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DRAFT PHASE 1 REPORT

X1939 Phase 1 Best Practices Research

Prepared for the CT Energy Efficiency Board and Evaluation Administration Team

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ABSTRACT

The Early Retirement programs are specific initiatives launched in CT to achieve energy savings by driving the removal of working equipment and replacement with higher efficiency models. The X1939 Early Retirement Evaluation project involves the evaluation of Early Retirement programs as well as providing feedback on the adoption of dual baseline methodologies for other programs where existing equipment may be used as the baseline. This study consists of five objectives addressed through two phases: best practices research and the impact evaluation of the programs.

This report addressed the first phase of the X1939 study, focusing on best practices recommendations for methods surrounding data and lifetime savings calculations, evaluation considerations and early retirement program design. The recommendations that are within the data and lifetime savings calculations and evaluation considerations categories apply to all programs that include a retrofit component (where existing equipment may be used as the baseline for replacement), while the early retirement program design recommendations focus on early retirement programs specifically. DNV reviewed practices in three key jurisdictions across the country, MA, NY, and CA. The authors performed secondary research, six in-depth interviews with program staff in other states, and six in-depth interviews with trade allies in CT, some of which had bid into the competitive bid programs released to date in CT.

The team identified eleven practices and recommendations that will aid the adoption of dual baseline calculation methodologies as well as the performance and the evaluation of Early Retirement programs. These recommendations and the categories within which they fall are summarized in the table below.

Recommendation Category	Recommendation Summary
Data and Lifetime Savings Calculations	1. Adopt clearly defined protocols with respect to assigning an event type (retrofit, replace on failure, early retirement). 2. Use the values in the CT PSD where they are listed for remaining useful life (RUL), site specific data to support an RUL, or a survival curve if appropriate data exists, and elsewhere where dual baseline calculations should be adopted, use 1/3 of the EUL. 3. Collect additional information on RUL to inform that 1/3 EUL assumption. 4. Expanded use of dual baseline calculation approaches should be adopted when calculating lifetime gross savings for retrofit measures. 5. Use of a calculation tool can help dual baseline adoption in the state.
Evaluation Considerations	6. Clear, defensible documentation is the most important aspect in ensuring that savings are upheld through evaluation.
Early Retirement Program Design	7. Timing is critical for the customer decision process. 8. Plan programs further in advance and hold vendor trainings well in advance of program release. 9. Use energy studies to bolster customer relationships and to identify target equipment for early replacement. 10. Consider different incentive rates by testing the BCR models at varying incentive levels, and if it passes the BCR tests, incent up to 40% of the cost to maximize market impact. 11. Use of market studies can be beneficial to identify opportunities and target replacement in bulk such as with residential or small commercial programs.

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1 EXECUTIVE SUMMARY

Most energy efficiency programs that target capital-intensive measures such as new boilers or chillers focus on new construction or replace-on-failure (lost opportunity) events types. Because the customer is facing at least basic equipment purchase installation costs regardless of efficiency choice, the program has only to convince the customer to spend the incremental funds to increase efficiency over a standard efficiency option.

Most other efficiency programs target retrofits[1]. These are measures that replace working equipment that would have run for an indeterminant amount of time. Retrofit measures tend to save more per year than replace-on-failure because the working equipment in place (which serves as the baseline) tends to be less efficient than the new alternatives. Lighting measures traditionally have been considered retrofits.

Early retirement programs (ER) and measures lie between the two traditional options. In them administrators persuade customers to retire working equipment early, as with retrofit-level savings. However, the baseline efficiency is not presumed to remain constant for the full measure life. At the time the pre-existing equipment would have failed, early retirement presumes new more efficient equipment—but still less efficient than the incentivized equipment— would have been installed. This dual baseline is characteristic of ER programs. ER lifetime savings and customers costs are more than lost opportunity but less than retrofit.

ER *programs* specifically target an otherwise lost opportunity measure that has high capital cost. In this scenario ER accelerates replacement, increases program savings and leads to higher associated customer costs compared to retaining the existing equipment. Outside of ER programs, best practice generally dictates using ER practices (such as dual baseline calculations) for measures that may have otherwise been considered retrofits. In this case, adopting ER practices for *measures* that are not part of an ER program typically have the reverse effect. ER practices *reduce* lifetime savings and cost compared to the same measure otherwise considered a retrofit.

The X1939 Early Retirement Evaluation covers both ER programs and ER measures outside of ER programs. This study has five objectives addressed through two phases: best practices research and the impact evaluation of the programs. The following table summarizes the objectives and the work phase in which they are addressed.

Objective	Source (Phase)	Applicable Programs
1. Provide feedback on ER program design, including which gross and net parameters are relevant for ER programs	Best practices/ER design (1)	Early retirement
2. Ensure that CT programs are accounting for dual baseline calculations where applicable as outlined in the CT PSD	Best practices/ER design (1)	All programs with existing equipment baselines
3. Ensure that the program is equipped to handle non-energy impact factor considerations for ER projects	Best practices/ER design (1)	All programs with existing equipment baselines
4. Optimize the process effectiveness and efficiency for ER programs	Best practices/ER design & CT ER impact eval (1&2)	Early retirement

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[1] Per the Massachusetts Commercial/Industrial Baseline Framework, April 26, 2017: *In most cases. The MA TRM Glossary defines "retrofit" as "the replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. 'Retrofit' measures are sometimes referred to as 'early retirement' when the removal of the old equipment is aggressively pursued." While the TRM typically associates retrofit with RUL-type measures, there are some measures where the term is used in the context of measures without RUL or discounted EULs.*

5. Use program EM&V to assess the performance of ER programs and to better inform the design of ER programs	CT ER impact eval (2)	Early retirement

This report addressed the first phase of the X1939 study, focusing on best practices recommendations for data and lifetime savings calculations, evaluation considerations and early retirement program design. DNV reviewed practices in three key jurisdictions across the country, MA, NY, and CA. The authors performed secondary research, six in-depth interviews with program staff in other states, and six in-depth interviews with trade allies in CT, some of which had bid into the competitive bid programs released to date in CT.

The team identified eleven practices and recommendations that will aid the adoption of dual baseline calculation (lifetime savings calculation that utilizes two efficiency levels and two time periods) methodologies as well as the performance and the evaluation of Early Retirement programs. For definitions of dual baseline calculations and some of the key concepts used in this report see Section 3.1.

Data and Lifetime Savings Calculation Recommendations

1. Adopt clearly defined protocols with respect to assigning an event type (retrofit, replace on failure, early retirement). This practice includes collecting evidence such as trend data, metered data, dated photos/videos of operation, bid quotations or similar demonstrating the condition and operation of existing equipment.

2. Use the values in the CT PSD where they are listed for remaining useful life (RUL),), site specific data to support an RUL, or a survival curve if appropriate data exists, and where they aren't but dual baseline calculations should be adopted, a default of 1/3 of the EUL can be used, as both CA and MA do. Additionally, CT X2001 is a CT specific study that has RUL information that can be referenced. If enough information can be collected, using the survival curve analysis method is also an acceptable approach to determining RULs.

3. Collect additional information on RUL to calculate a site-specific RUL using a survival curve analysis, to reference X2001 or to inform that 1/3 EUL assumption. For instance, collect site-specific RUL for any program where high capital cost equipment is targeted for early replacement. This information can be used specifically for the project being reviewed, or it can be stored for future research when a larger body of information has been collected Use market studies to gain a general understanding of the average age of equipment replaced for higher volume measures so that it does not have to be collected on a site by site basis.

4. Expanded use of dual baseline calculation approaches should be adopted when calculating lifetime gross savings for retrofit measures unless it can be established that the baseline would not have changed over time due to evolving codes or standard practice. This practice is being done in the Early Retirement programs but has not been broadly adopted beyond those programs.

5. Use of a calculation tool can help dual baseline adoption in the state. In this case, Evaluators recommend adopting and converting the MA Custom Screening Tool for use in CT.

Evaluation Consideration Recommendations

6. Clear, defensible documentation is the most important aspect in ensuring that savings are upheld through evaluation. This starts with evidence collected during the measure installation.

Program Design Recommendations

7. Timing is critical for the customer decision process. The study team recommends performing a survey of all top tier customers regarding when their fiscal calendars begin and end and how their budget planning is conducted.

8. Plan programs further in advance and hold vendor trainings well in advance of program release to build vendor relationships and help them succeed in promoting early retirement for the programs. PAs are limited by their 3 year planning cycle, however the earlier the programs can be planned the better in order to train vendors and to provide them with the information needed for them to begin communicating with their customers. This planning could also include additional data collection ahead of time, for example potentially data to support market information on existing equipment age.

9. Use energy studies to bolster customer relationships and to identify target equipment for early replacement. The study team recommends that whenever an energy study is conducted, information be collected on the age of all major energy consuming equipment, not just the equipment that is the focus of the study.

10. All vendors encouraged substantial installation incentives, 25% to 60%, of the full measure cost. Consider reviewing the measure cost levels, and if the program design changes from a competitive bid model to a traditional prescriptive or custom incentive model, we recommend testing the projects using BCR models at varying incentive levels and incentivizing up to 40% of the cost to maximize market impact

11. Use of market studies can be beneficial to identify opportunities and target replacement in bulk such as with residential or small commercial programs.

2 INTRODUCTION

This document presents the research findings from the first phase of two phases of research for the X1939 Early Retirement evaluation. In this phase, the evaluation team has conducted secondary research and interviews to provide recommendations about program design and implementation.

2.1 Evaluation objectives

The impact evaluation is designed to address five primary objectives. Objectives 1, 4 and 5 target the Early Retirement programs specifically while Objectives 2 and 3 are applicable to all programs that utilize existing equipment baselines but include individual ER measures:

1. Provide feedback on early retirement program design, including which gross and net parameters are relevant for these programs.

2. Ensure that CT programs are first correctly assigning the measure event type (early retirement or replace-on-failure) and then applying dual baseline calculations where applicable, as outlined in the CT PSD.

3. Ensure that the program is equipped to handle NEI considerations for early retirement projects moving forward, even though they are not currently included in the utility cost test. There may be NEIs that are specific to early retirement programs, such as O&M savings. The programs should be equipped to handle these savings.

4. Optimize the process effectiveness and efficiency for early retirement programs.

5. Use program EM&V to assess the performance of early retirement programs (including the development of gross RR and estimates of first-year savings) and to better inform the design of early retirement programs.

Feedback on the first four objectives are provided within this memo. The fifth objective will be addressed in the second phase of work.

2.2 CT program description

The following section describes the newly released early retirement programs in CT. In addition to these programs, there are other programs where several of the recommendations made in this report also apply and are summarized below.

2.2.1 Early Retirement Programs

Connecticut's 2019–2021 Conservation & Load Management Plan outlines several potential early retirement programs. The Plan includes considerations for smaller targeted initiatives, such as storage water heaters (natural gas and heat pump water heaters) and other HVAC equipment, as well as possibly offering early retirement incentives for air-to-air heat pumps (for central A/C) and natural gas high efficiency boilers and furnaces. The Plan also includes the development of programs that will structure incentives to drive the replacement of larger commercial or industrial equipment such as large chillers.

To date, four commercial early retirement programs have been launched:

- Two rounds of a chiller program (2019 and 2020) - both targeting larger chillers (600+ tons)

- Boiler program

- Rooftop unit (RTU) program

These programs have been competitive bid programs[2] that accept applications from individual customers or implementers. Savings have not been claimed for any of these programs yet as, at the time of completion of this document, the projects are just being installed for the first chiller program that was released in 2019.

2.2.2 ER Measures in Other CT Programs

As noted above, concepts contained in this document apply to ER measures in programs outside of those labeled as early retirement. Any other program that includes a retrofit component in CT should adopt the recommendations made in this report surrounding lifetime savings calculations and evaluation considerations. The event type determination criteria (whether or not a measure should be considered retrofit or early retirement) are described in Section 4.1.2. The primary programs that this is likely to be applicable to include:

- Energy opportunities (EO) – C&I retrofit program

- Small business energy advantage (SBEA) – small business program offers audit and recommendations

- Energy conscious blueprint – mostly new construction, which would not be applicable, but handles some retrofit measures as well

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[2] Competitive bid programs work like reverse auctions. The implementer solicits offers from developers for incentives they will accept to install projects. The implementer then awards the requested funds to the vendors bidding the lowest incentive dollars per unit of savings.

3 PHASE I METHODOLOGY AND CONTEXT

Evaluators completed secondary research and interviews in compiling this best practice information. The primary components were as follows:

1. **Literature review.** Evaluators performed research and review of programs with ER frameworks that have been implemented in three other states and territories: MA, NY, and CA. This secondary research task primarily consisted of finding program and process evaluation results, as well as other factors of interest such as dual-baseline treatment of NEIs and best practices for outreach in ER programs. Additionally, since the start of this project, CT has embarked on a study to collect CT specific RUL information, that study is CT X2001.
2. **External program staff interviews.** Evaluators interviewed selected program staff in the same jurisdictions researched above. Six interviews were completed across each of the three states (two per state).
3. **Analysis of existing program designs and savings.** Evaluators conducted an analysis of the CT portfolio to quantify potential implications of broadening the use of dual baseline methodologies. This involved gathering existing program tracking data and using it to determine the impact changes from a shift to a dual baseline approach.
4. **Interviews with trade allies.** Evaluators also conducted interviews with trade allies in CT. The goal of these interviews was to gather input from key program allies about which customers to target as well as any other input they may have about outreach or implementation in an ER context.

A more detailed description of this scope is provided in APPENDIX B.

3.1 Dual baseline context

The recommendations that address the approaches, policies, and practices characterized as data and lifetime savings calculations and evaluation considerations apply not only to programs that are designated Early Retirement/Replacement but any program that has a retrofit component where existing conditions may be used as the baseline.

Dual baseline is a lifetime savings calculation methodology that accounts for two separate baseline periods. With a standard lifetime savings calculation, the difference between the more efficient and less efficient equipment remains constant over the life of the measure. With a dual baseline calculation, a working piece of equipment is removed from service but presumably would have been replaced upon failure at some point during the life of the newly installed measure. In this scenario, the first baseline period energy savings are the difference between the existing piece of equipment and the newly installed equipment and the time period corresponds to the remaining life of that existing piece of equipment. The second baseline period is the period of the EUL of the new piece of equipment after which the facility would have been required to replace the existing equipment and savings are the difference between the installed equipment and a standard piece of equipment (could be code compliant or industry standard practice). The baseline associated with this second period is generally code or ISP. This calculation methodology is considered a best practice in program savings reporting and has been adopted in many states, including the three that evaluators researched for this project. Chart A4-1 from the CT PSD provides a figure that demonstrates this calculation.

Figure 3-1. CT PSD Chart A4-1: Retrofit, Retirement, and Lost Opportunity Savings
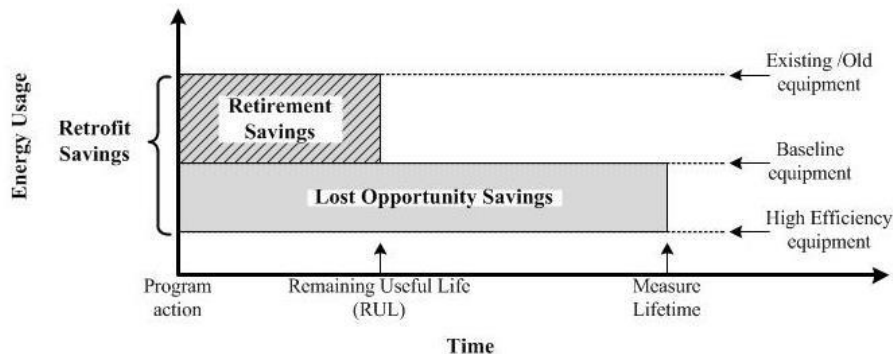
All three states the evaluators researched, as well as the CT PSD, recommend the use of dual baseline calculations. Despite the prevalence of this approach in program guidance documents, some of the PAs that evaluators interviewed (from CA, MA, and NY) were not familiar with the concept, or the importance of the calculation methodology. The confusion of this methodology can cause a hurdle in the adoption of the practice.

Five specific concepts are important to define and consider when discussing dual baselines. These concepts and definitions are listed below and form the outline of our recommendations, which are structured surrounding each of these steps:

- **Measure event type classification** – Outside of new construction, a measure can be one of three event types: Early retirement, retrofit, or a replace on failure. This research concentrates on those measures that would fall into the ER category.

  o Retrofit refers to a scenario whereby the pre-installation condition would have gone on indefinitely, absent the measure.

  o Replace on failure (ROF) is self-defined.

  o Early retirement (ER) means that the efficient measure replaced working equipment, but that after some period of time when the pre-existing equipment otherwise would have failed, the presumed replacement equipment would have had a different efficiency, generally higher than the working equipment.

- **Preponderance of evidence** of early retirement – The principle of preponderance of evidence is often invoked to determine event type. This simply means that when trying to determine if a measure is ER or ROF, evidence is gathered in support of both types. Whichever option is more compelling is the event type. Alternative methods could be to default to one or the other case absent overwhelming evidence (beyond a reasonable doubt), or to declare a certain event type under certain generalized conditions, regarding of the conditions of a specific measure. This principle is generally used for custom measures only, prescriptive or other high-volume measures should be handled through the use of market studies or other means. This is discussed further in Section 4.3.2.

- **Remaining useful life (RUL)** – In ER events, the RUL describes how long that pre-existing but replaced piece of equipment would have remained in operation if the measure had not been installed.

- **Effective useful life (EUL) –** The median number of years that the installed measure is in place and operable. In principle, this is the equipment technical life (e.g., median time to failure), discounted for measure persistence, the likelihood of the equipment being removed entirely from use due to business closure, remodeling, etc. EUL is not discounted for savings persistence, the possible gradual erosion of savings over time for a measure still in place.

■ **Adjusted measure life (AML)** – Some administrators have found it difficult to track and report the two-tiered savings streams (and correspondingly complex cost) associated with ER measures. In lieu of doing so they have adopted the concept of an AML, which is intended to reflect the equivalent lifetime savings as a dual baseline measure using a single constant stream of savings at the first-year retrofit savings rate, but with a shortened measure life. This concept may also apply when the lifetime of the efficient measure differs from that of the inefficient measure, such as with LEDs. MA and CT use this principle. The rigor of the AML basis varies.[3]

3.2 Research Questions

Evaluators grouped the research questions into three categories:

- Data and savings calculations

- Evaluation considerations

- Program design.

Table 3-1 shows some of the key questions researched, which type of program they apply to, and which category they fall into.

Table 3-1. Research question recommendation categories

Question	Evaluation Objective(s) Supported	Findings and Recommendations Category		
		Data and Savings Calculations	Evaluation Considerations	Program Design
How can all applicable programs best use dual baseline methodologies for determining savings from offerings that incentivize equipment replacement?	2,3	X	X	
What programmatic design considerations are most important when structuring this type of incentive program?	1,4		X	X
What approaches are used for identifying target customers for participation?	1,4		X	X
How are remaining useful lives determined for various pieces of equipment?	1,2	X	X	
What data is collected to support those assumptions?	1,2,3	X	X	
Are there any unique factors utilized to calculate lifetime savings for early retirement measures, such as an out-year factor?	1,2	X	X	
What are the impacts on program savings and evaluation results after implementing these dual baseline calculations?	1,2,3	X	X	

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[3] In Massachusetts, residential LED lighting AMLs were developed based on a consensus process.

In addition to the questions listed above, project cost is an important consideration as well in dual baseline treatment. This is discussed in Section 4.1.4.

4 FINDINGS AND RECOMMENDATIONS

The following sections summarize our findings and recommendations regarding program design and savings claims in ER programs as well as savings for ER measures outside of ER programs.

4.1 Data and lifetime savings calculations best practices

Data and savings-related findings and recommendations apply to both early retirement programs and individual ER measures in programs that also fund retrofit and ROF measures.

4.1.1 Findings summary

Table 4-1 summarizes the research findings surrounding data and lifetime savings calculations. APPENDIX A presents a more detailed collection of the information collected as part of our secondary research organized by category and state.

Table 4-1. Findings: ER savings principles in different states

Question	MA	NY	CA	CT
Dual Baseline: How can all applicable programs best use dual baseline methodologies for determining savings from offerings that incentivize equipment replacement	• Required, acknowledges there may be instances where baseline does not change. • Pre-made tool (custom measure tool) to perform calculations minimizing impact on implementer	• Required with exceptions for certain measures. • • Doesn't seem to be adopted state-wide • Contains special circumstances clause	• Dual baselines must be utilized for program-induced accelerated replacement measures • Senate Bill 6	• Required per the PSD for certain measures • Not fully adopted among all retrofit programs (which may also have measures that should be considered as ER)
RULs: How are remaining useful lives determined for various pieces of equipment?	• Implementers: Use custom screening tool (CST) – includes assumptions for out year factor (OYF)[4] • Evaluation: RUL is always one-third of the EUL	• Site by site – determined by implementer for C&I programs	• Use one-third of the effective useful life in DEER as the remaining useful	• Specified in PSD for dual baseline measures • PSD also has blended measure lives for other retrofit measures
Data: What data is collected to support those assumptions?	• MA recommends collecting data on RUL, but still to use 1/3 of EUL. It is not clear if this is being done. • Reasonable preponderance of evidence (POE) requirements	• NY has site by site questionnaire to determine EUL	• RUL is always 1/3, EUL is prescribed for deemed measures and site by site for custom measures • Extensive table and burdensome POE to allow for existing baseline use.	• Will be addressed in Phase II of this evaluation
Special Calculation Processes: Are there any special factors used to calculate lifetime savings for early retirement measures?	• MA implementers use the OYF to adjust the EUL to reflect dual baseline effects in a single baseline-based custom screening tool. The OYF was developed through evaluation activities	• Exempts machinery and multifamily central heating system replacement from dual baseline consideration and designates them as retrofits	• None identified	• Blended measure lives

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[4] OYF - The ratio of the second-period savings to the first-period savings is the outyear factor.

Impacts: What are the impacts on program savings and evaluation results after implementing these dual baseline calculations?	• C&I lighting: 27% reduction • C&I non lighting 3% reduction	• None explicitly called out in evaluation reports could be located	• None explicitly called out in evaluation reports could be located	• Will be addressed in Phase II of this evaluation
ER Guidance: Source of early retirement guidance in each state	• Policy guidance documents for evaluators and implementers • Custom screening tool for implementers	• TRM	• Legislative orders, policy document for POE	• PSD • Evaluation findings and feedback (this report)

Recommendations are based on best practices observed in our research and through the interviews we conducted. The summary of our findings and recommendations are organized around the key concepts discussed in the dual baseline context above.

4.1.2   Recommendations for assigning event type

Upon review of the procedures that have been adopted in each of the states researched, ***evaluators recommend adopting the following protocols with respect to assigning an event type.*** Many of these practices are used currently in CT, particularly for the ER programs released to date, however we recommend formalizing these for use across programs to support an ER event type classification. For ER specific programs this would be the minimum requirements for participation.

Use of ER should require evidence such as trend data, metered data, dated photos/videos of operation, bid quotations or similar demonstrating that the pre-existing equipment either:

- Is fully functional; or
- Needs only minor economically viable repairs (e.g. repair cost is < 20% of replacement cost) for continued operation; or
- Has run in failed or partially failed mode for more than two years; or
- Had failed but was replaceable with on-site in-stock inventory or back-up equipment similar in efficiency

In addition, evidence should be presented that demonstrates that the replace equipment either:

- Was less than 2/3 through its standard EUL; or
- Was beyond 2/3 of its EUL (including beyond the EUL), with documented evidence of either commitment to long-term maintenance or a facility's inability to make the capital commitment necessary to replace it, even if major repairs are needed.

Evaluators must, and implementers should, gather all possible evidence both in favor of and against the ER event type for judgment on a basis of the weight of preponderance of evidence.

It should be noted that the above requirements are considered best practice in all programs, however for practicality these requirements may be too burdensome for prescriptive programs, or other higher volume programs, such as residential programs. In these cases, we recommend the use of market studies to determine the average age of equipment in the market and the overall mix of ROF and ER measures that are implemented.

The above recommendations are based primarily on the approach in MA, with additional allowances for measures to be considered retrofits through custom programs beyond those named Early Retirement. This approach provided the most clearly outlined and practical definition for measure event type determination/program eligibility out of the states researched. CA has a more rigorous but burdensome decision process. NY was like MA but not as clearly laid out. For more information on NY and CA, see APPENDIX A.

4.1.3   Recommendations for determining RUL

Once a measure is determined to be early retirement, the next step is to determine the remaining useful life (RUL) for the replaced equipment. A summary of the current practices in CT and our recommendations are as follows.

Table 4-2. Comparison of CT Practice for RULs and Recommendations

Current CT Practice	Recommendation
RULs are specified in PSD for dual baseline measures and also has blended measure lives for other retrofit measures	Use PSD values where RULs are listed but move away from AMLs and adopt site specific RULs or default to 1/3 if necessary as the RUL for retrofit measures along with a full dual baseline calculation (see Section 3.1.4)

Recommendation: To start, use the values in the CT PSD where they are listed for RUL, site specific data to support an RUL, or a survival curve if appropriate data exists, and where those aren't available, but dual baseline calculations should be adopted, use 1/3 of the EUL be used, as both CA and MA do. Additionally, it should be noted that CT X2001 is a CT specific study that developed RULs and should be reviewed and referenced for CT specific data prior to defaulting to 1/3.

If the actual RUL varies from this, it can have a significant impact. The following example shows the range of lifetime savings for an example chiller replacement measure:

Measure EUL	23	years
Existing Efficiency	0.8	kW/ton
Code Efficiency	0.56	kW/ton
Proposed efficiency	0.4	kW/ton
Chiller Capacity	1,000	tons
EFLH	1,000	
Lost Opportunity savings	3,680,000	kWh
Retirement savings	1,840,000	kWh
Total Lifetime	**5,520,000**	**kWh**

The values above use 1/3 as the RUL to calculate lifetime savings. The table below shows a range of RULs and the associated lifetime savings for each.

RUL	Early Retirement Lifetime Savings (kWh)	Lost Oppurtunity Lifetime Savings (kWh)	Lifetime Savings (kWh)	% Different From 1/3	Benefit Cost Ratio
1/3	1,840,000	3,680,000	5,520,000	N/A	0.73
1/4	1,380,000	3,680,000	5,060,000	-8%	0.65
1/2	2,760,000	3,680,000	6,440,000	17%	0.90

In this example, an RUL of about two and a half years different from 1/3 in either direction has an impact of about 10% on the lifetime savings. This is likely to be on the high end due to the long measure life for this measure and does not include discounting, which will decrease the impact over the lifetime of the measure. Additionally, this is highly dependent on the efficiencies and operating hours of the equipment as well as the RUL, however this gives an idea of the relative impact an RUL can have, which is substantial.

We also have the following recommendations considering these impacts below.

- **For custom early retirement-specific programs**: *Recommendation: Site-specific equipment age information should be collected for any program where equipment is being targeted for early replacement.* This includes the programs that have been released to date in CT. These existing programs target large commercial equipment, and site-specific equipment age documentation should be collected. This can then be used to estimate what the RUL for that piece of equipment is. Ideally, this documentation would consist of evidence of the installation and replacement dates of the equipment. This may include a date stamped on the nameplate, invoices from the purchase and installation of the equipment, dated photos of the construction, or any other documentation that can defend the date of installation. This

site-specific information should be collected and compiled over time to enable going back through and quantifying more robust measure-specific RULs in the future that can be based on real data collected in CT.

- **<u>For residential or other higher volume programs</u>:** In the case of a program that is targeting a high volume of smaller measures, such as residential programs or small commercial programs, the high-volume replacement may make it cost-prohibitive to pursue site-specific information. If CT designs such an ER program, primary research to develop pre-determined RULs should be considered. A market study on EULs should be conducted at the same time. If a program is interested in collecting more detailed equipment age data during implementation, a bonus incentive could be offered to customers to provide that additional information.

- **Survival Curve Analysis –** There is a less adopted, but potentially more accurate method of determining RUL, which is the use of a survival curve analysis. A 2015 NEEP study points out that "studies of mechanical and electrical equipment indicate that the likelihood that an individual piece of equipment survives to a particular age increases as the individual piece of equipment successfully ages." If CT programs want to establish site specific RULs using the survival curve method, evaluators will accept this method provided that sufficient documentation can be provided as to the age and condition of the existing equipment and the survival curve used can also be provided. This can be used in place of the 1/3 EUL approximation where sufficient data exists.

4.1.4 Recommendations for broad adoption of a dual baseline calculation methodology

The Table below summarizes the current CT practices as well as recommendations in this area.

Table 4-3. Comparison of CT Practice for Dual Baselines and Recommendations

Current CT Practice	Recommendation
Dual baselines are required per the PSD for certain measures. Not fully adopted among all retrofit programs	❑ Expand use of dual baseline calculations to determine lifetime gross savings ❑ Adopt MA tool to help with the adoption of these calculations.

Recommendation: Expand the use of dual baseline calculation approaches to determine lifetime gross savings for retrofit measures unless it can be established that the baseline would not have changed over time due to evolving codes or standard practice.

Dual baselines have been adopted for Early Retirement programs in CT where they have been released. Additionally, the CT PSD utilizes slightly reduced measure lives for retrofit projects for the measures listed below (the full PSD table is shown Section 4.4.1).

- Automatic Photocell Dimming System
- Fixture (LED)
- Fluorescent Lighting System Power Reduction Control
- Occupancy Sensor
- Sweep Controls/EMS Based Control
- Energy-Efficient Motor
- 2-Speed Motor Control in Rooftop Unit
- Cooling Tower Alternates
- Dehumidifier
- Economizer - Air/Water
- Energy-Efficient Motor
- Variable Speed Drive
- EMS/Linked HVAC Controls
- Enthalpy Control Economizer
- New/Additional EMS Points
- Heat Recovery from Refrigeration System
- Air Compressor
- Energy-Efficient Transformer
- Energy-Efficient Motor
- Plastic Injection Molding Machine
- Refrigerated Air Dryer
- Variable Frequency Drive

Based on our best practice research, evaluators recommend eliminating this practice in most cases and moving to the use of dual baselines for all retrofit measures as noted above. The exception would be where a robust AML exists or can be created. This would generally be the result of an evaluation study on a specific measure life. There may be scenarios when

a dual baseline is technically not appropriate. If a case exists where the lost opportunity baseline is equal in efficiency to the retirement savings baseline, then a dual baseline approach is not warranted. For example, if a rooftop unit is replaced while still functioning, and meets the criteria for early replacement, but has an efficiency that is equal to the code value that would apply during the second period baseline, then a dual baseline calculation is not required. In these instances, documentation should be provided to demonstrate these efficiencies and the support the approach taken. It is important to note that this approach will significantly reduce the use of a market event type designation of retrofit. Additionally, AMLs may be appropriate, if an AML is determined with rigorous and defensible methods and the value is determined to be appropriate through review by evaluators, then AMLs may be used in place of a true dual baseline.

Recommendation: Adopt and converting the MA Custom Screening Tool for use in CT. This tool could be adopted to include prescriptive measures and calculations over time as well.

This tool is used to check for program eligibility by screening measures (and bundled projects) for the total resource cost test, but also has other calculations built in, including lifetime savings calculations. The tool has the following key factors built into it:

- Benefit cost ratio (BCR) (this would need to be updated to the utility cost test[5], which is used in CT)
- Single/dual baseline calculation selection
- Measure lives
- Out year factors
- Remaining useful lives

Many of the assumptions, factors, and calculations would need to be modified to reflect policies in CT and values used in the CT PSD. Additionally, while review of it was not within the scope of this evaluation, consideration should be given to the cost assignment of cost and the cost test used across programs as this policy is adopted.[6] Even after the tool is updated to use the UCT for screening, we feel it should be used to compile and track additional data that will not initially be used in the screening, such as NEIs and customer project costs (including the deferred costs associated with the baseline shift). However, once updated, evaluators believe this tool will have a positive impact with the adoption of dual baseline calculations by all programs in CT that have a retrofit or existing equipment replacement component. The tool can output the values that are needed to enter into the program tracking databases. These outputs can be tailored to meet the database need of the CT programs. Additionally, over time prescriptive measures will need to be included and addressed, and they can either be added here or the tool can be adopted to have a prescriptive version as well.

4.1.5   Recommendations for handling of NEIs

Evaluators researched non-energy impacts (NEIs) in all jurisdictions and asked about them in each of the interviews conducted. We did not find any dedicated literature relating to the handling of NEIs specific to retrofit projects or early retirement programs[7]. Interviews indicated they are generally treated as tertiary. Best practice dictates that NEIs be treated in the same manner as energy savings when determining the benefits of a measure and when calculating the cost benefit ratio. While CT uses the UCT, NEIs cannot currently be included in project screening, however they should still be quantified and tracked. To do that in a comprehensive manner, consideration must be given as to any difference in the NEI between the retrofit component and a new code or ISP compliant piece of equipment. One example could be that O&M costs for a

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[5] Currently, with CT using the Utility Cost Test, ER is likely to be more cost effective since this test uses only the utility costs (program administration and incentives) as the denominator for the calculation.

[6] For example, when a model applies savings using dual baseline principles then it should apply costs in the same way, with the customer's cost in the model reflecting a portion of the total installation cost (associated with early year savings) and a portion of the incremental cost of upgrading beyond a replace-on-failure baseline cost (associated with later year savings).

[7] While researchers found no dedicated literature, MA does distinguish in its NEI studies between NEIs associated with ER vs. ROF.

piece of equipment that is near the end of its EUL may be higher than a brand-new piece of equipment that would serve as the baseline for the second baseline period.

The MA custom screening tool does have some NEI factors built into it that can be reviewed and developed upon as a starting point.

4.2 Evaluation Impacts and Considerations

This section summarizes the data researchers found on the impacts on program savings and evaluation results from implementing many of the concepts discussed throughout this research and provides recommendations for evaluation considerations.

4.2.1 Findings by state

Many of these concepts are newly adopted (adopted within the last five years) in the states researched, and therefore evaluation impacts were somewhat difficult to identify. Below is a summary of the impacts adopting these concepts had in MA. Additional information on the process can be found in APPENDIX A.

4.2.1.1 Massachusetts

The Massachusetts Commercial/Industrial Baseline Framework, introduced in April 2017, requires that, starting in 2019, PAs use dual baseline calculations to determine lifetime gross savings for retrofit measures, unless it can be established that the baseline would not have changed over time due to evolving codes or standard practice. "Prior to 2019, dual baseline effects were factored into the measure life for a few measures as an adjusted measure life (AML)."[8]

PY2016 C/I Custom Gas Program

To help PAs prepare for reporting in 2019 and advise PAs about the potential impact of dual baseline practices on lifetime savings, evaluators of the PY2016 C/I Custom Gas Program (DNV and ERS) included a desk review of a sample of projects (86 measures across 55 sites) to examine the frequency and impact of baseline changes, dual baseline calculations, and lost opportunity vs. retrofit measure reclassifications. (Note that this was solely for informational purposes for the PAs and EEAC; results were included in a desk review memo and not included in evaluated metrics.) A summary of the key adjustments and findings are below:

- **Establishing measure event type:** The evaluation team reclassified the measure event type for 33 measures – three measures were reclassified from retrofit to lost opportunity, and the remaining 30 measures were reclassified from retrofit to add-on. Only one reclassification (from retrofit to lost opportunity) had an impact on savings; **program savings were decreased by less than 1% (-0.39%).**

- **Establishing baseline:** No measures were determined to be dual baseline as "the market is stable and there are no expectations of efficiency improvements within the remaining useful life of the measure."[9]

PY2017 C/I Custom Gas Program

Evaluators of the PY2017 C/I Custom Gas Program completed a similar desk review that estimated lifetime savings for all retrofit measures (41 measures at 31 sites) by applying dual baseline methods and by using the EUL specified in the 2016-2018 TRM. "The Team calculated that the **PY2017 lifetime savings would be reduced by about 1% when applying dual baseline methods and 4% when revising measure lives to better match TRM recommended EULs."[10]**

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[8] C&I Measure Life Study: Project MA19C02-B-EUL Final Report (pg. 27)

[9] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (P79)) (2016), pg. 9 of 18

[10] Impact Evaluation of PY2017 Custom Gas Installations, pg. 3

PY2017 and 2018 Custom Electric

Evaluators also completed an impact evaluation of PY2017 and 2018 custom electric installations for the MA PAs. The measures evaluated were split into custom lighting and custom non-lighting categories. "The results of the study, which were combined with those from the PY2016 study, will be used to report 2019 program savings in the 2020 Plan Year Report."

Lighting: "To determine the impact of using a dual baseline lifetime savings, the evaluators treated all early replacement lighting projects as dual baseline measures. In performing the lifetime savings analysis, all evaluated savings associated with lighting fixture kW reduction are treated as 1/3 of the life using the existing baseline and 2/3 of the life using the 60% outyear savings derating factor (OYF) developed as part of a separate study. As the OYF is updated annually through the lighting market model study, the custom electric impact evaluation will adopt these updates. The DNV GL team used a 15-year measure life for fixture replacement savings and a 9-year measure life for lighting control savings per the Massachusetts TRM. **The impacts of the more refined dual baseline treatment caused the weighted evaluated dual baseline lifetime savings totals for the sampled early replacement lighting applications to be 27% less than the single baseline evaluated lifetime savings.**"[11]

Non-Lighting: "For non-lighting lifetime savings estimates, the evaluation team defaulted to using the TRM measure life unless there was a clear established reason to do otherwise, such as change in event type or dual baseline treatment. If the measure life was changed by the evaluator, the change was stated and supported in the site level evaluation report. **In total the impacts of the dual baseline treatment on the non-lighting sites caused evaluated savings to decrease by 3%.**"

4.2.1.2   New York and California

Evaluators were unable to locate information on the impact of applying dual baseline methodologies in either of these states. As can be seen from MA, the impact of implementing these methodologies can vary significantly depending on the technology as well as the program's current practice.

4.2.2   Recommendation

Applying the dual baseline methodology to ER measures when evaluating non-ER programs will increase lifetime savings if the measures previously were considered lost opportunity and will decrease savings if they previously were retrofit. Based on CT program tracking data review the latter change is expected to be more common. Table 3-4 summarized our recommendation surrounding best practices with respect to data collection.

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[11] Impact Evaluation of PY2017-18 Custom Electric Installations, pg. 29

Table 4-4. Documentation Practices and Recommendations

Current CT Practice	Recommendation
Tracking data is fairly complete but does not include event type classification. Some POE information is collected	Collect clear defensible information that outlines event type classification, contains a complete POE, and if market studies are used for baseline characterization those studies need to be filed and provided.

Recommendation: Clear, defensible documentation is the most important aspect in ensuring that savings are upheld through evaluation. This starts with the preponderance of evidence that is collected during the measure installation. The evaluation team recommends the following best practices be implemented and rigidly followed by all programs that include a retrofit or early retirement component.

- **Data format** – Clear documentation of lifetimes as well as event types used should be kept and maintained so that it can be easily accessed and provided if it is needed during evaluation. This will help evaluators understand exactly what was used and why, so that adjustments during evaluation are less likely.

- **Preponderance of evidence** – Information that should be collected here is outlined in Section 4.1.2 above, both in favor of and against the ER measure classification. All documentation collected should be clearly labeled and organized so that the market event decision that is made by the program is clearly defensible.

- **Market studies** – In the program design considerations below, evaluators recommend using market studies to both identify opportunities and define the baseline for high-volume smaller measures as well as the average age of equipment in the market. This can help with identifying target opportunities for ER. If an opportunity is identified through a study, then the team should attempt also to use the study to determine the appropriate age, or efficiency of existing equipment. The population average may or may not be representative of projects that would be removed through ER. If a study is planned then this discussion should be a part of the planning phase with the evaluation team proactively, in order to agree on a reasonable approach as to how data is collected, and how the collected data can be used to identify baseline equipment ages and efficiencies for an ER program in place of site by site data collection. This can also prevent the need to collect site-by-site POE information, which is cost prohibitive for high-volume smaller saving measures. This market study should be kept readily available and provided to evaluation when the program gets evaluated so that the baseline is clearly defined for evaluators upon review.

4.3 Early Retirement Program Design

The two key questions that evaluators researched with respect to program design as well as a summary of the findings are shown in Table 4-5.

Table 4-5. Summary of program design findings

Question	Program Administrators	CT Vendors
What programmatic design considerations are most important when structuring this type of incentive program?	❑ Biggest barriers include upfront measure cost and customer ambivalence to investing in the replacement of functioning equipment. ❑ Collection of POE at a site level becomes expensive quickly and can make programs cost ineffective.	❑ Biggest barriers include upfront measure cost and customer ambivalence to investing in the replacement of functioning equipment. ❑ Securing customer commitment to retire large capital equipment early requires time. Program timelines must be designed with this in mind, so that vendors have the time they need to sell the measures.

What approaches are used for identifying target customers for participation?	❑ Utilization of market studies to demonstrate potential for specific kinds of territory-wide ER measures – creates efficiencies of scale when it comes to collecting POE ❑ Relationship developing programs such as study programs provide information sharing between customers and Pas and can help identify equipment to target for replacement	❑ Customers who would suffer greatly from the loss of functioning equipment could be good to target (e.g. schools, hospitals) ❑ Vendors must be conditioned to educate all customers that funding is available for equipment that is "nearing end of life," and not just failed equipment.

Upon review and consideration of our findings, we have grouped our recommendations into two categories: larger commercial programs and small commercial/residential programs.

4.3.1   Commercial program design findings and recommendations

The following summarizes our key commercial program design lessons from the interviews and supporting information reviews.

Finding: *Careful program planning, communication with vendors, and customer relationship management can bolster chance of program success.*

- Vendor education: The timing component inherent in every early retirement measure (i.e., equipment must not have yet reached its EUL) creates the need for the PA and the vendor to be forward-thinking and proactive in their marketing of early retirement incentives to customers, so that customers are caught at the opportune time to retire equipment before it reaches its EUL. One vendor remarked that customers understand the concept of incentives for replacement upon failure of existing equipment but are generally not seeking out incentives for functioning equipment. He suggested that contractors should more regularly introduce the concept of incentives available for "nearing end of life" equipment. This would require close and consistent communication between the PA and the vendors.

- Awareness of customer equipment status: One stakeholder noted an additional barrier to ER programs is if the measure is proposed at the wrong time in the capital budget cycle. The PAs should utilize existing auditing and customer engagement programs to collect information on equipment age and capital budget schedules so they can engage commercial customers at appropriate times in their capital budget planning. Possibly do a survey of top tier customers to see if there are more common annual budgeting schedules that could be targeted. Or, have more cyclical engagement – quarterly "program update" webinars.

Finding: *Both contractors and PA implementation stakeholders reported that upfront cost was the main barrier to commercial customers retiring equipment early.*

Of course, upfront cost is a major barrier in traditional, replace-on-failure energy efficiency measures as well, but in the early retirement scenario it is amplified. Both implementers and vendors expressed that outside of a few select scenarios, large commercial customers are unlikely to invest in the replacement of functioning equipment, especially only for efficiency gains.

The research team asked vendors to estimate the level of incentive they believed would motivate customers to replace functioning equipment early. Most said it would depend on the measure and the customer, but ranges given spanned from 25%-60% of the full measure cost. One vendor declined to make an estimate and suggested that the incentive provided would need to exceed the cost of repair to incite customers to invest in ER. The research team also asked vendors if CT's ER program RFP-style solicitation was effective. Some vendors were satisfied with the solicitation process, as it gave them and the customer an opportunity to fully articulate their financial needs to get the measure done. Other vendors were not as

content, saying that the RFPs introduced uncertainty. If a vendor couldn't guarantee up front what the incentive was going to be, it was hard to get a customer to commit to doing the measure.

Finding: *Besides cost and the "optional nature" of ER measures, vendors reported short program timelines and uncertainty around program continuity limiting their ability to recruit for the program.*

Especially with expensive capital measures, it can take a commercial customer a long time to decide to invest in the replacement of functioning equipment. The vendors need sufficient time to secure a commitment from the customer to do the measure. Vendors noted that the program solicitation process had recently been extended and were appreciative of that change. They also expressed the need for clearer communication on whether or not the program would be continued – this is also key to keeping vendors motivated in marketing the program and ER opportunities.

The research team also asked vendors which customer segments offered the best opportunities for ER, and for which equipment programs could be successful in driving early retirement. Two vendors mentioned having the best success recruiting schools and hospitals for the programs in CT thus far, because these kinds of facilities cannot afford a shutdown. One vendor also mentioned the industrial sector because in his experience, manufacturers tend to have aging technologies. Vendors said they would like to see the programs expanded to include smaller chillers (less than 600 tons), ductless mini-split air handling units, heat pumps, variable speed drives[12].

Recommendation: *Extend competitive bid RFP solicitation timelines.* Timing is critical for the customer decision process. The study team recommends performing a survey of all top tier customers regarding when their fiscal calendars begin and end and how their budget planning is conducted. Having a program available, or a planned program that is known to customers at the right time will significantly increase the chances of getting customers engaged and committed to participating in the programs. We recommend either significantly increasing the period during which an RFP is open (six months – one year) or starting to advertise the RFP at least that amount of time ahead of its release. This will allow for better planning on the customer side of things.

Recommendation: *Plan programs further in advance and hold vendor trainings well in advance of program release.* The vendors are the ones with the customer relationships. Having an ongoing relationship with them is critical. This needs to be planned and coordinated well in advance of any program releases so the vendors can communicate to their customers and help identify equipment that would be a good candidate for replacement. This does not mean it needs to be years in advance, but just done with enough time to communicate the programs to the vendors to allow them time to meet with customers and have the customers make informed decisions. This likely means planning 6 months to 1 year in advance of program release if the program will only be available for a short time.

Recommendation: *Use energy studies to bolster customer relationships and to identify target equipment for replacement.* CT offers energy studies in both the commercial and residential sectors. These studies, particularly in the commercial and industrial sector, are generally targeted at specific measures that have been identified. Energy studies provide the opportunity to engage with customers and identify equipment that could be targeted for early replacement. The study team recommends that whenever an energy study is conducted, information be collected on all major energy consuming equipment, not just the equipment that is the focus of the study. This would include an inventory of HVAC equipment and process equipment and should collect the following information:

- Size/capacity (hp, heating/cooling capacity)
- Area served
- Operating hours

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[12] Vendors also expressed interest in an ER program for building automation equipment. However, these measures are often classified as add-on.

- Age of equipment

Over time this can help create a database of equipment at a variety of end users in the state. The early retirement team should compile this information and use it to identify equipment that could be targeted for early retirement programs throughout the state.

4.3.2 Residential and small commercial customer program design findings and recommendations

The following summarizes key residential program design lessons from the interviews and supporting information reviews.

Finding: *Collecting POE at the site level for residential and small commercial non-custom programs can be cost ineffective.* Interviewed PA implementation staff at two different utilities have instead attempted to use market studies to establish grounds for early retirement programs. One PA was able to run a successful ER program for grocery store controls using a market study. The other PA used a market study to justify a residential pool pump early retirement program; when the regulator decided subsequently that the PA would need to collect POE at the site level, the program was no longer cost-effective.

Finding: *Both contractors and PA implementation stakeholders reported that upfront cost was the main barrier to residential and small commercial customers retiring equipment early, just like it is for commercial customers.* And, like with commercial customers, efficiency gains and the resulting cost reduction alone isn't enough to overcome the initial cost barrier as well as the inconvenience of replacing functioning equipment. One residential vendor reported encouraging customers to retire HVAC equipment early only when it can be replaced by mini-splits that provide both heating and cooling. Of note, the same vendor said that he did see residential customers retire equipment early, most often when they were doing an upgrade or renovation of their house.

Recommendation: ***For residential and small commercial measures, use market characterization studies to identify opportunities and target replacement in bulk.*** In these instances, the average age of equipment should be determined by a market study and that equipment could potentially be replaced in bulk. For example, if a market study identifies that ISP within the grocery industry is a certain type of refrigerated case, and there is a new alternative on the market that significantly improves on efficiency, then a targeted program could be implemented to try and shift that market toward the new technology, using an existing equipment baseline but without collecting site-by-site existing equipment information. Similarly, this could work in a residential setting with residential HVAC equipment or water heaters for example. An average age can be assumed as long as the market study provides statistically defensible information on the average age. This age should be used in all lifetime savings calculations regardless of the specific site information.

4.4 Impact of Expanded Use of Early Retirement in CT

Evaluators conducted an analysis of existing program data to estimate the likely statewide impact of adopting a dual baseline methodology. It focused on a review of three measures: chillers, condensing boilers, and SBEA lighting. Chillers and condensing boilers were both measures that were identified as having RULs defined in the PSD, so the team was reviewing to observe application of those RULs. Additionally, SBEA lighting was chosen due to the fact that the evaluation team understood that all of the measures were characterized as lost opportunities, and it may have represented a potential area of increased savings.

The purpose of the analysis was to determine how well the PAs are complying with the PSD savings calculation methods for retrofit measures and to identify measures that do not yet recommend early retirement treatment but may potentially benefit from early retirement treatment. The potential impact could increase savings if the administrators are underestimating ER measures relative to ROF or if ER could add new opportunities not being realized. It could decrease savings if administrators

are underestimating ER relative to retrofit events. If the ER methodology is flawed, correction could either increase or decrease savings. This database review looked at classification and methods. In summary, the review indicated that it is more likely for portfolio savings to decrease than increase with the likely largest impact being a decrease in lighting savings for programs other than SBEA.

4.4.1   Summary of CT PSD

The current CT PSD recommends using dual baseline methodologies for select measures in both the C&I and residential sectors. The measures that are recommended to use dual baseline methodologies have RULs listed in PSD Table A4-1 (C&I) or Table A4-2 (residential). For commercial measures, the PSD stipulates that "for retrofit/early retirement programs, the measure life will take into account both the expected remaining life of the measure being replaced and the expected changes in baselines over time." Currently there are 22 measures in the PSD that have blended retrofit EULs, which are slightly adjusted measure lives that are intended to account somewhat for dual baseline effects. Those measures also have lost opportunity EULs associated with them, that are intended to be used in ROF scenarios. A summary of those commercial measures is as follows.

Table 4-6. Commercial measures with recommended RULs

Description	Remaining Useful Life	Retrofit	Lost Opportunity[13] Measure Lives
Electric Chiller	5	N/A	23 (a)
Gas Fired Boiler (Condensing)	5	N/A	15 (m)
High-Efficiency Unitary Equipment (A/C and Heat Pumps)	5	N/A	15 (a)

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[13] *References per CT PSD*

[a]	GDS Associates Inc., *Measure Life Report, Residential and Commercial Industrial Lighting and HVAC Measures*, Jun. 2007, Table 2.
[a,*]	This measure is similar to those in the report, so a measure life from Table 2 was used.
[a,**]	This measure is similar to those in the report, so a measure life from Table 1 was used.
[b]	Energy & Resource Solutions. ERS *Measure Life Study*.: Prepared for the Massachusetts Joint Utilities, Oct. 10, 2005.
[b,1]	Table 1-1.
[b,2]	pp. 4-9.
[c]	California Public Utilities Commission, 2008 Database for Energy-Efficient Resources, Version 2008.2.05, Dec. 16, 2008, EUL/RUL (Effective/Remaining Useful Life) Values, MS Excel Spreadsheet.
[c/#]	Row number.
[c/#*]	Similar measure to row number; row number used.
[d]	Gas chiller measure life was set by the CT DPUC in their decision in Docket 05-07-14, in response to Public Act 05-01, "An Act Concerning Energy Independence". Dec. 28, 2005, p. 29, Table 4.
[e]	Energy & Resource Solutions (ERS), *Process Reengineering for Increased Manufacturing Efficiency Program Evaluation*, Mar. 26, 2007, pp. 1-5.
[f*]	Efficiency Maine TRM, 3/5/07, p. 91. Similar measure.
[g]	Energy and Environmental Analysis, Inc. *Steam Traps Workpaper for PY2006-2008*. Prepared for Southern California Gas Company, Dec. 2006, p. 14, Section 9.1.
[h]	Veritec Consulting, "*Region of Waterloo Pre-Rinse Spray Valve Pilot Study Final Report*", Jan. 2005, Executive Summary.
[i]	Appliance Magazine. *U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels*. Jan. 2010. p. 10.
[j]	GDS Associates, Inc. (2009). *Natural Gas Energy Efficiency Potential in Massachusetts*. Prepared for GasNetworks; Table B-2a.
[k]	ENERGY STAR commercial kitchen equipment savings calculator, at: https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator_0.xlsx.
[l]	Adjusted measure life, estimated based on residential lighting market saturation trends, penetration, and hours of use from NMR, *Connecticut LED Lighting Study Report (R154)*, Jan. 2016.
[m]	Estimated.
[n]	As part of the program, the Companies are providing 3 years of continual monitoring and check-ins with customers and expect savings to persist on average for at least one year beyond the 3 years of direct support. Measure life also supported by evaluated results of similar programs. See SBW Consulting, Inc. & The Cadmus Group, *Industrial Strategic Energy Management (SEM) Impact Evaluation Report*, February 2017, and CEE, *2016 Strategic Energy Management Program Summary*, Nov. 21, 2016

Table 4-7. Commercial measures with blended retrofit EULs

Description	Remaining Useful Life	Retrofit[8]	Lost Opportunity[8]
Automatic Photocell Dimming System	N/A	9 (a)	10 (a)
Fixture (LED)	N/A	13 (a)	15 (a)
Fluorescent Lighting System Power Reduction Control	N/A	9 (a,*)	N/A
Occupancy Sensor	N/A	9 (a)	10 (a)
Sweep Controls/EMS Based Control	N/A	10 (a,*)	15 (a,*)
Energy-Efficient Motor	N/A	15 (a)	20(a)
2-Speed Motor Control in Rooftop Unit	N/A	13 (a,*)	15 (a,*)
Cooling Tower Alternates	N/A	13 (m)	15 (c/45*)
Dehumidifier	N/A	13 (m)	15 (m)
Economizer - Air/Water	N/A	7 (a)	10 (a)
Energy-Efficient Motor	N/A	15 (a)	20 (a)
Variable Speed Drive	N/A	13 (b,1)	15 (b,1)
EMS/Linked HVAC Controls	N/A	10 (a)	15 (a)
Enthalpy Control Economizer	N/A	7 (a)	10 (a)
New/Additional EMS Points	N/A	10 (a)	15 (a)
Heat Recovery from Refrigeration System	N/A	10 (c/80)	13(m)
Air Compressor	N/A	13 (b,1)	15 (b,1)
Energy-Efficient Transformer	N/A	15 (a,*)	20 (a,*)
Energy-Efficient Motor	N/A	15 (a)	20 (a)
Plastic Injection Molding Machine	N/A	13 (m)	15 (m)
Refrigerated Air Dryer	N/A	13 (b,1)	15 (b,1)
Variable Frequency Drive	N/A	13 (b,1)	15 (b,1)

For residential measures, the PSD states, "The residential programs use a slightly different definition of 'retrofit' savings than C&I programs. Where 'retrofit' measures in C&I utilize a blended 'retrofit' lifetime, residential measures utilize a two-part lifetime savings calculation. For early retirement, savings includes two parts: (1) the retirement savings piece that lasts until the end of the remaining useful life ('RUL') of the existing equipment, after which (2) lost opportunity savings continue until the last year of the retrofit measure's effective useful life ('EUL'). This is illustrated by Chart A4-1."

The following table shows the residential measures where dual baseline calculations are currently required in the CT PSD.

Table 4-8. Residential measures using dual baseline

Measure	Retirement RUL[14]	Lost Opportunity EUL[9]
Air-Source Heat Pump	5 (b)	18 (c,1)
Boiler (Gas)	5 (b)	20 (a)

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[14] *References Per CT PSD*

[a]	*Appliance Magazine. U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels.* Jan. 2010. p. 10.
[b]	California Public Utilities Commission, 2008 Database for Energy-Efficient Resources, Dec. 16, 2008. Available at: http://www.deeresources.com/deer0911planning/downloads/EUL_Summary_10-1-08.xls, last accessed May 31, 2011, Version 2008.2.05.
[c,1]	Table 1.
[p]	Conservative estimate, based on 13-year median age for room air conditioners found in NMR, *R1706 Residential Appliance Saturation Survey & R1616/R1708 Residential Lighting Impact Saturation Studies*, DRAFT Report, Jun. 28, 2019.

Central Air Conditioning System	5 (b)	18 (c,1)
Furnace (Natural Gas)	5 (b)	20 (b)
Package Terminal Heat Pump	5 (b)	18 (c,1)
Clothes Washers, Clothes Dryer	4(b)	11(a)
Dehumidifier	4(b)	12(c,1)
Dish Washer	4(b)	10(a)
Freezer	4 (8)(b)	11(a)
Refrigerator	5 (10)(b)	12(a)
Room A/C Unit	4(b)	13(p)

4.4.2 Review of CT tracking data

Evaluators collected tracking data from both utilities for all programs in their portfolio. For the purposes of this review, evaluators grouped the tracking data and checked three measures within the commercial portfolio: boilers, chillers, and SBDI lighting. Evaluators reviewed the data and found the following number of projects for those three measures:

Table 4-9. Data review summary

Measure	Programs with Projects	# of Projects Identified	Total # of Projects Using Blended ML or RUL
Chillers	EO, ECBMR, ECBER, ECBNC	17	1
Boilers	EO, ECBMR, ECBER, ECBNC, EC, NE	71	0
SBEA Lighting	SBEA	21,062	21,062

None of the measures in the tracking data specify the event type (retrofit, lost opportunity, NC). Therefore, evaluators were only able to review the total measures and which EULs were used in the lifetime savings calculations. One chiller project appeared to use an RUL in the calculation, as the EUL used was a number between 20 and 23 years. All condensing boiler projects used the lost opportunity lifetime of 15 years, and the SBEA lighting projects used lifetimes of 5, 8, 9, 10, or 13 years – all of which are less than the lost opportunity lifetime, but it was unclear what the driver for lifetime selection was.

Based on this review, the impact of savings could not fully be quantified and will depend on the values implementers are using behind the savings that are not in the tracking data. Examples of these values include the existing efficiency, equipment loads, etc. The worst-case scenario would represent projects using an existing equipment efficiency over the entire EUL of the lifetime savings period. If this is the case, boiler and chiller measures could see a reduction of 30-40% of their lifetime savings. However, it is also possible that there could be projects that are being claimed as ROF and should be classified as ER. These cases would see an increase in savings.

CT implementers have started adopting practices in the PSD such as using the blended measure lives where they apply. This will somewhat mitigate the impacts of moving to a full dual baseline treatment. We do expect the largest impact to the portfolio to be from a reduction in savings for lighting projects that are outside of SBEA. These projects currently use a slightly reduced measure life for retrofit projects. As they move towards using a true dual baseline approach this is likely to result in a decrease in savings. MA observed a 27% reduction in savings for these measures and we expect a similar reduction in CT.

While an overall decrease is expected, there may be pockets of increased savings as well. From discussions with program staff early in the process, the SBEA program for one of the utilities assumed lost opportunities for all their measures. This is one area which would suggest a potential increase in savings with a dual baseline adoption.

5   PHASE II – EARLY RETIREMENT PROGRAM EVALUATION PLAN

The second phase of this evaluation is intended to be an impact evaluation of the early retirement programs that have been released in CT. To date, four early retirement programs have been launched: two rounds of chiller programs, both targeting larger chillers (600+ tons); a boiler program; and a rooftop unit program. These programs have been competitive bid programs that accept applications from individual customers or implementers.

Table 5-1 shows the participation numbers for each of the programs.

Table 5-1. Eversource Early retirement participation

Program	Number of Awarded Projects
2019 Chiller Program	4
2020 Chiller Program	1
2020 Boiler Program	1
2020 RTU Program	11
Total	17

In total, 24 projects have been awarded through these four programs, 17 by Eversource and 7 by UI. The table shows the breakdown of the Eversource projects as the UI breakdown was not available at the time of completion of this report. Savings have not been claimed for any of these programs yet, as at the time of completion of this document the projects are just being installed for the first chiller program that was released in 2019. The original evaluation plan laid out tasks including sample design, desk reviews, and customer interviews. The primary reason the review included desk reviews was that the key information to be reviewed for incented projects in these programs was program eligibility, measure event type, and baselines. Going on-site to measure equipment performance is not nearly as valuable to the program as evaluators confirming the program eligibility and reviewing the preponderance of evidence collected for completeness and program qualification.

With the current status of the programs, the evaluation team recommends that as an immediate next step desk reviews and customer interviews be completed for all 20 of the awarded projects to date. This can provide near-real-time feedback to the early retirement program implementers as well as the EA team as to how the decision and documentation process is going so far. Despite not having claimed savings yet, this can provide an estimate of what the desk reviewed realization rate would be for these projects. The evaluation team believes this will provide more immediate value to the program implementers than waiting for more participation prior to evaluating. The team can then re-assess the plan moving forward once that review is complete.

In order to complete this review, the evaluation team will need to request program data for the projects that have been approved to date. Examples of the requested files may include but will not be limited to:

• Project application, savings calculations, individual site reports, photos, M&V data if applicable, project invoices

• Possibly billing data if determined it would be valuable for any of the individual programs

The evaluation team will follow data request procedures when requesting these files.

APPENDIX A. STATE CASE STUDY COMPARISONS (MA, NY, CA)

The following provides excerpts and documentation of several state by state pieces of documentation that were reviewed as part of our research.

APPENDIX A

A-1 Assigning Event Type

The following provide state by state findings with respect to assigning an event type

A.1.1 Massachusetts

An assignment of early retirement (ER) event type is generally used when replacing equipment that is fully functional. However, there are circumstances in which event type could be considered early retirement *or* replace-on-failure:

1. Existing equipment has failed but repair is a viable option (e.g,. repair cost is < 20% of replacement cost, has run in failed mode > 2 years)
2. Existing equipment is still functional but beyond its useful life

To assign ER vs. ROF event type, evaluators have to consider the plausibility of the customer continuing operations in the pre-retrofit state. A "preponderance of evidence (PoE)," or a "greater weight of evidence" favoring one condition over the other (customer is likely vs. unlikely to continue operating in the pre-retrofit state) must be used by evaluators to determine event type. Examples of evidence that support the determination of one event type over the other:

Evidence of Early Retirement	Evidence of Replacement on Failure
- Evidence that the prior equipment was functional - Documentation that shows the replaced equipment was less than 2/3 through its standard EUL - The replaced equipment was beyond 2/3 of its EUL but there is documented evidence of commitment to long-term maintenance to the prior equipment - The replaced equipment was beyond 2/3 of its EUL but there is documented evidence of a facility's inability to make the capital commitment necessary to replace it, even if major repairs are needed - The facility managers had an inventory of back-up equipment similar in efficiency that they could have used to replace the old equipment had it failed	- Evidence that the prior equipment was not functional - Prior to measure implementation the replaced equipment was facing a repair, and that customer describes the prospective repair cost as being significant (>10%) relative to the replacement cost. - Evidence of actual or impending expected catastrophic failure of equipment that is less than 2/3 through its EUL - Documentation showing the replaced equipment was more than 2/3 through its standard EUL and there is no exceptional evidence that the facility couldn't make capital available to replace it - Simple payback calculations show that the benefit of replacing the old equipment with new baseline equipment is compelling: The annual savings approaches cost of replacement or incremental cost compared to repair.

If there is no evidence for either ROF or ER, in most cases the evaluator should define the baseline using the ROF condition.

A.1.2 California

What is accelerated replacement? According to the T1WG Baseline guidance, "the accelerated replacement category includes replacements of existing equipment with nominally higher efficiency equipment and where the preponderance of evidence supports that a) the existing equipment would have remained in operation for at least the remaining life of the existing equipment, performing its current service requirement and b) the energy efficiency program activity induced or

accelerated the equipment replacement. The RUL must be at least one year to qualify as Accelerated Replacement."[15] Note that even though the AR definition above says that PoE must demonstrate that the equipment would have remained in operation through its remaining useful life, equipment past its EUL *is* eligible for AR treatment[16].

Circumstances in which event type could be considered accelerated replacement as opposed to normal replacement are any measures for which the preponderance of evidence guidance is applicable. These measures include "custom or deemed retrofit measures that are delivered through downstream programs… that do not otherwise default to an existing conditions baseline per policy of D. 16-08-19 and Resolution E-4818."[17] The PoE guidance does not apply to weatherization, add-on, or BRO measures; measures incentivized through upstream or midstream programs; or measures whose savings determinations are determined through NMEC, RCT or experimental design. Those measures will utilize code or existing baselines. This is illustrated in Table 1.1.[18]

Table 1.1 Measure Level Baseline Guidance

Alteration Type	Delivery	Savings Determination		Customer Class	Installation Type	
					Weatherization / Add On / BRO	Efficient Equipment (ER/NR)
No Existing Condition	All				Code	
Existing Buildings	Upstream/ midstream	All			Code	
	Downstream	NMEC, RCT, exp. design			Existing	
		Calculated			Existing	Direct-to-Decision/ Direct-to-Default POE**
		Deemed			Existing	Deemed POE
Non-Building projects including industrial and agricultural processes	SEM* programs	NMEC	All		Existing	
	Other (not-SEM) programs	All			Existing	Direct-to-Decision/ Direct-to-Default POE**

*Strategic Energy Management programs are currently under development in a collaborative effort of Commission staff and Program Administrators.
**"Incentive Tiered POE" will apply here only following Commission approval of Tier 1 and Tier 2 preponderance of evidence requirements. These requirements are not adopted in this Resolution but assigned to the Track 2 Working Group, per ordering paragraph 25.

Event type is assigned differently for custom vs. deemed measures:

A.1.2.1   Assigning event type for custom measures

Determination must assess (1) the continued viability of the pre-existing system, and (2) the program influence on the decision to retire the system early.

"A PoE-based assessment is subjective by definition… To make the evidence evaluation process more predictable, transparent, and practical to apply, this guide provides a scoring system that shows the approximate relative value of different types of evidence assembled to determine AR versus NR. The process retains a degree of subjectivity and does not guarantee an outcome."[19] The PoE guidance document provides examples of evidence that support or disprove the continued viability of the pre-existing system and program influence. (The list is not meant to be exhaustive.) Evidence can either be strong, moderate, corroborative, or inconsequential, and are assigned scores of 3, 2, 1, or 0, respectively, according to the quality or strength of the piece of evidence, as shown in the table below[20]:

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[15] T1 Working Group Report, Baseline Guidance Document V1.0 (Dec. 7, 2016), pgs. 12-13

[16] Resolution E-4939 (pg. 27)

[17] Resolution E-4818, pg. 55

[18] Resolution E-4818, pg. 48

[19] T1 Working Group Report, Accelerated Replacement Using Preponderance of Evidence, pg. 5

[20] This is a modified version of the table that appears in the T1 Working Group Report, Accelerated Replacement Using Preponderance of Evidence, pg. 6 – to save space, we've removed the "Inconsequential" column, which does not include any examples in the document.

Table 2: Examples of evidence for and against continued equipment viability and program influence and relative value

Descriptor and Approximate Relative Value:	Strong, 3	Moderate, 2	Corroborative, 1
Evidence of Viable Operation through RUL			
Equipment serves its current load	Directly collected customer or implementer pre-installation metered data showing capacity is met.	IOU or independent site inspection report validates claim. Photos of EMS screen shots showing operation in expected bounds.	Customer inspection report. Photos or videos of system operating with customer statement to this effect.
The load served is expected to remain the same through the RUL period.	Interviews confirm and independent analysis of historic and projected trends show use/production is not changing.	PA or implementer statement that use/production is not expected to change.	Customer signed statement that use/production is not expected to change.
Evidence of Against Viable Operation through RUL			
Equipment is not operating or is poorly operating.	Repair costs > 25% of replacement costs, or customer interview indicates repair is an unattractive option.	Documented history of escalating repair costs, performance degradation, or user dissatisfaction.	Customer describes recent poor performance.
The load served is changing within the RUL period	Interviews confirm and independent analysis of historic and projected trends show use/production is changing.	Customer expects changes in load and can describe basis and expected magnitude of change.	Customer expects changes in load but without strong indication of timing, magnitude or certainty of change.
Evidence of More Program Influence			
Explicit customer communications concerning measure options	Customer formal affidavit affirming influence.	Customer email or other informal statement affirming influence.	
Timing/Customer Communications Trail	Documents form formal presentation of measure by program to customer, with attendees and discussion noted.	Absence of project in Year 1 CapEx plan. Documented intervention after that plan. Presence of budget set- aside for project in Year 2 CapEx plan.	Email chain showing program marketing outreach to customer and their response requesting follow-up for the measure.
History of Energy Efficiency Activity	The measure is Stage 2 of a previously funded Stage 1 event for which influence already has been demonstrated.	Documented prior engagement between implementer and customer resulting in efficiency project(s) for which influence was demonstrated.	Documented prior engagement between implementer and customer resulting in efficiency project(s).
Significant financial impact	Payback is reduced by 35% or more, or Payback time is reduced by 20% or more plus reduced from greater than 2 or 3 years to less.	Payback is reduced by 25% to 35%, or Payback time is reduced by 20% or more plus reduced from greater than 5 years to less.	Payback is reduced by 20% to 25%.
Evidence of Less Program Influence			
Timing/Customer Communications Trail	Communications that indicates the customer decided to install a measure before program engagement.		Customer's CapEx plan showed the measure before program intervention.
Incentive is a relatively small benefit.	Payback is reduced by 5% or less.	Payback is reduced by 5% - 15%	Payback is reduced by 15% - 20%
Equipment fulfills a regulatory mandate.	Equipment can be brought to compliance, but at high economic or other cost.	Equipment can be brought to compliance at moderate cost, nominally 20% to 40% of replacement cost.	Equipment can be brought to compliance at low cost, nominally 5% to 20% of replacement cost.
Corporate Sustainability Policy		Evidence that the customer prioritizes efficiency over other comparably economically attractive investments.	Customer has a sustainability policy and there is evidence that it has active support (not greenwashing).
Non-Program Energy Efficiency Investments	The customer previously installed the same measure at the same facility without an incentive.	The customer previously installed the same measure at another facility with or without an incentive.	The customer has a history of energy efficiency investments outside of California.
Proactive Replacement Scheduled	Customer indicates scheduled refresh is planned before program involvement.		The project timing coincides with a market-typical renovation cycle.

For a measure to qualify as AR, the sum of scores for evidence in favor of continued equipment viability must exceed the scores for the evidence against, and the same goes for program influence.

It is the implementer's responsibility to collect and present this evidence. "Implementers need not submit evidence associated with every row. If a compelling amount of evidence is assembled there is no need for more.[21]" If the implementer does have a lot of information to submit, the guidance document states that the submittal package should include a cover memo or completed template that will help reviewers navigate the package, which could include the measure description, a

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[21] T1 Working Group Report, Accelerated Replacement Using Preponderance of Evidence, pg. 5

summary of the overall measure timetable to date describing the stages of measure development and points of influence, what each document demonstrates, age of relevant pre-existing equipment and its EUL (if known), and a scoring summary.

All of the above has been codified by Resolution E-4818. Other considerations in the guidance document are not yet adopted:

Simplified site-based PoE protocol for custom and deemed measures: The document acknowledges that a full PoE assessment is an intensive process and for some measures (i.e. low uncertainty, low impact or low ability of the process to improve the AR assessment) a simplified approach to PoE is warranted. The document suggests a tiered approach with each tier corresponding to the rigor of the assessment and having their own "eligibility" and evidence requirements:

1. Full Rigor: applicable to projects with incentives over $100,000
2. Tier 1 (Medium Rigor): applicable to projects with incentives between $25K and $100K
3. Tier 2 (Low Rigor): applicable to projects with incentives less than $25K

Resolution E-4818 adopted the tiered approach but did not adopt the specific PoE requirements for Tier 1 and 2 (the standard PoE requirements explained above are applied in a Full Rigor assessment), so use of the tiered approach is prohibited until specific requirements for the tiers are adopted.

A.1.2.2 Assigning event type for deemed measures

For deemed measures, a program-level assessment (rather than site-specific which is required for custom measures?) is an option. A program level-assessment determines that all participant measures are either:

1. Accelerated replacement
2. Normal replacement
3. Could be either AR or NR, but the program shows under which market conditions they are one or the other
4. They're a predictable blend of the two (in which case a single weighted average deemed savings value would be used for all program measures).

Determination must rely on population-market research type data, i.e., data collected for the subject population through market or participant study rather than on-site performance assessment. But, as with custom measures, deemed measure evidence of AR must demonstrate both the continued viability of the pre-existing system and program influence on the decision to retire equipment early.

This PoE approach requires submission of program design and market data supporting the AR replacement claim as well as later submission of program data demonstrating the degree of accuracy of the design assumptions. The design document should describe rules and defining measures and markets expected to have high levels of accelerated replacement for commission approval, and the customer screening process. It also should describe data to be collected on-site to demonstrate that the customer/measure qualifies. Data collected is expected to be made available for evaluation. An interim approval process should be expected for new programs or new measures within programs, until sufficient data are collected to support or refute the accelerated replacement claim.

A.1.3 New York

A.1.3.1 Early replacement

Early replacement was defined in an October 18, 2010 order as the replacement of equipment before it reaches its EUL. To assign an ER event type, the PA must substantiate that the age of the equipment in place is less than its EUL. If the PA can't verify this, the replacement must be screened as normal replacement.

A.1.3.2   Special circumstances

Special circumstances were introduced in an October 18, 2010 order. A special circumstance replacement is a replacement of equipment operated by customers who are influenced by initial costs more than by life cycle economics. These customers include those with insufficient capital, a split incentive (such as a landlord incurring cost to provide a tenant benefit), short time horizons, and/or other factors which tend to prevent long range economic decision-making regarding the installation of high efficiency equipment. Applicable only to C/I machinery and multi-family central systems.

To be treated as SC, the circumstance must meet all the following criteria[22]:

- Equipment age must exceed its prescribed EUL by at least 25%
- If it can't be determined that the equipment is at least 125% of its prescribed EUL, existing equipment of most types must consume at least 20% more energy than the new high efficiency equipment to do the same amount of work (and at least 35% for chillers)
- There is a history of significant repair or replacement with used equipment
- The prospective next repair or replacement is likely to be much less expensive than replacement with new higher efficiency machinery

If these criteria are met, the program can capture savings against an existing baseline for 25% of the new equipment's EUL (called the default functional period, or DFP) as well as savings against code for the remainder of the new equipment's EUL.[23]

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[22] Outlined generally in Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Consolidation and Revision of Technical Manuals (issued October 18, 2010). First two bullets further defined in Case 07-M-0548, Energy Efficiency Portfolio Standard (EEPS), Order Approving Modifications to the Technical Manual (issued July 18, 2011).

[23] This was also established in the July 18, 2011 Order.

A-2   Determining RUL

The following are state by state findings with respect to determining RUL.

A.2.1 Massachusetts

Baseline Framework, pg. 19: "Given the deemed EUL, estimating site-specific RUL depends on knowing equipment age at replacement (RUL = EUL – replaced equipment age). The estimated age at replacement is vulnerable to substantial measurement error, as it typically depends on recollections of installations five to twenty years prior, absent the production year being stamped on the nameplate, and the implementer having saved documentation of it such as by photographing the nameplate prior to removal or copying the original filed sales invoice. The evaluator should attempt to collect site-specific age at replacement to inform future research on measure EULs and RULs, but should only provide the estimate if it is definitive and documented. **It should not use it for project retrospective gross savings evaluation even if provided. For retrospective use in impact evaluation the evaluator should use the RUL value of one-third of the EUL** unless evaluators previously have developed a program- or measure-specific RUL or the evaluation is of a unique measure that has exceptional available RUL data."

A footnote here says "as cited in the TRM, the Massachusetts Common Assumptions default RUL is one-third of the EUL. This is a reasonable compromise to balancing research cost and improving lifetime savings accuracy. This basis has also been used in California… The MA TRM uses the default for most retrofit measures. Selected measures use other adjustments based on technology-specific research."

A.2.2 California

Energy Efficiency Policy Manual (does not have page numbers): "For the case of program-induced accelerated replacement, the remaining useful life (RUL) of the existing equipment is to be used as the starting assumption for the period of accelerated retirement. To establish the period of accelerated retirement, we recommend using one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values (see Summary of effective useful life (EUL)-RUL Analysis for the April 2008 Update to DEER, p.2). CPUC staff has been given flexibility to utilize alternative remaining useful life values, based upon compelling project or technology specific evidence (D.12-05-015, p.348)."

A.2.3 New York

TRM v7, pg. 705: "The RUL, the full savings, and the full costs are provided by the program implementer. Note that documentation for PA estimates of these data must be retained for possible Staff review." A footnote notes that "upon request, Staff will provide a suggested questionnaire to assist in the determination of the RUL."

A-3 Dual Baseline Calculations

The following show state by state findings for dual baseline calculations.

A.3.1   Massachusetts

Assigning an ER event-type to an event does not automatically mean a dual baseline will be used to calculate savings.

Event Type *Alternate terms used*	Application	Examples
Early replacement (ER) with remaining useful life (RUL) consideration *"retrofit" in MA TRM*[24] *"early retirement"* *"accelerated replacement"* *"advancement"*	ER means the replaced system was fully operational. With RUL consideration means that the replaced system had a definable remaining life and the baseline efficiency for that system is certain to be different (usually higher) at the end of that remaining life than it was when it was replaced.	It is 2018. A customer replaces an operational 10-year old rooftop unit (RTU) with a high efficiency RTU. RTUs have an average effective useful life (EUL) of 15 years. The federal efficiency standard increases in 2023. The baseline is the replaced RTU's efficiency for the remaining 5 years of measure life, and the 2023 code efficiency in the 10 years after that.
Early replacement – without remaining useful life consideration	ER means replaced system was fully operational. Without RUL consideration means that either the replaced system had no definable period for end of life or the baseline efficiency for that system is not expected to be different at the end of its remaining life than it was when it was replaced.	A high efficiency fractional hp motor replaces a working motor installed in 2016. There is no standard that is expected to increase the minimum efficiency of this equipment compared to the pre-existing efficiency, so the baseline efficiency is that of the replaced motor for the entire measure life.

In MA, the pre-installation condition is the baseline for at least the first-year savings. After that, evaluators must determine whether or not to use a dual baseline to calculate savings. This decision will depend on whether savings will vary as a function of time due to changing codes, standards, and/or ISP after the RUL of the replaced equipment has passed (i.e. does the market baseline at the time of measure installation differ from the projected baseline at the time the replaced equipment would have naturally failed?). If so, dual baseline principles apply. Reasons for replaced system efficiency to materially differ from baseline efficiency at end of RUL can include:

- Known code or standard change will occur before the end of RUL
- Trends in standard practice will change the baseline efficiency
- The baseline efficiency will not change but already is materially different from pre-installation efficiency

"Early replacement measures should be evaluated as single baseline measures without dual baselines if the preexisting equipment likely would have been used over the full EUL of the measure had it not been replaced with the incentivized equipment. Specifically, a single baseline should be used for measures for which there is compelling evidence of commitment of long-term maintenance to the prior equipment."[25]

"If the replaced system efficiency is substantially the same as the projected baseline efficiency at the end of the replaced equipment's RUL, the measure is effectively a single baseline measure even if it is dual baseline in principle."[26]

"If the future baseline has been researched and projected by evaluators in an ISP study or similar, the research should be used to decide if dual baseline is applicable and, if so, what the out-year baseline level should be. (It is possible for this research to conclude that a single baseline approach should be taken.)"[27]

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[24] In most cases. The MA TRM Glossary defines "retrofit" as "the replacement of a piece of equipment or device before the end of its useful or planned life for the purpose of achieving energy savings. 'Retrofit' measures are sometimes referred to as 'early retirement' when the removal of the old equipment is aggressively pursued." While the TRM typically associates retrofit with RUL-type measures, there are some measures where the term is used in the context of measures without RUL or discounted EULs.

[25] MA Baseline Framework, pg. 15

[26] MA Baseline Framework, pg. 15

[27] MA Baseline Framework, pg. 15

A.3.2 California

Per the Energy Efficiency Policy Manual[28], dual baselines must be utilized for program-induced accelerated replacement measures.

A.3.3 New York

The NYS TRM and Orders established that a dual baseline approach should be taken to conduct a TRC analysis of ER projects. "The standard ER condition involves a customer who replaces equipment before it reaches the end of its EUL. That is, the equipment is fully functioning and would continue to function for some period of time referred to as the remaining useful life (RUL). However, the customer is induced by the program to replace this existing equipment with more efficient equipment. It is assumed that at the end of the RUL, absent the program, the customer would have installed equipment that would meet the existing efficiency code or appliance standard, i.e., equipment that represents the market average efficiency or the efficiency that had become the industry standard (referred to as the code/standard equipment)… Energy savings in this example would consist of two portions… to carry out these calculations, information on two (dual) baselines is required, the energy use of the pre-existing equipment and the energy use of code/standard equipment. Information on energy use for the high efficiency equipment provided through the program will also be required."[29]

There are exceptions for particular measures, though. "The EUL for a given measure is obtained from Table M-1, which is a compilation of the EULs for all the relevant measures in the consolidated Technical Manual effective January 1, 2011 that could qualify for early replacement (below)… Table M-1 also presents the normal replacement baseline equipment against which each of the 29 measures covered in this table is compared."

NOTE: For measures assigned an **a**, the efficiency of the old in place unit is still the common practice or no new standards have been adopted, i.e., the baseline for the full savings and the incremental savings are the same. As a result, the ratio of incremental to full savings is near 1.0, meaning that a PA can claim the full savings for the entire EUL of the new equipment (areas X and Y in Figure 4, below Table M-1). Therefore, the lookup tables do not apply.

For these measures assigned a **b**, the high efficiency equipment subsidized by the program is consistent with current code or standards. For these measures, the incremental savings are zero and thus the ratio of incremental to full savings is 0.0. This means that a PA can claim full savings for only the RUL (area X in Figure 5, below Table M-1), after which the high-efficiency replacement would have occurred anyway. Therefore, the lookup tables do not apply.

Table M-1. Early Replacement Measures, EULs and Baselines

Measures	EUL	Normal Replacement Baseline
Heat Pump Water Heater: Residential	10	Code Electric Storage Water Heater
Room Air Conditioner: Residential	10	EPACT Room Air Conditioner
Clothes Washer: Single Family: Residential	11	EPACT Clothes Washer
ENERGY STAR Dishwashers: Residential	11	EPACT Dishwasher
Water Heater: Gas: Residential	11	Code Gas Storage Water Heater
Energy Star Dehumidifier: Residential[a]	12	Standard Efficiency Dehumidifier
Refrigerators: Nonresidential	12	EPACT Refrigerator
Indirect Water Heaters: Residential	13	Code Gas Storage Water Heater
Water Heater: Electric: Residential	13	Code Electric Storage Water Heater
Clothes Washer: Multi-Family Residential	14	EPACT Clothes Washer
Air Compressor Upgrade: Nonresidential	15	Standard Efficiency Rotary Screw
Central Air Conditioning: Residential	15	Code Central AC with gas heat
Central Air Source Heat Pumps: Residential	15	Code Central Air Source Heat Pump

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[28] D.11-07-030 (pg. 23) says the EEPM has required dual baseline approach for accelerated replacement measures since August of 2008.

[29] NYS TRM pg. 702

Cool Roof: Nonresidential[a]	15	Standard Roof
Cooling Tower: Nonresidential[a]	15	Standard Efficiency Cooling Tower
Efficient Air-Cooled Refrigeration Condenser:	15	Standard Efficiency Refrigeration
Indirect Water Heaters: Nonresidential	15	Code Gas Storage Water Heater
Motors: Nonresidential[b]	15	EISA Minimum Efficiency Motor
Packaged Air Conditioners (Central AC): Nonresidential	15	Code Packaged Air Conditioner
Packaged Air Source Heat Pumps (CAC Cooling Only):	15	Code Packaged Air Source Heat Pump
Water Heaters: Nonresidential (Gas & Electric)	15	Code Storage Water Heater
Refrigerators: Residential	17	EPACT Refrigerator
Chillers: Nonresidential	20	Code Chiller
Gas Furnaces and Boilers: Nonresidential	20	Code Furnace and Boiler
High Efficiency Gas Furnaces: Residential	20	Code Furnace
High Performance Glazing: Nonresidential[b]	20	Code Glazing
High Performance Windows (Gas Heating Only):	20	Code Window
Instantaneous Water Heater: Residential	20	Code Storage Water Heater
Gas Boilers: Residential	25	Code Boiler

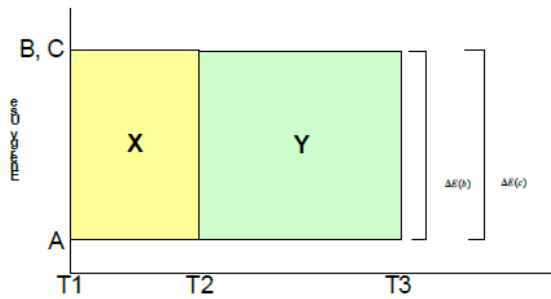Figure 4. Efficiency of the Old In Place Unit Is Still the Common Practice Or No New Standards

Figure 5. High Efficiency Equipment Subsidized by the Program Is Consistent with Current Code Or Standards
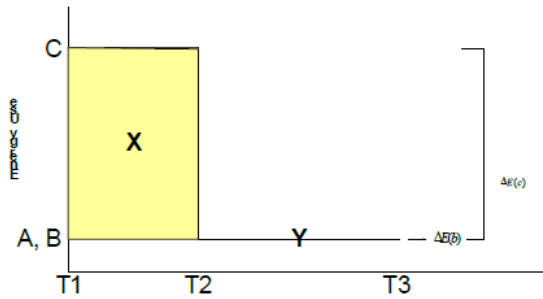
$$\Delta E(c) = C - A$$
$$\Delta E(b) = B - A$$

C = Energy use of pre-existing equipment
B = Energy use of equipment that meets code
A = Energy use of the efficient equipment rebated through program
T1 = Date on which new efficient equipment is installed
T2 = Date on which existing equipment was expected to have failed
T3 = Date on which the new efficient equipment is expected to fail
T3 – T1 = Expected effective useful life (EUL) of the new efficient equipment
T2 – T1 = Expected remaining useful life (RUL) of the pre-existing equipment
T3 – T2 = Expected remaining EUL of the new efficient equipment

A-4   Impacts on program savings

The following is additional information on impacts on program savings.

A.4.1   Massachusetts

The Massachusetts Commercial/Industrial Baseline Framework, rolled out in April 2017, requires that starting in 2019, PAs use dual baseline calculations to determine lifetime gross savings for retrofit projects unless it can be established that the baseline would not have changed over time due to evolving codes or standard practice. "Prior to 2019, dual baseline effects were factored into the measure life for a few measures as an adjusted measure life (AML)."[30]

To help PAs prepare for reporting in 2019 and advise PAs about the potential impact of dual baseline practices on lifetime savings, evaluators of the PY2016 C/I Custom Gas Program (DNV and ERS) included a desk review of a sample of projects (86 measures across 55 sites) to examine the frequency and impact of baseline changes, dual baseline calculations, and lost opportunity vs. retrofit measure reclassifications. (Note, this was solely for the informational purposes of the PAs and EEAC; results were included in a desk review memo and not included in evaluated metrics.) Fifty-five sites were included in the sample and each was assigned to an engineer for the DR. "The engineer established the measure event type and baseline based upon a preponderance of evidence gathered from the project files (technical assessment study report, measure cost-benefit screening document, savings calculation files, and other file information) and from an interview with the site contact. A new DR data collection instrument was designed to focus on measure specific assessments of:

- Measure event type classifications (five types): retrofit – single or dual baseline, add-on – single or dual baseline, and lost opportunity (includes replace on failure, end of life replacement, and new construction)
- Applicant and evaluator measure effective useful life (EUL) of pre-existing equipment
- Applicant baseline
- Evaluator assessment of the baseline (for retrofit: pre-existing condition and for lost opportunity: industry standard practice or unique)
- Assessment of the impact of a baseline change on the measure savings

If the engineer concluded that the measure event and/or baseline as defined by the PA were not reasonable, the engineer changed them and quantified the impacts of the new baseline on the measure tracking savings. If the reviewing engineer could not assess the measure event and/or the baseline, the engineer requested assistance from the BAG (Baseline Advisory Group). The BAG's role was to support the project engineers and ensure that they assessed the measures in a consistent manner, flagging measures for potential ISP baseline research."[31]

Establishing measure event type: The evaluation team reclassified the measure event type for 33 measures – three measures were reclassified from retrofit to lost opportunity, and the remaining 30 measures were reclassified from retrofit to add-on. Only one reclassification (from retrofit to lost opportunity) had an impact on savings; program savings were decreased by less than 1% (-0.39%).

Establishing baseline: No measures were determined to be dual baseline as "the market is stable and there are no expectations of efficiency improvements within the remaining useful life of the measure."[32]

Evaluators of the PY2017 C/I Custom Gas Program (still DNV and ERS) completed a similar desk review that estimated lifetime savings for all retrofit measures (41 measures at 31 sites)) by applying dual baseline methods and by using the EUL

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[30] C&I Measure Life Study: Project MA19C02-B-EUL Final Report (pg. 27)

[31] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (P79)), pg. 3 of 18

[32] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (P79)) (2016), pg. 9 of 18

specified in the 2016-2018 TRM. "The Team calculated that the PY2017 lifetime savings would be reduced by about 1% when applying dual baseline methods and 4% when revising measure lives to better match TRM recommended EULs."[33]

The same method as described above (for the PY2016 eval) was used and the same data was input into a data collection template workbook. Revisions of measure type and lost opportunity baselines were reviewed by the BAG. "The BAG has been in operation for about two years and has a growing record of reasoning and decisions from past project reviews. The BAG references past projects and the Baseline Framework in making baseline decisions about a project under review. The Baseline Repository will eventually record BAG decisions for new measures. The Repository update is intended to include ISP research which may be a more orderly pathway for queueing up ISP research."[34]

Establishing measure event type: "The evaluation team reclassified the measure event type from retrofit to add-on for 17 measures installed at 15 sites. Although lifetime savings can be impacted by reclassification from retrofit to add-on, it did not for any of the reclassified measures."[35]

Establishing baseline: "The third Baseline Framework practice requires dual baseline treatment of certain early replacement measures. While retrofit measures represent 83% of program savings, not all program lifetime savings are due to measures with a single baseline. The evaluators assigned dual baselines to two retrofit measures and two add-on measures. For retrofit measures, such as steam traps, the market is stable and there are no expectations of efficiency improvements within the remaining useful life of the measure, hence a single baseline is assigned."[36]

Desk review practice #1: "**Measure event type reclassification:** The appropriate reference baseline, either lost opportunity or retrofit, is established based on the preponderance of evidence supporting the selection. Reassignment from retrofit to lost opportunity usually results in lower savings; the converse usually results in more savings."

"The Team notes that the "Memorandum on Dual Baseline Calculation Practices and Assumptions, November 27, 2019" completed as part of P91, reached similar conclusions and included recommendations and considerations for ensuring compliance with dual baseline methods."[37]

DNV, ERS, and others completed an impact evaluation of PY2017 and 2018 custom electric installations for the MA PAs. The measures evaluated were split into custom lighting and custom non-lighting categories. "The results of the study, which were combined with those from the PY2016 study, will be used to report 2019 program savings in the 2020 Plan Year Report."

Lighting: "To determine the impact of using a dual baseline lifetime savings, the evaluators treated all early replacement lighting projects as dual baseline measures. In performing the lifetime savings analysis, all evaluated savings associated with lighting fixture kW reduction are treated as 1/3 of the life using the existing baseline and 2/3 of the life using the 60% outyear savings derating factor (OYF) developed as part of a separate study. As the OYF is updated annually through the lighting market model study, the custom electric impact evaluation will adopt these updates. The DNV GL team used a 15-year measure life for fixture replacement savings and a 9-year measure life for lighting control savings per the Massachusetts TRM. The impacts of the more refined dual baseline treatment caused the weighted evaluated dual baseline lifetime savings totals for the sampled early replacement lighting applications to be 27% less than the single baseline evaluated lifetime savings."[38]

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[33] Impact Evaluation of PY2017 Custom Gas Installations, pg. 3

[34] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (MA19C05-G-CUSTGAS))(2017), pg. D-5

[35] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (MA19C05-G-CUSTGAS))(2017), pg. D-8

[36] Appendix D: Desk Review Memo (Desk Review Results from the Impact Evaluation of Custom Gas Installations (MA19C05-G-CUSTGAS))(2017), pg. D-17

[37] Impact Evaluation of PY2017 Custom Gas Installations, pg. 4

[38] Impact Evaluation of PY2017-18 Custom Electric Installations, pg. 29

Non-Lighting: "For non-lighting lifetime savings estimates, the evaluation team defaulted to using the TRM measure life unless there was a clear established reason to do otherwise, such as change in event type or dual baseline treatment. If the measure life was changed by the evaluator, the change was stated and supported in the site level evaluation report. In total the impacts of the dual baseline treatment on the non-lighting sites caused evaluated savings to decrease by 3%."

Desk review memo – lighting program

"For lighting measures, the PAs accounted for dual baseline in the lifetime savings by reducing the measure life from 15 years to 13 years. That approach did not fully account for the dual baseline. Dual-baseline measures represent 99.95% of the lighting program first year savings. To calculate the changes in the lighting program first year savings because of the dual baseline, the evaluation team used the following approach:"[39]

- Assumptions:

    - PA lifetime: 13 years
    - Evaluator lifetime: 15 years
    - Remaining life of replaced system: 1/3 x 15 = 5 years
    - Savings over the measure lifetime (as defined by PA): 100%

- Calculations and results:

    - Savings over the measure lifetime during the second baseline (used by the PAs for reporting): 60%[40]

$$\text{Ratio of dual baseline to retrofit lifetime savings} = \frac{100\% \times 5\ years + 60\% \times (15\ years - 5\ years)}{13\ years} = 85\%$$

    - Lifetime savings reduction factor = 100% - 85% = 15%

A summary of early replacement measures and their share of program savings is shown below in Table F-11.

Table F-11. Lighting measures - summary of early replacement measures

Parameter	First-Year Program Savings Share	Lifetime Program Savings Share
Retrofit	96.15%	96.09%
Single baseline	0%	0%
Dual baseline	96.15%	96.09%
Retrofit dual baseline change impact on program savings	N/A	-13.41%
Add-on	3.8%	3.85%
Single baseline	0%	0%
Dual baseline	3.8%	3.85%
Add-on dual baseline change impact on program savings	N/A	-0.58%

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[39] Impact Evaluation of PY2017-18 Custom Electric Installations, pg. 110

[40] From P73-MA Baseline Framework Transition-Track A Dual Baselines TWGA CI Portfolio Modelling Findings and Conclusions, March 7, 2018

Desk review memo – non-lighting program:

"While retrofit non-lighting measures represent 52% of non-lighting program first year savings, not all non-lighting program lifetime savings are due to measures with a single baseline. For retrofit measures, the evaluators assigned a dual baseline to all but one measure. The evaluators did not assign a dual baseline to one compressed air leak repair measure because of its short measure life. For add-on measures, the evaluators assigned a dual-baseline to one replacement of a compressed air vacuum pump with an electric pump because its EUL (13 years) is more than 2/3 the EUL of the underlying equipment (15 years for air-compressors). A summary of early replacement measures and their share of program savings is shown below in Table F-12."[41]

Table F-12. Non-lighting measures - summary of early replacement measures

Parameter	First-Year Program Savings Share	Lifetime Program Savings Share
Retrofit	12.32%	17.23%
Single baseline	0.02%	0.01%
Dual baseline	12.3%	17.2%
Retrofit dual baseline change impact on program savings	N/A	-1.37%
Add-on	40.1%	34.6%
Single baseline	39.9%	34.2%
Dual baseline	0.2%	0.2%
Add-on dual baseline change impact on program savings	N/A	-0.02%

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[41] Impact Evaluation of PY2017-18 Custom Electric Installations, pg. 111

A-5   Summary of PA Interviews

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
How can programs best use dual baseline methodologies for determining savings from offerings that incentivize early retirement?	Use of custom screening tool. It would be a lot/unreasonable to ask of implementers (e.g. estimate EUL, do two calcs, 1st year savings and then RUL savings) – and none of that has anything to do with delivering a program to a customer. Screening tool is imperfect (timing is really tricky), but wouldn't want to push any of that onto the implementers. It seems much more academic than actually delivering a project to a customer.	Uses one line for blended savings. Savings is 1/3, 2/3, but in the system, putting same measure life as before. But when it goes to eval team, they use their own factors and multiply and divide savings. But I enter it as single lifetime savings number. The evaluation team does the actual reporting.	Tech dependent. 2 baselines for HVAC, pre-existing whole building (defined by vintage of the technology), 1st baseline is code to measure. Lighting is complicated. Creating 1st baseline is challenging. Calculations – have to look at the technology first and what's available in the market and makes sense to make it as simplistic as possible.	Just by declaring something "AR" it doesn't necessarily improve the TRC, because our cost on AR is the full cost of the measure whereas with NR it's the incremental cost as part of the TRC. So most of the time w/ all the measures, isn't a significant improvement with the TRC. Not sure that we have a system for tracking dual baselines. On custom side it's easier. If there's no code, we'll use ISP or try to determine what that is, and it's easier to get that info. In some cases they've measured what the current performance is with M&V/monitoring. (39:24) On the deemed side, it's really when they're developing the workpaper if there's a code or ISP at the time, that's the 1st baseline, and the measure case is whatever they're proposing. In that sense the calculation is pretty straightforward, RUL is 1/3. Calculations are laid out in the WP.	Not familiar or aware of DB calculations.	Not familiar or aware of DB calculations.

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
What programmatic design considerations are most important when structuring this type of incentive program?	Creating an easy pathway for the customer to the program. Working closely with the vendors and educating internal sales people. Besides cost, a big barrier to ER of large, expensive mechanical equipment is the budget cycle of the customer. Not only do energy savings have to be considerable, AND the incentive has to be considerable, but also the retrofit needs to fit within their budget schedule and cycle.	Clear rules would help with event determination. Big challenge for implementers is determining event type. Program rule stating prior to X age, can be considered ER would be helpful.	no real targeted AR programs. PGE arranges their savings claims by platforms – have deemed, custom, meter-based platform, and finance platform. Between the different platforms, are different rules for the claims. Are big distinctions between custom and deemed. In general, depends on how the program implementers or the core programs try to target the sectors and how that would happen, and also how cost-effective. Want to hit large market, minimal cost, repeatable. AR in a way it's harder to show that there is that influence and that repeatability. Streetlights – about year and a half ago, in inflection point: is LED baseline or not? But also want to do things for the community. Still a lot of streetlights that aren't LED – finding balance. In deemed or higher volume, want to do more of market study – how much can you do as part of market study that shows AR is	Key question; are we really influencing AR? Other IOUs removed AR measures in 2017, so don' have as many as they used to. Had to do with requirement for POE, are we truly influencing the AR of the measures? had something like 50-70 measures that they ended up screening. Ones that they could credibly say "yes, we'll keep it as AR" – that was because of the program design (i.e. custom measures), the deemed measures there was an opportunity to capture it only if delivery type was downstream or direct install. Measures that were probably best suited for upstream or midstream program delivery they were made just NR (couldn't get POE).	Don't have specific ER programs or targeted custom retrofit replacements. Use manual custom calculations but don't define event types. SBDI program would be the one area where retrofit would be significant. Targeting certain measures for replacement.	Programs here are reasonably new, no ER programs specifically, previously programs had been administered through NYSERDA

| | | | actually the influence vs. where the market is heading in general | | | |

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
What approaches are used for identifying target customers for participation?	Clear understanding of the market is key. MA uses a lot of targeted programs, for example a grocer program in an area where there are a lot of grocery stores. Have a grocery program for controls for refrigeration, and we have a pretty good program which entices customers sort of through the ease of the program, have our vendor who knows what they're doing (can do audits and get the projects installed). If there's something we want customers to do, we have to create an easy pathway for them, and then offer incentives	Target customers who don't have the capital. Marketed through vendors. Vendor relationship is key driver and primary tool for sale	Have to allocate 60% of funds to 3Ps. Meaning of that is 60% of dollars be hands-off. PGE is taking that to heart, not doing a ton of design – team isn't really developing a lot of WPs. Will do a lot of maintenance, or if they do, will be specific to requests from programs. So, not sure what they're thinking. In past, lighting was the #1 thing they looked at because it was in everybody's portfolio, low-hanging fruit. Finding cost-effective way to do it w/ least amount of touch points is a challenge.	For small or resi projects market studies: commercial and resi pool pumps (most in CA were either single or two speed, now transitioning to VFD à had credible data to say "here's % of pumps that are single, % of two speed, and measure case is VFD," so could do AR in that case. Had a midstream distributor-type network working on replacing the measures before they burned out. Actively marketing energy savings, which were substantial for these resi customers, to do that. There are like 4 measures that have "traction" for AR. LED tubes, faucets and showerheads (direct resi install for LI and disadvantaged).	Don't have any specific ER programs.	Corporate communications does education/marketing. But they have a carve out for some large industrial customers for audits/measure identification and push towards non-resi programs – more targeted marketing, wanted to help that segment specifically.
How are remaining useful lives determined for various pieces of equipment?	RUL, EUL, outyear factor: done behind the scenes. As of yet, only end use measures we've done anything besides the default assumptions is lighting, which we use lighting market model to put out out-year factors. Just now starting to look at RULs/measure lives for custom space, looking at that now.	Use custom screening tool	CA defaults to 1/3	For custom projects, have to confirm w/ POE that the measure would have been used for at least 1/3 of its EUL (i.e the RUL) for it to be considered AR. Deemed it would be looking at the market, can make that on a programmatic basis, not necessarily need to do it project-by-project (if had the market data for trends in the territory, to show e.g. 80% of chillers are in X category).	Determined in TRM	Have never really distinguished age of equipment

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
What data is collected to support those assumptions?	It's on implementation to say what the triggering event is, NC vs. ROF, so it's on the implementer to "justify" ER where db may apply vs. ROF where it wouldn't apply, so yes, it is on implementation to justify that call by providing maintenance logs or talking to the customer, but after that, they don't need to mess with the dual baseline assumptions, etc.	The maintenance log, service contract, statement from customer (how does the unit work? Is it reliable or do you have to spend a lot of money to up keep it?) – even a phone call w/ customer helps Reza understand if it's ER or not.		The data collection also got very very onerous, the data that needed to be collected drove up costs considerably, ended up making the measure only marginally cost effective. Also, just as that was happening, code was changing to make VFDs the ISP, so in June of 2021, we're retiring that WP For custom and/or particular customer, data gathering is easier to do, but at a program level (this was one of their forays into doing AR at program-level), and the program was designed b/c thought they had credible data for what was happening in the territory, but consultants said they had to collect certain information (e.g. make and model of the motor actually at customer's location, make sure that it was functioning/not burned out – only way to verify is customer OR distributor needs to send someone out and collect that info). Data requirements piled up, no longer was cost-effective, more of a burden for midstream distributors. Also had to ensure motor that was functioning is not re-sold as a used motor or used pump, had to be recycled.	Don't collect anything to determine different baselines	Have never really distinguished age of equipment. Do a pre-installation site visit if retrofitting existing equipment to observe the existing conditions

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
				For custom, they use the POE requirements as laid out in the T1WG doc. Deemed is different: the WP would make it specific for the particular measure.		
Are there any unique factors utilized to calculate lifetime savings for early retirement measures, such as an out-year factor?	Not necessarily unique, but MA uses out-year factor in the dual baseline calculations	Done by evaluation, not familiar		SCE's system has 1st baseline and then 2nd baseline all separate, database records that, and they do that for the WPs (deemed and custom)	Not familiar or aware of DB calculations.	Not aware of any

Primary Research Questions	MA1 - Former Evaluator working on Implementation Side at the moment	MA2 - Project Engineer for Implementation	CA1 - Program Supervisor	CA2 - Program Administrator	NY1 - Non-Resi Program Manager	NY2 - 2 Interviewees: GM of Energy Services Dept., EE Sales and Marketing
What are the impacts on program savings and evaluation results after implementing these dual baseline calculations?	N.D.	N.D.	N.D.	N.D.	ER not tracked or measured directly	N.D.
Are there any NEI considerations that you're aware of for ER or retrofit measures?	Not aware of anything unique, some baked in to CST.	BCR has defaults for different measures, not collecting anything special	N.D.	Doesn't think they track it. There are so many other requirements that tracking additional info is not made a priority. Not looking more at electrification and anticipating that, sometimes have measures that aren't just EE (e.g. load shifting, DR, electrifying something)	Not aware of anything unique	Not aware of any NEIs being tracked

A-6 Summary of CT Vendor Interviews

Interview Questions	Commercial Vendor - Have submitted 18 applications for boiler projects. "Beat out all other contractors for chiller incentive"	Commercial Vendor - Have 4 RTU projects and one chiller project in the pipeline. Got far along with a potential boiler project but customer pulled out at last minute.	Commercial Vendor - Working on RTU project proposals (had not submitted anything at the time of interview)	Residential and Light Commercial Vendor – non participating vendor	70% C&I, 30% Residential (including MF, b/c mostly do resi products for MF)	Large commercial and industrial Vendor. Lots of healthcare and manufacturing.
Before CT offered ER programs, did you have customers retiring equipment early?	Infrequently	Very rarely. More likely to retire them late, well past useful life.	Rarely	Do it all the time with boilers and central air conditioners, especially if people are doing other things to upgrade their houses. Also when people do oil to gas or to propane conversions - doesn't happen so much anymore but it happens.	It's rare that someone (commercial and resi) will replace a working product specifically for an upgrade in efficiency.

Any ER that is happening is purely coincidental and vendor driven (see "level of incentive" answer). | No, customers generally run equipment until it dies and the maintenance cost gets too high. If it's working, customers pretty much keep using it. |
| Do you feel that these newly offered programs in CT that targets ER is the best approach to driving ER? | There would be no other way to drive ER | I like the program and there seems to be a lot of participation. | Still to be seen, but it will likely be a help. | Based on other answers - it depends. | Yes, the program will be influential. Say for example that a property owner has five RTUs, one is broken and needs repairs. If there's an EE program that will incentivize ER and the contractor sells it that way, then those scenarios will work. | Absolutely. Makes a compelling story to incentivize customers to address their old equipment much sooner than they normally would. |

Interview Questions	Commercial Vendor - Have submitted 18 applications for boiler projects. "Beat out all other contractors for chiller incentive"	Commercial Vendor - Have 4 RTU projects and one chiller project in the pipeline. Got far along with a potential boiler project but customer pulled out at last minute.	Commercial Vendor - Working on RTU project proposals (had not submitted anything at the time of interview)	Residential and Light Commercial Vendor – non participating vendor	70% C&I, 30% Residential (including MF, b/c mostly do resi products for MF)	Large commercial and industrial Vendor. Lots of healthcare and manufacturing.
The programs have RFP-style solicitations whereby customers disclose the amount of funding they would require to replace their equipment. Do you think this program structure is effective at driving participation? Why/why not?	Yes. But smaller firms and ESCOs are going to have a harder time, because these projects require complex engineering calcs and man power to do the paperwork. Had to go back-and-forth with the utility to settle on the incentive the customer would get.	I like this part of the program because the customer can figure out how much incentive they need to move forward (including getting approvals from their bosses/corporate). If they get that incentive, you're pretty confident they'll move forward with the project. Normally, you're just submitting info and the utility decides the incentive, which may or may not be enough. It's good to be able to ask for 40, 50%. Not sure if people can win when they request that much, but it's nice to be able to ask for it.	This structure is not good for the customer because it introduces uncertainty. Not good for the contractor because they can't be sure how much of an incentive they'll be able to secure for the customer. This makes the customer unsure, which makes it hard to get a commitment from them. It requires a lot of work on the part of the contractor.	Winnelson is a wholesaler, so they don't sell directly to customers, so cannot say.	Yes - if utilities know exactly how much you need to do a project, they have all the power to influence the project to happen.	We were successful for a boiler project and we're hopeful for the RTUs. It's really all a function of the incentives. With a standard custom program the benefit would be that we wouldn't have to figure out how we can be competitive to secure the money. A standard program could be effective as well.
What level of incentive do you think is necessary to motivate customers to replace [X] kind of measure early?	50%+	Depends on the customer.	25-60%	Mini-splits/ductless now being made to replace central A/C, over 20 SEER, can heat and cool to 0 degrees, are very expensive. In ME and MA they give $500-$1,000 per ton, or $2,500 per unit, and sometimes they throw in a backup control thermostat. He sees that working in his stores in those states.	It has more to do with if the incentive matches vs. if it is more than the cost of repair, as well as other situational conditions.	Varies by measure, but 40%

Interview Questions	Commercial Vendor - Have submitted 18 applications for boiler projects. "Beat out all other contractors for chiller incentive"	Commercial Vendor - Have 4 RTU projects and one chiller project in the pipeline. Got far along with a potential boiler project but customer pulled out at last minute.	Commercial Vendor - Working on RTU project proposals (had not submitted anything at the time of interview)	Residential and Light Commercial Vendor – non participating vendor	70% C&I, 30% Residential (including MF, b/c mostly do resi products for MF)	Large commercial and industrial Vendor. Lots of healthcare and manufacturing.
What customer segments do you feel offer the best opportunities for ER? How should CT target customers?	N.D.	Schools and hospitals, because they can't close down.	Not sure. So far we've been successful at recruiting only municipalities for their schools.	Condo associations, property owners that own/manage multiple properties	Noted above - situational	So far hospitals and manufacturing facility have been working with us. Those are the strongest. Hospitals especially – they have a lot of old stuff, and they have a tough time spending money on HVAC replacements b/c they have so many other more medical equipment costs. Manufacturing tends to have a lot of older equipment as well.
What technologies or equipment would programs have the best success in driving/incentivizing early retirement?	Equipment that runs 24/7, e.g. chiller at a nursing home	Smaller chillers and heat pumps	The program should be expanded to include smaller chillers and other HVAC equipment.	The only times he will really advocate for ER is with mini-split AHUs, which will also provide heating.	N.D.	Chillers, boilers, RTUs. AHUs inside the building, heat pumps.
In your opinion, what are the biggest barriers for participation in early retirement programs and/or the early retirement of equipment?	Need longer timelines between program introduction and close. Also would be helpful to know if they're going to continue the program because it takes a while to find customers for this particular program. Processing of incentive needs to be faster as well.	It would be great if we weren't subject to when the RFPs come out. The program is limiting because only certain technologies are eligible for it; only chillers over 600 tons are eligible and there are a lot of customers who have 400 tons who would have participated but didn't meet the criteria. RTUs: had three potential customers w/ RTUs with chilled water coils, but that didn't fit the RFP. Money is a major barrier, even with the incentive sometimes customers just	The uncertainty in the structure of the program (not knowing your incentive amount up front).	A/C incentives aren't available, and those that are available are not great at all. $250 isn't enough of an incentive. The cost savings when you go from 14 SEER to 17 SEER A/C units just isn't there for most people/doesn't justify taking out a functioning unit (standard homeowners aren't going to drop $5K to go from 14 to 22 SEER to save $40/month). The only times he will really advocate for ER	N.D.	Big barrier is that customers need outside help to participate (i.e. help with the paperwork). Otherwise, money is the barrier.

Interview Questions	Commercial Vendor - Have submitted 18 applications for boiler projects. "Beat out all other contractors for chiller incentive"	Commercial Vendor - Have 4 RTU projects and one chiller project in the pipeline. Got far along with a potential boiler project but customer pulled out at last minute.	Commercial Vendor - Working on RTU project proposals (had not submitted anything at the time of interview)	Residential and Light Commercial Vendor – non participating vendor	70% C&I, 30% Residential (including MF, b/c mostly do resi products for MF)	Large commercial and industrial Vendor. Lots of healthcare and manufacturing.
		aren't going to be able to swing it.		is with mini-split AHUs, which will also provide heating. E.g. high-end resi customer with an 8-year old A/C system would definitely swap out if they could get full heating too from their new equipment. (This will get harder and harder because electric rates are really high in CT but we're still pushing those kinds of jobs.)		
Marketing/communication	Utility should "certify" these contractors to be eligible for the program, show that they're in that category somehow, this would help with marketing.	Marketing and communication from utility was fine - gave them what they needed to be able to sell the program to their customers.	Marketing will be the same for these programs as it is for other utility programs	Brian is a big proponent of Energize CT. He knows that they are in contact with wholesalers and contractors, but there are still plenty of folks who don't even know they exist - they should try to get them involved.	N.D.	Have to message that there are significant incentives available for equipment nearing end of life. The PAs don't often incentivize ER – this is a way for facilities to get incentives for doing that.

APPENDIX B.   METHODOLOGY AND APPROACH

The evaluation team researched programs in MA, NY, and CA. A summary of practices from each can be found in the sections following our summary and recommendations.

APPENDIX B

B.1.1   Literature review

DNV performed research on programs with early retirement frameworks that have been implemented in other states and territories. This research focused on best practices in early retirement framework design, dual baseline contributions to portfolio savings and NEIs, customer targeting, incentives, and messaging to overcome barriers in program participation. It also investigated the most up-to-date thinking on remaining useful life, how to establish it in each of the jurisdictions, what data is collected to support the determination and evaluation findings and results. DNV confirmed what is collected by the agency and collected values from each agency. The team reviewed the following states and programs:

- **New York State (NYS)** – In NYS there are two ways a dual baseline savings method could be adopted: those that are considered "early replacement" and those that are considered "special circumstances." A description of each is below.

  - Early replacement – The replacement of equipment before it reaches its end of its effective useful life (EUL). This includes the replacement of equipment that is still operational, where first-year savings can be calculated relative to the existing baseline conditions. Lifetime savings are calculated with a "dual" baseline: savings can be claimed against the existing baseline for the number of years left in the existing equipment's remaining useful life (RUL), and then against code for the remainder.

  - Special circumstances – The "special circumstances" approach was developed in NYS by the Commission for equipment that is well beyond its EUL but would presumably continue to operate indefinitely. For example, a customer may choose to continue to repair a multifamily steam boiler rather than replace it. The equipment must be at least 125% of the EUL and meet four other criteria regarding energy usage: 1) equipment age significantly exceeds its EUL; 2) energy consumption significantly exceeds that of current high efficiency models; 3) there is a history of significant repair or replacement with used equipment; and 4) the prospective next repair or replacement is likely to be much less expensive than replacement with new higher efficiency machinery. If these criteria are met, the program can capture savings against an existing baseline for 25% of the equipment's EUL (called the default functional period, or DFP) as well as savings against code for the remainder of the new equipment's EUL.

- **California** – DNV researched the programs designed to take advantage of the Senate Bill 8 retrofit policy. California has a strict definition of early retirement (referred to as "accelerated replacement") that requires preponderance of evidence that establishes that a) the existing equipment could have continued to provide service and b) the program influenced the decision to replace the equipment. Senate Bill 802 encouraged capturing more "stranded savings" by allowing an existing baseline when a normalized metered energy consumption (NMEC) program approach is employed.

- **Massachusetts** – Massachusetts has also adopted a dual baseline early retirement framework.[42] The MA Framework notes two early retirement event types: 1) early replacement with remaining useful life (RUL) consideration, and 2) early replacement without RUL consideration. The Framework specifies how to estimate the RUL of the replaced equipment (with 1/3 of the EUL allowed as a default in most cases) and how to characterize the future baseline for the RUL of the measure. This addition to the Framework means that evaluators now are

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[42] *Massachusetts Commercial/Industrial Baseline Framework,* Massachusetts Program Administrators and Energy Efficiency Advisory Council, February 2, 2017

required to compute first-year, RUL, and lifetime impacts of programs and measures being evaluated. DNV investigated the programs in MA that use this framework and determine how it has impacted their overall program savings.

The most critical research questions as a part of the literature review were:

- How can programs best use dual baseline methodologies for determining savings from offerings that incentivize early retirement?
- What programmatic design considerations are most important when structuring this type of incentive program?
- What approaches are used for identifying target customers for participation?
- How are remaining useful lives determined for various pieces of equipment?
- What data is collected to support those assumptions?
- Are there any unique factors utilized to calculate lifetime savings for early retirement projects, such as an out-year factor?
- What are the impacts on program savings and evaluation results after implementing these dual baseline calculations?

In addition to researching the above jurisdictions and programs, DNV also reviewed the current CT practices with respect to NEIs, EULs, dual baseline, remaining useful life, etc.

This secondary research task primarily consisted of a literature review of available program documentation and process evaluation results.

B.2.1 External program staff interviews

To supplement the literature review task, DNV interviewed six selected program staff in jurisdictions with programs that incentivize early retirement. The interviews focused on better understanding the structure of their early retirement frameworks and the handling of dual baselines, as well as the ongoing processes that they use to ensure that their programs are operating as planned. These interviews have provided supporting information in completing objectives 1 and 3 outlined in Section 1.2 above. DNV developed a list of questions specific to each program being investigated to obtain customized information. Some examples of types of questions included:

- What information or criteria is used to determine the remaining useful life for equipment when using dual baseline scenarios?
- What systems are used for tracking dual baselines?
- What challenges have been encountered with tracking of dual baselines and how have they been resolved?
- How are NTG and NEIs handled with respect to data that is collected as well as program savings calculations?
- Do you identify customers to target for early retirement? And how?
- How do you design your program and related messaging to address common barriers to early retirement participation?
- How do you engage with customers to help drive the early retirement of equipment?
- What does your program offer to convince customers to retire equipment before the end of its useful life?
- What have been the evaluation attribution results for your retrofit programs where equipment was retired ahead of the end of its useful life?
- What equipment have you been most successful in driving early retirement for?

B.3.1   Analysis of existing program designs and savings

Adopting a dual baseline usually entails more than just a boost to the first-year savings. It often requires, for example, complex benefit-to-cost ratio screening based on the prorated portions of the full and incremental installed costs, and a consistent application to all measures in a given portfolio, such as small business direct install. In Massachusetts, ERS conducted an analysis projecting a 7% reduction in portfolio lifetime savings under a dual baseline paradigm. DNV conducted a similar analysis of the CT portfolio to quantify potential implications. The analysis focused on three measures and extrapolated those measures' impacts across the portfolio to estimate statewide impact.

The purpose of the analysis was to determine how well the PAs are complying to the PSD savings calculation methods for retrofit measures as well as to identify measures that do not yet recommend early retirement treatment but may potentially benefit from early retirement treatment.

An outline of the analysis steps includes the following:

1. Aggregate the tracking data for all measures and programs and all PAs into a single data set.

2. Group like measures together. This will require mapping more detailed measures based on the descriptions to the measure categories in the PSD.

3. Identify measure groups that might have the measure application type misclassified. For example, we would expect that most of the small business direct install program lighting would be classified as early retirement.

4. Confirm that the EUL used in computing lifetime savings is consistent with the specified EUL in the PSD.

5. Estimate the impact of correcting any discrepancies found in this analysis.

B.4.1   Interviews with trade allies

DNV also worked with the EA team to identify key program trade allies and perform in-depth interviews. When selecting trade allies to target for interviews, the team took into consideration the initial focus on HVAC modernization in the early retirement context. The goal of these interviews was to gather input from program allies about which customers to target, how best to target customers given barriers in the market, as well as any other input they may have about outreach or implementation in an early retirement context. As part of this task, DNV conducted interviews with six different trade allies.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.