REVIEW DRAFT PHASE 2 REPORT

X1939 Phase 2 Impact Evaluation

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 second phase of the X1939 study, examining the performance of four Early Retirement programs (two chiller programs, a boiler program and a roof top unit program). The primary focus of the review was with respect to the event type determination (were the programs in fact retiring equipment ahead of the end of its useful life) and were dual baseline savings calculations being applied appropriately. The team performed desk reviews of all 24 participants across the four programs and completed customer interviews with 10 of the customers.

The team quantified realization rates and a net to gross factor for the programs as well as the total evaluated net energy savings and also provided four recommendations to help improve performance of the programs. A summary of the recommendations include:

1. Combine the early retirement factor realization rates from this study with the most recent prospective savings realization rates for commercial electric and gas HVAC measures to be applied to any dedicated C&I custom early retirement offerings.
2. Programs should work to bolster the preponderance of evidence that is collected to support the use of existing equipment as the baseline for these custom projects. This this should include evidence such as trend data, metered data, dated photos/videos of operation, bid quotations or similar demonstrating that the pre-existing equipment is a reasonable baseline.
3. Tracking data should be compiled into one organized file that includes key information for each project.
4. Non-Energy Impacts are not a factor in Connecticut's Utility Cost Test and thus cannot currently be included directly in project screening, however they should still be quantified and tracked.. The survey found that most sites who responded reported NEIs as a result of these projects which could be used to bolster the return on investment which may help to increase uptake in the programs.

The realization rates shown below. The combined net-to-gross factor is 86.9%.

Parameter *(combined for all programs[1])*	**First Year Elect. RR**	**First Year Gas RR**	**Lifetime Electric RR**	**Lifetime Gas RR**
Early Retirement Factor	**88.4%**	**98.5%**	**93.7%**	**98.8%**
Total Gross Savings	**89.8%**	**75.0%**	**96.0%**	**75.7%**
Total relative precision at 90% confidence	±41%	±14%	±38%	±14%

[1] These factors represent combined values across the four early retirement programs evaluated. They include the 2019 and 2020 chiller programs, a boiler program and a roof top unit program

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1 EXECUTIVE SUMMARY

This impact evaluation represents the second Phase of research for the X1939 Early Retirement (ER) Evaluation. The first phase provided best practices research and recommendations surrounding data and lifetime savings calculations, evaluation considerations, and early retirement program design[2]. Those recommendations were applicable to both ER programs and ER measures outside of ER programs, for example a roof top unit replacement that goes through the Energy Opportunities program but uses the existing equipment as the initial baseline.

This second phase was an impact evaluation of four custom C&I early retirement programs. Those programs were:

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

This study had five objectives addressed through the two phases of work. The following table summarizes the objectives and the work phase in which they are addressed.

Table 1-1. Evaluation Objectives

Objective	Source (Phase)
1. Provide feedback on ER program design, including which gross and net parameters are relevant for ER programs	Best practices/ER design (addressed in Phase 1 report)
2. Ensure that CT programs are accounting for dual baseline calculations where applicable as outlined in the CT Program Savings Document (PSD)	Best practices/ER design (addressed in Phase 1 report)
3. Ensure that the program is equipped to handle non-energy impact factor considerations for ER projects	Best practices/ER design (addressed in Phase 1 report)
4. Optimize the process effectiveness and efficiency for ER programs	Best practices/ER design & CT ER impact eval (addressed in Phase 1 report & in this report)
5. Use program measurement & verification data and customer interviews to assess the performance of ER programs and to better inform the design of ER programs	CT ER impact eval (addressed in Phase 2 report)

The impact portion of the study (Phase 2) included a review of projects that participated in these programs and the development of impact factors based on that review. The first year and lifetime reported savings are summarized below.

Table 1-2. Program Claimed Savings

Program	Number of Awarded Projects	Annual Program Reported Electric Savings (kWh)	Lifetime Reported Electric Savings (kWh)	Annual Program Reported Gas Savings (MMBtu)	Lifetime Reported Gas Savings (MMBtu)
2019 Chiller Program	4	2,654,180	30,118,355	N/A	N/A
2020 Chiller Program	1	421,502	4,280,870	N/A	N/A
2020 Boiler Program	5	116,783	727,235	38,797	447,023
2020 RTU Program	13	1,512,734	12,216,908	4,452	44,521
Total	**23**	**4,705,199**	**47,343,368**	**43,249**	**491,544**

[2] X1939 Phase 1 Best Practices Research

The realization rates shown in Table 1-3. The combined net-to-gross factor is 86.9% ±24%.

Table 1-3. RR Summary

Parameter *(combined for all programs)*	First Year Elect. RR	First Year Gas RR	Lifetime Electric RR	Lifetime Gas RR
Early Retirement Factor	**88.4%**	**98.5%**	**93.7%**	**98.8%**
Total Gross Savings	**89.8%**	**75.0%**	**96.0%**	**75.7%**
Total relative precision at 90% confidence	±41%	±14%	±38%	±14%

Applying these factors to the program reported savings yields the following results.

Table 1-4. Evaluated Net Savings

Program	Number of Awarded Projects	Evaluated Net First Year Electric Savings (kWh)	Evaluated Net Lifetime Electric Savings (kWh)	Evaluated Net First Year Gas Savings (MMBtu)	Evaluated Net Lifetime Gas Savings (MMBtu)
2019 Chiller Program	4	2,071,590	23,507,411	N/A	N/A
2020 Chiller Program	1	328,983	3,341,224	N/A	N/A
2020 Boiler Program	5	91,149	567,608	25,267	294,098
2020 RTU Program	13	1,180,691	9,535,311	2,899	29,291
Total	**23**	**3,672,413**	**36,951,553**	**28,166**	**323,388**
Relative Precision		±46%	±25%	±43%	±25%

In addition to the factors above, the evaluation team also has the following findings and recommendations that were a result of the review.

1. **The programs applied the early retirement logic correctly**

Dual baseline calculations were used to estimate lifetime savings in all cases, which is consistent with the recommendation made in the Phase 1 report for these programs. While these calculations were accurate, it is also worth noting, that the scope of this evaluation did not include site visits or metering, as the focus was more with respect to the event type determination and the use of dual baseline calculations.

Recommendation: Combine the early retirement factor realization rates (ER RRs) that were the result of this study with the most recent prospective savings realization rates for commercial electric and gas HVAC measures and apply them to any dedicated C&I custom early retirement offerings. These realization rates were quantified through the C1635 study which was an impact evaluation of the Energy Opportunities program. They cover all aspects of gross savings other than the ER RR. The calculation showing this combination can be seen in Section 4.1 below.

2. **Program data and project documentation are critical for evaluation and accurate reporting of savings**

While the evaluation team only adjusted the baseline on 3 projects, the reviews revealed that there was generally not a lot of convincing supporting detail on the project files to demonstrate that the existing equipment was in fact functioning effectively enough to be considered a reasonable baseline. In most cases there was a narrative and a photo or two, however the photos were generally of nameplate information and didn't demonstrate the functionality of existing equipment.

The tracking data provided was not compiled into one place, as is best practice.

Recommendation: Both Utilities should work with the participants to collect more information to bolster the preponderance of evidence that is collected to support these custom projects. Per the recommendation in the Phase 1 report, this should include 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 effective useful life (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.

Recommendation: Program tracking data should be compiled into one organized file that includes key information for each project. This information includes, but is not limited to, facility address, contact information, project description, annual energy savings, lifetime energy savings, and non-energy impacts. This will help reduce any errors when the program is reporting savings.

3. Customers are reporting significant non-energy impacts for their projects

The evaluation survey conducted through this research (post-installation) asked customers to estimate the value of non-energy impacts associated with the project. In most of the completed interviews, customer reported that there were non-energy impacts that exceeded the value of their energy savings. Per the Phase 1 report, best practice dictates that NEIs be treated in the same manner as energy savings when determining the impacts of a measure and when calculating the cost benefit ratio.

Recommendation: While CT uses the Utility Cost Test (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 industry standard practice (ISP) compliant piece of equipment. One example could be that O&M costs for a 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.

2 INTRODUCTION

This document presents the research findings from the second of two phases of research for the X1939 Early Retirement evaluation. In this phase, the evaluation team conducted an impact evaluation of the initially released early retirement programs in CT, which include two rounds of large chiller programs, a roof top unit program and a boiler program. These were initial early retirement program releases, and in total had 24 participants across the four programs.

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 and how they should be tracked.
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), review the information and data being collected by the Utilities, and to better inform the design and implementation of early retirement programs.

Feedback on the first four objectives were provided in the Phase 1 memo[3]. This report covers portions of the fourth and the fifth evaluation objective through an impact evaluation of the early retirement programs.

2.2 CT program description

The following section describes the early retirement programs in CT that fell under this evaluation.

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

[3] X1939 Phase 1 Best Practices Research

These programs have been competitive bid programs[4] that accept applications from individual customers or implementers. A summary of the reported savings by program can be seen below.

Table 2-1. Program reported savings

Program	Number of Awarded Projects	Annual Program Reported Electric Savings (kWh)	Lifetime Reported Electric Savings (kWh)	Annual Program Reported Gas Savings (MMBtu)	Lifetime Reported Gas Savings (MMBtu)
2019 Chiller Program	4	2,654,180	30,118,355		
2020 Chiller Program	1	421,502	4,280,870		
2020 Boiler Program	5	116,783	727,235	38,797	447,023
2020 RTU Program	13	1,512,734	12,216,908	4,452	44,521
Total	**23**	**4,705,199**	**47,343,368**	**43,249**	**491,544**

2.3 Summary of Phase I recommendations

The first phase of the X1939 study focused on best practices recommendations for data and lifetime savings calculations, evaluation considerations and early retirement program design. 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. DNV's impact evaluation of the early retirement programs included a review of the program documentation with consideration of several of these recommendations.

In developing these recommendations, 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. A summary of these recommendations is as follows.

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

[4] 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.

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.

3 PHASE II METHODOLOGY

Evaluators completed an impact evaluation of four early retirement programs. The original evaluation plan laid out tasks including sample design, desk reviews, and customer interviews. The primary reason the review was based on desk reviews and in-depth interviews 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 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 completed the following tasks:

1. **Desk reviews** – DNV perform desk reviews of all 23 projects with an eye toward program eligibility, measure event type, and baselines. These reviews investigated submitted documentation for the equipment that has been targeted for replacement, assessed the appropriateness of the first-year and lifetime savings, and confirmed program eligibility.

2. **Customer interviews** – For each desk review performed, DNV attempted interview the customer to discuss key project information. Customer interviews focused on the baseline, which consisted of the existing equipment. We also asked questions regarding the program's influence on the customer to retire their equipment early, as well as the facility's pre-existing conditions, in order to compare interview responses with program documentation. The questions relating to program influence were completed with the purpose of compiling information on free-ridership (FR) associated with the early retirement of equipment as well as spillover. We also included questions on NEIs as a result of the project.

The result of these tasks were quantified realization rates, free-ridership rates, spillover rates and NEIs for the programs. A single survey instrument was used to collect data for both the SRR and attribution.

3.1.1 Savings Realization Rate

The program-level RR is applied to the program-reported savings, resulting in the evaluated gross savings estimates. RRs represent an adjustment to the program-reported savings, upward or downward, to account for differences between the evaluated gross savings and program-reported savings.

$$RR = RR_{ER}\ x\ RR_{non-ER}$$

$$ER\ RR = \frac{Savings_{Evaluated\ ER}}{Savings_{Reported}}$$

where,

RR = Realization Rate

RR_{ER} = Early retirement factor realization rate

RR_{non-ER} = Realization rate for non-early retirement programs, based on large sample, high rigor review of factors such as time of use, load, and engineering formulas, from other research

$Savings_{Evaluated\ ER}$ = Savings adjusted for evaluators' judgment of appropriate application of early retirement dual baseline principles

$Savings_{Reported}$ = Savings as reported by the Program

More detail on the combination of these factors can be found in Section 4.1 below.

3.1.2 Net to Gross Factor

The savings attributed to the Program are equal to the recommended and installed savings induced by the program effort, above and beyond what would have occurred in the absence of the Program. This requires estimating the proportion of direct program savings that would have occurred without the Program (free ridership (FR)) and the indirect savings induced by the Program (spillover). This section discusses the methods that were used to assess these two components of net savings: FR and SO. These factors are combined to compute the NTGR through the following formula:

$$NTGR\ =\ (1 - FR\ +\ SO)$$

3.1.2.1 Free Ridership

The Impact Evaluation Team examined FR using a basic self-report survey method for specific measures. The survey instrument was based upon those used for other CT evaluations (C1902). The evaluators simplified and adapted the survey instrument for these program's participants. The FR portion of the survey addressed three different components of the decision. The timing, the efficiency of the equipment installed and the overall influence of the program. The table below summarizes the various components included in the FR calculation.

Table 3-1. Free Ridership Questions and Scoring

Type	Question	Responses	Calculation	Score
Timing	Would you have implemented any new [boiler/chiller/RTU] at the same time without assistance?	Yes	T = 0	FR_Timing = (1 - ((T-6) * 0.024))
	Would you have implemented the [boiler/chiller/RTU] earlier than you did, at a later date, or never, without assistance?	Same Time	T = 0	
		Never	T = 48	
	How much earlier/later would you have purchased the equipment?	_____ years	T = (Recorded # of Years * 12) + Recorded # of Months	
		_____ months		
Efficiency	Would your business have implemented the same high efficiency [boiler/chiller/RTU] equipment as what you installed through the program without assistance?	Yes	E1 = 100	FR_Eff = Q/100
		No	E1=0	
	Thinking about the [boiler/chiller/RTU] project you would have implemented on your own if the assistance had not been available, would you most likely have selected a unit that was	Same	E2=100	
		Different	E2=0	
Influence	Overall, how influential was the price discount you received on your company's decision to purchase the equipment?	Extremely influential	I = 0	
		Very influential	I = 0.35	
		Moderately influential	I = 0.5	
		Slightly influential	I = 0.89	
		Not at all influential	I = 1	

These scores are then combined using the following formulas to calculate the FR value.

$$FR = FR_{timing} * FR_{Eff}$$

$$If\ FR = 0\ \&\ I > 0.35\ then\ FR = 0.5$$

$$If\ FR = 1\ \&\ I < 0.89\ then\ FR = 0.5$$

This participant questionnaire can be viewed in Appendix B of this report.

3.1.2.2 Spillover

The same participants were asked about whether any additional measures were installed independent of Energize CTs programs at the participating site or any of their other facilities located in Connecticut and to which they attribute the influence of their participation in the Program. The table below summarizes the questions used to quantify SO.

Table 3-2. Spillover Summary

Question	Responses	Calculation
Have you installed this measure at any other facilities in CT since participation in the ER program?	Yes	Spill Factor in = 1
	No	Spill Factor in = 0
Have you installed this measure at any other facilities outside of CT?	Yes	Spill Factor out = 1
	No	Spill Factor out= 0

These scores are then combined using the following formulas to calculate the FR value.

$$Spillover = Spill_{Factorin} + Spill_{factorout}$$

3.1.3 Non-Energy Impacts

In addition to savings and net to gross factors, the DNV team also asked questions about any non-energy impacts that were the result of the installed measures. These questions then asked the respondent to compare the value of the non-energy impacts achieved to the energy savings from the installed measure. A table summarizing the questions and adjustment factors is as follows.

Table 3-3. Non-energy impact summary[5]

Question	Responses	Calculation
Has the project provided any benefits besides energy savings? Or caused any new increased costs?	Yes	Included in NEI totals
	No	Not included
Is that change you noted more valuable, or less valuable than the energy savings for the project (this applies whether this value represents an increase or a decrease)?	If positive NEI value	Extremely more valuable than the energy savings (LAM multiplier=1.90, scaled) • Very much more valuable (1.56) • Moderately more valuable (1.37) • Slightly more valuable (1.10) • About the same value – value and savings (1) • Slightly less valuable (0.9) • Moderately less valuable (0.56) • Very much less valuable (0.37) • Extremely much less valuable (0.1)
	If negative NEI value	Extremely more costly than the energy savings (-1.83). The negative effects are much larger than the energy savings. • Very much more costly (-1.54) • Moderately more costly (-1.29) • Slightly more costly (-1.09) • About the same costliness – the negative effects or costs are about balanced by the energy savings) (-1) • Slightly less costly (-0.83) • Moderately less costly (-0.54) • Very much less costly (-0.29) • Extremely much less costly (-0.09). The negative effects or costs are only a small share of the value of the energy savings / energy savings more than balances out the negative effects)

The NEI value was then calculated using the following formula.

$$NEI\ Value = Energy\ cost\ savings * NEI\ factor$$

[5] Method from ***4-230-21 D'Souza & Skumatz - ECEEE 2021*** *Likert Scales are Too Simplistic – Better and More Useful Alternatives in Four Applications in Energy Efficiency*

4 RESULTS

The following sections summarize the results and findings from the review of early retirement programs. These results include evaluated annual electric energy and natural gas savings as well as lifetime electric energy and natural gas savings.

4.1 Savings Realization Rate

DNV calculated ER RRs for each of the three evaluated programs. This ratio is calculated by dividing the evaluated gross savings by the program reported savings. Table 4-1 provides a comparison of the ER RRs calculated for each of the programs.

Tale 4-1. Summary of early retirement factor realization rates (ER RR)

Program/Measure	Population	Desk Reviews Completed	Customer Interviews Completed	First Year Elect. ER RR	First Year Gas ER RR	Lifetime Electric ER RR	Lifetime Gas ER RR
2019 and 2020 Chiller Programs	5	5	3	100%	N/A	100%	N/A
2020 Boiler Program	5	5	1	100%	100%	100%	100%
2020 Roof Top Unit Program	14	14	6	47%	80%	66%	80%
Total Combined	**24**	**24**	**10**	**88.4%**	**98.5%**	**93.7%**	**98.8%**
Relative Precision				±23%	±4%	±12%	±3%

For these programs, the realization rates calculated through this review were generally high. The savings calculations for both the annual savings and the lifetime savings were found to be robust and reasonable. The adjustments that were made were due to modifications of the early retirement baseline and a non-installed project. Due to the low number of participants in these programs, coupled with the varying number of completed interviews across the programs, DNV recommends using the total combined realization rates to calculate the gross program savings.

This study's primary research focused on early retirement considerations, As described in the methodology, DNV multiplied the ER RR by the non-ER RRs from a previous Energy Opportunities commercial evaluation[6] to account for adjustments in the actual performance and operation of the equipment and present a comprehensive view of the measures' realization rates. A summary of the combined realization rates can be seen in the table below.

Table 4-2. Combined Savings Realization Rates

Program	First Year Elect. RR	First Year Gas RR	Lifetime Electric RR	Lifetime Gas RR
X1939 Realization Rates	88.4%	98.5%	93.7%	98.8%
C1635 Realization Rates	102.1%	76.5%	102.1%	76.5%
Total Combined	**89.8%**	**75.0%**	**96.0%**	**75.7%**
Total relative precision at 90% confidence	±41%	±14%	±38%	±14%

The evaluated savings are shown in Section 4.3 below.

[6] C1635 Energy Opportunities Impact Evaluation

4.1.1 Event Type Review

DNV reviewed the project files and completed the interviews with an eye towards the baseline for these projects. In all cases, as is expected with early retirement projects, the initial period baseline was assumed to be the existing equipment. It is worth noting, that in half of the interviews completed, the respondent indicated that "the existing equipment had failed or was performing poorly". This alone does not indicate that the baseline was inappropriate but does indicate that specific documentation should be included in the project files to support the use of the existing equipment as the first period baseline. Out of these five cases:

- **In 3 cases, DNV did recharacterize the project from early retirement to lost opportunity.** To account for this in the analysis DNV modified the baseline to be a code compliant piece of equipment for the entire measure life of the newly installed unit.
- In one case, there were three chillers being replaced, but the lead unit was only installed in 2017, therefore DNV did allow this to continue to be characterized as an early retirement project.
- In one case, DNV continued to use the early retirement characterization since the program did provide BMS photos that showed the units operating. It was clear from the values on the screen that the roof top units were running and providing space conditioning.

4.2 Net to Gross

The total NTGR was calculated to be 0.87 for the program. This was derived from a combination of free ridership (FR) and participant spillover (SO). The total relative precision for the net to gross factor was 24%. The results for each of these factors can be seen in Table 4-4.

Table 4-3. Net-to-Gross Ratio

Factors	Ratio[1]
Free ridership (FR)	0.13
Participant spillover (SO)	0.0
Total	**0.87**

[1]The total NTGR is calculated using the formula in Section 3.1.2

All factors were derived from questions asked in the survey.

4.2.1 Free Ridership

The total survey-based FR was 13%. As discussed in Section 3.1.2.1 questions were asked regarding the influence of the program on the timing, efficiency, and their quantification of the overall program influence. The majority of the FR resulted from customers who otherwise would have installed the same efficiency piece of equipment as that installed through the program. There was an apparent difference in the FR between the boiler program and the other three, however the one program with higher free-ridership only had one completed customer interview. A summary of the free-ridership factors by program can be seen in Table 4-4.

Table 4-4. Free Ridership Summary

Program/Measure	Population	Desk Reviews Completed	Customer Interviews Completed	Free-Ridership
2019 and 2020 Chiller Programs	5	5	3	11%
2020 Boiler Program	5	5	1	50%

2020 Roof Top Unit Program	14	14	6	11%
Total	**24**	**24**	**10**	**13%**

4.2.2 Spillover

Spillover would be the result of measures reported as being installed and having been influenced by the program but outside of the program. DNV asked questions of each of the 10 interviewed customers and none of them reported having installed measures elsewhere, therefore no spillover was found to be attributable to this program.

4.2.3 Non-Energy Impacts

DNV also asked questions about and quantified the estimated non-energy impacts resulting from these measures. Based on the survey responses, a weighted average of $57,000 per year of additional impacts per site were reported for the ER portion of the project, more than their annual energy savings. The most common reported benefit was a reduction in O&M costs, with 7 out of the 10 completed customer surveys indicating this was a benefit for them. Other impacts reported included:

- Improved comfort/ventilation – Survey respondents indicated that their staff were more comfortable, which they also said improved morale.
- Improved reliability – New equipment is functioning without issues or causing shutdowns.

4.3 Net Savings Results

The first year and lifetime savings summaries for both the program reported and the evaluated savings are provided below for each of the three programs.

Table 4-5. Program Claimed Savings

Program	Number of Awarded Projects	Annual Program Reported Electric Savings (kWh)	Lifetime Reported Electric Savings (kWh)	Annual Program Reported Gas Savings (MMBtu)	Lifetime Reported Gas Savings (MMBtu)
2019 Chiller Program	4	2,654,180	30,118,355	N/A	N/A
2020 Chiller Program	1	421,502	4,280,870	N/A	N/A
2020 Boiler Program	5	116,783	727,235	38,797	447,023
2020 RTU Program	13	1,512,734	12,216,908	4,452	44,521
Total	**23**	**4,705,199**	**47,343,368**	**43,249**	**491,544**

Table 4-6. Program Evaluated Savings

Program	Number of Awarded Projects	Evaluated Net First Year Electric Savings (kWh)	Evaluated Net Lifetime Electric Savings (kWh)	Evaluated Net First Year Gas Savings (MMBtu)	Evaluated Net Lifetime Gas Savings (MMBtu)
2019 Chiller Program	4	2,071,590	23,507,411	N/A	N/A
2020 Chiller Program	1	328,983	3,341,224	N/A	N/A
2020 Boiler Program	5	91,149	567,608	25,267	294,098
2020 RTU Program	13	1,180,691	9,535,311	2,899	29,291
Total	**23**	**3,672,413**	**36,951,553**	**28,166**	**323,388**
Relative Precision		±46%	±25%	±43%	±25%

4.4 Findings and Recommendations

The impact evaluation team found that the program estimated savings well for both electric and natural gas saving measures. The evaluators did, however, encounter challenges with the tracking data and project documentation in several instances and believe that the project documentation should be bolstered. The following outline some key findings and recommendations that were the result of the desk reviews and customer interviews.

Some projects had missing files or the files contained information that did not match the tracking database. Additionally, the tracking data itself was not organized into one file and needed to be compiled by evaluators. These programs were one-off competitive bid programs, however the recommendations below apply to any program that uses the existing equipment as the baseline.

1. **The programs applied the early retirement logic correctly**

Dual baseline calculations were used to estimate lifetime savings in all cases, which is consistent with the recommendation made in the Phase 1 report for these programs. While these calculations were accurate, it is also worth noting, that the scope of this evaluation did not include site visits or metering, as the focus was more with respect to the event type determination and the use of dual baseline calculations.

Recommendation: Combine the early retirement factor realization rates (ER RRs) that were the result of this study with the most recent prospective savings realization rates for commercial electric and gas HVAC measures and apply them to any dedicated C&I custom early retirement offerings. These realization rates were quantified through the C1635 study which was an impact evaluation of the Energy Opportunities program. They cover all aspects of gross savings other than the ER RR. The calculation showing this combination can be seen in Section 4.1 below.

2. **Program data and project documentation are critical for evaluation and accurate reporting of savings**

While the evaluation team only adjusted the baseline on 3 projects, the reviews revealed that there was generally not a lot of convincing supporting detail on the project files to demonstrate that the existing equipment was in fact functioning effectively enough to be considered a reasonable baseline. In most cases there was a narrative and a photo or two, however the photos were generally of nameplate information and didn't demonstrate the functionality of existing equipment.

The tracking data provided was not compiled into one place, as is best practice.

Recommendation: Programs should work to bolster the preponderance of evidence that is collected to support these custom projects. Per the recommendation in the Phase 1 report, this should include 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 effective useful life (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.

Recommendation: Tracking data should be compiled into one organized file that includes key information for each project. This information includes, but is not limited to, facility address, contact information, project description, annual energy savings, lifetime energy savings, and non-energy impacts. This will help reduce any errors when the program is reporting savings.

3. Customers are reporting significant non-energy impacts for their projects

The survey asked customers to estimate the value of non-energy impacts associated with the project. In most of the completed interviews, customer reported that there were non-energy impacts that exceeded the value of their energy savings. Per the Phase 1 report, best practice dictates that NEIs be treated in the same manner as energy savings when determining the impacts of a measure and when calculating the cost benefit ratio.

Recommendation: While CT uses the Utility Cost Test (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 industry standard practice (ISP) compliant piece of equipment. One example could be that O&M costs for a 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.

APPENDIX A. CUSTOMER INTERVIEW INSTRUMENT

The following provides the instrument used during the customer interviews.

APPENDIX A

A-1 INSTRUMENT: INTERVIEW SCRIPT

Introduction

Thank you for taking the time to talk with me today. As a reminder, we're currently working on a study of the Early Retirement programs in CT. Our understanding is that you have received an award through the chiller/boiler/RTU program. We are interested in asking you a few questions about the pre-existing equipment as well as your decision to participate in the program. The questions should only take 15 – 30 minutes to complete.

S-1. Are you the best person to answer questions on this project?

i. Yes
ii. No
iii. Don't know

S-2. If no or don't know, can you please provide the name and contact info for the best person to talk to?

a. Record the name and contact details of the person you discussed:

Status of the Project

1. Our records show that your project received an award to install a new [chiller/RTU/boiler], is that correct?
    i. Yes
    ii. No
    iii. Don't know

2. Is the new equipment installed and functioning?
    1. If so, when was it installed?

3. Was the new equipment installed as originally proposed? (ie efficiency, size, etc.)

4. Is the equipment operating as originally proposed and designed?

5. Was this project part of a larger project such as a major renovation?

6. Did you install any other energy efficiency measures around the same time this project was installed?

Pre-Existing Equipment (Baseline) Condition and Event Type Determination

7. Could you describe the system that has been replaced through this project?
    1. If there are multiple chillers/boilers/RTUs, how does the replaced system fit with the others?

8. When was the pre-existing system installed?

9. Please describe your institution's replacement policy for major equipment. For example, is it generally to:
    1. Run to failure or a repair is prohibitively expensive
    2. Replace if ongoing repair costs gradually drift up too high
    3. Replace in advance of failure according to a prescribed schedule
    4. Other (please describe)

10. What motivated your company to replace the [Chiller/Boiler/RTU]?
    1. The existing equipment had failed or was performing poorly
    2. Needs in the space changed
    3. Improve energy efficiency
    4. Save money on utility/energy bills
    5. To take advantage of the Energize CT incentive
    6. Other (please describe)

[Ask if 10 = a, else skip to 12]

11. You said that you replaced the existing equipment because it had failed or was performing poorly, what aspects of the performance were you unhappy with?
    1. Please describe:

12. Before this project, were you making routine repairs on the existing [Chiller/Boiler/RTU] such as replacing broken components, or making significant upgrades?
    1. Yes
    2. No
    3. Other
    4. Don't know

13. How frequently were you making routine repairs?
    1. Has the frequency changed in the last 3 years?

14. Does the newly installed system have any significant differences from the old system beside efficiency? For example, does it have any enhanced features, or is it a different size?
    1. Yes, please describe:
    2. No
    3. Don't know

15. If the equipment had failed on its own, would you have replaced it with a [chiller/RTU/boiler] of:
    a. Equal efficiency to what you installed?
    b. Higher efficiency than what you installed?

c. Lower efficiency than what you installed?

d. Don't know

Influence of the Program

16. How did you hear about the Early Retirement Program?
    1. Record answer:

17. Had you ever participated in other Energize CT Programs?
    i. Yes, record other programs here:
    ii. No
    iii. Don't know

18. Would you have implemented any new [boiler/chiller/RTU] at the same time without assistance from [sponsor]?
    1. Yes
    2. No
    3. Don't know

19. Would your business have implemented the same high efficiency [boiler/chiller/RTU] equipment as what you installed through the program without assistance from [sponsor]?
    1. Same
    2. Different, record different equipment here:
        i. [*If Different]* Please elaborate why you would have chosen different equipment
    3. Don't know

20. Would you have implemented the [boiler/chiller/RTU] earlier than you did, at a later date, or never, without assistance from [sponsor]?

    1. Earlier
    2. Later
    3. Never
    4. Don't know

21. How much earlier/later would you have implemented the project?
    1. < 6 months
    2. 6-12 months
    3. 1 – 2 years
    4. More than 2 years
    5. Don't know

22. Thinking about the [boiler/chiller/RTU] project you would have implemented on your own if the assistance had not been available, would you most likely have selected a unit that was:
    1. The same or higher efficiency as what you installed through the program
    2. Standard efficiency on the market at the time
    3. Something above standard efficiency on the market, but less efficiency than what you installed through the program
    4. Don't know

23. On a scale of 1 to 5, with respect to the influence the program incentive had on the decision to implement the [boiler/chiller/RTU], how much influence did the program have?

    1. No influence
    2. Some influence
    3. A moderate amount of influence
    4. very much influence
    5. An extreme amount of influence
    6. Don't know
    7. Refused

Spillover

24. Have you installed this measure at any other facilities in CT since participation in the ER program in 20__?
    a. If yes:
        i. Did that project receive an incentive for the installation cost?
            1. *[If no]* Why not?
        ii. How big was/were the subsequent projects compared to the initial ER one?
        iii. Was the efficiency for them the same, less, or more?
        iv. Please describe how your experience with the ER program influenced the decision, if it did at all? (Probe for highly influenced, moderately, somewhat, slightly, or not at all)

25. Have you installed this measure at any other facilities outside of CT?
    b. If yes:
        v. Did that project receive an incentive for the installation cost?
            1. *[If no]* Why not?
        vi. Was it the same size as the measure installed through this program?
        vii. Was the efficiency for them the same, less, or more?

Non-Energy Impacts

26. Has the project provided any benefits besides energy savings? Or caused any new increased costs?

27. I'll ask about a few specific categories now:

i. *(Particularly prompt if O&M costs were indicated as being an issue in the baseline battery)* Changed O&M costs (estimate if possible). Have O&M costs:
    i. Gone up? *[continue to 27-b]*
    ii. Gone down? *[continue to 27-b]*
    iii. Stayed the same *[ski[to 27-d]*

b. Is that change you noted more valuable, or less valuable than the energy savings for the project (this applies whether this value represents an increase or a decrease)?
    i. More valuable
    ii. Less valuable

c. Which of the following would you say characterizes the value:
    i. Extremely more/less valuable than the energy savings
    ii. Very much more/less valuable than the energy savings
    iii. Moderately more/less valuable than the energy savings
    iv. Slightly more/less valuable
    v. Same value as the energy savings

d. Has occupant comfort changed due to the project? If so has it:
    i. Improved
    ii. Gotten worse
    iii. Stayed the same

e. *(If project=chiller),* Has the water use:
    i. Gone up? *[continue to 27-e]*
    ii. Gone down? *[continue to 27-e]*
    iii. Stayed the same *[skip to 27-h]*

f. Is that change you noted more valuable, or less valuable than the energy savings for the project (this applies whether this value represents an increase or a decrease)?
    i. More valuable
    ii. Less valuable

g. Which of the following would you say characterizes the value:
    i. Extremely more/less valuable than the energy savings (or extremely larger in scale than the energy savings if represents an increase in use or a negative value)
    ii. Very much more/less valuable than the energy savings (or very much more/less in scale than the energy savings if represents an increase in use or a negative value)
    iii. Moderately more/less valuable than the energy savings (or moderately more/less in scale than the energy savings if represents an increase in use or a negative value)

iv. Slightly more/less valuable (or slightly more/less in scale than the energy savings if represents an increase in use or a negative value)
v. Same value as the energy savings

h. Has there been any change in productivity? For example, do you believe your output (production if industrial), or worker productivity has changed due to the installed project?
    i. More productive *[continue to 27-i]*
    ii. Less productive *[continue to 27-i]*
    iii. Stayed the same *[skip to next section]*

i. Is that change you noted more valuable, or less valuable than the energy savings for the project?
    i. More valuable
    ii. Less valuable

j. Which of the following would you say characterizes the value:
    i. Extremely more/less valuable than the energy savings
    ii. Very much more/less valuable than the energy savings
    iii. Moderately more/less valuable than the energy savings
    iv. Slightly more/less valuable
    v. Same value as the energy savings

Closing

Those are all the questions I have, thank you very much for your time today. *(end call)*

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.