TIP 389: Realizing High-accuracy Low-cost Measurement and Verification for Deep Cost Savings

Context

There is growing recognition that whole-building-focused approaches to energy efficiency hold great promise in realizing deep and persistent energy savings in commercial buildings. Utility programs are increasingly exploring whole-building strategies that move beyond traditional component-based interventions, and the industry is seeing a movement toward continuous energy improvement practices that may include ongoing commissioning, strategic energy management, as well as retrofits and the implementation of advanced control and information technologies.

These program designs naturally lend themselves to measured, whole-building savings quantification, as opposed to deemed or calculated savings. In addition, they have the potential to generate deeper energy savings than single-measure approaches, and are being increasingly pursued in the northwest region.

The efficiency program industry, however, has historically relied nearly exclusively on deemed or calculated savings, and has adhered to evaluation, measurement and verification processes that are costly and time consuming. Analytics tools offer the potential to streamline the measurement and verification (M&V) process by automating the M&V approach, yet key questions must be addressed before they can be applied with confidence.

Description

The project was funded to conduct the technical analyses, demonstration, market evaluation, and regulatory engagement necessary to realize a cost-effective high-accuracy advanced measurement and verification (M&V) method that could be applied to certain efficiency programs in the Pacific Northwest. Advanced M&V (also known as M&V 2.0), is a method that uses advanced metering infrastructure (AMI) data in combination with analytics to quantify energy efficiency savings.

This project completed seven tasks. A partial description of each task follows:

Task 1. Literature and market review: Documented the current state of the industry with respect to M&V tool testing and verification, including prior work from LBNL, ASHRAE activities and research projects surrounding standard methods of test, standardization bodies, and interest from state energy agencies and utilities to implement these procedures.

Task 2. Automated identification of non-routine adjustments: Developed open-source, automated methods to identify the potential need for non-routine adjustments based on interval electric data and weather.

Task 3. Standardized quantification of non-routine adjustments: Developed standard methods to quantify commonly encountered non-routine adjustments, e.g. changes in occupancy, changes in operating hours, changes in computer loads, changes to building area based on the building type.

Task 4. Automated quantification of savings uncertainty and confidence: Developed open-source automated methods to quantify savings uncertainty at user-defined confidence levels. Evaluate the formulations in ASHRAE Guideline 14 to determine whether improvements can be made, particularly in the case of auto correlated time series data.

Task 5. Development of practitioner workflows: Expanding upon cost-shared work, developed a series of workflows for program implementers, administrators, and evaluators to use automated approaches for program M&V.

Task 6. Seattle City Light Demonstration: Using the outcomes of Task 5, demonstrated the use of automated M&V on Seattle City Light programs.

Task 7. Engagement of the northwest regulatory community Expanding upon cost-shared work, engaged regional regulatory community to determine acceptable levels of uncertainty and confidence.

Benefits

This project benefits BPA by producing a practical solution for the northwest to scale high-accuracy, low-cost savings estimation. As we strive to meet aggressive energy savings goals as the state, regional, and national levels, there is a pressing need to scale the delivery of efficiency programs. Today’s approaches to determining the savings impact of efficiency programs are costly and time consuming, and there is acknowledgement that the industry will benefit from ‘faster, better,’ and more cost effective solutions.

This project also promotes increased confidence and reliability in valuing energy efficiency as a resource, increased trustworthiness and transparency of savings claims, and advancement of energy efficiency.

Accomplishments

The project delivered solutions to decrease the time and cost required for M&V while maintaining a transparent and accurate result.

The project achieved this by conducting technical analyses, demonstration, market evaluation and regulatory engagement specifically targeting northwest energy efficiency policy and programs.

Deliverables

Final report: The project team synthesized task-specific deliverables into a final report that describes project outcomes and suggested next steps for scaled demonstration and deployment of the solutions for low-cost high accuracy M&V.

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Project Start Date: October, 2016

Project End Date: September, 2019

Reports, References, Links

Saved to BPA EE Sharepoint site here
U.S. DEPARTMENT OF ENERGY OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY
LBNL: Advanced M&V (“M&V 2.0”)

Participating Organizations

Lawrence Berkeley National Laboratory (LBNL)
US Department of Energy, Buildings Technology Office
Seattle City Light

Funding

Total Project Cost:	$600,000
BPA Share:	$175,000

Through co-funding BPA leveraged its share by 70%

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Conclusions

Valuable M&V content provided with the project deliverables that will support future BPA M&V Protocols update work, prove useful for our BPA EE Engineering staff performing custom project M&V, as well as our future collaborations with the external M&V community (i.e., Efficiency Valuation Organization) at large.

Key lessons learned and applicability of project findings for BPA, are summarized below.

Simple practitioner workflows were developed that integrate advanced M&V tools with supplementary automated routines for non-routine adjustments, and in combination with accuracy/documentation guidelines these are straightforward to apply. Guidance and case study examples of NRAs remain a gap (reinforced by RTF’s paper). We also learned that existing uncertainty calculations are unreliable for hourly models; hence recommend model fit criteria and out-of-sample testing for tool validation.

BPA applicability:
The workflows are ready to use, and complemented by accuracy/documentation guidance and EVO tool testing7.
NRE identification code is ready to use, though recommended only as 'filtering' tool which is then reviewed by experienced practitioners (in conjunction with CUSUM charts)
A meaningful start toward methods for non-routine adjustments was developed, but additional R&D is needed to further mature and test them. This could be complemented by RTF's call for a catalogue of example buildings' data with NREs documented.

Advanced M&V software testing portal, based on a test method developed by Berkeley Lab, has been made publicly available by EVO at: http://mvportal.evo-world.org/

Objective: Demonstrate practitioner workflows with Seattle City Light, in collaboration with their implementers and evaluators – determine labor and time/cost savings, and uncertainty of the results obtained.

What we learned: The advanced M&V tools and methods are effective, and the utility partner was enthusiastic about having a dynamic, data-driven view of project performance. The process is relatively streamlined (once data access/formatting is configured), so application on 'real-time' projects should be very cost-effective. Future applications will benefit from continued attention to assess the number of projects can realistically meet the 5% savings criteria, and to documenting utilities' process for addressing underperforming projects, NREs, and negative savings.

BPA applicability:
M&V 2.0 offers complementary benefits to existing savings estimation methods.
Advanced M&V could be used in combination with traditional ex-ante methods as a way to increase confidence in results, in some cases may be ideal as the primary verification method for complex projects, could provide an early indication of true savings impact at the meter, and could be used within a pay-for-performance program.
BPA can view these methods as 'program-ready,' though needing technical input during ramp-up phase, and noting earlier comments on NREs.

Objective: Engage the Pacific Northwest regulatory community to determine acceptance criteria for the required accuracy and reporting of advanced whole-building M&V.

What we learned: There is interest in the topic of advanced M&V, and stakeholders have looked to BPA and RTF to provide technical and programmatic guidance. Best practice methods are well defined, and there are two notable areas where challenges exist. Firstly, savings uncertainty calculation methods exist (referenced in advanced M&V guidance), but now that uncertainty calculations have been shown to be unreliable for daily or hourly models, there is a need to seek technical solutions that will allow for reliable uncertainty quantification for applications that extend beyond monthly data and monthly models. Secondly, conceptual guidance exists for identifying and adjusting for NREs, and this project has produced early research on data-driven methods. Clear program guidance based on current knowledge will enable the industry to continue deployment while also providing opportunity to learn more about the frequency and severity of NREs in the field.

BPA Applicability:
The outcomes of this project, in combination with the parallel efforts through Seattle City Light's pay-for-performance program, provide BPA with practical resources that can inform updates to technical guidance, and helps BPA-affiliated utilities to adopt advanced M&V methods while managing the risks associated with under-performing projects.

The final objective was to document the findings to facilitate broad industry uptake of the solutions. The outcomes of this project can help utilities develop rigorous, practical program designs, understanding the process implications and managing the risks involved. Given the lack of publicly documented examples of the application of advanced M&V, this project constitutes a major step forward in supporting uptake of these new methods in the Pacific Northwest.

Next steps and future opportunities

This project demonstrated the practical application of advanced M&V tools and methods, and surfaced additional opportunities to support scaled adoption. These include:

- Continued work to characterize, and develop and test analytics-based solutions to identify and adjust for non-routine events.
- Exploration of auto-regressive models to potentially overcome challenges in quantifying uncertainty due to model error, for hourly or daily data granularity.
- Further engagement of the regulatory community on key issues such as model type selection, NREs, uncertainty quantification, and further validation of approaches to address situations where independent variables in the reporting period fall outside the range observed in the baseline.

Another general area of research that could prove beneficial is to explore the connection between advanced M&V at the building/program level and grid-level concerns. Given the time-varying value of energy and demand reductions, and the changing mix of generation options at grid level, better understanding of building load shapes and savings load shapes will become more critical to utilities and grid planners. Advanced M&V methods could be a useful tool in that context, though that potential has not yet been extensively explored.