# Standardized, Sustainable and Transparent EM&V - Integrating New Approaches

## Subtask 1B.4

## Memo on Connecticut Residential Pilot Design and Advanced M&V Effectiveness

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## I. Introduction

This memo is the deliverable for subtask 1B.4—Document Residential Pilot Design and M&V 2.0 Effectiveness, under U.S. Department of Energy Statement of Project Objectives (SOPO) DE-EE0007779/0000. This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Weatherization and Intergovernmental Programs Office, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. In this memo, Connecticut Department of Energy and Environmental Protection (DEEP) and the Connecticut utilities—Eversource and United Illuminating—with support from Lawrence Berkeley National Laboratory (Berkeley Lab), document the residential pilot design and results.

**Subtask Summary:** The project team will document the program/pilot design including findings concerning overall effectiveness, and how the automated approach comports with current evaluation practices in terms of effectiveness of the automated approach in streamlining the time and costs of EM&V.

**Milestone 1B.4.1:** Pilot is completed. Information is provided to the public and posted on partners' websites. Activities under Task 2 will serve as primary strategy for dissemination of pilot findings and results to other states.

**Deliverable 1B.4.1:** Pilot design, results, and factsheets are documented in a Residential Pilot Summary, Findings and Results report, and posted on partner websites for public access. Activities under Task 2 will serve as primary strategy for dissemination of pilot findings and results to other states.

## II. Background

The Connecticut advanced M&V pilot is a collaborative effort by Connecticut DEEP, Berkeley Lab, Eversource, United Illuminating, and the Northeast Energy Efficiency Partnerships (NEEP). Pilot funding is provided by the U.S. Department of Energy. The primary pilot objective is to test the use, efficiency and accuracy of advanced data collection and analytics tools on selected commercial and residential programs, identify additional benefits to automated, continuous M&V, and compare to traditional practices and methods in terms of savings estimates, time and cost and transparency. This memo presents the results of the residential component of the pilot.

## III. Pilot Overview

### a) Pilot Design

Figure 1 illustrates the energy savings calculation process, which is explained in more detail below.

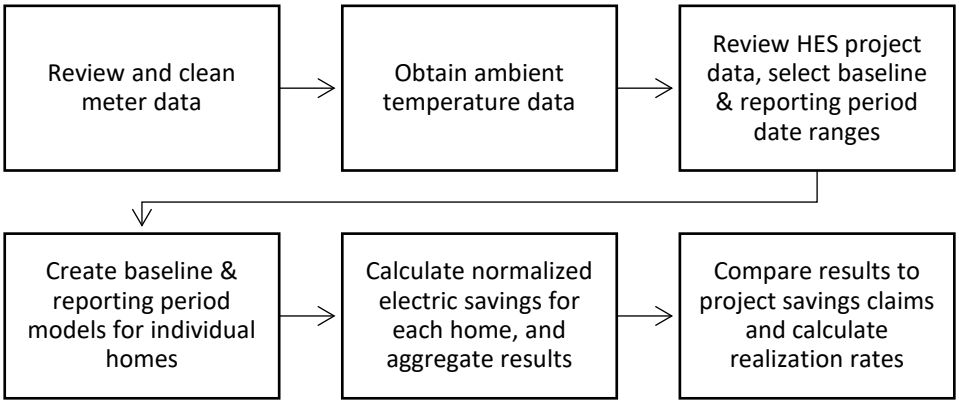


**Figure 1. Residential advanced M&V pilot process**

The CT residential pilot entailed pre-treatment and post-treatment analysis of monthly electric billing data for 2015 and 2016 participants in the single-family component of the EnergizeCT Home Energy Solutions (HES) program.[1] HES is one of Connecticut's largest residential energy efficiency programs, serving tens of thousands of customers per year with audits, direct installations, and rebates for a variety of energy-saving measures. The measures installed through the HES program includes "core services" measures—lighting, blower door-assisted air sealing, and domestic hot water savings measures—which are installed for all participants at the time of the home energy audit, as well as add-on measures such as insulation, HVAC systems, and windows, which are installed in a subsequent visit for those participants who chose to have them installed. In the 2015-2016 program years, the HES program served over 48,000 homes statewide. For the purposes of this pilot, analysis was conducted on 12,268 homes.

Work on the residential pilot began in 2019, with the project team assessing several advanced M&V vendors and platforms to determine which would fit within the project scope and budget and provide the required capabilities. Based on this review, the project team selected the Recurve platform (formerly OpenEEMeter), which employs the M&V modeling approach documented in CalTRACK. For additional detail, see memorandum submitted with respect to Subtask 1B.2, Deliverable 1B.2 of this SOPO.[2]

The pilot was scoped to align with the HES and HES-IE[3] impact evaluation conducted by West Hill Energy and Computing (WHEC) on behalf of the CT Energy Efficiency Board,[4] with the exception that WHEC's evaluation also included gas consumption and savings analysis. Given the pilot objectives and available

[1]The single-family component of HES and HES-IE includes single-family detached homes as well as 2-4 unit attached homes.

[2]Lawrence Berkeley National Laboratory, Building Technology and Urban Systems Division. Project: Standardized, Sustainable and Transparent EM&V - Integrating New Approaches, Subtask 1B.2 Residential Pilot Design and Implementation Plan, April 30, 2019

[3] The HES Income-Eligible Program was not within the scope of the CT advanced M&V pilot

[4]West Hill Energy and Computing. R1603, Impact Evaluation of CT Home Energy Solutions Programs, Final Report, October 22, 2019. Available at https://www.energizect.com/sites/default/files/R1603_HES%20Impact%20Evaluation_Final%20Report_10.22.19.pdf

budget, the Recurve analysis was limited to electric savings. Utility partners provided the same data sets to Recurve as they had provided to WHEC for the impact evaluation.

### b) Methods

Recurve follows CalTRACK methods for weather-normalizing energy consumption data to create counterfactual energy use predictions based on the pattern of usage observed in the 12 months prior to program enrollment.[5] The Recurve platform applies this method to individual homes in the dataset, and then aggregates the results to produces average savings per home in kWh and as a percentage of baseline energy use. Recurve's modeling method applied the "normalized savings" approach, whereby energy models are developed for the baseline and reporting periods, and each is normalized to typical meteorological year (TMY) data. In addition to reporting the normalized savings estimates, Recurve employed two comparison group matching methods (applicable to Eversource data only), to account for exogenous effects:

1. Site Level Matched Method: A comparison group of non-participants in Eversource territory, selected based on similarity of load profiles to the program participants (i.e., with minimum Euclidean distance compared to the subject program participant, see Figure 1)
2. Future Participant Comparison Method: A comparison group comprised of program participants but using data for the year prior to their enrollment in the HES program so that patterns of pre-enrollment energy behavior could be observed (i.e., a 'future participant' comparison group). Customers that participate in the program in the future—in this case 2017-2018 participants, compared to the 2015-2016 "current" participants being analyzed—may be considered similar to current participants given a homogenous population, and should have the same tendency to participate in the program as current participants.

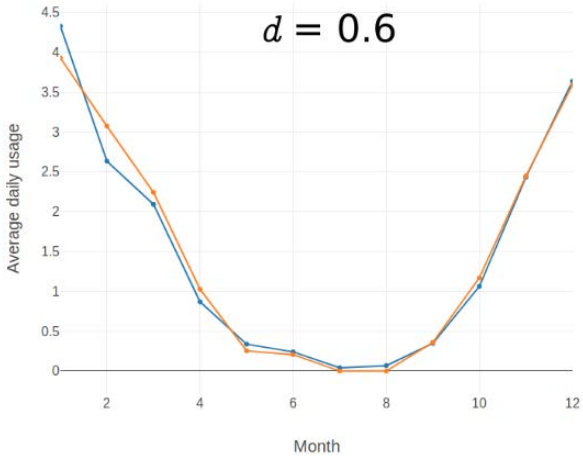


**Figure 2. Recurve dashboard chart of average daily consumption, by month, for treatment group (blue) and comparison group (orange), indicating Euclidean distance of 0.6.**

[5]CalTRACK is a set of methods for estimating energy savings associated with energy efficiency measures. CalTRACK methods yield whole building, site-level savings outputs, which are aggregated to estimate portfolio-level savings and determine associated fractional savings uncertainty. The methods are developed and periodically updated through a consensus process, and are published online at http://docs.caltrack.org/en/latest/methods.html.

For the purposes of calculating energy savings as would be observed in a typical weather year, Recurve extends CalTRACK to create a baseline model of energy consumption for both the prior 12 months as well as the 12 months following program enrollment. This approach allows the energy savings to be normalized to the same set of weather conditions irrespective of when the intervention took place. It also allows savings to be projected over the lifetime of the measure without the bias of the particular weather of the reporting period. In order to identify a comparison group of non-participants, Recurve follows a technique outlined in its joint publication with the Energy Trust of Oregon that matches individual participants with non-participants using 12 months of consumption information and a geographic specifier.[6] Finally, Recurve models comparison group homes and calculates difference-in-difference net savings (Figure 3 indicates monthly energy consumption for program participants and comparison group meters by month), and calculates a realization rate for the program as the ratio of program-reported energy savings versus to advanced M&V savings.

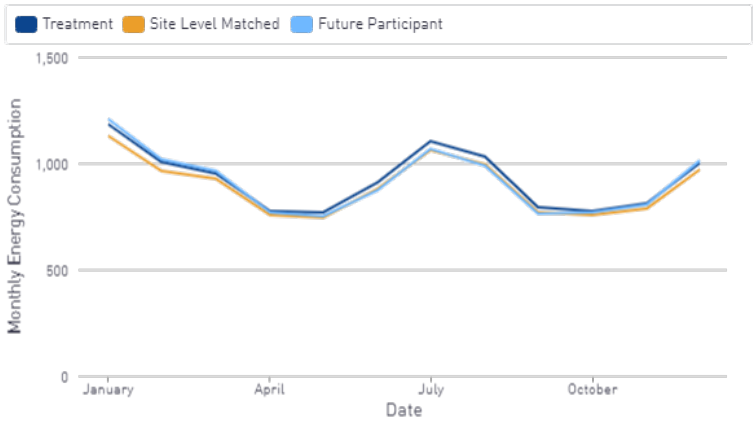


**Figure 3a. Average baseline monthly consumption for Advanced M&V treatment group and two types of comparison group**

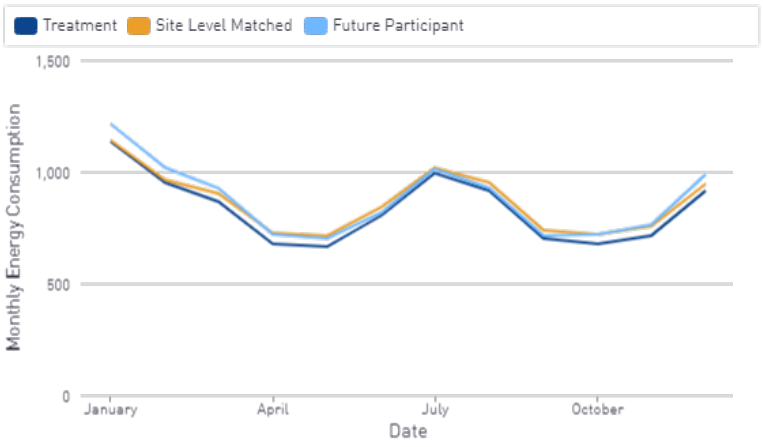


**Figure 3b. Average reporting period monthly consumption for Advanced M&V treatment group and two types of comparison group**

[6]See https://www.energytrust.org/wp-content/uploads/2018/11/OpenEE-Technical-Report-Comparison-group-identification-methods-FINAL-wSR.pdf

WHEC provided electric and gas savings estimates by program (HES and HES-IE), utility, and measure type. WHEC evaluated program reported savings using pooled, cross-sectional, time-series models interrupted at the time of the installation. All participants in 1-4 unit buildings with sufficient billing records were included in the final models and six of the seven National Oceanographic and Atmospheric Administration weather stations in Connecticut were used in the billing analysis. One notable distinction between the methods employed by Recurve and WHEC is that Recurve developed estimates for individual homes and then aggregated the results, whereas WHEC combined the data for all homes and applied their modeling approach to that combined dataset. WHEC's analysis did not incorporate a comparison group, noting that they can increase uncertainty in results, but the modeling description stated that *"In a pooled, cross sectional, time series model with customer-specific intercepts, each home acts as its own control. When multiple program years are included in the analysis, the analysis period covers at least four years and time effects can be incorporated into the analysis. Thus, there is no need to include a comparison group. The model produces gross savings."*

A full description of the methods employed in the WHEC impact evaluation can be found in Section 3 of the full report[7].

### c) Data

Eversource and UI provided data on customer billing and energy efficiency projects to Recurve, which were identical to the datasets that had been provided to WHEC. These included:

- Project data for 2015 and 2016 HES and HES-IE participants, including measure-level details and ex-ante savings
- Project data for 2017 and 2018 HES and HES-IE participants, including measure-level details and ex-ante savings (provided by Eversource only, for use as a *future participant* control group)[8]
- Monthly electric usage data from January 2014 through December 2017, for 2015 and 2016 HES and HES-IE participants
- Monthly electric usage data from January 2014 through August 2018, for 2017 and 2018 HES and HES-IE participants (provided by Eversource only, for use as a *future participant* control group)

After providing these data sets, Recurve cleaned, processed, and reviewed the data for completeness, ran standard data quality tests, and held ongoing discussions with the utilities during this work.

The advanced M&V analysis method defined qualification criteria for meter data to be included in the savings analysis. These criteria were customizable, and resulted in data attrition such that 7,510 meters were included in the final analysis for Eversource (from an initial 11,762 meters), and 4,758 meters for UI (from an initial 9604 meters). Table 1 lists attrition rates for the Eversource data, as an example.

[7] West Hill Energy and Computing. R1603, Impact Evaluation of CT Home Energy Solutions Programs, Final Report, October 22, 2019.

[8]Recurve did not receive data for UI that would allow it to create a similar comparison group of non-participants nor did it receive sufficient historical information to analyze changes in consumption relative to future program participants. However, the underlying performance of the treated group was similar to Eversource.

**Table 1. Advanced M&V data cleaning steps and meter attrition rates, Eversource**

| Filter | Number removed | Meters remaining | Percent remaining |
|---|---|---|---|
| Total meters (electric only) | -- | 11,762 | 100% |
| Meters with valid consumption data in baseline and/or reporting periods. | 1,715 | 10,047 | 85% |
| Other measure-specific filters | 113 | 9,934 | 84% |
| Meters with at least 11 months of valid consumption data | 1,566 | 8,371 | 71% |
| Meters with at least 5 site-level matched meters from the comparison group pool | 45 | 8,326 | 71% |
| Meters within specified percentile bends of normalized change in annual consumption (removed if consumption changed by >75%) | 540 | 7,786 | 66% |
| DNAC Percentile_Threshold[9]: Meters within specified percentile bands of normalized change in annual consumption. | 9 | 7,792 | 66% |
| Consumption Percentile_Threshold: Meters within specified percentile bounds of annual energy consumption (Remove Top and Bottom 0.5%) | 43 | 7,746 | 66% |
| R2_Threshold: Meters with valid model R-squared for the baseline and reporting periods that meet a specified threshold. Models may have invalid R-squared due to data issues. | 3 | 7,746 | 66% |
| CVRMSE_Threshold: Meters with valid model CV(RMSE) for the baseline and reporting period that meet required threshold (<100%) | 246 | 7,510 | 64% |

For the WHEC analysis, a two-stage process of data cleaning was conducted. This included an initial review, conducted to standardize program and billing data and remove meters with insufficient billing history in the analysis and a secondary review, centered around house-by-house regressions of weather variables to identify and remove homes with erratic consumption patterns. As shown in Table 2, after conducting the data cleaning, it resulted in data attrition such that 23,201 meters were included in the final analysis for both Eversource and UI (from an initial 39,932 meters). WHEC meter numbers include HES-IE program participants and also gas meters, so the attrition numbers cannot be directly compared, but the percentage values are observed to be very similar; Recurve ended up with 57% of the original meters (Eversource and UI combined), and WHEC ended up with 58%.

**Table 2. WHEC data cleaning steps and meter attrition rates, Eversource and UI**

| Reasons for Removal | Number Removed | Participants remaining | Percent Remaining |
|---|---|---|---|
| Total participants | - | 39,932 | 100% |
| Unable to match tracking record to a billing account | 4,670 | 35,262 | 88% |
| No Savings or Unidentifiable Measures | 1,533 | 33,729 | 84% |
| Insufficient Bills | 6,079 | 27,650 | 69% |
| Irregular or High/Low Usage | 4,449 | 23,201 | 58% |
| **Final Model Count** | | **23,201** | **58%** |

In addition, Recurve underwent security reviews with each utility prior to data transfer, to address data security and privacy requirements, given the need to analyze customer-specific data and provide granular results back to the utilities. Each utility could access a detailed view of customer-specific savings for their respective customers through a separate instance of the platform. However, due to data sharing

[9] "DNAC" stands for Difference in Normalized Annual Consumption.

restrictions, Recurve generated another instance of its platform to be accessible by non-utility team members such as DEEP staff, which displayed anonymized, summary-level data for both utilities. Once the platforms were developed and populated, Recurve staff provided trainings for the utilities and DEEP so that they understood how to use the interactive dashboards.

### d) Team Roles and Project Management Framework

As described in the memorandum submitted with respect to Subtask 1B.2, Deliverable 1B.2 of this SOPO,[10] the team roles for the Residential Pilot were as follows:

- DEEP managed the subcontract with Recurve, and approved vendor deliverables, and reviewed and approved other SOPO deliverables including memoranda and results reports.
- Eversource and UI provided data and addressed any data-related issues raised by Recurve, and developed the Pilot Summary, Findings, and Results Report
- All team members, including the utilities, Berkeley Lab, and NEEP participated in regular team meetings, reviewed deliverables as directed by DEEP, attended calls with Recurve, and provided other input and support as requested by DEEP.

The roles and process described above allowed for regular direct communication and coordination between all members of the team and Recurve.

Connecticut law prescribes a framework for traditional evaluation, measurement, and verification activities. More specifically, the law, restricts communication among evaluation venders, utility staff, and other stakeholders to ensure accurate results.[11] These restrictions have, in practice, limited feedback and discussion with evaluators regarding program implementation details, how to appropriately interpret data, or other contextual information that is more readily provided with open communication or regular meetings with evaluators.

## IV. Results

### a) Advanced M&V Savings results

The online, interactive Recurve platform provided detailed meter-level (i.e., project-level) analysis results, as well as program-level results of normal-year and comparison group net savings for various sets of participants.

The results below show electric savings for Eversource 2015-2016 HES participants (1) with all heating types, (2) with electric heating only, and (3) with non-electric heating only. In all cases, participants are filtered for single-family homes without net metered photovoltaics.

[10]Lawrence Berkeley National Laboratory, Building Technology and Urban Systems Division. Project: Standardized, Sustainable and Transparent EM&V - Integrating New Approaches, Subtask 1B.2 Residential Pilot Design and Implementation Plan, April 30, 2019

[11]The CT evaluation protocols were developed in accordance with Public Act 13-298, Public Act 11-80 S 33, the Final Decision in Docket 10-10-03, and Connecticut General Statutes section 16-245m(d)(4). See EEB Program Evaluation Roadmap, December 2014, available at https://www.energizect.com/sites/default/files/CTEvalRoadmap_Final_2014_Updated_Dec2014.pdf

**Table 3. 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 +/- 40 | 10 +/- 0.36 | 11,125 | 93% |
| Site-level matched comparison method (37,300 meters) | 783 +/- 42 | 7 +/-0.39 | 10,744 | 66% |
| Future participant comparison method (3,570 meters) | 628+/- 68 | 6+/- 0.62 | 10,990 | 54% |

**Table 4. Electric savings results for all 2015-2016 UI HES participants[12]**

| M&V Approach | Average normal year savings (kWh) | Average normal year savings (%) | Mean Baseline Consumption (kWh) | Realization rate (%) |
|---|---|---|---|---|
| Without comparison group | 371 +/- 41 kWh | 4+/-0.49 | 8,343 | 49% |

As can be seen in Tables 3 and 4, the realization rates for Eversource and UI HES programs (without comparison groups) vary significantly. When looking at Eversource savings where comparison groups were employed, realization rates dropped to 66% (site-level matched comparison) and 54% (matched future participants). These values reflect the general reduction in energy consumption among non-participants. Tables 3 and 4 also document the high precision in advanced M&V energy savings estimates; for example, the savings estimated for Eversource without comparison groups is 10% ± 0.36%.

In addition to the headline savings numbers shown in Tables 3 and 4, the Recurve dashboard offered additional charting capabilities to review the savings characteristics across the dataset, with an example shown in Figure 4. The histograms in Figure 4 illustrate the frequency of the difference in normalized annual consumption (DNAC[13]) values across the dataset, indicating that the results included some sites that increased consumption (in red). The area charts in Figure 4 show the variation in savings by month, indicating that savings were generally higher between April and November. These types of chart may be useful to program managers looking to gain a deeper understanding of energy savings across their program portfolio.

[12] Non-participant meters were not available for UI, so comparison group creation was not possible

[13] DNAC is interpreted as the site-level energy savings


**Figure 4. Energy savings charts from Recurve dashboard, for future participant-matched meters (right), matched comparison group dataset (middle), and analysis without comparison group (left)**

### b) HES Program Evaluation Results

As noted earlier, the official program evaluation covered both HES and HES-IE programs, and both gas and electric savings. Electric savings for the HES program are shown in Table 5, including total reported ("ex-ante") savings, total evaluated ("ex-post") savings, and realization rate.

**Table 5. HES program evaluation results (electric only)**

| | Program Reported MWh | Evaluated MWh | Realization Rate | Relative Precision |
|---|---|---|---|---|
| Eversource | 27,678 | 15,132 | 55% | 3% |
| UI | 3,910 | 2,074 | 53% | 5% |
| Overall | 30,739 | 17,206 | 56% | 4% |

### c) Comparison of advanced M&V results and evaluation

WHEC's documented modeling method does not use a comparison group. However, their pooled regression uses multiple years of meter data and includes a timing variable, both of which they consider contribute to capturing exogenous effects. Appendix B of WHEC's evaluation report documents an investigation into using a comparison group, with the conclusion that exogenous effects are sufficiently captured without a comparison group.[14] For the advanced M&V pilot, comparison groups are used to

[14] West Hill Energy and Computing. R1603, Impact Evaluation of CT Home Energy Solutions Programs, Final Report, October 22, 2019.

capture exogenous effects instead of a timing variable; therefore, it is considered most appropriate to compare WHEC's results with the advanced M&V results with comparison groups (thereby excluding UI from the comparison).

WHEC reported a 55% realization rate, which is 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 a 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, but it is encouraging to note that there are not wide disparities in results.

### d) Effort level

The original scope of the pilot included an objective to compare the effort level, in terms of time and cost to complete traditional evaluation (WHEC) and advanced M&V. Despite some common processes (e.g., requesting data, cleaning and processing and analyzing data, and drafting reports and other deliverables), an accurate comparison of time and cost was not feasible, due to several key differences in the approaches:

- **Scope differences.** Several differences in scope limited the ability to appropriately compare the time and costs involved in the pilot with those of the WHEC evaluation.
  - The pilot analysis examined electric savings, while the WHEC analysis included electric and gas savings.
  - The pilot scope included HES only, whereas the WHEC scope included HES and HES-IE.
  - The pilot analysis produced whole home savings estimates and realization rates, whereas the WHEC analysis produced measure level savings estimates and realization rates.
  - The WHEC scope included a written report, involving drafting and several iterations of reviews and revisions, with interim memos. The pilot deliverable provided by Recurve was an interactive dashboard utilizing their pre-existing platform.
  - WHEC expended time and cost exploring and analyzing HES multifamily data, before determining it would not be feasible to include in the billing analysis.
- **Procurement process differences**. WHEC's evaluation was procured consistent with the EEB Evaluation Roadmap. The roadmap required an open solicitation, an evaluation of bids, and included a significantly larger budget than the pilot. Given the small budget available for the pilot, the pilot team selected Recurve from among several advanced M&V vendors, based on their qualifications and prior work, and ability to perform the work within the project budget. Recurve provided their work at a lower cost than would normally be incurred for such support, due to opportunities presented by the pilot to test new approaches and demonstrate their potential value to CT stakeholders as a provider of such support at a larger scale in the future.
- **Oversight and management framework differences**. As described in section II, the residential advanced M&V pilot was a collaborative effort of the project team comprised of DEEP, Berkeley Lab, Eversource, United Illuminating, and NEEP staff, with technical analysis conducted by Recurve. The project timeline was driven by the DOE Statement of Project Objectives, and the budget was set based on the DOE grant amount. This framework entailed a more limited budget and timeframe than were in place for the WHEC evaluation—which

was scoped, funded, and managed under the CT EEBs' Evaluation Roadmap process.[15] The Roadmap provides a comprehensive, prescriptive process for developing and scoping studies, soliciting and selecting bidders, conducting and managing studies, and producing, revising, and finalizing deliverables. It also includes input and review from a broad set of stakeholders and an added layer of project oversight provided by the CT Evaluation Administrator team. These requirements have some impact on the cost and time required to complete an evaluation under EEB oversight.

More generally, aside from the time and costs required, the advanced M&V pilot approach and the traditional evaluation approach present two fundamentally different value propositions and use cases, as described below. Therefore, the time and costs required by these two approaches cannot be fairly compared without considering the different types of value they provide to programs—including value from optimizing and continually improving program implementation, and from demonstrating credibility and accountability through measurement of savings.

## V. Discussion

The CT residential pilot provided a rich set of experiences and insights on the process and outputs of advanced M&V, and a valuable opportunity to make a comparison with traditional evaluation methods. Key insights from the pilot are summarized below, including a comparison of transparency levels for advanced M&V and traditional evaluation, and a general overview of opportunities and challenges.

### a) Transparency

In comparing traditional evaluation as conducted under the CT Evaluation Roadmap process, with the advanced M&V conducted as part of the residential pilot, there were key differences in the level of transparency of the results and the ability to investigate underlying data to gain deeper insights on savings drivers. These differences were related both to the different oversight frameworks as discussed above, as well as the type of deliverables provided by the two approaches.

- **Deliverables:** Advanced M&V pilot results were delivered via an interactive dashboard that could be manipulated through various filtering and visualization tools, and project team members, including utility staff, could drill down as needed to better understand savings drivers. For example, filtering results by vendors revealed key differences in vendor performance—and further filtering those results revealed other underlying differences in the prevalence of heating fuel types and geographic differences in homes served by different vendors, which likely contributed to differences in savings across vendors.
  - Traditional evaluation results were delivered in the form of a report and interim memoranda, with static numbers and descriptive text, and methods and other details provided in an appendix.
- **Oversight and management framework**: The Advanced M&V pilot framework and team structure allowed for regularly occurring, direct discussions between the program experts at the utilities and the analytical team at Recurve. These discussions addressed data nuances, such as the definitions for various program enrollment and measure installation dates for use

[15] CT Energy Efficiency Board. EEB Program Evaluation Roadmap, December 2014 https://www.energizect.com/your-town/ct-eeb-evaluation-roadmap-revised-dec-2014

in determining the pre- and post-periods for billing analysis. Also, in the course of this work, the team discovered an analytical challenge which required the utilities to provide additional data. Specifically, the utilities provided unique site identifiers for participants, to allow Recurve to exclude usage data for customers who had relocated during the period of analysis—since customers who relocate within a utility company's territory maintain the same billing account number in both locations, but have different site identifiers at each location.[16]

- During the course of the traditional program evaluation, data discussions were occasionally held under the oversight of the CT Evaluation Administrator team, to address questions WHEC encountered or request additional data WHEC needed to complete the work. However, otherwise utility staff were uninvolved with and unaware of the details of the WHEC work, and were restricted from most communication with evaluators due to CT Evaluation Roadmap. As a result, for example, program and data nuances such as the issue of site identifiers noted above were not uncovered during the WHEC work. Any need for refinement of results or questions regarding savings drivers were addressed through formal, publicly-issued written memoranda from WHEC, each of which required a layer of Evaluation Administrator review. The administrative burden associated with this process limited the ability to investigate underlying savings drivers.

**b) Opportunities**

Connecticut Utilities:

The pilot and subsequent use of the advanced M&V platform has demonstrated value for both implementation and evaluation purposes. The advanced M&V capabilities present opportunities for the Companies and implementation vendors to optimize program performance and increase realized savings, and present opportunities for gaining deeper, more up-to-date feedback on performance than has typically been provided through traditional evaluation approaches.

From an implementation perspective, the Companies will be utilizing the platform to gain insight into vendor performance, which could allow for vendor management approaches such as tying some portion of vendor compensation to savings results, or providing public recognition to high-performing vendors. In addition, data on inspections could allow the Companies to determine if savings differ systematically between inspected and uninspected jobs. It is possible, for example, that because inspections occur at the time of project installation, inspected projects generally achieve greater savings because implementation vendors are aware they are being inspected. The platform also provides a non-participant targeting dashboard, which allows the Companies to operationalize the insights into savings drivers by identifying non-participants with characteristics—e.g., heating and cooling loads, total annual consumption, etc.—similar to those of the highest performing participants from prior years. This dashboard also includes non-participant customer information that can feed directly into the Companies' marketing software, to

[16]For the WHEC review, due to the Connecticut evaluation protocols described below, WHEC and the utilities were restricted from having regular meetings or discussions during the analysis process, so this issue was not uncovered or addressed with supplemental site identifiers.

enable targeted marketing and outreach efforts to non-participants with the greatest potential for savings.

From an evaluation perspective, the Companies are utilizing the platform to produce updated HES and HES-IE impact results for 2017-19. These results will provide more timely feedback and a more accurate reflection of current program technologies (e.g., LEDs rather than CFLs) and program processes (e.g., vendor training and inspection regimes) than the existing WHEC evaluation results based on the 2015-16 program years[17]. In addition, the advanced M&V results are planned to be reviewed by a third-party evaluator working under EEB oversight. The solicitation for the EEB evaluation included potential scope for reviewing and vetting the inputs and outputs of the Recurve-processed data, which could serve as a process check to ensure adherence to data quality standards and Caltrack methods. It is expected that utilizing the Recurve-processed data in this manner will allow the EEB evaluators to reduce the cost of conducting their own billing analysis from scratch, while providing assurances of the accuracy and rigor of Recurve's analysis to stakeholders involved in the EEB evaluation oversight process.

**The Connecticut Department of Energy and Environmental Protection:**

Connecticut's energy policy goals were a good fit for the advanced M&V approach; a method that had the potential to reduce evaluation costs, improve energy efficiency programs, while testing new software tools. Historically, the Legislature had taken away EE program budgets to help with the state deficit, while Connecticut law had expanded energy efficiency programs to focus on greater energy savings.

DEEP also recognized the opportunity to host a study that focused on piloting innovative technologies-while fostering partnerships with state energy offices, scientific research labs, businesses, and not-for-profit organizations. Connecticut was able to collaborate with a diverse group of stakeholders, while leveraging resources such as funding, experience, and information. Connecticut recognized the opportunity to "test the waters" by way of a pilot prior to investing lots of money and time into an adventure that may not work. Hence, the pilot provided a chance to implement a small-scale study and make adjustments along the way. The pilot served as a risk mitigation tool.

c) **Challenges**

The pilot team's experience with the residential advanced M&V platform, and the Companies subsequent experience with the expanded platform have identified certain challenges for users of advanced M&V solutions to consider in their own application of these tools.

**Data challenges.** Advanced M&V faces many of the same challenges in collecting, cleaning, and analyzing program and usage data that other evaluation methods entail—but to a greater extent, given the volume,

[17] As noted in the 2020 plan update, the Companies applied the results of the WHEC evaluation of the 2015-16 programs, with several adjustments agreed upon with the EEB Evaluation Administrator team and approved by the Evaluation Committee. The adjustments were made to ensure appropriate planned and claimed savings for the 2020 programs, by accounting for the significant changes made to the programs since the 2015-16 period of the evaluation. The plan update notes that the Companies will consider the advanced M&V savings estimates alongside the results of the WHEC evaluation in future revisions of HES and HES-Income Eligible savings assumptions and realization rates. See 2020 Plan Update to the 2019-2021 Conservation & Load Management Connecticut's Energy Efficiency & Demand Management Plan. Submitted by Eversource Energy, United Illuminating, Connecticut Natural Gas Corporation, and Southern Connecticut Gas. March 1, 2020.

granularity, and frequency of updates to the data that are needed to get the most value from these tools. Establishing a "data pipeline" with consistent queries, process steps, and dedicated data analyst staff, and process steps helps to streamline regular data updates and ensure that data quality standards are met. In addition, because of the granularity of customer-specific data that may be processed with these tools, customer privacy and data security is a critical concern, and may limit non-utility staff from accessing the full capabilities of these tools.

**Gaining regulatory and stakeholder support.** Given the existing statutorily-mandated evaluation framework in CT, using a utility-driven tool that is not directly subject to the oversight of the EEB Evaluation Committee poses challenges when looking to utilize the results to measure program savings and determine realization rates for application in the CT Program Savings Document (PSD). The EEB Evaluation Committee has scoped a task into the upcoming independent HES/HES-IE evaluation to review and verify the advanced M&V savings results, which may allow for the results to be applied to the PSD in accordance with CT's evaluation framework.

**Implementation vendor perceptions.** There is much benefit from gaining actionable insight on the relative performance of implementation vendors, but vendors themselves may not all react favorably to feedback on their performance—particularly if it is tied to compensation. Given the pressures and constraints the vendor workforce already faces, it is important that such feedback offers clear benefits to high-performing vendors and is not viewed as a punitive tool by other vendors—but as an opportunity to improve their performance.

## VI. Conclusions and Next Steps

The Advanced M&V pilot was a major success, as demonstrated by the decision of the CT utilities to continue deploying the platform and expand upon the functionality that was deployed in the pilot. Reflections and next steps from the perspective of the CT utilities and DEEP are summarized below.

**Connecticut Utilities:**

As a result of the learnings from this pilot, and the potential it demonstrated for deeper insights and faster feedback on project performance, Eversource and UI have continued utilizing advanced M&V to investigate more recent program performance, understand differences across vendors and other aspects of projects, and inform savings updates for future updates to the CT Program Savings Document.18 The Companies contracted with Recurve to build on the platform developed for the pilot, by adding full HES and HES-IE project data and electric and gas consumption data through 2019. The platform was also expanded to include gas and electric consumption data for the full set of CT residential customers through 2019, to enable comparative analysis of non-participant usage.

To date, Eversource and UI have used the expanded platform to analyze impacts of the 2017 and 2018 CT HES and HES-IE programs, and assess meter-based performance of each project to identify key drivers of program-wide savings. For example, this analysis identified that participating homes in the top half of pre-project electric consumption were responsible for nearly all of the meter-based electric savings for the programs in 2017 and 2018. In addition, electrically heated homes had significantly higher realization rates

[18] Connecticut's 2020 Program Savings Document, 16th Edition, filed on March 1, 2020. Available at https://www.energizect.com/sites/default/files/2020%20PSD_Final_3.1.20%20Filing.pdf

and evaluated savings than non-electrically heated homes. As of the date of this memo, collection and analysis of 2019 program and consumption data is ongoing, to provide for continued, updated insights into program performance, as described below.

**The Connecticut Department of Energy and Environmental Protection (DEEP):**

DEEP is responsible for energy planning and oversight with a focus on a cheaper, cleaner, and more reliable energy supply. In addition, DEEP must ensure that utility-administered energy efficiency programs are a good value for residents. The Advanced M&V pilot showed that these approaches have the potential to provide valuable benefits, such as greater energy reductions and cost savings in commercial and residential buildings. Subsequently, CT DEEP will continue to observe UI and Eversource's application of these Advanced M&V methods in CT utility-administered energy efficiency programs. In the future, DEEP could evaluate the value these approaches bring to traditional measurement and verification practices.