Post Install Validation for Commercial and Industrial Customers

Lisa Zagura, Eversource

ABSTRACT

Energy efficiency projects, if inspected at closure, are often only reviewed for installation verification. If these projects are not reviewed relative to their operational parameters at and later in time from installation, there is limited understanding of the true installed and persisting energy savings and decarbonization impact.

Post install validation involves comparing the projected energy savings based on design conditions to trend data demonstrating the installed performance at project close and 4-6 months after implementation. The trended data provides a snapshot of how the parameters impacting the energy savings and decarbonization are performing under varying operational conditions. The comparison of the current versus intended design operation informs the customer, project team, and other stakeholders about the next steps to energy savings recovery for improved energy savings persistence.

Eversource's efforts to improve project decarbonization outcomes for commercial and industrial customers and to proactively address the causes for energy savings differentials between projected and realized outcomes will be discussed. Given the insight this process has provided to commercial and industrial customers and vendors, efforts have been made to scale this validation effort in other states and programs to better serve energy efficiency and decarbonization outcomes.

Introduction

The Context

Eversource is an electric and natural gas utility and energy efficiency service provider in Massachusetts, Connecticut, and New Hampshire. Eversource empowers residents, businesses, and communities to make energy efficient upgrades by offering a wide range of services, rebates, incentives, trainings, and information.

The Massachusetts energy efficiency program was established by the 2008 Massachusetts Green Communities Act. This act requires the Massachusetts Program Administrators to provide customers with the estimated project energy cost savings that includes the reductions in energy and capacity costs (GCA 2008). Additionally, to fund the program, the distribution companies were provided with performance incentives based on success in meeting or exceeding the Mass Save® three-year plan's energy savings goals. At the program level, energy measures are required to be cost effective when comparing project costs to energy savings and non-energy savings benefits. In 2012 and in the program years that have followed, to ensure the accuracy of reported savings, the results of completed gross savings evaluations studies are applied retrospectively to the applicable program year as a realization rate (ECC 2012). The energy efficiency programs established in Connecticut and New Hampshire are similarly regulated as are others throughout the country.

Prior to the establishment of an energy efficiency program in Massachusetts, "consistent and practical definitions for use in developing estimates of the overall persistence of savings over time were developed for the Joint Massachusetts Utilities (Energy and Resource Solutions 2005)". Per the study, "persistence is divided into two components: (1) measure life and (2) savings persistence, where "measure life" as the median number of years that a measure is installed and operational, implicitly [including] equipment life and measure persistence. Savings persistence is the percentage of change in expected savings due to changed operating hours, changed process operation, and/or degradation in equipment efficiency relative to the baseline efficiency option (Violette 2013, 13-2)." The focus of the post install validation work in Massachusetts and Connecticut has been savings persistence.

The Value Proposition

As a regulated utility, Eversource is legislated to claim energy savings and report decarbonization efforts based on measures implemented by customers. A small, randomized sample of these measures later undergoes significant measurement and verification by a third party to determine the realized energy savings outcomes and create program realization rates. Given measures have "an almost inevitable 'drift' from where things should be" (Mills 2009, 2), if assumed they were implemented and operating as designed, departure from the desired singular project outcomes can have broader program implications. Applied to the gross savings claimed by the energy efficiency programs at large, realization rates impact the amount of effort needed for Eversource to achieve net savings goals. The lower the realization rate, the larger the amount of gross energy savings needed to meet net energy savings targets. The improvement in project savings persistence improves the realization rate which proportionally improves the level of effort needed by Eversource to achieve the program net energy efficiency and decarbonization goals.

Lifetime savings is the evaluated length of time an energy efficiency measure saves energy; the amount of annual energy savings multiplied by the measure life. Savings persistence is the variation in energy savings throughout the life of that efficiency measure. Energy efficiency programs, like those Eversource administers, have focused heavily on lifetimes of savings measures and the achievement of energy savings and decarbonization efforts relative to these lifetimes. There has been notably less focus on supporting savings persistence extending from the point of implementation to the end of a measure lifetime, however; "the persistence of energy savings… is an important input to the benefit/cost analysis of energy efficiency programs and portfolios (Violette 2013, 13-2)." Increasing program focus on savings persistence over time, the estimated lifetimes associated with measures would have justification to increase, helping improve lifetime energy savings outcomes.

Many parameters must be implemented appropriately to maintain the projected energy savings in increasingly complex commercial and industrial buildings. "Meanwhile, new technologies for saving energy have an intrinsic degree of risk simply due to the lack of field experience and because some are more complex than the traditional technologies they replace (Mills 2009, 11-12)." Measurement and verification (M&V) following implementation is therefore an essential risk-management element of any program intending to achieve energy savings targets and have confidence in the results of this achievement. "The primary purpose of

M&V is to validate that time, effort and money invested to reduce energy usage in buildings provides the expected results (Kummer 2011, 2).” While first year savings is important, f there is no verification beyond the time immediately following implementation, there is no guarantee the energy savings achieved will persist.

Provided the “industrial sector accounts for one-fourth of all US greenhouse gas emissions (Fitzgerald 2023),” commercial and industrial customers are also increasingly being required to demonstrate persistence in energy reduction efforts for compliance with municipal and organizational mandates. The metrics required for reporting include demonstrating continued reductions over time relative to efficiency or decarbonization efforts undertaken. Without the incremental validation that savings from implemented measures persist, customers will not have the evidence of compliance with the mandated sustainability goals. Partnering with their local energy efficiency program administrators to conduct analysis on trend data associated with energy efficiency measures undertaken would provide improved confidence in the measures incentivized by energy efficiency program administrators and support continued advancements in energy reduction and decarbonization offerings. The measurement and verification undertaken for post install validation was done at no cost to customer by Eversource and/or third-party vendors unaffiliated with the projects. This no cost approach was used to encourage participation, help customers realize the value of their investment, and minimize differences between program claimed and realized savings.

Overall, energy efficiency program administrators are stewards of the incentives provided from ratepayer funds, and as such, they have a responsibility to accurately project the energy savings the implemented measures deliver. “The persistence of energy efficiency measures refers to an estimation of how long the consequences of an implemented measure can be noticed on energy use (Nord 2014, 477)” but this impact is countered by certainty of the savings estimated when compared to the actual reduction the data available is able to demonstrate. “Shorter-term M&V does not address a critical challenge for the persistence of energy savings. It is commonly understood that buildings quickly move away from good or optimal performance if not monitored closely and maintained (Kummer 2011, 9).” Ensuring persistence in the energy savings is a longer-term investment that provides reassurance to the program administrator as well as customers about the accuracy and effectiveness of energy efficiency program delivery.

The Process

A key component to savings persistence is prioritizing operational over installation verification. Equipment with specific performance ratings (horsepower, SEER, COP, etc.) are expected, when installed properly, to perform per the nameplate data. Ensuring the unit is on a flat surface, has all the valves connected, and matches the specifications and mechanical schedule will provide insight that equipment has the potential to deliver the energy savings projected. Often, however, an effective understanding of the implemented savings goes beyond the installed components. Additional dependencies like run hours, ambient temperature, and building occupancy play a key role in determining the difference between the projected and realized energy savings. In complex and comprehensive energy efficiency and decarbonization projects, interdependencies between systems can have further deleterious effects to projected energy outcomes. These parameters and interdependencies evolve as the weather changes, staff

turns over, and needs for the building space change. Therefore, understanding equipment operation both at project close and later in the projected measure life leads to an improved understanding of the energy savings being realized. “M&V approaches based on ongoing measurements rather than one-time measurements are much more likely to ensure that energy savings persist (Kummer 2011, 8).”

The post install validation process begins with understanding which projects have the greatest amount of evaluation risk. Higher risk projects can include those where a repeatable evaluated method to determine energy savings is not readily applied, instead, there are a variety of parameters or approaches that have been used to determine energy savings with varying ranges of savings estimates. Further uncertainty in project energy savings may be caused by a lack of information in the design phase, physical differences in the building prior to, during or after the retrofit, occupant behavior, variations in the installed product and installation quality, as well as errors about the accuracy in pre- and post-measurement. Other factors that would make a project higher risk would be low-cost effectiveness on high savings or highly incentivized measures or technical elements that require programming or equipment interoperability. All these factors may put an energy efficiency project into a higher risk category and make it more likely to be selected for the post install validation process.

From the projects noted to be of higher risk in the database, a randomized selection is made four to six months after implementation, but prior to being claimed with the state and well before third party evaluation. The projects selected for the post install process are prioritized by evaluation risk but randomized from the pool to have a variety of sizes, project team compositions, implementation and third-party technical assistance vendors, and energy efficiency measures. The desired outcome of the random higher risk project selection is a broad directional understanding of the commercial and industrial portfolio at large.

ln Massachusetts, all projects considered for post install validation are custom, meaning the measures implemented have site specific savings calculations comparing baseline conditions to projected design conditions. The initially projected project energy savings have been determined via Excel-based or modeled calculations developed by third party vendors outside of the program administrators. All custom projects involve an initial review by the Eversource technical team of the third-party savings. These reviews are conducted for accuracy relative to the projected design and savings alignment with exiting baseline conditions. Upon completion of these reviews, should the project be cost effective, the customer and vendor is issued an incentive offer. A final review of project conditions is also habitually done following implementation prior to finalizing the energy savings in the project database. Four to six months after the project savings finalized in the project database, the projects are considered eligible for post installation analysis.

In Connecticut, project savings eligible for post install analysis are predominantly prescriptive meaning the savings are determined by parameters and calculations defined in the Connecticut Program Savings Document (PSD). These savings calculations are averages of what the commercial and industrial market would realize for energy savings but still dependent on third-party vendor selection or documentation of parameters that influence savings outcomes like the number of shifts the building is occupied, building shading, and the compressed air system daily load profile. Also, though Connecticut projects are prescriptive, they too are reviewed internally by the Eversource technical team prior to implementation and claiming with the state

to ensure alignment with site conditions and the project design. Similar to those in Massachusetts, Connecticut project selection for post install validation occurs four to six months after they are claimed in the project database but prior to being claimed with the state.

For each project selected for post install validation, a review of the parameters used to determine the projected savings is conducted to understand the key drivers energy reduction. From here, a list of the associated building system control points is compiled. Depending on the measure and project building's monitoring infrastructure, either building management data is solicited from the customer or a third-party vendor is acquired to install sensors or submeters with data loggers. Typically, three weeks of the trend data at a15-minute interval is requested, however some seasonal projects like hot water reheat or heating system steam trap replacement may require additional consideration for when the trend data is collected. These projects may need data logging via current sensors not available on the Building Management System (BMS), a broader set of monitoring criteria that captures a greater percentage of the Typical Meteorological Year (TMY) temperature bins, a smaller collection time interval, etc. Following trend data acquisition from the customer or controls vendor, the parameters influencing the project's projected energy savings are compared to the collected trends. When the data collection is associated with a customer's BMS, the analysis are most often done by Eversource, but when data loggers are required, often a third party vendor unaffiliated with the initial project will collect the data and on occasion conduct the post install analysis as well at no cost to the customer.

For the analysis, a heavy focus is paid to comparing the projected design parameters to the operation on site over other approaches to verification. There has been less emphasis on remodeling project savings because of the cost and underlying assumptions involved comparable to actual site data. Additionally, despite the emphasis on conducting post install validation on projects that may have a significant impact on a program administrator portfolio, it is often that the projected savings for most of the Connecticut prescriptive projects and many of the Massachusetts custom projects may result in energy savings less than 15 percent of the customer site natural gas or electric use. When a project's energy savings represents less than about 15 percent of overall customer consumption, even when correlating to degree days or outside air temperatures, it is difficult to specifically attribute any identified changes in energy use to the project implementation alone. Instead, changes in patterns of energy use may be attributable to changes in operation, occupancy, operating conditions, equipment loads, or other factors. Further, commercial and industrial customers very rarely have submetering at the equipment or system level to provide sufficient evidence that energy use reductions are directly attributable to a specific implemented project. As a result, though some project projected energy calculations may include billing analysis for determining the reasonableness of the customer savings, post install validation has only leveraged customer billing data analysis in less common projects where the percent of the customer's energy savings exceeds 15 percent. Again, the bulk of post install validation analysis is the direct comparison of the energy savings parameters used in the project design and savings calculations to site specific trended data.

This trend data is then compared to the parameters used to determine the project energy savings found in the database at project close. The post install trending of space temperatures, AHU discharge pressure and setpoints, bare metal pipe temperatures, supply and return water temperatures, and other parameters are compared to the parameters identified at the project close

and in the design as the basis for achieving the energy savings. As an example, when the setpoint of the air handlers are intended to run at a 0.5 to 2 in. W.C. and include discharge static pressure reset at project close but are found to be operating at a constant 2.5 in W.C. four to 6 months after, the projected amount of project energy savings would not align with what is persisting in the field. As a result, including this discrepancy in the post install validation report and sharing this information with the customer, project vendor and team could uncover why these circumstances exist and how the energy savings for this could be recovered or adjusted to a more realistic value.

In a prescriptive project example, a customer's air compressors were stated to run for two shifts, while data loggers showed the air compressors operated over two and a half shifts. Though this option of additional run time was unavailable in the prescriptive savings calculator used to determine the project savings, running the more efficient air compressor for a longer period of time would have the customer saving more energy than initially projected at project close as compared to the baseline equipment of a similar capacity. This this type of information at a program scale can help to determine whether the program is on average over or under claiming savings related to this measure relative to the values entered in the PSD.

When each design parameter impacting the projected savings has been compared to the data trended, a report explaining the comparative analysis is written and shared with the project team. The reports are intentionally customer and vendor neutral, as the data itself drives the energy savings differential between what was projected and what is being realized. The persistence or variability of the energy savings over the measure life is the result of the changes to these parameters, whether created by sub-optimal installation, unanticipated change in building occupancy, or the electrician switching the VFD to hand and forgetting to return it to automatic. Any of these factors may have impacted the projected lifetime savings of the measure, but the outcome- a reduction, increase or persistence of the projected energy savings- is the same regardless of root cause.

Following a review of the energy savings report with the project team and customer, consideration is given to next steps. Should the project be within the warranty period, the vendor may be able to return and take corrective action. If there is a known mechanical defect, the program administrators could seek additional savings to engage in the repair or replacement of the defective component. Should there be an inability or unwillingness to recover the energy savings for the project, the last option to align projected energy savings with those being realized would be an adjustment in the project database savings, again prior to being claimed by the state.

Further pursuit of post install validation beyond four to six months after project completion has not been considered because the window in which the savings could change with the state would be closed. Further, "the persistence of the energy efficiency measures [is heavily] influenced by the achieved savings in the first year (Nord 2014, 477)." If the project has not been adjusted to conform to the design intent within the first year, it is highly likely the projected savings would not be achieved in the time beyond. Given an Eversource focus on savings claimed with the state and associated evaluation risk, the heavy focus of the post install validation effort has been on recently completed measures. Further, because Eversource has been covering the costs associated with the data collection and analysis for post install validation, it makes sense to focus the efforts on the outcomes Eversource is trying to drive with evaluation and at a broader program level.

The Data

After conducting a post install validation review of almost 87 projects in Massachusetts between the middle of 2021 the end of 2023, approximately 70 percent of the project energy savings projected were being realized. This 70 percent differential is an average, not a statistically valid sample, as only 16 of the 87 projects in this sample were the actual savings validated relative to the savings claimed. For projects not analyzed following the initial post install validation project documentation review, the comparison of most recent site data to the claimed savings was unable to be finalized for myriad reasons: customer situations, control vendor responsiveness, internal Eversource team requests, and more. In the 20% of projects analyzed, analysis involved the collected BMS or logged customer data.

In Connecticut, project savings are more prescriptive but still dependent on the technical staff selection or documentation of parameters that influence savings outcomes like the number of shifts the building is occupied, building shading, and compressed air system daily load profile. Of over Connecticut 80 projects reviewed and seven projects analyzed, an average of greater than 100 percent of the project savings are realized. Again, though not a statistically valid sample of the overall Connecticut project portfolio, directionally, it appears the savings parameters entered in the prescriptive tools are underestimating the on-site operation and would cause lesser energy savings to be claimed by the Connecticut program towards their overall statewide programmatic savings goals. Like the projects pursued for post installation validation in Massachusetts, customer situations, timing, vendor availability, and more played a large role in the ability to collect and analyze post installation operational data of implemented projects closed in the project database.

Though averages of persisting energy savings are mentioned above for Massachusetts and Connecticut, the savings differentials between what was projected at project close to what savings persisted at project sites four to six months after installation ranged from zero percent to over 100 percent in the analyzed samples as shown in Tables 1 and 2 that follow. The factors leading to the energy savings differentials also covered a broad range. Of the analyzed projects, the main reasons for savings reductions were control sequences not implemented per the intended design, as found in 4 Massachusetts projects, and hours of operation being over or underestimated, as identified in four projects across Massachusetts and Connecticut. In yet another project, the parameters associated with pipe insulation (bare metal temperature, quantity of segments, and state of existing pipe insulation) were not accurately representative of site conditions. A few more project examples can provide greater insight as to why savings may not have persisted as projected at project close.

Table 1- Massachusetts Post Install Validation Project Analysis Summary

Post Install Project Review Year	Building Type	Project Total Gross Annual Savings	Measures Implemented	Deficiencies Identified	Post Install Savings Differential Identified
2021	Office	1,124,735 kWh	- VAV & AC unit schedules & temperatures - Heat pumps temperature control & night setback	- Control sequences did not align with design	-80%
2021	Lab	790,045 kWh	- Demand control exhaust	N/A- Performing to 8design sequences of operation	0%
2021	Industrial	156,856 kWh	- Chiller replacement - Ice rink & space temp control	N/A- Performing to design sequences of operation	0%
2021	Office	34,520 therms	- Steam boiler replacement - Domestic hot water heater replacement	N/A- Performing per design	0%
2021	Office	43,277 therms	- Steam trap repair & replacement - Pipe insulation	- Parameters used in projected insulation savings (surface temps, ambient temp, etc.) and steam trap ECM to not be representative of site conditions	-20%
2021	Lab	1,160,248 kWh	- Chiller replacement & control	- Sequences aligned with design - Cycling equipment led to savings differential	-10%
2021	Lab	234,904 kWh	- Lab Exhaust Demand Control - Lab Exhaust Pressure Control	- Fan speeds higher than designed and at project closeout - Bypass dampers not operating as designed	-15%
2021	Industrial	32,380 therms	Steam trap repair & replacement	- N/A repaired/replaced per scope	0%
2022	Other	1,160,248 kWh	- New VFDs on chilled & condenser water pumps - 950-ton chiller should run full load while the other two chillers should run at part load	- Cooling tower fan, CHW pump, and CW pump 1 cycled frequently - Both the chilled and condenser water pressure/flow were 0 not clear they modulate per design. - During periods of free cooling all CHW pumps are not staged off per the design sequences	-10%

2022	College	244,868 kWh	- RTU temperature setbacks - RTU economizer control - RTU discharge pressure reset - RTU demand control ventilation	- Sequences of operation not performing as designed	-100%
2022	Office	416,585 kWh	- RTU temperature control - RTU discharge Temp reset - VAV & FPT space temperature setbacks - VAV & FPT night fan control	- Sequences of operation not performing as designed	-80%
2022	Lab	183,516 kWh	- Exhaust demand control - Exhaust system pressure control	- N/A- Performing as designed	0%
2023	Industrial	28,075 therms	- Steam trap repair & replacement	- 2 trap locations not found - Greater savings due to mis-documented ambient & bare metal temps - Part of insulated piping valved off	-4%
2023	Industrial	200,224 kWh 3,916 therms	- RTU setback - Hot water pump removed - Scrubber & make up air setback - Batch furnace usage schedule	- Sequences of operation not performing per design	-23%
2023	Industrial	151,265 therms	- Air compressor heat recovery	- Air compressor exhaust not recovering at design temperature nor flow rate	-89%
2023	Industrial	1,684,191 kWh	- Airflow setback - Veg & flowering LEDs installed - Economizer & VRF installed	- Lighting savings inaccurately calculated	-46%

Table 2- Connecticut Post Install Validation Analysis Summary

Post Install Project Review Year	Building Type	Project Total Gross Annual Savings	Measures Implemented	Deficiencies Identified	Post Install Savings Differential Identified
2023	Industrial	182,432 kWh	- Air Compressor Replacement	- Increased operating hours improved the savings of all measures - Increase in pressure setpoint reduced savings for the compressor and dryer -Increased power consumption related to the higher setpoint increased the heat recovery savings	129%

2023	Industrial	742,635 kWh	- Air Compressor Replacement - Air Leak Repair	- The load profile is the main reason for the difference in energy savings. - Calculations stated all hours were above 600CFM, but data found very few hours above 600CFM	91%
2023	Industrial	300,840 kWh	- Install VFD on town water pumps	- Found secondary pump operates 36% of the time, the pumps average 72% when operating. Applying this to calculations increases annual energy savings.	167%
2023	Industrial	441,610 kWh	- Replaced air compressors and 2 different air dryers	- Compressed air loads (air flows) not changed prior to and following the installation of the new air compressors - 44% increase in annual runtime and 12% reduction in the average air compressor power based on the measured data.	176%
2023	Industrial	450,700 kWh 88,523 CCF	- Fan VFD installation - Process steam insulation - Steam trap repair & replacement	- Repaired steam trap continued leaking	97%
2023	Industrial	1,160,134 kWh	- Air compressor replacement - Desiccant dryer replacement	- Running fewer air compressors at lower load than design due to intermediate system leak repairs	52.30%
2023	Medical Offices	136,910 kWh -656 CCF	- Static pressure and discharge air temperature reset on 3 RTUs	- Duct static setpoint for all AHU's reduced from the original projected maximum & minimum values - Lower discharge air temperature in 2 RTUs - Additional run time hours	170%

In one example, a manufacturing plant, the incentive had been paid, the project was closed, and the program administrator and project team had disengaged. The customer, following the on-site visit and data collection, had realized they had not walked the measure scope with the vendor prior to install. As a result of the post installation validation effort, it was

realized 40 percent of the pipes that were insulated belonged to a de-energized section of the building. The result of this verification effort was an adjustment to the energy savings in the program administrator database.

In a second example, at an office building, the customer incentive had been paid and the project had been closed. Following data collection and analysis, only 30 percent of energy savings projected were being realized because control system parameters had deviated from the intended design. After the report had been shared with the project team and customer, because the installed controls and programming were outside of the warranty period, no action was pursued to recover the energy savings. Though no action was taken internally, this was a project identified before evaluation had the implementation and technical team had the opportunity to understand the broader impact this one project could have on the realization rate of the program.

In another project analyzed, the load profiles of the compressor at a manufacturing plant were based on data provided during reduced, COVID-based production times as opposed to a more representative production year. Revisiting the site following COVID operation, the plant had 24/7 production, which significantly increased the projected savings being realized by running a higher efficiency air compressor than had been previously installed on site. Though again no action was taken by the project team to adjust the energy savings in the project database, there was an understanding that greater effort would be needed to meet program energy savings goals if projects consistently represented operation during COVID times as opposed to a more representative average of annual equipment run time.

Identifying the differences between project projected and persisting savings in time to adjust claimed savings is significant. Taking action to minimize the risk of lower realization rates and inform the project team of where the implemented work may have had deficiencies or unforeseen incidents leading to savings differentials is important. It is acknowledged that even after a perfect installation and operation, the realized energy savings may differ from the estimated projected savings due to inaccurate assumptions in the savings estimates, and just as easily, perfect savings estimations based on accurate baseline and design conditions does not guarantee the savings will be realized after implementation, even one that follows the design to perfection. Energy savings persistence four to six months after implementation requires continual measurement, verification, and calibration though can be costly and time consuming. “In the energy efficiency industry, M&V is not always considered favorably, as it is thought to be an added expense that reduces both the funding available for energy efficiency measures and the project’s return on investment (Kummer 2011, 6),” however; as programs attempt to find deeper savings opportunities and ensure they deliver on the savings projected the additional funds spent to conduct analysis through traditional or automated means can provide further opportunities for energy savings when analysis is done longer term. Leveraging the lessons learned from doing post install validation on a small project sample to improve the efficiency program at large requires this understanding as well as broader institutional support.

From Pain Points to Proactive Progress

As identified above for both Massachusetts and Connecticut, there was a significantly larger pool of projects reviewed for post install validation consideration than analyzed. One impediment to achieving a greater number of commercial and industrial project analysis has

included the reluctance of project teams, motivated by the achievement of gross energy savings, to look back on completed projects that have the potential to reduce the amount of energy savings claimed. Additionally, there have been several customers that were either responsive but unable to finalize coordination with their building controls vendor to acquire trend data or were unresponsive about inquires to conduct post installation data collection on site. Finally, the seasonal nature of some energy efficiency measures like heat recovery, hot water temperature reset, and economizing, did not allow for the opportunity of operational trending prior to the energy savings being claimed with the state. Therefore, there were a variety of reasons a more statistically valid sample of projects could be analyzed for persisting savings, however; there was enough information resulting from the sample analyzed that has allowed Eversource to see the value in pursuing further post install validation work and begin improving internal workflows.

As, a result of the identified impediments to customer data collection, the post install validation team has improved its workflow to better align with the traditional commercial and industrial energy efficiency project process. As opposed to identifying projects for post install validation 4-6 months after implementation and notifying the project teams of the selection, the post install team has worked with the Eversource implementation and technical staff to proactively consider which projects should undertake savings persistence analysis as soon as the customers submit their energy efficiency project applications and calculations. This is the fastest and most thorough way to identify projects with higher evaluation risk or substantial energy savings. As opposed to waiting four to six months after the project has closed to inform the customer the project will be selected for post install validation, the implementation and technical teams can inform the customer that the post install team will conduct post install validation monitoring and verification analysis at the time the incentive offer is delivered. In this way, the customer is aware of the additional post install validation monitoring scope of work, the length of time it will occur after the implementation phase is completed and can ensure the post install validation trends have been set up during project implementation. Lastly, the customer can retain the services of a controls vendor to collect the data four to 6 months later if needed instead of having to attain the services as a separate effort later on, improving the post install workflow by being proactive with the customer and controls vendor.

The Eversource technical team conducting the initial and final project reviews before closeout has worked to improve the quality of their standard project verification documentation as a result of the post install validation findings as well Ensuring that the project parameters most aligned with the energy savings outcomes are well documented, trended, and compared to what the design intended at project close will better ensure the savings in the project database are more representative of implemented project conditions as compared to those projected before implementation. Additionally, the technical review team has given greater attention to project operational outcomes that show the dynamism of system performance as opposed to stagnant installation outcomes associated with nameplate data comparisons or pictures that the equipment is level. Instead, through requests for customer BMS screenshots, trend data, and performance testing following project completion, the technical review team is ensuring the project is performing as designed at project close and improving the probability the project will persist in performing as designed four to six months later.

The Eversource project implementation team has also been more proactive about project verification and improving the likelihood of the projected savings persistence by providing the

customer and vendor the list of the minimum implementation requirements. As mentioned above, this document, when provided with the energy efficiency project approval and incentive offer, catalogues the project parameters that will drive the projected energy savings outcomes. Further, prior to implementation, the customer and vendor are aware of the key project elements the Eversource technical team will be verifying at project close and consider for post install validation later. This proactive approach to project verification allows vendors and customers knowledge of what energy efficiency parameters are driving successful project outcomes. Finally, the implementation team has had discussions about selling the post installation validation to customers regardless of project size or complexity to increase their confidence and the confidence of their regulators in the project energy savings outcomes. "M&V is a common component of energy-related government incentive and education programs, … and contractual arrangements between two or more parties involved with the delivery of energy efficiency projects with savings guarantees– arrangements often referred to as energy savings performance contracting (Kummer 2011, 4)" if incentivized or sold by program administrator to support contracts or demonstrate alignment with state or local regulations, it may encourage more customers to participate in these programs if they do not have the in-house capabilities of conducting the analysis themselves.

The results of the findings from post install validation at the project level should not end with the progress made above. For roughly half of the projects analyzed through the Massachusetts and Connecticut post install validation, the deviations between the projected savings in the project database and the realized savings involved existing project workflow steps like double checking baseline assumptions, verifying calculations, or conducting improved monitoring and verification at project close. In the other half of the analyzed projects, circumstances impacting the persistence in savings was not attributable to existing program administrator best practices, but collecting a greater amount of site-specific information at the project start could have minimized the impact of savings persistence after project close. Asking whether the site had anticipated any changes in building or system use over the coming year, determining if there were any patterns in annual production as opposed to assuming constant output, or collecting the cadence of equipment shutdowns are examples of proactive actions the program administrators could have taken to improve the alignment between the projected and realized savings outcomes. All eventualities cannot be considered when projecting future outcomes, but taking a more wholistic approach to site circumstances at project start and addressing these in the associated savings calculations would proactively improve the alignment between projected and realized energy savings for program administrators and customers.

Beyond the commercial and industrial downstream project pathway, post installation validation has been leveraged in other Eversource programs. For the residential midstream heat pump offer, contractors installing partial displacement systems are now provided an added incentive to demonstrate that the controls were not only installed, but truly offsetting the fossil fuel use at the designated outdoor air temperature. Partial fossil fuel displacement and service of whole home installations were further validated by comparing customer heating season electricity usage before and after system installation. Based on the results of the residential contractor incentive engagement and heating season fuel use analysis, modifications were made to the delivery of our midstream residential heat pump program to ensure improved fossil fuel offsets and integrated control operation. Reflecting on the performance of individual projects and

programs has helped Eversource realign with intended outcomes and improve project and program delivery with our vendors and customers. Even "the best programs will not be identified – or valued and taken seriously by system planners and regulators – unless they are measured and verified (Skumatz 2009, 114)." Finally, other Massachusetts Program Administrators have seen the value that revisiting implemented projects for operational verification can provide. In the forthcoming Mass Save three-year plan for 2025- 2027 the Program Administrators have agreed to incorporate mechanisms in the energy efficiency programs to support the persistence of savings. These mechanisms include an increased focus and revised offering for existing building commissioning and an improved review and analysis of completed projects prior to claiming the energy savings with the state. Additionally, the Program Administrators have committed to a greater focus on customer training for building controls projects, and the establishment of a database for the significant number of evaluated projects over the years to not only reference for the appropriate assignment of project baseline information, but to also gather and share best practices proven instrumental to project energy savings persistence. As a result of these proposed additions the Massachusetts statewide energy efficiency program, there is projected to be improved realization rates, increased understanding of program outcomes, and better customer-centered focus on persistent energy savings outcomes.

The Bigger Picture

Beyond the benefits of including the post install validation framework in the forthcoming Massachusetts three-year plan, the support and verification of savings persistence can have an even greater benefit to the state and its customers. With improved program achievement of lifetime savings outcomes, the state moves closer to its greenhouse gas reduction goals. Further, through the post install validation efforts, there is added insurance for policymakers and program managers that the state's Program Administrators are actually meeting these targets.

By educating commercial and industrial customers about post install validation, Eversource is demonstrating its commitment to energy savings and its persistence. Assisting with post install validation, we ensure building owners get what they pay for when implementing energy efficiency measures for decarbonization outcomes. The additional measurement and verification can detect and allow for the correction of problems that may eventually surface as far more costly maintenance or safety issues (Hoffman et al. 2015). Informing customers and vendors of these concerns then creates a feedback loop that can lead to improved project outcomes. An additional bonus for customers engaged in achieving long term energy savings is the avoidance of increased demand charges. Further benefits for the utility and customers include reduced delivery infrastructure costs and avoided generation capacity costs.

For vendors, it is understood that project energy savings are a byproduct of installation and at present, part of their business model is to fix customer costs based on incentives energy efficiency program administrators provide. This approach is not in alignment with the persistence of savings outcomes, however; with consistent monitoring and verification of the minimum project requirements necessary to achieve savings and enlistment vendor services to take corrective action when needed, Eversource is tipping the scales to encourage longer term outcomes and greater investment in project support. By providing visibility into Eversource's approach and sharing best practices with other program administrators, it is hoped that there will

be more large-scale support for savings persistence efforts in energy efficiency programs beyond Massachusetts and Connecticut.

Next Steps

At present, there is not a mechanism to reinforce savings persistence with the technical and implementation teams beyond the program realization rate. This high-level program savings adjustment results in focused work on the acquisition of greater gross energy savings but does not foster a focus on the quality of individual project outcomes. The desired outcomes of proactively reinforcing the key parameters to the project savings at the project outset as well as during project closure and beyond is to improve customer satisfaction, realization rates, and understanding from vendors about the drivers of program incentives as mentioned above. Development of policy and evaluation support for the creation of a savings recovery workflow where savings and benefits could be claimed for revisiting implemented projects, encouraging corrective action on drifting measures would provide motivation for our sales and implementation teams to focus on realized savings. Additionally, support for revisiting project measurement and verification as well as taking corrective action would reinforce the benefits of other program administrator offerings like retro-commissioning and monitoring based commissioning.

Eversource has made an initial investment in revisiting projects. Expanding post install validation across further programs and states requires going beyond the status quo of completing projects and checking for installation requirements. This expansion will involve the technical resources and manpower to undertake the review of project documentation, understand the project parameters impacting the savings, engage with project teams, customers, and vendors to not only acquire the needed trend data but also clearly explain the implications of the resulting analyzed outcomes. Having analytic staff consistently engaged in this effort shifts focus from the short-term achievement of goals but provides greater confidence in the strength of longer-term outcomes.

The importance measuring and verifying energy savings to demonstrate persistence has increased as concerns intensify about securing reductions in greenhouse gas emissions, increasing energy prices, and demand-side programs come under closer scrutiny (Mills 2009). Additionally, improved attention to the factors involved during and after project completion can identify deficiencies that would otherwise go undetected and cause significant health, financial, and other adverse impacts on commercial and industrial customers. Adoption of a post install validation approach balances the time and attention after projects to conduct measurement and verification with the risk and cost of taking no action.

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