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List of acronyms used in this report

AML  Adjusted measure life – calculated measure life that produces dual baseline lifetime savings when multiplied by the first-year savings estimate
BAG  Baseline Advisory Group
BC Tool  Benefit-cost model used by Massachusetts PAs to plan and report program savings, benefits, and costs
C/I  Commercial and industrial
CI  Confidence interval
CST  Custom Screening Tool used by Massachusetts PAs to test benefits and cost modeling for custom measures
DR  Desk review
EEAC  Massachusetts Energy Efficiency Advisory Council
ER  Error ratio
eTRM  Massachusetts electronically published technical resource manual for the period evaluated
EUL  Effective useful life
FCM  Forward Capacity Market
HVAC  Heating, ventilating, and air-conditioning
ISP  Industry standard practice
LSAF  Lifetime savings adjustment factor, applied to measure life in the Benefit-Cost Model
NEEP  Northeast Energy Efficiency Partnership
NPV  Net present value
OYF  Outyear factor
PA  Program administrator
PY  Program year
RP  Relative precision
RR  Realization rate
RUL  Remaining useful life
The purpose of this study was to develop a statewide solution to define and implement ex-post evaluation adjustments to reflect lifetime evaluation findings and develop methods for implementing cost adjustments associated with dual baseline measures.

Research Objectives

1. Define the scope of the lifetime adjustment.
2. Define the conceptual mechanism for applying evaluation results to adjust lifetime savings.
3. Recommend any necessary changes to sampling methodology.
4. Recommend a method for implementing dual baseline cost adjustments.
5. Inventory support systems and tools.

Study Methods

The Working Group comprised representatives from the EEAC, the Massachusetts PAs, and the team of evaluation consultants. Its responsibilities were to review and approve the approaches, findings, and draft recommendations that arose from this study. The Working Group met five times.
1. **Add a Lifetime Savings Factor (LSAF) to the BC Tool.** For PY2020 savings in the 2020 term year report filed in 2021, the LSAF will be explicitly included in a formula for an adjusted measure life. The adjusted measure life value used to calculate lifetime savings for each measure line item in the BC Tool will be a product of the LSAF and the PA-weighted measure life for that measure line item. For the three-year term beginning in PY2022 and beyond, the BC Tool should be modified to include an additional evaluation factor column for the LSAF.

   1. **Represent measure-life related values as decimal values.** Measure life should be represented as a decimal number with one digit after the decimal throughout the data stream, consistent with the FCM specification for measure life.

   2. **Evaluators assess tracking values for lifetime savings.** Custom evaluations should assess measure life as it is represented in PA tracking.

2. **Continue to design samples for studies with annual savings as the precision target.** DNV recommends using annual savings for stratification unless or until such time that lifetime savings precision is inadequate allowing the LSAF to fall out of that design. The LSAF should be monitored with each evaluation to determine if the resulting error ratios and relative precisions are insufficient, which would drive the need for additional sample points in subsequent impact evaluations to improve their accuracy.

3. **Update the dual baseline method currently incorporated in the CST to match the enhanced Northeast Energy Efficiency Partnership (NEEP) methodology.** This methodology accounts for avoided and deferred replacement costs associated with measures where EULs are different for high efficiency equipment compared to the replaced equipment. To implement this recommendation, the Team suggests that the PAs update the MA CST formula for deferment credit based on the enhanced NEEP methodology per the Arkansas TRM.

4. **Annual review of the CST EUL and OYF.** The Working Group recommends that the evaluator review and approve the CST each year as part of its annual update cycle. Particular attention should be paid to matching CST EULs with authoritative values such as the latest eTRM EULs. This review would ensure that the values embedded in the CST reflect the eTRM for that year.

5. **Define protocols for measures without an EUL reference or where the CST has multiple EUL selections.** The eTRM does not include measure lives for every custom measure, particularly process measures. For these measures, the current evaluation practice is to select the life of an analogous measure from the eTRM or other documented sources. The Working Group recommends that the evaluators, in collaboration with the implementation team, develop a protocol for assigning a measure life based on a few objective factors.
1 EXECUTIVE SUMMARY

This document presents the final report for the Massachusetts Dual Baseline Cost and Lifetime Savings Methods Research conducted for the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants by the evaluator, DNV.

The program sponsor PAs include Berkshire Gas Company (Berkshire), Cape Light Compact, Columbia Gas of Massachusetts (Columbia), Eversource, Liberty Utilities (Liberty), National Grid, and Unitil.

1.1 Study purpose, objectives, and research questions

The study’s overall purpose was to develop a statewide solution to define and implement ex-post evaluation adjustments to reflect lifetime evaluation findings and develop methods for implementing cost adjustments associated with dual baseline measures. The Team’s objectives were as follows:

1. **Define the scope of the lifetime adjustment.** Define the programs and end uses to which it applies (i.e., custom and/or prescriptive, lighting/non-lighting) and the evaluated differences that are to be included in the adjustment (effective useful lives, or EULs), outyear factors (OYFs), single vs. dual baseline, and potentially other effects, like early failures.

2. **Define the conceptual mechanism for applying evaluation results to adjust lifetime savings.** Potential mechanisms include measure life adjustments or realization rates in the benefit cost model (BC model), or other suggested methods.

3. **Recommend any necessary changes to sampling methodology** required for reliable estimates of lifetime savings, how the adjustments will be incorporated into the current rolling regime, and any special considerations for retrospective and prospective application.

4. **Recommend a method for implementing dual baseline cost adjustments** that is informed by existing cost accounting methods employed in other programs and sectors.

5. **Inventory support systems and tools** (such as PA tracking systems, the custom screening tool, and the various Benefit-Cost, or BC, model versions) that produce or use lifetime savings. In addition, identify barriers to implementation of adjustments and discuss mitigation strategies. Recommend an implementation approach for adjustments to be applied to the program year (PY) 2020 savings in the 2020 term year report filed in 2021.

While ultimately the PAs are responsible for accounting for the lifetime savings adjustment beginning with the term report filed in 2021 for PY2020 savings, this effort provides research, analysis, and facilitation to support the Working Group’s development of a statewide solution to defining and implementing ex-post evaluation adjustments to reflect lifetime evaluation findings. Additionally, the working group also examined methods for implementing cost adjustments associated with dual baseline measures.

1.2 Methods

The research and analysis of this study was conducted under the review and engagement of a Working Group comprised of representatives from EEAC, Massachusetts PAs, and the team of evaluation consultants. The responsibilities of the Working Group were to review and approve the approaches, findings, and draft recommendations that arose from this study. The Working Group met five times.

DNV interviewed knowledgeable PA staff to document individual PA practice in the generation, tracking, and reporting of lifetime savings values and also the production of Forward Capacity Market (FCM) submissions for lifetime savings. The Team also reviewed and analyzed the BC model, the 2020 statewide Custom Screening Tool (CST), and previous custom sample designs.
1.3 Recommendations

The Working Group recommendations are as follows:

**R#1 Add a Lifetime Savings Factor to the BC Tool.** Evaluation lifetime savings findings should be captured in a lifetime savings adjustment factor (LSAF), which is applied to the measure life in the BC Tool. For PY2020 savings in the 2020 term year report filed in 2021, the LSAF will be explicitly included in a formula for an adjusted measure life.\(^1\) The adjusted measure life value used to calculate lifetime savings for each measure line item in the BC Tool will be a product of the LSAF and the PA-weighted measure life for that measure line item. For the three-year term beginning in PY2022 and beyond, the BC Tool should be modified to include an additional evaluation factor column for the LSAF. PAs may also modify their tracking systems to account for the LSAF.

**Represent measure-life related values as decimal values.** Measure life should be represented as a decimal number with one digit after the decimal throughout the data stream, consistent with the FCM specification for measure life. The rounding functions implemented in the CST and whole number data input requirements for the BC Tool should be removed allowing for decimal inputs and outputs.

PAs should update tracking systems to represent measure lives as a decimal value and establish a timeline for doing so.

**Evaluators assess tracking values for lifetime savings.** Custom evaluations should assess measure life as it is represented in PA tracking. This requires coordination of PA and DNV GL data teams to properly identify the correct fields and to communicate differences to the evaluation field teams.

**R#2 Continue to design samples for studies with annual savings as the precision target.** DNV recommends using annual savings for stratification unless or until such time that lifetime savings precision is inadequate allowing the LSAF to fall out of that design. The LSAF should be monitored with each evaluation to determine if the resulting error ratios and relative precisions are insufficient, which would drive the need for additional sample points in subsequent impact evaluations to improve their accuracy.

**R#3 Update the dual baseline method currently incorporated in the CST to match the enhanced Northeast Energy Efficiency Partnership (NEEP) methodology.** This methodology accounts for avoided and deferred replacement costs associated with measures where EULs are different for high efficiency equipment compared to the replaced equipment. Although the update would require additional data collection for measures where EULs of high efficiency equipment are different compared to the replaced equipment, the cost adjustment calculations will become more accurate for early replacement measures. To implement this recommendation, the Team suggests that the PAs update the MA CST formula for deferment credit based on the enhanced NEEP methodology per the Arkansas TRM. There are no updates needed in the BC Tool to reflect any dual baseline cost adjustments. The total resource costs brought into the BC Tool from the PA tracking systems should already reflect any dual baseline adjustments to costs in aggregate. This method does not change methods for estimating project related costs, but only how measure life is factored into discounting calculations.

To improve lifetime savings estimates, the Working Group recommends instituting the following procedures:

**R#4 Annual review of the CST EUL and OYF.** The Working Group recommends that the evaluator review and approve the CST each year as part of its annual update cycle. Particular attention should be paid to matching CST EULs with

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\(\text{\textsuperscript{1}}\) National Grid has internal requirements which prevent the application of the LSAF in the annual term report filed in 2021 for PY2020 savings but will apply the corrections in the 2019-2021 three year term report filed in 2022.
authoritative values such as the latest eTRM EULs. This review would ensure that the values embedded in the CST reflect the eTRM for that year.

**R#5 Define protocols for measures without an EUL reference or where the CST has multiple EUL selections.** The eTRM does not include measure lives for every custom measure\(^2\), particularly process measures. For these measures, the current evaluation practice is to select the life of an analogous measure from the eTRM or other documented sources. The Working Group recommends that the evaluators, in collaboration with the implementation team, develop a protocol for assigning a measure life based on a few objective factors. These factors might include the total installed budget, whether the equipment is an add-on (like controls) or a stand-alone unit, or whether the equipment was custom built or a standard unit. In addition, the Baseline Advisory Group (BAG) should review and assess site M&V measure EULs flagged by evaluators for revision. Implementing this practice will ensure measure life assignments are consistent and that the adjustment is warranted.

\(^2\) National Grid has notified that starting with the 2020 eTRM update, the PAs have included the ML table in CST within the TRM.
2 INTRODUCTION

This document presents the final report for the Massachusetts Dual Baseline Cost and Lifetime Savings Methods Research conducted for the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants from 08/01/2020 to 02/19/2021. This study was led by ERS and included expertise from our partner firm DNV GL (the Team).

The program sponsor PAs include Berkshire Gas Company (Berkshire), Cape Light Compact, Columbia Gas of Massachusetts (Columbia), Eversource, Liberty Utilities (Liberty), National Grid, and Unitil.

2.1 Study purpose, objectives, and research questions

The study’s overall purpose was to develop a statewide solution to define and implement ex-post evaluation adjustments to reflect lifetime evaluation findings and develop methods for implementing cost adjustments associated with dual baseline measures. The Team’s objectives were as follows:

1. **Define the scope of the lifetime adjustment.** Define the programs and end uses to which it applies (i.e., custom and/or prescriptive, lighting/non-lighting) and the evaluated differences that are to be included in the adjustment (effective useful lives, or EULs), outyear factors (OYFs), single vs. dual baseline, and potentially other effects, like early failures.

2. **Define the conceptual mechanism for applying evaluation results to adjust lifetime savings.** Potential mechanisms include measure life adjustments, realization rates, or other suggested methods.

3. **Recommend any necessary changes to sampling methodology** required for reliable estimates of lifetime savings, how the adjustments will be incorporated into the current rolling regime, and any special considerations for retrospective and prospective application.

4. **Recommend a method for implementing dual baseline cost adjustments** that is informed by existing cost accounting methods employed in other programs and sectors.

5. **Inventory support systems and tools** (such as PA tracking systems, the custom screening tool, and the various BC model versions) that produce or use lifetime savings. In addition, identify barriers to implementation of adjustments and discuss mitigation strategies. Recommend an implementation approach for adjustments to be applied to the program year (PY) 2020 savings in the 2020 term year report filed in 2021.

While ultimately the PAs are responsible for accounting for the lifetime savings adjustment beginning with the term report filed in 2021 for PY 2020 savings, this effort provides research, analysis, and facilitation to support the Working Group’s development of a statewide solution to defining and implementing ex-post evaluation adjustments to reflect lifetime evaluation findings. Additionally, the working group also examined methods for implementing cost adjustments associated with dual baseline measures.

2.2 Study background

This study was designed to aid the PAs in implementing methods for adjusting lifetime savings to account for evaluation findings and to adjust incremental costs for dual baseline measures. Dual baseline techniques are applied to early replacement measures to account for the likelihood that the baseline equipment would be replaced after its remaining useful life (RUL) with industry standard practice (ISP) equipment. The first baseline uses an existing equipment baseline with savings accrued over the RUL of the existing equipment. The second baseline uses an ISP baseline accrued over the EUL of the existing equipment, reduced by the RUL. Implementing dual baseline methods tends to reduce lifetime savings and reduce incremental installed costs that are incorporated in benefit-cost tests. The early replacement measures with dual
baselines shift the replacement cycle by accelerating the purchase of new equipment (i.e., deferring the replacement of baseline equipment) thereby having incremental costs differ from a replace on burnout measure.

**Evolving practices.** Prior to 2019, the PAs calculated lifetime impacts using a reduced measure life (also called the adjusted measure life, or AML) for select commercial and industrial (C/I) early replacement measures. In the 2019-2022 cycle, the Massachusetts C/I Baseline Framework\(^3\) requires a more rigorous approach to calculate early replacement impacts using a “dual baseline” method that explicitly calculates the savings considering both an existing baseline and a future ISP baseline. The future baseline savings is estimated using an “outyear factor” (OYF) that reflects the expected change in annual savings. Some PAs implement this calculation by calculating an AML that effectively adjusts the lifetime savings to equal that of calculating it separately for both periods.

This new emphasis dual baselines has focused evaluation activity on the calculation of lifetime savings. Now that lifetime savings are subject to evaluation, the PA-reported lifetime savings must be adjusted to accommodate those additional impacts. This study examines the evaluation findings affecting lifetime savings, the sources of lifetime savings adjustment, and any sources of errors that should be included in the lifetime savings adjustment.

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3 METHODOLOGY AND APPROACH

The Team’s approach used the steps detailed in the following sections to achieve the research objectives and ensure that the evaluators met the study goals of the PAs and EEAC Consultants.

3.1 Working Group sessions

The Working Group comprised of representatives from EEAC, Massachusetts PAs, and the evaluation consultants (the Team). The Working Group reviewed and approved the approaches, findings, and draft recommendations that arose from this study.

The Working Group met five times for durations ranging from 60 to 90 minutes over a period of approximately five months (the duration of the study). The topics discussed during each meeting are presented in Table 3-1. After each Working Group session, the Team circulated meeting minutes and key takeaways to the members for review, revision, or identification of further issues associated with the topics that were discussed.

<table>
<thead>
<tr>
<th>Session</th>
<th>Date</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 90’</td>
<td>9/9/2020</td>
<td>• Confirmation of the objectives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Discussion and consensus on the definition and scope of the lifetime savings adjustments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Initial schedule of subsequent meetings</td>
</tr>
<tr>
<td>2 – 60’</td>
<td>10/14/2020</td>
<td>• Review interview objectives, guides, and target data tracking systems and interviewees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Review cost adjustment results and consider strawman proposal for dual baseline cost adjustments</td>
</tr>
<tr>
<td>3 – 60’</td>
<td>11/20/2020</td>
<td>• Review sample design analysis and strawman proposal for rolling sample approach for both lifetime and annual savings and retrospective/prospective rules</td>
</tr>
<tr>
<td>4 – 60’</td>
<td>12/18/2020</td>
<td>• Review key findings for tools and systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Review research regarding a strawman proposal for BC model adjustment factor implementation</td>
</tr>
<tr>
<td>5 – 90’</td>
<td>1/29/2021</td>
<td>• Finalize the recommendations to be included in the draft report to be sent to the MA C&amp;I stakeholder group</td>
</tr>
</tbody>
</table>

3.2 PA staff interviews

Lifetime savings are tracked or calculated, used as an input, and reported throughout the energy efficiency ecosystem. To consider whether an evaluated lifetime savings factor or retrofit measure cost adjustment is required for the tools and systems that incorporate lifetime savings in some manner, the Team performed interviews with the PA staff most knowledgeable with each of the systems/tools, including the staff familiar with the processes used to produce and submit ISO NE FCM resources. Prior to developing the interview guides, the Team reviewed the content and structure of the tools and systems to focus the questions on the areas of uncertainties and to explore the implications of the adjustment factors with the interviewees. Table 3-2 summarizes the tools and systems that the Team examined as part of this study and the interviews that supported this investigation.
Table 3-2. Systems impacted by the lifetime and cost adjustment factor

<table>
<thead>
<tr>
<th>System</th>
<th>Interviews</th>
<th>System Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC model including variations between planning and reporting and by PA</td>
<td>7 (1 per PA + panel)</td>
<td>Spreadsheet used by PAs to report program-evaluated savings, including lifetime savings, and program cost-effectiveness</td>
</tr>
<tr>
<td>CST</td>
<td>6 (1 per PA)</td>
<td>Spreadsheet used by PAs to screen custom projects for cost-effectiveness and select measures lives from a menu of allowable option.</td>
</tr>
<tr>
<td>FCM</td>
<td>4 (1 per electric PA)</td>
<td>System used by PAs to report demand impacts over the life of the measure to ISO NE.</td>
</tr>
<tr>
<td>PA Tracking Systems</td>
<td>2 (National Grid and Eversource)(^4)</td>
<td>Systems used by PAs to internally track project savings and costs</td>
</tr>
</tbody>
</table>

The interview guide developed by the Team is included in Appendix B.

### 3.3 Ancillary analysis

The Team also received the 2020 statewide BC model (electric and gas) and the 2020 statewide CST spreadsheets from National Grid and performed detailed reviews of the tools, focusing on parameters that would be affected by the potential inclusion of LSAFs and dual baseline cost adjustments. The Team utilized multiple examples of measure scenarios in each of these tools to track impacts and to come up with the various study findings and recommendations provided in sections 4 and 5, respectively of this report.

\(^4\) The Tracking System and BC tool teams intersect for the remaining PAs, therefore the BC model interviews also cover Tracking system questions.
4 STUDY FINDINGS

The Team has gathered the following findings from the study based on methods and approaches utilized per Section 3.

4.1 Definition of a Lifetime Savings Adjustment Factor (LSAF)

The Massachusetts C/I Baseline Framework has placed new emphasis on lifetime savings, which are subject to evaluation. The PA-reported lifetime savings must be adjusted to reflect evaluation findings. The LSAF is a factor applied to the tracking measure life to account for the evaluation findings from ex-post evaluation affecting lifetime savings incremental to the effects of the first-year savings realization rate (FYS RR%).

4.1.1 Evaluated lifetime savings effects

While a FYS RR% impacts lifetime savings, the LSAF isolates the incremental (or decremental) effects captured in the following observations:

- Incorrect applicant event type that changes the baseline from a single baseline to dual (or vice versa).
  - Other event types or changes that do not change single/dual status may impact first-year savings directly and lifetime savings indirectly but will not result in a lifetime savings adjustment.
- Incorrect applicant EUL, RUL, AML, or OYF references.
  - The evaluators will reference the most appropriate Massachusetts eTRM or other authoritative source for values.
  - For unique sites, the evaluators will assess the rational unique measure life and use the applicant measure life when appropriate, following the review protocols established for reviewing unique baselines.
- Reduced lifetime for equipment/measures removed after the first year of service.
  - Equipment removed before the first year of service is treated as not installed and therefore yield no first-year savings, so there is no further reduction for lifetime adjustments.
  - Equipment removed after the first year but prior to the evaluator’s site visit will be credited with first-year savings. The lifetime savings for the site is calculated as the product of the evaluated first year savings and the verified years that the equipment did operate.
- Other unanticipated factors. It is possible that other future evaluation outcomes will arise that are best captured in the LSAF.

Prescriptive vs. Custom. The research and discussions of the Working Group were focused on custom measures; however, the concepts and procedures in the development of the LSAF also apply to prescriptive measures at which time that research is done on those measures.

There is almost no opportunity for an implementer’s unintentional measure life selection error since it is PA practice to build the measure life into their tracking systems, rather than have implementers enter the values for each application.

In an ex-post evaluation of prescriptive measures, the evaluators will incorporate measure life or OYF corrections if they do occur and adjustments for equipment after the first year but prior to the evaluation activity in the LSAF. The LSAF may also include revisions to measure life that may arise from a measure life study or other study outcomes such as revised AMLs for lighting.

4.1.2 Application of the LSAF

First-year savings and measure life are entered into the BC Tool for each measure grouping, but not lifetime savings. In the BC Tool, the lifetime savings value is a calculated output (the product of first-year savings and measure life). The importance
of measure life is in calculating benefits. Measure life is used as an index into a benefit table to select a dollar benefit value per energy unit.

Implementation of an LSAF must operate on the measure life input to impact lifetime savings and lifetime benefits. The easiest and most transparent approach to adding an LSAF to the calculation of lifetime savings and lifetime benefits is add it to the BC Tool as an additional evaluation factor to the input tab of the BC Tool. The Tool already includes nine evaluation factors, including a first-year savings realization rate ("kWh Savings Realization Rate"); the LSAF would be a tenth. The correct implementation will apply the LSAF to the Measure Life entry seen in the first column in the screen shot of the BC Tool input tab and propagate the "Adjusted Measure Life" throughout the remaining BC Tool calculations.

It was hypothesized by the Working Group that it might be possible to drop the first-year savings RR and add a single lifetime savings RR that captures all evaluation effects including first-year and lifetime. However, the Team analysis demonstrated that while this approach would estimate the lifetime saving correctly, it would not estimate the benefits correctly. See Appendix C for details.

### 4.1.3 LSAF calculations

The LSAF is calculated as the ratio of the lifetime savings RR and the first-year savings RR. The formulas below provide the calculation for each of the RRs and the LSAF.

**First-year savings realization rate.** As a starting point, the annual savings RR is calculated as the weighted sample verified annual savings divided by the weighted sample tracked savings.

\[
FYS\ RR\% = \frac{\sum w_i \times FYS_{i}^{\text{evaluated}}}{\sum w_i \times FYS_{i}^{\text{tracking}}}
\]

where:

- \(FYS\ RR\%\) = first-year savings realization rate
- \(w_i\) = site weight
- \(FYS_{i}^{\text{evaluated}}\) = site evaluated first-year savings (therm/kWh/kW)
- \(FYS_{i}^{\text{tracking}}\) = site tracking first-year savings (therm/kWh/kW)

**Measure-level lifetime savings.** For each evaluated measure, the evaluators calculate an evaluated lifetime savings using the following formula:

\[
LS_{\text{evaluated}} = FYS_{\text{evaluated}} \times [ RUL_{\text{evaluated}} + OYF \times (EUL_{\text{evaluated}} - RUL_{\text{evaluated}}) ]
\]

where:

- \(LS_{\text{evaluated}}\) = evaluated lifetime savings (therm/kWh/kW)
- \(FYS_{\text{evaluated}}\) = evaluated first-year savings (therm/kWh/kW)
$EUL_{\text{Evaluated}}$ = evaluated measure life (years in decimal form) – Reflects revisions to measure life due to alignments with eTRM measure lives or to account for equipment removal after one year.

$RUL_{\text{Evaluated}}$ = 1/3 of $EUL_{\text{Evaluated}}$ (years)

$OYF$ = This factor accounts for dual-baseline impacts - the ratio of second baseline annual savings to first baseline annual savings; it is 100% for single-baseline measures.

We note that PAs are required to account for dual baseline beginning in PY2019; therefore, evaluators used an OYF of 100% for evaluation of program activity prior to 2019, effectively removing dual baseline adjustments from the calculation of evaluated lifetime savings.

**Program lifetime savings realization rate (LSRR%).** The LSRR is calculated in similar fashion to the annual savings RR. To calculate LSRR, the weighted evaluated lifetime savings is divided by the weighted tracked lifetime savings. The Team calculated LSRR using the following formula:

$$LSRR\% = \frac{\sum w_i \times \bar{LS}^\text{Evaluated}_i}{\sum w_i \times \bar{FYS}^\text{Tracking}_i \times \bar{EUL}^\text{Tracking}_i}$$

where:

$LSRR\%$ = program lifetime savings realization rate

$w_i$ = site weight

$\bar{LS}^\text{Evaluated}_i$ = site evaluated lifetime savings (therm/kWh/kW)

$\bar{FYS}^\text{Tracking}_i$ = site tracking first-year savings (therm/kWh/kW)

$\bar{EUL}^\text{Tracking}_i$ = tracking measure life

**Program LSAF.** To maintain the FYS RR% in program databases and adjust for differences in LSRR and FYS RR%, we calculated the LSAF as a proportion of the LSRR to the FYS RR%. This avoided double counting the impacts of both the FYS RR% and the LS RR%.

$$LSAF = \frac{LSRR\%}{\text{FYS RR\%}}$$

where:

$LSAF$ = lifetime savings adjustment factor

$\text{FYS RR\%}$ = program first-year savings realization rate

$\text{LSRR\%}$ = program lifetime savings realization rate

The program-level LSAF can be used by PAs for reporting lifetime savings and will incrementally impact the lifetime savings after the annual savings RR is applied. To calculate lifetime adjusted gross savings, PAs will use the following formula:

$$\text{Lifetime adjusted gross savings (therms, kWh, kW)} = (\text{Annual Gross Savings}_{\text{tracking}} \times \text{Annual RR\%}) \times (\text{Measure life}_{\text{tracking}} \times \text{LSAF})$$

where:

$\text{Annual gross savings}_{\text{tracking}}$ = tracking annual gross savings (therm/kWh/kW)
4.1.4 Sample design methods

It might be expected that the current sample design targeting first-year savings would produce poor lifetime savings precisions. Lifetime savings changes the relative weight of each measure, increasing the size of long-life measures relative to short-life measures. A sample design based on annual savings will select larger annual savings measures, which are only partially correlated with large lifetime savings measures (first-year savings correlation). A sample design based on lifetime savings adjusts for more factors, including measure life, and starting with PY2019, dual baseline and might be expected to increase the likelihood of higher error ratios. However, a review of past lifetime savings findings shows that this is not the case. DNV estimated the anticipated precisions for lifetime savings using a sample that utilized first-year savings. In the sample design analyzed, no forecasted lifetime precision changed by more than +/-2% from the corresponding first-year precision. A single design can be used for both first-year and lifetime savings RRs under the current regime, but efficiency will be optimized for only the primary goal of first-year savings. Likewise, the demand LSAF is expected to track lifetime savings. These assumptions should be monitored each year to determine if the resulting ERs and RPs are insufficient, which would drive the need for additional sample points in subsequent impact evaluations to improve their accuracy.

Sampling procedures do not require significant change to incorporate lifetime savings estimation into evaluation. The same general process of stratified random sampling should be employed regardless of whether annual or lifetime savings are the focus of the study. A sample design with size-based strata determined by annual savings may also be used in estimating lifetime savings and vice-versa. Whichever type of savings is the primary outcome of the study should be the one used in stratification and choice of error ratios. This improves the sampling efficiency and anticipated precisions for the primary savings type.

Finally, sample designs based on meeting precision targets for both annual and lifetime savings may be larger than targeting only one of the two.

4.1.5 LSAF update process

The LSAF will normally be the results of an impact evaluation study, referred to as a ‘Study’. The LSAF will be applied retrospectively and prospectively following the same conventions as the first-year RR:

**Retrospective.** LSAF study results will apply retrospectively to the first annual report after the Study is finalized until program process changes are verified or there is a new Study. It is possible that program process changes will be verified before the first annual report after the study, in which case a valid prospective LSAF will be applied.

**Prospective.** When program process improvements are likely to impact the LSAF, an adjustment will be made to the LSAF reflecting verified program changes. The prospective LSAF will be applied after the study is approved until the program process changes are verified or there is a new study.

It is possible that a prospective LSAF could be applied in the first annual report after the study, if changes are verified to have occurred. As an example, an incorrect CST measure life reference noted in the evaluation of PY2018 may have been corrected in the PY2019 CST; therefore, a prospective LSAF should be applied to PY2019 savings estimated using the PY2019 CST and reported in the annual term report published in 2020.
4.2 Dual baseline cost adjustments

Early retirement measures assume that a customer accelerates the replacement of equipment that they would need to replace anyway in the not-too-distant future. Since the equipment must be replaced eventually, the measure cost in the measure cost-effectiveness calculation deducts the net present value (NPV) of the future equipment replacement from today’s high efficiency installation cost. The future equipment is assumed to be ISP. This cost accounting applies to all retrofit measures whether they require a single or dual baseline treatment of the lifetime savings.

Cost-effectiveness is tested by the PAs in the BC Tool and the CST. The Team performed an in-depth review of the BC Tool and CST and identified that the cost accounting calculations for all custom retrofit measures and projects take place in the CST, which then propagates through the tracking system to the BC Tool.

There are different methods for calculating the NPV of the future equipment cost and also assumptions required for this calculation. As part of this task, DNV inventoried the current Massachusetts and select jurisdiction practices for incorporating the cost of the future ISP equipment into benefit-cost calculations.

4.2.1 Current CST cost treatment

The current methodology in the 2020 statewide CST for calculating cost adjustments for dual baseline projects is as follows:

\[ Adjusted\ Measure\ Cost = Incremental\ Cost - Deferment\ Credit \]

where:

Incremental cost = Measure installed cost for Existing Building Retrofit projects

The deferment credit is calculated as follows:

\[ Deferment\ Credit = \frac{PV(disc\ rate, age\ existing, PMT(disc\ rate, EUL, Second\ Period\ Costs))}{(1 + disc\ rate)^{RUL}} \]

where:

Discount rate = 20%, for all dual baseline measures based on typical C&I customer investment considerations

EUL = Effective useful life for the high efficiency equipment

Age existing = EUL - RUL

Second Period Costs = OYF x Total Measure Installed Cost

RUL = 33% of EUL, assumed

4.2.2 NEEP cost methods

The team then compared the 2020 statewide MA CST cost adjustment methodology with what is incorporated in the Massachusetts residential sector for early replacement measures. The residential sector cost adjustment methodology is based on the NEEP Early Replacement Measure Study\(^5\) and applies an equation that takes into account the EUL, RUL, and installed cost of both the future ISP replacement and high efficiency equipment, as shown below:

Adjusted Measure Cost = (ER Cost Factor × Standard Efficiency Cost) + Incremental Cost

where:

Incremental cost = high efficiency equipment cost – standard efficiency equipment cost

The ER cost factor is calculated as follows:

$$ER \text{ Cost Factor} = \frac{PV(RDR, RUL \text{ of existing equipment}, RLCC \text{ of Existing Equipment})}{PV(RDR, EUL \text{ of new equipment}, RLCC \text{ of Existing Equipment})}$$

where:

RDR = real discount rate

RLCC = real levelized carrying costs (annualized baseline installed cost at RDR)

4.2.3 Enhancements to NEEP Cost Methods

While the NEEP cost methods explained in section 4.2.2 account for deferred replacement costs in its cost equations, it wasn’t fully built to account for the avoided replacement costs associated with measures where the EULs were different for high efficiency equipment compared to the replaced equipment. The avoided replacement costs are addressed appropriately as an enhancement to the NEEP cost methods in the Arkansas TRM⁶ which applies the following equations to capture both deferred and avoided replacement costs.

$$Adjusted \ Measure \ Cost = Incremental \ Cost - Avoided \ Baseline \ Replacement \ Cost$$

where:

Incremental cost = Measure installed cost for Existing Building Retrofit projects

The deferred baseline replacement cost is calculated as follows:

$$Avoided \ Baseline \ Replacement \ Cost = \frac{-PV(RDR, EUL_{\text{new}} - EUL_{\text{base}}, RLCC_{\text{base}})}{(1 + RDR)^{EUL_{\text{base}}}}$$

where:

RDR = real discount rate

EUL_{\text{new}} = effective useful life for the high efficiency equipment

EUL_{\text{base}} = effective useful life of baseline equipment

RLCC_{\text{base}} = -PMT(RDR, EUL_{\text{base}}, Baseline \ Installed \ Cost)

4.2.4 Discussion

The Team compared the current MA CST cost adjustment methodology with the NEEP framework and the Arkansas TRM which includes avoided replacement cost enhancements to the NEEP method. The comparisons provided identical results for two different scenarios considered by the Team when the EULs of high efficiency equipment and replaced equipment

were the same. The adjusted cost metrics diverged profoundly when EULs were different for high efficiency equipment compared to the replaced equipment and as discount rate dropped. Where this difference in EULs exist – for example for lighting changes from fluorescent to LED technology – the current CST method is less accurate. The various scenarios used by the Team, the assumptions used, and the associated results are shown in Table 4-1.

Table 4-1. Comparison of MA Dual Baseline cost adjustments methods with NEEP and Arkansas TRM

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MA CST</th>
<th>NEEP</th>
<th>Enhancements to NEEP (Arkansas TRM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High Efficiency Furnace Installation</td>
<td>Adjusted Measure Cost = $2,527</td>
<td>Adjusted Measure Cost = $2,527</td>
<td>Adjusted Measure Cost = $2,527</td>
</tr>
<tr>
<td>Installed Cost = $3,500</td>
<td>Assumptions</td>
<td>Assumptions</td>
<td>Assumptions</td>
</tr>
<tr>
<td>Measure EUL = 18 years</td>
<td>Standard efficiency cost = 0.9 *</td>
<td>Baseline installed cost = 0.9 *</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>OYF = 0.9</td>
<td>$3,500</td>
<td>$3,500</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>Installed Cost = $5,400</td>
<td>Assumptions</td>
<td>Assumptions</td>
<td>Assumptions</td>
</tr>
<tr>
<td>Measure EUL = 15 years</td>
<td>Standard efficiency cost = 0.9 *</td>
<td>Baseline Installed Cost = 0.9 *</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>OYF = 0.9</td>
<td>$5,400</td>
<td>$5,400</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>3. Custom Lighting with Different high efficiency and replaced technology measure lives</td>
<td>Adjusted Measure Cost = $4,009</td>
<td>Adjusted Measure Cost = $3,382</td>
<td>Adjusted Measure Cost = $3,029</td>
</tr>
<tr>
<td>Installed Cost = $5,000</td>
<td>Assumptions</td>
<td>Assumptions</td>
<td>Assumptions</td>
</tr>
<tr>
<td>Measure EUL = 15 years</td>
<td>Standard efficiency cost = 0.55 *</td>
<td>Baseline Installed Cost = 0.55 *</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>Existing lighting EUL = 8 years</td>
<td>$5,000</td>
<td>$5,000</td>
<td>RDR = 20%</td>
</tr>
<tr>
<td>OYF = 0.55</td>
<td>RDR = 20%</td>
<td>RDR = 20%</td>
<td>RDR = 20%</td>
</tr>
</tbody>
</table>

The NEEP and enhanced NEEP methods require the following additional data points to calculate adjusted costs, when compared to the MA CST:

- Accurate costs of a standard efficiency option
- Age and RUL of existing equipment

4.3 FCM findings

The gross summer and winter peak kW savings from the custom screening tool are input directly into the tracking system of each PA. These estimates, after the appropriate realization rates are applied, provide evaluated gross savings to be used to calculate lifetime savings. ER measures use an existing equipment baseline credit. When an FCM submission is required, the PAs pull these estimates from their tracking systems.

Resources are removed from FCM at the end of their measure life, either the EUL or going forward using the measure’s AML for early replacement dual baseline measures. This treats the accounting of dual baselines for peak demand the same as it does for annual energy savings. In both cases, the use of AML with full baseline credit masks a drop-off in actual peak and annual savings in second period years by taking the average savings over a shorter measure life. This has been deemed acceptable for state-filing purposes and has been shared with ISO in public meetings as the method used for LED measures. ISO has not offered any concerns with this approach to date.
The PAs are prepared to apply LSAFs to AMLs for FCM purposes, though the need to apply such an adjustment for FCM is unclear at this time with a resolution of this need outweighed by the primary short-term focus of developing a system to use the lifetime savings adjustment factor for claimed lifetime energy savings. We have examined the guide to the EEM (energy efficiency measure database7) to understand the ability of this FCM platform to accept decimal lifetimes. Table 5.2 in that document indicates that it can accept lifetimes with up to one decimal place. Assuming the use of an AML is acceptable by ISO NE, the application of an LSAF to AMLs for use in FCM does not raise any short-term concerns.

4.4 PA lifetime savings practices

This section describes the results of the interviews with knowledgeable PA staff about lifetime savings practices and the implications of those findings.

4.4.1 Summary of PA interviews

Each PA has different tracking systems and slightly different procedures for estimating, tracking, and reporting lifetime savings. Knowledgeable staff were interviewed to map out the specific process of each PA. Table 4-2 summarizes the typical data processing steps for all PAs and then any PA-specific exceptions.

### Table 4-2. Common practices and individual PA exceptions

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Tracking</th>
<th>BC Model Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common practices</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For custom, enter in project parameters, first-year savings, and incremental costs.</td>
<td>Track first-year savings and a whole number measure life sourced from the CST.</td>
<td>For custom measure groupings, compute a weighted measure life.</td>
</tr>
<tr>
<td>Measure Life is a from a lookup table value in the Custom Screening Tool (CST)</td>
<td>Track incremental labor and material costs.</td>
<td>For prescriptive, fixed values from eTRM measure life.</td>
</tr>
<tr>
<td>Select Measure Life from choices (when there is more than one.)</td>
<td>Tracking system calculates lifetime savings based on measure life and first-year savings.</td>
<td>Round the adjusted measure life entered into the BC Tool to the nearest integer.</td>
</tr>
<tr>
<td>For dual baseline measures the AML is calculated in the screening tool using the EUL and OYF. Enter the first-year savings, the AML/EML, and incremental costs into tracking. The AML/EML values are rounded in the BC Tool.</td>
<td></td>
<td>BC tool TRCs calculated based on incentives and installed costs from screening tool, propagating through tracking.</td>
</tr>
<tr>
<td><strong>Individual PA Exceptions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eversource</td>
<td>No exceptions</td>
<td>No exceptions</td>
</tr>
<tr>
<td>National Grid</td>
<td>Other PAs provide a hard-coded value for measure life entry into tracking, whereas National Grid implementers select based on options provided in tracking for the measure type.</td>
<td>No exceptions</td>
</tr>
<tr>
<td>Berkshire</td>
<td>No exceptions</td>
<td>No exceptions</td>
</tr>
<tr>
<td>Cape Light Compact</td>
<td>No exceptions</td>
<td>Lifetime savings are not maintained in the tracking system, but externally.</td>
</tr>
<tr>
<td>Unitil</td>
<td>No exceptions</td>
<td>Previously did not maintain lifetime savings in tracking system, but will track these values in their new tracking system beginning 1/1/2021 for Massachusetts.</td>
</tr>
<tr>
<td>Liberty</td>
<td>No exceptions</td>
<td>No exceptions</td>
</tr>
</tbody>
</table>

### 4.4.2 Key findings

The key findings related to the PA implementation process are summarized as follows:

**CST structure and assumptions will drive lifetime savings.** The PAs use a common state-wide CST spreadsheet to screen custom measures for cost-effectiveness. The screening tool is a Microsoft Excel™ workbook field tool used by program implementation staff to qualify every custom project. The measure workbook inputs include project identification descriptors, first-year energy and demand savings, project incremental or full installed costs, and the selection of the measure type (e.g., HVAC, compressed air) and the program type (e.g., retrofit or lost opportunity). Two CST outputs related to lifetime savings are entered into tracking: the measure life (EUL/AML) and measure cost. The CST guides the users to the correct measure event type (ER, ROF, or add-on) and dual or single baseline through the combined selection of program
type and measure type. Based on those combinations, the user can select a measure life from one or more EUL values which the CST uses to calculate an AML and lifetime savings.

While the implementers rely on the CST for measure life selection, evaluators reference the eTRM or other authoritative sources. When a measure is not listed in the eTRM, evaluators reference other TRMs or the published life of a measure with similar features. Ambiguous cases should be reviewed and resolved in the Baseline Advisory Group (BAG) meetings following the same protocols used to resolve baseline issues.

As noted in the 2019 “C&I Measure Life Study: Project MA19C02-B-EUL Final Report”8, “[the CST] does not prevent a user from selecting an inappropriate EUL.” The memo recommended the PAs align the CST with the eTRM measure lives since discrepancies between the CST and eTRM can potentially alter lifetime savings.

Tracking lifetime savings related values. Starting with the PY2016 evaluation, lifetime savings have been assessed by ex-post evaluation teams as part of the site-specific M&V for site-based impact evaluations. Since neither ex-ante lifetime savings nor measure life was universally available from PA tracking systems, the site engineers reviewed the measure life and lifetime savings present in the CST runs included in the project files demonstrating that a project is cost-effective. Since tracking savings are used directly to populate the BC Tool and not CST values, the evaluators should be evaluating tracking lifetime savings or tracking measure lives rather than the values maintained in the CST. This will require close coordination between PA and DNV GL data teams since lifetime savings related fields are relatively new.

Table 4-3 summarizes the tracking field name for project measure lives. This field is extracted to determine the measure life entered in the BC Tool for planning and production of lifetime savings reported in the Annual Report and should be the value assessed in ex-post evaluations.

<table>
<thead>
<tr>
<th>Individual PA Exceptions</th>
<th>Tracking Measure Life Field Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eversource</td>
<td>“Project Measure: Measure Life”</td>
</tr>
<tr>
<td>National Grid</td>
<td>“MEASURE_LIFETIME”</td>
</tr>
<tr>
<td>Berkshire</td>
<td>“MEASURE_LIFE”</td>
</tr>
<tr>
<td>Cape Light Compact</td>
<td>EECP field is named “measure life.”</td>
</tr>
<tr>
<td>Liberty</td>
<td>“TRM_MEASURELIFE”</td>
</tr>
<tr>
<td>Unitil</td>
<td>EETs- “Unit Msr Life” (prior to 1/1/2021)</td>
</tr>
<tr>
<td></td>
<td>E-track- “Unit Measure Life” (from 1/1/2021)</td>
</tr>
</tbody>
</table>

Rounding measure lives. PAs have established a practice of rounding measure lives to the nearest whole digit. The CST output is rounded, tracking systems are designed to accept whole numbers only, and the BC Tool only accepts whole number inputs. PA rounding practices are further specified in Section 4.4 and discussed in Section 4.5.

4.4.3 Discussion

The Working Group noted that the eTRM does not include references for measure lives for all of the measures and almost none for custom measures. PAs argued that the CST is also an authoritative source for measure life and that the applicant measure life should stand, unless it is egregiously incorrect (e.g., claiming a chiller control software update has the same life as a chiller). The evaluators were opposed to this approach. While it is true that there are few custom-specific measure lives in the eTRM, most custom measures have a clear deemed measure prescriptive counterpart, and there is no evidence that

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8 https://ma-eeac.org/wp-content/uploads/MA19C02_B_EUL-final-report-03_31_20-v2.pdf; Section 2.3
custom and deemed prescriptive measure lives are different. Establishing the standard for flagging something as "egregious" is also problematic.

There was agreement that there are steps that evaluation and implementation can take to minimize differences in measure lives, as follows:

**Conduct an annual review of the CST EUL and OYF factors and include them in the eTRM for custom measures explicitly.** The evaluators could review the CST as part of their annual update cycle to identify measure gaps and ensure that the factors reflect the latest measure lives and potential. This review would ensure that the values embedded in the CST reflect the eTRM for that year.

**Define protocols for measures without an EUL reference in the eTRM.** The eTRM does not include measure lives for every measure, particularly process measures and the CST, in some cases, it offers many EUL options for the same measure type. This suggests that the evaluators, in collaboration with implementers, could develop a protocol for assigning a measure life based on a few objective factors. These factors might include the total installed cost budget, whether the equipment is an add-on (like controls) or a stand-alone unit, or whether the equipment was custom built or a standard unit.

### 4.5 Impact of rounding on lifetime savings

Dual baseline measures will usually produce a decimal measure AML life; however, current PA practice is to enter whole number measure lives into tracking systems. Likewise, calculating a weighted measure life is likely to create a decimal result, however, the value is rounded to a whole number before entry in the BC Tool.

There is an assumption that rounding numbers will produce a correct overall answer, with rounding ups balancing the rounding downs and any differences, if they exist, will be small. This assumption is not entirely correct.

- Microsoft Excel rounds up 0.5, which creates a slight upward rounding bias.
- The dual baseline calculations are based, at least for the present, on a small number of assumptions, which will have repeatable non-random outcomes. For example, a common custom measure life of 10 years with the default OYF of 90% yields an AML of 9.33, which will always round down to 9.0 a reduction of 3% in benefits and lifetime savings for any current dual baseline measure using an EUL of 10.
- Initial analysis shows that LSAF values between 90% and 100% are more likely to overestimate lifetime savings by about 1% and LSAF between 100% and 110% are more likely to underestimate lifetime savings by 1%. Since initial analysis indicates the LSAF will be close to 100%, the LSAF effect could be cancelled out by systemic rounding.

Appendix C includes detailed explanations and examples.

### 4.6 Implementation of LSAF in tools and systems

This section discusses the implementation of the LSAF, starting with the recommended final recommendations and a short-term work-around.

**Long-term implementation:**

Full implementation of an accurate LSAF requires changes throughout the data stream:

- **CST.** Remove the rounding function in the CST. This is a straightforward change to the exiting CST tool and can leverage existing procedures for regular distribution of new versions of the tool to users.
- **Tracking.** PAs must revise tracking systems and procedures to either:
o Accept decimal value entries into measure life fields. Revising the datatypes of data fields is not trivial since it requires a revision to data structure definitions and impacts data storage and internal processes.

o Have users enter gross lifetime savings estimates instead of measure life. Like the first option, this would likely require data structure changes and revisions to existing input screens.

Each PA will need to initiate, budget, schedule, and execute the appropriate revisions to its tracking system. PAs have indicated that this change will not be implemented this year and might be expected in 2022 or beyond.

- **BC Tool data entry.** Remove the data entry restrictions to allow for decimal value measure lives. This is a straightforward change to the existing tool.

- **Modify BC Tool to add an LSAF evaluation factor column.** Revisions to the BC Tool is overseen and approved by the DPU. While the addition of a new evaluation factor is conceptually straightforward, it would require testing to ensure that there were no unintended consequences and approval by the DPU before distribution to users. The BC Tool is under development for the next three-year cycle (2022-2024) and now is an ideal time to implement the LSAF factor in the approved model for the next cycle.

- **National Grid has internal requirements which prevent the application of the LSAF in the annual term report filed in 2021 for PY2020 savings but will apply the corrections in the 2019-2021 three year term report filed in 2022.**

**Short-term workaround:**

Adding an evaluation factor to the BC Tool will require approval by the DPS. Instead of adding a column to the BC Tool, the PAs can include the LSAF factor as an explicit factor in the Measure Life cell of the input tab (i.e., “8.3 * 98%”). While less transparent than adding a column, it does offer a method of verifying that the LSAF was applied in reporting the PA’s lifetime savings in the term report filed in 2021 for PY2020 savings by examining the cell formulas.
5 RECOMMENDATIONS

The team has the following recommendations based on the study findings.

R#1 Add a lifetime savings factor to the BC Tool. Evaluation lifetime savings findings should be captured in an LSAF that is applied to the measure life in the BC Tool. For PY2020 savings in the 2020 term year report filed in 2021, the LSAF will be explicitly included in a formula for measure life.\(^9\) The adjusted measure life value used to calculate the lifetime savings for each measure line item in the BC Tool will be a product of the LSAF and the PA-weighted measure life for that measure line item. For the three-year term beginning in PY2022 and beyond, the BC Tool should be modified to include an additional evaluation factor column for the LSAF. PAs may also modify their tracking systems to account for the LSAF.

**Represent measure life related values as rational (decimal) values.** Measure life should be represented as a decimal number with one digit after the decimal throughout the data stream, consistent with the FCM specification for measure life. The rounding functions implemented in the CST and whole number data input requirements for the BC Tool should be removed allowing for decimal inputs and outputs.

PAs should update tracking systems to represent measure lives as a rational number and establish a timeline for doing so.

**Evaluator assess tracking values for lifetime savings.** Custom evaluations should assess measure life as it is represented in PA tracking. This requires coordination of PA and DNV GL data teams to properly identify the correct fields and to communicate differences to the evaluation field teams.

R#2 Continue to design samples for studies using a primary savings type (annual or lifetime). The team recommends using annual savings for stratification unless or until such time that lifetime savings precision is inadequate allowing the LSAF to fall out of that design. The LSAF should be monitored with each evaluation to determine if the resulting ERs and RPs are insufficient, which would drive the need for additional sample points in subsequent impact evaluations to improve their accuracy.

R#3 Update the dual baseline cost adjustment method currently incorporated in the CST to match the enhanced NEEP methodology. This methodology accounts for avoided and deferred replacement costs associated with measures where EULs are different for high efficiency equipment compared to the replaced equipment. Although the update would require additional data collection for measures where EULs of high efficiency equipment are different compared to the replaced equipment, the cost adjustment calculations will become more accurate for early replacement measures. To implement this recommendation, DNV suggests that the PAs update the MA CST formula for deferment credit based on the enhanced NEEP methodology per the Arkansas TRM in the next revision of the tool. There are no updates needed in the BC Tool to reflect any dual baseline cost adjustments. The total resource costs brought into the BC Tool from the PA tracking systems should already reflect any dual baseline adjustments to costs in aggregate. This method does not change methods for estimating project related costs, but only how measure life is factored into discounting calculations.

To improve lifetime savings estimates, the Working Group recommends instituting the following procedures:

R#4 Annual review of the CST EUL and OYF factors. The Working Group recommends that the evaluators review and approve the CST factors each year as part of their annual update cycle. Particular attention should be paid to matching CST

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\(^9\) National Grid has internal requirements which prevent the application of the LSAF in the annual term report filed in 2021 for PY2020 savings, but will apply the corrections in the 2019-2021 three year term report filed in 2022.
EULs with authoritative values such as the latest eTRM EULs. This review would assure that the values embedded in the CST reflect the eTRM for that year.

R#5 Define protocols for measures without an EUL reference or where the CST has multiple EUL selections. The eTRM does not include measure lives for every custom measure\(^\text{10}\), particularly process measures. For these measures, the practice is to select the life of an analogous measure. The Working Group recommends that the evaluators, in collaboration with the implementation team, develop a protocol for assigning a measure life based on a few objective factors. These factors might include the total installed budget, whether the equipment is an add-on (like controls) or a stand-alone unit, or whether the equipment was custom built or a standard unit. In addition, the Baseline Advisory Group (BAG) should review and assess site M&V measure EULs flagged by evaluators for revision. Implementing this practice will ensure measure life assignments are consistent and that the adjustment is warranted.

\(^{10}\) National Grid has notified that starting with the 2020 eTRM update, the PAs have included the ML table in CST within the TRM.
APPENDIX A. GLOSSARY OF TERMS

First-Year Savings – The first-year savings are calculated as the difference between the measure baseline and the consumption of the installed equipment. For lost opportunities, the baseline is industry standard practice (ISP); for retrofit, both dual and single baseline measures, it is existing equipment.

Lifetime Savings – Lifetime savings are calculated as the total savings of a specific input over the life of the measure.

Dual Baseline Concept – The traditional “retrofit” project assumes that the savings between the existing, operational system and the installed, high-efficiency system are appropriate for the full measure life of the installed measure. However, in many cases the retrofit occurs on equipment that is already well into its expected useful life. It is therefore likely that the existing equipment would naturally fail at some point in the future and require the customer to repair or replace it. A dual baseline approach accounts for the natural replacement of the existing equipment through some high-level, non-project-specific assumptions.

First-Period Savings – The first-period savings represent the difference between the consumption of the existing equipment and the consumption of the installed, high-efficiency equipment over the period of the remaining useful life of the existing equipment.

Second-Period Savings – The second period or outyear savings represent the difference between the consumption of a future standard efficiency option and the consumption of the installed, high-efficiency equipment. The outyear savings of a dual baseline project is calculated using an assumed, non-site-specific outyear factor (OYF).

Outyear Factor (OYF) – While the first-year savings for a retrofit measure compare the consumption of the existing equipment to the consumption of the installed equipment, the out-year savings represent the savings between the "standard equipment" that may be installed at the natural point of failure of the existing equipment and the installed equipment. The OYF is an assumed value based on the initiative and measure type. The OYF is applied to the first-period savings estimate to estimate the second-period savings. The OYF only applies to dual baseline measures.

Effective Useful Life (EUL) – The EUL is, theoretically, the year in which half of the installed equipment is operational (in years). The Massachusetts electronic Technical Reference Manual (eTRM) is the current source of EULs.

Remaining Useful Life (RUL) – The RUL is the remaining life of the baseline equipment (in years). The default estimate is 1/3 of the EUL of the baseline equipment.

Adjusted or Equivalent Measure Life (AML/EML) – The AML/EML is a calculated measure life that will produce dual baseline lifetime savings when multiplied by the first-year savings estimate.
APPENDIX B. PA IN-DEPTH INTERVIEW GUIDE

Purpose

This research focuses on implementing adjustments to lifetime savings that reflect impact evaluation findings and dual baseline adjustments to costs. The in-depth interviews (IDIs) will focus on the systems and tools that incorporate lifetime savings in some manner and investigate whether that system requires an evaluated lifetime savings factor or retrofit measure cost adjustments.

Table 5-1: Research Objectives Mapped to Questions in this Instrument

<table>
<thead>
<tr>
<th>Research Objectives</th>
<th>Survey Questions That Address the Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Determine sources for measure life (Column I) and resource cost (Column J) in the BCR tool</td>
<td></td>
</tr>
<tr>
<td>• Determine how individual application and/or CST inputs are added to tracking</td>
<td>All questions</td>
</tr>
</tbody>
</table>

Instrument and Data Collection Information

Table 5-2: Overview of Data Collection Approach

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Description – Up to 21 Individuals</td>
<td>For each of the seven PAs:</td>
</tr>
<tr>
<td></td>
<td>• Staff member knowledgeable about data development for the annual report and the BC Model tool</td>
</tr>
<tr>
<td></td>
<td>• Staff member knowledgeable about tracking data fields, contents, and methods of population</td>
</tr>
<tr>
<td></td>
<td>• Staff member knowledgeable about development of EUL, AML, lifetime savings, and projects costs and how those are entered into tracking</td>
</tr>
<tr>
<td>Population Size/Sample Frame</td>
<td>N/A</td>
</tr>
<tr>
<td>Type of Sampling</td>
<td>Census of PAs</td>
</tr>
<tr>
<td>Target Sample - Survey Completions</td>
<td>N/A</td>
</tr>
<tr>
<td>Instrument Type</td>
<td>Phone In-Depth Interview</td>
</tr>
<tr>
<td>Survey/Interview Length</td>
<td>30-45 minutes</td>
</tr>
<tr>
<td>Description of Contact Sought</td>
<td>Those involved in updating inputs in the BCR, CST, FCM and tracking tools</td>
</tr>
</tbody>
</table>

Interviewer Information

Interviewer instructions are in [brackets].

The interviewers will send preparatory materials 24 hours in advance, which includes a slide deck that describes the intention of the study as a whole and a description of the series of interviews planned for this study. The materials will include a process flow diagram, similar to the following to help guide the discussion:
Additional slides will be included specific to each PA.

**Instrument**

Can you provide a brief explanation of your current role?

**Questions for the staff member responsible for data development for the annual report and reporting:**

[Prior to the interview, we will send the link to both the 2019 planning BCR Model and the 2019 Annual Report from the EEAC website. We will include a description of specific questions and the purpose of the interview.]

Q1. Can you explain the specific steps that were used to produce the electric (and gas) CI Lifetime savings in the Annual Report for PY2019 (page 5)?

   We are most focused on how measure life is derived, given that the BCR Model does not include a field for PA tracking lifetime savings inputs.

   We would like the actual data source names of any tracking values that are used in the estimates of measure life, gross savings, and resources costs and the sources of any other assumptions used to calculate lifetime savings and total resource costs.

Q2. Please describe any differences in the treatment of custom and prescriptive measures.

   We are also interested in the development of the CI resource costs and any differentiating for single vs. dual baseline measure costs.

Q3. Will this process be revised for reporting PY2020 achievements in 2021? PAs are accountable for dual baseline treatment reporting, which impacts lifetime savings. [ERS will note any new fields that have been created for this purpose per the team's review of tracking data.]

Q4. There is an intention to factor in an adjustment to the lifetime savings in the 2021 report to account for evaluation findings. When does this value need to be provided to your team so that it is factored into the PY2020 reported savings?

Q5. Is the measure life field integers or real values?

Q6. [Where it applies] It doesn’t appear that measure life is included in your tracking data. What is the source of assumptions for measure life in the BC Model?

Q7. We are scheduling a panel discussion to consider revisions to the BCR Model team to better accommodate lifetime savings inputs. Do you have any ideas or concerns that should be discussed?
Questions for staff members responsible for tracking data:

[Prior to the interview, we will send a spreadsheet with a list of tracking data fields identified as associated with reporting lifetime savings compiled from DNV GL’s review of tracking data and any additional inputs from the BCR Model staff interview. We will include a description of specific questions and the purpose of the interview.]

Q8. Can you please provide the sources and any processing associated with each of the fields in our list of tracking variables of interest that were noted by the BCR Model team?

Q9. Does this list include all the fields associated with the production of lifetime savings and with developing resource costs? If not, what others should be included?

Q10. Please describe any differences in the treatment of custom and prescriptive measures.

Q11. Are fields associated with measure life integers or real values?

Q12. [Where it applies] You indicated that the source of field [TBD] was a look-up value. What are the index values for the looked-up value and what is the source of the actual value?

Q13. Can you please confirm a list of the fields that are populated by the implementation team – in particular, for the custom measures?

Questions for staff members responsible for the application values entered in tracking data:

[Prior to the interview, we will send a spreadsheet with a list of tracking data fields identified by tracking staff as sourced from implementation. We will include a description of specific questions and the purpose of the interview.]

Q14. Can you please describe the source for the values for each of the fields in the list of tracking values and whether that source varies depending on the measure type (either custom or prescriptive)?

Q15. What are the sources for measure life assumptions?

Q16. How do you estimate lifetime savings for each measure?

FCM related questions asked of staff members involved in maintaining, calculating, and submitting ISO NE FCM resources [after confirming role in FCM process for their PA]

Q1. Are you using two stream or one stream savings calculations for retrofit measures?

Q2. If single stream, are you using AML values in your tracking system?

Q3. Are you currently rounding AMLs? Can your tracking system handle AMLs with fractions?

Q4. What are your plans to implement the lifetime realization rate?

Q5. What is the process to store, calculate and submit FCM resources? What adjustments happen in vs outside of your tracking system?

Q6. Do you anticipate any problems with using lifetime realization rates to adjust AMLs used to remove FCM resources?
APPENDIX C. BC TOOL DETAILED ILLUSTRATIONS

Rounding

Rounding in Excel. The "= Round(x, 0)" function, which is the standard method for rounding in Excel, rounds values with a "5" as the tenth digit up to the next whole number. The figure on the right presents a range of values ("Actual Values") between 1 and 2 in tenth increments and the rounded actual value using the Excel Round function. The error is calculated as the difference between the actual and rounded value. Note that five values are rounded down versus six of the values rounded up. This produces a 3% overstatement of the sum of the actual compared to the sum of the rounded values showing that the 'ups' do not balance the 'downs' with a measure life between 1 and 2 years.

The error diminishes as the Actual Value increases. For example, for a range of Actual Values between 10 and 11, the error is 0.4%.

This known phenomenon is discussed further here in this article with a catchy title:

https://excelribbon.tips.net/T002829_Rounding_Religious_Wars.html

Typical rounding outcomes of measure lives. The table at right shows the distribution of custom lifetime gross savings by measure life for Eversource 2019 custom measures. The 13-year measure life is characteristic of lighting, while the most prevalent custom non-lighting measure life is 10 years.

A dual baseline measure with a 10-year effective useful life (EUL) is likely to have the default 90% outyear factor (OYF) and a remaining useful life (RUL) that is 1/3 of the EUL. The adjusted measure life will be:

\[ AML = \frac{1}{3} \times EUL + \frac{2}{3} \times EUL \times OYF \]

\[ AML = 9.33 \]

The rounded AML will be 9.0, reducing lifetime savings and benefits by 3%. Whereas we might expect rounding effects to be neutral, when significant portions of the portfolio have similar assumptions, the rounding will be in the same direction and the error as a percentage of the portfolio can be significant.

<table>
<thead>
<tr>
<th>Measure Life</th>
<th>Sum of Gross LT</th>
<th>Pct of Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>125</td>
<td>0%</td>
</tr>
<tr>
<td>9</td>
<td>11,475</td>
<td>1%</td>
</tr>
<tr>
<td>10</td>
<td>283,150</td>
<td>14%</td>
</tr>
<tr>
<td>11</td>
<td>81,950</td>
<td>4%</td>
</tr>
<tr>
<td>12</td>
<td>178,080</td>
<td>9%</td>
</tr>
<tr>
<td>13</td>
<td>929,500</td>
<td>46%</td>
</tr>
<tr>
<td>14</td>
<td>97,300</td>
<td>5%</td>
</tr>
<tr>
<td>15</td>
<td>85,500</td>
<td>4%</td>
</tr>
<tr>
<td>17</td>
<td>153,000</td>
<td>8%</td>
</tr>
<tr>
<td>20</td>
<td>200,500</td>
<td>10%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>2,020,580</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
**Portfolio impact.** The figure at right summarizes the rounding error associated with a random selection of LSAF between 0.9 and 1.1 applied to the Eversource 2019 custom measures. Each line item illustrates the impact on all custom measures assuming a different random LSAF.

In this simulation run, an LSAF of 0.90 appeared twice, for example and produced a net lifetime increase of 1.9% greater than the actual gross would have been without rounding.

The conclusion is that rounding will produce small errors on a portfolio level.

**One vs. two gross evaluation factors**

The Working Group initially considered moving to a single lifetime savings factor that would include both first-year evaluation findings (reflecting, for example, changes in hours of operation) as well as lifetime savings effects. While this approach would yield a correct lifetime savings values, it would not produce the correct benefits.

As shown in the table at right, equal lifetime savings (LF kWh) does not yield the same lifetime benefits depending upon the mix of measure life and first year savings realization rate.

In the table, the first four data sets represent a measure with a first-year RR of 70% and nominal 10-year measure life. The LSAF in the four cases are, in order: 50%, 75%, 90% and 110%. The subsequent benefits deviate for the “correct” value by up to 31%.

<table>
<thead>
<tr>
<th>Case</th>
<th>LF kWh</th>
<th>Total Benefit</th>
<th>ML</th>
<th>1st Yr RR</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>3,500.00</td>
<td>$989</td>
<td>5.00</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>3,500.00</td>
<td>$1,299</td>
<td>10.00</td>
<td>35%</td>
<td>131%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>3,500.00</td>
<td>$901</td>
<td>3.50</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>Correct</td>
<td>5,250.00</td>
<td>$1,463</td>
<td>7.50</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>5,250.00</td>
<td>$1,607</td>
<td>10.00</td>
<td>53%</td>
<td>110%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>5,250.00</td>
<td>$1,330</td>
<td>5.25</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>Correct</td>
<td>6,300.00</td>
<td>$1,737</td>
<td>9.00</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>6,300.00</td>
<td>$1,791</td>
<td>10.00</td>
<td>63%</td>
<td>103%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>6,300.00</td>
<td>$1,583</td>
<td>6.30</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>Correct</td>
<td>7,700.00</td>
<td>$2,087</td>
<td>11.00</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>7,700.00</td>
<td>$2,038</td>
<td>10.00</td>
<td>77%</td>
<td>98%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>7,700.00</td>
<td>$1,919</td>
<td>7.70</td>
<td>100%</td>
<td>92%</td>
</tr>
<tr>
<td>Correct</td>
<td>12,600.00</td>
<td>$3,284</td>
<td>18.00</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>12,600.00</td>
<td>$3,409</td>
<td>20.00</td>
<td>63%</td>
<td>104%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>12,600.00</td>
<td>$3,002</td>
<td>12.60</td>
<td>100%</td>
<td>91%</td>
</tr>
<tr>
<td>Correct</td>
<td>2,520.00</td>
<td>$722</td>
<td>3.60</td>
<td>70%</td>
<td></td>
</tr>
<tr>
<td>Single RR</td>
<td>2,520.00</td>
<td>$748</td>
<td>4.00</td>
<td>63%</td>
<td>104%</td>
</tr>
<tr>
<td>Adj Year</td>
<td>2,520.00</td>
<td>$659</td>
<td>2.52</td>
<td>100%</td>
<td>91%</td>
</tr>
</tbody>
</table>
About DNV
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