Connecticut Advanced M&V Pilot

Advanced measurement and verification (M&V) shows great promise as a means to provide higher granularity feedback on energy efficiency project savings, while supporting new program approaches. In 2017 a group of project partners initiated a pilot with the goal to test and track experience using advanced M&V methods using data from a Connecticut residential efficiency program. The pilot provided valuable insights on best practices for implementing advanced M&V, and resulted in the use of advanced M&V beyond the end of the pilot.

What is Advanced M&V?

Advanced M&V (sometimes called M&V 2.0), is characterized by (1) Increased data availability, in terms of finer time scales or higher volume and (2) enabling the processing of large volumes of meter data at high speed via automated analytics, to give granular feedback on efficiency program performance. These approaches are intended to be conducted more quickly, more accurately, and potentially at lower cost than non-automated methods

Advanced M&V Modeling Approach

The EnergizeCT Home Energy Solutions (HES) Program was chosen for study under the pilot. HES is one of Connecticut's largest residential energy efficiency programs, serving tens of thousands of Eversource and UI customers per year with audits, direct installations, and rebates for a variety of energy-saving measures. In the 2015-2016 program years, the HES program served over 48,000 homes statewide. This particular cohort was chosen as it was concurrently undergoing formal third party evaluation, which would enable comparison of results with advanced M&V.

Recurve was selected to execute the advanced M&V under this pilot (electric savings only), which was based on the CalTRACK method. CalTRACK is a set of M&V methods which includes an aggregated approach for residential savings estimation using monthly billing data.

The first step in the advanced M&V approach (see Figure 1) was to select suitable time periods prior to and subsequent to program participation (known as the baseline and reporting periods). Since the program covered 2015-2016, calendar years 2014 and 2017 were selected as the baseline and reporting periods.

After selecting analysis time periods, ambient temperature data and monthly meter data for those time periods was obtained for each program participant. This data was reviewed and cleaned, to remove erroneous data and filter out any meters with significant data gaps. These initial cleaning steps resulted in the initial 21,366-meter data set being reduced by approximately 29%.

Weather-normalized energy models were created for each meter in the cleaned dataset (the "treatment" meters), for both the baseline and reporting periods, and additional data cleaning steps were then applied. For example, meters where weather-normalized consumption changed by more than 75% between baseline and reporting periods were removed, on the

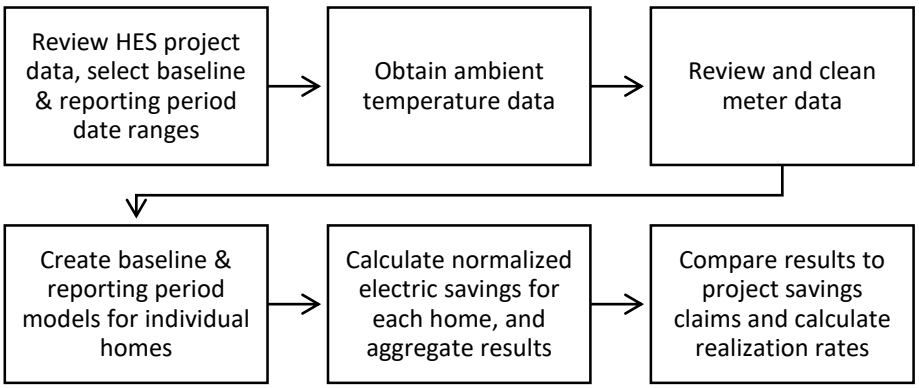

Figure 1: Residential advanced M&V pilot process

assumption that the changes were non-program related. Based on this and other cleaning steps the data set was reduced by a further 7% (relative to the initial dataset). For the remaining meters the baseline and reporting period energy models were adjusted to "normal year" temperature data, and the aggregated difference in consumption showed that electric consumption reduced by 10% between the baseline and reporting periods.

Comparison Groups

The initial estimate of 10% electric savings was an accurate reflection of program participants' consumption, but is not necessarily an accurate reflection of the program's impacts. For example, a portion of those savings might have been achieved even in the absence of the program, due to factors outside of the program's influence ("exogenous" factors).

The use of comparison groups is a common means of capturing impacts of exogenous factors. CalTRACK does not include comparison group methods, but Recurve offered two types of comparison group under the pilot:

- **Site-level matching.** For each treatment meter, five nearby meters with similar baseline data profiles were selected (37,300 meters)
- **Future participants.** 2014 and 2017 meter data was obtained for homes that participated in the HES program *after* 2017 (3,570 meters)

Due to data access restrictions, comparison groups' meter data could only be obtained for Eversource meters under the pilot. Energy savings estimates were established for site-level matched meters and future participant meters using the same method as for the treatment meters. These savings results were used to adjust the initial 10% savings estimates, and savings were then compared to the claimed program savings (estimated using non-meter-based methods). A realization rate was then calculated, being the advanced M&V estimate divided by the program-claimed savings.

Savings Analysis and Reporting

As shown in Table 1, the advanced M&V savings estimates were less when comparison groups were employed (7% and 6%), reflecting a reduction in consumption for the comparison group homes that did not participate in the HES program in 2015-2016. The realization rate (initially 93%) was reduced to 66% or 54% when using site-level matching and future participant comparison groups respectively.

In addition to reporting savings per meter, savings percent, and realization rate, the Recurve dashboard used in the pilot offered charting and visualization capabilities (example shown in Figure 2), for assessing the distribution of savings across the whole population and the average savings by month. This type of advanced analytics can also be used to aggregate savings impact by contractor, in case a utility wants to identify long term trends and make general improvements in training or program design prior to evaluation results which may come years after the program ends.

Advanced M&V and Program Evaluation

One important aspect of the advanced M&V pilot was to compare results to a formal third party program evaluation. The 2015-2016 HES Program evaluation, conducted by West Hill Energy and Computing (WHEC), also used monthly meter data but a different modeling method with no comparison groups. However, their "pooled regression" used multiple years of meter data and included a timing variable, both of which they considered contribute to capturing exogenous effects. Therefore, it was considered most appropriate to

Table 1. Electric savings results for all 2015-2016 Eversource HES participants

M&V Approach	Average normal year savings (kWh)	Average normal year savings (%)	Mean Baseline Consumption (kWh)	Realization rate (%)
Without comparison group	1106 ± 40kWh	10% ± 0.36%	11,125	93%
Site-level matched comparison method (37,300 meters)	783 ± 42 kWh	7% ± 0.39%	10,744	66%
Future participant comparison method (3,570 meters)	628 ± 68 kWh	6% ± 0.62%	10,990	54%

Figure 2. Energy savings charts from Recurve dashboard, for future participant-matched meters (right), matched comparison group dataset (middle), and analysis without comparison group (left)

compare WHEC's results with the advanced M&V estimates made using comparison groups. WHEC reported a 55% realization rate, very similar to the advanced M&V result with future participant matching (54%), and slightly lower than the result with site-level matching (66%). Without more detailed comparison of methods and datasets after filtering, and in the absence of ground truth, it is hard to draw concrete conclusions on the relative merits/accuracy of each calculation method. However, it was encouraging to note that there are not wide disparities in results between advanced M&V and the formal evaluation.

Key Takeaways and Future Plans

As a result of the experiences from this pilot, and the potential it demonstrated for deeper insights on project performance, Eversource and UI continued utilizing Recurve's advanced M&V platform to get quicker feedback on program performance, better understand the key factors driving high/low savings, and support improvement of program savings estimation methods. A second program was added to the platform, along with natural gas consumption data. In concert, the utilities worked to address some of the key barriers to advanced M&V adoption, such as:

- Establishing efficient, consistent meter data management for program participants and non-participants;
- Collaborating with regulators / stakeholders to align advanced M&V with established frameworks;
- Coordinating with program contractors to ensure advanced M&V is seen as a continuous improvement resource rather than a punitive tool.

While it may take to time to reach scaled adoption, the CT pilot made a compelling case for advanced M&V as a program risk management tool, and program managers gained valuable experience and insights.

Partnering for Success in Advanced M&V

The Connecticut advanced M&V pilot was a collaborative effort by Connecticut Department of Energy and Environmental Protection, Berkeley Lab, Eversource, United Illuminating, and the Northeast Energy Efficiency Partnerships (NEEP). Pilot funding was provided by the U.S. Department of Energy. The pilot complements other areas of Berkeley Lab research into advanced M&V. More information on Berkely Lab's advanced M&V research can be found at: https://buildings.lbl.gov/emis/assessment-automated-mv-methods