

Is simple better: can programs get more done by simplifying calculations?

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ABSTRACT

Energy efficiency programs use energy models to back up their savings claims. Energy modelers commonly refer to the International Performance Measurement and Verification Protocol to create rigorous energy models that withstand the scrutiny of evaluators and regulators. Some measures may employ simple models that yield similar results to more complex models. Simpler models, with smaller data collection requirements may reduce engineering and administrative costs and provide similar accuracy. This will leave more resources to the design, implementation and operation of energy efficiency projects and thus yield greater energy savings and greenhouse gas reductions.

This paper provides results from a custom industrial energy savings impact evaluation of measures installed in 2019 for an entity serving customers in the Northwestern United States. In this impact evaluation, evaluators estimated first-year savings for each of 40 sampled measures based on actual operations during the first. The evaluators applied best M&V practices to create energy models for all measures in the sample. The evaluators also calculated energy savings using on a simplified models for each measure. For example: a simplified variable speed drive (VSD) compressor model will use 2 weeks or less of baseline operations data and a 4-bin operations model with nominal values for baseline and energy efficient systems. A best practice model would use an hourly model with compressor specific efficiency curves.

The analysis will compare both model types and evaluate which types of projects are better suited to simpler models.

Introduction

Bonneville Power Administration (BPA) is an electric power marketing and production entity managed by the US department of Energy which serves the Pacific Northwest including Washington, Oregon, Idaho, and Western Montana. BPA provides energy efficiency engineering and support services to utilities as part of their electric power purchasing contracts. BPA requires its engineering staff and energy efficiency implementers to follow the custom project energy measurement and verification (M&V) protocols developed for their agency. BPA's custom project M&V protocols come in two general categories: Energy Calculation with Verification (ECwV) and International Performance Measurement and Verification Protocol (IPMVP) adherent. The typical characteristics two categories are highlighted in Table 1.

Table 1 Selection Criteria of BPA M&V Protocols

ECwV	All other custom M&V
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< 200,000 kWh estimated savings	≥200,000 kWh estimated savings
Not IPMVP adherent	IPMVP adherent
Little or no pre/post energy metering	Pre/post energy metering needed
Short time frame for implementation	Longer time frame for implementation
Lower cost for M&V	Higher costs for M&V
Low expected variance in savings (year to year)	

Source: kW Engineering Inc, BPA M&V selection-guide, October 2018

Note that while these differences are typical, ECwV projects are not limited to all listed characteristics. Projects that do not meet the <200,000 kWh size may still follow an ECwV protocol if they have other ECwV qualities. ECwV and IPMVP adherent methods primarily differ in their pre/post energy measurement requirement for verification. A typical ECwV M&V process may include spot energy measurements of baseline conditions or even short-term metering; but the only requirement is enough knowledge of baseline conditions and installed equipment to develop an engineering model. Well understood measures such as a change in motor efficiency may only need nameplate efficiency values and operating hours for the savings calculation, while more complex measures may also need other operating conditions verified, like average power or flowrate (kW Engineering, Inc., 2018).

The guidelines for selecting a protocol was originally developed in 2012 and updated in 2018, and is outlined in the flow chart in Figure 1 (kW Engineering, Inc., 2018). Energy Calculations with Verification (ECwV) features prominently as a preferred protocol under a variety of M&V conditions. Engineering costs were not a part of this study, but generally the ECwV M&V approach requires fewer resources to implement than other custom project M&V protocols. The selection guide considers ECwV as the first option among M&V methods because it is efficient to deploy and consumes fewer engineering resources for implementers. The cost efficiency of deploying ECwV projects conserves staffing resources for other energy efficiency measures.

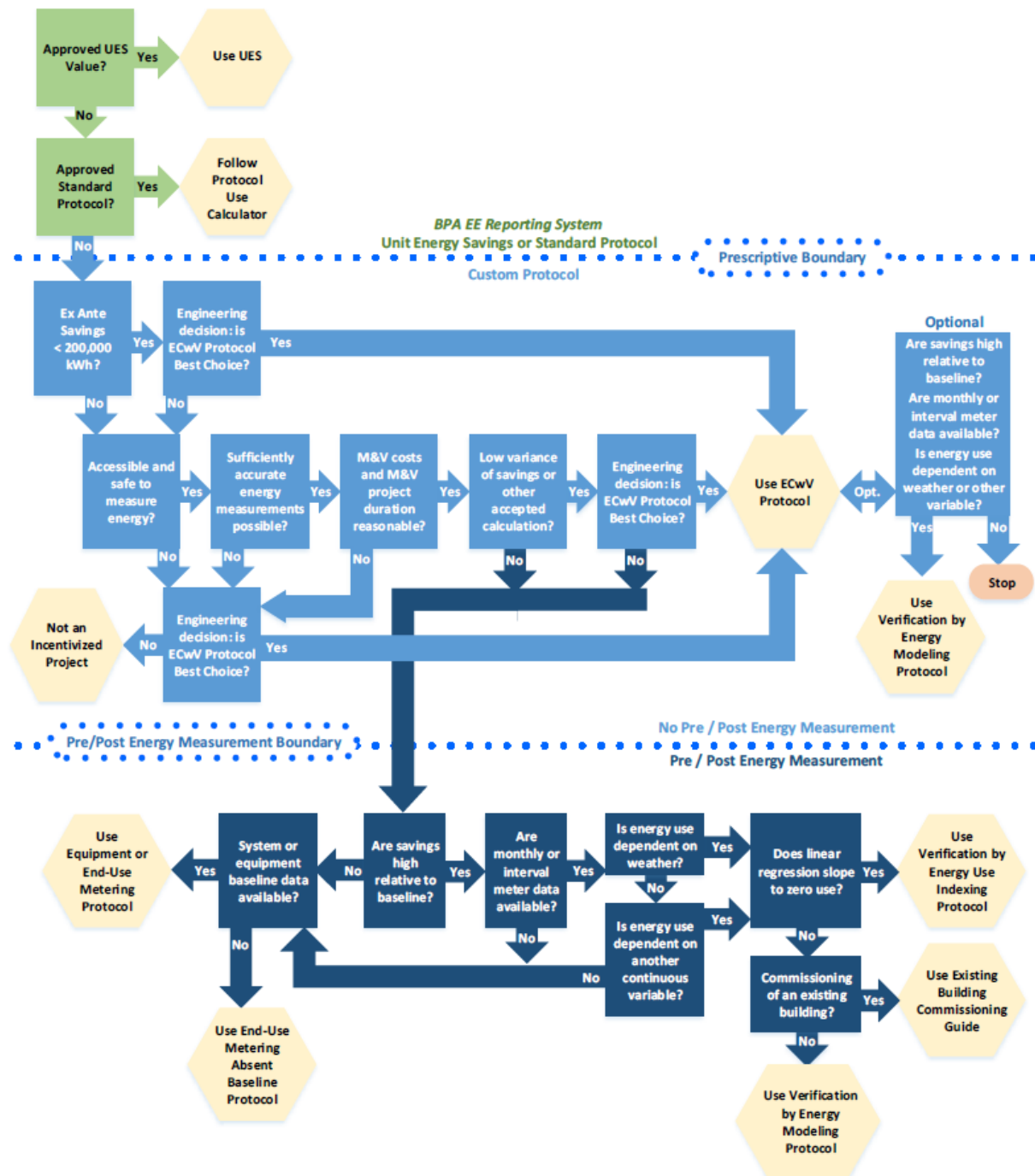


Figure 1 M&V Selection flowchart. Source: kW Engineering Inc, BPA M&V selection-guide, October 2018

To understand the choice to implement ECwV, consider an example: a facility will add VFDs and demand control ventilation to air handlers that serve an assembly space. Ventilation requirements for the space are not met in the baseline conditions, so appropriate baseline energy conditions could not be measured. Engineers develop a spreadsheet analysis of heating and cooling loads based on operating schedules and the nominal building size assuming the

ventilation fans run at full speed when the building is occupied. The analysis is done again assuming variable requirements for ventilation.

The spreadsheet analysis shows that expected savings are less than 200,000 kWh with a steady and predictable relationship between fan speeds and energy savings. The M&V selection protocol recommends the ECwV M&V protocol (kW Engineering, Inc., 2018). The ECwV model will be like what was used in the initial proposal, with an additional verification of average fan speeds taken from the fan VFD controls during the two weeks of normal building operation. Alternately, building occupancy could be tracked with standalone occupancy sensors.

If the project was expected to save more than 200,000 kWh with varying fan speeds during occupancy, the End-Use Metering Absent Baseline Condition M&V protocol might be preferable. The IPMVP adherent End-Use Metering Absent Baseline Condition M&V plan would require logging samples of true fan power for part of the heating and cooling seasons.

Methodology

BPA needs to evaluate the validity of their ECwV methods and decide whether the criteria used to select ECwV projects should be changed. The 200,000 kWh savings threshold for ECwV limits its applicability to larger projects which BPA assumes are not accurately modelled by ECwV. The limit was set by BPA program designers and engineers because it seemed reasonable, but the decision was unsupported by empirical data. This impact evaluation study tried to answer these questions:

- Are ECwV evaluation results accurate compared to claimed savings.
- Could the size limits for ECwV be changed with relatively low risk to energy efficiency programs?

If the expected savings limit for ECwV could be increased, then a portion of projects in BPA's portfolio would have lower M&V costs. Lower M&V costs for some projects would improve cost effectiveness and allow for more projects with the same amount of resources.

The evaluation team drew a random sample of measures from BPA's industrial energy efficiency portfolio completed September 2019-August 2020. The smallest sample unit (measure) was a unique Technology/Activity/Practice (TAP)¹ within an energy saving project. There were some projects that had multiple measures within the sample, and all measures within a project followed the same M&V protocol. The sample was stratified by size and end use. A few measures with very large savings for each end use were all selected with certainty². Measures with the smallest savings³ represent 5% or less of the savings for each end use and are excluded from the sample (Evergreen Economics, 2022). The evaluation team designed the sample to calculate realization rates for the overall population and by end-use. The existing M&V selection protocols are strongly dependent on expected savings, which makes saturation of ECwV measures higher in stratum 1. In contrast, strata 2 and 99 contain few ECwV measures and fewer measures overall. We will compare stratum 1 which contains the most ECwV measures to larger strata to see how the results may change with size. We will also examine the plotted results for other correlations. The sample population statistics are summarized in Table 2.

¹ Such as Motors/Drives Control Improvements (VFD) or Evaporator Fan System Improvements

² Stratum 99

³ Stratum 0

Table 2 Evaluation sample summary

End Use	Strata	Size	Maximum size (kWh)	Average size (kWh)	Population count	Sample count
Compressed Air	0	Very Small	62,800	34,785	2	0
Compressed Air	1	Small	188,640	145,034	5	4
Compressed Air	2	Medium	492,975	371,347	5	3
Compressed Air	99	Large	1,192,160	1,192,160	1	1
HVAC	0	Very Small	61,045	61,045	1	0
HVAC	1	Small	367,466	250,264	3	2
HVAC	99	Large	966,660	966,660	1	1
Motors/Drives	0	Very Small	67,941	45,857	7	0
Motors/Drives	1	Small	192,104	140,978	5	4
Motors/Drives	2	Medium	905,606	531,617	13	7
Motors/Drives	99	Large	5,229,873	5,229,873	1	1
Process Loads	0	Very Small	21,205	14,327	2	0
Process Loads	1	Small	493,021	273,246	5	3
Process Loads	99	Large	3,857,843	3,338,859	2	2
Refrigeration	0	Very Small	78,809	42,000	5	0
Refrigeration	1	Small	180,658	169,752	4	3
Refrigeration	2	Medium	1,020,747	537,259	15	8
Refrigeration	99	Large	3,509,036	3,509,036	1	1

All evaluated measures required examination of their energy savings calculations and verification of assumptions for the first year of operation. Project engineers and end users were interviewed to verify baseline and efficient operating conditions, and model validity. When necessary and feasible, end users and project engineers provided operations data and facilitated onsite data collection. Collected data was used to verify actual operating conditions where possible. In some cases where representative data could not be collected, only a model review was performed. Evaluation models were not all IPMVP compliant, but IPMVP compliant models

were preferred by evaluators. In addition to the evaluation energy model, evaluators created energy models that followed ECwV guidelines. The ECwV models intentionally excluded data that would not normally be part of an ECwV M&V process. For example: if an evaluation model for a VSD pump motor collected 6 months of energy and operations data, the ECwV model would use an average daily schedule developed from two weeks of motor operating speeds.

Results & Analysis

The sample weighted evaluated savings and ECwV savings results for the sampled population are shown in Table 3. The results for the evaluated savings which use all available data and models adopted or developed during impact evaluation engineering review are in the column labeled “Evaluated savings (kWh)”. These values represent the reported impact evaluation portfolio savings. The evaluation results modeled with an ECwV compliant method are shown in “ECwV savings (kWh)”. The ratio of these two results represents the closeness of the two methods for a given stratum. Results close to 100% have the most similar observed savings and ECwV savings results. The results for all end uses in stratum 1 are within $\pm 15\%$ of 100%, which indicates that the ECwV approach is best suited to this stratum for accurate results. The overall weighted result shows a ratio of 73%.

Table 3 Sample weighted evaluated savings and ECwV savings results

End Use	Strata	Size	Sample count	Evaluated savings (kWh)	ECwV savings (kWh)	Ratio of ECwV savings to Evaluated savings
Compressed Air	1	Small	4	702,048	439,241	63%
Compressed Air	2	Medium	3	2,090,674	1,342,380	64%
Compressed Air	99	Large	1	1,134,546	727,380	64%
HVAC	1	Small	2	177,134	177,134	100%
HVAC	99	Large	1	734,657	821,931	112%
Motors/Drives	1	Small	4	686,598	605,542	88%
Motors/Drives	2	Medium	7	4,564,470	3,810,575	83%
Motors/Drives	99	Large	1	3,899,184	2,522,162	65%
Process Loads	1	Small	3	1,119,010	1,161,192	104%

Process Loads	99	Large	2	7,486,239	4,829,097	65%
Refrigeration	1	Small	3	927,213	1,044,520	113%
Refrigeration	2	Medium	8	5,513,268	5,427,151	98%
Refrigeration	99	Large	1	2,626,875	1,443,150	55%
Total				31,222,408	22,830,723	77%

The results from Table show that the ECwV method applied by evaluators typically underestimated savings across the sampled population. This underestimation is more likely for larger measures. A similar relationship is shown in Figure 2. The unweighted ECwV model results are plotted against the unweighted evaluation model results with each dot representing a single measure. The gray middle line represents a theoretical 100% match, while the blue lines indicate $\pm 25\%$ deviation from a perfect match. The solid black line is the sample weighted trend between ECwV and Evaluation models. The measures with evaluated savings greater than 800,000 kWh all had lower savings estimated from the evaluators implemented ECwV model. The overall trend indicates that ECwV models will estimate savings 33% lower than standard evaluation models. Figure 3 shows the same results for measures with evaluated savings less than 800,000 kWh. The trended ECwV modeled results in this range are 5% lower than the evaluation model results. This size range eliminates systematic bias from larger projects shown in Figure 2 while still maintaining similar relative error. End use does not appear to explain structural biases in Figure 2.

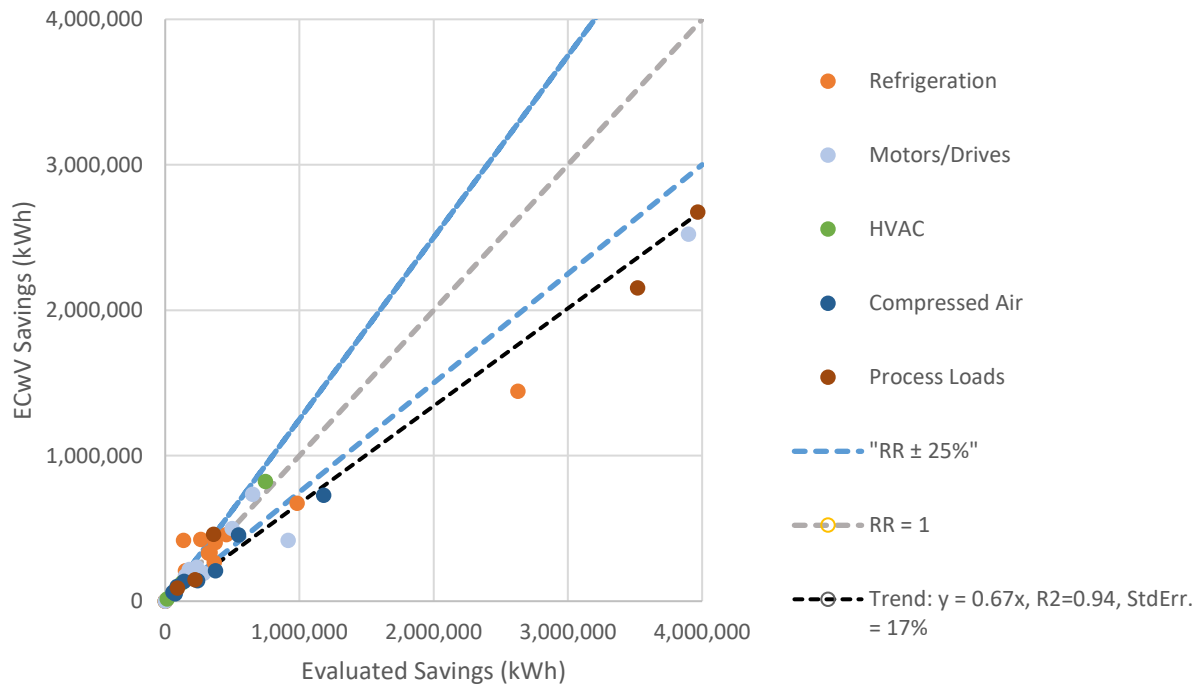


Figure 2. Evaluated model and ECwV model savings results for all measures.

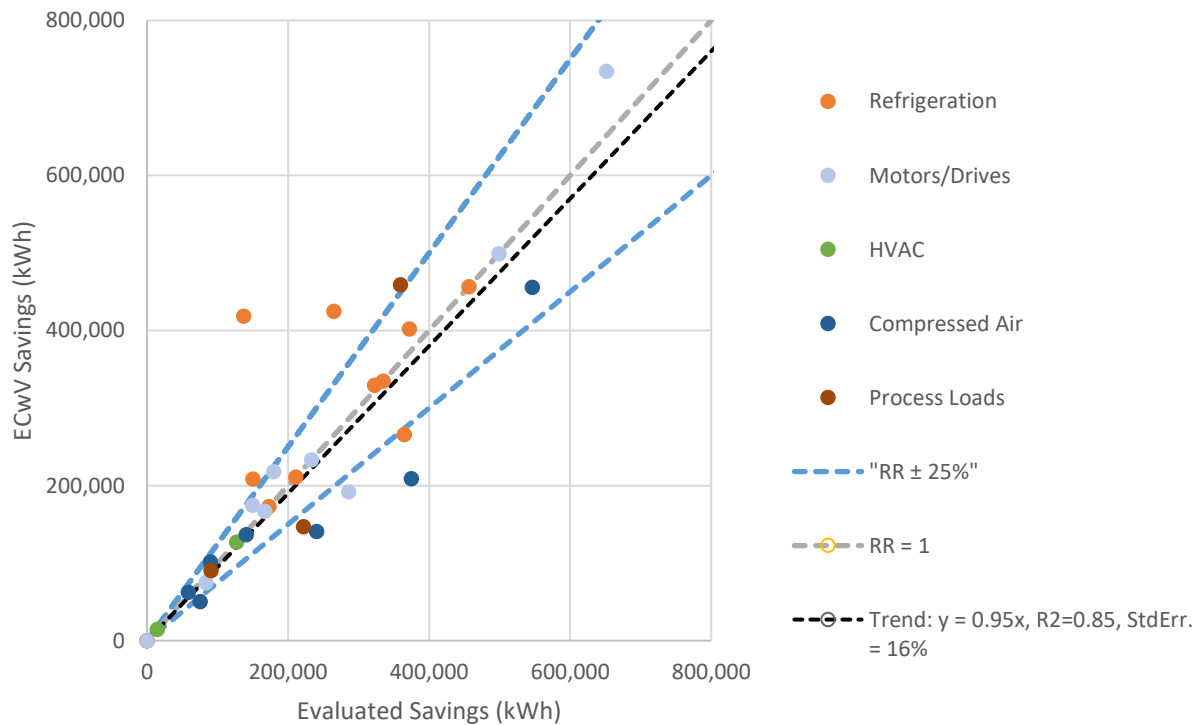


Figure 3. Evaluated model and ECwV model savings results for measures less than 800,000 kWh evaluated savings.

Conclusion

Energy conservation program managers must meet conservation and greenhouse gas reduction targets required by their IRPs and stakeholders. These needs are balanced against delivering verifiable and reliable outcomes for their stakeholders. What outcome should we expect from allocating the same amount of engineering resources across a larger number of measures? Would reducing the rigor for some smaller measures increase portfolio risk?

BPA's ECwV protocol is designed to be less expensive for energy efficiency implementers and to use ratepayer resources more efficiently. BPA's 2020-2021 Industrial Impact Evaluation (Evergreen Economics, 2022) showed that the ECwV protocol performed as expected by the designers of the protocol. The current threshold for automatic ECwV consideration is 200,000 kWh although larger values up to 800,000 kWh seem defensible and could be considered by BPA. The evaluated values larger than 800,000 kWh appear to be systematically underestimated by ECwV models. Increasing the maximum threshold for ECwV measures and other similar simplified M&V protocols may yield sufficiently accurate savings for custom energy efficiency programs. Further research could refine parameters such as maximum size. Implementation of simplified M&V protocols such as ECwV for measures up to 800,000 would liberate engineering resources to devote across a larger population of projects.

References

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