# ComEd Virtual Commissioning Impact Evaluation Report

## Energy Efficiency / Demand Response Plan: Program Year 2019 (CY2019) (1/1/2019-12/31/2019)

**Presented to**
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**FINAL**

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# ComEd Virtual Commissioning Impact Evaluation Report

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# 1. Introduction

This report presents the results of the impact evaluation of ComEd's CY2019 Virtual Commissioning (VCx) Program. It includes a summary of the energy and demand impacts for the total program broken out by relevant measure and program structure details. The appendix provides the impact analysis methodology and details of the Total Resource Cost inputs. CY2019 covers January 1, 2019 through December 31, 2019.

# 2. Program Description

The VCx Program is an energy efficiency program, designed and operated for ComEd by Power TakeOff (PTO), that provides qualified ComEd business customers[1] with energy management and information system (EMIS) services to better manage their energy usage, identify energy savings opportunities, and achieve energy savings through low- or no-cost energy-saving measures. The VCx Program follows a step-by-step process to identify customers with significant potential for low- or no-cost energy savings, work with them to understand their energy usage and identify savings opportunities, enroll them in the VCx Program, and monitor their progress throughout the program. All energy savings actions taken by each participant are documented as part of the program, and PTO estimates energy savings throughout the year for each action using a regression analysis of the participant's pre- and post-enrollment energy usage data.

Unlike behavioral energy efficiency programs that provide participating customers with generic energy savings recommendations, where little or nothing is known about the specific actions taken by individual participants, the VCx Program collects a substantial amount of information about each participant, including a detailed log of each contact PTO had with the customer, the actions each participant agreed to take, and the date each action was undertaken.[2] Additionally, the program collects at least one year of pre-enrollment and three to six months of post-enrollment interval usage data from each meter.

The program had 177 participants in CY2019 and 177[3] energy management projects, as shown in Table 2-1.

**Table 2-1. CY2019 Volumetric Findings Detail**

| Participation | Count |
|---|---|
| Participants | 177 |
| Installed Projects | 177 |

*Source: ComEd tracking data and Guidehouse analysis*

[1] To qualify, a participant must be a ComEd business customer with at least one year of 30-minute interval AMI energy usage data available.

[2] Recommended actions may include, but are not limited to, adjusting HVAC schedules to match occupancy, installing smart timers to turn off unneeded equipment during off hours, managing equipment start-up and shut-down schedules, and delamping.

[3] Guidehouse received data for 199 projects but 21 were deemed ineligible by PTO and not included in the analysis. Guidehouse removed one additional project due to insufficient AMI data.

## 3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the VCx Program achieved in CY2019. This evaluation did not assess gas savings.

**Table 3-1. CY2019 Total Annual Incremental Electric Savings**

| Savings Category | Energy Savings (kWh) | Non-Coincident Demand Savings (kW) | Summer Peak* Demand Savings (kW) |
|---|---|---|---|
| Electricity | | | |
| Ex Ante Gross Savings‡ | 14,970,001 | NA | NA |
| Program Gross Realization Rate | 0.96 | NA | NA |
| Verified Gross Savings | 14,422,775 | 1,646 | 1,414 |
| Program Net-to-Gross Ratio (NTG) | 1.00 | 1.00 | 1.00 |
| Verified Net Savings | 14,422,775 | 1,646 | 1,414 |
| Converted from Gas† | | | |
| Ex Ante Gross Savings | NA | NA | NA |
| Program Gross Realization Rate | NA | NA | NA |
| Verified Gross Savings | NA | NA | NA |
| Program Net-to-Gross Ratio (NTG) | NA | NA | NA |
| Verified Net Savings | NA | NA | NA |
| Total Electric Plus Gas | | | |
| Ex Ante Gross Savings‡ | 14,970,001 | NA | NA |
| Program Gross Realization Rate | 0.96 | NA | NA |
| Verified Gross Savings | 14,422,775 | 1,646 | 1,414 |
| Program Net-to-Gross Ratio (NTG) | 1.00 | 1.00 | 1.00 |
| Verified Net Savings | 14,422,775 | 1,646 | 1,414 |

NR = Not reported (refers a piece of data that was not reported, i.e., non-coincident demand savings)
NA = Not applicable (refers to a piece of data that cannot be produced or does not apply)
* The coincident summer peak period is defined as 1:00-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.
† The program did not report and the evaluation did not document gas savings.
‡ Ex Ante Savings only included totals for participants included in the impact analysis. Guidehouse did not estimate savings for one participant due to data deficiency (see Appendix 3).
*Source: ComEd tracking data and evaluation team analysis*

## 4. Cumulative Persisting Annual Savings

Table 4-1 and Figure 4-1 show the measure-specific and total verified gross savings for the VCx Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2019. The electric CPAS across all measures installed in 2019 is 14,422,775 kWh (Table 4-1). The increase in savings in the final draft is based on additional evaluated customers which were not previously included. Guidehouse did not evaluate gas savings for this program, so electric CPAS is equivalent to total CPAS. The “historic” rows in the table are the CPAS contribution back to CY2018. The “Program Total Electric CPAS” is the sum of the CY2019 contribution and the historic contribution.

## Table 4-1. Cumulative Persisting Annual Savings (CPAS) – Electric

| End Use Type | Research Category | EUL | CY2019 Verified Gross Savings (kWh) | NTG* | Lifetime Net Savings (kWh)† | Verified Net kWh Savings 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other | VCx | 8.6 | 14,422,775 | 1.00 | 138,458,643 | | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 |
| CY2019 Program Total Electric Contribution to CPAS | | | 14,422,775 | | 138,458,643 | | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 |
| Historic Program Total Electric Contribution to CPAS‡ | | | | | | 8,148,664 | 8,148,664 | 8,148,664 | 8,148,664 | 8,148,664 | | | | |
| Program Total Electric CPAS | | | | | | 8,148,664 | 22,571,439 | 22,571,439 | 22,571,439 | 22,571,439 | 14,422,775 | 14,422,775 | 14,422,775 | 14,422,775 |
| CY2019 Program Incremental Expiring Electric Savings§ | | | | | | | | - | - | - | - | - | - | - |
| Historic Program Incremental Expiring Electric Savings‡§ | | | | | | | - | - | - | - | 8,148,664 | - | - | - |
| Program Total Incremental Expiring Electric Savings§ | | | | | | | - | - | - | - | 8,148,664 | - | - | - |

| End Use Type | Research Category | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other | VCx | 14,422,775 | 8,653,665 | | | | | | | | | | |
| CY2019 Program Total Electric Contribution to CPAS | | 14,422,775 | 8,653,665 | - | - | - | - | - | - | - | - | - | - |
| Historic Program Total Electric Contribution to CPAS‡ | | | | | | | | | | | | | |
| Program Total Electric CPAS | | 14,422,775 | 8,653,665 | - | - | - | - | - | - | - | - | - | - |
| CY2019 Program Incremental Expiring Electric Savings§ | | - | 5,769,110 | 8,653,665 | - | - | - | - | - | - | - | - | - |
| Historic Program Incremental Expiring Electric Savings: | | - | - | - | - | - | - | - | - | - | - | - | - |
| Program Total Incremental Expiring Electric Savings§ | | - | 5,769,110 | 8,653,665 | - | - | - | - | - | - | - | - | - |

Note: The green highlighted cell shows program total first year electric savings. The gray cells are blank, indicating values irrelevant to the CY2019 contribution to CPAS.

* A deemed value. Source: is to be found on the Illinois SAG web site here: https://www.ilsag.info/ntg_2019.

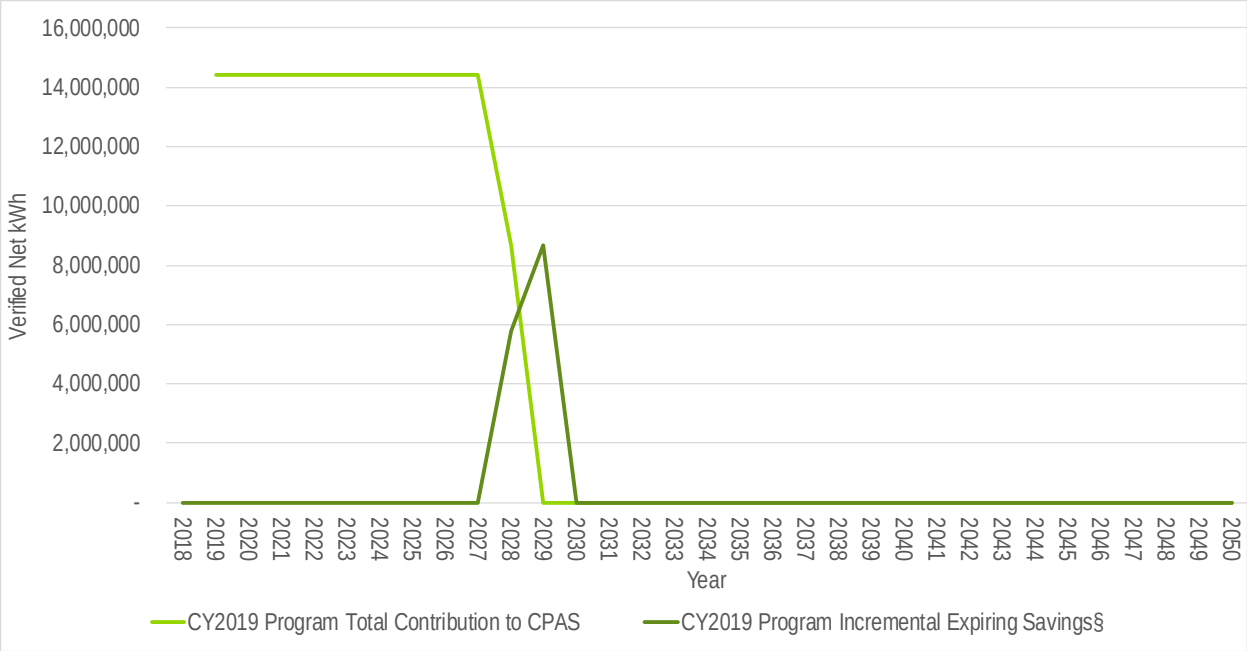
† Lifetime savings are the sum of CPAS savings through the EUL.

‡ Historical savings go back to CY2018

§ Incremental expiring savings are equal to CPAS $Y_{n-1}$ - CPAS $Y_n$

*Source: Evaluation team analysis*

**Figure 4-1. Cumulative Persisting Annual Savings**




* Expiring savings are equal to CPAS $Y_{n-1}$ - CPAS Y
*Source: Evaluation team analysis*

# 5. Program Savings by Measure

There is only one measure in this program and so measure-level results are the same as the program-level results discussed in the previous section.[4]

# 6. Impact Analysis Findings and Recommendations

## 6.1 Impact Parameter Estimates

The VCx Program does not have relevant impact parameters.

## 6.2 Other Impact Findings and Recommendations

The evaluation team developed several recommendation based on findings from the CY2019 evaluation.

**Finding 1.** Guidehouse found that while the overall realization rate (RR) of 0.96[5] for the VCx Program was reasonable, the range of verified savings and RRs observed for the 177 individual customer participants in CY2019 (see Section 8) was much wider than in previous years, despite the evaluation team and PTO having access to the same customer AMI

[4] See Section 8 below for detailed savings results.
[5] As noted in Table 3-1, Ex Ante savings, and therefore the realization rate, only used totals from participants included in the impact analysis.

energy usage data and weather data, and using broadly similar analytical approaches to measure savings.

**Finding 2.** At PTO's suggestion, Guidehouse adopted an hourly model as the default method to measure savings in CY2019 except in cases where a daily model was deemed superior.[6] PTO recommended using a daily model for 93 cases, but did not provide clear reasons for doing so. Guidehouse agreed to these changes as long as the model fit, as indicated by the adjusted R-squared, was improved by switching to the daily model.[7]

**Recommendation 1.** Guidehouse recommends that PTO share its individual participant regression results along with the customer energy consumption data, as it has done in prior years. This would help to clarify PTO's choice trails with respect to data cleaning and model selection.[8]

**Recommendation 2.** Guidehouse recommends that PTO provide additional supporting details for individual participants whose energy savings from VCx exceed 50 percent.[6]

**Recommendation 3.** Guidehouse recommends that PTO provide supporting details for its recommendations to use a daily rather than an hourly model.

## 7. Appendix 1. Impact Analysis Methodology

Guidehouse measured the VCx Program's CY2019 annualized energy savings by developing baseline hourly energy usage models for each CY2019 program participant, calibrated to their year of pre-enrollment daily usage data and available post-enrollment usage data using a regression model of the form shown in Equation 1, and using the fitted models, together with degree-day data derived from local weather data[9], to estimate each participant's gross energy savings attributable to the program. CY2019 gross program savings comprise the sum of the individual participants' gross annualized savings.

**Equation 1. VCx Hourly Load Model**

$$E_{t,d} = \sum_{h=1}^{24} \alpha_h HOD_{h,t} + \sum_{h=1}^{24} \beta_h HOD_{h,t} * Weekend_d + \sum_{m=1}^{12} \sum_{h=1}^{24} \beta_{m,h} HOD_{h,t} * Month_{t,m} +$$

$$\gamma_L CDH_{t,d} + \gamma_Q CDH_{t,d}^2 \gamma_L + \delta_L HDH_{t,d} + \delta_Q HDH_{t,d}^2 + \theta Change_{t,d} + \varepsilon_{t,d}$$

where:

- $t$, $d$, $m$ and $h$ index time of day, day of week, month of year and hour, respectively
- $E_{t,d}$ is the customer's energy consumption at time $t$ of day $d$
- The $HOD_{h,t}$ comprise a set of 24 binary hour-of-day indicators, which equal 1 if $t$ falls in the $h$th hour of the day, and 0 otherwise

[6] In previous years, Guidehouse used a daily model, fitted to participant AMI usage data aggregated to daily totals.
[7] See Table 8-1 for details on the projects PTO recommended be estimated with each type of model, and Guidehouse's choices of which model to use for evaluation.
[8] We understand that PTO intends to implement this recommendation starting in CY2020.
[9] Source: ZIP Code-level weather data from World Weather Online provided by PTO. https://www.worldweatheronline.com

- $Weekend_d$ is a binary indicator that equals 1 if $d$ is a weekend or holiday weekday, and 0 otherwise
- The $Month_{t,m}$ comprise a set of 12 month-of-year indicators, which equals 1 if $t$ falls in month $m$, and 0 otherwise
- $CDH_{t,d}$ are the cooling degree-hours during hour $t$ of day $d$
- $HDH_{t,d}$ are the heating degree-hours during hour $t$ of day $d$
- $Change_{t,d}$ is a binary indicator that equals 1 if $t$ falls after the date of the agreed-upon change(s), and 0 otherwise
- The $\alpha_h$, $\beta_h$, $\beta_{m,h}$, $\gamma_L$, $\gamma_Q$, $\delta_L$, $\delta_Q$, and $\theta$ are unknown parameters to be estimated
- $\varepsilon_{t,d}$ is a mean-zero disturbance term

When indicated by model fit, Guidehouse instead employed a daily version of the above model, shown in Equation 2.

**Equation 2. VCx Daily Load Model**

$$E_d = Weekend_d + \sum_{m=1}^{12} \beta_{d,m} Month_{d,m} + \gamma_L CDH_d + \gamma_Q CDH_d^2 + \delta_L HDH_d + \delta_Q HDH_d^2 + \theta Change_d + \varepsilon_d$$

where:

- $E_d$ is the customer's energy consumption during day $d$
- $CDH_d$ are the cooling degree-hours during day $d$
- $HDH_d$ are the heating degree-hours during day $d$
- $\varepsilon_d$ is a mean-zero disturbance term

and all other definitions are the same as in Equation 1.

Guidehouse applied a net-to-gross (NTG) ratio of 1.0 to the adjusted gross savings to estimate the verified net savings in CY2019 using the NTG value deemed through the SAG consensus process.

Guidehouse selected base temperatures used to calculate HDD and CDD values through an optimization process on a site-specific basis. Guidehouse chose to optimize base temperatures for each site as this information was not provided by the program participants. The Illinois Technical Reference Manual (TRM) states that while the default base temperature for C&I settings is 55 degrees for cooling and heating, developing custom degree-days with building-specific base temperatures is permissible, and recommended for larger C&I projects.[10]

[10] Illinois Statewide Technical Reference Manual for Energy Efficiency Version 8.0, available at: http://www.ilsag.info/technical-reference-manual.html.

Guidehouse obtained participant site-specific parameter values by fitting the regression model (Equation 1) to each participant's hourly usage data and weather data using all available (pre- and post-enrollment) data. Participant usage data consisted of hourly roll-ups of 30-minute interval meter data provided by PTO.

When calculating the cooling and heating degree-day variables from the weather data, Guidehouse identified site-specific optimal base temperatures for each participant site using a grid-search process. We fitted models to each participant site's data for all combinations of (integer) cooling and heating base temperatures on the [50°F, 75°F] grid, and selected the pair of base temperatures that yielded the highest model $R^2$ value in each case.

The set of Change dummy variables included indicators for exogenous (non-program) site changes in cases where PTO identified and confirmed such events. For example, an exogenous change could be a lighting retrofit that was done independently of participation in the VCx Program. Guidehouse included these exogenous dummy variables during parameter estimation to control for changes to usage that should not be attributed to program changes.

Guidehouse measured the VCx Program's CY2019 coincident peak demand savings using a modified form of the methodology used to measure energy savings. We applied a modified regression equation, shown in Equation 2, to a data set consisting only of summer peak days as defined in the Illinois TRM.(TRM) [11]

**Equation 3. VCx Peak Demand Model**

$$E_{t,d} = \sum_{h=1}^{24} \alpha_h HOD_{h,t} + \sum_{h=1}^{24} \beta_h \, HOD_{h,t} * Weekend_d + \gamma_L CDH_{t,d} + \gamma_Q CDH_{t,d}^2 \gamma_L + \delta_L HDH_{t,d} + \delta_Q HDH_{t,d}^2 + \theta_p Change_{t,d} + \theta_{op} Change_{t,d} * Offpeak_{t,d} + \varepsilon_{t,d}$$

where:

- $Offpeak_{t,d}$ is a binary indicator that equals 1 if $t$ falls outside of peak hours
- $\theta_p \; and \; \theta_{op}$ are unknown parameters to be estimated
- All other definitions are the same as in Equation 1

The coincident summer peak was calculated as the product of the weighted average of the individual participant $\theta_p$ coefficients, where the weights were the number of peak hours each customer had in the data set used to estimate Equation 2, and the number of customers in the sample.

## 8. Appendix 2. Detailed Customer-Level Results

Table **8-1** presents VCx Program verified savings and ex ante savings by customer, ranked in decreasing order by RR. The RRs shown in the table represent the ratio of Guidehouse's verified energy savings to the ex ante savings estimates produced by PTO analysts. As noted in Section 6.2, the evaluation team and PTO relied on the same customer AMI usage time-series data and weather data to generate their respective results. Thus, the wide range of verified percent savings and RRs raises concerns about our respective choice trails with respect to data cleaning and model selection.

[11] IL TRM v8.0, vol. 1, p. 50.

## Table 8-1. CY2019 Verified Saving by Custom

| VCx ID | Project Category | PTO Model Resolution | Guidehouse Model Resolution | Verified Savings (kWh) | Verified Savings % | Approved Ex Ante Savings (kWh) | Realization Rate |
|---|---|---|---|---|---|---|---|
| 0061Q00000mCdbvQAC | Lighting | Daily | Daily | 19,270 | 8.9% | 9,200 | 2.09 |
| 0063600000i5DcTAAU | HVAC/Lighting | Hourly | Hourly | 25,009 | 4.4% | 15,861 | 1.58 |
| 0061Q00000obTw6QAE | HVAC/Lighting | Hourly | Hourly | 29,678 | 15.9% | 18,916 | 1.57 |
| 0061Q00000obSoEQAU | HVAC/Lighting | Hourly | Hourly | 35,446 | 11.2% | 25,127 | 1.41 |
| 0061Q00000mDFyzQAG | Lighting | Hourly | Hourly | 363,430 | 28.5% | 258,919 | 1.40 |
| 0061Q00000mCYDtQAO | HVAC/Lighting | Hourly | Hourly | 162,645 | 11.8% | 119,689 | 1.36 |
| 0063600000i5DcqAAE | HVAC/Lighting | Hourly | Hourly | 16,788 | 5.3% | 12,385 | 1.36 |
| 0061Q00000mH79lQAC | HVAC | Hourly | Hourly | 4,334 | 6.4% | 3,202 | 1.35 |
| 0063600000fumPbAAI | HVAC | Hourly | Hourly | 9,300 | 7.8% | 7,011 | 1.33 |
| 0061Q00000mCfT8QAK | HVAC | Daily | Daily | 50,657 | 7.8% | 39,046 | 1.30 |
| 0061Q00000mH29WQAS | HVAC/Lighting | Daily | Hourly | 148,093 | 9.4% | 117,150 | 1.26 |
| 0063600000g4SdlAAE | HVAC/Lighting | Hourly | Hourly | 12,508 | 11.0% | 9,927 | 1.26 |
| 0061Q00000mCXPYQA4 | HVAC | Daily | Hourly | 4,379 | 5.0% | 3,506 | 1.25 |
| 0061Q00000mDFmtQAG | HVAC/Lighting | Hourly | Hourly | 60,576 | 9.4% | 48,899 | 1.24 |
| 0063600000g4E3IAAU | HVAC | Hourly | Hourly | 42,192 | 9.9% | 34,776 | 1.21 |
| 0061Q00000mCWkmQAG | HVAC | Hourly | Hourly | 108,081 | 12.7% | 89,678 | 1.21 |
| 0061Q00000mCXPUQA4 | HVAC | Daily | Hourly | 6,267 | 6.0% | 5,224 | 1.20 |
| 0061Q00000mCWEIQA4 | HVAC | Hourly | Hourly | 28,118 | 8.8% | 23,752 | 1.18 |
| 0063600000fuzhSAAQ | Lighting | Daily | Daily | 67,469 | 7.8% | 58,671 | 1.15 |
| 0061Q00000mCXP2QAO | HVAC | Hourly | Hourly | 6,315 | 4.9% | 5,599 | 1.13 |
| 0061Q00000mCcFVQA0 | HVAC | Hourly | Hourly | 62,904 | 21.6% | 56,738 | 1.11 |
| 0063600000fuzj3AAA | HVAC/Lighting | Hourly | Hourly | 69,355 | 8.0% | 62,802 | 1.10 |
| 0061Q00000mCWFGQA4 | HVAC | Daily | Daily | 57,876 | 23.7% | 52,497 | 1.10 |
| 0061Q00000mD0SMQA0 | HVAC/Lighting | Daily | Daily | 2,689 | 4.2% | 2,486 | 1.08 |
| 0061Q00000mDFncQAG | HVAC | Daily | Daily | 19,174 | 6.8% | 17,729 | 1.08 |
| 0063600000fuoxiAAA | HVAC/Lighting | Hourly | Hourly | 36,264 | 13.3% | 33,536 | 1.08 |
| 0063600000i5qdaAAA | HVAC/Lighting | Daily | Daily | 43,645 | 24.7% | 40,529 | 1.08 |
| 0061Q00000mH2gLQAS | HVAC | Hourly | Hourly | 37,990 | 13.5% | 35,313 | 1.08 |
| 0063600000g4SWFAA2 | HVAC/Lighting | Hourly | Hourly | 33,733 | 43.9% | 31,365 | 1.08 |
| 0063600000g4SVyAAM | Lighting | Daily | Daily | 66,190 | 21.2% | 61,781 | 1.07 |
| 0061Q00000mD0ghQAC | Lighting | Hourly | Hourly | 9,213 | 7.8% | 8,625 | 1.07 |
| 0061Q00000mCNRfQAO | HVAC/Lighting | Hourly | Hourly | 197,366 | 10.7% | 185,317 | 1.07 |
| 0061Q00000mCNQXQA4 | HVAC/Lighting | Hourly | Hourly | 128,381 | 18.7% | 120,778 | 1.06 |
| 0063600000g4SVvAAM | HVAC/Lighting | Hourly | Hourly | 376,300 | 77.8% | 355,686 | 1.06 |
| 0063600000fumPwAAI | HVAC/Lighting | Daily | Daily | 4,711 | 4.9% | 4,455 | 1.06 |
| 0063600000i6RclAAE | HVAC/Lighting | Daily | Daily | 3,470 | 3.8% | 3,296 | 1.05 |
| 0061Q00000mCXPCQA4 | HVAC | Daily | Daily | 1,961 | 3.4% | 1,864 | 1.05 |
| 0063600000g4E3EAAU | Lighting | Hourly | Hourly | 22,237 | 8.1% | 21,314 | 1.04 |
| 0061Q00000mGurpQAC | Lighting | Hourly | Hourly | 168,961 | 8.8% | 162,802 | 1.04 |
| 0061Q00000mCXPaQAO | HVAC | Hourly | Hourly | 4,394 | 3.6% | 4,237 | 1.04 |

| VCx ID | Project Category | PTO Model Resolution | Guidehouse Model Resolution | Verified Savings (kWh) | Verified Savings % | Approved Ex Ante Savings (kWh) | Realization Rate |
|---|---|---|---|---|---|---|---|
| 0061Q00000mGus8QAC | HVAC | Hourly | Hourly | 52,680 | 9.7% | 50,874 | 1.04 |
| 0061Q00000mGusMQAS | HVAC | Hourly | Hourly | 396,125 | 43.4% | 382,993 | 1.03 |
| 0063600000g4SgqAAE | HVAC/Lighting | Daily | Daily | 126,005 | 16.6% | 121,890 | 1.03 |
| 0061Q00000muPCuQAM | HVAC | Daily | Daily | 156,205 | 9.9% | 151,379 | 1.03 |
| 0061Q00000mCXPLQA4 | HVAC | Daily | Daily | 68,604 | 11.3% | 66,500 | 1.03 |
| 0061Q00000mCdm1QAC | HVAC | Daily | Daily | 157,910 | 24.2% | 153,097 | 1.03 |
| 0061Q00000mCWFTQA4 | Lighting | Daily | Daily | 134,058 | 22.8% | 130,260 | 1.03 |
| 0061Q00000mCXOoQAO | HVAC | Hourly | Hourly | 7,190 | 16.2% | 6,996 | 1.03 |
| 0061Q00000odUMiQAM | HVAC/Lighting | Daily | Daily | 10,251 | 17.9% | 9,987 | 1.03 |
| 0061Q00000mGurfQAC | HVAC/Lighting | Hourly | Hourly | 34,024 | 11.6% | 33,230 | 1.02 |
| 0063600000funPkAAI | HVAC/Lighting | Hourly | Hourly | 10,461 | 6.7% | 10,222 | 1.02 |
| 0061Q00000mCXPMQA4 | HVAC | Hourly | Hourly | 3,059 | 6.4% | 2,990 | 1.02 |
| 0061Q00000mCCv8QAG | HVAC | Hourly | Hourly | 26,178 | 8.2% | 25,592 | 1.02 |
| 0063600000fuzdUAAQ | HVAC/Lighting | Hourly | Hourly | 177,477 | 5.4% | 173,822 | 1.02 |
| 0061Q00000odJCsQAM | HVAC/Lighting | Hourly | Hourly | 230,618 | 34.0% | 226,016 | 1.02 |
| 0061Q00000mCddhQAC | HVAC | Daily | Daily | 25,160 | 13.0% | 24,668 | 1.02 |
| 0063600000fuzg6AAA | HVAC/Lighting | Hourly | Hourly | 267,907 | 8.4% | 262,860 | 1.02 |
| 0061Q00000mCdm7QAC | HVAC | Daily | Daily | 77,888 | 14.9% | 76,455 | 1.02 |
| 0061Q00000mCIk9QAG | HVAC | Hourly | Hourly | 381,182 | 18.6% | 374,943 | 1.02 |
| 0061Q00000mD0geQAC | Lighting | Hourly | Hourly | 30,006 | 41.1% | 29,543 | 1.02 |
| 0061Q00000mtsBWQAY | HVAC | Daily | Daily | 574,192 | 33.5% | 565,353 | 1.02 |
| 0061Q00000mGutGQAS | HVAC | Daily | Daily | 33,776 | 11.2% | 33,260 | 1.02 |
| 0061Q00000mH2fxQAC | HVAC/Lighting | Daily | Daily | 124,603 | 38.2% | 122,795 | 1.01 |
| 0061Q00000mCr3UQAS | Lighting | Daily | Hourly | 11,943 | 8.7% | 11,774 | 1.01 |
| 0063600000i5DcaAAE | Lighting | Daily | Daily | 133,825 | 29.1% | 131,968 | 1.01 |
| 0061Q00000mCXOfQAO | HVAC | Hourly | Hourly | 8,495 | 12.0% | 8,387 | 1.01 |
| 0061Q00000mCWgzQAG | HVAC | Hourly | Hourly | 182,055 | 5.0% | 179,796 | 1.01 |
| 0063600000i5qdpAAA | Lighting | Daily | Daily | 54,375 | 17.7% | 53,703 | 1.01 |
| 0063600000g4E2QAAU | Lighting | Hourly | Hourly | 7,621 | 6.5% | 7,527 | 1.01 |
| 0061Q00000od3uEQAQ | HVAC | Daily | Daily | 13,800 | 19.5% | 13,635 | 1.01 |
| 0063600000g4ScrAAE | Lighting | Daily | Daily | 15,388 | 14.2% | 15,212 | 1.01 |
| 0063600000fuzhPAAQ | HVAC/Lighting | Daily | Hourly | 123,540 | 13.7% | 122,442 | 1.01 |
| 0061Q00000mGus7QAC | HVAC/Lighting | Daily | Daily | 132,415 | 6.8% | 131,291 | 1.01 |
| 0061Q00000mCCv3QAG | Lighting | Daily | Daily | 110,449 | 34.7% | 109,549 | 1.01 |
| 0063600000g4SW1AAM | HVAC/Lighting | Hourly | Hourly | 38,408 | 28.0% | 38,126 | 1.01 |
| 0061Q00000mGusoQAC | HVAC | Daily | Daily | 70,672 | 8.4% | 70,180 | 1.01 |
| 0061Q00000mH0atQAC | Lighting | Daily | Daily | 91,562 | 12.3% | 91,061 | 1.01 |
| 0061Q00000mGwujQAC | HVAC | Daily | Daily | 914,901 | 27.5% | 909,940 | 1.01 |
| 0063600000g4E39AAE | HVAC/Lighting | Hourly | Hourly | 47,712 | 30.0% | 47,510 | 1.00 |
| 0061Q00000mH78YQAS | HVAC | Daily | Daily | 48,852 | 33.5% | 48,706 | 1.00 |

| VCx ID | Project Category | PTO Model Resolution | Guidehouse Model Resolution | Verified Savings (kWh) | Verified Savings % | Approved Ex Ante Savings (kWh) | Realization Rate |
|---|---|---|---|---|---|---|---|
| 0063600000g4SWdAAM | HVAC | Daily | Daily | 5,494 | 4.3% | 5,481 | 1.00 |
| 0061Q00000mCWFIQA4 | Custom | Daily | Daily | 28,181 | 11.8% | 28,116 | 1.00 |
| 0063600000g4SeOAAU | HVAC/Lighting | Daily | Daily | 29,315 | 22.8% | 29,266 | 1.00 |
| 0061Q00000kQaf6QAC | HVAC | Daily | Daily | 131,356 | 23.2% | 131,140 | 1.00 |
| 0063600000g4E2gAAE | Lighting | Daily | Daily | 83,361 | 69.4% | 83,256 | 1.00 |
| 0061Q00000mGqlUQAS | Lighting | Daily | Daily | 87,553 | 30.9% | 87,469 | 1.00 |
| 0063600000g4E2NAAU | HVAC | Daily | Hourly | 22,046 | 20.9% | 22,026 | 1.00 |
| 0063600000g4SW4AAM | HVAC/Lighting | Daily | Daily | 42,502 | 24.7% | 42,474 | 1.00 |
| 0061Q00000oc5mwQAA | HVAC | Daily | Daily | 214,275 | 20.1% | 214,390 | 1.00 |
| 0061Q00000mGurJQAS | Lighting | Hourly | Hourly | 170,692 | 7.7% | 170,974 | 1.00 |
| 0061Q00000kQagoQAC | Lighting | Daily | Daily | 53,677 | 30.6% | 53,806 | 1.00 |
| 0061Q00000mDL5bQAG | HVAC | Daily | Daily | 39,155 | 9.3% | 39,251 | 1.00 |
| 0063600000fuoxqAAA | Lighting | Daily | Daily | 383,744 | 55.5% | 385,134 | 1.00 |
| 0061Q00000kS208QAC | Lighting | Hourly | Hourly | 76,808 | 50.5% | 77,102 | 1.00 |
| 0061Q00000mGusQQAS | HVAC | Daily | Daily | 169,087 | 13.5% | 169,897 | 1.00 |
| 0061Q00000mu195QAA | HVAC | Daily | Daily | 125,470 | 14.3% | 126,090 | 1.00 |
| 0061Q00000mH2fnQAC | HVAC/Lighting | Hourly | Hourly | 17,186 | 8.7% | 17,286 | 0.99 |
| 0061Q00000mCXOKQA4 | HVAC | Hourly | Hourly | 20,367 | 12.8% | 20,500 | 0.99 |
| 0061Q00000mCXPIQA4 | HVAC | Hourly | Hourly | 20,593 | 11.8% | 20,736 | 0.99 |
| 0063600000g4SWbAAM | HVAC | Daily | Daily | 18,587 | 18.5% | 18,719 | 0.99 |
| 0063600000g4SW2AAM | Lighting | Daily | Daily | 88,573 | 14.9% | 89,226 | 0.99 |
| 0061Q00000kQmEYQA0 | HVAC | Hourly | Hourly | 126,414 | 29.4% | 127,360 | 0.99 |
| 0061Q00000mD0gfQAC | HVAC/Lighting | Daily | Daily | 33,107 | 26.3% | 33,357 | 0.99 |
| 0061Q00000mH8mrQAC | HVAC/Lighting | Hourly | Hourly | 332,826 | 22.6% | 335,415 | 0.99 |
| 0061Q00000mCWg1QAG | HVAC | Hourly | Hourly | 208,551 | 24.5% | 210,784 | 0.99 |
| 0063600000fuzg3AAA | HVAC/Lighting | Daily | Daily | 12,909 | 7.6% | 13,060 | 0.99 |
| 0061Q00000mGusPQAS | HVAC/Lighting | Daily | Daily | 31,144 | 12.6% | 31,594 | 0.99 |
| 0063600000g4SW5AAM | Lighting | Hourly | Hourly | 67,102 | 16.9% | 68,124 | 0.98 |
| 0061Q00000mCXOdQAO | HVAC | Hourly | Hourly | 10,785 | 10.6% | 10,970 | 0.98 |
| 0061Q00000mH8rXQAS | HVAC/Lighting | Daily | Daily | 622,494 | 15.4% | 633,857 | 0.98 |
| 0061Q00000mCXPAQA4 | HVAC | Daily | Daily | 20,918 | 20.2% | 21,308 | 0.98 |
| 0061Q00000mCXP0QAO | HVAC | Daily | Daily | 12,173 | 12.6% | 12,407 | 0.98 |
| 0061Q00000od7aqQAA | Lighting | Daily | Daily | 40,357 | 15.9% | 41,187 | 0.98 |
| 0063600000i5fYiAAI | HVAC/Lighting | Hourly | Hourly | 278,159 | 8.9% | 284,613 | 0.98 |
| 0063600000fuzcRAAQ | Lighting | Daily | Hourly | 56,334 | 29.9% | 57,749 | 0.98 |
| 0061Q00000mCXOUQA4 | HVAC | Daily | Daily | 10,220 | 9.3% | 10,479 | 0.98 |
| 0061Q00000mCgxZQAS | HVAC/Lighting | Hourly | Hourly | 242,643 | 36.8% | 249,315 | 0.97 |
| 0061Q00000obm82QAA | HVAC/Lighting | Hourly | Hourly | 17,461 | 18.9% | 18,035 | 0.97 |
| 0061Q00000mCXP6QAO | HVAC | Daily | Daily | 20,521 | 23.2% | 21,205 | 0.97 |
| 0061Q00000mH0ayQAC | Lighting | Daily | Daily | 195,779 | 23.5% | 202,393 | 0.97 |

| VCx ID | Project Category | PTO Model Resolution | Guidehouse Model Resolution | Verified Savings (kWh) | Verified Savings % | Approved Ex Ante Savings (kWh) | Realization Rate |
|---|---|---|---|---|---|---|---|
| 0061Q00000mGurzQAC | HVAC | Hourly | Hourly | 12,781 | 2.7% | 13,215 | 0.97 |
| 0061Q00000mH2fsQAC | HVAC | Daily | Hourly | 67,802 | 19.2% | 70,224 | 0.97 |
| 0063600000g4SVrAAM | HVAC | Daily | Daily | 33,914 | 11.6% | 35,161 | 0.96 |
| 0061Q00000mCXOqQAO | HVAC | Daily | Daily | 4,764 | 6.2% | 4,948 | 0.96 |
| 0061Q00000mCWDWQA4 | HVAC | Daily | Daily | 161,163 | 12.0% | 167,398 | 0.96 |
| 0061Q00000mCXOYQA4 | HVAC | Hourly | Hourly | 41,882 | 13.8% | 43,536 | 0.96 |
| 0061Q00000mH8R8QAK | HVAC | Daily | Daily | 42,377 | 9.1% | 44,074 | 0.96 |
| 0061Q00000mCWFCQA4 | Custom | Daily | Hourly | 23,108 | 14.8% | 24,041 | 0.96 |
| 0061Q00000mCXOaQAO | HVAC | Hourly | Hourly | 23,370 | 17.1% | 24,349 | 0.96 |
| 0061Q00000mCXPEQA4 | HVAC | Daily | Daily | 20,631 | 17.7% | 21,568 | 0.96 |
| 0063600000g4E2xAAE | HVAC/Lighting | Daily | Daily | 82,741 | 46.3% | 86,625 | 0.96 |
| 0061Q00000mCXPKQA4 | HVAC | Daily | Daily | 31,877 | 14.5% | 33,542 | 0.95 |
| 0061Q00000mCXOvQAO | HVAC | Daily | Daily | 18,295 | 25.4% | 19,252 | 0.95 |
| 0063600000fuzgpAAA | HVAC/Lighting | Daily | Daily | 44,957 | 17.1% | 47,312 | 0.95 |
| 0061Q00000mGutKQAS | HVAC | Daily | Daily | 50,636 | 10.3% | 53,298 | 0.95 |
| 0061Q00000mCXObQAO | HVAC | Daily | Daily | 14,916 | 25.0% | 15,800 | 0.94 |
| 0061Q00000mCXOsQAO | HVAC | Hourly | Hourly | 109,197 | 12.5% | 116,176 | 0.94 |
| 0063600000fuoxhAAA | HVAC/Lighting | Daily | Hourly | 83,437 | 21.8% | 89,075 | 0.94 |
| 0061Q00000mCXOkQAO | HVAC | Daily | Daily | 2,613 | 3.9% | 2,790 | 0.94 |
| 0061Q00000mCWEmQAO | HVAC/Lighting | Daily | Hourly | 118,670 | 18.2% | 127,268 | 0.93 |
| 0061Q00000mCXPdQAO | HVAC | Hourly | Hourly | 98,245 | 21.8% | 105,610 | 0.93 |
| 0061Q00000mCXOeQAO | HVAC | Daily | Daily | 14,104 | 12.7% | 15,175 | 0.93 |
| 0061Q00000mH2fkQAC | HVAC/Lighting | Daily | Hourly | 15,845 | 11.1% | 17,079 | 0.93 |
| 0061Q00000mGusKQAS | HVAC | Hourly | Hourly | 110,802 | 21.0% | 119,896 | 0.92 |
| 0061Q00000mCXP9QAO | HVAC | Hourly | Hourly | 5,896 | 7.6% | 6,404 | 0.92 |
| 0061Q00000mCXOuQAO | HVAC | Hourly | Hourly | 9,363 | 11.1% | 10,238 | 0.91 |
| 0061Q00000mCdlvQAC | HVAC | Hourly | Hourly | 39,384 | 6.8% | 43,105 | 0.91 |
| 0061Q00000mCdmGQAS | HVAC | Daily | Daily | 33,214 | 10.5% | 36,360 | 0.91 |
| 0061Q00000mCXOZQA4 | HVAC | Hourly | Hourly | 2,214 | 3.9% | 2,428 | 0.91 |
| 0061Q00000mCXOMQA4 | HVAC | Daily | Hourly | 21,857 | 18.0% | 23,982 | 0.91 |
| 0061Q00000mCXPDQA4 | HVAC | Daily | Daily | 26,500 | 26.1% | 29,138 | 0.91 |
| 0061Q00000mCXOVQA4 | HVAC | Hourly | Hourly | 2,784 | 9.1% | 3,100 | 0.90 |
| 0061Q00000mCXOwQAO | HVAC | Hourly | Hourly | 186,436 | 14.8% | 208,138 | 0.90 |
| 0061Q00000mCXPHQA4 | HVAC | Daily | Daily | 10,168 | 10.3% | 11,443 | 0.89 |
| 0061Q00000mCXOOQA4 | HVAC | Hourly | Hourly | 15,934 | 5.8% | 17,934 | 0.89 |
| 0061Q00000mCdlzQAC | HVAC | Daily | Hourly | 3,612 | 7.1% | 4,138 | 0.87 |
| 0061Q00000mCXOzQAO | HVAC | Hourly | Hourly | 6,480 | 4.9% | 7,462 | 0.87 |
| 0063600000g4SdmAAE | HVAC/Lighting | Daily | Daily | 6,533 | 7.0% | 7,607 | 0.86 |
| 0061Q00000mGurMQAS | HVAC | Daily | Daily | 25,192 | 3.4% | 29,379 | 0.86 |
| 0061Q00000mCTZrQAO | HVAC/Lighting | Hourly | Hourly | 17,227 | 11.9% | 20,119 | 0.86 |

| VCx ID | Project Category | PTO Model Resolution | Guidehouse Model Resolution | Verified Savings (kWh) | Verified Savings % | Approved Ex Ante Savings (kWh) | Realization Rate |
|---|---|---|---|---|---|---|---|
| 0061Q00000mCXOyQAO | HVAC | Hourly | Hourly | 4,414 | 4.1% | 5,263 | 0.84 |
| 0061Q00000kQWFkQAO | HVAC | Hourly | Hourly | 139,600 | 6.5% | 167,439 | 0.83 |
| 0061Q00000mCXOrQAO | HVAC | Hourly | Hourly | 96,739 | 8.5% | 116,440 | 0.83 |
| 0061Q00000mCrbrQAC | HVAC | Hourly | Hourly | 135,840 | 10.9% | 164,620 | 0.83 |
| 0063600000g4SWVAA2 | Lighting | Hourly | Hourly | 1,931 | 2.6% | 2,374 | 0.81 |
| 0061Q00000mCXOiQAO | HVAC | Daily | Hourly | 4,730 | 5.0% | 5,830 | 0.81 |
| 0061Q00000mGvztQAC | HVAC | Hourly | Hourly | 71,938 | 4.8% | 96,047 | 0.75 |
| 0063600000funBiAAI | Lighting | Hourly | Hourly | 11,197 | 6.2% | 14,973 | 0.75 |
| 0061Q00000mGus3QAC | HVAC/Lighting | Hourly | Hourly | 39,876 | 6.1% | 53,558 | 0.74 |
| 0063600000g4SauAAE | HVAC/Lighting | Daily | Hourly | 39,589 | 12.9% | 62,260 | 0.64 |
| 0061Q00000mDCH3QAO | HVAC | Hourly | Hourly | 31,351 | 4.1% | 51,510 | 0.61 |
| 0063600000i5Dd8AAE | HVAC/Lighting | Daily | Hourly | 19,144 | 4.3% | 31,742 | 0.60 |
| 0063600000fuzhQAAQ | Lighting | Hourly | Hourly | 11,430 | 9.0% | 22,143 | 0.52 |
| 0061Q00000mCWGPQA4 | HVAC | Hourly | Hourly | 68,517 | 16.6% | 157,684 | 0.43 |
| 0063600000fun6RAAQ | HVAC/Lighting | Daily | Daily | 23,793 | 9.5% | 61,332 | 0.39 |
| 0061Q00000mH2fjQAC | HVAC/Lighting | Hourly | Hourly | 249,312 | 8.0% | 761,993 | 0.33 |
| 0063600000g4SdOAAU | HVAC/Lighting | Hourly | Hourly | 5,593 | 1.7% | 24,635 | 0.23 |
| 0063600000i5DcgAAE | HVAC/Lighting | Hourly | | - | - | 28,822 | - |
| Total | | | | 14,144,078 | | 14,998,823 | 0.94* |

* Note: Guidehouse excluded one participant from the analysis (see Appendix 3). This total Ex Ante and RR count all participants with approved Ex Ante savings rather than only the participants included in the impact evaluation.
*Source: ComEd Data and Guidehouse evaluation team analysis*

## 9. Appendix 3. Data and Data Cleaning Details

Guidehouse performed several data cleaning steps prior to modeling. Table 9-1 shows details about the AMI data, the data cleaning process, and attrition at each cleaning step. The descriptions of each step are as follows:

**Table 9-1. AMI Data Attrition**

| Step | Customer Count | Observation Count | Customers Removed | Observations Removed | % Customers Removed | % Observations Removed |
|---|---|---|---|---|---|---|
| 0 - Raw AMI Data | 199 | 18,589,827 | | | | |
| 1 - Only Meters in Tracking & AMI Data | 198 | 11,000,445 | 1 | 7,589,382 | 0.50% | 40.83% |
| 2 - Aggregate to Hourly | 198 | 5,501,856 | 0 | 5,498,589 | 0.00% | 49.99% |
| 3 - Remove Incomplete Intervals | 198 | 5,497,867 | 0 | 3,989 | 0.00% | 0.07% |
| 4 - Aggregate Multiple Meters | 198 | 5,497,867 | 0 | 0 | 0.00% | 0.00% |
| 5 - Customers With Full Year of Pre Period Data | 197 | 5,459,809 | 1 | 22,508 | 0.51% | 0.41% |
| 6 - Data Addendum | 198 | 5,506,017 | | | | |

*Source: Guidehouse evaluation analysis*

Table 9-2 provides details as to why Guidehouse removed specific customers from the analysis.

| | |
|---|---|
| 0 – Raw AMI Data | This represents the data as received. |
| 1 – Only Meters in Tracking & AMI Data | Guidehouse removed one customer whose listed meter did not appear in the AMI data. This customer was added back in step 6 – Data Addendum. |
| 2 – Aggregate to Hourly | Guidehouse rolled up half-hourly kWh intervals to hourly. |
| 3 – Remove Incomplete Intervals | Guidehouse removed hourly intervals that were missing any half-hour component. |
| 4 – Aggregate Multiple Meters | Guidehouse summed usage from different meter numbers with the same account id and premise id. |
| 5 – Customers With Sufficient Pre Period Data | Guidehouse removed one customer that did not have AMI data going back at least 330 days prior to their VCx change date. |
| 6 – Data Addendum | PTO provided supplemental data to address some deficiencies. This data had a slightly different format and had to be added back after tracking attrition. |

**Table 9-2. Customers Removed**

| VCx ID | Reason for Removal |
|---|---|
| 0063600000i5DcgAAE | Only had 296 pre-period days |

## 10. Appendix 4. Total Resource Cost Detail

Table 10-1 shows the Total Resource Cost (TRC) cost-effectiveness analysis inputs available at the time of finalizing this impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to the evaluation team later.

## Table 10-1. Total Resource Cost Savings Summary

| End Use Type | Research Category | Units | Quantity | EUL (years)* | ER Flag† | Verified Gross Electric Energy Savings (kWh) | Verified Gross Peak Demand Reduction (kW) | Verified Gross Gas Savings (Therms) | Gross Heating Penalty (kWh) | Gross Heating Penalty (Therms) | NTG (kWh) | NTG (kW) | NTG (Therms) | Verified Net Electric Energy Savings (kWh) | Verified Net Peak Demand Reduction (kW) | Verified Net Gas Savings (Therms) | Net Heating Penalty (kWh) | Net Heating Penalty (Therms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other | VCx | Projects | 177 | 8.6 | No | 14,422,775 | 1,414 | NA | NA | NA | 1 | 1 | NA | 14,422,775 | 1,414 | NA | NA | NA |
| | Total | | | 8.6 | | 14,422,775 | 1,414 | 0 | 0 | 0 | 1.00 | 1.00 | NA | 14,422,775 | 1,414 | 0 | 0 | 0 |

NA = Not applicable
* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.
† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.
*Source: Guidehouse evaluation analysis*