although rarely done, contains measurements, which again, could be interactive, greatly complicating the calculation of uncertainty. There is also measurement error to consider because the instruments are not perfect. There is modeling error. How many inputs are there to consider? Each assumption, and there will be many, has great uncertainty. But really, how does one go about calculating the uncertainty of a building model? How do you know if your model's chiller usage is high, and your air-handling unit (AHU) usage is low? You might if you had interval data to compare against. But what if your chiller usage is close and the AHU usage is off, and there was no way to get them both close to your measured data. (This happens.) There is so much complexity here. When you do Option D, there often are no utility bills to compare the model to. How did you disaggregate the usage for that one building when you had no bills? How do you put an uncertainty number on that? Again, the uncertainty would be so great, as to be laughable.

So, why do people get all bent out of shape calculating uncertainty for Option C? This is totally inconsistent. From a birds-eye view, it does not make sense to care about uncertainty for one M&V option but not for others, especially when Option C appears to have the most certainty of any method. Uncertainty is performed on Option C (by the utility people) because it is the only option of M&V in which it can be done relatively simply. It is just too difficult to do using the other options. That makes no rational sense whatsoever. The ability to calculate uncertainty should not be used as an impediment to Option C.

I was communicating about this with Bill Koran, a known expert in the M&V statistics field. He wrote: "I have often, in comparisons of Option C to D said, 'why should I have to model every wall, window, and door to estimate energy use? I have real data!' With that, I agree that 'Option C appears to have the most certainty of any method' in most cases, which is why I focused my work on it."*

In addition, when calculating uncertainty for Option C, we do not consider metering error, and as you get to the interval data level, metering error is substantial. Interval data often will have hours or days with no readings, or impossible readings near 0. Software applications that use interval data have to "scrub" or "massage" the data to render it workable.

---

*From an email conversation with Bill Koran, 10/20/2020.

Often, they use data from the prior week, even though the weather is not the same. Does uncertainty handle this? Even monthly bill data often will have estimated and actual bills. These estimated/actual bills will drop the R2 values and increase the coefficient of variation of the root mean square error (CVRMSE) values unless we drop them from the fit. This source of uncertainty is not even mentioned in the literature that I have seen. This means that our uncertainty calculations that statisticians have taken great pains to develop for our industry are only addressing part of the story. So even if we decided we should calculate uncertainty with Option C, why would we accept these uncertainty values when large determinants of uncertainty are left out. Maybe there should be an uncertainty calculation of the uncertainty calculation.

But the biggest disqualifier of the entire uncertainty issue is how do you handle non-routine adjustments?* How do you assign uncertainty to these? Often the calculations for non-routine adjustments are done using spreadsheet models with many assumptions. Sometimes non-routine adjustments are made using building modeling programs. I have yet to hear of anyone calculating uncertainty on either of these methods for creating non-routine adjustments. Over the life of a 10-year contract, it is likely that there will be at least one non-routine adjustment applied to every meter being tracked. So, why are we so focused on uncertainty of a regression equation, when whatever uncertainty we have estimated will likely become invalidated by a non-routine adjustment uncertainty before the contracted savings period expires?

I think we in the industry need to take a step back from all of these unnecessary details and look at the big picture here. Why are we doing M&V in the first place? For ESCOs it is a contractual thing. We need an understandable and dependable yardstick with which to measure a project's performance. How can we improve the M&V with this in mind? I suggest that we drop all this needless complexity like uncertainty. As I hope I have demonstrated, uncertainty is not applied to all M&V options, and for no good reason. It does not handle metering error or

*A non-routine adjustment is added to the savings equation to address changes in building usage patterns that have nothing to do with the energy efficiency retrofits that were installed. For example, if the building owner adds 4 hours to the AHU schedules, then the building is using more energy, and you will have to make an adjustment in your savings equation to remove the effect of this scheduling change.

non-routine adjustments. It is an arbitrary concept, which really should not be applied at this time.

AUTHOR BIOGRAPHY

John Avina, CEM, CEA, CMVP, CxA, has worked in energy analysis and utility bill tracking for over 25 years. During his tenure at Thermal Energy Applications Research Center, Johnson Controls, SRC Systems, Silicon Energy and Abraxas Energy Consulting, Mr. Avina has managed the measurement and verification (M&V) for a large performance contractor, managed software development for energy analysis and M&V applications, created M&V software that is used by hundreds of energy professionals, taught over 250 energy management classes, created hundreds of building models and utility bill tracking databases, modeled hundreds of utility rates, and has personally performed energy audits and RCx on over 25 million square feet. Mr. Avina currently chairs the Certified Energy Auditor Exam Committee for the Association of Energy Engineers. Mr. Avina has a MS in Mechanical Engineering from the University of Wisconsin-Madison. John may be contacted via email at john.avina@abraxasenergy.com.